30. *The CARBONIFEROUS LIMESTONE of COUNTY CLARE (IRELAND).*
By JAMES ARCHIBALD DOUGLAS, M.A., B.Sc., F.G.S. (Read
June 16th, 1909.)

[PLATES XXVI & XXVII—FOSSILS.]

CONTENTS.

	Page
I. Introduction.....	538
II. Sequence of the Deposits	541
III. Nature and Extent of the Outcrop, and Topographical Features	541
IV. Generalized Description of the Faunal Succession	548
V. Description of certain Fossil Localities	557
VI. Correlation of the Succession in County Clare with that of other Districts in the British Isles	564
VII. Summary of Conclusions	570
VIII. Palæontological Notes	571
IX. Bibliography.....	582

I. INTRODUCTION.

THE work of examining the Carboniferous Limestone of County Clare was undertaken with a view to ascertaining whether the zonal sequence of the fauna, established by Dr. Arthur Vaughan for contemporaneous rocks in the Bristol district, and since proved to hold good for other localities in Great Britain, was also applicable to these beds in the West of Ireland. This district, which forms the western limit of the great limestone-plain of Central Ireland, furnishes one of the most typical examples of a limestone country in the British Isles, and it is strange that it has not attracted more attention from Irish geologists. Although Dr. Wheelton Hind¹ has studied the overlying shales and shown them to be the equivalent of the Pendleside Series, the fauna of the limestone has up to the present remained undescribed.

A brief allusion to the limestone in the extreme south of the county is given in the recent Survey Memoir on the Geology of the Limerick District; but, with the exception of accounts of cave-explorations,² there are, so far as I am aware, no papers bearing on the geology of Eastern Clare of more recent date than the original Memoirs published by the Irish Geological Survey in 1860 and 1863.

¹ 'Notes on the Homotaxial Equivalents of the Beds which immediately succeed the Carboniferous Limestone in the West of Ireland' Proc. Roy. Irish Acad. vol. xxv (1905) Sect. B, pp. 93-116.

² R. F. Scharff, R. J. Ussher, G. A. J. Cole, E. T. Newton, A. F. Dixon, & T. J. Westropp, 'The Exploration of the Caves of County Clare' Trans. Roy. Irish Acad. vol. xxxiii (1906) Sect. B, pp. 1-76.

Mapping, at that time, was executed by sole reference to the lithological characters of the rocks, and little attention seems to have been paid to their fossil contents. The evidence, now adduced by a study of the latter, necessitates very little alteration in the subdivision, the main line of division between the Lower and Upper Limestones of the Survey being found to correspond with the transition from a Tournaisian to a Viséan fauna. It will be shown, however, that the Lower Limestone Shales are not separable, as mapped at present, from the Lower Limestone, and that the Middle Limestone, or 'Calp' of other districts which is not recognized here, may still on palæontological grounds be readily distinguished from the Upper Limestone.

The meagre fauna hitherto recorded from the limestone of County Clare is, I think, due to certain adverse conditions which the nature of the country presents. In the north and centre of the county, the bare surface of the rock is exposed over vast areas; and, although the rainfall is considerable, it is nearly all absorbed directly and carried off by subterranean channels.¹ In consequence, sections afforded by river- or stream-valleys are practically absent; and, as building-material lies ready to hand on the surface of the ground, quarries exposing fresh surfaces of rock are seldom available.

The limestone is traversed by a great series of open joints or 'grikes,' the edges of which become carved and rounded by solution; and fossils, which are not often visible except in the form of hollow casts, are extremely difficult to extract. The sea-cliffs, too, afford no better collecting-ground, for the spray has etched out the limestone between high and low-water marks until it resembles a great bed of scoriaceous lava, the face of which it is impossible to penetrate.

The southern part of the county is covered to a large extent by drift and peat-bogs; the beds, however, become less horizontal and the stratigraphy is easier to make out, sections in quarries and stream-valleys, though somewhat isolated, being comparatively numerous.

From the foregoing remarks it will be readily understood that the description in minute detail of any one complete section, such as that presented by the Avon Gorge of the Bristol area, is a practical impossibility. My aim, therefore, has been to make a more or less complete examination of the whole area, and determine the more important details of the faunal succession; and it is hoped that the results included in this paper will show that a faunal correlation can undoubtedly be made with the Carboniferous Limestone of other remote localities.

¹ The amount of water carried off in this way must be considerable, and solution of the limestone very rapid. During my first visit to Ballyvaghan, it rained unceasingly for two whole days, but after its cessation all trace of moisture had disappeared in a few hours' time. During a rainy season, the sea-water of the bay is rendered brackish for some distance from shore, sufficiently so for cattle to drink it.

Fig. 1.—*Barren surface of limestone, with 'grikes': Ballyvaghan (Clare).*

E. R. L. fotogr.

Fig. 2.—*Results of pluvial and marine action on the limestone: Black Head (Clare).*

E. R. L. fotogr.

The large area of country dealt with, and the impracticability of working, in detail, sections many miles in length, have rendered it impossible to study carefully the evolution of any one group of organisms; but, if connecting links have been found which can be added to the rapidly lengthening chain of our knowledge of the faunal development during Avonian time, one of the objects of this paper will have been partly realized. My primary object, however, being to test the value of the generally accepted Carboniferous zone-fossils, in working the rocks of more distant regions than those already dealt with, I have not deemed it advisable to overburden the somewhat extensive list of fossils which now exists, by a description of any new or rare species which is not of practical use for zonal purposes.

II. SEQUENCE OF THE DEPOSITS.

The accompanying table (p. 542) illustrates the relation between the palæontological zones and the former stratigraphical divisions of the Geological Survey.

The vertical thicknesses, which show a considerable variation throughout the county, are taken from the Survey Memoirs; they can only be considered approximate, owing to the absence of clear measurable sections. The great thickness of the Upper Limestone, of which nearly 1500 feet must be assigned to the *Dibunophyllum*-Zone, finds a parallel in the Midland area of Derbyshire and Staffordshire.

III. NATURE AND EXTENT OF THE OUTCROP, AND TOPOGRAPHICAL FEATURES.

The Carboniferous Limestone floors nearly the whole of Eastern Clare, from the southern shore of Galway Bay to the banks of the Shannon. This area, for the purposes of description, may be conveniently divided into a northern district comprising the baronies of Burren and Inchiquin, and a southern district comprising those of North and South Bunratty and North and South Tulla.

Nearly the whole of the northern district is formed by a vast elevated plateau of Upper Limestone, with a surface of bare rock many square miles in extent, practically devoid of vegetation. The beds, though slightly undulating, have an average dip of about 2° to the south and south-west, in which direction they pass beneath the Coal Measures. On the south and east, however, they end abruptly in steep escarpments with terraced sides; these great limestone-terraces can be traced for mile after mile across the country, and their formation by subaërial agencies is a point of considerable geological interest.

They are, I consider, primarily due to the influence of jointing, and the alternation of coarse and fine bedding and their unequal

Stratigraphical Zones of the Survey.	Approximate thickness in feet.	Palæontological Zones and Subzones.	Provisional Correlation.
<p>BLACK GONIATITE SHALES of the Coal Measure series.</p>	80-150	<p>GONIATITE SHALES.¹</p>	
<p>UPPER LIMESTONE.</p> <p>Light and dark-grey crinoidal limestones, often very argillaceous. Chert occurs in nodules and layers throughout, with a well-defined cherty zone (20-60 feet) at the base. Occasionally oolitic, and exhibiting characters indicative of deposition in shallow water. The thickness of individual beds varies from a few inches to several feet.</p>	1900	<p>DIBUNOPHYLLUM-ZONE.</p> <p>{ D₃ <i>Cyathaxonia</i> subzone. D₂ <i>Lonsdaleia</i> subzone. D₁ <i>Dibunophyllum</i> θ subzone. }</p> <p>SEMINULA-ZONE.</p> <p>{ S₃ <i>Productus cora</i> (mut. S₂) subzone. S₁ <i>Productus</i> aff. <i>semitridentatus</i> subzone. }</p>	<p>VISEAN.</p>
<p>LOWER UNSTRATIFIED LIMESTONE.</p> <p>Massive grey and mottled limestones containing abundant bryozoa. Often very dolomitic; crinoidal at the base. Chert never present.</p>	450-1000	<p>SYRINGOTHYRIS-ZONE.</p> <p>O <i>Syringothyris</i> aff. <i>cuspidata</i> mut. C.</p>	<p>(WAULSORTIAN PHASE.)</p>
<p>LOWER STRATIFIED LIMESTONE.</p> <p>Thick cherty zone at the summit, underlain by thinly-bedded dark-blue or grey fetid argillaceous limestones, in which chert may occur but is never abundant.</p>	600-750	<p>ZAPHRENTIS-ZONE.</p> <p>(horizon γ).</p> <p>{ Z₂ <i>Zaphrentis koninckii</i> subzone. }</p>	
<p>LOWER LIMESTONE SHALES.</p> <p>Interbedded black shales and limestones, the latter often crinoidal.</p> <p>Sandy shales and yellow sandstone at the base.</p>	150	<p>{ Z₁ <i>Spirifer</i> aff. <i>clathratus</i> subzone. Cleistopora Zone (?) (<i>Modiola</i> Phase.) }</p>	<p>TOURNAISIAN.</p>

¹ According to Dr. Wheelton Hind, these beds, which contain *Posidoniella levis*, *Glyphioceras reticulatum*, *Pterinopecten papyraceus*, etc., are homotaxial with some part of the British Pendleside Series; but *Posidonomya becheri* and *Prolecanites compressus*, which characterize the lowest beds of the Pendleside Group, have not yet been recorded from County Clare.

Fig. 3.

resistance to weathering ; not to any essential difference of lithological character, such as the presence of argillaceous beds. If the latter were present to the extent of having this marked effect on the scenery, springs would be far more numerous than they are, and the terraces would be clothed with vegetation. The few springs which do occur are for the most part situated at the foot of the cliffs in fertile valleys, not on the barren terraced slopes.

Fig. 4.—*Terrace in the limestone-escarpment : Burren (Clare).*

J. A. D. fotogr.

[The foreground shows the nature of the surface of a terrace.]

The best idea of this elevated plateau is obtained by driving from Ardrahan, in County Galway, to Ballyvaghan. For 10 miles or so the road traverses a limestone-plain, but near Aughinish Bay and the village of Corranroo, just at the boundary between the counties of Galway and Clare, the great eastern escarpment is first met with, rising suddenly to over 1000 feet (Slieve Carran, 1073 feet) and stretching far to the south in an almost unbroken line. The road is continued westwards along the foot of the northern escarpment; the latter, though somewhat more indented and irregular in outline than the eastern escarpment, is by no means less remarkable. Extending far inland, it forms the steep sides of the Turlough Valley, sweeps round Moneen Mountain and

Ballyconreagh, and again passes inland forming the huge amphitheatre of Ballyvaghan. This is a magnificent dry valley, bounded on three sides by steep terraced cliffs, and opening to the north on Galway Bay.

Fig. 5.—*Foot of the main escarpment, showing scree-formation :
Burren (Clare).*

J. A. D. fotogr.

The insignificant Rathborney River disappears underground at its southern end, and flows to the sea by a subterranean course (see footnote, p. 539). The escarpment then forms the southern shore of the bay as far as the conspicuous promontory of Black Head, which a short distance inland rises to over 1000 feet. Here it turns southwards, and dipping down to sea-level, passes beneath the Coal Measures¹ near Fisherstreet. This western margin is interrupted by the valley of the Caher River between Slieve Elva and Black Head.

¹ These beds have been shown by Dr. Wheelton Hind (*op. cit.*) to be the homotaxial equivalents of the Pendleside Series and the Millstone Grit.

Fig. 6.—*Natural limestone amphitheatre of Ballyvaghan (Clare).*

E. R. L. fotogr.

Fig. 7.—*Eastern edge of the Burren plateau, showing the sudden rise from the central plain: Glencolumbkille (Clare).*

J. A. D. fotogr.

Turning again to the eastern edge of the plateau, the main escarpment can be followed southwards, from Slieve Carran and Eagle's Rock, a magnificent vertical cliff 500 feet high, past the remarkable valleys of Glencolumbkille and Glenquin, to the north-west of Inchiquin Lough, near Corrofin. The successive terraces which build up these escarpments are well shown in the hills east of Glencolumbkille. The beds to the immediate south of this neighbourhood undulate considerably to the north-west and south-east, being well exposed on the outlying hill of Mullagh More.

The major features of this extensive plateau are repeated on a smaller scale over the whole of its surface, and many remarkable examples may be observed of more or less circular depressions and deep valleys surrounded on every side by steep terraced rock-faces. No wilder or more desolate spot can be found in the British Isles, and well does it deserve the name of Burren (burr=great, onn=a stone or rock).

From the eastern escarpment to the border of the county stretches a broad limestone plain covered by numerous lakes. This low ground never rises above 200 feet, and has a mean altitude of 100 feet.

The southern district presents a totally different aspect. The limestone no longer forms a prominent topographical feature, but occupies all the low-lying ground in the centre of the county; while the high ground is formed, on the west by Coal Measures, and on the east by Old Red Sandstone and Silurian rocks. These older formations appear in two large anticlinal flexures with a north-easterly trend, forming the mountains of Slieve Aughty and Slieve Bernagh, between which lies a broad syncline of Carboniferous Limestone. The outer margin of this syncline is formed by Lower Limestone and Shales (Tournaisian), the successive zones of which can be traced continuously round its outcrop, while the Viséan or Upper Limestones occupy the core. All these beds are more or less strongly folded, the dips, though varied by minor flexures, as a rule following the general trend of the syncline.

The structure of the country, which is thus comparatively simple, is, however, greatly obscured by a covering of Drift, chiefly composed of limestone-débris from the underlying rocks. This central limestone area has a mean altitude of 150 feet, but reaches sea-level along the estuary of the Shannon. It rises to 300 feet in the neighbourhood of Tulla, and also to the west of Ennis, where it forms conspicuous rocky crags beneath the abrupt Coal-Measure escarpments. The drainage is effected, to the south by means of the Fergus and Owengarney Rivers and their tributaries, which flow into the Shannon; and to the east by the Graney River and other minor streams flowing into Lough Derg.

Lower Limestone beds are again met with, on the south-eastern slopes of the Slieve Bernagh Mountains, in the district north of Limerick.

