THE CARBONIFEROUS ROCKS BETWEEN THE OX MOUNTAINS AND DONEGAL BAY

By

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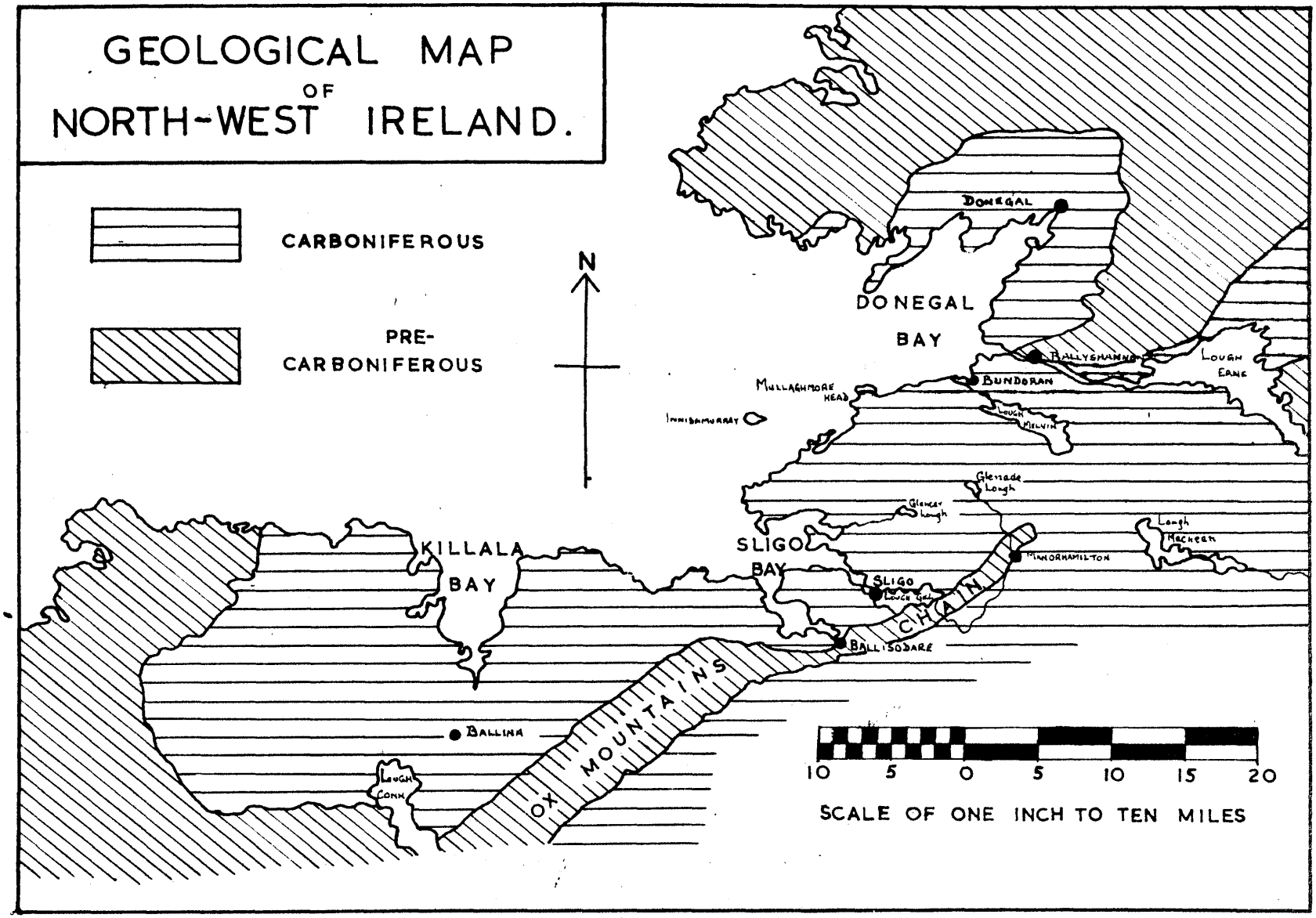
Table of Contents


GEOLOGICAL MAP
OF
NORTH-WEST IRELAND.
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PRE-
CARBONIFEROUS
N
DONEGAL
DONEGAL
BAY
BALLYSHANNON
LOUGH
ERNE
BUNDORAN
MULLAGHMORE
HEAD
INNISHMURRAY
LOUGH
MELVIN
Glenade
Lough
Glencar
Lough
KILLALA
BAY
SLIGO
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Macnean
MANORHAMILTON
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Lough Gill
CHAIN
BALLISODARE
MOUNTAINS
OX
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10 5 0 5 10 15 20
SCALE OF ONE INCH TO TEN MILES

1. INTRODUCTION.

The Lower Carboniferous rocks described in this paper cover a wide outcrop in the Counties of Sligo, Leitrim and southern Donegal; coming to outcrop over an area of some 230 square miles, they extend from Ballyshannon in the north to Ballisodare in the south, and thence westwards along the Ox Mountains chain to Kiltycloughter. The Carboniferous outcrop is continued in the north-east into the mountains of Fermanagh, and to the east it passes under rocks of Upper Carboniferous age.

The district generally may be regarded as mountainous; the Benbulben Range and the Dartry Mountains occupy the central parts, being bounded on the north and west by a low coastal belt three to five miles wide. The northern extremity of the Ox Mountains chain enters the area from the south-west and extends as far as Manorhamilton; between this and the Benbulben Range lies a rugged mountainous area similar to the central tracts.

The Benbulben Range and the Dartry Mountains consist of a deeply dissected plateau rising by sharp precipitous escarpments to more than 1300 or 1400 feet above the coastal plain. The undulating moorlands of the Benbulben plateau culminate in Truskmore (2113 feet),

while the Dartry Mountains above Lough Melvin rise in many places above 1500 feet, and reach over 1700 feet in the north-west.

Two great passes, Glenade and Glencar, intersect the central mountain mass, each with its lake of the same name enclosed by sharp and often sheer precipices. These passes have resulted from the deepening and widening of pre-Glacial valleys by ice action.

Lough Gill and the south-western flanks of Lough Melvin also lie within the area.

Throughout the area there is an intimate relationship between geology and topography. The lower limestones and shales form the coastal plain and occupy the valley floors, while above this tract the overlying sandstone rises as a small escarpment to the foot of the mountain ranges which are crowned by steep or overhanging cliffs of massive limestone. The undulating, bog-covered, mountain tops are formed of shale which is capped by sandstone rising from it in another small escarpment.

Drainage.

The rainfall of the area is 40-50 inches per annum, and the local drainage is principally westwards.

The drainage is by swift rushing mountain torrents which descend into lakes or sluggish rivers and thence to the sea. Lough Melvin receives the drainage of the northern and eastern slopes of the Dartry Mountains, and flows into Donegal Bay by the Drowes River, south of Bundoran. The western slopes of the mountains are drained by the Grange and Duff rivers. Glencar Lough drains by the Drumcliffe River into Drumcliffe Bay. Glenade Lough is drained by the Bonet River, which flows south-east through the end of the Ox Mountain chain, turns south at Manorhamilton and leaves the area; it returns again through the Ox Mountains and flows north into Lough Gill, which has its outlet to the sea by the Garvoge at Sligo.

In the north, the River Erne flows into Donegal Bay at Ballyshannon.

2. HISTORY OF RESEARCH.

The first geological map of the area was published by Sir Richard Griffith---"The Father of Irish Geology"---in 1818, and included the area west and south-west of Sligo. Griffith, who commenced mapping in 1811, carried out the first detailed stratigraphical study of the area. His "Geological Map of Ireland", which he presented to the British Association in 1835, was subsequently published in 1837, together with an "Outline of the Geology of Ireland". A revised edition was published in 1855. Griffith used lithology as the basis for his mapping, and subdivided the Carboniferous into three main groups---the Yellow Sandstone, the Limestone Group and the Coal Group. In the area now considered only the Limestone Group is present, and this was subdivided by Griffith into the Lower Limestone, the Middle Limestone or Calp, and the Upper Limestone.

Griffith's map was the greatest single contribution ever made to Irish Geology. His conclusions did not, however, pass unchallenged, especially in the ground between Ballyshannon and the Dartry Mountains. Griffith considered the succession to be an ascending one from Ballyshannon of :- Lower Limestone, Calp

(shale, sandstone and shales with impure limestones) and Upper Limestone; but Verschoyle (Apjohn 1842) suggested that the sandstone was Old Red Sandstone, and the lower series Silurian. Kelly (1857), who denied the existence of Calp, considered the sandstone to be Old Red Sandstone. The beds underlying this sandstone he regarded as the same as the overlying beds, dropped down by a great fault.

The first geological account dealing specifically with the Sligo area was by Wynne, in 1863. It provided a more detailed description than that given by Griffith, and included some new observations.

