PROCEEDINGS
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THE FAUNAL SUCCESSION IN THE LOWER
CARBONIFEROUS ROCKS OF WESTMORLAND
AND NORTH LANCASHIRE.*

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THE map (Fig. 1) illustrates the five districts into which the lower Carboniferous rocks of the N.W. Province have been divided for convenience of description, namely :—

1. Ravenstonedale and Shap.
2. Kendal and Kirkby Lonsdale.
3. Arnside and Carnforth.
4. Grange and Furness.
5. The Westmorland Pennines and Middleton-in-Teesdale.†

A series of zones and sub-zones have been established, and are shown in the Table, Fig. 2, while certain bands of limited vertical thickness, also shown in Fig. 2, have been found invaluable in correlating the succession in the different districts.

The lowest beds are best developed in the Shap-Ravenstonedale district, in the west of the Kendal district, at Meathop in the Arnside district, and near Elliscales in the Furness district, *i.e.*, in the areas bordering the lower palæozoic rocks of the Lake District and the Howgill Fells. As we recede from this area the lowest zones are found to be absent, since the submergence of the pre-Carboniferous land-surface took place later and later, as we travel E. and S.E. Thus along the Pennine Fault, near Roman Fell, the earliest deposits laid down are found to be on the horizon of the *Thysanophyllum* band and the Brownber pebble bed, while, under Ingleborough, the lowest beds met with appear to represent the very top of the *Michelinia* zone. In Upper

* The following field notes have been drawn up in view of the Long Excursion to Westmorland this summer (1916). The author is indebted to Mr. Tutchter for the photographs reproduced in Plate 12, Figs. 1 and 2; Plate 14, Fig. 4; Plate 16, Fig. 1, in addition to those already acknowledged in the *Quart. Journ. Geol. Soc.* for 1912. He also has to thank the Council of the Geological Society for permission to reproduce the following: Figs. 1 and 2, Plate 4.A, Plate 7.A, Plate 8.A and B; and Messrs. Frith & Co. for leave to publish the photograph Plate 6.

† These districts are not dealt with in the present paper, as it is not proposed to visit them during the Excursion of the Association of 1916.

Map of RAVENSTONEDALE and Southern portion of SHAP DISTRICT.

Fig. 2.— Vertical section of the succession in the North-Western Province.

NOT TO SCALE.

dolomites, and shales which have yielded a fauna unknown elsewhere.

The lower portion of the *A. glabristria* zone is specially characterised by the presence of layers rich in the remains of *Solenopora*, while the upper portion contains abundant examples of *Seminula gregaria*. The zone is also marked by six palæontological horizons or bands numbered (1)–(6) in the Table Fig. 2, and illustrated in Plate 12 and Plate 13, Figs. 1 to 8.

The beds overlying the *A. glabristria* zone are characterised in their lower portion by massive limestones, and contain large examples of *Michelinia grandis* associated with *Camarophoria isorhyncha* (Pl. 13, Figs. 9–10), while the upper portion of the zone (which is best exposed at Arnside and on the shore of the Leven Estuary) is marked by alternations of shaly mudstones and cement-stones and contains abundant remains of a smaller compact form of *M. grandis* associated with *Chonetes carinata*, *Zaphrentis konincki* var. *kentensis*, and a rich general fauna (Pl. 13, Figs. 11–14, Pl. 14.)

The middle portion of the succession in the N.W. Province (the *Productus corrugato-hemisphericus*-zone) was accumulated in deeper water and under more generally uniform and widespread conditions and the beds resemble, very closely in their general characters, that portion of the succession in the S.W. of England which has been included under the terms *Seminula*-zone and lower *Dibunophyllum*-zone by Dr. Vaughan.

In our district the "*Seminula*"-zone (of the S.W.) is capable of subdivision into three sub-zones, namely, (1) a lower group of compact blue-grey limestones without any markedly characteristic forms but containing locally a rich general molluscan fauna and notably species of *Bellerophon*; (2) a middle portion often impregnated with silica containing *Cyrtina carbonaria* in abundance; (3) an upper portion consisting of pure white limestones with *N. (Lithostrotion) minus* and locally, in the west, an abundance of *Chonetes papillionacea*. This horizon is largely worked for lime in the Arnside, Grange, and Furness districts (Pl. 15).

The Lower *Dibunophyllum* sub-zone forms the massive upper portion of the "lower Scar limestone" of the North of England (Melmerby Scar and Knipe Scar), and is often crowded with the remains of *Cyathophyllum murchisoni*, *Dibunophyllum* and *Campophyllum*. The base is marked everywhere in the eastern districts by a layer containing abundant remains of bryozoa and *Spiriferina laminosa*, forming the highest horizon of the *N. minus*-sub-zone, while the summit is defined, both in the eastern and western districts, by a bed of platy buff-coloured limestone containing the remains of *Chonetes comoides*, *Cyrtina septosa* and *Productus striatus* (Pl. 16). Two persistent lithological features can be noted in this sub-zone:—

(a) A curious concretionary segregation of the colouring matter of the rock, producing a general spotted appearance, which is especially characteristic of the lower portion of the sub-zone, and

(b) Layers of "pseudo-breccia" at the summit of this division, which form the chief limestone scars and plateaux and are frequently intersected by "grikes" (Pl. 9.B).

The Upper *Dibunophyllum* sub-zone comprises two types of deposit characterising the eastern and western districts respectively—the northern and eastern tracts, forming the Shap-Ravenstonedale and Pennine districts, belong to Phillip's "Yoredale" type, while the development in the south and west forms the "Western or Kirkby Lonsdale" type.

The Yoredale type is characterised by detrital deposits in which are intercalated a series of thin impure limestones. The lower three limestones are marked by *Lonsdalia floriformis* (Pl. 17, Fig. 1) and *Lithostrotion junceum*, the basal layer being also characterised by a marked development of *Girvanella* nodules (Pl. 18, Fig. 6) (the *Girvanella* Nodular Bed), which has been traced from north Northumberland to Penygent, and is specially well exposed at Humphrey Head in the Grange district.

The fourth limestone from the base is crowded with the remains of the foraminifer *Saccamina carteri* and is also the chief horizon for *Productus edelburgensis* (Pl. 17, Figs. 4 and 6).

The highest limestone of the series containing *Dibunophyllum muirheadi* (Pl. 17, Fig. 2) together with a compound coral resembling *Phillipsastraea* (the Botany Beds) occurs in the Pennine district some distance up in the beds coloured as Millstone Grit in the Geological Survey Map. These beds are therefore of somewhat special interest and appear to correspond to the D.3 horizon of Derbyshire described by Dr. Sibly.

The "Western or Kirkby Lonsdale" development of these beds differs from the Yoredale type in the absence of limestones, except near the base, and by the close resemblance of the brachiopod fauna to that of D₂-D₃ in Derbyshire and also to the fauna of the highest Knoll reefs at Clitheroe and Cracow. These two types of deposit appear to have been originally laid down at some distance from one another and to have been brought into their present positions by subsequent earth movements.

COMPARISON WITH OTHER AREAS.

The submergence in Lower Carboniferous times in the north-west of England took place everywhere later than in the south-western Province (with the possible exception of the area where the Pinsky beds are now found). This period corresponds to "γ," or possibly to the upper part of Z₂ of the south-western

Province. On the other hand, marine conditions appear to have continued to a later date than in the Bristol district, so that not only do we find a great thickness of Upper Yoredale Beds (Dy) above the typical *Lonsdalia* horizon of D2 of the S.W., but at Botany, in the Middleton district, we find marine beds still characterised by *Dib. muirheadi* and containing a fauna strongly reminiscent of D.3 of Derbyshire, several hundred feet above the base of the Millstone Grit Series of the Survey Maps.

RAVENSTONEDALE DISTRICT.

See the Map, Pl. I. Section Pl. II, Fig. A.

Pinskey Gill.—The Shap basement-conglomerate is exposed below the road bridge, and contains fragments of Shap granite felspars. A short distance above the bridge we find an outcrop of cellular dolomite, with obscure casts of lamellibranchs, and a little farther up stream a cliff, on the right bank, shows compact mudstones overlain by shales. The mudstones have yielded *Lingula, orbiculoidea*, some casts of lamellibranchs, and a tooth of *Psephodus*. The overlying shales contain worm-tracks and stems of *Pteridorhachis*. Farther up stream again, a bed of sandy mudstone overlies the shales and forms the dip-slope in a tributary gill coming in from the west. This bed has supplied numerous specimens of *Spirifer pinskeyensis* and *Athyris* cf. *concentrica*, with the shells entirely destroyed, together with bryozoa and a tooth of *Psephodus*; casts of a small rhynchonellid not unlike *C. mitcheldeanensis* also occur. The exact age of these beds is uncertain, but the presence of *Psephodus*, determined by Dr. Smith Woodward, would appear to indicate their Carboniferous age, though their exact position in the sequence in the S.W. Province is still undecided. They are undoubtedly the oldest Carboniferous rocks yet met with in Westmorland, and appear to have been laid down before the Shap granite was exposed to denudation. They differ from the beds overlying the conglomerate in their lithological character and in the mode of preservation of their fossils.

Stone Gill.—No section is seen in Pinskey Gill of the beds overlying the conglomerate, but an excellent exposure of this portion of the succession occurs in Stone Gill, a little to the west of Ravenstonedale village (Pl. 2.A). The lowest beds here consist of limestone and shales with *A. glabristria*, *Spiriferina* sp., *Spirifer clathratus*, ostracoda and plants. The shales are succeeded by thick beds of compact dolomite containing *Vaughania cleistoporoides* and these again are overlain by dolomites and shales in which three well-marked horizons occur: (1) a layer largely made up of the plates and spines of *Archæocidaris* and *Palæchinus*, and containing specimens of *Zaphrentis omaliusi*; (2) a layer of dolomite crowded with the thalli of

Solenopora
Bed.

Prouva
Band.

Photo by E. J. Garwood.

A.—STONE GILL, RAVENSTONEDALE, SOLENOPORA SUB-ZONE.

Photo by E. J. Garwood.

B.—SCANTAL BECK, STOLEN DRAINAGE.

Solenopora garwoodi; (3) a "fragmental" bed, containing flat pebbles derived from the underlying dolomite, pointing to contemporaneous erosion.

At the corner where the stream turns at right angles and flows down the dip we reach the base of the "proava" beds which from here onwards occupy the bed of the stream as far as Colbeck village. They form a thick series of compact porcellaneous limestones crowded in certain layers with *Camarotachia proava* and *Solenopora*. Crossing the main road at Colbeck we reach the *P. globosus* band exposed in a small cliff near Park House Farm, at the foot of the golf links opposite the first tee. *Productus rotundus* and *Rhynchonella fawcettensis* can be obtained here, while the underlying algal layer is well exposed at several points in Scandal Beck between Colbeck Bridge and the "Black Swan" Inn. A little farther down the beck the *Thysanophyllum* band forms the right bank of the stream and is also well exposed in Cowpland Sike, where it contains large silicified specimens of *Fistulipora incrustans*. This depression appears to mark the spot where the Scandal Beck, formerly a tributary of the Lune, has been captured and diverted through the waterparting into the Eden drainage down the gap now occupied by the North-Eastern Railway, an admirable example of stolen drainage still in its early stages* (Pl. 2.B). Continuing along this depression to Friar Bottom we reach the base of the *Seminula gregaria* sub-zone, this being the type locality for *P. globosus*. Beyond the farm a lane leads by an archway under the railway to a good exposure of the Brownber pebble-bed in a small quarry by the roadside. Some of the layers here show quartz pebbles embedded in a matrix composed of coarse oolite, the whole deposit showing signs of current action. A few rolled fragments of shells may be obtained, notably *Syringothyris cuspidata*, *Camarophoria isorhyncha*, and *Athyris glabristria*.