IV. GENERALIZED DESCRIPTION OF THE FAUNAL SUCCESSION.

Tournaisian or Lower Carboniferous Limestone.

M = *Modiola* Phase.

Lithological characters.—Thinly-bedded yellow sandstones.

Faunal characters.—These beds contain a rich lamellibranch-fauna, but no brachiopods characteristic of the succeeding zone have been recorded.

Dr. Wheelton Hind has kindly examined the lamellibranchs obtained from these beds; he reports that they have a 'very Silurian look', but may be similar to those occurring at the base of the Carboniferous at Pinskey Gill in Westmorland. They may probably be referred to *Grammysia* and *Modiolopsis*.

It has been suggested by Dr. Vaughan that the presence of this *Modiola* Phase, at the base of the Carboniferous Limestone Series, indicates a conformable transition from the underlying Old Red Sandstone. This point is of considerable interest, for the small thickness and faunal characters of the *Cleistopora* Zone in this district would suggest an unconformity. Throughout the whole of County Clare, however, the exposures in these beds are so poor, that there can be said to be no conclusive evidence.

K = Zone of *Cleistopora* aff. *geometrica* (CLEISTOPORA Zone).

Lithological characters.—Olive-green and yellow sandy shales.

Former designation.—Sandy basement-beds of the Lower Limestone Shales.

Faunal list:—

¹ <i>Orthotetes crenistria</i> (Phill.) mut. K ₁ .	<i>Camarotoechia mitchelleanensis</i> ,
<i>Leptæna</i> cf. <i>analogæ</i> (Phill.).	Vaughan.
<i>Chonetes laguessiana</i> , de Kon.	<i>Eumetria</i> aff. <i>carbonaria</i> (Dav.).
<i>Spiriferina octoplicata</i> (Sow.).	<i>Rhynchonella</i> cf. <i>acutirugata</i> ,
<i>Productus</i> cf. <i>bassus</i> , Vaughan.	de Kon.
<i>Productus</i> sp. [precursor of <i>Pr. pustulosus</i> , Phill.].	<i>Reticularia reticulata</i> , M'Coy.

Special faunal characters:—

The beds included in this zone have a thickness of not more than 20 feet. They contain an assemblage of brachiopods characteristic of the *Cleistopora* Zone, but a further division into subzones was not found practicable.

The zonal index *Cleistopora* aff. *geometrica* has not been recorded, but *Spiriferina octoplicata* and a bassiform *Productus*, the subzonal

¹ To avoid confusion, I have adhered for the most part to the terminology used in Dr. Vaughan's paper on the Bristol area, although certain genera, such as *Orthotetes*, *Chonetes*, *Spiriferina*, etc., are now undergoing revision.

For reference to the work of Mr. R. G. Carruthers on the Tournaisian corals, see under the heading 'Correlation,' § VI, p. 564.

indices of the Bristol area, are of common occurrence throughout. *Leptaena* cf. *analoga*, *Orthotetes crenistria* in a characteristic mutation, and a small *Chonetes* with very fine ribbing (cf. *Chonetes laqueusiana*, de Kon.) are abundant. *Eumetria*, *Camarotoechia*, and *Reticularia* occur sparingly.

Z=Zone of *Zaphrentis omaliusi* (ZAPHRENTIS Zone).

The lithological characters are dealt with in the description of the subzones.

Former designation.—Lower Limestone Shales and Lower Stratified Limestone.

{ Z_2 = subzone of *Zaphrentis konincki*.
 { Z_1 = subzone of *Spirifer* aff. *clathratus*.

Faunal list:—

Corals:

Zaphrentis omaliusi, M.-Ed. & H.
 and var. *densa*, Carruthers.
Zaphrentis konincki, M.-Ed. & H.
Zaphrentis vaughani, sp. nov.
Caninia cornucopiæ, Mich.

Campophyllum cylindricum
 (Sculer) [= *Caninia*].
Syringopora 'θ' of Vaughan.
Michelinia favosa (Goldf.).
Cyathophyllum patula, Mich.

Brachiopods:

Spirifer aff. *clathratus*, M'Coy,
 Vaughan.
Spiriferina cf. *octoplicata* (Sow.).
Athyris lamellosa (L'Éveillé).
Athyris cf. *glabristria* (Phill.).
Rhipidomella michelini (L'Éveillé,
 Dav.).
Schizophoria aff. *resupinata*
 (Mart.).
Syringothyris aff. *cuspidata*
 (Mart.) mut. Z.

Syringothyris laminosa (M'Coy).
Orthotetes crenistria muts. (Phill.).
Chonetes cf. *hardensis*, Phill.
Chonetes cf. *crassistria* (M'Coy).
Reticularia cf. *reticulata*, M'Coy.
Derbya bristolensis, Vaughan.
Productus aff. *pustulosus*, Phill.
Leptaena cf. *analoga* (Phill.).
Productus cf. *burlingtonensis*, Hall.
Productus aff. *semireticulatus*
 (Mart.).

Other groups:

Phillipsia gemmulifera (Phill.).
Phillipsia truncatula (Phill.).
Actinocrinus polydactylus (Miller) and other crinoid-stems.
 Palatal teeth of fishes.
Fenestella sp.

Subdivisions:—

Horizon β.

The only indication of this horizon of faunal overlap is the co-occurrence of *Zaphrentis* and *Spiriferina* cf. *octoplicata* at the base of the Lower Limestone Shales. Exposures are very poor, and the evidence is far from satisfactory.

Athyris lamellosa occurs commonly in these beds; a form which is characteristic of the 'octoplicata subzone' (K_2) in the Mendip area.

Z_1 = Subzone of *Spirifer* aff. *clathratus* (*CLATHRATUS* subzone).

Lithological characters.—Dark-grey and black shales, with occasional bands of crinoidal limestone; chert-bands rare.

Special faunal characters:—

A densiphylloid *Zaphrentis* is extremely abundant at the base, where it is associated with *Productus* cf. *burlingtonensis* and *Syringothyris cuspidata* in a characteristic mutation.

Syringopora θ is rare; no other corals have been recorded.

Spirifer aff. *clathratus* and *Rhipidomella michelini* attain their maxima in this subzone.

Leptaena analoga, *Reticularia* cf. *reticulata*, *Athyris lamellosa*, and *Orthotetes crenistria* mut. are common at certain levels.

Spiriferina cf. *octoplicata* and *Derbya bristolensis* are represented by single specimens.

Z_2 = Subzone of *Zaphrentis konincki*.

Lithological characters.—Compact dark-blue and black, thinly-bedded limestones with shaly partings, which become more persistent towards the base.

The bedding is in places obscured by a strongly developed cleavage.

Chert is abundant throughout this subzone, and a well-defined cherty band about 40 feet thick forms a noticeable and constant feature at the summit.

Special faunal characters:—

Zaphrentis konincki enters at the base, and becomes enormously abundant at the summit, where it is associated with *Caninia cornucopiæ* and *Campophyllum cylindricum*.

Michelinia favosa and *Syringopora* θ range throughout.

Trilobites and fish-teeth occur frequently in the cherty beds.

Syringothyris aff. *cuspidata* and *Chonetes hardrensis* crowd certain shaly beds near the base.

Orthotetes crenistria, in a characteristic mutation, and *Leptaena analoga* are common.

Schizophoria resupinata enters but is never abundant, and *Syringothyris laminosa* is rare.

Spirifer aff. *clathratus* is still common at certain levels.

A characteristic pustulose *Productus* is abundant.

Horizon γ .

Strictly speaking, there is no horizon of faunal overlap between this and the succeeding zone, for the incoming of the latter is marked by a more or less complete change of fauna, indicating a sudden change of bathymetrical conditions. Since, however, in the top beds of the *Zaphrentis* Zone, *Zaphrentis konincki* and *Campophyllum cylindricum* occur together in some abundance, a correlation may be made with horizon γ of the Bristol area.

C=Zone of *Syringothyris cuspidata* mut. C
(*SYRINGOTHYRIS* Zone).

Former designation.—Lower Unstratified or *Fenestella* Limestone.

Lithological characters.—Massive limestones, with a characteristic dark-grey and white mottled coloration, often assuming the aspect of marble.

The rock is, in many exposures, crowded with the remains of bryozoa, the cross-sections of which give it a peculiar spotted appearance. The interiors of molluscan and brachiopod shells are usually filled with pure white crystalline calcite. Bedding is rarely visible, except in a pale-grey crinoidal band near the base.

The limestone is often magnesian, and becomes a true dolomite of a yellowish colour at the summit.

Chert is never found in this zone.

Faunal list:—

Brachiopods:

<i>Syringothyris cuspidata</i> (Mart.).	<i>Dielasma hastatum</i> (J. de C. Sow.).
<i>Spirifer</i> (<i>Brachythyris</i>) <i>pinguis</i> , Sow.	<i>Dielasma kingi</i> , de Kon.
<i>Spirifer</i> (<i>Brachythyris</i>) <i>ovalis</i> , Phill., and var. <i>hemispherica</i> , M'Coy.	<i>Productus</i> aff. <i>semireticulatus</i> (Mart.).
<i>Spirifer</i> aff. <i>clathratus</i> , M'Coy, Vaughan.	<i>Productus</i> cf. <i>concinnus</i> (Sow.).
<i>Spirifer attenuatus</i> , J. de C. Sow.	<i>Productus</i> aff. <i>quincuncialis</i> , Phill., mut. C.
<i>Spirifer subcinctus</i> , de Kon.	<i>Productus cora</i> , D'Orb., mut. C.
<i>Spirifer konincki</i> , sp. nov.	<i>Productus plicatilis</i> , Sow.
<i>Pugnax reniformis</i> (Sow.).	<i>Athyris</i> aff. <i>glabristria</i> (Phill.).
<i>Pugnax pugnus</i> (Mart.).	<i>Athyris hibernica</i> , nom. nov.
<i>Schizophoria resupinata</i> (Mart.)	<i>Leptæna</i> cf. <i>analogæ</i> (Phill.).
	<i>Athyris planosulcata</i> (Phill.).
	<i>Spiriferina</i> cf. <i>insculpta</i> (Phill.).

Corals:

Amplexus coralloides, Sow.

Mollusca:

<i>Vestinautilus carinifer</i> (J. de C. Sow.).	<i>Euomphalus pentangulatus</i> , J. Sow.
<i>Trigonoceras paradoxicum</i> (J. de C. Sow.).	<i>Euomphalus</i> cf. <i>latus</i> , Hall.
<i>Solenocheilus dorsalis</i> (Phill.).	<i>Loxonema lefebvrei</i> (L'Eveillé).
<i>Apheleceras mutabile</i> (M'Coy).	<i>Naticopsis plicistria</i> (Phill.).
<i>Glyphioceras sphericum</i> (Martin).	<i>Naticopsis</i> aff. <i>phillipsi</i> , M'Coy.
<i>Orthoceras leinsterense</i> , Foord.	<i>Cardiomorpha egertoni</i> (M'Coy).
<i>Asymptoceras</i> sp., Ryckholt.	<i>Cardiomorpha oblonga</i> (J. de C. Sow.).
<i>Poterioceras fusiforme</i> (J. de C. Sow.).	<i>Edmondia lyelli</i> , Hind.
	<i>Conocardium hibernicum</i> , Sow.
	<i>Sanguinolites omalianus</i> (de Kon.).
	<i>Aviculopecten plicatus</i> , Sow.

Crinoids:

Actinocrinus tessellatus (Phill.).

Bryozoa :

Fenestella multiporata, M'Coy, and other species.

Ichthyorachis cf. *newenhami*, M'Coy.¹

Special faunal characters :—

The remarkable and sudden change in the lithological character of these beds is accompanied by the incoming of a perfectly distinct fauna, of which not more than half-a-dozen species pass up from the beds below. The numerous and varied corals of the *Zaphrentis* Zone have here disappeared, and are replaced by a luxuriant molluscan fauna. The abundance of large-sized individuals, both among the mollusca and brachiopoda, seems to indicate a change to relatively shallow-water conditions. The nature of the rock points to rapid deposition²; and the absence of corals, with the exception of *Amplexus*, may be possibly thus accounted for; the essentially tabulate character of this genus suggests the power of rapid growth, which alone would enable it to survive these adverse conditions.

In this district the rocks are disturbed by minor flexures, and as they are only visible in isolated exposures, it is impossible in the absence of stratification to determine the exact range of individual species throughout the zone; the faunal assemblage, however, in nearly every exposure was found to be identical.

The zone is characterized by the great abundance of *Amplexus coralloides*, which is the only coral recorded. The zonal index, *Syringothyris cuspidata*, here reaches the acme of its development, attaining an immense size compared with specimens from lower beds. It is never abundant however, and *Syringothyris laminosa* has not been recorded. *Spirifer clathratus* is still represented, but in diminished numbers, whereas *Spirifer attenuatus*, *Spirifer pinguis*, and *Spirifer ovalis* are abundant. *Spirifer subcinctus* is of frequent occurrence.

Pugnax reniformis, *Athyris* aff. *glabristria*, *Dielasma hastatum*, and *Productus semireticulatus* are also common.

Productus aff. *quincuncialis* and *Productus* cf. *concinnus* are widely distributed, but never abundant.

Schizophoria resupinata here exhibits its typical characters, but is rare. The other brachiopods mentioned in the faunal list occur sparingly.

The abundance of mollusca, of which the cephalopod *Vestinautilus carinifer* is the most prolific, forms one of the distinguishing features of the zone.

¹ The above represents a very incomplete list of the prolific fauna obtainable from this zone, but I was unfortunate to be working these beds when the quarries had been cleared and most of the material had been broken up as road-metal. Mr. Walsh, the schoolmaster at Cratloe, near Limerick, has however a large collection, and I have to thank him for several of my specimens.

² The lamellibranchs, as a rule, preserve their two valves intact, so there cannot have been much transportation.

The most abundant forms are *Apheleceras mutabile*, *Conocardium hibernicum*, *Cardiomorpha egertoni*, and *Euomphalus pentangulatus*, but many of the others mentioned are hardly less important.

The abundance of bryozoa has been already noted; these belong chiefly to the genus *Fenestella*.

Viséan or Upper Carboniferous Limestone.

S=Zone of *Seminula ficoides* and its allies (*SEMINULA* Zone).

Former description.—Lower part of Upper Limestone; the 'Calp' Limestone of other districts is not recognized in County Clare.