Jukes published his "Geological Map of Ireland" in 1868, and this was followed by Hull's in 1878; both these maps incorporated the latest findings of the Irish Geological Survey.

The area is covered by parts of the one inch sheets Nos. 31, 32, 42, 43, 44 and 55, published 1873-1888, and is described in the accompanying memoirs. The mapping was on a lithological basis and the stratigraphical divisions adopted were founded on those of Griffith.

An excursion of the Geologists' Association to the West of Ireland was held in 1912. A pamphlet issued for this excursion included a paper by Cole on

the Mallaranny and Sligo Districts, and by Wright on the Lower Carboniferous succession at Bundoran. In this latter the first attempt to zone the strata was made.

In 1924 a "Handbook of the Geology of Ireland" by Cole and Hallisey was published. This added little to what was already known of the Sligo district.

3. GENERAL OUTLINE OF THE SUCCESSION.

The Lower Carboniferous rocks of the north-west of Ireland were deposited in what finally became a deep basin of sedimentation between the Dalradian rocks of the Ox Mountain chain in the south and those of Donegal and Londonderry in the north. The Ox Mountains chain divides two contrasting areas of Lower Carboniferous sedimentation in Ireland.

The term 'Dalradian' is employed throughout this paper in conformity with the name given to the metamorphic rocks in the north and west of Ireland by the Geological Survey. Some of these rocks in Ireland which were termed 'Dalradian' by the Geological Survey have, however, since been proved, by Anderson, to be the equivalent of the Moine Series in Scotland.

The Lower Carboniferous succession is readily divisible into a series of well-defined lithological groups. A thicker succession is present between Ballyshannon and the Benbulben Range than elsewhere, the succession present in the Lurganboy and Manorhamilton areas being reduced particularily in the lower members. Along much of the contact various members of the Carboniferous strata are faulted against the Dalradian rocks.

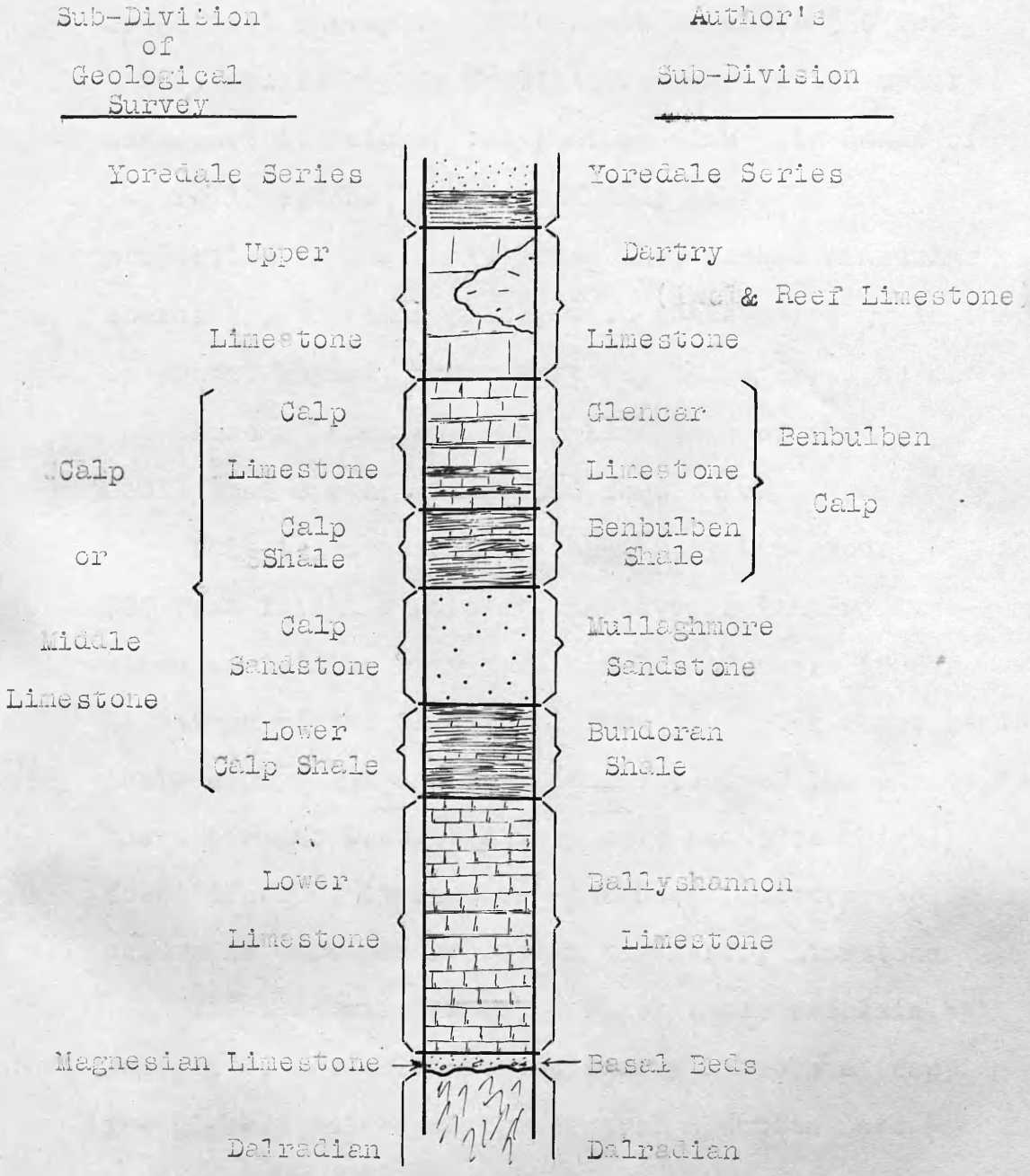
(a) Ballyshannon---Benbulben.

The oldest Carboniferous rocks of the area lie in the extreme north, resting with strong unconformity on the metamorphic rocks east of Ballyshannon. The Basal Beds (Magnesian Limestone of the Geological Survey) are a dolomitic limestone, with fragments of schist and pebbles of vein quartz, about 50 feet thick. They form the base of a conformable sequence, of about 4000 feet, of gently dipping Lower Carboniferous strata. (Fig. 1).

They are succeeded by the Ballyshannon Limestone (Lower Limestone of the Geological Survey), a highly fossiliferous, thin-bedded, argillaceous limestone with bands of chert and intercalations of shale, 1200 feet thick.

The Ballyshannon Limestone is overlain by the Bundoran Shale (Lower Calp Shale of the Geological Survey) which throughout its 450 feet is highly fossiliferous.

The next member of the series is the 600 foot-thick Mullaghmore Sandstone (Calp Sandstone of the Geological Survey), a felspathic sandstone with intercalations of fossiliferous shale, which passes upwards through flaggy micaceous passage beds into



Vertical Scale: One inch to 800 feet.

Fig. 1.

the Benbulben Shale (Upper Calp Shale of the Geological Survey). This shale is about 350 feet thick, and is highly fossiliferous. In its uppermost part it becomes interbedded with thin bands of impure limestone, which gradually increase in proportion to the shale beds; they assume a nodular character, becoming platey with shale partings in the uppermost layers, where they may be referred to as the Glencar Limestone (Calp Limestone of the Geological Survey), some 600 feet thick.

This is succeeded by the Dartry Limestone, 600 to 700 feet thick, a compact, massive, splintery limestone containing bands and nodules of chert (Upper Limestone of the Geological Survey). The chert bands increase upwards and form 50 per cent of the strata in the uppermost beds. A very pure, and often highly fossiliferous, limestone---the Reef Limestone---occurs as unbedded masses in the Dartry Limestone.

The Yoredale Series, a black shale overlain by sandstone, occurs above the Dartry Limestone, capping the highest points of the central mountain mass.

(b) Lurganboy---Manorhamilton.

At the north-eastern end of the Ox Mountains chain the disposition of the Carboniferous strata on

the west, at Lurganboy, and on the east, at Manorhamilton, is very much disturbed by faults, so that a continuous vertical section is not seen.

Lurganboy Area.

A basal conglomerate passing up into a coarse grit rests on the metamorphics near the village of Lurganboy. This Basal Bed is of varying thickness from 60 to 80 feet maximum, and is overlain by a dolomitic limestone which passes up, in some 400 to 500 feet, through limestone with chert, and oolitic limestone and argillaceous limestones and shales, into a felspathic sandstone. This sandstone, which is about 400 feet thick, is overlain by 500 to 600 feet of shales and limestones which pass up into the reef facies of the Dartry Limestone, no massive limestone with chert being present.

Manorhamilton Area.