EXPOSURES EAST OF RAVENSTONEDALE VILLAGE.—Leaving Ravenstonedale village by the Sedberg Road, we pass Piper Hole quarries, excavated in the "proava" beds, where slabs covered with the silicified shells of *Camarotachia proava* may be obtained. About a mile farther on we join the Sedberg-Kirkby Stephen road. Two good sections are exposed here. One in the right bank of Scandal Beck opposite Brunt Hill farm and the other in the bed of Tarn Sike. The former shows the base of the *Thysanophyllum* band and the upper portion of the underlying shales of the *P. globosus* band, some of the layers of which are rich in ostracoda and the remains of a small species of *Schellwienella*. The exposure in Tarn Sike shows a section of the beds from the Brownber pebble-bed to the lower *Productus* beds. It is interesting as affording one of the few exposures of the *Michelinia* zone in the district. Many of the characteristic

* See Marr, J. E., *Proc. Geol. Assoc.*, vol. xx, 1907, p. 146.

fossils of the Arnside section have been obtained here, including *Caninia cylindrica*, *Chonetes carinata*, *Zaphrentis konincki*, and *Clisiophyllum multiseptatum*. The lower portion of the *Productus*-zone, which here emerges from beneath the Ashfell sandstone, contains the large *Diphyphyllum* aff. *lateseptatum* of Blackstone Point and includes layers crowded with a small form of *P. corrugato-hemisphericus* and clusters of *Syringopora*.

The beds are here turning over towards the Dent Fault which occupies the low ground a little to the eastward. This fault cuts out the lower beds of the Carboniferous succession on its south-eastern side. Continuing along the Kirkby Stephen road we meet with good exposures of the middle *Productus*-beds on the brow of the escarpment. Here abundant silicified specimens of young examples of *Cyrtina carbonaria* may be collected.

Returning to Ravenstonedale by the upper road we pass Blea Flatt Spinny which marks a fine exposure of the *Thysanophyllum* band with *Caninia subibicina*, above which good exposures of the *Michelinia* zone may be visited between Keld Sike and Ashfell farm. Before reaching Ravenstonedale we pass a small quarry in the red beds of the *Seminula gregaria* sub-zone, which has yielded an interesting new bryozoan, *Stenophragma lobatum*, Munro, together with *Rhynchonella favcettensis* and *Seminula* aff. *ficoidea*.

Ascending the main road from Ravenstonedale to Kirkby Stephen, we reach a good exposure of the calcareous layers in the Ashfell sandstone, containing *Spiriferina laminosa*, *Seminula ambigua*, *Lophophyllum ashfellenae*, *Zaphrentis enniskilleni*, and fragments of *Griffithides*. The overlying limestone is rich in *Cyrtina carbonaria* and *Syringopora geniculata*, together with gastropods and the teeth of *Psephodus* and *Streblodus*.

Descending the dip-slope to Kirkby Stephen, we pass over the *Nematophyllum minus* beds (exposed in shallow workings on the left hand of the road), and reach the "Bryozoa" band at Blue Quarries. This is taken throughout the districts as marking the transition to the overlying lower *Dibunophyllum* sub-zone. From here to the Midland Railway station the dip nearly corresponds to the slope of the surface, so that the *Davisiella llangolensis* band, exposed between the two railway stations, cannot lie far above the base of D_1 , a position corresponding with that at which it occurs in the type locality in Wales.

The highest Carboniferous rocks in this district which must lie somewhere near the top of D_1 ,* or the base of D_2 , crop out to the west of the N.E. Railway, where they contain reefs of *Lithostrotion junceum*. They are unconformably overlain by the Permian Brockrams, so well exposed in the famous pot-holes in the river Eden close by.

* The D_1 beds are here abnormally shaly and the typical white limestones of other districts are here absent. The fauna is also abnormal and scanty.

Map of the Northern portion of
SHAP DISTRICT

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E. J. GARWOOD.

From Kirkby Stephen a visit may be paid to Great Asby, to the east of which good exposures of the *Lonsdalia* beds, with *Dibunophyllum muirheadi* occur in Beacham's Quarry and Coalpit Sike.

RAVENSTONEDALE TO SHAP.

Between Ravenstonedale and Shap the road to Orton lies at first along the horizon of the Algal layer at the base of the *Seminula gregaria* sub-zone. Leaving the main road just before reaching Ravenstonedale station and ascending the track to the right, a good exposure of the Brownber pebble-bed may be visited on Ravenstonedale Moor (the walls near the station are built of this bed). It here contains casts of Bellerophons and large specimens of *Murchisonia angulata* in addition to the usual fragments of *Syringothyris* and *C. isorhyncha*. Below Raisbeck, where the road bridge crosses the stream, good exposures of the *Thysanophyllum* reef occur with *Caninia subbicina* and this band may be followed almost continuously to Shap.

Good exposures of the Algal layer are seen near Warth and in the right bank of Raisbeck, a little above Fawcett Mill. Here, undulating sheets of "*Spongiostroma*" are overlain by nodular *Ortonella* beds which in turn are succeeded by the *Productus globosus* band. This is the type locality for *Productus rotundus* and *Rhynchonella fawcettensis*.

About a mile to the east of Orton we pass the foot of Orton Knott which shows a good exposure of the *Productus* beds, and especially of the Bryozoa band at the top. The band, which forms a prominent yellow scar on the horizon, is here much more calcareous than it is in the Blue quarries near Kirkby Stephen and contains additional species of mollusca. From Orton a digression may be made along the Appleby road, over Orton Scar to Gathorn Plain and Bank Moor, where good exposures of the *Chonetes comoides* band and the lower beds of *D*₂ with *Lonsdalia* occur. The third limestone from the base of the Yoredale beds here includes a shale bed crowded with the remains of *Productus* (cf.) *giganteus*, a form which, in the state of casts, is strongly reminiscent of *P. "humerosus."** (Pl. 17, Fig. 3.) On the way up Orton Scar a good exposure of the *N. minus* beds may be seen in a small quarry on the north side of the road, which has also yielded specimens of *Pemmatites constipatus*. A quarry at the summit of the Scar affords a good section of the lower portion of *D*₁, and is especially rich in large examples of *Alveolites septosus*, a form which occurs abundantly at this horizon throughout the Shap district. From Orton to Shap toll-bar the road runs along the *Thysanophyllum* band which is exposed at intervals in shallow workings on either side of the

* This form is probably that figured by Davidson, Carb. Brach., Pl. xl, Fig. 1, and Pl. xxxvii, Fig. 1.

road; it then descends on to the Algal layer at the toll-bar,* an horizon which it keeps as far as Force Bridge over Docker Beck, at the south end of Shap Village.

SHAP DISTRICT.

See the Map, Pl. 3.

The lowest beds of the succession are well seen in the cliff on the right bank of the River Lowther opposite Shap Abbey. (Pl. 4.A.) The basement conglomerate is exposed close to the bridge where it rests upon the upturned edges of the Borrowdale ashes. The horizon of the overlying dolomites is identical with that of the lower *Solenopora* beds of Stone Gill in the Ravenstonedale district. Two well-marked layers of *Solenopora* nodules occur, one near the base, a short distance above the conglomerate, and the other near the top of the cliff at the base of the *C. proava* band. A bed crowded with *Athyris glabristria* also occurs at the top of the cliff and a layer of black shale, near the base, contains the remains of the same organisms with the fringes preserved, associated with bryozoa. The (*proava*) beds are much thinner here than in Stone Gill and are not now well exposed; they were formerly quarried in the fields above the cliff but specimens can still be obtained *in situ*. The *P. globosus* band, with the Algal layer at the base, is seen cropping out near the top of the field behind the cliff. An irregular spotted appearance is given to the bed by the presence of aggregates of *Spongiostroma* associated with somewhat fragmentary specimens of *Ortonella*. The *Thysanophyllum* band which here contains a small early mutation of *Chonetes papillionacea*, is exposed in a small quarry by the side of the Shap-Bampton road at the top of the lane leading down to Rosgill hamlet. The outcrop of this band crosses Shap village about midway between the station and the church where it is exposed in a small escarpment behind some modern houses on the east side of the road. The specimens of *Thysanophyllum* are small and are here associated with conspicuous "fucoid," impressions, common also at about this horizon in the Meathop outlier near Grange.

DOCKER BECK SECTION.

In Docker Beck, a quarter of a mile south of the Greyhound Inn, a good section is exposed from the base of the *Seminula gregaria*-sub-zone to the *Nematophyllum minus* beds.

The "Algal layer" is well seen at Force Bridge between the road and the railway and formerly there existed a good

* The locality where *Archæosigillaria vanuxemi* was first found, and the type locality for *Murchisonia marri*.

Photo by P. de G. Benson.

A.—SHAP ABBEY CLIFF, SOLENOPORA SUB-ZONE.

- The figure points to the Lower Solenopora Band. The Proava Band lies at the top of the cliff.

Photo by E. J. Garwood.

B.—BROWNER PEBBLE BED, SHAP CUTTING.

exposure of the *Productus* band above the limekiln, with *P. rotundus*, abundant specimens of *Seminula gregaria* and *Rhynchonella fawcettensis*, but this has now been filled in. The beds, up to the lower waterfall, are mostly barren dolomites but a few "fucoid" impressions occur. The *Thysanophyllum* band forms the cliff below the fall; the rock is white and slightly oolitic. Specimens of *Bellerophon* are numerous. The overlying Brownber pebble-bed is here hidden by alluvium. Just above the upper waterfall we find an outcrop of the *Spirifer furcatus* band so well developed in the Meathop district; it contains *Bellerophon costatus* and abundant young forms of *Seminula* cf. *ambigua*. Pl. 13, Fig. 8. Farther up, above the ford and about 12 ft. above the last band, we reach the base of the *Michelinia*-zone, and with it the incoming of sandstone conditions (the Orton Sandstone).* A richly fossiliferous layer occurs at the base, containing *Michelinia grandis*, *Camarophoria isorhyncha* and *Cyathophyllum multilamellatum* also the latest examples of *Athyris glabristria* and *Syringothyris cuspidata* together with early hemispherical producti. Above this the sandy episode becomes established and exposures of grit and sandstone, containing obscure plant remains and casts of lamellibranchs, can be seen below Waters' Farm. Immediately above the farm we find an outcrop of compact calcareous mud-stone with *Productus* cf. *punctatus*, *P. pyxidiformis* and *Zaphrentis enniskilleni*, together with the earliest specimens of *Lithostrotion*. This bed evidently lies near the base of the *Productus* zone (S_1). No fossiliferous beds are seen above these in the stream which runs chiefly on drift with numerous Shap granite boulders, but an exposure of the *N. minus* beds is seen near a dried-up pond close to the Nab Farm, the farm itself being built on the Bryozoa bed. The best exposures of this portion of the succession are found farther south under Long Scar Pike where the *Cyrtina carbonaria* beds emerge above the sandstones. Good exposures of the Bryozoa bed also occur here and again as an inlier at the head of Lyvennet Beck. In the latter exposure porcellaneous layers with *Calcisphæra* are associated with plant remains.

