THE DRUMMUCK GROUP, GIRVAN; A STRATIGRAPHICAL REVISION, WITH DESCRIPTIONS OF NEW FOSSILS FROM THE LOWER PART OF THE GROUP.

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THE DRUMMUCK GROUP, GIRVAN; A STRATIGRAPHICAL REVISION, WITH DESCRIPTIONS OF NEW FOSSILS FROM THE LOWER PART OF THE GROUP.

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CONTENTS.

I N T R O D U C T I O N.

The Drummuck Group as defined in this paper falls entirely within the one-inch Geological Map, Scotland, Sheet 14. It forms part of the succession in the Craighead-Glenshalloch inlier. This elongate, anticlinal inlier - which comprises all the Ordovician and Silurian beds north of the Girvan valley - consists of three main blocks:- (1) Craighead Hill, (2) Drummuck and Quarrel Hill, and (3) a less well-defined north-eastern block, entirely (Lapworth, 1882, pl. XXIV) or partly (Geological 1" Map, Scotland, Sheet 14) divided by faulting from the Drummuck and Quarrel Hill block.

T A B L E O F S T R A T A I N T H E C R A I G H E A D - G L E N S H A L L O C H I N L I E R.

The following table embodies the findings of previous authors (Lapworth 1882, Peach and Horne 1899, Jones 1928, etc.) and also additions proposed in the present revisory paper:-

SILURIAN.

BIRKHILL (b^4)	N e w l a n d s S e r i e s. Saugh Hill Group. Glenshalloch shales with *Monograptus gregarius* Lapworth. Newlands ochreous flagstones with *Barrandella undata* (Sowerby). Mulloch Hill Group. Glenwells shales with *Cephalograptus acuminatus* (Nicholson). Mulloch Hill sandstone. b. Craigens ochreous sandstone. a. Rough Neuk sandstone. Mulloch Hill conglomerate. High Mains sandstone with "Orthis" *sagittifera* McCoy.	LLANDOVERY.

ORDOVICIAN.

HARTFELL (b^3)	Ardmillan Series.	ASHGILLIAN.
	Drummuck Group.	
	2. Upper	
	Ladyburn mudstones, at South Threave, etc. with Dicellograptus anceps (Nicholson).	
	"Starfish Bed" of Drummuck.	
	Mudstones (massive).	
	1. Lower	
	Mudstones (fine, splintery).	
	"Crinoid Bed" of Quarrel Hill.	
	Quarrel Hill mudstones.	
	Basal conglomerate and grits.	
	Barren Flagstone Group.	
	Flagstones and shales.	
	Whitehouse Group (not recognised in inlier; upper beds contain Dicellograptus complanatus (Lapworth)).	
	Ardwell Group.	CARADOCIAN.
	Ardwell flagstones, at Trochraigue.	
	Plantinhead flagstones with "Upper Glenkiln" graptolites ($b^{?2-3}$)	
GLENKILN (b^2)	Barr Series.	
	Balcletchie Group (not recognised in inlier).	
	Benan Conglomerate.	
	Stinchar Limestone Group.	
	Craighead shaly limestone.	
	" massive-breccia limestone.	
	Igneous Detritus.	
ARENIG (b^1)	Ballantrae Rocks.	
	Pillow-lavas with cherts and shales.	

NOTES ON PREVIOUS RESEARCH.

An early contribution to the reading of this succession was that by Murchison who distinguished an ascending series consisting of (1) lavas, (2) Craighead limestone, (3) sandstone and conglomerate of Mulloch Hill, and (4) Drummuck shales (1851, pp. 143-146). Hugh Miller, while deferring to Murchison, was not quite sure that the Drummuck beds succeeded those of Mulloch Hill (1858, Everyman Edition, p. 299). The age and stratigraphical order of the beds were not settled until Archibald Geikie wrote a substantially correct summary interpretation (1869, pp. 8-10). It remained, however, for Lapworth, as part of his paper "The Girvan Succession," to publish, in full detail, what is still the definitive account of the inlier (1882, pp. 614-621). In this paper, which is illustrated with a large scale map, the author indicates a division of the Drummuck Group into lower (Quarrel Hill) and upper (Ladyburn) parts. Peach and Horne in the Geological Survey memoir (1899, pp. 522-526) closely follow Lapworth's account. They emphasise the fact that south of the Girvan valley the Drummuck Group and the Mulloch Hill Group do not appear. Since these are of considerable thickness - at least 750 feet (op. cit., pp. 81-82) - it is probable that this is not due to faulting but to non-deposition. The Ordovician sequence south of the Girvan valley ends in the Barren flagstones. These succeed the Whitehouse Group - not recognised north of the

Girvan valley - the upper beds of which contain Dicellograptus complanatus (Lapworth), the index graptolite of the Lower Ashgillian. The Barren flagstones are thus above the earliest occurrence of D. complanatus, and provide a link connecting the southern succession with that in the Craighead-Glenshalloch inlier. Before we obtain a record of the Upper Ashgillian zonal graptolite, Dicellograptus anceps (Nicholson), we have to traverse the Barren flagstones and the Drummuck Group to the highest mudstones of the latter at South Threave where D. anceps was collected by Mrs. Robert Gray. Lapworth incorrectly, as it seems to the writer, placed these mudstones beneath the "Starfish Bed," a point which will be dealt with presently.

In Plate III the outcrops of the Drummuck Group and the Mulloch Hill Group are terminated by an east-west fault that passes north of Craighead Hill. On the other hand, Lapworth (p. 622), following Geikie, treated the conglomerate on which Trochraigue mansion-house stands as that of Mulloch Hill. He also considered certain flagstones dipping under the conglomerate south of the mansion-house as of Drummuck age (p. 620). In this he differed from Geikie who had mapped them as b^2 beds. Peach and Horne distinguished the conglomerate at Trochraigue as probably the Benan, and assigned the flagstones, from which they obtained a considerable fauna, to a position not far above the Craighead limestone (1899, pp. 504-505). Dr. J. E.

Richey and Mr. Eckford came to the same conclusions, but in other shaly-flagstones overlying the conglomerate in an old quarry north-west of Trochraigue House they found Dicellograptus morrisi Hopkinson, which they thought might be of Ardwell flagstone age (Richey reported by Bailey, 1927, p. 57). Further suggestions on this question will be made in the next section.

RELATIONS OF THE DRUMMUCK GROUP TO OLDER FORMATIONS.

Such changes in Lapworth's description as are suggested under this heading mainly affect the area south of the fault bounding the north side of Craighead Hill (Pl. III). Richey on the Geological Survey maps interprets the northern boundary of the lava exposures here as a line of fault, and the present writer considers that the fault continues due westward to cut off the Drummuck mudstones and the Mulloch Hill conglomerate. On the south side of the fault as now drawn neither Richey nor the writer has found any exposure of Drummuck or Mulloch Hill type. There are, however, a number of shaly outcrops, including those already mentioned north-west and south of Trochraigue mansion-house, which have a very distinctive appearance. They consist of rapid alternations of sandy with shaly bands. Two or more sudden changes of texture may occur in an inch of strata, and the bedding in

the arenaceous layers often shows perceptible grading. With the help of this it is possible to determine with reasonable certainty that the beds south of Trochraigue House are steeply inverted. They have their original base towards the conglomerate - presumably the Benan - on which Trochraigue House stands. They are thus younger than the Benan conglomerate, and should be correlated with the beds, lying above the conglomerate in the old quarry, which were regarded by Richey and Eckford as probably of Ardwell age. This conclusion is backed by the exceptional nature of the sedimentation. Such rapidly alternating bedding is typical in the Ardwell Group, and in parts of the Whitehouse and Barren flagstone formations. It is certainly not found, in the Ordovician succession at Girvan, before the end of Balcletchie times or above the base of the Drummuck Group.

Other two exposures of alternating beds may be examined on the north-west side of Craighead Hill. They occur not far south of the east-west fault which I believe forms the southern boundary of the Drummuck Group. In both cases the beds are seen crossing the "tails" of glaciated lava-hillocks. In the more north-easterly the strata are steeply inverted, dipping at 50° towards the lavas, the junction probably being a fault. In the other exposure the alternating beds are vertical. No fossils are available to fix the age of the beds. They may be equivalent to the Ardwell flags; or they may be part of the Barren flagstone suite. They closely resemble beds usually

taken as Barren flags, which outcrop east of Blair mansion-house, on the north side of the east-west fault. These show grading, are not inverted, and dip south-east at 45°. Somewhat similar beds of grey green mudstones with sandy streaks appear still farther north-west in much faulted country. The exposures of these lie almost exactly 200 yards north-west of the site of Glenmard. Again in these cases fossil evidence is not available, but the uppermost limit for such sedimentation is the base of the Drummuck Group. It is in view of this difficulty that in the accompanying map (Pl. III) it has been thought inadvisable to attempt to map Ardwell and Barren flagstones separately.

Just on the north side of the east-west fault, in a stream west of Plantinhead farmhouse, there is an interesting occurrence of alternating beds which must be considered by itself. Here, Richey states that the shales "closely approximate in stratigraphical position to the Craighead (Stinchar) Limestone which in the field they apparently overlie" (Richey reported by Bailey, 1927, p. 57). The graptolites they contain - Climacograptus antiquus Lapworth, Cl. lineatus Elles and Wood, and Amplexograptus perexcavatus (Lapworth) - are regarded by Dr. Elles as well up in the Glenkiln (op. cit., p. 58), i.e., somewhere below the Balcletchie Group. The present writer, however, is influenced by the lithology of the beds, and is inclined to take them as post-Balcletchie. They are grey and purple flaggy shales with rapid alternations of

sandy and finer layers. Lithologically they definitely fall into the same group as those at Trochraigue. On this account they may best be included in the Ardwell Group, as its earliest member, distinguished by the local name of Plantinhead flagstones. Richey conjectures that the hill which stretches for half a mile east of this exposure consists of "Benan Conglomerate (not exposed)" (Geological 6" Map, Ayrshire, Sheet L. SW.), but it may equally well be made of Ardwell or Barren flagstones, either of which would provide a rock mass resistant to weathering.

RELATIONS OF THE DRUMMUCK GROUP TO YOUNGER FORMATIONS.

At the north-eastern extremity of the Drummuck Group outcrop, modification in the Survey interpretation must also be proposed. High Mains farmhouse stands on Mulloch Hill conglomerate, dipping steeply to the east. One hundred yards west of the farmhouse there is an elongate hillock of buff-weathering sandstone dipping under the conglomerate at 45°. This outcrop is mapped by the Survey (Geological 6" Map, Ayrshire, Sheet L. NE.) as Drummuck Group, but the fossil evidence excludes this possibility. The fauna is like that of the Mulloch Hill Group with abundant Meristella sp. It is, however, specially characterised by "Orthis" sagittifera McCoy, a fossil typical of the Hirnant beds in Wales, but unknown in the main part of the

Mulloch Hill Group. It is true that Peach and Horne recorded "O". sagittifera from the Mulloch Hill sandstone (1899, pp. 529-530), but Dr. Reed showed that the species in question is distinguished by a bilobed cardinal process, and described it as Stropheodonta (Brachyprion) columbana (1917, pp. 896-897). A fresh discussion of the affinities of these species is appended (vide infra, pp. 36-40). The newly distinguished sandstone yielding "O". sagittifera may be spoken of as the High Mains sandstone[1] and treated as basal member of the Mulloch Hill Group.

Another strip of the High Mains sandstone, dipping north-east at 55° under the conglomerate, occurs 300 yards west-south-west of High Mains on a steep slope facing towards the burn (Pl. III). This outcrop is apparently continued west of the burn in an old quarry of slabby sandstone dipping at 30° under the Mulloch Hill conglomerate. The nearest exposure of Drummuck strata consists of fine, splintery mudstones typical of the lower division of the Group. The absence here of the sandier and more massive upper division points almost certainly to an unconformity such as is shown in Plate III. On this interpretation the High Mains sandstone would represent the first stage of a transgression in Mulloch Hill times.

A further change affects mapping rather than stratigraphy.

(1) In a table of strata Lapworth (p. 618) makes one reference to "High Mains beds," meaning sandstones immediately above the Mulloch Hill conglomerate, but he does not repeat the term in the text of his paper, and it was not adopted by Peach and Horne. I have, in these circumstances, ventured to use the name "High Mains sandstone" in a different connotation, for the sandstones below the conglomerate, since no other appropriate topographical name is available.

Two sandstone exposures, respectively one third of a mile north-west and one quarter of a mile north-north-west of Woodhead farmhouse were mapped by the Survey (Geological 6" Map, Ayrshire, Sheet L. SW.) as "?Barren Flagstones." They are, however, lithologically indistinguishable from the Lower Old Red sandstone in the near neighbourhood to north and west. The boundary of the L. O. R. S. has been altered accordingly in Plate III.

D I V I S I O N S O F T H E D R U M M U C K G R O U P.

After this digression regarding adjacent older and younger strata, we may conclude that the Drummuck Group as now defined extends from an indeterminate area on the west of Blair Hill, through Drummuck farm, and Threave Glen, to Quarrel Hill. The ruin of "Auldthorns"(2) stands on a faulted strip of the Drummuck beds, which continues at least as far as the steeply incised burn separating Quarrel Hill from High Mains. The Group is bounded below by the Barren flagstones, and above by the Mulloch Hill conglomerate, except at its north-east extremity where we find the High Mains sandstone.

(2) Lapworth uses the term "Auldthorns Hill" for the escarpment on which the ruin that he and other geologists have termed "Auldthorns" stands (Lapworth, p. 617, pl. XXIV, Peach and Horne, pp. 523, 524). Local inquiries and the Ordnance maps do not support the use of these names. They were probably coined with reference to a number of weatherbeaten hawthorn trees near the ruin, the original name of which, I am told, was Quarrel Hill House.

The territory occupied is about three miles long from south-west to north-east, and half a mile broad.

The subdivision of the Drummuck Group depends upon the shelly faunas, and is complicated by the fact that different kinds of facies, sandy and muddy, are present. A discussion of these has been included in an earlier paper (Lamont, 1934, pp. 170-176). Sessile forms like the Brachiopoda, it may be accepted, depend largely upon suitable sea-floor, currents, etc. Trilobites are less definitely restricted. They probably migrated between contrasting facies. Species living in off-shore waters may, like the modern Limulus, have come to the sandy shallows to deposit their eggs. This does not mean that a form like Proetus girvanensis Etheridge and Nicholson, which is by far the most abundant fossil in the muds at the cliff section (locality 8) and at South Threave, is anything like so common in the sandy "Starfish Bed." But on the evidence of the trilobites we can distinguish, irrespective of facies, a Lower Drummuck and an Upper Drummuck succession:-

The LOWER DRUMMUCK includes (a) the conglomerate and sandy grits which form the base of the Drummuck Group at "Auldthorns" and on Quarrel Hill (localities 1 and 2), (b) the fine green mudstones of Quarrel Hill in which two horizons on the east brow of the hill, discovered by Mr. T. MacTaggart, have now been studied (localities 3 and 4), and (c) a stratum of shelly sand, the "Crinoid Bed" of Quarrel Hill, which lies at a higher horizon with fine mudstones above and below (localities 5 and 6).