From Manorhamilton north-east to the end of the Ox Mountains chain the basal member of the Carboniferous is a dolomitic limestone. This is overlain by a shale and sandstone group, which passes up through a highly fossiliferous argillaceous limestone and shale into the Dartry Limestone. The reef facies is well developed in the north, and Dough Hill forms

a Reef Knoll on which the Yoredale Sandstone rests.

The Carboniferous Limestone passes under the Yoredale Series to the east, the lowest member of which is a sandstone, overlain by the Yoredale Shale.

4. DETAILED DESCRIPTION OF THE SUCCESSION.

The area may be conveniently divided into two regions, western and eastern. In the former, which includes the coastal plain and all the central and southern mountain district, from Lough Melvin to Lough Gill, the full succession is seen.

The name "calp" was given as a lithological term by Kirwan, in 1800, to the black argillaceous limestone in the vicinity of Dublin. Griffith used the name "Calp" as a stratigraphical term. In this region the Calp Series of the Carboniferous is best developed, and Griffith stated that ".....it was solely from the clear exhibition of their strata, as seen in the precipitous cliffs of the remarkable mountain district of the counties of Sligo, Fermanagh, Cavan, Leitrim and Roscommon, that the subdivision of the series has been attempted."

The eastern region lies around the north-eastern end of the Ox Mountains chain and here sedimentation has been influenced by the anticlinal effect of this old axis of uplift, producing a reduced thickness in the succession.

(1) The Western Region.

(a) Basal Beds.

The local base of the Carboniferous rocks, recognisable about a mile east of Ballyshannon, is poorly exposed, for much of the ground in which it occurs has been flooded by the lower lake of the new hydro-electric scheme constructed on the River Erne. However, this is partly compensated for by an excellent section of the basal unconformity seen in a new road cutting south of Knader Lough. At this point the base is seen to consist of a coarse brown pebbly dolomite with large (up to 18 inches) and small derived angular fragments of schist and vein quartz, dipping to the south at 10°-12° and resting with marked unconformity on a quartz-mica-schist which dips to the north at 40°-50°.

This basal bed is about two feet thick, and passes up into a finer saccharoidal dolomite with pebbles of vein quartz up to three-quarters of an inch diameter. Exposures are more abundant further east where the outcrop widens, and in the uppermost part coarse detrital material is almost absent.

The basal series is about 40-50 feet thick. The

exact thickness cannot be accurately determined, as the overlying Ballyshannon Limestone is faulted against the dolomite to the west. To the east the junction is covered by the new lake. I was able to consult the geological maps of this area made for the construction company before the area was flooded, and the thickness has been calculated from the information thus gained.

No fossils have been recorded from the Basal Beds.

(b) Ballyshannon Limestone. (1200 feet).

The Ballyshannon Limestone forms a wide outcrop in the country south from Ballyshannon almost to Bundoran. The lower passage beds are not seen. Strata lying not far above the base are well exposed, however, in the newly deepened channel of the River Erne between Kathleen's Falls and the sea, where they are seen dipping south at 10°. They consist of highly fossiliferous thin-bedded, dark, earthy limestones with shale partings. Further south the limestone becomes more massive, and assumes a coarsely fragmental character with abundant crinoidal debris and nodules of chert. The beds are extensively exposed in nearly all the fields for about two miles south of the River Erne, and also in two large quarries

just south of Ballyshannon railway station. Dipping gently southwards at about 6°, they are very much dolomitised.

In the fields on both sides of the road from Ballyshannon to Bundoran, the limestones crop out continuously and are locally dolomitised. From Finner Camp the limestone can be followed west along the strike to the Fairies Bridge, north of Bundoran. They are here well exposed, and are very fossiliferous in the cliff section between the Fairies Bridge and Aughrus Point. At the latter place they are followed by an argillaceous limestone, and then pass upwards abruptly into the Bundoran Shale.

Further south, the Ballyshannon Limestone forms the coastal plain in the broad stretch of low country which lies west of a line from Grange to Carney. Inland exposures are poor, the half-dozen south of Grange displaying dips up to 45°. North of Grange the limestone, a massive dark-grey, slightly argillaceous rock with thin bands and nodules of chert, is exposed in five quarries where it is seen dipping steeply and in various directions.

The coast provides an almost continuous section from the mouth of the Grange river at Streedagh Point south-westwards to Serpent Rock, and thence east along

the north shore of Sligo and Drumcliffe Bays. The continuity is broken only by sandy bays and storm beaches.

At Streedagh Point thick-bedded argillaceous limestones and shales are underlain by about 25 feet of thin fossiliferous shale with bands of impure limestone. These beds dip almost due west at from 10° to 14°. The beds are extremely fossiliferous, many of the fossils, being silicified, standing out above the weathered limestone. Vast numbers of corals referred to Caninia cylindrica occur on every bedding plane of the limestone and project from the weathered bands of shale. Wynne described them as ".....like stumps in a cabbage-garden, and one is almost dissappointed to find that they cannot pull them up; some of them are from 18 inches to 2 feet long, and 2 to 3 inches in diameter". The description is apposite, but corals are much more numerous than it suggests, often several lying on top of one another on one bedding plane.

The succession can be followed through a thickness of about 300 feet southwards along the coast, for the dip swings south and the beds lie in a gentle syncline between Streedagh Point and Serpent Rock, where as the name suggests, a similar profusion of large Caninias is found. Between these two head-

lands the limestone is thick-bedded and often contains much chert in nodules and bands. The limestone is not so fossiliferous, but about a mile south of Streedagh Point two bands of Lithostrotion, about 9 inches thick, occur and can be followed along the shore for about 100 yards before they swing out to sea. Overlying these a thin band of shale occurs which is often very fossiliferous. The limestones along the shore are often incompetently folded into a series of small anticlines and synclines pitching in the direction of regional dip.

A similar succession is repeated from Serpent Rock to Lissadell. On the shore below Lissadell garden a bed of shale, about 25 feet thick, similar to that seen below the limestone at Streedagh Point, is highly fossiliferous.

At Rosses Point the lithology is similar to that seen south of Ballyshannon; the limestone is dolomitised, and is faulted against the schist on both the north and the south and dips away from it at from 10° to 15°, and more steeply so close to the fault. In the bay to the east of the peninsula, the limestone is at one point interstratified with black chert, the alternating bands being about 3 to 4 inches thick

throughout a cliff of about 30 feet. The limestones here on both the north and the south sides of the peninsula contain many large Caninias.

The succession is continued on Coney Island, where the limestone is interbedded with shales, the strata being highly fossiliferous, especially on the north shore of the island.

On the south shore of Sligo Bay, at Gibraltar Point, the rocks have a lithology and a fauna like those seen at Streedagh Point, though the Caninias are not so abundant. The succession can be followed upwards for about 50 feet in the shore section to the west, and interbedded shales are often highly fossiliferous.

Inland exposures are poor, the limestone being seen in only three quarries and one small crag between the shore and the base of Knocknarea.

The Ballyshannon Limestone is again seen north of Ballysodare, where it occurs faulted between the Dalradian and the Dartry Limestone. It is well exposed in a fossiliferous quarry south of the main Sligo-Ballisodare road as a thick-bedded, dark, argillaceous limestone with bands of chert, dipping almost due west at 35°.

Fossils obtained from the Ballyshannon Limestone include:

Athyris expansa (Phillips)

Camarotechia sp.

Chonetes cf. papilionacea (Phillips)

Dielasma hastata (Sowerby)

Leptaena cf. analoga (Phillips)

Linoproductus cf. corrugato-hemisphericus Vaughan

Productus garwoodi Muir-Wood

Productus sp.

Pustula cf. nodopustulosa Parkinson

Pustula sp.

Rhipidomella michelini (L'Éveillé)

Schellwienella sp. (large)

S. sp.

Schizophoria resupinata (Martin)

Spirifer princeps (M'Coy)

S. sp.

Tylothyris laminosa (M'Coy)

Caninia cornucopiae Michelin

C. cf. cylindrica (Scouler)

Cladochonus crassus (M'Coy)

Clisiophyllum multiseptatum Garwood

Cryptophyllum hibernicum Carruthers

Cyathaxonia cornu / Michelin

Lithostrotion affine Fleming

L. martini Edwards & Haime

L. portlocki (Bronn)

Michelinia grandis (M'Coy)

M. megastoma (Phillips)

Palaeacis sp.

Syringopora sp

Zaphrentis koninckl Edwards & Haime

Z. omaliusi Edwards & Haime

Z. enniskilleni Edwards & Haime

Belerophon sp.

Euomphalus sp. (large)

Conocardium hibernicum (Sowerby)

Phillipsia pustulata Phillips

Bryozoa, crinoids and foraminifera.

(c) Bundoran Shale. (450 feet).