At the base of Hardendale Nab we reach the lower *Dibunophyllum*-zone with *Cyathophyllum murchisoni*, *Dibunophyllum* ϕ , *Carcinophyllum* θ and abundant *Lithostrotions*. At the foot of the dip-slope, near Grandy, the *Cyrtina septosa* band succeeds and is soon followed by the basal sandstone of the upper *Dibunophyllum*-zone. The Yoredale beds, comprising this zone, form a succession of limestones, sandstones and shales. The three lower limestones contain *Lonsdalia floriformis*, *Cyathophyllum regium* and reefs of *Lithostrotion junceum*, while the fourth limestone from the bottom is characterised by *Saccamina carteri* and *Productus edelburgensis* and also contains well

* The sandstone episode enters here earlier than on Ashfell Edge.

preserved specimens of *Aulophyllum*. The former beds are exposed near the Druid circle on Wickerslack Moor and in Wintertarn quarry farther to the north, and the latter are well seen at High Sides quarry on the road to Sleagill where the shallow face of the quarry is covered with weathered-out specimens of this characteristic foraminifer. The *Girvanella* nodular band is seen at Wintertarn Quarry but is not so conspicuous as it is further north at Tirill, where the nodules are stained bright red by hæmatite. The higher limestones of the series are almost unfossiliferous and are frequently dolomitized, especially when they are overlain by the Permian "Brockram," as near Burrells.

A notable feature of the Lonsdalia beds to the east of Shap is the rarity of *Dibunophyllum*; when, however, we pass to the south of Great Asby, abundant specimens of *D. muirheadi* may be collected from Beacham's quarry and Coalpit Sike. Returning from Wintertarn farm to Shap we cross an exposure of the *Chonetes comoides* band at the corner where the lane from Wintertarn joins the Crosby Ravensworth-Shap road, while a little farther down at a quarry marked by a "thunder stone" occur large examples of *P. cf. maximus*. Descending from here to Trainrig farm we pass over the scars formed by the lower *Dibunophyllum* zone, the "spotted" beds near the base, being well exposed in a quarry on the north side of the road just above "the Edges," beyond which the road plunges down over the Bryozoa bed on to the Orton Sandstone. At the foot of the hill where we cross the railway the Brownber pebble-bed is well exposed in the cutting behind St. Michael's Church, where its characteristic lenticular current bedding is well displayed. Pl. 4.B. It here contains fragments of *Syringothyris* and *C. isorhyncha* and specimens of the rock may be examined in the neighbouring walls. To the north of Shap a series of small quarries have been opened in the lower *Dibunophyllum* zone, which afford good collecting ground between "the Edges" and Knipe Scar and one of the best exposures of the Bryozoa bed occurs at the Limekiln at Sweet Holme where it is very fossiliferous and recalls the calcareous development of this band on Orton Knott.

The succession in the Shap district therefore resembles closely that of the Ravenstonedale area but the sandstone episode enters earlier (*i.e.*, at the base of the *Michelinia* zone) and continues later, so that with the exception of the fossiliferous band at Waters' Farm at the base of the *Productus* zone, the beds between the base of the *Michelinia* zone and the *Nematophyllum minus* sub-zone are represented by unfossiliferous sandstones. The beds of the lower *Dibunophyllum* zone are clear-water limestones resembling the development at this horizon in the lower Scar Limestone of Melmerby and Horton-in-Ribblesdale, which contains the typical fauna of D_1 of

Map of

DIBULPHUS ZONE		Upper
DIBULPHUS ZONE	i	Girvanella band
	h	Cyrtina septosa band
PRODUCTUS COMPACTUS ZONE	g	Lower
	f	Nematophyllum - minus SUB-ZONE
MICHELINIA ZONE	e	Cyrtina - carbonaria . SUB ZONE
	d	Gastropod Beds
ATHELINIA ZONE	c	Ch. carinata SUB-ZONE
	b	or Michelinia Zone undivided
ATHELINIA ZONE	a	C. isorhyncha SUB-ZONE
		Seminula-gregaria SUB-ZONE
ATHELINIA ZONE		Thysanophyllum band
		P. globosus band & Algal layer at base
ATHELINIA ZONE		Solenopora SUB-ZONE

the S.W. Province, whereas near Kirkby Stephen, as we have seen, they show a much more shaly development.

THE KENDAL DISTRICT.

See the Map, Pl. 5.

The development of the Lower Carboniferous beds in this district shows features intermediate between those of the Shap and Arnside districts. The lowest beds met with are apparently near the base of the *Seminula gregaria* sub-zone. The *Thysanophyllum* band is again well exposed, and may be best seen in the old quarries behind Hall Head Farm, at the extreme north end of the district, where it is associated with china-stone layers containing *Calcspherae*. Interesting evidence is there afforded of horizontal movements along the bedding planes of the Lower Carboniferous rocks, one bed of limestone being puckered into numerous folds, while the beds above and below remain nearly horizontal. (Pl. 7.A.) The overlying Brownber pebble-bed is reduced to a hard silicious oolite in which however the characteristic fossils of the band still occur. It may be examined at the base of Cunswick Scar.

Returning to Kendal by the fields we pass at Kettlewell a block of the upper *Michelinia* beds brought up by a branch of the Kendal fault; these have yielded the typical Arnside fauna. A little farther on we reach an old quarry excavated in the *Cyrtina carbonaria* sub-zone where good specimens of the index fossil may be obtained. These beds pass up into the overlying *N. minus* beds which occupy so much of the surface of the dip-slope above, between Cunswick Scar and Kendal. The only exposure of the lower *Dibunophyllum* zone preserved here is a small outcrop seen in Serpentine Walks.

A complete traverse of the Carboniferous rocks may be made from here over the Kendal Fells by the road either to Brigsteer or to Underbarrow. The dip-slope forming the Fells is composed chiefly of beds belonging to the *N. minus* sub-zone but some of the quarries are excavated in the underlying "Gastropod" beds (*S.*). A fine panorama showing the general structure of the country and the relation of the Carboniferous rocks to the underlying Silurian beds may be seen from the summit of Scout Scar. (Pl. 6.) This is the type locality for *N. minus*, McCoy. Descending to Brigsteer, good sections of the upper *Michelinia* beds and the overlying Gastropod beds are seen in the road cutting. The former have yielded all the typical Arnside species. At a bend in the road, about half-way down the hill, a gate gives access to the summit of Crag Mollet Scar which forms the projecting lower portion of the main escarpment. The cart track from the gate runs along the base of the *Michelinia* zone and silicified specimens of *M. grandis* and

Cyathophyllum cf. *multilamellatum* may be collected here. Near the base of the Scar occurs an outcrop of the *Thysanophyllum* band with large examples of *Syringopora* and layers of *Seminula gregaria*. A similar section is seen on descending the escarpment by the Underbarrow road.

The Kendal Museum contains an interesting collection of local Carboniferous fossils and is specially rich in species of gastropods and lamellibranchs from the *Productus* beds which have been extensively worked on Kendal Fell. It is well worth a visit.

From Brigsteer to Grange the road is first carried along the base of the *Michelinia* zone and then passes down on to the Meathop dolomite, finally reaching the Silurian rocks near Levens bridge. From Levens an exposure of the upper *Michelinia* zone may be visited in the River Kent, the beds being brought up here by an anticlinal fold visible in the bed of the stream. A detour may also be made by Stainton to Summerlands, a short distance to the west of which an exposure of the Algal band and the top of the underlying *Solenopora* sub-zone are seen in the wood. This patch of limestone belongs therefore to the upthrow side of the Kendal fault, and represents the same basement beds as those which are exposed as outliers on the Silurian rocks at Grayrigg and Stickley farther to the north.*

Returning to Levens and continuing again along the road to Grange we cross, near Gilpin bridge, one of the N.—S. faults which cut up the Lower Carboniferous rocks on the north side of Morecambe Bay into a series of isolated hills or "barrows" separated by valleys floored with Silurian slates. To the north rises Whitbarrow, the first and perhaps the most striking of these limestone blocks. The beds at the summit are composed of the thick limestone of the lower *Dibunophyllum* sub-zone, while the lowest beds, formed of the *Thysanophyllum* band, which rest on the Silurian close to Witherslack Hall, are exposed at Broad Oak at the N.W. end of the block. The fine white screes at the south end, behind Whitbarrow Lodge, cover the *Nematophyllum minus* beds. Just after passing the "Derby Arms" Inn we cross the next fault which brings in the Yewbarrow block, the junction with the underlying Silurian being well seen at Cat Crag. About a mile to the southward we see the outlying mass of Meathop Fell, which also belongs to this block, but which is separated by the denuded area covered by Meathop Moss. A short distance farther on we cross the next fault, near Castle Head, which runs through Lindale village and along the east side

* In the Geological Survey Map the Kendal Fault is here carried too far to the east, so as to include this patch of limestone on the supposition that it belongs to the main mass of limestone on the west side of the fault. See Map, Pl. liv, *Quart. Journ. Geol. Soc.* Vol. lxxviii.

SCOUT SCAR.

Photo by Messrs. Frith & Co.

To face page 14.

Photo by E. J. Garwood.

A.—FOLD IN THYSANOPHYLLUM BAND, HALL HEAD HALL, KENDAL.

Photo by E. J. Garwood.

B.—MEATHOP QUARRIES, SEMINOLA GREGARIA SUB-ZONE.

of Holme Island, thus bringing the highest beds of D, of the island against the *Solenopora* sub-zone of the Meathop outlier. This fault brings in the Hainpsfell block, on the south end of which Grange village is built.

THE ARNSIDE DISTRICT.

The lowest beds of the Arnside sequence crop out on the north side of the Kent estuary under Meathop Fell, where we meet with a complete succession of the beds from the top of the *Solenopora*-sub-zone to the base of the lower *Michelinia* sub-zone inclusive. The junction of the Lower Carboniferous Beds with the Silurian is seen just above Low Meathop farm where the basal layers of the Carboniferous succession contain specimens of *Solenopora*, *Camarotæchia proava* and a large form of *Rhynchotreta angulata* together with a few small gastropods. A good section of the overlying dolomites of the *Seminula gregaria*-sub-zone is seen in the old quarry cliff to the East of the gas works. (Pl. 7.B.) The Algal layer crops out in the road at the foot of the cliff and contains nodules of *Ortonella*, *Spongiostroma* and *Aphralysia*, fine weathered examples of which can be seen in the walls surrounding the gas works. The beds forming the lower half of the cliff are almost unfossiliferous except for "fucoid" markings and the remains of *Archæosigillaria vanuxemi*. The *Spirifer furcatus* band lies at the top of the cliff and constitutes the richest development of this band met with in the north-west province. The beds of dolomite immediately beneath it have yielded an interesting coral fauna, mostly new forms: namely, *Carruthersella compacta*, *Lophophyllum meathopense*, *L. vesciculosum* and *Camphophyllum ciliatum* together with the earliest examples of *Zaphrentis konincki*. Layers rich in *Seminula gregaria*, *S. aff. ficoidea*, and three species of *Syringopora* occur in the upper half of the cliff, together with the silicified shells of a small form of *Cyrtina* cf. *carbonaria* which is also common at this horizon in the Yewbarrow section. The highest bed, forming the dip-slope on the top of the Fell, contains *C. isorhyncha*, while the walls made from it also enclose large silicified specimens of *Michelinia grandis*. The finest examples of *Lophophyllum meathopense* occur on the south-east side of the Fell, in a black shale which forms the floor of the quarry behind Meathop Marsh farm.