The UPPER DRUMMUCK includes (d) rather massive mudstones, followed by (e) the "Starfish Bed," just above a point where a tributary from Quarrel Hill joins the Ladyburn (locality 7), and (f) a sandy mudstone which makes a notable outcrop in the cliff section, a hundred yards north of the "Starfish Bed," before the right-angled bend in the Ladyburn (locality 8). This mudstone from its lithology and fossils is the same as that at South Threave (localities 9 and 10), and a suitable name to include both is Ladyburn mudstones. As already mentioned Lapworth in his account (pp. 619-620) has stated that these mudstones underlie the "Starfish Bed." He did not recognise, however, the small fault east of South Threave farmhouse, shown in the 1933 edition of the Geological 1" Map, Scotland, Sheet 14 (also on Pl. III). Apparently this led him to consider the beds with Dicellograptus anceps, exposed opposite South Threave, as older than the "Starfish Bed" farther up stream. The beds at South Threave occur much nearer the Mulloch Hill conglomerate than does the "Starfish Bed." Moreover, the trilobite assemblage at South Threave closely associates the mudstones at that locality with those in the cliff section (locality 8). This view that the South Threave beds are younger than the "Starfish Bed" has been advanced verbally by Dr. J. Pringle during different excurions to the Girvan district.

The palaeontological reasons for the separation of the Lower and Upper divisions of the Drummuck Group may be briefly summarised. As regards the Trinucleidae, all the Lower Drummuck

horizons yield Cryptolithus portlockii var. nov. girvanensis, sometimes associated with Tretaspis seticornis (Hisinger) var. Both varieties are allied to those from the Killey Bridge beds, Pomeroy (Fearnsides, Elles, and Smith, 1907). In the Upper Drummuck the common trinucleids are Tretaspis granulata (Wahlenberg) Størmer, 1930, and Tretaspis aff. cerioides (Angelin), which have affinities respectively with Lower Trinucleus shale and Upper Chasmops limestone species in Norway, etc. A study of the Calymenidae leads to the same division. The Lower Drummuck may see the entry of Calymene drummuckensis (Reed), but the characteristic species are C. cf. meeki Foerste and very occasional C. aff. drummuckensis. The latter Mr. J. Shirley believes to be identical with a species from the Calymene beds, near Cautley, Yorkshire, described by Professor Marr as Upper Caradocian (1913, pp. 3, 5), although probably Lower Ashgillian. The common Upper Drummuck calymenid is C. drummuckensis. In other families at least one cyphaspid, Cyphaspis rotunda sp. nov., is specially typical of one locality in the Lower Drummuck, while distinctive species from the Upper Drummuck are Phillipsinella parabola (Barrande) and Proetus girvanensis. The former is quite common at locality 8, and the latter is abundant throughout the Ladyburn mudstones, but they do not occur in the mudstones of the Lower Drummuck.

So far as the brachiopods are concerned, the biggest contrast may be drawn between those of the "Crinoid Bed,"

Lower Drummuck, and those of the "Starfish Bed," Upper Drummuck. The two commonest species in the "Crinoid Bed" are Fardenia scotica gen. et sp. nov. and Brachyprion matutinum sp. nov., both unknown in the Upper Drummuck. Other distinctive Lower Drummuck species recorded in the latter part of this paper are Leangella discuneata sp. nov. and Stropheodonta bilix sp. nov. It is interesting also to note that while Nicolella actoniae var. asteroidea Reed appears in the "Crinoid Bed" and in the "Starfish Bed," there is also present in the lower of the two a form approximating rather to the more widespread N. actoniae (Sowerby).

While there are these noteworthy differences, it must be remembered that many species of trilobites, brachiopods, etc., are common to horizons in both the lower and Upper divisions of the Group, though facies changes prevent almost any species except Parmorthis elegantula var. drummuckensis (Reed) from occurring at every locality. A point which may also be noted in this connection is that while muddy beds in the Drummuck Group seem for the most part to yield their original inhabitants as fossils, sandy beds appear to give a mixed assemblage swept up from both sand and mud, so that to determine actual sand-dwellers a subtraction process is needed. Typical sandy brachiopods common to both divisions of the Drummuck Group are Dinorthis porcata (McCoy), Glyptorthis crispa (McCoy), Nicolella actoniae var. asteroidea Reed, and probably Austinella thraivensis (Reed).

An outline fauna of the Lower Drummuck Group is as follows:-

Locality 1. - Basal conglomerate, south of "Auldthorns" ruin.

TRILOBITA.

Cryptolithus portlockii var. nov. girvanensis.

BRACHIOPODA.

Schizophorella fallax (Salter).

Platystrophia biforata (Schloth).

Nicolella actoniae (Salter) var.

Glyptorthis crispa (McCoy).

Dinorthis porcata (McCoy).

Parmorthis elegantula var. drummuckensis (Reed).

Leptaena rhomboidalis var. γ Reed.

Brachyprion matutinum sp. nov.

Christiania tenuicincta (McCoy).

Leangella discuneata sp. nov.

Strophomena valens Reed.

Eochonetes advena Reed.

Rhynchotreta cuneata (Dalman) var.

The assemblage consists almost entirely of brachiopods with occasional corals - Petraia sp., etc. - and a few pleurotomariids.

Locality 2. - Basal grit, escarpment north-west of "Auldthorns" ruin.

TRILOBITA.

Cryptolithus portlockii var. nov. girvanensis.

BRACHIOPODA.

Parmorthis elegantula var. drummuckensis (Reed).

Eochonetes advena Reed.

Locality 3. - Quarrel Hill mudstones (lower horizon), east brow of Quarrel Hill.

TRILOBITA.

Cryptolithus portlockii var. nov. girvanensis.

Tretaspis seticornis (Hisinger) var.

Eoharpes hornei Reed.

Stygina latifrons (Portlock).

Illaenus sp.

Cyphaspis rotunda sp. nov.

Cyphaspis sp. nov.

Encrinurus multisegmentatus Portlock var.

Cybele sp.

Calymene cf. meeki Foerste.

Calymene aff. drummuckensis.

Phacops (Pterygometopus) retardatus Reed.

BRACHIOPODA.

Lingula sp.

Philhedra drummuckensis Reed.

Schizophorella fallax (Salter).

Platystrophia biforata (McCoy).

Skenidioides lewisi (Davidson) var.

Dinorthis porcata (McCoy).

Vellamo ascendens (Davidson).

Parmorthis elegantula var. drummuckensis (Reed).

Leptaena rhomboidalis var. γ Reed.

Strophonella sp.

Sowerbyella subcorrugatella (Reed).

Strophomena valens Reed.

Eochonetes advena Reed.

Triplecia insularis (Eichwald).

Dalyia cymbula var. girvanensis Reed.

GASTROPODA.

Archinacella sp.

Sinuites subrectangularis Reed.

Kokenospira lingualis var. girvanensis Reed.

Bucaniopsis nicoli Reed.

Zonodiscus grayae Reed.

Trematonotus cf. portlocki Reed.

Omospira orientalis Donald.

Lophospira instabilis Donald.

Lophospira cf. bicincta (Hall).

Lophospira spp.

Cyrtostropha robusta Donald.

Bembexia sp.

Eccyliomphalus cf. bucklandi Portlock.

LAMELLIBRANCHIA.

Byssonychia radiata (Hall).

Cyrtodonta cf. gibbosa Wheelton Hind.

Nucula cf. varicosa Salter.

Nuculana curta Wheelton Hind.

Ctenodonta cf. dissimilis (Portlock).

Ctenodonta cf. eastnori (Portlock).

CEPHALOPODA.

Phragmoceras sp.

TETRACORALLIA.

Petraia sp.

CHAETOPODA.

Cornulites sp.

Some of the specimens referred to in this list, from locality 3, are in the collections of Mr. J. L. Begg, Glasgow, and Mr. H. G. Vevers, London.

Locality 4. - Quarrel Hill mudstones (higher horizon) east brow of Quarrel Hill.

TRILOBITA.

Cryptolithus portlockii var nov. girvanensis.

Ampyx (Lonchodomus) drummuckensis Reed.

Encrinurus sp.

Calymene cf. meeki Foerste.

Phacops (Pterygometopus) retardatus Reed.

Phacops (? Pterygometopus) quarrelensis Reed.

BRACHIOPODA.

Schizophorella fallax (Salter).

Parmorthis elegantula var. drummuckensis (Reed).

Leptaena rhomboidalis var. γ Reed.

Sowerbyella subcorrugatella (Reed).

Strophomena valens Reed.

Christiania temuicincta (McCoy).

Eochonetes advena Reed.

GASTROPODA.

Hyolithes (Orthotheca) sp.

CHAETOPODA.

Cornulites sp.

Locality 5. - "Crinoid Bed" of Quarrel Hill (sandy facies), east brow of Quarrel Hill.

TRILOBITA.

Cryptolithus portlockii var. nov. girvanensis.

Tretaspis seticornis (Hisinger) var.

Eoharpes hornei Reed.

Asaphus sp.

Illaenus sp.

Lichas (Hemiarges) sp.

Encrinurus multisegmentatus Portlock var.

Calymene cf. meeki Foerste.

Calymene sp.

Cheirurus sp.

Phacops (Pterygometopus) retardatus Reed.

BRACHIOPODA.

Lingula sp.

Philhedra drummuckensis Reed.

Schizophorella fallax (Salter).

Skenidioides lewisi var. asteroidea (Reed).

Nicolella actoniae var. asteroidea Reed.

Nicolella actoniae (Sowerby) ? var.

Glyptorthis crispa (McCoy).

Austinella thra~ivensis (Reed).

Austinella ? cf. subplicatella (Reed).

Vellamo ascendens (Davidson).

Dalmanella (s.l.) cf. federata Reed.

Parmorthis elegantula var. drummuckensis (Reed).

Bilobites sp.

Leptaena rhomboidalis var. γ Reed.

Sampo ruralis (Reed).

Leangella discuneata sp. nov.

Sowerbyella subcorrugatella (Reed).

Sowerbyella sp.

Brachyprion matutinum sp. nov.

Fardenia scotica sp. nov.

Stropheodonta bilix sp. nov.

Christiania temuicincta (McCoy).

Strophomena cf. simulans McCoy.

Eochonetes advena Reed.

Camarotoechia sp.

Zygospira sp.

Dayia cymbula var. girvanensis Reed.

GASTROPODA.

Zonodiscus grayae Reed.

Hormotoma sp.

Hyolithes (Orthotheca) sp.

SPONGIAE.

Rhoeaspongia mactaggarti sp. nov.

TETRACORALLA.

Petraia sp.

CHAETOPODA.

Cornulites sp.

These species are accompanied by a large number of crinoid ossicles, but cups have not yet been found.

Locality 6. - "Crinoid Bed" of Quarrel Hill (sandy facies), half mile north-east of Glenlochrie.

TRILOBITA.

Cryptolithus portlockii var. nov. girvanensis.

Encrinurus sp.

BRACHIOPODA.

Parmorthis elegantula var. girvanensis (Reed).

Sowerbyella sp.

Fardenia scotica sp. nov.

Crinoid ossicles.

For faunal lists of Upper Drummuck species reference may be made to the monographs on Girvan fossils by Etheridge and Nicholson (1878-80), F. R. Cowper Reed (1903-6, 1908, 1909, 1914, 1917, 1931, 1933, etc.), Wheelton Hind (1910), F. A. Bather (1914). Other important works in which many Drummuck fossils are described include J. Donald (1902, 1906, 1924), I. L. Slater (1907), Reed (1920-21), and W. K. Spencer (1914 - in progress). In these monographs practically all the Drummuck fossils are from the Upper Drummuck of the present paper.

C O R R E L A T I O N W I T H O T H E R A R E A S.

The Ashgillian has been defined in two ways, by its graptolites and by its trilobites (of. Watts, 1929, pp. 72-73). According to graptolites there are two zones:-

2. Dicellograptus anceps.
1. Dicellograptus complanatus.

According to trilobites there are also two recognized zones:-

2. Phacops mucronatus Brongniart.
1. Phillipsinella parabola.

The graptolite and trilobite zones do not correspond exactly.

The Drummuck Group is certainly Ashgillian according to graptolites, since D. complanatus has been found in the Upper

Whitehouse Group, while D. anceps occurs in the Ladyburn mudstones at the top of the Drummuck Group. The same Ladyburn mudstones yield P. parabola, but the higher trilobite zone of P. mucronatus is not represented. It may be concluded that much of the Upper Ashgillian is absent owing to the unconformity which separates the Drummuck Group from the Mulloch Hill Group.

During this research, on the advice of Mr. J. Shirley, special care was taken to look for fossils such as Calymene quadrata W. B. R. King, that might relate any part of the Girvan Ashgillian with the Dolhir beds which come just above the P. parabola beds on the Welsh border. The new Calymene aff. drummuckensis may be common to both formations, but on the whole it does not seem that the Ladyburn mudstones reach as high as the base of the Dolhir beds. It would seem most likely that the highest beds at Girvan correspond with Phillipsinella parabola beds elsewhere in the British Isles, and that they reach - and little more - the lower part of the Dicellograptus anceps horizon. The Lower Drummuck beds lie below the horizon of P. parabola. They appear to fall along with the Barren flagstones within a lower division of the Ashgillian than has so far been defined by means of trilobites in this country. Into this division would fall a formation like the Calymene beds of the Cautley area in Yorkshire, which have so far been regarded as Upper Caradocian (Marr, 1913, p. 5).

The closest parallel to the Drummuck Group, it has been supposed, is to be found in the Desertcreat Group, in Pomeroy, Ireland. Fearnsides, Elles, and Smith correlate the two successions in their entirety (1907, pp. 116-117):-

DESERTCREAT GROUP.	DRUMMUCK GROUP.
Tirnanskea beds.	Threave beds.
Killey Bridge beds.	Trinucleus mudstones.
Bardhessiagh beds.	Quarrel Hill beds.

But, although the Irish and Scottish faunas have many striking points of contact, this correlation cannot be supported on an exact palaeontological basis. The discovery of Cryptolithus portlockii var. nov. girvanensis, a variety probably a little further advanced in the evolutionary scale than Salter's species, seems to put the Lower Drummuck beds on a slightly higher horizon than the Killey Bridge beds. At the same time the Upper Drummuck beds are almost certainly older than the Tirnanskea beds, for the latter yield Phacops mucronatus in their lower part (op. cit., p. 111). It is true that P. mucronatus is associated in the Tirnanskea beds with Dicellograptus complanatus, but the latter is known to overlap into the zone of D. anceps (Elles and Wood, 1914, p. 518). To sum up:- The Upper Drummuck beds appear to be mainly older than the Tirnanskea beds. The Lower Drummuck beds are possibly slightly younger than the Killey Bridge beds.