The Bundoran Shale is well exposed throughout its thickness in the coast section from Aughrus Point to the mouth of the Drowes river. At Aughrus Point the shales dip to the south at 20° and are interbedded with bands on impure limestone; they are very fossiliferous. In Bundoran Bay the succession is broken by many small faults and there is much incompetent folding of the strata, which consist of very fossiliferous thin black shales. A bed of limestone about 3 feet thick forms the foreshore west of Bundoran; it can be traced for about half a mile along the shore and in the cliff. This is overlain by black shales with impure limestone bands and passes up into an argillaceous limestone with a band of sandy micaceous shale about 4 feet thick.

These and the overlying beds of calcareous sandstone and thin limestones form the passage between the Bundoran Shale and the Mullaghmore Sandstone. The junction is partly obscured by the estuary of the Drowes river which enters Donegal Bay at this point, but the passage seen east of the river appears to be a very gradual one.

In the Grange river estuary, shales similar to

those at Bundoran are exposed on the mainland shore opposite Dernish Island. They dip at 28° to 32° south-east on the shore, and inland a small exposure of shaley limestone is seen in the wood at Moneygold House.

The Bundoran Shale is seen again on the north-western slopes of Benbulben where, in the Grange river above Ardnaglass Bridge, muddy limestones are overlain by about 50 feet of thin black shales, and above them dark limestones and sandy limestones form the upper passage beds into the overlying sandstones.

In the area east of Rosses Point the Bundoran Shale appears to be absent. While the proximity of the Dalradian, at Rosses Point, may account for a slight change in lithology and reduction in thickness, it is unlikely that the whole thickness of the Bundoran Shale is included in the limestone and shale in the uppermost beds of the Ballyshannon Limestone. It is therefore inferred that the Bundoran Shale is here faulted out; the discordance in dip of the limestone and the overlying sandstone suggest that a fault is in fact present.

A small pocket of shale at the western end of the Rosses Point peninsula may well be of Bundoran Shale age; its position is discussed on page 82.

Fossils obtained from the Bundoran Shale include:

Athyris expansa (Phillips)

A. planosulcata (Phillips)

Camarophoria sp.

Chonetes destinezi Vaughan

C. sp. (small)

Leptaena cf. analoga (Phillips)

Linoproductus cf. corrugato-hemisphericus Vaughan.

Productus cf. flemingi Sowerby

P. cf. margaritaceus Phillips

Pustula cf. pustulosa (Phillips)

Rhipidomella michelini (L'Éveillé)

Schizophoria resupinata (Martin)

Spirifer striatus (Martin)

S. sp.

Tylothyris laminosa (M'Coy)

Amplexus coralloides Sowerby

Caninia cornucopiae Michelin

Cryptophyllum hibernicum Carruthers

Cyathaxonia cornu Michelin

Emmonsia parasitica (Phillips)

Michelinia grandis (M'Coy)

Michelinia tenuisepta (Phillips)

Zaphrentis enniskilleni Edwards & Haime

Z. enniskilleni (small) "

Z. koninckl "

Z. omaliusi "

Conocardium hibernicum (at base) (Sowerby)

Belerophon sp.

Euomphalus sp.

Bryozoa, crinoids and foraminifera.

(d) Mullaghmore Sandstone. (600 feet).

From the mouth of the Drowes river west to Mullaghmore Head there is a continuous exposure of a massive-bedded, often flaggy, felspathic sandstone dipping gently south-east. The sandstone varies in colour from yellowish-brown to nearly pure white. The continuity of the exposures is broken by a sandy bay at Mullaghmore, but the sandstone, anticlinal in structure, is well exposed on the headland. On the west side of the headland two thin bands of fossiliferous micaceous shale are exposed. The sandstone is often ripple-marked and strongly current-bedded, notably on Conors Island and Dernish Island where the outcrop is continued to the south, the beds dipping out to sea at 15°. On Conors Island it frequently assumes a lenticular character, with lenticles six feet high and three to four yards long.

The anticline between the islands and the mainland is broken by a fault throwing down to the northwest, the outcrop on the shore west of Bundoran being continued inland at Moneygold where the sandstone overlies the shale seen in the tidal estuary of the Grange river. This outcrop is cut off in the south-west by the Grange Fault which brings down the Mullaghmore

Sandstone against the Ballyshannon Limestone between Grange and Moneygold.

South of Bundoran the sandstone is exposed in an old quarry at the Rock of Bundoran, and again further east where it is quarried for road-metal. From the mouth of the Drowes river east through these two quarries the base of the sandstone forms a small escarpment. At the Rock of Bundoran the sandstone is often grey-coloured and flaggy, with coarse bands and bands of micaceous shale. These latter are frequently carbonaceous and contain small particles of coal.

In the Drowes river and north of Lough Melvin, the outcrop of the sandstone can be followed further east, the dip being to the south usually at from 3° to 6°, though sometimes increasing to 12°.

In all this ground, north of Lough Melvin and south-west of Bundoran, the Mullaghmore Sandstone is faulted down to the north and west by a great fault, the Kinlough Fault, which runs south-west from Kinlough towards Grange.

The sandstone forms the base of the whole central mountain district from the northern slopes of the Dartry Mountains south-west into Glenade and Gleniff and round the base of the Benbulben escarpment to the

Drumcliffe river. The dip is everywhere gentle in a south or south-easternly direction. The sandstone forms a small escarpment south of Kinlough and is exposed in small hillside bluffs and old quarries on the lower slopes of the Dartry Mountains. Further south the exposures are mainly confined to stream sections, but at Ballaghnatrillick it is seen in an old quarry and also in small crags above the village. Below the Benbulben escarpment the sandstone forms a prominent step rising above the bog-covered ground of the Bundoran Shale. The base of the sandstone is seen in a small waterfall half a mile east of Ardnaglass Bridge. Here it contains pebbles of vein quartz up to three-quarters of an inch in diameter. It is underlain by thin sandy micaceous shales and sandy argillaceous limestones, and then passes down through sandy shales into beds similar to those seen on the coast west of Bundoran.

Exposures further upstream reveal the same varying lithology and bedding structures as that seen on the shore. At Lukes Bridge the transition to the Benbulben Shale is well seen. These passage beds are flaggy dark sandstones with sandy limestones and sandy micaceous shales.

The outcrop of the sandstone is continued round to the south-west of Benbulben, but the only exposures in this area are near the top of the group, thin sandstones and dark sandy micaceous shales being seen 1½ miles north-west of the village of Drumcliffe; they dip at 3° east and pass below the Benbulben Shale.

South of Castlegal Mountain the Mullaghmore Sandstone occupies a small anticlinal outlier between the Castlegal Fault and the Sligo Fault. Exposures are frequent in the northern part, the sandstone being exposed in small crags and in most of the streams, where it is seen to dip northwards at 3°. In the southern part exposures are confined to stream sections, the sandstone dipping more steeply in a southernly or south-easternly direction. An excellent section is provided in a gorge on the northern side of the Urban Council Reservoir, where massive yellow sandstones, with some flaggy beds, almost horizontal, form two opposing cliffs over 25 feet high. Just north of this gorge the sandstone is seen in a river below the road bridge dipping at 30° to the south-west in a local flexure.

Lithology.

No heavy-mineral analysis of the sandstone has been made, but an examination of over forty thin sections, of specimens taken from widely separated localities and different horizons from the lower passage beds to the base of the overlying shale, shows that throughout there is a uniformity of composition and that the sandstone contains a high proportion of felspar.

The passage beds above and below are very similar; mica being present in the shales up to 10 per cent and calcareous material being preserved in the matrix.

The sandstone is generally fine-grained, the average size of the grains being 0·5 mm., though in coarser bands the grains reach 1·0 mm. In the hand specimen some beds are seen to contain pebbles of vein quartz up to three-quarters of an inch diameter (rarely an inch), and it is in these beds that the sandstone approaches a grit. Graded bedding has been observed on Conors Island.

The thin sections show the rock to be composed almost exclusively of quartz and felspar, the latter forming 40-50 per cent. The quartz grains are angular or subangular, a high degree of rounding never being obtained. The grains sometimes show an

addition of secondary silica to their margins. Many of the grains have a thin coating of iron oxide and all show undulose extinction between crossed nicols.

The felspar grains are always more rounded than the quartz, varying from subangular to round. Three types of felspar are present---orthoclase, microcline, and albite. The orthoclase is always cloudy and very much altered to kaolin and often to sericite. Some crystals have broken down into a fine mosaic of sericite and quartz. The microcline and albite show less alteration than the orthoclase, though neither is ever fresh and clear.

The interstitial cement is provided by a certain amount of secondary silica, but largely by the decomposition of grains of felspar resulting in clayey material between the grains of quartz. A few flakes of muscovite are always present in the cement, but this mineral, as noted above, is mainly carried in the shales.