Lithological characters.—These beds vary considerably in character in different parts of the county. At the base occur dark-grey limestones with an abundance of chert, above which there is often an impure dolomite.

Towards the centre of the zone, black compact crinoidal limestones are succeeded by oolitic beds, which in some localities contain pebbles of a considerable size. Pale-grey limestones of a finely crystalline texture form a characteristic feature near the summit.

Faunal list:—

Corals:

Campophyllum cylindricum (Scouler) mut. S₁ [= *Caninia*].
Zaphrentis omaliusi, M.-Ed. & H.,
 var. *densa*, Carruthers.
Zaphrentis aff. *enniskilleni*,
 M.-Ed. & H.
Campophyllum cf. *caninoides*,
 Sibly.
Carcinophyllum aff. *mendipense*,
 Sibly.

Carcinophyllum sp.
Michelinia grandis, M'Coy.
Cyathophyllum aff. *murchisoni*
 (M.-Ed. & H.).
Lithostrotion martini, M.-Ed. & H.
Nematophyllum minus, M'Coy.
Syringopora reticulata, Goldf.
Syringopora geniculata, Phill.
Syringopora cf. *ramulosa*, Goldf.
 Early Clisiophyllids.

Brachiopods:

Productus cora, d'Orb., mut. S₂.
Productus aff. θ of Vaughan.
Productus punctatus (Mart.).
Productus elegans, M'Coy.
Productus cf. *semireticulatus*
 (Mart.).
Productus pustulosus, var. *ovalis*,
 Phill.

Daviesiella cf. *comoides* (Sow.).
Chonetes papilionacea, Phill.
Orthotetes aff. *crenistris* (Phill.).
Seminula ambigua (Sow.).
Dielasma aff. *hastatum* (Sow.).
Camarophoria isorhyncha, M'Coy.

S₁=Subzone of *Productus* cf. *semireticulatus* mut. S₁
 (*SEMIRETICULATUS* subzone).

Special faunal characters:—

This subzone is characterized by the incoming of a typical Viséan fauna, including the earliest Clisiophyllids and *Lithostrotion*.

Corals:

Carcinophyllum aff. *mendipense* enters at the base, where it is associated with *Campophyllum cylindricum* mut. S₁. The latter here attains its second maximum, and is enormously abundant locally.

Lithostrotion martini occurs commonly throughout, appearing in some localities at the base, in others being absent or extremely rare at this level.

Syringopora geniculata becomes increasingly important, but *S. reticulata* is restricted to the lower part.

Michelinia grandis and *Zaphrentis omalusi* var. *densa* occur locally at the base, but are never common.

Campophyllum cf. *caninoides* is rare.

Brachiopods:

Daviesiella cf. *comoides* is abundant in the lower part.

Productus punctatus and var. *elegans* are not uncommon.

Productus aff. *θ* occurs sparingly.

Camarophoria isorhyncha is locally common.

Productus cf. *semireticulatus* is nowhere abundant.

Orthotetes aff. *crenistris* is of common occurrence near the base.

S₂=Subzone of *Productus* aff. *cora* mut. S₂ (*cora* subzone).

Special faunal characters:—

Corals:

Nematophyllum minus is enormously abundant near the summit, forming a well-marked horizon; it is associated with *Carcinophyllum* sp., which genus attains its maximum at this level.

Syringopora geniculata and *S. ramulosa* are common, especially in the topmost beds.

Lithostrotion martini is abundant throughout.

Cyathophyllum aff. *murchisoni* occurs sparingly, but is never common.

Zaphrentis aff. *enniskilleni* was recorded from the summit of this zone.

Brachiopods:—

Productus aff. *cora* mut. S₂ is very abundant locally.

Dielasma aff. *hastatum* and *Seminula ambigua* are common in the topmost beds. *Chonetes papilionacea* occurs sparingly. All the other brachiopods mentioned in the faunal list are rare.

The oolitic beds mentioned above are, in some localities, crowded with gasteropods, the commonest genera being *Loxonema*, *Euomphalus*, and *Straparollus*.

A characteristic bryozoan in this subzone is *Hemitrypa*.

D=Zone of *Dibunophyllum* aff. *turbinatum* (*DIBUNOPHYLLUM* Zone).

Lithological characters.—It is hardly possible to record any definite lithological characters in this zone, as the rocks attain a thickness of over 1500 feet, and vary considerably throughout the county. In the northern or Burren district, from which most of the fossils were collected, the limestone at the base is usually dark grey and very crinoidal, thinly bedded, and argillaceous; it becomes magnesian locally, and contains an abundance of chert. Higher up, the beds vary in thickness from a few inches to several feet; the limestone is here usually much purer, and is often pale grey and of a finely crystalline texture; chert is rare.

Near the summit occurs locally a compact black limestone, in which chert is found as well-defined bands; above this, and immediately followed by the black shales of the Pendleside Series, the rock is built up almost entirely of crinoidal fragments, and contains small patches and veins of dolomite.

Former designation.—Upper or Burren Limestone.

Subzones { D₃, subzone of *Cyathaxonia rushiana*.
D₂, subzone of *Lonsdalia floriformis*.
D₁, subzone of *Dibunophyllum* θ, φ.

Faunal list:—

Corals:

Alveolites septosa (Flem.).
Syringopora geniculata, Phill.
Lithostrotion martini, Ed. & H.
Lithostrotion irregulare (Phill.).
Lithostrotion junceum (Flem.).
Lithostrotion affine (Flem.).
Lithostrotion portlocki (Bronn).
Diphyphyllum subbicipitum
(M'Coy).
Clisiophyllid *Lithostrotion*.
Lonsdalia duplicata (Mart.).
Dibunophyllum θ of Vaughan.
Dibunophyllum aff. *muirheadi*,
Thoms. & Nich.

Dibunophyllum aff. ψ, Vaughan.
Carcinophyllum sp.
Campophyllum aff. *marginatum*,
Thoms.
Cyathophyllum murchisoni, Ed. & H.
Cyathophyllum regium, Phill.
Cyclophyllum sp.
Zaphrentis enniskilleni, Ed. & H.
Zaphrentis oystermouthensis,
Vaughan MS.
Densiphyllum cf. *rushianum*,
Vaughan.
Densiphyllum sp.
Caninia aff. *cornucopiae*, Mich.

Brachiopods:

Productus giganteus (Mart.) and
allied forms.
Productus hemisphericus, Sow.
Productus striatus (Fischer).
Productus 'corrugato-hemispheri-
cus,' Vaughan.
Productus cf. *corrugatus*, M'Coy.
Productus punctatus (Mart.).
Productus cf. *elegans*, M'Coy.
Productus aff. *scabriculus* (Mart.).
Productus sulcatus, Sow.
Productus aff. *concinuus*, Sow.
Athyris expansa (Phill.).

Athyris planosulcata (Phill.).
Daviesiella aff. *comoides* (Sow.).
(Papilionaceous) *Chonetes* cf.
compressa, Sibly.
Chonetes cf. *hardrensis*, Phill.
Seminula ambigua (Sow.), mut. D₁.
Martinia glabra (Mart.).
Reticularia lineata (Dav.).
Spirifer aff. *increbescens*, Hall.
Cyrtina septosa (Phill.).
Dielasma aff. *virgoides* (M'Coy).
Dielasma cf. *ficus* (M'Coy).

D₁=Subzone of *Dibunophyllum* θ and ϕ (θ , ϕ subzone).

Special faunal characters:—

Corals:

The simple Clisiophyllids, such as *Dibunophyllum* θ and *D. muirheadi*, are abundant throughout this subzone.

Carcinophyllum sp. is common at the base, where it is associated with Clisiophyllid *Lithostrotions*.

Lithostrotion martini is still abundant, but becomes replaced by *L. irregulare*.

Lithostrotion affine occurs commonly near the base, and *L. junceum* makes its appearance towards the summit.

Alveolites septosa is also common at this level.

Syringopora geniculata is rare, except near the base.

Cyathophyllum murchisoni is prolific at certain levels.

Brachiopods:

Productus aff. *giganteus* is abundant, but the typical form of this species has not been recorded. A small form of *Pr. punctatus* is very characteristic of this subzone, but *Pr. hemisphericus* is never common.

Daviesiella aff. *comoides* occurs sparingly.

Seminula ambigua mut. D₁, *Dielasma* aff. *virgoides*, *D.* cf. *ficus*, *Athyris planosulcata*, and *Reticularia lineata* are all of common occurrence, especially near the base.

One of the most characteristic features of this subzone in County Clare is the abundance of large *Euomphali* of the type of *Euomphalus acutus*.

D₂=Subzone of *Lonsdalia floriformis* (*LONSDALIA* subzone).

Special faunal characters:—

Corals:

Lonsdalia duplicata is abundant near the summit, but *L. floriformis* has not been recorded.

Dibunophyllum, near ψ , is the only other common Clisiophyllid; but this is of local occurrence.

Cyathophyllum regium is common.

Lithostrotion junceum and *L. irregulare* are abundant.

Alveolites septosa and *Syringopora* cf. *geniculata* are rare.

Campophyllum sp., *Carcinophyllum* sp., and *Diphyphyllum subbicum* occur locally near the base.

Brachiopods:

Productus giganteus reaches the acme of its development, and *Pr. striatus* and *Pr. 'corrugato-hemisphericus'* are locally abundant.

Cyrtina septosa is common in certain localities, and has not been recorded outside this subzone.

Athyris expansa and *Chonetes* cf. *hardrensis* occur sparingly.

D_3 = Subzone of *Cyathaxonia rushiana* (*CYATHAXONIA* subzone).

Special faunal characters:—

The Clisiophyllids and Lithostrotions are typically absent, and are replaced by Zaphrentids of the type of *Zaphrentis ennis-killeni* and *Z. oystermouthensis*; *Caninia* aff. *cornucopiæ* is everywhere common. No specimen of *Cyathaxonia* has yet been recorded.

Productus aff. *scabriculus* and *Pr. punctatus* are found here.

Martinia glabra, *Athyris æpansa*, and *Spirifer* aff. *increbescens* have been recorded, but the most characteristic brachiopod is *Productus sulcatus*.

V. DESCRIPTION OF CERTAIN FOSSIL LOCALITIES.

(A) Barony of Lower Bunratty.

Lower Limestone Shales (*Modiola* Phase to lower part of Z_2).—These beds occur along the north-western foot of the Slieve Bernagh Mountains, but are everywhere covered by Drift except in the Gourná River section: the latter is a small tributary of the Owengarney, about a mile east of Sixmilebridge. The section commences at Ballyroe Bridge, where beds of unfossiliferous green shales and sandstones, belonging to the Old Red Sandstone Series, are seen. About 100 yards down stream occurs a prominent band of hard blue grit, and immediately above this the basement-beds of the Carboniferous are met with, consisting of a few feet of thinly-bedded yellow sandstones, which contain a rich lamelli-branch fauna (the *Modiola* Phase). They are succeeded by shaly sandstones of the *Cleistopora* Zone; all the fossils mentioned in the faunal list (K) were found at this locality. The stream at this point takes a bend, following the strike of the beds; and as the latter are only exposed in a few feet of overhung bank, their conformability with the underlying Old Red Sandstone is difficult to prove. These sandy beds cannot be directly measured, but their thickness probably does not exceed 20 feet. They are overlain conformably by the black fossiliferous shales of the *clathratus* subzone (Z_1), which are here especially rich in fossils (*Syringothyris* aff. *cuspidata*, *Rhipidomella michelini*, *Productus* cf. *burlingtonensis*, *Zaphrentis* sp.). These beds can be followed for some distance down stream, but soon become obscured by Drift, and are not exposed along the small stream-valley entering on the east.

When they are again met with, forming a small cascade in the main stream, several new species have made their appearance (*Zaphrentis konincki*, *Michelinia favosa*, *Syringopora* θ), and inter-bedded limestone-bands become more persistent. I regard these beds as forming the lowest exposure in the *konincki* subzone (Z_2). They crop out continuously almost as far as Gourná Bridge, the last

beds to be exposed being thin shales crowded with *Syringothyris* aff. *cuspidata* and *Chonetes* cf. *hardrensis*.

Lower Stratified Limestone ($Z_2-\gamma$).—These beds are best seen in the vicinity of Sixmilebridge. West of Oilmill Bridge there is a considerable tract of land free from Drift, in which are exposed dark-grey impure limestones, often highly cleaved.

These beds contain *Zaphrentis konincki*, *Caninia cornucopiæ*, *Michelinia favosa*, and *Camphophyllum cylindricum* in abundance, but brachiopods are not common. (Beautiful examples of weathered coral-calices can be obtained from this locality.) Several small quarries are also to be noted on the south-east of the road opposite the Roman Catholic chapel.

Somewhat similar beds are again seen in the Owengarney River section, north of Sixmilebridge. From Annagore Bridge they have an average dip of 15° to the north by west, as far as Ballymulcashel Bridge, south of Castle Lake. They are here highly fossiliferous, containing *Phillipsia gemmulifera*, *Spirifer* aff. *clathratus*, *Leptæna analoga*, *Syringothyris laminosa*, *Orthotetes crenistria*, *Chonetes* cf. *hardrensis*, *Athyris* cf. *glabristria*, *Caninia cornucopiæ*, and *Zaphrentis konincki*. At the top of the hill west of Ballymulcashel Bridge, they are seen to pass beneath the unbedded limestone of the *Syringothyris* Zone, and the cherty beds dividing the two zones may be traced far to the north-east.

Lower Massive Limestone (*Syringothyris* Zone).—These beds can be traced from Newmarket-on-Fergus north-eastwards beyond Kilmurry. They are more easily examined, however, in the neighbourhood of Cratloe, a small village about 4 miles north-west of Limerick, where they crop out along the south of the Slieve Bernagh anticline. The rock is here extensively quarried for road-metal, and is rich in fossils, of which the following are most abundant:—*Vestinautilus carinifer*, *Solenocheilus dorsalis*, *Syringothyris cuspidata*, *Dielasma hastatum*, *Pugnax reniformis*, *Spirifer attenuatus*, *Sp. pinguis*, and *Sp. konincki*. The dolomite at the top of this zone is well exposed to the north of Cratloe Castle.

Upper Limestone (*Seminula* Zone).—Beds included in this zone crop out in bare tracts of rock over the northern part of the Barony. From Newmarket, or Ballycar Railway-station, which is situated on the cherty basement-beds, they can be followed up the western side of Fin Lough to the crags south of Lough Caherkine; here a black compact limestone, with *Lithostrotion martini*, *Productus punctatus*, and other common forms, is seen to pass into an oolite, which is crowded with gasteropods and contains small pebbles often measuring more than 2 centimetres in diameter.