F. A. Bather (1913) correlated the Drummuck Group, from which at that time only the fossils of the Upper Drummuck were properly known, with the Kildare limestone (Reynolds and Gardiner, 1896) in Ireland; with the Keisley limestone (Reed, 1896, 1897), which is the same as the Staurocephalus limestone (Watts, 1929, p. 65), in the Lake District; with the Rhiwlas beds containing abundant Phillipsinella parabola (Elles, 1922, pp. 167, 172) in North Wales; and with the top of the Sholeshook limestone (cf. Marr, 1907, p. 63) in South Wales. Dr. Elles accepts these correlations (op. cit. p. 168). but points out there are great faunal contrasts; two areas may yield Cheirurids, Lichads, and Remopleurids, and yet have no species of these in common. In the case of correlation by sessile forms like the Brachiopoda, the divergences in fauna are probably just as confusing. After making allowance for the fact that so many sessile and semi-sessile marine invertebrates are localised in definite sedimentary facies, we are still confronted with the possibilities of muddy water, deep water, and land, as barriers. And again, if we judge from the invertebrates in modern seas, the degree of faunal radiation must have been very variable. It, therefore, may be necessary, even within the British Isles, to understand the recognised correlations in a rather general way.

Elsa Warburg (1925, p. 412, etc.) correlates the Keisley limestone with the Upper Leptaena limestone in Dalarne,

Sweden. This is taken to correspond with Kjaer's Etage 5 in Norway. We may here remark that the Drummuck Group from some of its trilobites (vida supra, page 13) must fall rather low in the Norwegian Ashgillian, and may include beds still retained as Caradocian, for stratigraphical expedience, by Norwegian geologists (see Størmer, 1934, pp. 330-331,336). F. Schmidt's correlation (1882, pp. 523-524), which has been generally accepted, joins Etage F of the East Baltic region - the Lyckholm F_1 and the Borkholm F_2 - with the Upper Leptaena limestone (Warburg, 1925, p. 420). It has recently been discovered, however, that at least part of the Upper Leptaena limestone contains black shales with Birkhill graptolites. G. A. Troedsson makes this discovery a ground for a general attack on the status of Scandinavian strata at present assigned to the Upper Ordovician. He would draw the Ordovician-Silurian boundary some distance below the horizon of Phacops mucronatus, and above that of Dicellograptus complanatus. The zone of D. anceps has not yet been found in Sweden, and may be represented by a hiatus (1929, pp. 179-180). On this basis he would put the entire Leptaena limestone, the Borkholm, and the Norwegian Etage 5b into the Silurian, leaving it an open question whether the Lyckholm and Etage 5a are to follow (p. 181). If Troedsson is right, this destroys Warburg's association of the Upper Leptaena limestone with the Keisley limestone and with the present writer's Upper Drummuck Group. The Norwegian correlation of the Drummuck beds, however, still

holds good, and it seems that Troedsson's Ordovician-Silurian boundary lies in much the same position as that at which the Drummuck Group terminates. The question of the Ordovician-Silurian boundary will be discussed further, at the end of this section, in connection with views by E. O. Ulrich.

In Bohemia the horizon of the Drummuck group appears to fall within D_5 of Barrande, and 2d of Katzer (1889, 1902).

When we come to long range correlations of European with American series, we must recognise the factor of faunal radiation as an even more formidable difficulty, and dependence must usually be placed on other data than specific correspondence. Schuchert (1916, pp. 499-500) gives the range of 60 per cent. of living marine invertebrates as between 2,000 and 3,000 miles, while only 5 per cent. have a coastal distribution of over 5,000 miles. In transatlantic comparisons, therefore, we cannot look for many exact coincidences. This view naturally implies non-acceptance of the theory of continental drift so far as Britain and America are concerned. There is marked affinity of many Scottish Ordovician fossils (see P. E. Raymond, 1925, pp. 168-169 and 179-180; and Bradford Willard, 1928, pp. 307-309) to North American species of similar age. But, there is an almost entire absence of identical American and Scottish species, and this affords evidence against a former proximity of the deposits.

Probably the most interesting American parallels with certain Drummuck fossils are found among the Upper Ordovician

faunas of Percé, Quebec. The Percé faunas, which are mostly of Middle and Upper Richmondian age, compare in a general way with the Lower and Upper Drummuck of Scotland and with the Lower Ashgillian of the Lake District (Schuchert, 1930, p. 170). Some important additional evidence on this point from this side of the Atlantic is contributed in the latter part of the present paper. One of the new trilobites described, Cyphaspis rotunda, approaches very nearly to C. minima Cooper, from Percé, while one of the new brachiopods, Leangella discuneata, is nearly akin to L. septata (Cooper).

While Schuchert regards these Ashgillian beds as Upper Ordovician, Ulrich's correlations are considerably different. They are difficult to follow because Ulrich intentionally departs from Lapworth's definition which takes the base of the Silurian at the base of the Llandovery. He regards the Richmondian as a pre-Llandovery formation, and draws the base of the Silurian between it and the underlying Cincinnatian (1930, p. 73, etc.). For him the Richmondian is the lower member of the Medinan Series, which latter he correlates with the Drummuck, placing the Barren flagstones and the Whitehouse Group with the Cincinnatian. Ulrich was only acquainted with the Upper Drummuck fossils. Certain Lower Drummuck species, especially Calymene cf. meeki, have Cincinnatian affinities. But many species, as we have pointed out, are common to both the Lower and Upper divisions of the Drummuck beds. It might seem, therefore, as if Ulrich would draw the boundary of his

Ordovician and Silurian Systems through the Drummuck beds. While Ulrich's proposals regarding the base of the Silurian System are thus unacceptable in Scotland, the same conclusion does not necessarily apply to those put forward by Troedsson, which we have mentioned above.

S P O N G I A E.

R h œ a s p o n g i a gen. nov.

Definition. A bowl-shaped sponge with almost smooth outer wall and with a number of radial walls separating pockets which are of varying sizes. At the base there is a small circular disc for attachment. The affinities seem to lie in the direction of Brachiospongia Marsh (1867, p. 88), and hence with the suborder Lyssacina Zittel of the order Hexactinellida Schmidt. Type: Rhœaspongia mactaggarti sp. nov.

R h oe a s p o n g i a m a c t a g g a r t i sp. nov.

Pl. II, fig. 1.

Diagnosis. Subcircular, bowl-like body, consisting of central vase-shaped cloaca from which numerous large posticae open into flattened pockets, the four or five larger of which divide at about a third their length into two unequal parts. There are also some six smaller pockets (fig. I) opening into the cloaca. The smaller of these do not reach as far distally as the peripheral wall. The internal walls are rather thick, as also are the lower and lateral parts of the external wall. The upper part of the external covering was presumably much finer. The external wall is almost smooth, but shows a few faint longitudinal depressions corresponding to the position of the main internal radial walls. Attachment was effected by a small irregularly circular area at the base of the cloacal chamber.

Dimensions. Height 15 mm. Diameter varying from about 38 mm. to 35 mm. Diameter of base of attachment 5 mm.

Holotype. H.M. P. 5200, Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group (Ashgillian).

Locality. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Remarks. Only one specimen, a nearly perfect cast, internal and external, has been obtained. No trace of spicules remains as far as can be seen, but the approximately radial symmetry, the presence of what may be regarded as a cloaca, and the irregular radial pockets, almost certainly warrant the reference of the specimen to the class Spongiae.

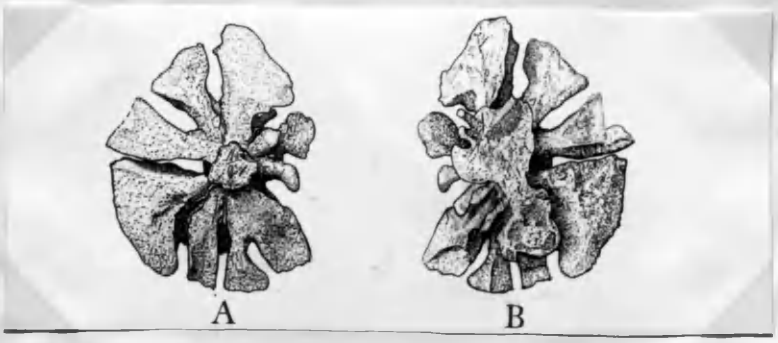

Fig. 1. Rhoaspongia mactaggarti gen. et sp. nov. Internal cast. A. Viewed from below (as in Pl. II, fig. 1); B. Viewed from above. Nat. size.

Affinities. The nearest affinity appears to be with the genus Brachiospongia, as above noted, members of which have large subequal peripheral pockets in separate radial "arms," each of which opens proximally into a very broad central cloaca. This genus is found in the Trenton Group, and is therefore older than the Girvan genus. Rhoeaspongia, while probably related, differs in having a much narrower cloaca; the radial pockets also are of various sizes, do not all lie in the one plane, and have their outer walls intimately joined and forming a bowl-shaped integument. The longitudinal furrows, faint as they are in the Girvan species, I take as the possible indication of the existence, at an earlier evolutional stage, of separate "arms" such as are seen in Brachiospongia. Whether the two forms are correctly related together must remain an open question. We may note that on account of the thickness of the walls (cf. Zittel, 1927, p. 52) the affinities of Rhœaspongia may actually be with the order Lithistida Schmidt. Whatever the final decision on these points, the several distinctive features of the Girvan species certainly require the founding of a new genus. The species has been named after Mr. T. MacTaggart, who, so far as I know, was the first collector from certain of the Lower Drummuck localities.

B R A C H I O P O D A.

Superfamily Strophomenacea Schuchert.

Genus *Brachyprion* Shaler, 1865.

Brachyprion matutinum sp. nov.

Pl. I, figs. 8-11.

Diagnosis. Shell sub-semicircular, plano-convex; maximum width near hinge-line; cardinal angles not produced. Ventral valve gently convex, with small sharp beak subtending hinge-area which lies nearly in plane of valve. Interior of ventral valve: the teeth are short triangular thickenings fused to the hinge-line; diductor scars indistinctly bounded, flabelliform, divergent, about quarter the length of the valve; adductors small, indistinct, separated by fine median ridge. Surface of valve with fine regular radial threads - about 10 threads in a width of 1 mm. - which are bent back laterally, and one strong median rib. There is extremely fine concentric striation. A few concentric rugae are present, strongest at a little less than half the length of the radii. Dorsal valve almost flat; beak inconspicuous; hinge-area very narrow. Fine radial ornament. Interior with delicate anterior walls to dental sockets curving back almost parallel with hinge-line; cardinal process of two divergent lobes (fig. 2).

Dimensions.	Ventral valves.	Width	9 - 12 mm.
		Length	5.8 - 9 mm.
	Dorsal valves.	Width	9 - 12.5 mm.
		Length	5 - 8 mm.

Syntypes. H.M. L 1956-1974, Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group (Ashgillian).

Locality. Basal conglomerate (locality 1), south of "Auldthorns." "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Remarks. This species is abundant in the "Crinoid Bed" of Quarrel Hill, and one specimen has also been found in the basal conglomerate at "Auldthorns." Some of the specimens assume a more transverse form in which width approaches nearly twice the length. There is also a tendency to failure in development of the external median rib and internal median furrow in the ventral valve, a trend especially marked in the less equidimensional forms.

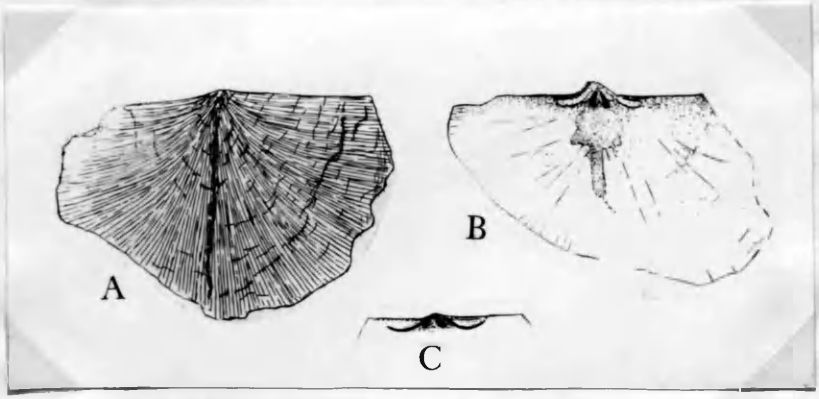

Fig. 2. Brachyprion matutinum sp. nov.

A. Exterior of ventral valve, showing radial threads, rugae, etc. (as in Pl. I, fig. 8); B. Cast of interior of dorsal valve, showing cast of dental sockets and of bilobed cardinal process (H.M. L 1963); C. Cast of part of dorsal valve, showing casts of anterior walls of dental sockets curving back nearly parallel to hinge-line (H.M. L 1962). x 4.

Affinities. In general the characters of Brachyprion matutinum are very like those of B. mediocostalis (Reed), from the Slade beds, Pembrokeshire (1905, pp. 449-450, Pl. XXIII, figs. 10, 10a, 11) which are at a higher horizon than the Lower and Upper Drummuck beds. One difference shown by B. mediocostalis is that it has the cardinal margin produced into small sharp-pointed "ears." Mr. B. B. Bancroft informs me that on specimens of B. mediocostalis in his collection the flat faces of the proximal parts of the hinge-line, to which the teeth are fused, each carry three or four denticulations. In most specimens of B. matutinum examined no denticulations are seen, but in one case one or two fine oblique lines cross the anterior part of the flattened faces of the solid teeth. From this it

appears that the Girvan species is a true member of the genus Brachyprion, but more primitive than the Welsh form.

Another possible ally is Brachyprion sp. described by A. F. Foerste (1923, pp. 75-76, Pl. XIV, fig. 12) from muds beneath the Brassfield limestone, at the top of the Medinan formation, in Ohio. This is presumably a higher horizon than that reached by any part of the Drummuck group. Only a nearly perfect ventral interior of the American species is known. It differs from ours in very sharp "ears," very narrow delthyrial opening, and in proportionately larger size and coarser radii. On the inner surface of this ventral valve "a strong median striation extends from a short distance anterior to the beak forward to a point about half-way between the beak and the anterior margin of the shell." Casts of B. matutinum show similar median striation, which is clearly distinct immediately in front of the ventral muscular field, but usually becomes faint near the anterior margin. The American shell is 21.5 mm. long, i.e., two and a half times the length of an average Girvan specimen, and has 10-12 radii in a width of 3 mm. It is possible that Brachyprion sp. Foerste may thus be regarded as a larger species with distinctive features but definitely allied to B. matutinum.

Fardenia gen. nov.