The weak nature of the cement renders the sandstone liable to deep weathering when exposed to subaerial agencies; consequently it presents a friable nature on the exterior.

Source of the Detrital Material.

Although microcline and albite are present in the Donegal granite to the north, the ubiquituous presence of strained quartz in the sandstone points to the metamorphic rocks of the Ox Mountains and of Donegal as the obvious source of the detrital material. Thin sections of the metamorphics have shown that both microcline and albite are abundant in them, and orthoclase is a major constituent of the gneiss. Although garnet is locally abundant, and tourmaline has been recorded from the gneiss south of Lough Gill, neither of these minerals has been observed in any of the thin sections; a heavy-mineral analysis would no doubt reveal their presence.

Fossils obtained from the Mullaghmore Sandstone include:

Athyris sp.

Tylothyris laminosa (M'Coy)

Rhipidomella michelini (L'Éveillé)

Zaphrentis enniskillenl Edwards & Haime

Z. omaliusi "

Bryozoa and crinoid remains.

Indeterminable plant remains.

(e) Benbulben Shale. (350 feet).

Succeeding the Mullaghmore Sandstone is the Benbulben Shale, which is well exposed all round the lower slopes of the Dartry Mountains and the Benbulben Range, in stream and cliff sections.

Earthy limestones occur in the lowest beds. These are succeeded by 300 feet of thin black shales, with some bands of impure limestone in their upper layers. The shales are highly fossiliferous with brachiopods, corals, and bryozoa, especially in the top 100 feet where large Caninias occur in a profusion comparable with that seen at Streedagh Point.

The shale forms most of the southern shore of Lough Melvin where it dips at 3° to 5° to the south. The shale outcrop parallels that of the underlying sandstone, penetrating more deeply into the mountain passes and forming a wide outcrop on the valley floors. On the mountain-sides its upper limit is marked by a change in slope. The cliff face above is often sheer, but on the shale outcrop the angle of slope is seldom more than 60° to 70°.

Many landslips occur on the mountain slopes caused by the great weight of the porous limestone resting on the impermiable shale, the latter providing a plane of lubrication. One such landslip, in

Glencar, forms a small tree-covered hill separated from the sheer cliffs behind, and gives rise to the picturesque Swiss Valley which it isolates from the main Glencar valley.

In many other landslips, bare pyramids of shale occur surrounded by a vast accumulation of large blocks of the overlying limestone; this is very well displayed north of Benbulben and also on the northern slopes of the Dartry Mountains where several landslips have occurred in a small area. The shale banks are easily weathered and fossils, especially large Caninias, abound on the lower slopes.

Fossils obtained from the Benbulben Shale include:

Chonetes sp. (small)

Productus cf. flemingi Sowerby

Productus cf. margatitaceus Phillips

P. sp. (large)

Pustula cf. pustulosa (Phillips)

Leptaena cf. analoga (Phillips)

Spirifer cf. striatus (Martin)

Tylothyris laminosa (M'Coy)

Caninia cornucopiæ Michelin

C. cf. cylindrica (Scouler)

Lithostrotion irregulare (Phillips)

Zaphrentis enniskilleni Edwards & Haime

Z. omaliusi "

Bryozoa, crinoids and foraminifera.

(f) Glencar Limestone. (600 feet).

The transition from the Benbulben Shale into the Glencar Limestone is a very gradual one. The bands of impure limestone increase in thickness and the shale bands develop into bands of shaly and nodular limestone, until the mass becomes a thick-bedded, dark grey limestone with thin shale partings which disappear towards the top.

The Glencar Limestone is well exposed throughout the central mountain district, in the Glencar valley and south of Castlegal Mountain. In Glencar valley it forms the floor of the valley east of the lake. In the central mountain district it forms the lower part of the steep precipituous scarps which characterise the district. It may occur in the floor of the Glenaniff valley in the north, but since the overlying Dartry Limestone is seen at the mouth of the valley, a fault, for which there is no evidence, would be required to account for such an inlier.

The Limestone is excellently exposed in the valley of Glenade, where, especially on the southern side, the stratification forms a series of bands on the cliff which can be traced for several miles around the mountain sides.

Unlike the lower 'Calp' the Glencar Limestone is not richly fossiliferous.

Fossils obtained from the Glencar Limestone include:

Athyris expansa (Phillips)

Camarotechia sp.

Dielasma hastata (Phillips)

Leptaena cf. analoga (Phillips)

Linoproductus cf. corrugato-hemisphericus Vaughan

Productus multispiniferous Muir-Wood

Pustula cf. pustulosa (Phillips)

Spirifer sp.

Tylothyris laminosa (M'Coy)

Caninia cornucopiae Michelin

C. cf. cylindrica (Scouler)

Lithostrotion irregulare (Phillips)

L. martini Edwards & Haime

Zaphrentis enniskilleni "

Z. omaliusi "

Bryozoa, crinoids and foraminifera.

(g) Dartry Limestone. (600-700 feet).

The Dartry Limestone is the most widely distributed and extensively exposed formation in the area. The upper part of the great escarpment faces over the whole of the area are cut in it, and everywhere it forms the floor of the great dissected plateau of the central mountain mass. It caps most of the ground south of Glencar and Sligo to the Ox Mountains chain, against which it rests in faulted contact.

It is a massive, well jointed, grey crinoidal limestone, completely devoid of shale and containing bands and nodules of black or grey chert which increase in the uppermost part to form about 50 per cent of the rock. The purity of the limestone also increases upwards, the rock becoming a light grey, coarsely crystalline, crinoidal limestone towards the top. It is often locally dolomitised.

Its base can be easily traced on the mountain faces, for the dip is everywhere gentle, and the limestone well jointed; it therefore breaks away easily under subaerial erosion and the scarp is bare, steep, and often precipituous; and below it the more easily weathered Glencar Limestone gives a grassy slope,

though this too is often very steep.

The magnificent escarpments of Benbulben and Benwisken, and the sheer cliffs of Glenade and south of Lough Melvin, display this striking contrast at its best.

Most of the plateau is covered with mountain bog and the limestone is then seen only in swallow-holes, which abound upon the plateau surface. Where the limestone rises above the bog it presents strikingly the effects of chemical weathering; large areas, up to an acre in extent, are composed of isolated piles of dove-grey limestone, about two feet square and three feet high. These result from the opening of the joints and the bedding planes, the latter causing the impression of piled up plates of rock.

The high ground between Glencar and Lough Gill occupied by the Dartry Limestone presents a very rugged appearance, being made up of isolated hills with steep sides separated by narrow glens mostly controlled by massive bedding and strong jointing. The limestone here dips gently to the south-east or south, in many places being almost horizontal.

The southernly dip brings the Dartry Limestone onto the low ground south and west of Lough Gill,

along the southern shore of which it is faulted against the metamorphic rocks of the Ox Mountains range.

South-west of Lough Gill the Limestone dips away from the Ox Mountains at angles up to 30°, and forms the southern flank of a synclinal structure extending to the gently dipping strata east of Knocknarea. Knocknarea, in outline somewhat similar to some of the isolated hills south of Glencar, is composed of the Dartry Limestone, which also occupies all the ground between Knocknarea and the Ox Mountains except for the small faulted block of Ballyshannon Limestone recorded on page 21.

The limestone contains abundant silicified remains of corals, especially Lithostrotion.

Fossils obtained from the Dartry Limestone include:

Composita cf. ficoides Vaughan

Linoproductus cf corrugato-hemisphericus Vaughan

Productus sp. (large)

P. sp. (small)

Pustula cf. punctata (Martin)

Caninia cf. cylindrica (Scouler)

Cladochonus crassus (M'Coy)

Lithostrotion affine Fleming

L. junceum "

L. irregulare Phillips

L. martini Edwards & Haime

Zaphrentis enniskilleni Edwards & Haime

Bryozoa, crinoids and foraminifera.

(h) Reef Limestone.

A massive reef limestone is locally developed in the Dartry Limestone. The passage upwards from the bedded cherty limestone to the overlying reef can be examined at the head of the Gleniff valley and on the south side of the Castlegal Reef, where the transition is clearly defined. Two or three beds of pure, dove-grey, crinoidal limestone, about 4 feet thick, separate the cherty limestone from the overlying unbedded reef. The transition from the reef to the overlying bedded limestone is not so sharp, the massive relatively pure rock passing insensibly upwards into bedded impure limestone with much chert.

The reef occurs in very flat lenticular masses, sometimes over large areas. It is lithologically uniform throughout, being an extremely pure, pale grey, porcellaneous limestone, unbedded and massive. It is extremely fine-grained, and in thin section is seen to consist almost entirely of microscopic crystals of secondary calcite. The macrofossils are filled with clear, crystalline calcite, as are also the pores of some of the bryozoa.