The *Thysanophyllum* band is only represented in this section by a few stray corallites which were found half-way up the north side of the cliff: while the Brownber pebble-bed has died out altogether here, and the only specimens of *Syringothyris cuspidata*, yet found, occur in the *Spirifer furcatus* band above.

Crossing the viaduct, we find the upper *Michelinia* bed (C2

of Bristol), exposed on the shore at Arnside, and between here and Blackstone Point we have the richest development of this sub-zone in the north of England. The faunal list from these beds is a long one and the species are specially characterised by their large size. Among others we may mention *Michelinia grandis* and *M. tenuisepta* which occur in great numbers in the shale bands near the bathing shed and *Chonetes carinata*, whose convex valves are conspicuous in the rocks on the foreshore at several points, but are difficult to extract. *Zaphrentis konincki* and its variant, *Z. kentensis*, often occur in clusters; *Cyathophyllum multilamellatum* and variants often attain a fair size; while large specimens of *Schellwienella crenistria* and several species of *Productus*, allied to *P. punctatus* and *P. fimbriatus*, are not uncommon in the shales. Near Blackstone Point the highest layers of the sub-zone are well exposed, and the shale band above the old lime kiln has yielded numerous examples of *Clisiophyllum multiseptatum* and *Zaphrentis enniskilleni*, with a few dwarfed specimens of *Cyathophyllum multilamellatum*.* The cliff, farther west, contains abundant examples of *Caninia cylindrica* and terminates in that direction with reefs of *Diphyphyllum* cf. *lateseptatum*, *Lithostroton* and *Syringopora distans*. These beds mark a passage into the overlying *Productus* zone.

This zone is well exposed on Arnside Knott. The Gastropod beds are worked in the "Bluestone" quarries at the base of the Knott and contain little in the way of fossils except *Bellerophon*, while the *N. minus* beds, which are here rich in *Chonetes papillionacea*, *S. ambigua* and *P. corrugato-hemiphericus*, form the bulk of the Knott certain layers of which are almost entirely made up of the shells of *Chonetes papillionacea*. These beds are best seen on the west between the Golf Links and Arnside Tower and in Hare Parrock quarries.

The *Cyrtina carbonaria*-sub-zone has not been separated from the *N. minus* beds in mapping the western districts. Further detailed work would however probably show that such a division could be traced though the deeper water conditions which prevailed at this period in the west make for greater uniformity throughout the "*Productus*" zone. A short distance to the south of Arnside Tower we reach the base of the lower *Dibunophyllum* sub-zone. The beds are exposed in Middlebarrow Quarry where a few years ago an admirable example of one of the numerous thrust-planes prevalent in the district was exposed. (Pl. 8.B.) The "spotted" beds at the base of this zone crop out between the railway and Silverdale village, while the overlying *Cyrtina septosa* band and accompanying pseudo-breccia are

* The locality for M'Coy's type specimen of *C. multilamellatum* is doubtful. It is labelled "Arnside" in the Sedgwick Museum, but the red colour is not characteristic of the fossils from Arnside, and it may have come from the Bristol area. The species called "*multilamellatum*" in my paper, *Quart. Journ. Geol. Soc.*, 1912, vol. lxviii, and figured in Pl. L, figs. 6-7, is the Arnside form.

Photo by E. J. Garwood.

A.—TROWBARROW QUARRY, SILVERDALE, SHOWING VERTICAL BEDS OF D1.

Photo by E. J. Garwood.

B.—MIDDLEBARROW QUARRY, SILVERDALE, SHOWING THRUST-PLANE IN D1.

Photo by E. J. Garwood.

A.—SANDSIDE CUTTING, REVERSED BEDS.
M. = Michelinia Beds, dipping off Lower Productus Beds

Photo by E. J. Garwood.

B.—PSEUDO-BRECCIA DI, SHOWING GRIKES HAMPSFELL GRANGE.

well exposed on the coast to the south of the village. The beds of the upper *Dibunophyllum* sub-zone have however been removed by denudation.

ARNSIDE TO SANDSIDE.

The low ground along which the railway runs from Silverdale to Arnside is occupied by an important N.-S. dislocation, probably the continuation of that which has produced the Gilpin estuary to the north, and the beds to the east of it are much disturbed and are locally inverted.

Leaving Arnside by the Sandside road we reach, in about three-quarters of a mile, an admirable section of the *Michelinia* beds on the east side of the road. The beds are here dipping

N.N.E.

S.S.W.

FIG. 3.—SECTION ACROSS THE REVERSED BEDS AT SANDSIDE.—E. J. Garwood.

about 30° E.N.E. and contain the characteristic corals of the Arnside sections. As we continue northwards the dip of the beds gradually increases until by the time we reach the bridge over the railway the beds have become reversed and at the entrance to the railway cutting the beds of the *Michelinia*-zone appear to be dipping off the lower *Productus* beds. (Pl. 9 A.) This reversal is well seen on the coast to the west of the Sandside Inn, where the interior of the pedicle valves of *Chonetes carinata* are exposed on the underside of the bedding-planes, whereas on Arnside shore the exterior surfaces of these valves are displayed on the upper surfaces of the beds. The section in the railway cutting is particularly instructive and exhibits numerous curved thrust-surfaces connected with the overfold. A theoretical section through this disturbance is given above (Fig. 3). At the northern end of the section the beds of the *N. minus* sub-zone are arched into a dome which is well seen in Sandside Quarry. The top of the quarry is formed of the beds belonging to the base of *D1* and includes a good exposure of the "spotted" beds. Evidence of the disturbance which this portion of the district has

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undergone is plainly visible in the thrust-planes which traverse the beds exposed in the quarry.

From Sandside the strike of the beds trends at first due southwards but gradually sweeps round to S.S.W., while the axis of the overfold remains steadily north and south, with the result that it gradually traverses the zones, bringing different portions of the sequence into a vertical position. This belt of vertical beds may be traced from Sandside past the corner of Hazelslack Lane through the neighbourhood of Hawes Water to Silverdale Station. Near this point the vertical beds which here lie near the summit of the lower *Dibunophyllum* sub-zone, are admirably exposed in Trowbarrow Quarry. (Pl. 8.A.) A diversion may be made to the summit of the escarpment about a mile to the east of Hazelslack hamlet where a small outlier of the upper *Dibunophyllum* sub-zone has been quarried in former years. There is no good exposure of these beds now to be seen *in situ*, but specimens of the lowest *Lonsdalia* beds, containing excellent examples of the *Girvanella* nodular band, may be observed in the walls in the neighbourhood. To the south of Trowbarrow the chief exposures of interest are found in the *Productus* beds of Warton Crag and in two small patches of limestone which have been thrust in among the Millstone Grit beds at Swantley and Halton Park. The former exposure is of interest chiefly on account of the abrupt manner in which the beds terminate on the west, apparently as the result of an important disturbance which brings down the Millstone Grit at Ing's Point half a mile to the westward. This dislocation appears to be a continuation of the disturbance which we have just traced and its southerly continuation passes by Carnforth to the limestone inlier at Swantley. A parallel disturbance, passing between Bolton and Nether Kellet, heads directly for the second limestone inlier at Halton Green. These two patches differ from all other limestones so far described in the N.W. Province and appear to be exotic blocks brought by thrusting from the S.E. They resemble, both in petrological and palæontological characters, the Knoll reef limestones and breccias of the Cracoe district. The two parallel N.W.-S.E. faults mentioned above traverse an anticlinal axis and show in an admirable manner the sudden widening of the outcrop on either side of the anticlinal on the denuded upthrow side of the fault.

THE GRANGE AND FURNESS DISTRICTS.

Map Pl. 10, Section Pl. 11.B.

The Carboniferous rocks which occupy the north side of Morecambe Bay are, as already mentioned, broken up by a series of N.-S. faults into a number of detached blocks separated from one another by tracts of Lower Palæozoic rocks.

Map of
GRANGE AND FURNESS DISTRICTS.

B. " " " N. side of Morecambe Bay

E. J. GARWOOD.

This line of blocks ranges from Kendal on the east to the Duddon Estuary on the west giving rise to the following outliers, namely: Scout Scar and Kendal Fell, Whitbarrow, Yewbarrow, Hampsfell, Frith Hall and Holker, Plumpton and the Furness district. This last, though forming an uninterrupted spread of Carboniferous rocks, is itself divided by at least two important N.-S. faults. The faults, which run in a general N.N.W.-S.S.E. direction, have given rise to a series of valleys and estuaries, namely, the Kendal Valley, the Gilpin Valley, the depression between Whitbarrow and Yewbarrow, in which lies Witherslack Hall, the Lindale Valley, the low ground occupied by the road from Cark to Haverthwaite, the Leven estuary and the depression running through Great Urswick Tarn. The Hampsfell block on which Grange is built is bounded on the east by the fault which, running through Lindale village, passes out to sea to the east of Holme Island, while on the west it is separated from the Holker block by the Cark-Haverthwaite dislocation. The sequence includes the beds from the base of the *Michelinia* zone to the Lonsdalia beds of the upper *Dibunophyllum* sub-zone. The former crop out to the north-west near Cartmel, the latter being exposed along the shore on the east side of Humphry Head. The *Productus* beds occupy the western flank of the block, while the lower *Dibunophyllum* sub-zone forms the summit of Hampsfell. As the dip is in a general southerly direction it brings down the upper beds of this sub-zone to the fore-shore at Grange and Holme Island where we find the pseudo-breccia beds including the *Cyrtina septosa* band, exposed near the pier. The most interesting section is seen at Humphry Head where the *C. septosa* band is overlain on the east side of the peninsula by the *Lonsdalia floriformis* beds at the base of D₂. The lowest layer is formed by the nodular *Girvanella* band which is here exposed for a distance of nearly two miles and affords the finest section of this interesting horizon in the North of England. The fauna of the Lonsdalia beds is quite normal, including *Cyathophyllum regium*, *Aulophyllum fungites* and variants, *Dibunophyllum muirheadi* and a small form of *Michelinia tenuisepta*, with reefs of *Lithostrotium irregulare* and *L. McCoyanum*. The west side of the peninsula marks an important fault which brings down the Permian near the coast at Low Marsh where the lower "Brockram" is well exposed on the shore. The included fragments of Carboniferous limestone have been derived from the adjacent beds of the D₁ zone, as shown by the fossils they contain. This fact alone points to the extensive denudation which the Carboniferous rocks had undergone here, as in the Kirkby Stephen district, during Permo-Carboniferous times.

The Holker block bordering the Leven Estuary is of interest on account of the sections in the *Michelinia* zone which it affords at Park Head and Frith Hall where the relation

between the two divisions of the zone may be studied. It also furnishes an admirable example of a fault-scarp to the west of which the road to Haverthwaite is carried.

THE FURNESS district affords good confirmatory sections of the *Michelinia* zone at Plumpton and Gascow on the east and at Elliscales on the west. The latter locality is especially important on account of the fine exposure of the beds of the lower sub-zone, which contains abundant examples of the large form of *M. grandis* characteristic of this horizon.

The *Athyris glabristria* zone is also exposed in the same locality and contains good examples of the index fossil. In the south of the district near Gleaston we find exposures of the upper *Dibunophyllum* sub-zone. These are interesting, as the beds here contain a fauna characteristic of this horizon elsewhere only on the south side of the Craven fault. Their presence here may point, possibly, to a continuation of that dislocation into this area.

DESCRIPTION OF THE PLATES OF FOSSILS.