Definition. The genus *Fardenia* is proposed to cover species of strophomenoid outline, sub-equally bi-convex, and having rather strong costae. Primitively these consist of coarse primaries with a few finer radii between, but they tend in later forms to equality of calibre. Ventral hinge-area high with open delthyrium. Ventral interior with typical strong dental plates making a high angle with the hinge-line. Dorsal valve with correspondingly thick anterior walls to the dental sockets. Cardinal process of two stout lobes.

Type: *Fardenia scotica* sp. nov. The genus also comprises *Stropheodonta (Brachyprion) columbana* Reed (1917, pp. 896-897, Pl. XVII, figs. 13-19), and *Orthis? applanata* Salter (1862, p. 72, Pl. V, fig. 1a-e) attributed by Reed to *Schuchertella* (1916, p. 906) but at least not belonging to the same genus as *Schuchertella pertinax* Reed (1917) from which it differs in its stronger dental plates and coarse radii. Forms like *Sch. creditensis* Foerste (1923, p. 52, Pl. XIII, fig. 6) probably fall within the genus *Fardenia*. The genus *Brachyprion*, we may note, differs from *Fardenia* in having the dental plates entirely fused to the hinge, and in having fine external ornament. The genus *Stropheodonta* differs from *Fardenia* in its denticulation of the whole length of the hinge-line and in its fine ornament.

Fardenia scotica sp. nov.

Pl. I, figs. 1-7.

Diagnosis. Shell semicircular to subquadrate, wider than long, almost equally bi-convex, widest at or immediately in front of the hinge-line; cardinal angles approximately rectangular. Ventral valve gently convex, most so along median line for half length of shell, with lateral and anterior flattening. Beak sharp, acute, reaching well behind hinge-like, subtending high, apsacline area, with large triangular delthyrium reduced towards hinge-line by ingrowth. Ventral interior with strong dental plates inclined at 60° to the hinge-line; muscle-scars deeply impressed posteriorly, often clearly but faintly defined in front; diductors large, flabelliform; adductors obscure; median ridge.

Dorsal valve gently convex with antero-lateral compression corresponding to ventral valve; no median depression but slight flattening; beak small, protruding a little behind hinge-line; hinge-area narrow, anacline. Interior with prominent thick antero-lateral walls to dental sockets, about 1 mm. long, stopping abruptly in front; strong bilobed cardinal process; broad low median elevation strongest in front of ends of anterior walls of dental sockets; adductor scars ill-defined, represented by elongate narrow depressions.

The surface is traversed by stout radiating rounded ribs with intercalated finer ribs. The ribs contrast most in

calibre laterally, where up to four fine ribs may occur between coarse primaries. On the median surface of the shell the ribs approximate more in size, the finer ribs becoming coarser and occurring in pairs between stronger ribs. Many of the intercalated radii originate quite close to the beak, and the others at less than two thirds the length of the shell. Fine concentric striation of a subsidiary nature is present, and becomes specially marked postero-laterally in some shells (Pl. I, fig. 2). On the swollen part of the shell there is a little reflexion of the ribs, reflexion being most marked where certain of the ribs emerge on the flattened postero-lateral parts.

Dimensions.	Ventral valves.	Width 7 - 14 mm. Length 6 - 12 mm.
	Dorsal valves.	Width 9 - 15 mm. Length 8 - 10 mm.

Syntypes. H.M. L 1940-1955, Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group (Ashgillian).

Locality. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly; ditto (locality 6), half mile north east of Glenlochrie.

Remarks. Fardenia scotica is very abundant in the sandy "Crinoid Bed," and possibly also occurs in the fossiliferous conglomerate (locality 1) near "Auldthorns." It does not occur in the Upper Drummuck beds.

Affinities. The nearest ally of Fardenia scotica is F. columbana (Reed), from which it differs in being more transverse, and in not showing small crenulations on the hinge-line on each side of the delthyrium. This is a characteristic feature of the latter species, which is nevertheless almost necessarily related to F. scotica by close parallelism in all other critical features. As might be expected in the more primitive form, F. scotica has less clearly developed muscular impressions. F. scotica also does not show clear ovarian pits like the other. Externally the calibre of the ribbing in F. columbana is much more uniform and the fine concentric striae never become so strong as in F. scotica. It is concluded that the latter may be taken to be the early Ashgillian representative of a genus which in the Lower Llandovery gives us F. columbana.

Hirnantia gen. nov.

Definition. A genus closely allied to Fardenia, but differing in having simple cardinal process, markedly greater convexity of dorsal valve, and radii of nearly equal calibre. The last two characters would only necessitate specific separation from Fardenia scotica, but the first is taken as requiring generic recognition.

Type: Hirnantia sagittifera (McCoy).

Remarks. Authentic specimens of dorsal valves (H.M. L 1986-1990) of this new genus have been discovered in a sandstone dipping under the Mulloch Hill conglomerate, a hundred yards west of High Mains farmhouse, in territory previously mapped as Drummuck Group. The beds involved have been termed the High Mains sandstone (vide supra, pp. 8-9). The Girvan specimens of Hirnantia sagittifera appear identical with specimens in the British Museum (Natural History) from Bwlch-hannerob and Cwn-yr-aethnen, south-east of Bala, B.M. B 40818 (Pl. I, fig. 21), B.M. B 40815, etc., from the Hirnant beds. This occurrence of H. sagittifera apparently just above the Ordovician-Silurian unconformity at Girvan appears to support Dr. Elles' contention that the Hirnant beds in Wales are at the base of the Llandovery (1922, p.168).

Two of the Girvan specimens are illustrated (Pl. I, figs. 20, 22). The only difference between these and the Bwlch-hannerob form is that the latter has exceptionally distinct muscle-impressions.

Genus Strophеodonta Hall, 1892.

Strophеodonta bilix sp. nov.

Pl. I, figs. 12-16.

Diagnosis. Shell transversely semi-elliptical, about two thirds as long as wide; biconvex, but compressed; maximum width along hinge-line; cardinal angles rectangular or slightly less. Ventral valve flat except near beak which projects behind hinge-line; hinge-area triangular, apsacline; hinge-line denticulate. Ventral interior with strong dental plates diverging at 90°, narrowing and bent back a little laterally; muscle-area pentagonal, with ill-defined flabellate diductors enclosing oval adductor scar which is surrounded by ridge.

Dorsal valve gently convex with slight median depression most pronounced at one third length of shell; linear hinge area; inconspicuous beak; cardinal process of two lobes with flattened proximal faces; anterior walls of dental sockets diverging at 90°, then curving outwards nearly parallel to hinge-line; muscle-scars obscure; internal median raised area corresponding to external depression.

Surface of shell covered by roughly 110 subequal rounded radii, about 30 of which are primaries. The intercalated ribs are fine at their origin, but increase in calibre peripherally. The ribs are joined together by close-packed fine concentric threads about equal in calibre to the radii where these are fine. This gives a characteristic woven

appearance to the ornament. Internally the radii show clearly from half the length of the shell to the border.

Dimensions. Length 9 mm.
Width 16 mm.

Syntypes. H.M. L 1976-1981, Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group (Ashgillian).

Localities. ?Quarrel Hill mudstones (locality 4); and "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Affinities. This species seems to be closely allied to Stropheodonta filosa var. mullochensis Reed. This may be deduced especially from a comparison of the internal characters of the ventral valves. Reed's figure (1917, Pl. XVII, fig. 5) shows a precisely similar oval adductor scar to that in S. bilix (Pl. I, fig. 12). Differences are to be seen in the coarser ornament of our form, the total absence in it of rugae intersecting the hinge-line, and in the fact that it has its greatest breadth at, and not in front of, the hinge-line.

A possibly allied species is Schuchertella? inexpectata Reed, from the "Starfish Bed." Outline and ornament seem to

connect the two, and apart from the non-recognition of denticulation in S? inexpectata, the only points of difference observed are poor development of dental plates and greater clearness of radii in all parts of the interior of S? inexpectata. So far as external ornament is concerned, another form which closely resembles S. bilix is Rafinesquina hirnantensis (McCoy). Here again the denticulate hinge-line in the former appears as a barrier to relationship, but on the other hand we know that a single structural feature may not be a safe criterion to judge by. Furthermore denticulation appears to arise independently in genera like Brachyprion and Fardenia. In the circumstances it is quite possible that the genus Stropheodonta is not well founded in so far as denticulation of the hinge-line has been given as the chief distinction from Rafinesquina. It may be that a species like Stropheodonta bilix is very nearly, if not even generically, related to R. hirnantensis. The two are also probably related to the genus Fardenia from which, in structural features other than their fine ornament and more delicate development of the dental parts, they differ very little.

Among foreign species Stropheodonta katuglåsensis Reed (1932, p. 136, Pl. XXI, figs. 1-6, and ?13), from Hølandet, from a horizon probably somewhere near that of the Stinchar or Balcletchie Group (J. Kjaer, 1932, p. 57) is apparently allied to S. bilix. The ornament is almost identical. In the earlier species, however, the interior of the

dorsal valve shows a median pair of long straight slightly divergent septa extending three fourths the length of the shell; the cardinal process is trilobed; and the denticles are finer than in S. bilix. In the ventral valve there are similar median septa, and the dental plates are shorter than in the Girvan species. These features seem to point back to a relationship with genera like Sowerbyella. This was the view held by Brøgger (1877 , p. 19).

Genus *Leangella* Öpik, 1933.

Leangella discuneata sp. nov.

Pl. I, figs. 17-19.

Diagnosis. Shell small, tumid, subtriangular, concavo-convex. Ventral valve highly inflated along median line, but laterally somewhat depressed; cardinal angles produced, sub-cylindrical; beak moderately swollen, slightly overhanging the area which lies in the plane of the valve. Internally there is a stout elongated tooth on each side of the triangular delthyrium. Supporting the teeth are two dental lamellae which run forward and outward to join the ridge bounding the muscle-scars. The muscle impressions occupy a quarter of the length and a little less than a third of the width of the valve; the diductor pits are broad, subtriangular in outline, and rather deeply sunk; they are separated by a marked septum; the anterior ridge bounding the muscle-scars varies from emarginate to almost straight. Faint short vascular ridges arise from the antero-lateral angles of the muscle impressions. In front of the muscular region, a sharp-edged high median septum originates and runs forward for about 2 mm. along the median line.

Dimensions. Length 5.5 mm.
Width 10 mm.

Holotype. H.M. L 1982. Paratypes. H.M. L 1983-1984.

Horizon. Lower Drummuck Group (Ashgillian).

Localities. Basal conglomerate (locality 1), south of "Auldthorns"; and "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Remarks. Not a common fossil, but easily distinguished from the other Girvan Leptelloideae by the sharply defined cleft in the casts of the ventral valve. No satisfactory specimen of the dorsal valve has yet been found. From the left anterolateral part of the external cast of the holotype, the ornament made out in that region seems to consist of fine costae about half a millimetre apart, presumably with finer costellae in the interspaces, but the nature of the matrix practically excludes the observation of these. For a like reason it is impossible to pronounce on whether the interior is papillate, though this is probable.

Affinities. There is a close affinity of Leangella discuneata with L. septata Cooper (1930, pp. 272-273, Pl. I, figs. 9-13) from the Upper Ordovician F_1 beds of Percé, Quebec. The two species are nearly alike in outline and dimensions. Differences appear to be that in L. septata (1) the muscle pits are narrower and more deeply impressed, and (2) the ornament is probably different, the strong costae being farther apart and rarer. At the same time we may note that in the specimen from

locality 1, which has been taken as holotype of L. discuneata, the median septum is sharper and does not reach so near to the front margin as the rather thicker septum in L. septata. L. derfelensis Jones, so far as primary costae which number five are concerned, is similar in ornament to L. septata; but if we take into account the short costae intercalated near the margin in L. derfelensis, it probably more nearly resembles L. discuneata. While some such form as L. derfelensis may be regarded as ancestral to L. discuneata and L. septata, the two latter are quite distinct in possessing the strong median septum.

G. A. Cooper has an interesting note (1930, p. 273) that a septate form, probably a separate species, is included with non-septate specimens in Plectambonites gibbosa Winchell and Schuchert (1895, pp. 416-417, Pl. XXXII, figs. 13-17) although this is not made clear by the figured specimens. It seems unlikely the septum should be an evanescent feature without specific value.

TRILOBITA.

Genus *Cryptolithus* Green, 1832.

Cryptolithus portlockii (Salter)

var. nov. *girvanensis*.

Pl. II, figs. 2-5.

Diagnosis. Outline of cephalon approximately semicircular, but lateral margins tending to be straight or slightly concave. Glabella clavate, strongly arched, high above cheeks, with carina posteriorly. Median part of glabella showing fine reticulation of circular depressions varying in size.

First and second pairs of glabellar furrows represented by a lateral depression in the glabella. Third pair each represented by a pit on the glabellar side of the axial furrow, with fine depression running obliquely behind paired elevated nodes - occipital lobes - near base of glabella. Occipital furrow broad, well-marked, arching forward in front of nuchal spine, having lateral pits larger than those in third glabellar furrows. Axial furrows distinct, shallow, with pseudo-antennary pits, anterior to which the preglabellar furrow is practically absent and there is an arcuate encroachment of the glabella into the fringe.

Cheeks usually about as long as broad, with rounded postero-lateral margin, evenly inflated, rising towards glabella, sharply bent back towards deep posterior marginal furrow.

Posterior border of cephalon a narrow elevated rim. Occipital ring also narrow with spine standing up at right angles to glabella.

Fringe flat, narrow in front of glabella, but rapidly increasing in breadth posteriorly. Posterior parts of fringe reaching back beyond rest of cephalon and ending in spine flexed outwards. Surface of upper lamella with fine ridge opposite anterior margins of cheeks, but discontinuous in front of glabella, situated inside second concentric row of pits. Concentric rows of pits reduced to three in front of glabella. Anterior pits radially arranged in shallow sulci. Simple radial arrangement ceases outside concentric ridge, where the two outer pits in each radius are flexed anteriorly. In the posterior angles of the fringe the radii appear as flexed posteriorly.

Laterally to the encroaching anterior part of the glabella, and inside the concentric ridge, a concentric row of pits which rapidly increase in size laterally, is intercalated. Concentric rows of pits also originate on the cheek margins, (1) on the anterior margin at a distance equal to about its own breadth from the glabella, (2) just in front of the most distal part of the cheek, and (3) on the postero-lateral margin of the cheek. Seven concentric rows of pits, with some additional pits not analysed, are present, the latter lying in the broad posterior part of the fringe where the arrangement of pits is approximately quincuncial.

The girder is developed on the lower lamella within the outermost row of pits, and the surface of the lamella is bent upwards anteriorly to it.

Thorax unknown.

Pygidium about three times as wide as long, sub-triangular, postero-lateral margin arched outwards especially towards the front. Rachis narrow, bounded by shallow, distinct, axial furrows, decreasing gradually in breadth posteriorly, where it ends in a distinct swelling in the elevated margin. The rachis appears to have something like 14 segments, but only the first 6 are clearly defined, the first three being very strongly developed indeed. The pleurae corresponding to the 6 anterior segments clearly seen, without furrow, and become broader and swollen laterally. As a result, the proximal parts of the pleurae are depressed as contrasted with the distal parts.