The reef is immediately noticeable, even at a distance, for wherever it occurs it crops out con-

tinuously on ground free from heather and mountain bog. It does so over two square miles on the Benbulben Range, between Glencar and Gleniff; at the head of the latter valley it forms a sheer cliff over 200 feet high, being capped by the typical cherty limestone of the Dartry Limestone. Throughout this area pockets of cherty limestone occur as cappings to the Reef Limestone; these often occur in topographic hollows, and presumably represent deposits which formed as infillings of channels in the reef; for nowhere in the Western Region does the reef form the highest stratigraphical horizon of the Carboniferous Limestone.

The Reef Limestone occurs further east along the Glencar valley as a small isolated mass, the Glencar Reef, and a similar mass occurs on Castlegal Mountain, the Castlegal Reef.

It is, however, in the area of Leean and south to Lough Gill that the Reef Limestone achieves its most spectacular development, occurring over almost the whole of this area (more than four square miles). Along the southern shore of Lough Gill, near Innisfree and at Doonee Rock, the Reef Limestone occurs as three steep-sided crags between the Ox Mountains

Fault and the shore of the lake.

Locally the Reef Limestone is richly fossiliferous, the fauna consisting chiefly of small brachiopods--- lamellibranchs and trilobites being rare. In many places the limestone is apparently barren, and in others, macrofossils are absent only bryozoa being found, though these often are matted and form a considerable proportion of the rock. Goniatites, referred to the Beyrichoceras micronotum group, were found in abundance on Leean Mountain. Corals and crinoids are rare except at the base.

Fossils obtained from the Reef Limestone include:

Athyris lamellosa (L'Éveillé)

A. sp.

Brachythyris planicostata (M'Coy)

Camarotechia cf. isorhynchia (M'Coy)

Leptaena cf. analoga (Phillips)

Phricodothyris sp.

Plicatifera plicatilis (Sowerby)

Productus cf. productus (Martin)

P. semireticulata (Martin)

Pustula lirata (Phillips)

P. punctata (Martin)

P. scabricula (Phillips)

Pugnax acuminatus (Martin)

P. pleurodon (Phillips)

Reticularia cf. reticulata (M'Coy)

Spirifer globularis (Phillips)

S. semicircularis "

S. triradialis "

S. sp.

Tylothyris laminosa (M'Coy)

Caninia cornucopiae Michelin

Cladochonus crassus (M'Coy)

Emmonsia sp.

Lithostrotion irregulare Edwards & Haime

Zaphrentis enniskilleni "

Orthoceras sp.

Beyrichoceras cf. micronotum (Phillips)

Schizoblastus rofei

Phillipsia sp.

Cyathocrinus sp.

Cidarid spines

Bryozoa.

(i) Yoredale Series.

The name 'Yoredale' was applied by the Geological Survey to the sandstone and shale series which overlie the Carboniferous Limestone. The nomenclature is confusing for the contained fauna is typical of the Pendleside Series of the North of England. The term, however, is so well established in Ireland that its use is continued in this paper despite its inappropriateness.

In the Western Region the lower member of this series is a shale and the upper member a sandstone.

The passage from the Dartry Limestone to the Yoredale Shale is abrupt, the massive cherty limestone of the former being immediately overlain by the thin dark shales with occasional thin impure limestones of the latter. The junction is clearly seen on the Dartry Mountains south of Glenaniff, where the upper limit of the limestone is marked by a series of swallow-holes, often twenty or more feet deep, into which the streams flowing off the shales disappear underground. When the junction is not directly visible its approximate location is usually marked by the sodden boggy nature of the ground at the shale outcrop, contrasting with the better drained lime-

stone ground.

The Yoredale Shale crops out over a wide area between Glenade and Glenaniff, but is very poorly exposed except in a few stream sections and around the swallow-holes in the limestone. It occurs farther south of Truskmore and Truskbeg, and at the eastern end of the Benbulben Range where the base is well displayed.

The Shale is about 200 feet thick. It contains Posidonomya becheri, and Dimorphoceras sp. and Sudeticeras sp.

The Yoredale Sandstone occurs as a capping to the two shale outliers north of Benbulben, and also over a wide area between Glenade and Glenaniff. It is absent from the eastern end of the Benbulben Range.

The sandstone is lithologically similar to the Mullaghmore Sandstone, though the felspar, which forms rather less than 50 per cent, is fresher. It is generally massive bedded and well jointed. It is rarely seen in situ occurring mainly as loose blocks distributed (possibly by Glacial action) over a large area on the highest ground of the central mountain district reaching down over the outcrop of

the Dartry Limestone. These blocks together with the cover of peat largely conceal the outcrop of the Shale and may account for the fact that the Shale was not recorded at all in the Western Region by the Geological Survey.

(2) The Eastern Region.

This region is divided by the outcrop of the metamorphic rocks of the Ox Mountains into a north-western outcrop lying north and south of the village of Lurganboy, and a south-eastern outcrop from Manor-hamilton to Lough Melvin and east to Kiltyclougher.

(I) The Lurganboy Area.

(a) Basal Beds.

The local Carboniferous basal strata about Lurganboy are conglomerates with pebbles of vein quartz up to 1½" set in a coarse-grained white quartzite. It is well seen resting on the Dalradian about a mile north-west of the village of Lurganboy. South of the village they form a prominent dip-and-scarp feature. Though the lowest beds are not exposed they are also seen in a small stream and an old quarry on the road between Lurganboy and Shanvaus Cross, where they consist of a coarse grit, the upward passage into the overlying dolomite being well exposed in mining excavations on the Twigspark estate. A measured section through over 40 feet in this exposure, where the beds dip north-north-west at 6°, is given attached. (Fig. 2).

Massive brown dolomite with galena and blende. Dolomite with few grains of quartz.	4'-2"
Coarse grit with pebbles of vein quartz up to 1½" and sub-angular fragments of schist and quartzite pebbles 2½" diameter.	15'-3"
Fine grained gritty dolomite	6'-4"
Coarse gritty dolomite	5'-7"
Black carbonaceous shale	0'-8"
Fine grained gritty dolomite becoming coarser towards the top.	9'-4"

Vertical Scale:

1 inch to 6 feet.

Fig. 2.

The Basal Beds at Lurganboy are of variable thickness, but reach a maximum of about 70 feet in the ground south of the village. No fossils have been recorded from them.

(b) Ballyshannon Limestone and Bundoran Shale.

These beds have not been recognised as the two distinct lithological units seen in the Western Region, and in mapping they have been grouped together as a single unit.

A gradual passage occurs between the Basal Beds and the overlying limestone. In its lowest beds this limestone is a fine-grained, brown saccharoidal dolomite, which passes up into a light grey, very pure, crinoidal limestone. The dolomite is well exposed in the fields north-west of Lurganboy, and in a quarry on the road opposite the church where thick-bedded grey limestone, partially dolomitised, dips south-east at 10°. Dolomitised limestone, dipping south-south-east at 10°, is seen again further north overlying the basal sandstones; but in the village of Lurganboy a similar dolomite is seen close to the Dalradian rocks, the intervening sandstone being apparently faulted out. The relationship of these

beds to those exposed in the Twigspark estate is not readily determined, for the latter pass up into a bed of sandy oolitic limestone about 15 feet thick, not recognised about Lurganboy itself.

The oolite consists of ellipsoidal or spheroidal ooliths with either a calcitic (crystalline-calcite or calcareous-mud) or a quartz-grain nucleus. The quartz grains are angular or sub-angular, rarely rounded. Grains with a nucleus of a fragment of a bryozoa or the test of a foraminifera (Plate I, Fig. 1) also occur.

There are numerous ellipsoidal grains in which the nucleus is a shell fragment, these have only a very thin coating. The spheroids, which average 0·2 mm. diameter, show a radial-fibrous as well as a concentric structure. (Plate I, Figs. 1 & 2).

The matrix between the ooliths is filled with finely crystalline calcite and detrital grains of quartz and fresh angular felspar showing no oolithic filming. This suggests a shallow water mode of deposition in which the currents which assisted in the formation of the ooliths also redistributed them and introduced detrital material.

The oolite, which is exposed in a field about

400 yards west of Twigspark House, dips north-east at 10°. It can be followed along the strike for about a quarter of a mile, where it forms a small wooded ridge. Forming the dip slope of this ridge it is seen in a stream-bed below to be overlain by thin black shales and sandstones. These in their turn are followed by another bed of similar oolite about 15 feet thick, above which a rusty sandstone is well exposed in a small cliff.

The exact relationships of these beds are very difficult to interpret; nor are they made any easier by comparison with the succession south of Shanvaus Cross, where the sandy oolite has not been found (which may be accounted for by the paucity of the exposures).