PLATE 12.

FOSSILS FROM THE *ATHYRIS GLABRISTRIA*-ZONE A.

Solenopora
sub-zone (a)	{	Figs. 1 and 2. <i>Spirifer pinskeyensis</i> . <i>Garwood</i> . Below the Shap Conglomerate.
		Figs. 3 and 4. <i>Athyris glabristria</i> (<i>Phill.</i>). Shap Abbey Cliff. Index fossil of zone A.
		Fig. 5. <i>Spiriferina</i> cf. <i>octoplicata</i> (<i>Sby.</i>). Stone Gill.
		Fig. 6. <i>Vaughania cleistoporoides</i> . <i>Garwood</i> . Index fossil of band (1).
		Fig. 7. <i>Solenopora garwoodi</i> . <i>Hinde</i> . Index fossil of sub-zone (a).
		Fig. 8. <i>Camarotoechia proava</i> (<i>Phill.</i>). Index fossil of band (2).
Seminula
gregaria
sub-zone (b)	{	Fig. 9. <i>Seminula</i> aff. <i>ficoidea</i> . <i>Vaughan</i> . Meathop.
		Fig. 10. <i>Productus globosus</i> . <i>Garwood</i> . Index fossil of band (3).
		Fig. 11. <i>Productus rotundus</i> . <i>Garwood</i> . Band (3).
		Fig. 12. <i>Seminula gregaria</i> (<i>M'Coy</i>). Index fossil of sub-zone (b).
		Figs. 13 and 14. <i>Rhynchonella fawcettensis</i> . <i>Garwood</i> . Band (3).

PLATE 13.

FOSSILS FROM THE *ATHYRIS GLABRISTRIA*-ZONE A AND THE *MICHELINIA*-ZONE B.

Seminula gregaria
sub-zone (b) of zone A	{	Figs. 1 and 2. <i>Thysanophyllum pseudovermiculare</i> (<i>M'Coy</i>). Index fossil of band (4).
		Fig. 3. <i>Caninia sub-ibicina</i> . <i>M'Coy</i> . Band (4).
		Fig. 4. <i>Syringothyris cuspidata</i> (<i>Mart</i>). Brownber Pebble Bed. Index fossil of band (5).
		Figs. 5 and 6. <i>Lophophyllum meathopense</i> . <i>Garwood</i> .
		Fig. 7. <i>Spirifer furcatus</i> . <i>M'Coy</i> . Index fossil of band (6) at summit of A. <i>glabristria</i> -zone.
		Fig. 8. <i>Seminula</i> cf. <i>ambigua</i> (<i>Sby.</i>). Band (6).
Michelinia-
zone B.	{	Figs. 9 and 10. <i>Camarophoria isorhyncha</i> (<i>M'Coy</i>). Index fossil of sub-zone (c).
		Fig. 11. <i>Zaphrentis konincki forma kentensis</i> . <i>Garwood</i> . Sub-zone (d).
		Fig. 12. <i>Zaphrentis enniskilleni</i> . <i>Ed. and H.</i> Young example.
		Figs. 13 and 14. <i>Lonsdalia prænuntia</i> . <i>Smith</i> . Slightly enlarged. Sub-zone (d).

PLATE 14.

FOSSILS FROM THE MICHELINIA-ZONE B SUB-ZONE (d).

- Fig. 1. *Michelinia grandis*. *M'Coy*. $\times \frac{1}{2}$. Index fossil of zone B.
 Fig. 2. *M. grandis*. *M'Coy*. Vert. section showing pores.
 Fig. 3. *M. grandis*. *M'Coy*. $\times \frac{1}{2}$. Showing epitheca.
 Fig. 4. *Chonetes carinata*. *Garwood*. $\times \frac{2}{3}$. Index fossil of sub-zone (d).
 Fig. 5. *Caninia cylindrica* (*Scouler*). Transverse section.
 Fig. 6. *Clisiophyllum multiseptatum*. *Garwood*. Index fossil of band (7) at summit of zone.
 Fig. 7. *Cyathophyllum multilamellatum*. *M'Coy*.

PLATE 15.

FOSSILS FROM THE PRODUCTUS-ZONE C.

- Fig. 1. *Productus corrugato-hemisphericus*. *Vaughan*. From the lowest sub-zone (e).
 Figs. 2 and 3. *Spiriferina laminosa* (*M'Coy*). From the lowest sub-zone (e). Ashfell Sandstone.
 Fig. 4. *Lithostrotion* sp. From the lowest sub-zone (e). Ashfell Sandstone.
 Figs. 5 and 6. *Cyrtina carbonaria* (*M'Coy*). Young forms. Index fossil of sub-zone (f). Ashfell Edge.
 Fig. 7. *C. carbonaria* (*M'Coy*). Pedicle valve showing median septa and dental plates.
 Fig. 8. *Chonetes papillionacea*. *Phill*. Young specimen showing spine bases along hinge. Base of Arnside Knott.
 Fig. 9. *Nematophyllum* (*Lithostrotion*) *minus*. *M'Coy*. Index fossil of sub-zone (g). Transverse section slightly enlarged. Type locality, Scout Scar, Kendal.
 Fig. 10. *N. minus*. *M'Coy*. Scout Scar, Kendal.
 Fig. 11. *Daviesiella llangollensis* (*Dav.*) Index fossil of band (9) from the base of the lower *Dibunophyllum* sub-zone (h). Kirkby Stephen.

PLATE 16.

FOSSILS FROM THE DIBUNOPHYLLUM ZONE D SUB-ZONE (h).

- Fig. 1. *Productus* cf. *maximus*. *M'Coy*. $\times \frac{2}{3}$.
 Fig. 2. *Dibunophyllum* Φ . *Vaughan*. Road cutting. Grange.
 Fig. 3. *Carcinophyllum* Θ . *Vaughan*. Road cutting. Grange.
 Fig. 4. *Chonetes comoides* (*Sby.*). $\times \frac{2}{3}$. Index fossil of band (10) at summit of (h). Shap.
 Fig. 5. *Cyrtina septosa* (*Phill.*). Index fossil of band (10) at summit of (h). Humphrey Head, Grange.

PLATE 17.

FOSSILS FROM THE UPPER DIBUNOPHYLLUM ZONE D2 SUB-ZONE (i) AND YOREDALE (Dy) BEDS (k).

- Fig. 1. *Lonsdalia floriformis*. *Mart*. Transverse section. Index fossil of sub-zone (i). Humphrey Head, Grange.
 Fig. 2. *Dibunophyllum muirheadi*. *Nich. and Thom.* Transverse section. Shap.
 Fig. 3. *Productus* cf. *giganteus*. *Mart.* $\times \frac{2}{3}$. *Lonsdalia* Beds (i), Gathorn Plain, Shap.
 Fig. 4. *Saccamina carteri*. *Brady*. Index fossil of band (12). Fourth limestone. Dy. High Sides, Shap.
 Fig. 5. *Aulophyllum fungites*. *Flem.* *Lonsdalia* Beds (i), Humphrey Head, Grange.
 Fig. 6. *Productus edelburgensis*. *Phill.* $\times \frac{2}{3}$. *Saccamina* Band (12). High Sides, Shap.

PLATE 18.

MICROSCOPIC SECTIONS OF CALCAREOUS ALGÆ OF THE ATHYRIS GLABRISTRIA ZONE AND THE GIRVANELLA NODULAR BAND AT THE BASE OF D2.

- Fig. 1, *Solenopora garwoodi*. *Hinde*. $\times 40$. Transverse section. Index fossil of sub-zone (a). Base of cliff, Shap Abbey.
 Fig. 2, *S. garwoodi*. *Hinde*. $\times$ Longitudinal section. Index fossil of sub-zone (a). Base of cliff, Shap Abbey.
 Fig. 3, *Ortonella furcata*. *Garwood*. $\times 20$. Algal band (3); base of *Seminula gregaria* sub-zone (b). Ravenstonedale.
 Fig. 4, *Spongiostroma* $\times 2.5$. Algal Band, Fawcett Mill, Shap.
 Fig. 5, *Aphralysia carbonaria*. *Garwood*. $\times 30$. Algal Band, Fawcett Mill, Shap.
 Fig. 6, *Girvanella* sp. $\times 100$. Index fossil of band (11). Nodular Bed, base of (i). Humphrey Head, Grange.

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 ————“On the Important Part played by Calcareous Algæ at certain Geological Horizons, with special reference to the Palæozoic Rocks” (with table of distribution). *Geol. Mag.*, dec. v, vol. x (1913), pp. 440, 490, 545.
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Fossils from the *Athyris glabristria* - Zone A.

Fossils from the *Athyris glabristria*-Zone A and the *Michelinia*-Zone B.

Fossils from the Michelinia-zone B.

Fossils from the Productus-Zone C.

Fossils from the Lower *Dibunophyllum* Zone, Sub-zone (h).

Fossils from the Upper Dibunophyllum (D2) sub-zone (i) and Yoredale (Dy) Beds (k).

1

2

3

4

5

6

Microscopic sections of Calcareous Algæ of the *Athyris glabrifolia* Zone and the *Girvanella* nodular band at the base of D 2.

- HINDE, G. J.—“On *Solenopora garwoodi*, sp. nov., from the Lower Carboniferous Rocks in the North-west of England.” *Geol. Mag.*, dec. v, vol. x (1913), p. 289. Plate x.
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- “On the Discovery of *Archæosigillaria vanuxemi* (Göppert) at Meathop Fell, Westmorland, with a Description of the Locality.” *Geol. Mag.*, dec. v, vol. vii (1910), pp. 78-81.
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- “*Archæosigillaria vanuxemi*.” *Trans. Nat. Hist. Soc., Glasg.*, vol. vi (1899), p. 38.
- MUNRO, MADELINE.—“Description of some New Forms of Trepomatous Bryozoa from the Lower Carboniferous Rocks of the North-western Province.” *Quart. Journ. Geol. Soc.*, vol. lxviii (1912), pp. 574-579, figs. 8-12.
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TABLE OF SPECIES OCCURRING IN THE LOWER CARBONIFEROUS ROCKS OF WESTMORLAND AND NORTH LANCASHIRE (EXCLUSIVE OF THE PENNINE DISTRICT).

The collection is deposited in the Geological Museum, University College, London.

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E. J. GARWOOD ON

Zones. P. A. B. C. D. Subzones. (a), (b), (c), (d), (e), (f), (g), (h), (i), (k). Bands. (1), (2), (3), (4), (5), (6), (7), (8), (9), (10), (11), (12). Names in italics are zone, subzone, and band index species figured in the Plates.	P. A. B. C. D. Athyris glabristria. Michelinia megastoma Productus cori-hemisphaericus. Dibunophyllum.										REMARKS.	
	Sp. pinskeyensis.	Solenopora garwoodi.	Seminula gregaria.	Camarophoria isorhyncha.	Chonetes carinata.	Gastropod Beds.	Cyrtina Carbonaria.	N. minus.	D. 1.	D. 2.		D. y.
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)		
	PLANTÆ.	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)		(k)
Aphralysia carbonaria, Garwood ...	...	...	*	...	...	...	...	...	...	...	...	Provisionally placed here.
Girvanella spp. ...	...	...	...	...	...	...	...	...	...	*	...	{ Characteristic band at base of D ₂ ; everywhere in N. of England The index species of the Algal band at base of (3).
Ortonella furcata, Garwood ...	...	...	*	...	...	...	...	...	...	...	...	
Ortonella sp. ...	...	...	*	...	...	...	...	...	...	...	...	
Solenopora garwoodi, Hinde ...	...	...	*	...	...	...	...	...	...	...	...	Very abundant throughout the sub-zone.
Spongiostroma sp. ...	...	...	*	...	...	...	...	...	...	...	...	Ch. of the Algal Band (3).
Archæosigillaria vanuxemi, Göppert ...	...	...	S.A.	...	...	...	...	...	...	...	...	Found at Shap Toll Bar and Meathop.
Pteridorachis sp. ...	... R	S.R.	...	...	...	...	...	...	...	...	...	{ Obscure plant remains often abundant in (a).