Dimensions. Length of cephalon 9 - 11 mm.
Width of cephalon 18 - 23 mm.

Syntypes. H.M. A 580-596, and J.D., the former specimens in the Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group (abundant); ?Upper Drummuck Group (very rare): Ashgillian.

Localities. Basal conglomerate and grits, near "Auldthorns" (localities 1 and 2); Quarrel Hill mudstones, east brow of Quarrel Hill (localities 3 and 4); "Crinoid Bed" of Quarrel Hill (locality 5); ditto (locality 6), half mile north-east of Glenlochrie; ? "Starfish Bed" of Drummuck (locality 7).

Remarks. A specimen, reported as from the "Starfish Bed," Threave Glen, Girvan, described and figured by Dr. Reed (1914 b, p. 356, Pl. XXIX, fig. 7), as Trinucleus gibbifrons - a Caradocian form - is probably an example of Cryptolithus portlockii var. nov. girvanensis; but, while C. portlockii var. nov. girvanensis is common at all Lower Drummuck localities, it is noteworthy that in several weeks collecting from Upper Drummuck localities only a few fragments dubiously referable to C. portlockii var. nov. girvanensis have been found by the writer.

The only feature distinguishing the Girvan variety from Cryptolithus portlockii (Salter) is the presence of the seventh row of pits mentioned under (3) above.

Mr. B. B. Bancroft (1929, pp. 68-72) analyses the fringe ornament in the Cryptolithinae as consisting of series of concentric rows of pits external to the girder (fig. 3) and internal to it. Those outside the girder he terms E_1, E_2, etc. and the internal rows are I_1, I_2, I_3, etc. The rows on either side of the girder are E_1 and I_1.

Mr. Bancroft writes me as follows:- "The concentric rows present in Cryptolithus portlockii are:-

E_1 marginal.

E_1, I_1, I_2 forming continuous rows.

I_3 extending anteriorly to about the "antennary pit" - but rather variable.

I_4 extending anteriorly to about the middle of the cheek.

I_5 a short row confined to the posterior margin of the cheek= not always clearly separated as a concentric row.

"Other characters of importance are:-

(1) There are no elevated plates in E_1.

(2) An elevated concentric ridge between I_1 and I_2.

(3) The concentric rows are flexed outwards in the posterior region of the fringe. There is a corresponding slight concavity in the fringe-margin.

(1) and (3) distinguish C. portlockii from the known Cryptolithi; but if we have regard to the fact that (1) is also found in the later derivatives of Broeggerolithus (vide Appendix) in England, and (2), in any case, is an unimportant character, I can see no reason why C. portlockii should not be regarded as a true Cryptolithus."

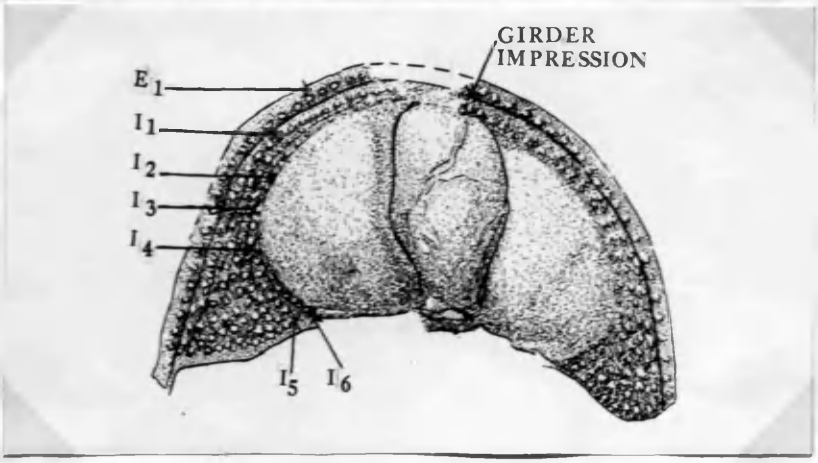

Fig. 3. Cryptolithus portlockii var. nov. girvanensis; explanatory diagram (same as Pl. II, fig. 2). x 3.

In addition to the foregoing characters, C. portlockii var. girvanensis has an I_6 row consisting of 5 pits with perfect concentric arrangement, e.g. Pl. II, fig. 4. The evolutional trend (vide Appendix) has advanced a slight step further in the Girvan variety than in C. portlockii from the Killey Bridge mudstones, at Pomeroy (Portlock, 1843, pp. 262-265, Pl. I, figs. 3-7, 11-12; Salter, 1853, Dec. VII, 7, p. 6; Fearnsides, Elles and Smith, 1907, pp. 121-122, Pl. VIII, figs. 1-4). In these references C. portlockii is divided into different varieties, chiefly on grounds of proportional size of cheeks, etc., but it is Bancroft's opinion - and my own from study of material from Pomeroy in the Hunterian Museum - that the different Pomeroy specimens represent a homogeneous species.

Affinities. The genus Cryptolithus, originally due to Green (1832), was redefined in a broad way by Bancroft (1929, pp. 76-77) and from it he has since proposed to remove three new genera (1933, p. 2) leaving the genus much restricted with C. tesselatus Green, recently redescribed by Madeleine Fritz (1924, p. 22, Pl. II, fig. 16) as genotype. C. portlockii belongs to Cryptolithus (s.s.).

C. portlockii is not closely related to any English or Welsh species, but is probably descended from the same stock as Caradocian forms with four concentric rows of pits continuous in front of the glabella, such as C. transiens Bancroft (1929, pp. 90-92), now ascribed by its author to his genus Broeggerolithus.(3)

The genus Cryptolithus has also been defined in a much broader way by Størmer (1930, p. 15) and naturally includes C. portlockii.

Størmer figures one Scandinavian species as Cryptolithus cfr. portlocki (op. cit., pp. 43-44, Pl. 6, fig. 13), but although allied this form is almost certainly specifically distinct from the Scottish and Irish forms, since it does not have radial arrangement of the pits in front of the glabella. Størmer's form, which comes from a lower horizon than ours, also differs in having a concentric ridge inside the E_1 row of pits, while in the original C. portlockii the

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(3) Bancroft MS.; referred to Broeggeria preoccupied, by Bancroft (1933, p. 2); correction due to Dr. Stubblefield.

ridge is within the I_1 row. In these circumstances C. cfr. portlocki Størmer must be a different species.

Two Bohemian species from Etage D are comparable with C. portlockii. These are Trinucleus ornatus and Trinucleus ultimus, which Barrande describes as having the concentric rows of pits numbering seven laterally, but reduced to three or four in front of the glabella (1852, pp. 623-628, Pl. 29, figs. 1-9, and pp. 631-632, Pl. 29, figs. 18-20).

Certain American forms, of an earlier date than C. portlockii, may also be mentioned as showing like evolutional tendencies. Cryptolithus sp. Foerste (1924, p. 236, Pl. XLIII, fig. 17), like ours, has a slightly raised ridge on the upper lamella inside the outer two concentric rows of pits; it also usually has three concentric rows of pits in front of the glabella, but the trend towards reduction of this part of the fringe is strong and some specimens show the median radial row with only two pits. Another American species which resembles ours is Cryptolithus recurvus Ulrich (Bassler, 1919, p. 334, Pl. 56, figs. 14-17, and Foerste, 1924, pp. 238-239, Pl. XLV, fig. 12 a, b, and Pl. XLIII, fig. 18). C. portlockii, however, has shorter nuchal spine, the pleural part of the fringe not so much bent back towards the genal angles, less massive and shorter genal spines, and probably other distinctive characters.

Regarding the fact that the pleural parts of the pygidium of C. portlockii are swollen distally, we may note

that very similar features appear in the pygidium of C. dicors (Angelin) as shown by Størmer (1930, Pl. 6, figs. 3, 10).

Genus *Cyphaspis* Burmeister, 1843.

Cyphaspis rotunda sp. nov.

Pl. II, figs. 8-9.

Diagnosis. Middle-shield small, broad, not very convex. Glabella much inflated, nearly as broad as long, about three quarters the length of the cephalon, standing high above the cheeks; it narrows rapidly opposite the glabellar lobes to a third of its width, at the occipital furrow. Axial furrows well defined, preglabellar furrow deeper forming a smooth curve. Basal glabellar lobes about one third length of glabella, broad, pointed anteriorly. Occipital furrow wide, rounded; occipital ring of similar calibre. Fixed cheeks elevated opposite lateral parts of glabella. Preglabellar field narrow; where narrowest, at median line of cephalon, it is no wider than the preglabellar furrow or the deep frontal furrow which divides it from the rounded rim of the slightly curved anterior border. Cephalon with fine tubercles varying in size.

Dimensions. Middle-shield 3 mm. in length.

Holotype. H.M. A 597, Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group (Ashgillian).

Locality. Quarrel Hill mudstones (locality 3), east brow of Quarrel Hill, Dailly.

Remarks. The specimen figured was collected by the writer, and a number of other specimens have been obtained by Mr. J. L. Begg.

The occipital ring may have a low median node.

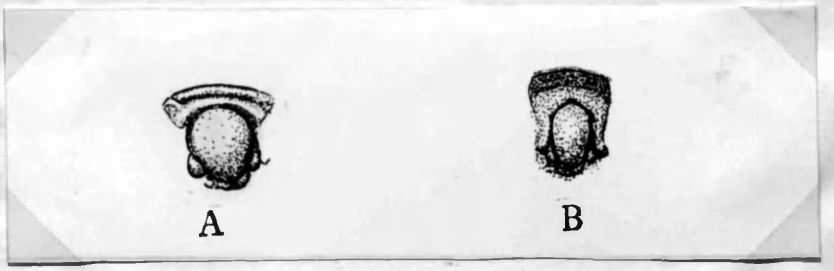

Fig. 4. A. Cyphaspis rotunda sp. nov. (as in Pl. II, fig. 9); B. C. sp. nov.? (as in Pl. II, fig. 7). x 4.

Affinities. Cyphaspis rotunda appears to have its general affinities with the group of species resembling the Silurian C. megalops,[4] as illustrated by Salter (1853, Pl. V, figs. 1 and 1*), but probably differs in rounder glabella, smaller basal lobes, and conjectural median node on occipital ring. One of the most closely related species is probably C. minima Cooper (1930, pp. 377-378, Pl. 5, fig. 12; p. 390, fig. 5)

(4) C. megalops is recorded by Reed (1906, p. 167) from the "Starfish Bed," Upper Drummuck group, but it is doubtful whether C. megalops occurs in the Ordovician.

from the Upper Ordovician beds at Perce, Quebec. In Cooper's plate 5, fig. 12, the preglabellar area is apparently foreshortened, since his text fig. 5, shows the preglabellar field with considerable length, too great to allow exact identification with C. rotunda. Other differences seem to be the larger basal lobes in C. rotunda, with correspondingly more rapid tapering of the posterior part of the glabella. C. minima has the occipital ring carrying a definite node, and its cephalon, unlike that of C. rotunda, is said to be unornamented.

Among Cyphaspids of earlier than Ashgillian times, C. rotunda possibly has its affinities with the same stock as C. planifrons Eichwald, from the Kuckers, C_2 beds - Caradocian - of the East Baltic, one specimen of which figured by Schmidt (1894, Taf. IV, fig. 40) shows glabellar, basal lobar, and occipital features very like those in C. rotunda. The latter differs in having proportionately longer anterior border of the middle shield, glabella rising higher above cheeks, and in its narrower preglabellar field. C. planifrons is also related to the American C. trentonensis Weller (1907). These may be taken as representing, at an earlier date, the group to which C. rotunda and C. minima belong.

C. rotunda falls into Weller's group of Cyphaspids with glabellae of intermediate length, that is, measuring about 80 per cent. of the total length of the cephalon. This group includes the Upper Ordovician C. slocomi Raymond (1925,

pp. 123-124, Pl. 8, fig.9) from the Lower Maquoketa, a species resembling ours but with the glabella much narrower anteriorly, and - among later forms - from the Alexandrian series C. girardeauensis Shumard, a species with highly inflated glabella very broad in front like ours, and C. intermedia Weller from the Channahon. C. slocomi, it may be noted, has a node on the strongly convex occipital ring, while C. intermedia has this ring narrow, flat and depressed with reference to the glabella. "These differences," as Raymond says (op. cit., p. 123), "are admittedly small, but sufficient to permit a separation."

Cyphaspis sp. nov.?

Pl. II, figs. 6-7.

Diagnosis. Middle-shield narrow, convex; anterior border arcuate, with incipient median angle. Glabella two thirds length of cephalon, arched, oval, twice as long as wide, standing above cheeks. Axial furrows deep, straight, slightly converging in front. Preglabellar furrow broader, deep, bent in an angle of about 100°, extending postero-laterally a little beyond anterior ends of axial furrows. Basal glabellar lobes isolated, small, narrow, finely tapering anteriorly, about quarter length of glabella. Occipital furrow broad, rounded, not deep like axial furrows, crosses narrow very convex base of glabella at right angles. Occipital ring rounded, of semi-circular convexity, distinct, its lateral extremities in line with median line of each glabellar lobe. Small median node on occipital ring.

Fixed cheeks narrow, elevated opposite sides of glabella. Preglabellar area long, inclined upwards dorsally in an obtuse angle at half its length (measured along median line). Proximal part of area - preglabellar field - convex; distal part - anterior border - almost flat with narrow furrow incised around outer margin.

Dimensions. Middle-shield 3.5 mm. in length.

Holotype. H.M. A 598, Hunterian Museum, University of Glasgow.

Horizon. Lower Drummuck Group, ? Upper Drummuck Group; (Ashgillian).

Locality. Quarrel Hill mudstones (locality 3), east brow of Quarrel Hill, Dailly; ? "Starfish Bed" of Drummuck (locality 7).

Remarks. This form is represented by one middle-shield, with dorsal part of the glabella damaged. The writer has also collected a somewhat similar imperfect specimen from the "Starfish Bed." The surface may be covered with fine tubercles, but preservation prevents a definite statement.

Cyphaspis sp. nov.? presents several highly distinctive features, notably the flattened anterior border of the preglabellar area, the very narrow glabella, and its very small basal lobes, which probably justify its establishment as a new species. C. sp. nov.? we may note differs from C. rotunda in the proportionately shorter and much less inflated glabella, smaller basal glabellar lobes, longer preglabellar field, flat - not rim-like - anterior border, angular - not crescentic - preglabellar furrow, shallow front furrow, etc. (fig. 4).

Affinities. So far as the small basal lobes and the deep preglabellar and axial furrows are concerned, Cyphaspis sp. nov.? resembles the middle-shield from Cader Dinmael, Denbighshire, - Bala limestone - attributed to C. megalops var. by Salter (1853, Pl. V, fig. 7), but there the similarities end.