(B) Barony of Upper Tulla.

Lower Limestone Shales (K—Z₂) and Lower Limestone (Z₂—γ).—These beds, when followed northwards from the Gounra River along the foot of the Slieve Bernagh Mountains, are found to be everywhere covered by Drift: the only exposure being that of the Anamullaghaun River, between Bodyke and Tomgraney. This section, though fully described in the Irish Geological Survey Memoir (Explanation of Sheet 133), is now almost entirely 'overgrown', and the junction with the Old Red Sandstone cannot be accurately determined. The following fossils were obtained from this locality:—*Spirifer* aff. *clathratus*, *Rhipidomella michelini*, *Orthis crenistria*, *Productus* cf. *pustulosus*, and *Zaphrentis omaliusi*, var. *densa*. These basement-beds are again seen south of the Roman Catholic chapel at Tomgraney, and their passage into the Lower Limestone is well shown, the lowest beds of the latter forming a conspicuous rocky knoll in the centre of the village.

Lower Massive or *Fenestella* Limestone (C).—Most of the country to the west of Bodyke is covered by esker-like mounds of Drift; but several isolated exposures are met with along the road to Tulla, which is built on the highest point of the central limestone plain. In the neighbourhood of this village the beds form extensive tracts of bare rock, and are quarried for road-metal. Between Tulla and Miltown Mine, which is situated on the junction between the stratified and the massive limestones, the rocks everywhere abound in fossils, the following being of common occurrence:—*Athyris* aff. *glabristria*, *Dielasma hastatum*, *Productus* aff. *quincuncialis*, *Euomphalus pentangulatus*, *Vestinautilus carinifer*, *Trigonoceras paradoxicum*, and *Fenestella multiporata*.

Upper Limestone, base (S₁).—The junction of the basement cherty beds of this zone with the mottled limestones below is well seen near Dangan Villa, north-west of Lough Cullaunyheda, the beds having an average dip of 5° to the south-east. The intervening dolomite is also exposed, and can be traced almost continuously westwards to Ballyhickey Mine. The lowest beds are dark-grey, compact, crinoidal limestones with very few fossils; *Lithostrotion martini* enters at the base, and is associated with a large *Daviesiella* in the form of hollow casts.

(C) Baronies of Upper Bunratty and Islands.

The southern part of this district is occupied by Upper Limestone, forming the central core of the great east-to-west syncline, which is for the most part obscured by Drift and patches of bog.

Though extensive tracts of bare rock are of local occurrence, fossils are, as a rule, scarce.

South of Jasper's Bridge, 2 miles to the west of Quin, there is a considerable development of oolitic limestone, which seems to occur at a higher level than that previously mentioned at Caherkinne Lough. Half a mile to the north, at Ballyglass House, lower beds are seen containing a great abundance of chert; the limestone is here crowded with the bryozoan *Hemitrypa*.

The following fossils were obtained from the district between Kilbreckan Mine and Ennis; *Lithostrotion martini*, *Cyathophyllum* sp., *Productus elegans*, papilionaceous *Chonetes*, and a small convex *Chonetes* cf. *hardensis*.

The road from Tulla to Ennis for about the first 8 miles is situated on the Lower Massive Limestone, which everywhere abounds in fossils. The following were obtained from Sandhill Bridge:—*Amplexus coralloides*, *Productus semireticulatus*, *Dielsma hastatum*, *Productus* aff. *quincuncialis*, *Vestinautilus carinifer*, and *Fenestella* sp.

Near Castletown Lough the dolomite and the basement cherty beds of the Upper Limestone are met with, and from this point as far as Ennis there is a fairly constant westward dip: a feature due to the extension of the Slieve Aughty anticline. West of Ennis the Upper Limestone forms conspicuous rocky crags, beneath the Coal-Measure escarpment. The rocks consist for the most part of thickly-bedded, black and dark-grey, compact, crystalline limestones, with an abundance of chert at several horizons. A large quarry in the hill north of Inch Bridge affords an interesting exposure near the base of the *Lonsdalia* subzone. The following fossils are abundant at this locality:—*Productus giganteus*, *Pr. 'corrugato-hemisphericus'*, *Pr. striatus*, *Athyris expansa*, *Cyrtina septosa*, *Alveolites septosa*, *Syringopora* cf. *geniculata*, *Lithostrotion junceum*, *L. irregulare*, *Cyathophyllum regium*, and *Lonsdalia duplicata*. (The two last-mentioned forms occur near the summit of the hill, but are apparently absent in the quarry.)

Farther north, near Bushy Park House, still higher beds are met with. These contain *Zaphrentis enniskilleni*, *Z. oystermouthensis*, *Densiphyllum* sp., *Caninia* aff. *cornucopie*, *Productus punctatus*, *Pr. sulcatus*, and *Athyris expansa*, and are taken as representative of the D₃ subzone.

In a field west of the road leading down to Shallee Castle is a dripping well, in which is exposed the junction between the limestone and the overlying shales.

(D) Barony of Inchiquin and the northern half of Upper Bunratty.

In this central area the outcrop of the limestone narrows to its smallest limits, and the complete succession can be traversed from

Crusheen on the east to Corrofin on the west, although the country is covered to a large extent by lakes and superficial Drift-deposits.

The lowest beds, which occur along the north-western foot of the Slieve Aughty Mountains, are for the most part obscured by esker-like mounds of Drift, but the shales of the *clathratus* subzone are visible in one or two localities in the neighbourhood of Doon Lough. The *konincki* subzone is also poorly exposed, but its junction with the *Syringothyris* Zone, which here shows traces of stratification, is visible about 200 yards north of Inchieronan Lough, the intervening cherty beds being strongly developed. The following fossils were found at this locality:—*Syringothyris cuspidata*, *Spirifer konincki*, *Productus semireticulatus*, *Pr. aff. quincuncialis*, and *Amplexus coralloides*.

The district to the south along the Ennis road abounds in fossils, of which *Vestinautilus carinifer*, *Apheloceras mutabile*, *Pugnax reniformis*, *Productus semireticulatus*, and *Amplexus coralloides* are the most abundant.

The small patch of country to the east of the bog near Curraderra Lough, coloured on the Geological Survey map as Upper Limestone, was found to contain *Zaphrentis konincki*, *Z. omaliusi*, *Caninia cornucopiæ*, *Campophyllum cylindricum*, and *Michelinia favosa*, an assemblage of corals characteristic of the top of the *Zaphrentis* Zone; and it is probable that the cherty beds which occur at this level were mistaken for those at the base of the Upper Limestone.

About a mile north-west of Crusheen is exposed an extensive tract of bare limestone, which stretches far to the north and west. The rock is here dark-grey, compact, and crystalline, and is quarried for building purposes. To the west of Garlick Hill the contained fossils indicate a Lower *Seminula* age, the following being abundant at this locality:—*Campophyllum cylindricum* mut. S., *Syringopora reticulata*, *Michelinia grandis*, early *Clisio-phyllids*, and *Daviesiella cf. comoides*. The beds to the westward undulate considerably; and, though south of Moyree Castle *Dibunophyllum* is of common occurrence, the *Seminula* Zone is again met with in the neighbourhood of Lough Nabrickoge: *Productus cora* mut. S., papilionaceous *Chonetes*, *Seminula ambigua*, *Carcinophyllum*, and *Lithostrotion martini* being the most abundant fossils. From this point as far as Corrofin the rocks contain a fauna characteristic of the *Dibunophyllum* Zone, the district between Loughs Cullaun and Inchiquin being especially rich in fossils, such as *Dibunophyllum muirheadi*, *D. θ.*, *Cyathophyllum murchisoni*, *Lithostrotion junceum*, *L. martini*, and *Productus aff. giganteus*. No fossils characteristic of the *Lonsdalia* subzone were recorded from this neighbourhood; but the topmost beds of the limestone were found to contain *Zaphrentis enniskilleni*, *Caninia aff. cornucopiæ*, *Densiphyllum* and *Productus cf. scabriculus*, while the overlying black shales were crowded with goniatites and other

fossils.¹ The latter beds, which Dr. Wheelton Hind has shown to be the equivalents of the Pendleside Series, crop out along the conspicuous escarpment to the west of Inchiquin Lough. Chert is very abundant in the Upper Limestone Beds of this locality, occurring in continuous well-defined bands, one of which forms the summit of Slate Island in the centre of the Lough.

(E) Barony of Burren.

Nearly the whole of the Barony of Burren, which lies in the extreme north of the county, is formed by a vast elevated plateau of Upper Limestone, rising on the west, north, and east in steep terraced cliffs and dipping gently to the south and south-west beneath the Coal Measures.

The thickness of limestone visible above sea-level amounts to about 1500 feet; and, as the beds undulate considerably, though the dip rarely exceeds 5°, it is almost impossible to trace their stratigraphical sequence over this large area, the bare surface of rock which it presents being too vast to admit of the detailed work necessary for accurate zoning. It is possible, however, by following a definite line across the country, to identify the zones and trace them within certain limits; but to map their extension over the whole area would entail many years of arduous work, and the results would hardly repay the time expended.

The district of Oughtmama in the extreme north, between the bays of Aughinish and Muckinish, is almost completely covered by Drift, and the lowest visible beds occur farther south, from the foot of Ballyconreag, along the southern shore of Ballyvaghan Bay, as far as the promontory of Black Head. These beds were found to contain a fauna characteristic of the S₂ subzone, the profusion of *Nematophyllum minus* at one horizon being a conspicuous local feature; other fossils recorded from these beds were:—*Carcinophyllum* sp., *Syringopora geniculata*, *Campophyllum* sp., *Lithostrocion martini* and *L. affine*, *Seminula ambigua*, *Dielasma aff. hastatum* and *Chonetes papilionacea*.

Passing inland, attention was chiefly directed to the investigation of a section drawn slightly east of south from Lough Rask (an interesting inland tidal lake) past Wood Village and Ballyallaban House, and another from Acres Village over Moneen Mountain. An examination was also made of the district to the west comprised in the townland of Gleninagh, including Black Head and the western shore-line. The following description, however, deals chiefly with the first section.

¹ The following fossils were obtained from this locality:—*Orthoceras steinhaueri*, Sow., *Myalina peralata*, de Kon., *Glyphioceras reticulatum*, Phill. *Posidoniella levis*, Brown, and plant-remains.

The S_2 subzone seems to extend about a mile inland from the shore-line; but the comparative scarcity of fossils renders it a matter of some difficulty to locate the approximate base of the *Dibunophyllum* Zone. The floor of the Ballyvaghan amphitheatre, which has a gradual slope up to about 250 feet, is formed by somewhat impure limestone-beds yielding the following D_1 fossils:—*Dibunophyllum muirheadi*, *Lithostrotion irregulare*, Clisiophyllid *Lithostrotion*, *Productus* 'aff. *giganteus*', *Pr.* aff. *hemisphericus*, *Pr.* cf. *elegans*, *Daviesiella* aff. *comoides*, *Reticularia lineata*, and *Athyris planosulcata*.

A well marked horizon of chert occupies the base of the two rather prominent spurs which jut out from the foot of the main escarpment.

Between 250 and 500 feet the ground rises suddenly in a series of vertical cliffs. The first main scarp, which occurs along this line of section, immediately above the 300-foot contour-line, is formed by thickly-bedded limestone, free from chert, containing *Productus* 'aff. *giganteus*', *Dibunophyllum* sp., and *Cyathophyllum murchisoni*; a characteristic feature at this level, also noted in other parts of the county, is the abundance of *Euomphalus acutus*. At the top of the second scarp *Alveolites septosa* and *Lithostrotion junceum* are abundant. The ground above 500 feet, though rising in a number of minor scarps, has a gradual slope up to the summit (939 feet). Fossils are everywhere extremely scarce, though the occurrence of *Cyathophyllum regium* at certain levels suggests that the D_2 subzone has been reached. *Productus giganteus*, a large *Chonetes* cf. *compressa*, *Carcinophyllum* sp., and *Lithostrotion junceum* were also recorded. Chert is once more found in abundance near the summit.

The limestone-beds immediately below the Pendleside Shales were examined in the region around Slieve Elva, but with the exception of crinoid fragments and a small *Chonetes*, they appeared to be devoid of fossils. Dr. Wheelton Hind, however, has recorded¹ *Pterinopecten papryraceus*, *Glyphioceras diadema*, and *Lithostrotion* sp. from the topmost beds of the limestone in the neighbourhood of Lisdoonvarna. The presence of the last-named genus is somewhat remarkable, for in other parts of the county it is typically absent at this level, which is characterized by Densiphylloid Zaphrentids and *Caninia*. The evidence thus suggests, either a slight local unconformity, or merely a difference in bathymetrical conditions.²

¹ See Bibliographical List, § IX, p. 582.

² Though I have explored most of the surface of the Burren plateau, a stretch of bare rock over 100 square miles in extent, it was found impossible to furnish any connected results of zonal value: I must, therefore, of necessity omit an account of this wild and remarkable district.

VI. CORRELATION¹ OF THE SUCCESSION IN COUNTY CLARE WITH THAT
OF OTHER DISTRICTS IN THE BRITISH ISLES.

The *Modiola* Phase.

The lamellibranchs found in these beds cannot, in the present state of our knowledge, be definitely correlated with those occurring at the base in other districts. In this district they are not associated with a brachiopod fauna, and consequently the beds are strongly marked off from those of the succeeding zone. Their chief interest lies in the suggestion which they afford of a conformable transition from the Old Red Sandstone. (I have retained the term '*Modiola* Phase' to preserve uniformity with former papers on the Carboniferous sequence.)

The *Cleistopora* Zone.

The sandy basement-beds assigned to this zone exhibit an incomplete development of the fauna characteristic of the *Cleistopora* Zone in the South-Western Province (Bristol area and the Mendips). The correlation is based on the simultaneous occurrence of a bassi-form *Productus* and *Spiriferina octoplicata*; on the presence of *Eumetria* aff. *carbonaria*, *Camartœchia mitcheldeanensis*, and *Orthotetes crenistria* in a mutation similar to that found in K₁ of the Avon section; and on the complete absence of *Zaphrentis*, which occurs in great abundance in the overlying beds.