At Shanvaus Cross the Basal Beds are cut out by a fault and the Ballyshannon Limestone is brought down against the gneiss. The Limestone is exposed in three quarries at the cross-roads, where it dips south-west at 18°. A small exposure of limestone with chert at a higher horizon occurs just south of the cross-roads, and between this and the overlying sandstone are poor outcrops of disturbed thin argillaceous limestones and shales dipping north-east at 12°.

The argillaceous beds both south of Shanvaus Cross and in the oolite series, cannot attain any great thickness unless faults of a considerable magnitude, for which there is no other evidence, are postulated. The oolites and shales have been included in the Ballyshannon Limestone group of the Lurganboy area, and appear despite their thinness to represent all that occur of the equivalent of the Ballyshannon Limestone and the Bundoran Shale of the Western Region.

An accurate estimate of the thickness of the Ballyshannon Limestone group cannont be made, but dip and outcrop would suggest that there are 400 to 500 feet of strata south of Shanvaus Cross beneath the Mullaghmore Sandstone.

(c) Mullaghmore Sandstone.

Only a small thickness, less than 30 feet, of sandstone is seen north of the Manorhamilton-Glencar road, in the cliff overlying the oolite series at the northern extremity of the Shanvaus townland. It dips at 20° north-east, being then cut off by the Ox Mountains Fault.

South of the road the sandstone is exposed in an old quarry, two-thirds of a mile from Shanvaus Cross, where it dips south-west at 8°. In the direction of dip it is again cut off by the Ox Mountains Fault, but its outcrop can be followed south-east along the strike in several small exposures, either in road-metal quarries or hill-side bluffs, and in the dip-and-scarp feature which it makes. It attains a thickness of at least 400 feet in this area. It is unfossiliferous throughout.

The texture of the Sandstone is, on the whole, finer than that seen in the Western Region though the lithology is otherwise similar.

(d) Benbulben Shale and Glencar Limestone.

These beds are grouped together as the Benbulben Calp in the Eastern Region, not being divisible into the two lithological units seen in the Western Region.

The Benbulben Calp is well exposed west of the Ox Mountains Fault, it is also seen in the wedge between the fault and Benbo where it overlies the Mullaghmore Sandstone.

About a mile south-west of Shanvaus Cross, close to its faulted contact with the Dalradian, it is seen dipping at 30° to 40° north-west, and consists of richly fossiliferous well-bedded limestones, with large Caninias, brachiopods and bryozoa.

West of Shanvaus Cross the outcrop of the Calp widens out, and in Glencar valley, near Diffreen Bridge, thin dark sandstones and sandy shales appear which are overlain by the full thickness of the Benbulben Shale, the succession then being similar to that described for the Western Region. Further east, however, the Shale is cut out by the Glencar Fault, and although beds close to the Mullaghmore Sandstone are exposed near Shanvaus Cross, only a small thickness of shales is seen before the over-

lying calp limestone appears.

North of Lurganboy shales of the Benbulben Calp are exposed close to the Dalradian rocks; they dip steeply and in various directions. They are overlain by calp limestone which passes up into the Dartry Limestone at the south-east end of Glenade, and into the Reef Limestone at Nure and Kilroosk.

The Benbulben Calp is faulted out at Kilroosk, but is exposed again to the north between the Reef Limestone and the Ox Mountains Fault. The dip is very variable, especially close to the fault where the strata are very much broken.

(e) Dartry Limestone and Reef Limestone.

The Dartry Limestone can be traced from the Western Region along the Dartry Mountains and the Benbulben Range, near to the Ox Mountains chain where the Reef Limestone is well seen in the area about Leean Mountain, and at Nure and Kilroosk.

Throughout the Lurganboy Area the Benbulben Calp passes up directly into the Reef Limestone, the cherty limestone being developed west and north of the reef but never being seen between the Benbulben Calp and the Reef Limestone.

The base of the reef is well seen west of Benbo, where the Reef Limestone forms an escarpment overlooking the valley of the Ox Mountains Fault. Steep cliffs rise above the basal beds of the reef similar to those seen in Gleniff and on Castlegal Mountain. The base is also seen about a mile west of Shanvaus Cross in a quarry beside the main road. Thin clay partings are seen in the beds which form the base, and these, when weathered, yield a rich fauna of well preserved specimens.

South of Lurganboy the Reef Limestone gives rise to rugged topography, many hills having steep cliff-like faces. This rising ground culminates in Leean

Mountain, 1373 feet. The outcrop is continuous over some 5 square miles, and can be traced south to Lough Gill.

The Dartry Limestone occurs at only two localities within this reef outcrop. In each case it is at a higher topographic level than the surrounding reef, though not higher than the reef on Leaan Mountain or south of Doon Lough. These isolated outcrops may be relics of deposits formed within channels in the reef, as suggested by similar deposits on Benbulben.

In the north, at Nure and Kilroosk, the Reef Limestone is developed over an area of more than two square miles; its base is not exposed.

North-west of the Nure Reef the cherty limestone passes beneath the outlier of Yoredale Shale at the eastern end of the Benbulben Range. The junction of the limestone and the shale is especially well seen in two stream sections on the northern side of the outlier.

The Yoredale beds which overlie the Kilroosk Reef may be down-faulted. To the north, where the Reef Limestone is secondarily dolomitised, the shale member of the Yoredale Series is absent, so that the sandstone appears to rest on the Reef Limestone,

though the shale is developed to the north and south. A fault was mapped between the reef and the Yoredale Series by the Geological Survey; the variable dips seen in the Yoredale may have been the reason for their conclusion. It is improbable, however, that a fault is present, the structures in the shale being incompetent folds caused by compression between the competent limestone below and sandstone above. The relationship remains uncertain, however, until more is known about the Yoredale Series in the area.

The reefs in the Lurganboy Area are richly fossiliferous, containing the same fauna as the Benbulben, Glencar and Castlegal Reefs. The fossils tend to be more localised and there is not the same profusion of bryozoa as further west--some parts are indeed, apparently completely barren.

(II) The Manorhamilton Area.

(a) Ballyshannon Limestone.

The local base in this area is a crinoidal limestone. South of Manorhamilton it is grey in colour, and slightly argillaceous; while in the town of Manorhamilton and to the north it is a brown saccharoidal dolomite. There is no basal conglomerate or sandstone in the Manorhamilton Area.

The Limestone forms a narrow outcrop at the end of the Ox Mountains Chain and extends south to Manorhamilton where the outcrop widens. It is faulted against the Dalradian south of the town.

Exposures south of Manorhamilton are poor. In two outcrops about a mile south of the town a grey crinoidal limestone, slightly argillaceous, is seen dipping at 20° south of east. Farther south a thick covering of Glacial drift obscures the solid geology.

The dolomitised basal bed is exposed both in Manorhamilton itself, and in a small stream west of the town and in an adjacent field where it forms a small escarpment. The dip is 30° to 40° or more away from the metamorphic rocks.

Farther north the junction, which runs parallel

to the road from Manorhamilton to Saddle Hill, can be followed in stream sections and quarries, and in a series of small escarpments. The basal dolomite is well exposed; because of its massive character the dip is often difficult to observe but appears to be 20° or 30° south east.

At the north-eastern end of the Ox Mountains chain the Limestone is faulted against the metamorphic rocks. The lowest beds are highly dolomitised and pass up into a coarsely fragmental limestone with thin shale partings. Dipping at 15° or 20° south-east, it is well exposed about a half a mile north of the fault. The overlying beds crop out as a series of small, gently dipping escarpments between the quarry and the fault.

The Ballyshannon Limestone attains a thickness of at least 1000 feet in the Manorhamilton Area. It is sparsely fossiliferous and only fragmentary fossils have been found.

(b) Bundoran Shale.

South of Manorhamilton the Bundoran Shale is very well exposed, dipping at 10° south-east, in a stream section west of O'Donnell's Rock escarpment. The shale is thin-bedded and contains thin bands of impure limestone. It forms the lower slopes of the escarpment, where about 300 feet of strata are present.

South-east of Manorhamilton, in the Owenmore river, thin-bedded shales and argillaceous limestones dip east at 15° to 30°.

The Bundoran Shale is poorly exposed farther north, the outcrops being confined to isolated exposures in drainage ditches and in a small stream south of Saddle Hill; but the ditches in the fields of the northern part abound in fragments of shale and argillaceous limestone. In one exposure the dip is 20° north of east, but in other exposures the dip is obscure.

A mile south of Saddle Hill in a stream section and in a small bank, near the Manorhamilton Fault, the shale is very much shattered, dipping east at 40° to 50°.

(c) Mullaghmore Sandstone.

The exposures of the Mullaghmore Sandstone are confined to a stream section about a mile south of Saddle Hill, and to two quarries in a field nearby: most of them following the strike. It is never to seen to obtain the massive character which it possesses in the Western Region.