The nature of the preglabellar furrow recalls one of the Upper Leptaena limestone species, C. trigoda Warburg (1925, pp. 190-193, Pl. V, figs. 38-39) in which this feature is described as follows:- "Preglabellar furrow deep and wide, widening in the middle so as to make a slight indentation on the surface of the preglabellar field; it generally reaches a little further out than the lateral extremities of the axial furrows - owing to its greater width." In this description the indentation apparently corresponds with the point of the angle in the preglabellar furrow of C. sp. nov.? and the rest of the description is also applicable. But in most other features, narrower fixed cheeks, narrower occipital ring, smaller basal glabellar lobes, shallow front furrow, C. sp. nov.? is decidedly different. The same set of features also distinguish it from the much larger C. burmeisteri Barrande (1852, pp. 484-486, Pl. 18, figs. 61-71) from Etage D of Bohemia, and from C. planifrons as described by Schmidt (1892, pp. 58-60, Taf. VI, figs. 40-43).

Genus *Calymene* Brongniart, 1822.

Calymene cf. *meeki* Foerste.

Pl. II, figs. 10-11.

Remarks. This Girvan middle-shield, of which specimens have been obtained by Mr. J. L. Begg, Mr. H. G. Vevers, and the writer, appears to coincide very nearly with *Calymene meeki* Foerste (1910, 1924) from the Cincinnatian. To describe it would be practically to repeat the descriptions by Foerste and by M. A. Fritz (1925). The pygidium of *C. meeki* is rather distinctive, having little trace of the furrow often seen running lengthwise on the pleurae in other species. Pygidia referable to *C. meeki* have not yet been found at Girvan; and it may be that the Girvan specimens belong to a species differing chiefly in characters other than those of the middle-shield.

The Girvan middle-shield also resembles that of *C.* cf. *fayettensis* Slocom, 1913, described by Mr. Cox from the Richmondian of Akpatok Island (1933, p. 363, Pl. XX, fig. 1). *C. fayettensis*, however, is apparently distinguished by its papillose surface. *C. fayettensis* differs from *C. meeki*, also, in its less sharply upturned anterior border. In this last respect the Girvan form may possibly prove to be intermediate.

Dimensions. Length of middle-shield 4.7 mm.

Width of middle-shield (posteriorly) 8 mm.

Syntypes. H. G. V. and H.M. A 599-601.

Horizon. Lower Drummuck Group (Ashgillian).

Localities. Quarrel Hill mudstones (localities 3 and 4), east brow of Quarrel Hill, Dailly.

A C K N O W L E D G M E N T S.

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B I B L I O G R A P H Y.

Bailey, E. B. 1928. "Summary of Progress of the Geological Survey for 1927," part 1, pp. 57-58.

Bancroft, B. B. 1929. "Some New Species of Cryptolithus (s.l.), from the Upper Ordovician." Mem. Proc. Manchester Lit. Phil. Soc., vol. LXXIII, pp. 67-98, pls. I-II.

Bancroft, B. B. 1933. "Correlation Tables of the Stages Costonian-Onnian in England and Wales." Published by the Author, Blakeney, Gloucestershire.

Barrande, J. 1852. "Système Silurien du Centre de la Bohême." vol. I, pp. i-xxx, 1-935, Pls. 1-51, Prague and Paris.

Bassler, R. S. 1919. "The Cambrian and Ordovician Deposits of Maryland - Systematic Paleontology" Maryland Geol. Surv. pp. 189-373, pls. XXIV-LVIII. Baltimore.

Bather, F. A. 1913. "Caradocian Cystidea from Girvan." Trans. Roy. Soc. Edin., vol. XLIX, pp. 359-529, pls. I-VI.

Brøgger, W. C. 1877. "Om Trondhjemsfeltets midtre Afdeling mellem Guldalen og Meldalen." Christiania Videnskaps-selsk. Forhandl. No. 2.

Cooper, G. A. 1930. "Upper Ordovician and Lower Devonian Stratigraphy and Palaeontology of Percé, Quebec. Part II. New Species from the Upper Ordovician of Percé," American Journ. Sci., Ser. 5, vol. XX, pp. 265-288, pls. 1-3, and pp. 365-392, pls. 4-5.

Cox, I. 1933. "Richmondian Trilobites from Akpatok Island," Geol. Mag. vol. LXX, pp. 359-373, pl. XX.

Davidson, T. 1866-71. "The British Silurian Brachiopoda," Mon. Brit. Foss. Brachiopoda (Palaeont. Soc.), vol. III, pt. 7, pp. 1-397.

Davidson, T. 1882-83. "Supplement to the British Silurian Brachiopoda," Mon. Brit. Foss. Brachiopoda (Palaeont. Soc.), vol. V, pp. 64-242.

Donald, J. (Mrs. Longstaff). 1902. "On some of the Proterozoic Gasteropoda which have been referred to Murchisonia and Pleurotomaria, with Descriptions of New Subgenera and Species," Quart. Journ. Geol. Soc., vol. LVIII, pp. 313-339, pls. VII-IX.

Donald, J. (Mrs. Longstaff). 1906. "Notes on the Genera Omospira, Lophospira, and Turritoma; with descriptions of the New Proterozoic Species," Quart. Journ. Geol. Soc., vol. LXII, pp. 552-572, pls. XLIII-XLIV.

Donald, J. (Mrs. Longstaff). 1924. "Descriptions of Gasteropoda, chiefly in Mrs. Robert Gray's Collection, from the Ordovician and Lower Silurian of Girvan," Quart. Journ. Geol. Soc., vol. LXXX, pp. 408-446, pls. XXXI-XXXVIII.

Elles, G. L. and Wood, E. M. R. 1901-1918. "A Monograph of British Graptolites." Palaeont. Soc., London.

Elles, G. L. 1922. "The Bala Country. Its Structure and Rock Succession." Quart. Journ.Geol. Soc., vol. LXXVIII, pp. 132-172, pl. II.

Fearnsides, W. G., Elles, G. L. and Smith, B. 1907. "The Lower Palaeozoic Rocks of Pomeroy." Proc. Roy. Irish Acad., vol. XXVI, sect. B, pp. 97-128, pls. 7-8.

Foerste, A. F. 1923. "Notes on Medinan, Niagaran, and Chester Fossils," Bull. Sci. Lab. Denison Univ., vol. XX, pp. 37-120, pls. IV-XVa.

Foerste, A. F. 1924. "Upper Ordovician Faunas of Ontario and Quebec," Canada, Geol. Surv. Memoir, No. 121, Geol. Series, pp. 1-255, pls. I-XLVI.

Fritz, M.A. 1925. "The Stratigraphy and Palaeontology of Toronto and Vicinity, Part IV, Hydrozoa, Echinodermata, Trilobita, and Markings," pp. 1-34, pls. I-IV. Ontario Dept. Mines, vol. XXXII, part VII, 1923. Toronto.

Geikie, A. 1869. "Ayrshire: Southern District - Explanation of Sheet 14." Mem. Geol. Surv. Scotland, paragraphs 11-17.

Green, J. 1832. "A Monograph of the Trilobites of North America." Philadelphia.

Hall, J. and Clarke, J. M. 1892. "An Introduction to the Study of the Genera of the Palaeozoic Brachiopoda," vols. 1-11. Geol. Surv. State of New York, Palaeontology, vol. VIII.

Hind, Wheelton. 1910. "The Lamellibranchs of the Silurian Rocks of Girvan." Trans. Roy. Soc. Edin., vol. XLVII, pp. 479-548, pls. I-V.

Jones, O. T. 1928. "Plectambonites and some Allied Genera," Mem. Geol. Surv. Gt. Britain, Palaeontology, vol. I, pt. 5, pp. 367-527.

Katzer, F. 1889-1892. "Geologie von Böhmen, u.s.w." pp. 1-xxii, 1-1606, maps 4. Prague.

Katzer, F. 1902. Ditto. Second edition.

King, W. B. R. 1923. "The Upper Ordovician Rocks of the South Western Berwyn Hills." Quart. Journ. Geol. Soc., vol. LXXIX, pp. 487-507, pl. XXVI.

Kjaer, J. 1932. "The Hovin Group in the Trondheim Area," with palaeontological contributions by O. A. Høeg, A. Hadding, F. R. C. Reed, A. F. Foerste, T. Strand, L. Størmer, and the Author. Skrifter Norsk. Vidensk. Akad. Oslo, 1, Math. Nat. Kl. No. 4, pp. 1-175, pls. I-XXVIII.

Lamont, A. 1934. "Lower Palaeozoic Brachiopoda of the Girvan District; Suggestions on Morphology in Relation to Environment." Ann. Mag. Nat. Hist., Ser. 10, vol. XIV, pp. 161-184, figs. 1-5.

Lapworth, C. 1882. "The Girvan Succession," Quart. Journ. Geol. Soc., vol. XXXVIII, pp. 537-664.

Marr, J. E. 1907. "On the Ashgillian Series," Geol. Mag., vol. XLIV, pp. 59-69.

Marr, J. E. 1913. "The Lower Palaeozoic Rocks of the Cautley District (Yorkshire). Quart. Journ. Geol. Soc., vol. LXIX, pp. 1-18.

Marsh, O.C. 1867. "Notice of a new Genus of fossil Sponges from the Lower Silurian." American Journ. Sci., Ser. 2, vol. XLIV, p. 88.

Miller, H. 1858. "On the Ancient Grauwacke Rocks of Scotland," appended to The Old Red Sandstone, Everyman Edition, Dent and Sons, London.

Murchison, R. I. 1851. "On the Silurian Rocks of the South of Scotland," Quart. Journ. Geol. Soc., vol. VII, pp. 137-178, pls. VIII-XI.

Nicholson, H.A. and Etheridge, R. jun. 1878-1880. "A Monograph of the Silurian Fossils of the Girvan District in Ayrshire," vol. 1, pp. 1-341, pls. I-XXIV.

Peach, B. N. and Horne, J. 1899. "The Silurian Rocks of Britain," vol. 1, Scotland, Mem. Geol. Surv., pp. 484-550.

Öpik, A. 1933. "Über Plectamboniten," Acta et Commentationes Universitatis Dorpatensis, A XXIV. 7. pp. 1-79, pls. I-XII.

Portlock, J. E. 1843. "Report on the Geology of the County of Londonderry and of Parts of Tyrone and Fermanagh." Geological Dept. of the Ordnance Survey of Ireland. Dublin.

Raymond, P. E. 1925. "Some Trilobites of the Lower Middle Ordovician of Eastern North America," Bull. Mus. Comp. Zoöl., Harvard University, vol. LXVII, pp. 3-180, pls. 1-10.

Reed, F. R. C. 1896. "The Fauna of the Keisley Limestone - Part I." Quart. Journ. Geol. Soc., vol. LII, pp. 407-437, pls. XX-XXI.

Reed, F. R. C. 1897. "The Fauna of the Keisley Limestone - Part II." Quart.Journ. Geol. Soc., vol. LIII, pp. 67-106, pl. VI.

Reed, F. R. C. 1903-1906. "The Lower Palaeozoic Trilobites of the Girvan District, Ayrshire." Palaeont. Soc., London.

Reed, F. R. C. 1905. "New Fossils from the Haverfordwest District, IV." Geol. Mag., vol.XLII, pp. 444-454, pl. XXIII.

Reed, F. R. C. 1907. "Crustacea, etc., from Girvan," Geol. Mag., vol. XLIV, pp. 108-115, pl. IV.

Reed, F. R. C. 1908. "New Fossils from Girvan." (Receptaculites etc.) Geol. Mag. vol. XLV, pp. 291-296, pl. XII.

Reed, F. R. C. 1909. "Lower Palaeozoic Hyolithidae from Girvan." Trans. Roy. Soc. Edin., vol. XLVII, pp. 203-222, pls. I-III.

Reed, F. R. C. 1911. "A New Fossil from Girvan" (Helminthochiton thraivensis), Geol. Mag., vol. XLVIII, pp. 337-339, pl. XV.

Reed, F. R. C. 1914. "The Lower Palaeozoic Trilobites of Girvan. Supplement." Palaeont. Soc., London.

Reed, F. R. C. 1914b. "Notes on the genus Trinucleus - Part III." Geol. Mag., vol. LI, pp. 349-359, pls. XXVIII-XXIX.

Reed, F. R. C. 1917. "Ordovician and Silurian Brachiopoda of the Girvan District," Trans. Roy. Soc. Edin., vol. LI, pp. 795-998.

Reed, F. R. C. 1920-21. "A Monograph of the British Ordovician and Silurian Bellerophontacea." Palaeont. Soc., London.

Reed, F. R. C. 1931. "The Lower Palaeozoic Trilobites of Girvan. Supplement No. 2." Palaeont. Soc., London.

Reed, F. R. C. 1933. "Some New Ordovician Species of Conularia from Girvan." Geol. Mag., vol. LXX, pp. 354-358, pl. XIX.

Reynolds, S. H. and Gardiner, C. I. 1896. "The Kildare Inlier." Quart. Journ. Geol. Soc., vol. LII, pp. 587-605, pl. XXVIII.

Salter, J. W. 1853. "Figures and Descriptions illustrative of British Organic Remains." Dec. VII. Mem. Geol. Surv. United Kingdom.

Salter, J. W. 1862. In F. McCoy's "A Synopsis of the Silurian Fossils of Ireland." pp. 1-72, pls. I-V. Williams and Norgate, Dublin.

Schmidt, F. 1882. "On the Silurian (and Cambrian) Strata of the Baltic Provinces of Russia, as compared with those of Scandinavia and the British Isles." Quart. Journ. Geol. Soc., vol. XXXVIII, pp. 514-536, pl. XXIII.

Schmidt, F. 1894. "Revision der Ostbaltischen Silurischen Trilobiten; Abt. iv, Calymmeniden, Proetiden, Bronteiden, Harpediden, Trinucleiden, Remopleuriden und Agnostiden." Mem. Acad. Imp. Sci. St. Petersbourg, VII[e] Série, tome XLII, No. 5, pp. 1-93, Taf. I-VI.

Schuchert, C. 1916. "Correlation and Chronology in Geology on the Basis of Palaeogeography." Bull. Geol. Soc. America, vol. 27, pp. 491-514, pl. 19.

Schuchert, C. 1930. "Upper Ordovician and Lower Devonian Stratigraphy and Palaeontology of Percé, Quebec, Part I. Stratigraphy and Faunas." American Journ. Sci., Ser. 5, vol. XX, pp. 161-176.

Schuchert, C., and Cooper, G.A. 1932. "Brachiopod Genera of the Suborders Orthoidea and Pentameroidea," Mem. Peabody Mus. Nat. Hist., vol. IV, pt. 1, pp. 1-270.

Slater, I. L. "British Comulariae." Palaeont. Soc. London.

Slocom, A. W. 1913. "New Trilobites from the Maquoketa beds of Fayette County, Iowa." Chicago Field Mus. Nat. Hist. Geol. Ser. 4, pp. 43-83, pls. XIII-XVIII.