The absence or great rarity of *Spirifer* aff. *clathratus*, *Rhipidomella michelini*, *Productus* cf. *burlingtonensis*, and *Syringothyris* aff. *cuspidata*, from beds immediately below those containing *Zaphrentis*, enables a more marked divisional line to be drawn between this and the succeeding zone than in the South-Western Province, and suggests a relative acceleration of the coral-fauna on the brachiopod-fauna at the base of the sequence.

The extreme thinness of this zone has been mentioned above.

¹ Since the publication of Dr. Vaughan's paper on the Bristol area, much detailed work has been done on Carboniferous palæontology. I have adhered for the most part to the original names given in that paper, for the purpose of avoiding confusion in correlation. The following changes have, however, been inserted (taken from the work of Mr. R. G. Carruthers on certain Tournaisian corals, *Geol. Mag.* dec. 5, vol. v, 1908, pp. 25, 67, & 159):—

Zaphrentis omaliusi = *Z. aff. phillipsi* (pars). (Bristol paper.)

Zaphrentis konincki = *Z. cornucopiæ*. (Bristol paper.)

Caninia cornucopiæ = *Amplexi-Zaphrentis*. (Rush paper.)

The *Zaphrentis* Zone.

The correlation of these beds with the *Zaphrentis* Zone of the Bristol area is based on the following details of the faunal sequence common to the two districts.

A. The *clathratus* subzone.

1. The entrance of *Zaphrentis* at the base, but the absence of *Zaphrentis konincki*.
2. The maximum of *Rhipidomella michelini*, *Productus* cf. *burlingtonensis*, and *Spirifer* aff. *clathratus* (the subzonal index).
3. The absence or rarity of *Michelinia*, *Caninia*, and *Syringopora*.
4. The absence of *Schizophoria* aff. *resupinata* and *Syringothyris laminosa*.
5. The absence of *Camarotoechia mitcheldeanensis*, and *Spiriferina octoplicata*, except at the base.
6. The abundance of *Leptæna analoga* and *Syringothyris* aff. *cuspiata*.

B. The *konincki* subzone.¹

1. The entrance of *Zaphrentis konincki* and its maximum at the summit, where it is associated with *Campophyllum cylindricum* and *Caninia cornucopie* (horizon γ).
2. The entrance and abundance of *Michelinia* and *Syringopora*.
3. The entrance of *Syringothyris laminosa*.
4. The development of a characteristic fish-fauna.
5. The absence of Clisiophyllids and *Lithostroton*.

The following points of difference are to be noted:—

In County Clare *Spirifer* aff. *clathratus* is still abundant at the top of Z_2 ; but *Schizophoria resupinata* does not occur abundantly until the succeeding zone (compare the Mendip area).

Amplexus is either absent or extremely rare in Z_2 .

The thickness of this zone is about 800 feet, and it is thus comparable with the development in the Mendip area, being more than twice as thick as in the Avon section.

The *Syringothyris* Zone.

The remarkable development of this part of the sequence in the West of Ireland renders it impossible to compare it in detail with any well-known locality in Great Britain. The unfossiliferous oolites, shales, and dolomites of the Bristol area, which form so

¹ For the reasons for adopting this form as the subzonal index, in preference to *Schizophoria resupinata*, see T. F. Sibly, Quart. Journ. Geol. Soc. vol. lxii (1906) p. 355, and A. Vaughan, *ibid.* p. 301, footnote.

marked a break in the succession, are represented in the Mendips by fossiliferous limestones exhibiting a complete transition from the Tournaisian fauna to the Viséan. In County Clare, on the other hand, although these beds afford abundant evidence of the existence of relatively shallow-water conditions and at the same time are the most fossiliferous of the whole sequence, the fauna which they contain is, on the whole, distinct from the Tournaisian below and the Viséan above, and seems to bear a marked resemblance to that of M. Édouard Dupont's Waulsortian Phase of Belgium.

The correlation of these beds with the *Syringothyris* Zone of Great Britain is, however, based on the following points, and a more detailed comparison with the Belgium sequence will be given below:—

1. These beds occur immediately above the maximum of *Zaphrentis konincki*, *Michelinia favosa*, *Caninia cornucopiæ*, and *Campophyllum cylindricum* (horizon γ).
2. They are succeeded by beds containing the earliest Clisiophyllids and *Lithostrotion*, associated with a typical S_1 fauna.
3. *Syringothyris cuspidata*, the zonal index of the Mendip area, attains its maximum development in this zone.
4. Both in County Clare and in the Mendips there is an abundance of large *Euomphali* at this horizon (*Euomphalus pentangulatus*).

The main differences in the faunal succession are, of course, due to the entirely distinct conditions under which the deposits in the two areas were laid down; and it is hardly necessary again to emphasize the predominance of a molluscan fauna at this horizon in County Clare, as also the entire absence of corals with the exception of *Amplexus*.

This type of deposit seems to extend over the greater part of Central Ireland, occurring in Limerick, Queen's County, Kildare, etc. Dr. Vaughan informs me that there is a similar development of the *Syringothyris* Zone at St. Doolagh's (County Dublin).

Note on the Comparison of the *Syringothyris* Zone, as developed in County Clare, with the Waulsortian Phase of Belgium.

A preliminary comparison of the British Carboniferous succession with that of Belgium was given by Dr. Vaughan in his paper on the Bristol area, and he, I believe, contemplates further work on this subject. I shall, therefore, not attempt here to give more than a brief outline of the points of resemblance, both palæontological and lithological, which exist between the uppermost beds of the Lower Avonian (the *Syringothyris* Zone) as developed in the West of Ireland, and the deposits of the Waulsortian Phase of Belgium (Étage II of M. Édouard Dupont).

	<p><i>Belgian sequence.</i> (M. Éd. Dupont.)¹</p>	<p><i>County Clare.</i></p>	
Étage II.	<p>WAULSORTIAN PHASE.</p> <p>'Calcaire gris à veines bleues et dolomie grise et calcaire gris souvent magnésien, dont un groupe des couches est rempli de noyaux spathiques radiés.' (Assise IV, <i>op. cit.</i> p. 623.)</p>	<p>SYRINGOTHYRIS ZONE.</p> <p>Grey, white, and black-veined and mottled limestones, often magnesian and becoming a true dolomite at the top. Certain beds are crowded with bryozoa, which give in cross-section a characteristic spotted appearance to the rock.</p>	Syringothyris Zone.
	<p>The following list comprises a few of the more important fossils which are common at this level in the two areas. (My authorities for the Belgian forms are Prof. Gosselet and L. G. de Koninck):—</p> <p><i>Spirifer subcinctus.</i> <i>Spirifer pinguis.</i> <i>Syringothyris cuspidata.</i> <i>Productus semireticulatus.</i> <i>Spirifer attenuatus.</i> <i>Dielasma kingi.</i> <i>Dielasma hastatum.</i> <i>Athyris ingens</i> = <i>Athyris</i> aff. <i>glabristria.</i> <i>Tetinautilus carinifer.</i> <i>Conocardium hibernicum.</i> <i>Cardiomorpha egertoni.</i> <i>Euomphalus pentangulatus.</i></p>		
Étage I.	<p><i>Tournaisian.</i></p> <p>'Calcaire à crinoïdes, avec schistes argileux...à la base: sans schistes...à la partie moyenne; avec phanites à la partie supérieure.'</p>	<p>Crinoidal limestone with the Lower Limestone Shales below, and a well-marked cherty horizon at the summit.</p>	

The Seminula Zone.

The distinction between a lower subzone (S_1), containing survivors of a Tournaisian fauna, and an upper subzone (S_2) is not well marked in County Clare; and, although the base is defined by a characteristic faunal assemblage distinct from that of the *Syringothyris* Zone, with no horizon of faunal overlap, the topmost beds of the zone merge insensibly into those of the *Dibunophyllum* Zone.

¹ Bull. Acad. Roy. Belg. ser. 2, vol. xx (1865) pp. 621 *et seqq.*

The following points are of especial interest in correlating these beds with the *Seminula* Zone in the South-Western Province of Great Britain :—

1. In County Clare, Clisiophyllids and *Lithostrotion* have not been recorded from the *Syringothyris* Zone, but appear for the first time in S_1 . Since, however, *Lithostrotion martini*, which throughout is the dominant coral, is in some localities absent, or extremely rare, at the base of the subzone, this horizon is defined by the first appearance of the Clisiophyllids.
2. The survivors of a Tournaisian fauna are not numerous. They include *Campophyllum cylindricum*, which, as in the Bristol sequence, attains its second maximum in S_1 , *Zaphrentis omaliusi* var. *densa*, and *Michelinia grandis*.
3. *Syringothyris cuspidata* does not extend into these beds.
4. *Daviesiella* cf. *comoides* is abundant in S_1 (compare the Mendips).
5. *Productus punctatus* is not uncommon (compare Weston-super-Mare).
6. *Productus* cf. *semireticulatus* occurs sparingly in S_1 , and *Pr. cora* is abundant throughout S_2 .
7. The most characteristic feature in S_2 is the horizon of *Nematophyllum* and *Carcinophyllum*, which I believe is also recognized in the North of England.
8. *Seminula* is everywhere rare, except at the summit of S_2 .
9. As in the Bristol area, this zone is characterized lithologically by the development of oolitic limestone; here, however, it sometimes attains the nature of a conglomerate, and is remarkable for its abundant gasteropod-fauna, whereas *Seminula* is absent or extremely rare in these beds. I have been unable to determine the exact level of these oolitic beds, but they probably occur at or about the base of S_2 .

The simultaneous occurrence of *Syringopora reticulata* and *Michelinia grandis* at the base of S_1 suggests a correlation with the *megastoma* beds of the Rush sequence.

The *Dibunophyllum* Zone.

D_1 = subzone of *Dibunophyllum* θ .

This subzone in County Clare attains a thickness which cannot be less than 1000 feet, and is thus comparable with the sequence in the Midland area. The corals are more or less similar in the two districts, though certain forms, such as *Cyathophyllum murchisoni*, *Alveolites*, and *Carcinophyllum*, which are rare in the Midlands, are here of common occurrence. The brachiopods are more numerous in County Clare, and it is interesting to note that such forms as *Dielasma hastatum*, *Seminula ambigua*, *Productus elegans*, *Athyris planosulcata*, and *Martinia lineata* which in the Midlands characterize D_2 are here abundant in D_1 ; whereas many of the Midland D_1 forms are in County Clare more commonly associated with *Lonsdalia*.

The correlation of these beds with the D_1 subzone of the South-

Western Province of Great Britain is based on the following facts:—

1. The abundance throughout of simple *Dibunophylla*.
2. The absence of more advanced Clisiophyllids, including *Lonsdalia*, and of *Cyathophyllum regium*.
3. The maximum of *Cyathophyllum murchisoni*.
4. The gradual replacement of *Lithostrotion martini* by *L. irregulare* and *L. junceum*.
5. The presence of Clisiophyllid Lithostrotions.
6. The abundance of *Alveolites* and *Syringopora geniculata*.
7. The abundance throughout of *Productus* 'aff. giganteus.'
8. The occurrence of *Productus hemisphericus* and *Daviesiella* aff. *comoides*.

D₂=subzone of *Lonsdalia floriformis*.

The fauna of this subzone is very scanty, and corals are poorly represented; brachiopods, too, are nowhere abundant, and there is no evidence of the existence at this period of a 'knoll-phase,' such as occurs in the Midlands.

A correlation with the D₂ subzone of the South-Western and Midland Provinces of Great Britain is based on the following facts:—

1. The occurrence of highly specialized Clisiophyllids. *Lonsdalia duplicata*, as in the Midlands, is here abundant in the topmost beds.
2. The relative abundance of *Cyathophyllum regium*.
3. The abundance of *Lithostrotion junceum*. (Compare the Midlands.)
4. The abundance of *Productus giganteus* and *Pr. 'corrugato-hemisphericus'*.

D₃=subzone of *Cyathaxonia rushiana*.

The topmost beds of the limestone in County Clare contain a fauna which is distinct from that of the *Lonsdalia* subzone and bears a marked resemblance to that of the *Cyathaxonia* Zone of the Midlands, the Rush sequence, and the upper D beds of Oystermouth (Gower).

Cyathaxonia, the subzonal index, has not been recorded, and such forms as *Beaumontia* and *Cladochonus* are either absent or extremely rare.

The facts on which the correlation is based are:—

1. The abundance of Densiphylloid Zaphrentids—*Zaphrentis enniskilleni* and *Z. oystermouthensis*.
2. The common occurrence of *Caninia* aff. *cornucopie* (*Anplexi-Zaphrentis*).
3. The absence or great rarity of Clisiophyllids, including *Lonsdalia*.
4. The absence of *Lithostrotion*.¹
5. The abundance of scabriculate, costate, and punctate *Producti*.

¹ Dr. Wheelton Hind has recorded *Lithostrotion* from the topmost limestone beds in the neighbourhood of Lisdoonvarna.

VII. SUMMARY OF CONCLUSIONS.

The total thickness of Carboniferous Limestone in County Clare amounts to about 3250 feet, and the zonal sequence of the contained fauna is found to be essentially similar to that of other British areas, and to admit of more or less accurate correlation.

The Lower Limestone is found to contain a Tournaisian fauna, the Upper a Viséan, the distinction between the two being well marked.

The Old Red Sandstone is succeeded in apparent conformability by a bed of sandstone containing abundant modioliform lamellibranchs.

The *Cleistopora* Zone is poorly represented by a few feet of sandy shales at the base of the sequence.

To the *Zaphrentis* Zone is assigned the whole of the so-called Lower Limestone Shales and bedded cherty limestones.

The faunal characters of the *clathratus* and *konincki* subzones are well marked, and the succession of the fauna is very similar to that of the South-Western Province of Great Britain.

Between the uppermost beds of the *Zaphrentis* Zone and the base of the Viséan occurs a considerable thickness of massive unbedded limestone, which is remarkable for its luxuriant molluscan fauna, especially large cephalopods. The peculiar nature and the faunal contents of this rock suggest the incoming of shallow-water conditions, and thus afford evidence of the extension westwards of that general elevation which is indicated by the deposits of the Bristol area, the volcanic rocks of Weston-super-Mare, and the Pendine and Rush Conglomerates.

Syringothyris cuspidata here attains the acme of its development, and the beds are assigned to the *Syringothyris* Zone. A comparison is made between this part of the sequence and the Waulsortian Phase of Belgium.