* Found in all Districts.
S. limited to Shap District.
R. " Ravenstonedale District.
A. " Arnsdale District.
G. " Grange District.
F. " Furness District.
K.L. " Kirkby Lonsdale District.

RHIZOPODA.														
Archædiscus karreri, Brady	...	...	...	...	...	*	...	...	...	*	*	*	*	*
Endothyra sp.	...	...	...	...	...	*	*	*	*	*	*	*	*	*
<i>Saccamina carteri</i> , Brady	...	...	...	...	...	...	...	...	...	...	...	...	S.	Characteristic of band (12).
Textularia sp.	...	...	...	...	...	...	...	...	...	...	...	...	*	...
PORIFERA.														
Valvulina sp.	...	...	...	...	...	...	...	...	...	...	*	*	*	...
Hyalostelia cf. smithii, Young and Young	...	...	...	...	R.	...	...	...	...	...	...	...	...	...
Pemmatites constipatus, Hinde	...	...	...	...	...	...	...	...	...	...	S.	...	...	Bryozoa Band.
ANTHOZOA.														
Alveolites capillaris (Phill.)	...	...	...	...	...	...	...	...	...	...	*	*	*	Very abundant in (g).
A. etheridgii, Thom.	...	...	...	...	...	...	...	...	...	...	*	*	...	...
Amplexus sp.	...	...	...	...	...	...	...	*	...	...	...	...	...	...
Aulophyllum fungites (Flem.)	...	...	...	...	...	...	A.	...	...	...	S A.	G.F.	...	...
„ mut. cumbriense, Smith	...	...	...	...	...	...	...	...	...	...	...	G.	...	...
„ mut. towards pachyendothecum	...	...	...	...	...	...	...	...	...	...	*	*	F.	...
„ mut. tenbiense, S. Smith	...	...	...	...	...	...	...	...	...	...	...	G.S.	...	...

	P.	A.		B.		C.		D.				
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)	
<i>Aulopora gigas</i> , M'Coy	...	*	...	...	*	...	*	...	...	*	...	
<i>Campophyllum ciliatum</i> , Garw.	...	...	A.	...	...	...	...	...	...	...	...	Rare.
<i>Caninia</i> cf. <i>cornucopia</i> (Mich.)	...	...	...	...	A.	...	...	...	...	...	...	
<i>C. cylindrica</i> (Sculer)	...	...	...	...	*	A.	...	...	...	...	...	A. Limited to base of zone.
<i>C.</i> cf. " "	...	...	...	...	...	...	...	...	...	G.	...	
<i>C. sub-ibicina</i> , M'Coy	...	...	*	...	*	...	...	...	...	...	...	{ The form in the <i>Thysanophyllum</i> band appears to be an early mutation.
<i>C.</i> cf. " "	...	...	...	...	...	...	...	...	...	F.	...	
<i>Carcinophyllum simplex</i> , Garw.	...	...	A.F.	...	...	...	...	...	...	...	...	A. Found chiefly at Meathop.
<i>C. θ</i> , Vaughan	...	...	...	...	...	...	...	...	*	...	...	
<i>C. φ</i> , Vaughan	...	...	...	...	...	...	...	...	...	G.A.	...	
<i>Carruthersella compacta</i> , Garw.	...	...	A.F.	...	...	...	...	...	...	...	...	A. Found only at Meathop. Rare.
<i>C. garwoodi</i> , Salée	...	...	A.	...	...	...	...	...	...	...	...	A. At Meathop in <i>Sp. furcatus</i> band.
<i>Clisiophyllum</i> cf. <i>keyserlingi</i> , M'Coy	...	...	...	...	...	...	...	...	...	G.	...	
<i>C. multiseptatum</i> , Garw....	...	...	...	...	*	...	...	...	...	...	...	Limited to band at summit of this zone.
<i>Cyathophyllum</i> (<i>Diphy.</i>) <i>dianthoides</i> , M'Coy	...	...	...	...	A. G.	F.	...	...	...	...	...	
<i>Cyathophyllum multilamellatum</i> , M'Coy	...	...	*	*	*	...	...	...	...	...	...	{ An early mutation in the (b) and (c) sub-zones. Abundant in (d) sub-zone with variants.

	P.	A.		B.		C.			D.		
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)
<i>L. aff. portlocki</i> (Bronn.)	...	...	...	...	...	...	...	...	...	*	...
<i>Lonsdalia floriformis</i> , Mart.	...	...	...	...	...	...	...	...	...	*	...
<i>L. prænuntia</i> , Smith	...	...	...	...	A.	...	...	...	...	...	From the shales of Arnside shore.
<i>L. sp.</i>	...	...	R.	...	...	...	...	...	...	...	
<i>Lophophyllum ashfellenae</i> , Garw.	...	...	...	...	...	R.	...	...	...	...	
<i>L. fragile</i> , Garw.	...	...	...	...	A.	...	...	...	...	...	
<i>L. meathopense</i> , Garw.	...	...	A.F.	...	...	...	...	...	...	...	
<i>L. vesiculosum</i> , Garw.	...	...	A.	...	...	...	...	...	...	...	
<i>L. sp.</i>	...	...	...	...	R.	...	...	...	...	...	
<i>Michelinia grandis</i> , M'Coy	...	...	...	*	*	...	...	...	...	...	Large form in (c), without epitheca.
<i>M. tenuisepta</i> (Phill.)	...	...	...	...	*	...	...	...	...	...	Large form.
<i>M. cf. tenuisepta</i> (Phill.)	...	...	...	...	...	...	...	...	G.	...	{ A minute form, often forming the nuclei of girvanella nodules.
<i>Syringopora distans</i> , Fischer	...	...	...	...	*	*	...	...	...	...	
<i>S. cf. distans</i> , Fischer	...	...	*	...	...	...	...	...	...	...	{ The members of this genus require revision.
<i>S. geniculata</i> , Phill.	...	...	...	...	*	*	*	*	*	*	
<i>S. reticulata</i> , Goldf.	...	...	...	...	...	*	...	...	...	...	

S. cf. reticulata, Goldf....	...	...	...	...	*	*	...	...	...	...	...	...	...	...	...	} The members of this genus require revision.
Syringopora spp.	...	...	...	...	...	*	...	...	...	...	*	*	...	...	...	
<i>Thysanophyllum pseudovermiculare</i> , M'Coy	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	
<i>Vaughania cleistoporoides</i> , Garw.	...	...	...	...	R.	...	...	...	...	...	...	...	...	...	...	} Not found in Furness and Grange Districts. Limited to band (4). Limited to band (1) in Ravenstonedale.
<i>Zaphrentis</i> aff. <i>constricta</i> , Car. Mss.	...	...	...	...	...	...	...	...	...	...	...	...	G.	...	...	
<i>Z.</i> aff. <i>costatum</i> , M'Coy	...	...	...	...	R.	...	...	...	...	...	...	...	...	...	...	
<i>Z. densa</i> , Car.	...	...	...	...	R.	...	...	...	...	...	...	...	...	...	...	} Several varietal forms also occur in (e) on Ashfell Edge. Abundant in the Arnside, Grange, and Furness Districts. K. from band (5).
<i>Z. enniskilleni</i> , Ed. and H.	..	...	...	...	...	...	...	A.	S.R.	...	...	...	...	...	...	
<i>Z. kentensis</i> , Garw.	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	
<i>Z. konincki</i> , Ed. and H.	...	...	...	...	R.	K.	...	*	...	...	...	...	...	...	...	
<i>Z. omaliusi</i> , Ed. and H.	...	...	...	...	S.R.	...	...	...	...	...	...	...	...	...	...	
VERMES.																} Rare.
<i>Spirorbis</i> cf. <i>caperatus</i> , M'Coy	...	...	...	...	R.	...	...	...	...	...	...	...	...	...	...	
<i>Sp. sp.</i>	...	...	...	...	...	...	...	...	R.	*	...	...	...	...	...	
CRINOIDEA.																
<i>Platycrinus</i> sp.	...	...	...	...	...	...	...	F.	*	...	...	...	...	...	...	Gascow.

<i>Stenopora compacta</i> , Munro ...	...	...	...	...	...	...	...	...	...	*	...	...	...	
<i>Tabulipora</i> sp. ...	...	...	...	...	...	...	...	...	...	*	...	...	...	
BRACHIOPODA.														
<i>Athyris</i> cf. <i>ambigua</i> (Phill.) ...	...	...	...	...	*	...	...	...	...	...	...	...	...	{ Characteristic of the <i>Spirifer furcatus</i> band (6).
<i>A.</i> cf. <i>concentrica</i> , von Buch.	...	...	R	...	...	...	...	...	...	...	...	...	...	
<i>A. expansa</i> (Phill.) ...	...	...	...	...	...	...	*	*	...	*	...	F.	...	
<i>A. expansa-sulcata</i> , Garw.	...	...	...	...	...	...	*	...	...	...	...	...	...	
<i>A. glabristria</i> (Phill.) ...	...	...	...	...	*	*	*	...	...	...	...	...	...	{ A few specimens survive into the base of (c.)
<i>A.</i> cf. <i>lamellosa</i> (L'Ev.) ...	...	...	...	S.R.	...	...	...	...	...	...	...	...	...	
<i>A.</i> cf. <i>planosulcata</i> (Phill.) ...	...	...	...	...	...	...	...	*	*	...	...	F.	...	
<i>Camarophoria isorhyncha</i> (M'Coy)	...	...	...	S.R.	*	...	R.	...	...	...	...	...	...	{ First enters sparingly in Brownber Pebble Bed (5). A few fragmentary specimens in R, ? derived.
<i>C. crumena</i> (Mart.) ...	...	...	...	...	...	...	...	...	...	...	...	F.	...	
<i>Camarotoechia preava</i> (Phill.) ...	...	...	...	*	...	...	...	...	...	...	...	...	...	Characteristic fossil of band (2).
<i>Camarotoechia</i> aff. <i>mitchelleanensis</i> , Vaughan	R.	...	...	...	...	...	...	...	...	...	...	...	...	Occurs in the form of casts.
<i>Chonetes carinata</i> , Garwood M.S.	...	...	...	...	...	...	*	...	...	...	...	...	...	{ Distinguished by large size and by the presence of a median ridge in the convex valve.
<i>C. comoides</i> , Sby. ...	...	...	...	...	...	...	...	...	...	...	*	...	...	Characteristic of summit of band (10).
<i>C. compressa</i> , Sibly ...	...	...	...	...	...	...	...	...	...	...	...	*	...	
<i>C.</i> cf. <i>hardrensis</i> (Phill.) ...	...	...	...	...	...	...	...	...	...	*	...	...	...	Characteristic of the Bryozoa Band (8).