Spencer, W. K. 1914. - in progress."British Palaeozoic Asterozoa" Palaeont. Soc., London.

Størmer, L. 1930. "Scandinavian Trinucleidae, with special references to Norwegian Species and Varieties." Skrifter Norsk. Vidensk. Akad. Oslo, 1 Math. Nat. Kl. No. 4, pp. 1-111, pls. 1-14.

Troedsson, G. T. 1929. "On the Middle and Upper Ordovician Faunas of Northern Greenland. Part II." Meddelelser om Grønland, Bind LXXII, pp. 1-197, pls. 1-56.

Tyrrell, G. W. and Begg, J. L. 1933. "Summer Field Meeting, 1932; Girvan - Ballantrae," Proc. Geol. Assoc. vol. XLIV, pp. 57-81, pls. 8-9.

Ulrich, E. O. 1930. "Ordovician Trilobites of the Family Telephidae and Concerned Stratigraphic Correlations," Proc. U.S. Nat. Mus., Washington, D. C., vol. 76, Art. 21, pp. 1-101, pls. 1-8.

Warburg, E. 1925. "The Trilobites of the Leptaena Limestone in Dalarne." Bull. Geol. Inst. Univ. Upsala, vol. XVII, pp. i-vi, 1-446, pls. I-XI.

Watts, W. W. 1929. In "Handbook of the Geology of Great Britain," pp. 58-80. Murby and Co., London.

Weller, S. 1907. "The paleontology of the Niagaran limestone in the Chicago area. The Trilobita." Chicago Ill. Acad. Sci., Bull. Nat. Hist. Surv., No. 4, pp. 155-281. pls. XVI-XXV.

Willard, B. 1928. "The Brachiopods of the Ottosee and Holston Formations of Tennessee and Virginia," Bull. Mus. Comp. Zoöl., Harvard University, vol. LXVIII, pp. 255-309, pls. 1-3.

Winchell, N. H. and Schuchert, C. 1895. "The Lower Silurian Brachiopoda of Minnesota," Geology of Minnesota, vol. III, part 1, Palaeontology, pp. 333-474, pls. XXX-XXXIV.

Wood, A. 1933. "On Three Trilobites from Girvan," Proc. Geol. Assoc. vol. XLIV, pp. 81-84, pl. 10.

Zittel, K. A. 1927. "Text-Book of Paleontology" (edited by C. R. Eastman), vol. I, pp. i-x, 1-839. MacMillan and Co., London.

EXPLANATION OF PLATES.

Plate I. Brachiopoda.

Fig. I. H.M. L 1940. *Fardenia scotica* gen. et sp. nov. Internal cast of ventral valve. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Fig. 2. H.M. L 1943; plasticine cast. Ditto. Exterior of dorsal valve. Same locality.

Fig. 3. H.M. L 1943. Ditto. Impression of exterior of dorsal valve. Same locality.

Fig. 4. H.M. L 1942. Ditto. Young specimen. Internal cast of ventral valve. Same locality.

Fig. 5. H.M. L 1942; plasticine cast. Ditto. Interior of ventral valve. Same locality.

Fig. 6. H.M. L 1941. Ditto. Internal cast of dorsal valve. Same locality.

Fig. 7. H.M. L 1941; plasticine cast. Ditto. Interior of dorsal valve. Same locality.

Fig. 8. H.M. L 1956. *Brachyprion matutinum* sp. nov. Exterior of ventral valve. "Crinoid Bed" (locality 5), easy brow of Quarrel Hill, Dailly.

Fig. 9. H.M. L 1957. Ditto. Internal cast of ventral valve. Same locality.

Fig. 10. H.M. L 1958. Ditto. Ditto. Same locality.

Fig. 11. H.M. L 1957; plasticine cast. Interior of ventral valve. Same locality.

Fig. 12. H.M. L 1976. Stropheodonta bilix sp. nov. Internal cast of ventral valve. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Fig. 13. H.M. L 1977; plasticine cast. Ditto. Exterior of ventral valve. Same locality.

Fig. 14. H.M. L 1978. Ditto. Impression of exterior of dorsal valve. Same locality.

Fig. 15. H.M. L 1976; plasticine cast. Interior of ventral valve. Same locality.

Fig. 16. H.M. L 1978. Ditto. Internal cast of dorsal valve. Same locality.

Fig. 17. H.M. L 1982. Leangella discuneata sp. nov. Internal cast of ventral valve. Conglomerate at "Auldthorns" (locality I), Quarrel Hill, Dailly.

Fig. 18. H.M. L 1983. Ditto. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly.

Fig. 19. H.M. L 1983. Ditto. Ditto. Same locality.

Fig. 20. H.M. L 1986. Hirnantia sagittifera (McCoy) gen. nov. Internal cast of dorsal valve. High Mains sandstone, 100 yards west of High Mains farmhouse, Dailly.

Fig. 21. B.M. B 40818. Ditto. Ditto. Hirnant Beds, Bwlch-hannerob, south-east of Bala, North Wales.

Fig. 22. H.M. L 1987. Ditto. High Mains Sandstone, 100 yards west of High Mains farmhouse, Dailly.

All specimens, except figs. 20-22, from Lower Drummuck Group.
H.M. = Hunterian Museum. B.M. = British Museum (Nat. Hist.).
Figures twice actual size.

Plate II. Spongiae, Trilobita, etc.

Fig. 1. H.M. P 5200. Rhoeaspongia mactaggarti gen. et sp. nov. Internal cast viewed from the base of attachment. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly. Nat. size.

Fig. 2. J.D. Cryptolithus portlockii var. nov. girvanensis. Cephalic shield; impression of lower lamella. Quarrel Hill mudstones (locality 3), east brow of Quarrel Hill, Dailly. X 2.

Fig. 3. H.M. A 580. Ditto. Cephalic shield; surface of upper lamella. Same locality. X 2.

Fig. 4. H.M. A 580. Ditto. Ditto. (lateral view). Same locality. X 2.

Fig. 5. H.M. A 581. Ditto. Pygidium. Same locality. X 2.

Fig. 6. H.M. A 598. Cyphaspis sp. nov.? Middle-shield. Quarrel Hill mudstones (locality 3), east brow of Quarrel Hill, Dailly. X 2.

Fig. 7. H.M. A 598. Ditto. Ditto. Ditto. Same locality. X 4.

Fig. 8. H.M. A 597. Cyphaspis rotunda sp. nov. Middle-shield. Quarrel Hill mudstones (locality 3), east brow of Quarrel Hill, Dailly. X 2.

Fig. 9. H.M. A 597. Ditto. Ditto. Same locality. X 4.

Fig. 10. H.G.V. Calymene cf. meeki Foerste. Middle-shield. Quarrel Hill mudstones (locality 3), east brow of Quarrel Hill, Dailly. X 2.

Fig. 11. H.G.V. Ditto. Ditto. (lateral view.) Same locality. X 2.

Fig. 12. H.M. L 1975. Block with specimens including Brachyprion matutinum sp. nov. (internal and external impressions of ventral valve), Fardenia scotica gen. et sp. nov., eye of Phacops, etc. "Crinoid Bed" (locality 5), east brow of Quarrel Hill, Dailly. Nat. size.

All specimens from Lower Drummuck Group. H.M. = Hunterian Museum. The specimens with reference numbers J.D. and H.G.V. are in the collections of Mr. J. Dougan, Knockcushion Street, Girvan, and of Mr. H. G. Vevers, Hampstead, London.

Plate III. Map of the Craighead-Glenshalloch Inlier.

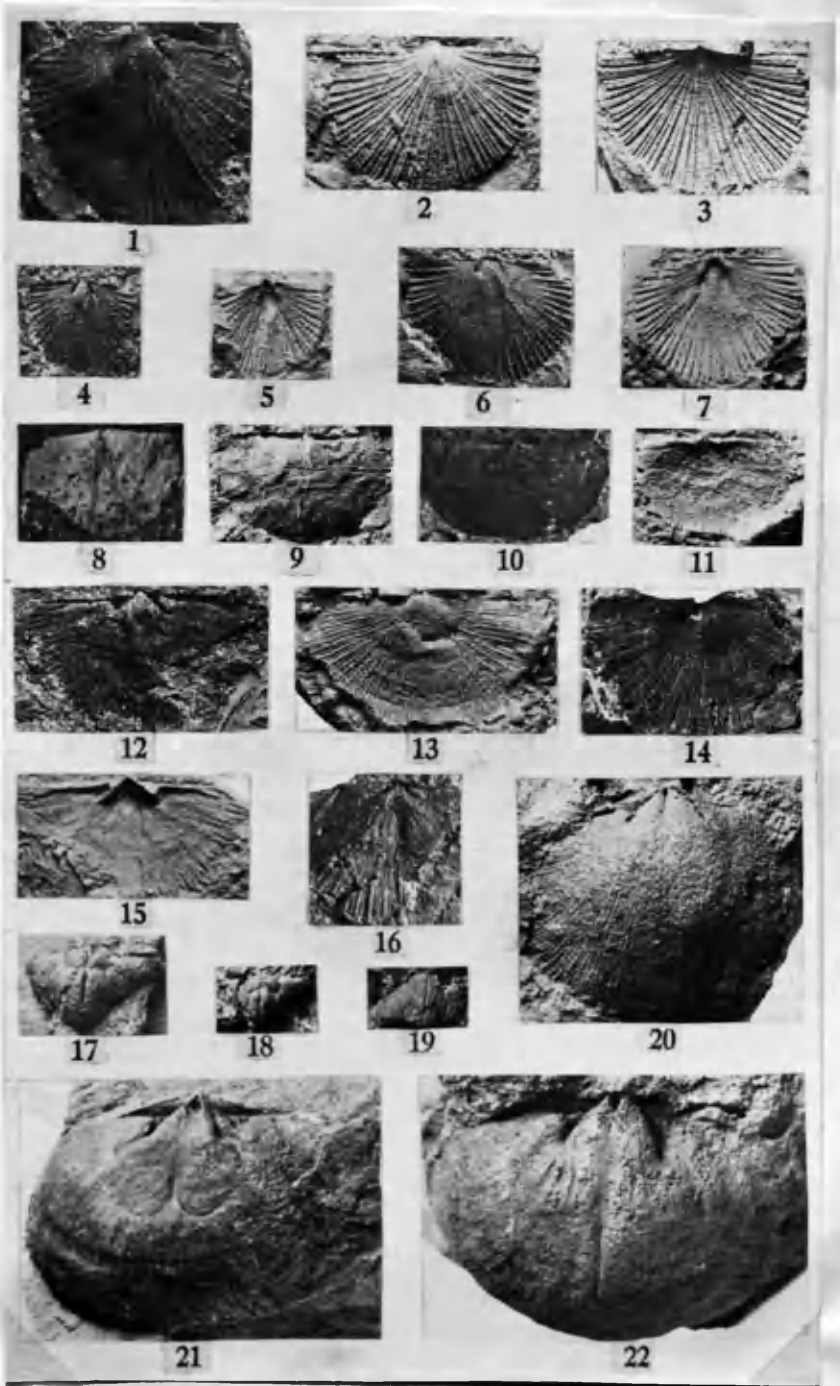
The Ordovician-Silurian unconformity is shown by the separate mapping of the Lower and Upper Drummuck beds. The Drummuck group fossiliferous localities are indicated as follows:- 1. Basal conglomerate, south of "Auldthorns"; 2. Basal grit, escarpment north-west of "Auldthorns"; 3. Quarrel Hill mudstones (lower horizon), east brow of Quarrel Hill; 4. Quarrel Hill mudstones (higher horizon), ditto; 5. "Crinoid Bed" of Quarrel Hill, ditto; 6. "Crinoid Bed" of Quarrel Hill, half mile north-west of Glenlochrie. 7. "Starfish Bed," Threave Glen; 8. Ladyburn mudstones, cliff section, ditto; 9. Ladyburn mudstones, field section, South Threave; 10. Ladyburn mudstones, in bank of stream, South Threave.

Plates IV-XIV.

Photographs of Craighead-Glenshalloch Inlier, illustrating topography, fossil localities etc.

The photographs for Plates I-III are by Mr. D. M. Filshill. Plate IX is by Rev. J. M. Ewing. The other plates are by the author.

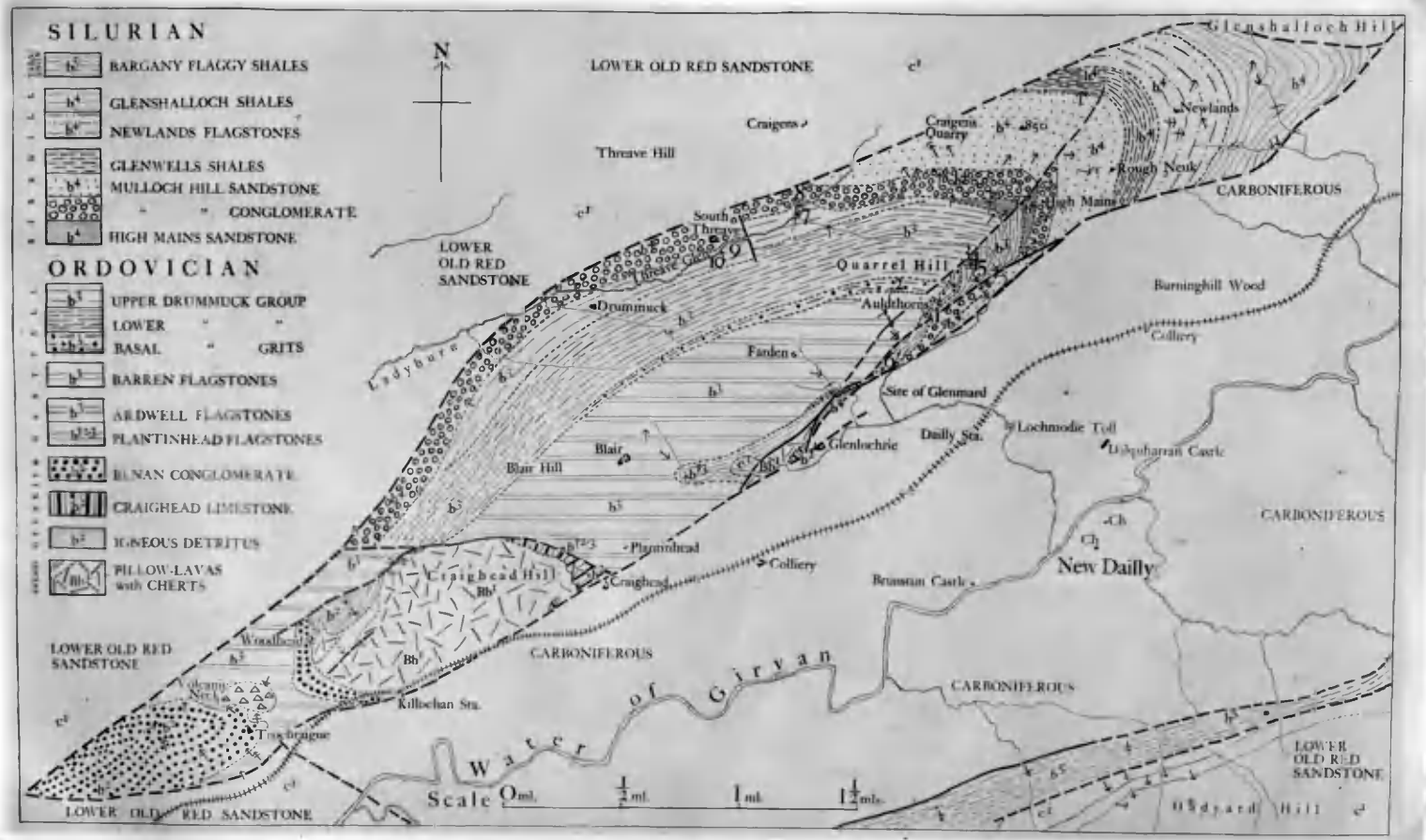
Plate I.