The Viséan is marked by the incoming of a perfectly distinct fauna, including the Clisiophyllids and *Lithostroton*, and by a notable change in the nature of the rock: at least one horizon of oolitic limestone occurs in the *Seminula* Zone. This portion of the sequence is poorly fossiliferous, and the subzones are not well marked. *Productus cora* mut. *S.*, however, occurs abundantly near the summit.

The *Dibunophyllum* Zone attains a thickness equal to that of the Midland development, and is composed of limestone from base to summit. The *D.* subzone is characterized by the abundance of simple *Dibunophylla*; the *D.* subzone by the occurrence of *Lonsdalia* and *Cyathophyllum regium*; and *D.* by the abundance of Densiphylloid *Zaphrentids* and *Caninia*, and by the apparent absence of Clisiophyllids and *Lithostroton*.

Fossils characteristic of the lowest Pendleside Beds have not been recorded from County Clare; but it has been shown by Dr. Wheelton Hind¹ that the so-called 'Coal Measure Shales' which immediately succeed the limestone are the homotaxial equivalents of some part of that series.

¹ See Bibliographical List, § IX, p. 582.

In conclusion, I wish to offer my sincere thanks to all those who have given me their help in the preparation of this paper. To Dr. Vaughan I owe a deep debt of gratitude for his continuous encouragement and invaluable advice, and for permission to study his collection of Avonian fossils.

I have to thank Dr. Bather, for naming crinoids; Dr. Wheelton Hind, for help in regard to some of the lamellibranchs; and Mr. R. G. Carruthers, for naming several of my corals. My thanks are also due to Mr. Woods, for assistance in finding M'Coy's type-specimens in the Sedgwick Museum at Cambridge; to Prof. Grenville Cole, for permission to examine the 6-inch MS. Geological Survey maps of the county; and to Prof. Sollas and Prof. Garwood, for several helpful suggestions during the course of my work.

I am much indebted to Mr. E. R. Lloyd, for his assistance and companionship in the field during the summer of 1907; and to Mr. C. J. Bayzand, for the map (fig. 3, p. 543) showing the outcrop of the limestone.

VIII. PALÆONTOLOGICAL NOTES.

(A) Brachiopods.

Dielasma.

DIELASMA HASTATUM (Sow.).

British examples of the genus *Dielasma* are exceedingly numerous and varied, and a systematic study of the group would no doubt tend to separate forms now included under the specific name of *Dielasma hastatum* into a number of distinct species. The Belgian shells were studied in detail by L. G. de Koninck, who figured and described no less than thirty-two species.¹ Sowerby's original type-specimen, figured in his 'Mineral Conchology,' was obtained from Limerick, and without doubt came from the *Syringothyris* Zone. Identically similar forms are common in this zone in County Clare. It would be outside the limits of this paper to give a detailed account of the different forms of *Dielasma* found in this area, but a few well-marked types seem to demand reference.

1. *Dielasma* aff. *kingi* (de Kon.), Pl. XXVI, fig. 3. This shell bears a close resemblance to *Dielasma kingi*, de Kon., figured in Ann. Mus. Roy. Hist. Nat. Belg. pl. ii, figs. 36-37 & pl. iv, figs. 14-15. It agrees with this species in the relative dimensions of length to breadth, which are much less than in *D. hastatum*, and in the thick truncated anterior margin, which is only very slightly indented. The sinus in the ventral valve is shallow, though well marked, and confined to the anterior portion of the shell. The dorsal valve is flattened or feebly convex, and does not possess a sinus. The nearest approach to this form, figured by Davidson in his

¹ Ann. Mus. Roy. Hist. Nat. Belg. vol. xiv, 1887.

'Monograph of the British Fossil Brachiopods' vol. ii, is represented by fig. 7 in pl. i (*Terebratula hastata*).

2. In D_1 occurs a form with a narrow wedge-shaped anterior margin, and very convex valves without depressions, which resembles *Dielasma itaitubense*, de Kon. (*op. cit.* pl. v, figs. 4 & 5). This is probably closely related to *D. ficus* (M'Coy).

3. The most abundant form in D , however, is similar to that figured by Davidson (*op. cit.* pl. i, fig. 12) as *Terebratula virgoides*, M'Coy.

It would appear then, from a brief study of the history of the genus, that *D. virgoides* (M'Coy) and *D. ficus* (M'Coy), which Davidson includes as varieties of *D. hastatum* (Sow.), must rank as distinct species.

Athyris.

ATHYRIS GLABRISTRIA (Phill.). (Pl. XXVI, fig. 2.)

The typical form of this shell, as described and figured by Phillips in the 'Geology of Yorkshire' pt. ii, p. 220 & pl. x, fig. 19, and by Davidson, under the name of *Athyris royssii*, in his 'British Fossil Brachiopoda' (vol. ii, pl. xviii, figs. 1-11), is enormously abundant in the *Syringothyris* Zone of County Clare, though somewhat scarce in the beds below. This species exhibits a remarkable variation in growth, and hardly any two specimens obtained from this level have the same relative dimensions.

The ratio of length to breadth in three specimens taken at random was found to be 4 : 7, 4 : 10, and 4 : 13.

The young shell is depressed, with a slight median fold. In some cases, further growth is chiefly directed towards increasing the depth of the shell, resulting in a deep form with rounded fold; in others, there is little increase in depth: the shell remains flattened, and may become extremely transverse; the fold in this type is often very prominent, with steep sides. There can be little doubt that this form is identical with *Athyris ingens* of L. G. de Koninck, which characterizes the Waulsortian Phase of Belgium (*op. cit.* pl. xx, figs. 1-10). In comparing this species with other *Athyris* the author lays stress on the absence of ornamentation:—

'... l'auteur [Davidson] a dû admettre que les spécimens représentés avaient perdu leurs ornements pendant la fossilisation, ce qui ne paraît pas d'accord avec leur parfait état de conservation.' (Pp. 83-84.)

The preservation of fringe-like expansions on the shell is dependent largely on the mode of fossilization, and their apparent absence from the Belgian type of *A. ingens* cannot be taken as proof of their non-existence. Many specimens that I have collected from County Clare present, at first sight, a perfectly smooth surface which shows little trace of ornamentation; but, on grinding and polishing the matrix in which they are embedded, the presence of fringes can always be determined.

ATHYRIS HIBERNICA, nom. nov. (Pl. XXVI, fig. 5.)

Athyris phalæna (M'Coy); *Athyris squamigera*, de Kon. & Davidson.

This species, though incorrectly referred to Phillips's *Spirifer phalæna*, was first described by M'Coy in 1844.¹ In 1857 Davidson figured and described M'Coy's actual specimen² under the name of *Athyris squamigera*, a species first described by L. G. de Koninck in 1851,³ and stated that he had communicated his specimens to the latter, who with some hesitation referred them to this species.

The strongly-marked ornamentation shown in de Koninck's figures, together with the shape and relative dimensions of the shell, would appear, however, to distinguish it at once from M'Coy's type, which is transversely elongated and has very feeble concentric ornamentation.

In 1887⁴ L. G. de Koninck again described *A. squamigera*, and stated that he had grave doubts whether M'Coy's form figured by Davidson belongs to the same species; and a comparison of the two figures can only lend strong support to this view. M'Coy's type is common in the *Syringothyris* Zone of Clare, and, as the original name of *Athyris phalæna* by the law of priority belongs to Phillips's Devonian form, I have substituted the new specific name *hibernica*, this shell at present being only known from Ireland.

Description:—

'Transversely oval, much broader than long; valves convex, sometimes gibbous; beak in the ventral valve moderately produced, incurved and truncated at its extremity by a small circular aperture. In the dorsal valve there exists a prominent broad mesial fold, and in the ventral a corresponding sinus of variable depth, both commencing at a short distance from the extremity of the beaks. Surface with small imbricating striae.'

The concentric striae are the more strongly marked, and probably indicate the original presence of fringed ornamentation as in *Athyris glabristria*; in fact, this shell may ultimately prove to be an extremely transverse variant of that species.

ATHYRIS LAMELLOSA (L'Éveillé). (Pl. XXVI, fig. 4.)

A form similar to that figured by Dr. Sibly⁵ occurs commonly at the base of the *Zaphrentis* Zone in County Clare. The shell-expansions are, however, seldom preserved, although the two series of concentric ridges resulting from their fracture are well shown in the figure of a young specimen.

¹ 'Syn. Carb. Limest. Fossils of Ireland' p. 140.

² 'Monogr. Brit. Foss. Brach.' (Palæont. Soc.) vol. ii, p. 83 & pl. xviii, fig. 13.

³ 'Description des Animaux fossiles du Terrain Carbonifère de Belgique' (Suppl.) p. 667 & pl. lvi, fig. 9.

⁴ Ann. Mus. Roy. Hist. Nat. Belg. vol. xiv, pp. 82-83.

⁵ Quart. Journ. Geol. Soc. vol. lxii (1906) pl. xxxii, figs. 1 a & 1 b.

Spirifer.**SPIRIFER ATTENUATUS, Sow. (Pl. XXVI, fig. 7.)**

The opinion that this shell was only a variety of *Spirifer striatus* was held by de Verneuil, M'Coy, Davidson, and for a long time by de Koninck. The last-mentioned author, however, has since published a description of *Spirifer attenuatus* as a separate species, and has brought forward abundant evidence to justify the distinction. This shell, which is characteristic of the Waulsortian Phase of Belgium, occurs also in great numbers in the *Syringothyris* Zone of County Clare. The specimen that I have figured was selected to show the nature of the ribbing, but the posterior lateral extremities, which are always angular, are unfortunately broken. De Koninck's figures are somewhat poor, and the best example is to be found on pl. ii, fig. 13 of Davidson's 'Monograph of British Fossil Brachiopoda' vol. ii (1857-63).

The following is L. G. de Koninck's description of this species (Ann. Mus. Roy. Hist. Nat. Belg. vol. xiv, 1887, p. 115):—

'Shell transverse, much broader than long, of a subsemicircular form with angular lateral extremities; valves of nearly equal depth. The median fold of the dorsal valve is fairly broad at its anterior border, but is very little elevated and evenly rounded. The sinus of the ventral valve is fairly deep, and bounded on each side by a radial rib, a little more strongly marked than the adjacent ones. . . . The surface of each valve is covered by narrow ribs separated by grooves of equal width and fairly deep. The ribs, which are the same on the fold and sinus as on the rest of the shell, bifurcate several times, and thus preserve almost their initial width throughout their length. The first bifurcation takes place at a short distance from the beaks, and the ribs sometimes collect into bundles which divide the surface into several small, more or less isolated lobes. . . . The ribs are smooth for the greater part of their length, and are only interrupted by transverse lines of growth, often at unequal distances, near the margin of the shell.'

The figured specimen shows three well-marked bundles on the dorsal fold, which have their origin in three primary ribs.

This species differs from *Spirifer striatus*, chiefly by its smaller size, and by the fineness and regularity of its ribs and the characteristic grouping into bundles.

SPIRIFER aff. CLATHRATUS, M'Coy & Vaughan. (Pl. XXVI, fig. 6.)

As interpreted by Dr. A. Vaughan, Proc. Bristol Nat. Soc. n. s. vol. x (1902-1903) pp. 125-27, and Quart. Journ. Geol. Soc. vol. lxi (1905) p. 300 & pl. xxvi, fig. 5.

This species is abundant throughout the *Zaphrentis* Zone in County Clare; it continues into the *Syringothyris* Zone, from which the figured specimen was derived.

SPIRIFER KONINCKI, sp. nov. (Pl. XXVI, figs. 1 a & 1 b.)

Description.—The young shell is nearly circular in outline, but becomes transversely oval with increased growth. Area rather broad, concave, with subparallel sides; cardinal angles rounded. Beaks prominent, incurved over the large triangular delthyrium.

The ventral valve is more convex than the dorsal. Ribs numerous, rounded or slightly flattened.

In the dorsal valve a median fold, bounded on each side by a distinct groove, has its origin near the extremity of the beak; but it does not become prominent until it approaches the anterior margin of the shell, where it is considerably elevated, with steep sides, and bears usually about twelve ribs. The sides of the dorsal valve in an adult shell are somewhat flattened, and each bears about fifteen prominent ribs and numerous smaller ones towards the cardinal angles. A few ribs on each side of the median fold increase by bifurcation.

The ventral valve possesses a prominent though shallow sinus. In the young shell this is simple; but, as growth proceeds, it tends to be divided by a small median fold, formed by the fusion of four or five ribs.

In a well-preserved specimen the ribs are seen to be covered by fine longitudinal striae, crossed by obscure lines of growth which give them a reticulated appearance.

Discussion.—This shell, in general form, in the nature of its ribbing, and in the finely reticulate surface, bears a close resemblance to the Belgian species figured and described by L. G. de Koninck as *Spirifer cinctus*, de Keys.¹ The fold, however, is stronger than in the Belgian shell, and the double nature of the sinus seems to be a distinct feature, although there is perhaps a suggestion of this in fig. 7 (*op. cit.*). The ribs, too, appear to be less numerous and not so flattened.

De Koninck's interpretation of *Spirifer cinctus* seems to be open to adverse criticism, for his figures and description bear little resemblance to those of A. von Keyserling, the founder of the species; see the latter's 'Wissensch. Beobacht. auf einer Reise in das Petschoraland im Jahre 1843' St. Petersburg 1846, p. 229 & pl. viii, fig. 2. The original type of this author appears to be readily distinguishable from all other Carboniferous *Spirifers* by the absence of a median fold and sinus, and by the possession of a uniplanar valvular intersection (*op. cit.* pp. 229–30):—'Der entschiedne Mangel eines Sinus unterscheidet ihn von allen Arten auf das ausgezeichnetste. . . In Folge dessen wird die Stirncommissur nicht so wie bei anderen Arten zur Ventral-schale herabgedrängt, sondern liegt fast in derselben Ebene ringsum.'

It is not easy to understand how de Koninck confounded with this species a form having a strong fold and sinus² (see de Kon. *op. cit.* p. 108: 'La valve ventrale . . . est déprimée dans sa partie médiane par un large sinus correspondant au lobe de la valve opposée').