	P.	A.		B.		C.			D.		
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)
<i>C. laguessiana</i> , de Kon.	...	...	...	...	...	...	...	...	...	F.	...
<i>C. papillionacea</i> (Phill.)	...	...	...	...	*	*	*	*	...	...	...
<i>C. aff. papillionacea</i> (Phill.)	...	...	...	S.	...	...	...	...	...	...	...
<i>Cliothyris roysii</i> (L'Ev.)	...	...	...	...	...	...	...	...	...	F.	...
<i>C. cf. roysii</i> (L'Ev.)	...	...	...	...	...	R.	...	...	...	...	...
<i>Crania quadrata</i> (M'Coy)	...	...	S R.	...	...	...	...	...	...	...	...
<i>C. cf. quadrata</i> (M'Coy)	...	...	...	...	...	...	...	*	...	...	...
<i>Cyrtina carbonaria</i> (M'Coy)	...	...	...	...	...	...	*	*	...	...	...
<i>C. cf. carbonaria</i> (M'Coy)	...	...	...	G.A.	...	...	...	...	...	...	...
<i>C. septosa</i> (Phill.)	...	...	...	...	...	...	...	...	*	...	...
<i>Daviesella langollensis</i> (Dav.)	...	...	...	...	...	...	...	...	R.	...	...
<i>D. cf. langollensis</i> (Dav.)	...	...	...	...	...	...	...	...	S.	...	...
<i>Derbya</i> spp.	...	R.	R.S.	S.	...	...	...	...	...	G.	...
<i>Dieclasma hastatum</i> (Sby.)	...	...	...	...	*	...	...	...	...	G.	...
<i>D. sacculum</i> (Mart.)	...	...	...	...	...	*	...	...	...	...	...
<i>D. cf. sacculum</i> (Mart.)	...	...	...	...	...	...	...	...	*	...	...

{ Rare in sub-zones (d) (e). Abundant in
N. minus sub-zone (g).

Early mutation small convex form.

In the Ashfell sandstone.

Bryozoa Band (8).

{ Rare in the Arnside, Grange, and Fur-
ness Districts. Rare in sub-zone (g).
Silicified fragments at Meathop and
Beck Head.

{ Characteristic of band (10) at summit
of (h).

{ Abundant between the railway stations
at Kirkby Stephen.

? Young form. in the *C. comoides* band

Rare.

Rare.

Rare.

PROC. GEOL. ASSOC., VOL. XXVII, PART 1, 1916.]	Leptaena analoga, Phill.	...	...	...	...	...	...	A.	...	...	...	...	F.	...	{ It occurs also in the Breccia beds at Halton Park inlier, Arnside district.
	Lingula squamiformis, Phill.	...	...	...	R.	...	...	...	...	...	...	...	...	...	
	Martinia glabra (Mart.)	...	...	...	...	...	...	...	...	...	...	...	F.	...	
	Martinia ovalis (Phill.)	...	...	...	...	...	...	...	...	...	...	...	K.L.	...	
	M. cf. ovalis (Phill.)	...	...	...	...	...	...	*	...	...	...	...	...	...	{ Early mutation in <i>Ch. carinata</i> sub-zone (d). Large form in <i>N. minus</i> sub-zone (g). It also occurs in Breccia beds of Halton Park inlier, Arnside district. Characteristic of the <i>S. carteri</i> band (12).
	Orbiculoidea nitida, Phill.	...	...	...	...	R.	...	...	...	...	...	...	G.	...	
	O. spp.	...	...	...	...	R.	S.R.	...	...	...	...	...	...	...	
	Productus cf. antiquatus, Sby.	...	...	...	...	...	...	...	...	...	...	...	K.L.	...	
	P. cf. auritus, Phill.	...	...	...	...	...	...	...	...	...	...	...	F.	...	
	P. cf. cora (d'Orb.)	...	...	...	...	...	...	...	...	...	...	*	...	...	
	<i>P. corrugato-hemisphericus</i> , Vaughan	...	...	...	...	...	...	*	*	*	*	...	...	...	
	P. costatus, Sby.	...	...	...	...	...	...	...	...	...	...	...	F.	...	
	P. edelburgensis, Phill.	...	...	...	...	...	...	...	...	...	...	...	*	...	
	P. elegans (M'Coy)	...	...	...	...	...	...	...	R.	*	...	...	...	...	
	P. fimbriatus, Sby.	...	...	...	...	...	...	...	...	...	...	...	F.	...	
	P. cf. fimbriatus, Sby.	...	...	...	...	...	...	...	...	...	*	...	...	...	
	P. giganteus, Mart.	...	...	...	...	...	...	...	...	...	...	...	*	...	{ The true form is rare in Westmorland. Forming a very characteristic band at summit of Lonsdalia bed.
	P. cf. giganteus, Mart.	...	...	...	...	...	...	...	...	...	...	...	S.	...	

	P.	A.		B.		C.			D.			
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)	
<i>P. globosus</i> , Garw.	...	...	S.R.	...	...	...	...	...	...	...	...	Characteristic of band (3).
<i>P. cf. globosus</i> , Garw.	...	...	R.	...	...	...	...	...	...	...	...	An early mutation.
<i>P. aff. grandicostatus</i> , M'Coy	...	...	...	...	...	...	...	...	...	G.	...	
<i>P. hemisphericus</i> , Sby.... ..	...	...	...	...	...	*	...	...	*	...	...	
<i>P. cf. hemisphericus</i> , Sby.	...	...	S.R.	*	...	...	...	...	...	...	...	
<i>P. laciniatus</i> , M'Coy	...	...	...	...	*	*	*	*	*	...	...	
<i>P. latissimus</i> , Sby.	...	...	...	...	...	...	...	...	...	*	*	
<i>P. cf. magaritaceus</i> , Phill.	...	...	...	...	...	...	...	...	...	G.	...	
<i>P. cf. martini</i> , Sby.	...	...	...	...	*	...	...	*	*	...	...	
<i>P. cf. maximus</i> , M'Coy	...	...	...	...	...	...	...	...	*	...	...	Characteristic of sub-zone (h).
<i>P. productus</i> (Mart.)	...	...	...	...	...	R.	...	...	...	...	...	{ Several forms belonging to this group occur at different horizons. The group requires revising.
<i>P. pugilis</i> , Phill.	...	...	...	...	...	...	...	...	...	F.	...	
<i>P. punctatus</i> , Mart.	...	...	...	...	...	...	...	*	...	...	...	
<i>P. cf. punctatus</i> , Mart.... ..	...	...	*	*	...	R.	*	...	...	...	...	Early mutation in (a) and (b).
<i>P. pustulosus</i> , Phill.	...	...	...	...	...	R.	...	...	...	...	...	
<i>P. pyxidiformis</i> , de Kon.	...	...	*	...	*	*	...	...	...	...	...	

<i>P. quincuncialis</i> , Phill....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	G.	...	
<i>P. rotundus</i> , Garw. ...	...	...	...	...	...	R.S.	...	...	...	...	...	...	...	...	...	...	
<i>P. cf. rotundus</i> , Garw. ...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...	Confined to band (4).
<i>P. aff. rotundus</i> , Garw.	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	
<i>P. scabriculus</i> , Mart. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	F.G.	...	
<i>P. semireticulatus</i> , Mart.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	F.G. K L.	...	
<i>P. spinulosus</i> , Sby. ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	F.	...	
<i>P. striatus</i> , Fischer ...	...	...	...	...	...	...	...	...	...	...	S.	S.	...	...	...	...	{ In the <i>Ch. comoides</i> band (10). Also Halton Park inlier.
<i>P. sulcatus</i> , Sby. ...	...	...	...	...	...	...	...	...	...	...	...	...	K.L.	...	...	...	
<i>P. cf. youngianus</i> , Dav.	...	...	...	...	...	...	...	...	...	...	...	...	F.	...	...	...	
<i>P. spp.</i>	...	...	...	...	...	*	*	*	*	...	...	*	*	...	...	...	
<i>Pugnax acuminatus</i> (Mart.)	...	...	...	...	...	...	...	...	...	...	...	...	A.	...	...	...	{ Occurs in Breccia beds at Halton Park, Arnside district.
<i>P. fawcettensis</i> , Garw. ...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	Almost confined to band (3).
<i>P. pleurodon</i> (Phill.) ...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	
<i>P. cf. pleurodon</i> (Phill.)	...	...	...	...	...	...	...	...	S.R.	*	...	...	G.	...	...	...	
<i>P. pugnus</i> (Mart.) ...	...	...	...	...	...	...	...	...	...	...	*	...	S.	...	...	...	Also Halton Park.
<i>P. spp.</i>	...	...	...	...	...	*	*	...	...	*	...	...	...	...	...	...	
<i>Reticularia lineata</i> (Mart.)	...	...	...	...	...	S.	*	...	...	...	A.	F.	...	...	...	...	Rare in (d).

	P.	A.		B.		C.			D.			
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)	
R. cf. lineata (Mart.)	...	...	*	...	...	...	...	...	...	...	...	In <i>Sp. furcatus</i> band.
R. aff. lineata (Mart.)	...	...	...	...	...	R.	...	...	...	...	...	
Rhipidomella michelini (L'Ev.) ...	...	R.	*	...	*	R.	*	...	A.	*	...	Also Halton Park and Swantley inliers.
Rhynchotreta angulata (Linn.) ...	...	A.	A.	...	...	...	...	S.	...	...	...	In (g) in band (8).
Schellwienella crenistria (Phill.) ...	...	*	...	...	...	...	...	...	...	I.	...	
S. cf. crenistria (Phill.)	...	...	...	...	*	...	...	...	...	...	...	
S. cf. senilis (Phill.)	...	...	...	...	...	...	...	...	...	G.	...	
S. spp.	...	...	*	...	...	*	...	...	...	...	...	
Schizophoria resupinata, Mart. ...	...	...	...	...	...	...	...	...	...	K.L.	...	
Seminula ambigua (Sby.)	...	...	...	...	...	R.A.	*	*	...	...	...	Common in (f).
S. cf. ambigua (Sby.)	...	...	*	...	...	...	...	...	...	...	...	<i>Sp. furcatus</i> band (6).
S. ficoidea, Vaughan	...	...	...	...	...	*	*	*	...	...	...	
S. aff. ficoidea, Vaughan	...	...	*	*	...	...	...	...	...	...	...	At summit of (a).
<i>S. gregaria</i> (M'Coy)	...	...	*	...	...	...	...	...	...	...	...	
Spirifer antiquatus, Sby.	...	...	...	...	...	...	...	...	...	G.	...	
S. bisulcatus, Sby.	...	...	...	...	...	...	*	*	*	F.G.	...	