Brachiopoda.

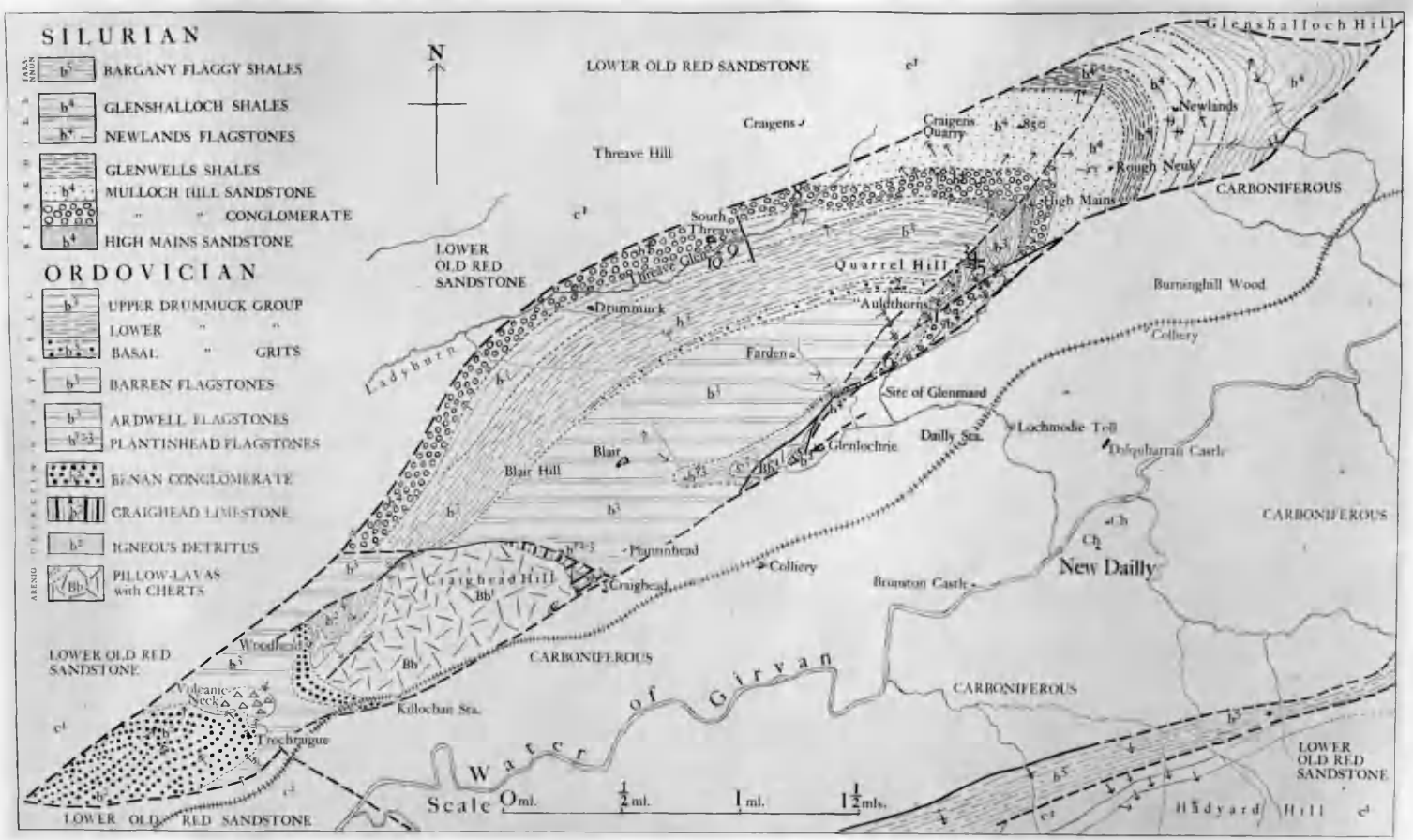
Plate II.

Spongiae and Trilobita etc.



Map of the Craighead-Glenshalloch inlier, with fossil localities in the Drummuck group indicated as follows: (1) Basal conglomerate S. of "Auldthorns," (2) Basal grit N.N.W. of "Auldthorns," (3) Quarrel Hill mudstones; lower horizon, (4) Quarrel Hill mudstones; higher horizon, (5) "Crinoid Bed," E. brow of Quarrel Hill, (6) "Crinoid Bed," ½ ml. N.E. of Glenlochrie, (7) "Starfish Bed" of Drummuck, (8) Cliff-Section; 100 yds. N. of Starfish Bed, (9) South Threave; field locality, (10) South Threave; Ladyburn locality.

Plate III.



Maps of the Craighead-Glenshalloch Inlier (additional copy with thesis).

Plate IV.

The Girvan valley, with Craighead Hill (pillow-lavas etc.) on the skyline. View from Girvan Railway Station.

Plate V.

North slope of Craighead Hill (pillow-lavas), with agricultural lands on the sedimentary rocks presumably faulted against the lavas.

Plate VI.

Threave Glen with South Threave farmhouse on the left hand. The knoll reaching the skyline is of Mulloch Hill conglomerate resting uncomfortably on the Drummuck Group. View from Drummuck farmyard.

Ladyburn beside South Threave. Fossil locality 10 is on the right hand side under the large tree. Locality 9 is in field beyond footbridge.

"Starfish Bed" (locality 7) with Mulloch Hill conglomerate on left hand skyline. The cliff-section (locality 8) is immediately beyond the drystone wall on extreme right.

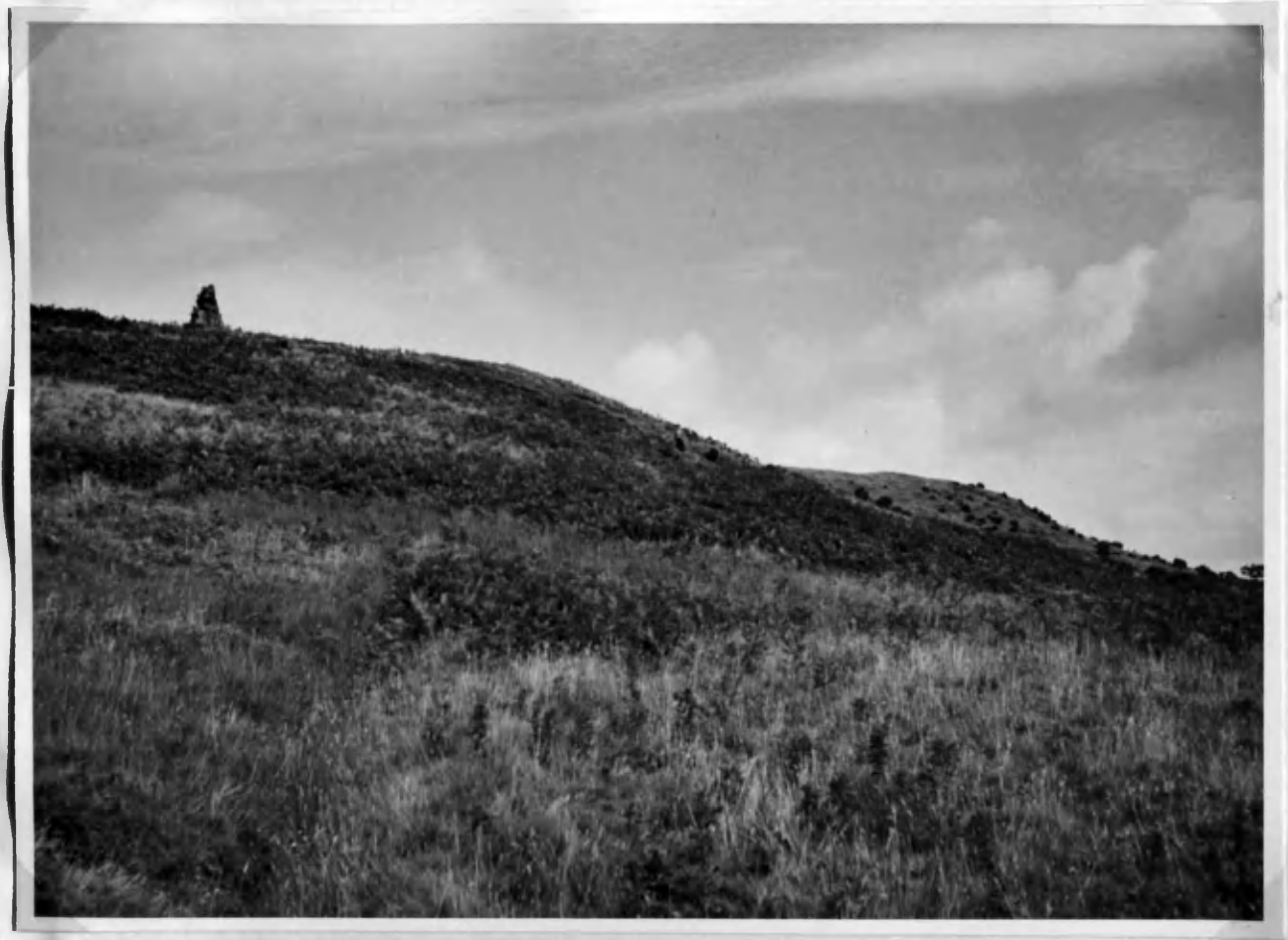
Plate IX.

"Starfish Bed"; the actual sandy layer, in the lower part of which the fossils tend to be concentrated, is behind the hammer, the head of which indicates the dip to north-north-east.

Plate X.

Quarrel Hill from east of Glenlochrie. The gable of "Auldthorns" ruin is seen on the skyline. A short distance below the ruin there is an outcrop of Basal Drummuck conglomerate (locality 1) with abundant brachiopods. The "Crinoid Bed" (locality 6) outcrops in the partly whin-covered field enclosed on three sides by trees, on the left hand side of the photograph.

Plate XI.



"Auldthorns ruin" on escarpment of Basal Drummuck conglomerate and grit. The figure is standing at the fossiliferous conglomerate outcrop (locality 1). The escarpment to the right consists of down-faulted Mulloch Hill conglomerate, the fault running through a short distance below the conglomerate exposure.

Plate XII.

"Crinoid Bed" (locality 5), east brow of Quarrel Hill. The fossil localities 3 and 4 in the Quarrel Hill mudstones occur about 60 yards upstream opposite the small excavation seen on the left hand side of the large birch-tree.

Plate XIII.

The High Mains sandstone outcrops on the steep slope on the right hand side of the photograph. The escarpment in the centre of the photograph is Mulloch Hill conglomerate. The lower ground is in the Drummuck group, which here consists, so far as exposed, of the fine, splintery mudstones typical of the Lower Drummuck.

Plate XIV.

High Mains farmhouse, with in the right hand foreground the elongate hillock of High Mains sandstone from which Hirnantia sagittifera has been collected. Here the High Mains Sandstone dips due west under the Mulloch Hill conglomerate on which the farmhouse (and the conifers in the photo) stand. Hills south east of the Girvan valley are seen on part of the skyline to the left hand of the farmhouse.

A P P E N D I X.

THE DESCENT OF GENERA IN CRYPTOLITHINAE.

By B. B. Bancroft, M.Sc.

The line of descent that has been worked out in the greatest detail is that which leads from Marrolithus to Reuscholithus. Briefly the facts are these: Marrolithus extends from the Llandeilian to the higher horizons of the Costonian and exhibits a gradual simplification of the fringe (reduction of number of concentric rows in I-region) as it is traced upwards. Together with these changes there is a tendency for the margin of the head-shield to become less angular. Now, during the Llandeilian and earliest Costonian the external concentric row is E_1; but during the later Costonian a few pits of E_2 appear in front of the glabella, an event which marks a very important turning point in the line. In the Harnagian the number of pits in E_2 in front increases and the same row is represented in the postero-lateral region: associated with this change there is an increase in the number of rows in the I-region. This Harnagian form is the first Reuscholithus.

The interesting things about this line are (1) a period of simplification in one direction is followed by a period of complication in new directions; and (2) characters which have remained fixed or virtually fixed throughout the history of a genus may lose their fixity (E_1 external in

Marrolithus) and their regions become the theatre of trend-line changes in a derived genus. All this helps to explain what happens in the line Salterolithus ⟶ Cryptolithus. Of the line Salterolithus ⟶ Ulricholithus ⟶ Broeggerolithus I shall note only that E_1, E_2, I_1, and I_2 are continuous concentric rows and I_3 extends anteriorly to about the middle of the cheek, and that the ensemble of these characters is fixed in these genera. Broeggerolithus arises through mutations of Ulricholithus by reduction in the number of pits in the concentric rows, complete elimination of E_3, re-development of a reticulate surface, and formation of elevated plate-like ridges between the pits of E_1.

As regards the rows of pits and their extension anteriorly, Upper Longvillian and later Broeggerolithi are without the elevated plates in E_2. This is important. Normal Broeggerolithus persists into the Actonian, but as early as the zone of B. broeggeri we find individuals with assemblages in which E_2 is defective in front of the glabella, 1-3 pits of E_1 being external. These rare mutations herald the appearance of B. soudleyensis of the Upper Soudleyan and Lower Longvillian in which E_2 is always defective in front, there being as many as 16 pits of E_1 external.

Now, near the base of the Upper Longvillian in the U.S.A. there appears the first true Cryptolithus (C. tesselatus) a form which differs from Broeggerolithus soudleyensis only in

the complete absence of E_2. E_1 with its characteristic elevated plates, is now the external row. The other characters of the fringe remain fixed till the end of the Trenton. After the Trenton E_1 as the external row remains a fixed character, but the region internal to the girder, which was fixed in the ancestral Broeggerolithus, now becomes a theatre of progressive modification. The number of concentric rows in this region increase to as many as 6. This is the Cryptolithus trend.(5)

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(5) The passage quoted from Mr. Bancroft (vide supra, page 52) may be read consecutively from this point. A.L.

C O N T E N T S.