A form, somewhat similar to the Irish species and probably representing a parallel stock, occurs in the Keokuk Limestone of America, which appears to correspond to our *Syringothyris* Zone. This species (*Spirifer logani*, Hall) is, however, rather more transverse, and bears more numerous ribs.³ Of British examples

¹ Bull. Musée Roy. Hist. Nat. Belg. vol. ii (1883) pl. xv, figs. 3–5; and Annales, *ibid.* vol. xiv (1887) p. 108, pl. xxiv, figs. 6–7 & pl. xxvi, figs. 1–2.

² De Koninck records *Spirifer cinctus* from Ballydoole (County Limerick).

³ 'Natural History of New York: Part VI—Palæontology' vol. viii, pt. ii (1894) pl. xxxii, fig. 7.

which are comparable with this species, mention must be made of the mutation of *Spirifer clathratus* figured by Dr. Vaughan.¹ This author considers that *Sp. konincki* is a late mutation of one of the *clathratus* group.

The form figured by Davidson on pl. iv, fig. 14, of his 'British Fossil Brachiopoda' as *Spirifer mosquensis* from Little Island (Ireland) occurs at an horizon far below that of the Russian shell; and, since the strong dental plates, diagnostic of that species and its allies which are grouped under the generic name *Choristites*, have never been determined in his specimens, it appears likely that they are related to the species now described, which (though it does not possess large dental plates) has somewhat the outward appearance of a *Choristites*.

SPIRIFER SUBCINCTUS, de Kon.

Specimens which occur commonly in the *Syringothyris* Zone agree closely with the form described and figured by L. G. de Koninck from the Waulsortian of Belgium.²

(B) Corals.

Michelinia.

MICHELINIA GRANDIS, M'Coy.

'British Palæozoic Fossils' 1855, p. 81 & pl. iii C, figs. 1-1 a; and Ann. & Mag. Nat. Hist. ser. 2, vol. iii (1849) p. 123.

I have examined M'Coy's type-specimen, preserved in the Sedgwick Museum at Cambridge, and have no hesitation in assigning the form common at the base of S_1 in County Clare to this species.

Zaphrentis.

ZAPHRENTIS OMALIUSI, M.-Edw. & H. (var. DENSA, Carruthers). (Pl. XXVII, fig. 9.)

As interpreted by Mr. R. G. Carruthers, Geol. Mag. dec. 5, vol. v (1908) p. 25 & pl. iv, fig. 7.

A densiphylloid *Zaphrentis*, which Mr. Carruthers refers to the above species and variety, occurs in some abundance in Z_1 of County Clare. Nearly every specimen collected was found to be silicified, and the structure thereby almost completely obscured; the figured specimen, however, shows the radial disposition of the septa and the fusion of their inner ends.

ZAPHRENTIS KONINCKI, M.-Edw. & H.

As interpreted by Mr. R. G. Carruthers, *op. cit.* p. 67 & pl. v, figs. 1-4.

This species occurs in great abundance throughout Z_2 , reaching its maximum at horizon γ . Forma α of Carruthers is the type usually met with.

¹ Proc. Bristol Nat. Soc. n. s. vol. x (1902-1903) pl. ii, fig. 3.

² Ann. Mus. Roy. Hist. Nat. Belg. vol. xiv (1887) pl. xxiv, figs. 4 & 5.

ZAPHRENTIS VAUGHANI, sp. nov. (Pl. XXVII, fig. 11.)

Description.—Form conical or slightly cornute; epitheca exhibiting longitudinal striations and faint annular lines of growth.

Horizontal section.—The cardinal fossula, which is situated on the concave side of the corallum, is not well marked in the lower part of the coral, but in sections taken higher up is well defined and extends to the centre, the two septa which bound it being almost parallel. Just below the floor of the calyx the inner end expands rapidly. A counter-fossula is not developed. The septal arrangement is almost radial, though a slight curvature towards the fossula is sometimes noticeable. The major septa are strong, and their inner ends become fused together into a compact mass, giving the coral a densiphylloid appearance.

The cardinal septum at first completely divides the fossula, but is seen to become rapidly shorter as the sections approach the calyx-floor. The counter-septum is readily distinguished by the fact that the minor septa on each side of it are strongly developed and reach the central fused mass. These, at first sight, simulate major septa, but their true nature is easily recognizable on closer examination of the wall. The remaining minor septa, though rudimentary, are conspicuous even in the early stages of growth; towards the upper part of the corallum they project inwards a short distance from the wall.

The tabular intersections, which are rather numerous, are evenly spaced, and preserve a regular concentric arrangement.

Discussion.—This coral occurs rarely in Z_1 of County Clare, but has not been previously recorded from Great Britain; Mr. Carruthers informs me that he has a single specimen from Tournai in Belgium.

In the position of the fossula on the concave side of the corallum, the curvature of the major septa convex to the fossula, the rapid dwindling of the cardinal septum on approaching the calyx-floor, and the absence of a counter-fossula, it bears some resemblance to *Zaphrentis delanouei*, M.-Edw. & H., but is readily distinguished from that species by the fusion of the major septa, the greater number of tabular intersections, and the abnormal development of the minors on either side of the counter-septum, although the last feature is sometimes noticeable to a less extent in *Z. delanouei*.

ZAPHRENTIS sp. (Pl. XXVII, fig. 4.)

This form is represented by a single specimen from the top of S_2 . Its relations are necessarily somewhat obscure.

In its longitudinally striated epitheca and the presence of the fossula on the concave side of the corallum, it is apparently related to *Zaphrentis enniskilleni*. The fossula in the lower part of the corallum has, however, almost parallel sides, and is completely bisected by the cardinal septum. In higher sections, this septum dwindles rapidly in length, and the fossula expands widely at its inner end, having a thick stereoplasmic lining as in *Zaphrentis konincki*.

Densiphyllum.

DENSIPHYLLUM sp. (Pl. XXVII, fig. 7.)

This form, which occurs in the topmost beds of the limestone in County Clare, seems in its type of septation to bear some relation to *Cyathaxonia costata*, M'Coy, but lacks the central axis of that genus.

Campophyllum.

This genus was revised in detail by Thomson in 1893,¹ who includes in it those corals which are intermediate in structure between *Calophyllum* on the one hand and *Cyathophyllum* on the other.

Mr. R. G. Carruthers has recently shown² that the genotype of Michelin's genus *Caninia* is *Caninia cornucopie*, and the results of his investigations seem to indicate that the reasons given by Thomson for the inclusion of the forms commonly known as *Caninia cylindrica* and *C. gigantea*, which are regarded by that author as distinct species, in the genus *Campophyllum*, at least merit further consideration. Horizontal sections, however, cut near the base of *Campophyllum cylindricum*, show a striking resemblance to certain stages of growth in *Caninia cornucopie*, and it thus appears doubtful whether the two species should be assigned to different genera. (In County Clare, the first maximum of *C. cylindricum* occurs at the same level, Horizon γ , as that of *C. cornucopie*.)

CAMPOPHYLLUM CYLINDRICUM (Scouler). (Pl. XXVII, fig. 8.)

The mutation of this species which is common at Horizon γ is characterized by a broad vesicular outer zone, completely radiated by the two series of septa; in this respect it resembles the form characteristic of S_1 in the South-Western Province of Great Britain. It possesses, however, more numerous and thinner septa, its structure being somewhat *Cyathophylloid* in appearance, though the septal fossula and associated thickened septa are strongly marked.

A characteristic mutation, distinguished by the abnormal development of the minor septa, is also abundant at the base of S_1 . These septa project some distance from the strong inner wall into the median area, where, together with the major septa, they become greatly thickened. Their inner ends have a rounded or blunt appearance, totally distinct from the tapering points of the major septa. The vesicular outer zone is similar to that of the form mentioned above, being radiated by the two series of thin septa, with several rows of interseptal vesicles.

¹ Proc. Roy. Irish Acad. ser. 3, vol. ii, pp. 667-758 & pls. xv-xxi.

² Geol. Mag. dec. 5, vol. v (1908) p. 158.

CAMPOPHYLLUM sp. (Pl. XXVII, fig. 10.)

Description.—External characters: form cylindrical and curved; epitheca strong, with longitudinal costæ.

Horizontal section.—Outer wall strong. A peripheral vesicular zone is almost entirely absent.

Major septa about 35 in number, short and never extending far towards the centre. Minor septa rudimentary. The median area is occupied solely by the tabulæ, which are remote and extend to the wall. There are no interseptal dissepiments, though intersections of downwardly curved tabulæ are seen uniting the septa. A pronounced septal fossula is visible.

Discussion.—The characters of this species seem to warrant its inclusion in the genus *Calophyllum* of Dana, which constitutes a group of corals distinguished, on the one hand from *Amplexus* chiefly by the presence of a series of minor septa, and on the other from *Campophyllum* by the absence of a vesicular outer zone. It is well known, however, that in many instances the latter is a senile character, merely denoting a comparatively late stage in the life-history of a coral; and it must, therefore, be admitted that its presence or absence is a matter of little importance in classification, and can hardly furnish sufficient grounds for the distinction of the two genera.

This species has a very feebly developed vesicular zone, and it thus seems to furnish a connecting link between *Calophyllum danai*, Thomson¹ and *Campophyllum caninoides*, Sibly.²

Caninia.*CANINIA CORNUCOPIÆ*, Mich. (Pl. XXVII, fig. 14.)

As interpreted by Mr. R. G. Carruthers, Geol. Mag. dec. 5, vol. v (1908) p. 160 & pl. vi.

This species, which frequently presents the peculiar contorted form figured by Carruthers (*op. cit.* diagram E), is abundant throughout Z₂, attaining its maximum at Horizon γ. It also occurs sparingly near the base of S₁, but has not been recorded from the massive limestones of the *Syringothyris* Zone.

CANINIA aff. *CORNUCOPIÆ*, Mich. (Pl. XXVII, fig. 12.)

A form closely related to the above occurs in some abundance in the topmost beds of the limestone (D₂₋₃) in County Clare. Its chief distinguishing features are its cylindrical habit, inconspicuous septal fossula, and greater number of tabular intersections.

A similar mutation has been recorded by Dr. Vaughan from D₂₋₃ of the South-Western Province, and by Dr. Sibly from D₃ of the Midlands.

¹ Proc. Roy. Irish Acad. ser. 3, vol. ii (1893) p. 687 & pl. xv, fig. 1.

² Quart. Journ. Geol. Soc. vol. lxii (1906) p. 368 & pl. xxxi, fig. 2b.

Diphyphyllum.

DIPHYPHYLLUM aff. SUBIBICINUM (M'Coy). (Pl. XXVII, fig. 13.)

A form somewhat similar to that described by Dr. Vaughan¹ occurs at the base of D₂ in County Clare, associated with *Campophyllum* aff. *marginatum*, Thomson.

Lithostrotion.

NEMATOPHYLLUM (LITHOSTROTION) MINUS, M'Coy. (Pl. XXVII, figs. 1, 2 a, & 2 b.)

M'Coy, Ann. & Mag. Nat. Hist. ser. 2, vol. iii (1849) p. 17; and 'Brit. Palaeozoic Fossils', 1855, p. 99 & pl. iii B, fig. 3.

A form which occurs in great abundance, and constitutes a definite horizon near the summit of S₂ in County Clare, bears a close resemblance to M'Coy's species. The type, figured in his 'Palaeozoic Fossils,' which is now in the Sedgwick Museum at Cambridge, is but a poorly preserved specimen, and a description of this species from further material seems desirable.

The corallites are slightly larger than in the Clare form, but a small fragment, polished to show a vertical section, appears to have an identical structure.

The following is an emended description of this species:—Corallites prismatic, with rarely more than six sides: average diameter=about 3 lines; epitheca, when visible, exhibiting longitudinal striations. M'Coy's distinction between separable and non-separable corallites does not appear justifiable, as in many cases this is merely a matter of fossilization; specimens from the same bed differ widely in this respect, though identical in a thin section.

Vertical section.—The centre of the corallite is occupied by a thin rod-like columella, measuring about half a line in width; inner area composed of slightly curved vesicular plates, with their convex sides directed outwards and upwards; and it takes as a rule about three plates to reach from the axis to the external boundary of the area.

The outer area is of approximately the same width as the inner: it consists of four or five rows of vesicular plates, of smaller size and more regular arrangement than those of the inner area, and having their convex sides directed upwards and inwards.

Horizontal section.—Boundary between individual corallites well marked. Columella usually ill-defined, compressed laterally.

The septa average 42 in number, and the major and minor series are of equal thickness. The former reach the columella, but the latter only project a short distance beyond the inner wall. The medial area comprises about three rows of obscure vesicles, bounded by a more or less distinct inner wall. The external area has five or more rows of vesicles, with, as a rule, a regular concentric arrangement.

¹ Quart. Journ. Geol. Soc. vol. lxiv (1908) p. 461 & pl. xlix, fig. 7.

CLISIOPHYLLID LITHOSTROTION. (Pl. XXVII, fig. 3.)

This form, which is essentially similar to that figured by Dr. Vaughan¹ from D₁ of the Bristol District, occurs in some abundance near the base of D₁ in County Clare.

Dibunophyllum.

DIBUNOPHYLLUM aff. ψ , Vaughan. (Pl. XXVII, fig. 6.)

In a horizontal section this form appears to be closely related to *Dibunophyllum* ψ .² It agrees with the Bristol form in the thickening and extension of the mesial plate, and in the approximate number of vertical lamellæ. The central area is, however, less strongly bounded, and its cuspidate nature is not well marked, although the septal fossula is conspicuous.

The minor septa are much more strongly developed in the Irish form, even more so than in *D. matlockense*, Sibly,³ and extend to the inner wall. The latter feature is not so well defined as in the typical *Dibunophyllum* ψ .

Carcinophyllum.

CARCINOPHYLLUM sp. (Pl. XXVII, fig. 5.)

Form conical, epitheca with faint longitudinal striations.

Horizontal section.—The central area is nearly circular, and has a sharply defined boundary. There is usually some indication of an irregular, thickened, mesial plate from which project a number of vertical lamellæ, which, as they approach the outer margin of the area, assume a spiral arrangement and often produce an open vesicular structure.

The major septa are 35 to 37 in number, and the majority of them reach the central area. The minor septa project inwards a short distance from the inner wall.

A septal break is marked by a considerable elongation of one of the minor septa. The inner wall is very conspicuous, and forms a dense ring due to the approximation and thickening of the outer ends of the two series of septa. A narrow peripheral vesicular ring is sometimes seen; but, as rejuvenescence is common, it is rarely developed to any great extent.