<i>S. cf. bisulcatus</i> , Sby. ...	...	...	...	...	...	...	...	...	R.	...	...	...	...	...	
<i>S. clathratus</i> , M'Coy ...	...	...	...	...	R.	...	...	...	...	...	...	...	...	...	
<i>S. crassus</i> , De Kon. ...	...	...	...	...	...	...	...	...	...	...	...	...	G.	...	
<i>S. duplicicostus</i> , Phill. ...	...	...	...	...	...	...	...	...	...	...	*	...	G.	...	
<i>S. furcatus</i> , M'Coy ...	...	...	...	...	...	*	S.	...	...	...	...	...	...	...	Rare in sub-zone (c).
<i>S. aff. grandicostatus</i> , M'Coy ...	...	...	...	...	...	...	...	...	...	...	...	...	G.	...	
<i>S. integricostus</i> (Phill.) ...	...	...	...	...	...	...	...	R.A	...	...	...	...	...	...	
<i>S. pinguis</i> , Sby....	...	...	...	...	...	...	...	...	...	...	...	...	F.	...	
<i>S. pinskeyensis</i> , Garw. ...	...	...	...	...	R.	...	...	...	...	...	...	...	...	...	
<i>S. striatus</i> , Fischer ...	...	...	...	...	...	...	...	...	...	...	...	?	A.F.	...	{ A. in the Halton Park inlier. F. at Gleaston.
<i>S. cf. striatus</i> , Fischer ...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	
<i>S. triangularis</i> , Mart. ...	...	...	...	...	...	...	...	...	...	...	...	...	FKL	...	Occurs in Breccia beds at Halton Park.
<i>S. spp.</i> ...	...	...	...	...	...	*	*	...	...	*	...	...	...	...	
<i>Spiriferina laminosa</i> (M'Coy)	...	...	...	...	...	...	...	...	R.	R.	*	...	...	...	{ Rare in (f), abundant in Bryozoa Band (8).
<i>S. octoplicata</i> (Sby.) ...	...	...	...	...	...	...	...	...	...	...	...	...	F.	...	
<i>S. cf. octoplicata</i> (Sby.) ...	...	...	...	...	S.R	...	...	...	...	...	...	...	...	...	{ A small form characteristic of this horizon.
<i>S. spp.</i> ...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	
<i>Syringothyris cuspidata</i> (Mart.)	...	...	...	...	...	*	*	A.	...	...	...	...	...	...	{ Ch. of Brownber Pebble bed horizon, just reaches the base of (d).

LAMELLIBRANCHIATA.	P.	A.		B.		C.			D.		
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)
Allorisma sulcatum, Flem. ...	...	...	...	...	...	*	...	...	...	...	...
A. variabilis, M'Coy ...	...	...	...	...	...	S	...	...	...	...	...
A. sp. ...	...	...	...	...	...	...	...	...	*	...	...
Aviculopecten dissimilis, Flem. ...	...	...	...	...	...	R.	...	S.	...	...	...
A. cf. interstitialis, Hind ...	...	...	...	...	...	S.	...	...	...	...	...
A. cf. plano-clathratus, M'Coy ...	...	...	...	R.	...	...	...	...	...	...	...
A. spp. ...	...	R.	...	S.	...	...	...	...	...	...	...
Conocardium alæforme, Sby. ...	...	...	R.	...	...	A.	R.	...	*	...	...
Crenipecten semi-circularis, M'Coy ...	...	...	...	...	...	S.	...	...	...	...	...
Cucullæa tenuistria, M'Coy ...	...	...	...	...	...	K.	...	...	...	...	...
Edmondia sulcata (Phill.) ...	...	...	...	...	...	...	...	...	A.	...	...
Ed. sp. ...	...	...	...	...	...	R.	...	...	...	...	...
Gervillia squamosa, Phill. ...	...	...	...	...	...	...	...	...	...	A.	...
Modiola cf. lata, Port. ...	...	...	...	S.A.	...	...	...	...	...	...	...
Myalina crassa, Flem. ...	...	...	...	...	...	K.	...	...	...	...	...

Breccia beds of Halton Park.

<i>M. verneuilli</i> , M'Coy	...	...	...	...	...	...	...	...	...	K.	..	*	...	...	...	
<i>M. spp.</i>	...	...	...	...	...	R.	A.	...	...	...	..	...	...	...	...	
<i>Nucula gibbosa</i> , Flem.	...	...	...	...	...	...	...	...	...	K.	...	...	...	...	...	
<i>Posidoniella pyriformis</i> , Hind...	...	...	...	...	...	...	...	...	...	...	...	...	A.	...	Breccia beds of Halton Park inlier.	
<i>P. sulcata</i> , Hind	...	...	...	...	...	...	...	...	...	...	...	A.	...	...		
<i>P. sp.</i>	...	...	...	...	...	R.	...	...	...	...	...	...	...	...		
<i>Pterinopecten dumontianus</i> , De Kon...	...	...	...	...	...	...	...	...	...	...	S.	...	...	...	Bryozoa band, Orton Knott.	
<i>P. cf. rigidus</i> , M'Coy	...	...	...	...	...	...	...	...	...	...	...	A.	...	...		
<i>Sanguinolites clavus</i> , M'Coy	...	...	...	...	...	...	...	...	...	K.	...	...	...	...		
<i>S. sub-carinatus</i> , M'Coy	...	...	...	...	...	...	...	...	...	K.	...	...	...	...		
<i>S. spp.</i>	...	...	...	...	...	...	...	...	...	R.	...	...	R. A.	...		
GASTROPODA.																
<i>Baylea simplex</i> , De Kon.	...	...	...	...	...	...	...	A.	...	...	...	...	...	...		
<i>Bellerophon costatus</i> , Sby.	...	...	...	...	...	*	...	A.	*	*	...	...	...	...	Very abundant in (e).	
<i>B. (Bucania) cornuarietis</i> , Sby.	...	...	...	...	...	...	...	K.	...	...	...	...	...	...		
<i>B. scalifer</i> , De K.	...	...	...	...	...	...	...	...	...	...	*	S.	...	...		
<i>B. sulcatus</i> , Sby.	...	...	...	...	...	...	...	...	*	...	...	...	...	...		
<i>B. obsoletus</i> , M'Coy	...	...	...	...	...	...	...	...	...	*	...	...	...	...		

	P.	A.		B.		C.			D.		
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)
B. spp.	...	...	*	...	*	...	...	...	*	...	...
Capulus trilobus (Phill.)	...	...	...	...	...	K.	...	...	...	...	...
C. sp.	...	...	...	...	...	...	...	S.	...	...	...
Euomphalus crotalostomatus, M'Coy	...	...	...	...	...	K.	...	...	...	...	...
E. pentangulatus (Sby.)	...	...	...	*	...	*	...	...	*	...	...
E. sp.	...	S.R.	S.R.	...	...	...	...	...	...	...	...
E. (Phymatifer) pugilis, Phill.	...	...	...	...	...	K.	...	...	...	...	...
Flemingia suturalis (Phill.) ...	...	...	S.	...	...	...	...	...	...	...	...
F. sp.	...	...	...	...	...	*	...	*	...	...	...
Loxonema acutum, de Kon.	...	...	S.	...	...	...	...	...	...	...	...
L. rugiferum, Phill.	...	...	S.	...	...	...	...	A.G.	...	...	...
Murchisonia angulata, Phill. ...	...	...	S.	...	...	...	...	...	...	...	...
M. kendalensis	...	...	...	...	...	K.	...	...	...	...	...
M. marri, Donald	...	...	S.	...	...	...	...	...	...	...	...
M. spp.	...	S.	R.	...	...	*	*	...	...	...	...
Naticopsis ampliata (Phill.) ...	...	...	...	...	...	*	...	...	...	...	...

Casts of a very large form in (a).

{ Brownber Pebble bed, Ravenstonedale Moor.

{ Abundant in the *P. globosus* band, Shap Toll Bar.

<i>N. elliptica</i> (Phill.)	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...
<i>N. elongata</i> (Phill.)	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...
<i>N. (Pileopsis) neritoides</i> (Phill.)	...	...	...	...	...	S.	...	...	...	...	...	...	...	...	...
<i>N. plicistria</i> (Phill.)	...	...	...	...	...	*	...	*	...	...	*	...	...	...	...
<i>N. sp.</i>	...	...	...	...	...	P.	...	...	...	...	...	...	...	...	...
<i>Platyschisma helicoides</i> (Sby.)	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...
<i>P. tiara</i> , Phill.	...	...	...	...	...	...	...	A.	...	...	...	...	...	...	...
<i>Pleurotomaria (Ptychomphalus) vittata</i> , Phill.	...	...	...	...	...	S.	...	...	...	...	...	...	...	...	...
<i>P. sp.</i>	...	...	...	...	...	R.	S.	...	...	...	S.	*	...	...	...
<i>Rhineoderma fragile</i> , de Kon	...	...	...	...	...	...	...	...	...	K.	...	...	...	...	...
<i>Schizostoma catillus</i> (Mart.)	...	...	...	...	...	...	...	A.	*	*	R.	...	...	...	...
<i>Straparollus acutus</i> (Sby.)	...	...	...	...	...	...	...	...	K.	...	...	...	...	...	...
<i>S. sp.</i>	...	...	...	...	...	*	*	...	*	...	*	*	...	...	...

CEPHALOPODA.

<i>Cycloceras lævigatum</i> , M'Coy	...	...	...	...	...	S.	...	...	...	...	...	...	...	...	...
<i>Nautilus biangulatus</i> , Sby.	...	...	...	...	...	S.	...	...	...	...	...	...	...	...	...
<i>Orthoceras sp.</i>	...	...	...	...	...	*	S.R.	...	...	...	...	A.	...	...	...

Trowbarrow shale.

	P.	A.		B.		C.			D.			
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(k)	
Poterioceras cf. cordiformis, Sby. ...	...	...	...	..	...	...	...	...	R.	...	...	Lane Head quarry only.
Vestinautilus sp. ...	...	...	...	...	...	...	...	...	A.	...	...	Trowbarrow shale.
OSTRACODA.												
Kirkbya costata, Jones ...	...	R.	R.	...	...	...	...	...	...	...	...	Abundant in the <i>P. globosus</i> band.
Leperditia okeni, Muenst. ...	...	...	R.S.	...	...	...	...	...	...	...	...	
L. spp. ...	...	*	*	...	...	...	...	...	...	...	...	
TRILOBITA.												
Griffithides globiceps, Phill. ...	...	...	...	...	...	R.	...	...	...	...	...	In the Ashfell Sandstone.
Phillipsia Eichwaldi, Fisch. ...	...	...	...	...	...	...	...	...	...	F.	...	Fragmentary.
P. spp. ...	...	...	...	...	*	*	...	...	*	*	...	
PISCES.												
Cochliodus virgatus, Smith Woodward ...	...	R.	...	...	...	...	...	...	...	...	...	{ A new species from the <i>V. cleistoporooides</i> band. Only known at present from these localities.
Deltodus garwoodi, Smith Woodward ...	...	S.R.	...	...	...	...	...	...	...	...	...	
D. sp.	...	...	R.	...	...	...	...	...	...	...	...	From the Bryozoa band.
Pleuroplax woodi, Davies ...	...	...	...	...	...	...	...	S.	...	...	...	

<i>P. sp. nov., Davies</i>	...	...	R.	...	...	...	...	...	...	...	...	...	...	...
<i>Polyrhizodus magnus, M'Coy</i> ...	...	...	...	...	...	A.	...	...	...	...	...	...	...	...
<i>P. sp.</i>	...	...	...	...	...	S.	...	...	...	...	...	...	...	...
<i>Petalodus sp.</i>	...	...	...	...	...	...	R.	...	...	...	...	...	...	...
<i>Psammodus rugosus, Ag.</i>	...	...	...	...	...	...	R.	...	...	...	...	...	...	...
<i>Psephodus magnus (M'Coy)</i> ...	...	...	R.	...	...	...	R.	R.	R.	...	..	...	...	...
<i>P. sp.</i>	...	...	P.	...	...	...	...	...	...	...	...	...	...	...
<i>Streblodus cf. oblongus, Portl.</i> ...	...	...	...	...	...	...	R.	...	...	...	...	...	...	...

Fairly common in (e).
 { The presence of this genus would appear
 to confirm the Carboniferous age of
 these beds.