Discussion.—This form, which is abundant at the top of S₂ in County Clare, is closely related to *Carcinophyllum mendipense* from S₁ of the Mendip area,⁴ agreeing with that species in the character of the inner wall, the marked septal break, and the compressed peripheral vesicular area, but differing in the nature of the central area which, in the Irish form, is spiral in structure as opposed to radial. It is distinguished from *Carcinophyllum curkeenense*, Vaughan,⁵ by

¹ Quart. Journ. Geol. Soc. vol. lxi (1905) pl. xxiii, fig. 5.

² A. Vaughan, *ibid.* pl. xxiv, fig. 2a. ³ *Ibid.* vol. lxiv (1908) pl. i, fig. 2.

⁴ See T. F. Sibly, Quart. Journ. Geol. Soc. vol. lxii (1906) p. 360 & pl. xxxi, fig. 4.

⁵ *Ibid.* vol. lxiv (1908) p. 464 & pl. xlix, fig. 5.

the projection of the minor septa from the inner wall, and from *Carcinophyllum* θ , Vaughan,¹ by the absence of a coarsely vesicular peripheral area, by the more strongly marked inner wall, and by the nature of the central area. The character of the inner wall readily distinguishes it from *Carcinophyllum kirsopianum*, Thomson.²

It has not been deemed advisable to assign a new specific name to this form, since it is distinguished from others chiefly by the character of its central area, which is of little value as a diagnostic feature, varying, as it does, in different sections cut from the same specimen.

IX. BIBLIOGRAPHY.

The following is a list of the sources from which I have drawn information in the preparation of the palæontological portion of this paper:—

- CARRUTHERS, R. G. 'A Revision of some Carboniferous Corals' *Geol. Mag.* dec. v, vol. v (1908) pp. 20, 63, & 158.
- DAVIDSON, T. 'Monograph of the British Fossil Brachiopoda' vol. ii (1858-63). Palæontographical Society.
- FOORD, A. H. 'The Carboniferous Cephalopoda of Ireland' 1897-1903. Monographs of the Palæontographical Society.
- HIND, WHEELTON. 1. 'The British Carboniferous Lamellibranchiata' vols. i & ii, 1896-1905. Monographs of the Palæontographical Society.
- . 2. 'Notes on the Homotaxial Equivalents of the Beds which immediately succeed the Carboniferous Limestone in the West of Ireland' *Proc. Roy. Irish Acad.* vol. xxv (1905) Sect. B, pp. 93-116.
- KEYSERLING, A. G. VON. 'Wissenschaftliche Beobachtungen auf einer Reise in das Petschora Land im Jahre 1843' St. Petersburg, 1846.
- KONINCK, L. G. DE. 1. 'Nouvelles Recherches sur les Animaux Fossiles du Terrain Carbonifère de la Belgique' 1872.
- . 2. 'Faune du Calcaire Carbonifère de la Belgique' (Brachiopods) *Ann. Mus. Roy. Hist. Nat. Belg.* vol. xiv (1887) and others of the same series.
- M'Coy, F. 1. 'Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland' 1844.
- . 2. 'Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge' 1851-55.
- MILNE-EDWARDS, H., & JULES HAIME. 'Monograph of the British Fossil Corals' pt. 3, 1852. Palæontographical Society.
- PHILLIPS, J. 'Illustrations of the Geology of Yorkshire,' pt. ii, 1836.
- SIBLY, T. F. 1. 'The Carboniferous Limestone (Avonian) of the Mendip Area' *Quart. Journ. Geol. Soc.* vol. lxii (1906) p. 324.
- . 2. 'The Faunal Succession in the Carboniferous Limestone (Upper Avonian) of the Midland Area' *Quart. Journ. Geol. Soc.* vol. lxiv (1908) p. 34.
- THOMSON, J. 1. 'On the Development & Generic Relation of the Corals of the Carboniferous System of Scotland' *Proc. Phil. Soc. Glasgow*, vol. xiv (1882-83) p. 296.
- . 2. 'On the Genera *Calophyllum* & *Campophyllum*' *Proc. Roy. Irish Acad.* ser. 3, vol. ii (1893) p. 667.
- VAUGHAN, A. 1. 'Notes on the Corals & Brachiopods obtained from the Avon Section & preserved in the Stoddart Collection' *Proc. Bristol Nat. Soc. n. s.* vol. x (1902-1903) pp. 90-134 & pls. i-ii.
- . 2. 'The Palæontological Sequence in the Carboniferous Limestone of the Bristol Area' *Quart. Journ. Geol. Soc.* vol. lxi (1905) p. 181.
- & C. A. MATLEY. 3. 'The Carboniferous Rocks at Rush (County Dublin)' *Quart. Journ. Geol. Soc.* vol. lxii (1906) p. 275.
- . 4. 'The Carboniferous Rocks at Loughshinny (County Dublin)' *Quart. Journ. Geol. Soc.* vol. lxiv (1908) p. 413.

¹ *Quart. Journ. Geol. Soc.* vol. lxi (1905) p. 235 & pl. xxiv, fig. 3 b.

² *Proc. Phil. Soc. Glasgow*, vol. xiv (1882-83) p. 456 & pl. xii, fig. 9 a.

EXPLANATION OF PLATES XXVI & XXVII.

[All the figures are of the natural size, unless otherwise stated.]

PLATE XXVI.

Avonian Brachiopods from County Clare.

- Fig. 1 *a. Spirifer konincki*, sp. nov., dorsal view. *Syringothyris* Zone, Cratloe.
 1 *b. The same specimen, ventral view.* (See p. 574.)
 2. *Athyris glabristria* (Phill.). *Syringothyris* Zone, Tulla. (See p. 572.)
 3. *Dielasma* aff. *kingi*, de Kon. *Syringothyris* Zone, Crusheen. (See p. 571.)
 4. *Athyris lamellosa* (L'Éveillé). *Clathratus* subzone, Gourn River. (See p. 573.)
 5. *Athyris hibernica*, nom. nov. *Syringothyris* Zone, Cratloe. (See p. 573.)
 6. *Spirifer* aff. *clathratus*, M'Coy & Vaughan. *Syringothyris* Zone, Cratloe. (See p. 574.)
 7. *Spirifer attenuatus*, J. de C. Sow. *Syringothyris* Zone, Cratloe. (See p. 574.)

PLATE XXVII.

Avonian Corals from County Clare.

- Fig. 1. *Nematophyllum (Lithostrotion) minus*, M'Coy. Much enlarged. S₂, Ballyvaghan. (See p. 580.)
 2 *a. The same. Natural size.*
 2 *b. Vertical section of one corallite.*
 3. Clisiophyllid *Lithostrotion*, Vaughan. D₁, Ballyvaghan. (See p. 581.)
 4. *Zaphrentis* sp. S₂, Ballyvaghan. (See p. 577.)
 5. *Carcinophyllum* sp. S₂, Ballyvaghan. (See p. 581.)
 6. *Dibunophyllum* aff. *ψ*. D₂, Glencolumbkille. (See p. 581.)
 7. *Densiphyllum* sp. D₃, Corrofin. (See p. 578.)
 8. *Campophyllum cylindricum* (Scouler). Horizon γ, Sixmilebridge. (See p. 578.)
 9. *Zaphrentis omaliusi*, var. *densa*, Carr. Z₁, Gourn River. (See p. 576.)
 10. *Campophyllum* sp. S₁, Crusheen. (See p. 579.)
 11. *Zaphrentis vughani*, sp. nov. Z₁, Gourn River. (See p. 577.)
 12. *Caninia* aff. *cornucopiæ*, Mich. D₃, Bushy Park House. (See p. 579.)
 13. *Diphyphyllum* aff. *subibicinum* (M'Coy). D₂, Glenquin. (See p. 580.)
 14. *Caninia cornucopiæ*, Mich. Calyx. Horizon γ, Sixmilebridge. (See p. 579.)

DISCUSSION.

THE PRESIDENT (Prof. SOLLAS) congratulated the Author on his earnest and long-continued labours having culminated in so successful a conclusion. It was extremely gratifying to find that the facts in County Clare were in general harmony with those observed on the banks of the Avon; confidence in the zonal method and in the particular system of zones proposed for the Carboniferous Limestone was thereby strengthened. The discovery of the Waulsortian fauna in its proper place, between the Viséan and the Tournaisian, was a very fortunate circumstance; it added to the completeness of the British series in a locality as far west as the zoning of the Carboniferous could be carried in the Old World. The next step must be to

Fig. 1a.

Fig. 2.

Fig. 1b.

Fig. 3.

Fig. 5.

Fig. 4.

Fig. 6.

Fig. 7.

J. A. Douglas, Photogr.

Bemrose, Collo., Derby.

AVONIAN BRACHIOPODS FROM COUNTY CLARE.

Fig. 1.

Fig. 2b.

Fig. 2a.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

J. A. Douglas, Photogr.

Bemrose, Collo., Derby.

AVONIAN CORALS FROM COUNTY CLARE.

trace the zones into the East, and the discovery of leading fossils in Tian-Shan was of happy augury. The alliance of petrological and palæontological characters, so strikingly illustrated by the correspondence between the boundary-line adopted by the Irish surveyors in the field and that based on zonal palæontology, was continually gaining in importance, and might still have some unexpected application in store.

Dr. T. F. SIBLY expressed his satisfaction in learning that the faunal succession of the South-Western Province was so closely paralleled in the distant region of the West of Ireland. The sequence described by the Author was one of exceptional interest. Each zone, and almost every subzone, of the typical Avonian succession appeared to be clearly defined; while the additional development of a *Cyathaxonia* subzone constituted an extension of the typical sequence, and furnished an interesting point of agreement with the succession in the Midland Province, where that subzone formed so conspicuous a feature. The great thickness of the *Dibunophyllum* Zone was another characteristic in common with the Midland development. Special points to which the speaker drew attention were, the large development of chert in the Upper *Zaphrentis* Zone (paralleled in the Mendip area), and in the Burren Limestone (paralleled in part by the great cherty series of D_2 in the Midlands); also the occurrence of *Lonsdalia duplicata*, an uncommon and very distinctive fossil, at the precise horizon at which the same species occurred in Derbyshire, namely, the top of D_2 . In conclusion, he wished to congratulate the Author upon his successful investigation of a very important area.

Mr. COSMO JOHNS said that he was pleased to learn that a normal Carboniferous development, so far west as County Clare, had been carefully investigated. He would have liked a more detailed account of the fauna which marked the base of the Viséan: in many parts of Britain it formed a distinct and very important horizon. It would also be interesting to learn the nature of the evidence on which the Author relied when drawing a line between the several zones. A very desirable method of investigation would be to map the more important faunal lines for comparison with a map indicating the lithological divisions. He thought that caution should be exercised in referring to the divisions that had been made in the Belgian sequence. The tangled sections of that country would best be straightened out by reference to the many clear and uninterrupted exposures in Britain.

Dr. IVOR THOMAS deprecated the use of the names 'Viséan' and 'Tournaisian' at the present stage of Carboniferous Limestone research, especially as the Belgian sequence had not yet been zoned on the lines suggested by Dr. Vaughan. Moreover, the typical Viséan and Tournaisian of Belgium appeared to be only locally developed. The Viséan of Visé passed downwards into a mass of practically unfossiliferous dolomitic rocks—the so-called 'Devonian' of certain Belgian geologists; while the Tournaisian of the Namur

district was not followed by typical Viséan. Since the district under consideration showed such an agreement with the Bristol sequence, it would seem preferable to use Dr. Vaughan's names—Clevedonian and Kidwellian. The Author was to be congratulated upon the clearness with which the paper was set forth.

Mr. W. P. D. STEBBING drew attention to the, to him, peculiar physical features shown by some of the views of the bare fissured limestone of the northern part of the area dealt with, and said that it reminded him of the eaten-out surface of the top of one of the spurs of the Carrara range above Massa-Carrara. The mountain-top, from which a black-veined marble was quarried, to which he referred, was similarly cut up; but a certain amount of coarse vegetation grew on the surface, and the quarrying showed that red earth partly filled the fissures.

Mr. R. H. TIDDEMAN begged to remind the previous speaker that bare and arid tracts of Carboniferous Limestone were by no means so rare as he had seemed to imply. They were quite common in the North-West of England on and about the Pennine chain, as, for instance, around Ingleborough. The Author's description of the limestone reminded him generally of the succession in the Clitheroe district near Pendle.

Prof. GARWOOD referred to the name *Syringothyris-cuspidata* Zone, and asked the Author whether this species occurred also in beds of D_2 age in his area, as was the case in Derbyshire. Martin's type-specimen (he understood) came from beds of D_2 age at Castleton, not from C_2 . He was interested to hear that the well-marked break which occurred above C_2 in the Northern Pennines was also found in the Author's district; he thought that a widespread period of submergence would be found everywhere at the beginning of S_2 . He considered that the coincidence between the lithological character and the faunal zones to which previous speakers had alluded was only what might be expected: for instance, *Zaphrentis enniskilleni*, which was limited to the shaly beds at the top of C_2 in Westmorland, survived into higher beds in the Isle of Man, where the argillaceous type of deposit continued longer, and was again characteristic of D_2 under similar conditions elsewhere. He congratulated the Society on receiving another important contribution on this interesting subject.

The Author regretted that lack of time prevented him from answering many of the questions in detail. In reply to Prof. Garwood, he said that very large specimens of *Syringothyris cuspidata* were common in the *Syringothyris* Zone, but the genus seemed to be entirely absent from the Viséan. Zaphrentids closely allied to *Zaphrentis enniskilleni* were found as low down as the *Seminula* Zone.

Replying to the President, he thought that the enormous abundance of large-sized individuals in the *Syringothyris* Zone among all classes of the mollusca and of the brachiopoda, as well as the great number of species represented, was not at all suggestive of

deep-water conditions ; moreover, a few miles to the south, the Limerick volcanic rocks were found at this level, affording further proof of elevation. With regard to the origin of the chert, it was of interest to note that in the topmost beds it was found to occur in well-defined tabular bands, but elsewhere in the succession as nodules scattered throughout the limestone.

In reply to Dr. Thomas, the Author said that he had visited Belgium, and had been much impressed with the similarity between the fauna of the Tournaisian and Viséan limestones and that of the British Carboniferous Limestone. In conclusion, he thanked all those Fellows who had taken part in the discussion, and at the same time took the opportunity of expressing his thanks to the Council of the Society for their award to him of the Daniel Pidgeon Fund.