In the stream section argillaceous limestones and shales pass up into a two-foot bed of sandstone. Overlying this are beds of sandstone up to 4 feet thick interbedded with bands of micaceous shale. A bed of grey sandstone 6-foot thick, with bands of flaggy micaceous sandstone and thin micaceous shales, forms the highest beds of the stream section. Thin sandy shales mark the passage into the overlying Benbulben Calp.

An accurate thickness cannot be given for the Mullaghmore Sandstone in this area, but it is at least 400 or maybe 500 feet thick. It is unfossiliferous throughout.

(d) Benbulben Calp.

The passage from the Mullagmore Sandstone to the overlying Calp is gradual. It is well seen in the stream section south of Saddle Hill. The thin sandy shales at the top of the sandstone are interbedded with argillaceous limestones which in their lowest layers contain a great profusion of large Caninias.

The best section of the Benbulben Calp is exposed on O'Donnell's Rock escarpment south of Manorhamilton, where a road running up the scarp face provides a section through nearly 500 feet of strata dipping south of east at 5°.

The lithology is uniform in the lower beds, being that of a thin argillaceous limestone with alternating bands of shale 6 to 9 inches thick. In the upper 200 feet the shale is reduced to thin partings between the limestone bands and finally disappears towards the top. In the uppermost beds the limestone is frequently secondarily dolomitised.

In the Owenmore river, about a mile west of Manorhamilton, the Calp is again exposed. It is a thin-bedded argillaceous limestone with thin shale partings dipping east at 10° to 12°. The beds are exposed for about a quarter of a mile along the river and become

more massive when followed in the direction of dip.

North of the Owenmore river the ground is covered by thick Glacial drift and a peat bog. The Calp being seen at only three points. The strata, which are lithologically similar to those west of Manorhamilton, dip east at 10° to 12°.

In all these exposures there is a profusion of large Caninias. In the isolated exposures north of the Owenmore river and in that river they are abundant. On O'Donnell's Rock escarpment the large Caninias lie along the side of the road, and in the rock face they project from the easily weathered shale and can be seen also in the limestone bands.

In contrast to the Benbulben Calp of the Western Region the lower beds contain more limestone and the higher beds more shale. The Caninias, which in the Western Region were more abundant in the lower member, are distributed abundantly throughout the whole thickness.

(e) Dartry Limestone.

A coarse grey crinoidal limestone forms the base of the Dartry Limestone, which passes up into a massive grey crinoidal limestone with very much chert, similar to that seen in the Western Region. The junction is well seen at the top of O'Donnells Rock.

The Limestone is well exposed on the mountain top east of O'Donnell's Rock escarpment, where the outcrop can be followed north from this, passing east of Manorhamilton and extending almost to Dough Hill. It is brought down by a fault south of Saddle Hill and can be followed north from this point to the Garrison river.

West of Manorhamilton the Dartry Limestone is exposed dipping to the west in the Owenmore river, in the fields about a mile south of which it forms a small escarpment. Farther west, in the Owenmore river and in a small stream south-west of Dough Hill, the limestone dips to the north. There is an almost continuous exposure in the stream bed, the jointing in the massive strata has led to much solution, so that , even after heavy rain, the river course is almost dry.

The thick-bedded cherty limestone of the Dartry

Limestone, overlain by reef limestone, is seen north-west of Dough Hill dipping south of east at 20°. At Saddle Hill the cherty limestone is well exposed with the same dip. Farther north the dips are more gentle except near the Ox Mountains Fault.

The Dartry Limestone has been recorded in only one exposure between Dough Hill and the Garrison river, where in a large quarry it dips south at 20°. Exposures are poor in the Garrison river, flowing through an alluvial plain, the river falls less than 100 feet in over three miles. The limestone is exposed in three places dipping south-east at 5°.

(f) Reef Limestone.

The Reef Limestone is well developed in the Dartry Limestone at Saddle Hill, where it is commonly secondarily dolomitised to a coarse, brown crystalline porous rock, frequently containing geodes of dolomite.

In the Western Region secondary dolomitisation of the Reef Limestone has not been observed. In the Eastern Region it has taken place at two localities--- the northern part of the Kilroosk Reef and the reefs in the Saddle Hill area---where the Yoredale Sandstone is seen close to the reef.

At the western side of Dough Hill the Reef Limestone rises above the general level of the surrounding ground in the typical dome- or knoll-shape seen in the reef-knolls of Northern England. The knoll is an original structure formed by reef sedimentation, though control by contemporaneous fault movement, as seen in the Craven Reef belt, has not influenced sedimentation here.

The limestone of this knoll is a fine grained, massive, dove-grey, porcellaneous limestone. The Reef Limestone is developed to the north and south of the knoll. About 200 yards north of the knoll the reef is well exposed in a small quarry, where it

is coarsely crystalline containing abundant crinoid debris and corals, being typically stratified as in the lower parts elsewhere. It is immediately underlain to the west by the thick bedded cherty limestone of the Dartry Limestone.

The limestone of the knoll does not show the quaquaversal dip which characterises many reef-knolls in other areas, but maintains a massive unbedded character throughout. It is richly fossiliferous containing abundant brachiopods---goniatites, lamellibranchs and trilobites being rare.

On the eastern side of the reef-knoll the Yoredale Sandstone, with basal conglomerate, dips at 25° beneath the Yoredale Shale on Dough Hill. The Sandstone appears to have been banked against the knoll. To the north it forms a small escarpment, dipping south-east at 5° to 10°, at a lower topographic level than the knoll about which it appears to have been deposited.

In addition to the fauna recorded on pages 47 ff. the following forms have been obtained at Dough Hill:

Campophyllum sp.

Dibunophyllum sp.

Palaeosmilia cf. murchisoni Edwards & Haime.

(g) Yoredale Series.

In the Eastern Region the Yoredale Sandstone forms the base of the Yoredale Series. It occurs in a faulted outlier north-west of Saddle Hill where it dips at 10° to 12° south-east and forms a small escarpment rising from the bog-covered ground of the Dartry Limestone. In the southern part of the outlier, where the Reef Limestone is developed, an unconformable relationship appears to exist between the two.

The main outcrop of the Sandstone is seen farther east on the flanks of Dough Hill where it dips under the Yoredale Shale.

5. ZONAL SUCCESSION and STRATIGRAPHICAL CORRELATION.

An attempt to apply sub-zonal sub-divisions in the Sligo area presents considerable difficulty; not only is the area far removed from the North-West Province and South-West Province of England, but in these latter areas the faunal phases are brought about by changing conditions, while in the Sligo area a Caninia phase persists throughout some 4000 feet of strata, from the Ballyshannon Limestone upwards into the Dartry Limestone.

The occurrence of the giganteid Caninias and the presence of Michelinia megastoma and M. grandis in the Ballyshannon Limestone indicate a Visean age. This is further substantiated by Chonetes destinezi, Leptaena cf. analoga, Pustula pyxidiformis, Linoproductus cf. corrugato-hemisphericus, Clisiophyllum multiseptatum and Zaphrentis enniskilleni forms typical of the top of the C_2 subzone in the North-West Province.

Lithostrotion martini makes its first appearance in the S_1 sub-zone in the North-West Province, and its occurrence together with the forms above suggests a C_2S_1 age for the Ballyshannon Limestone.

Tylothyris laminosa does not make its entry in

the North-West Province till the Productus corrugato-hemisphericus zone (S_2) but is found in abundance in the Ballyshannon Limestone. However, a small form enters in Z_2 in the South-West Province, and at a similar horizon at Hook Head, Co. Wexford, a form closely comparable to that occurring in the Ballyshannon Limestone has been recorded.

The upward limit of the C_2S_1 zone is difficult to define. The Bundoran Shale contains a faunal assemblage essentially similar to that of the underlying limestone, and the Mullaghmore Sandstone has yielded only a limited fauna that might well be of C_2S_1 age. Z. enniskilleni which occurs in the Sandstone continues into the Dartry Limestone where the type specimen was obtained in the Lough Gill area, and T. laminosa occurs in the overlying Benbulben Shale and also at the base of the Reef Limestone. The Benbulben Shale also contains giganteid Caninias, which although they differ from those of the Ballyshannon Limestone (as judged by sampling statistics), do not suggest anything other than a lower Visean age. Superficially similar giganteid Caninias also occur in the overlying Dartry Limestone in its highest beds.

Beyrichoceras cf. micronotum which has been found

high up in the Reef Limestone on Leean Mountain suggests a D_1 age for at least part of the Reef Limestone.

In the Eastern Region one specimen of Dibunophyllum sp. and one specimen each of Palaeosmilia sp. and of Campophyllum sp. have been found at the base of the Dough Hill reef Knoll, together with B. cf. micronotum. These again suggest a D_1 age.

The lower limit of the Dibunophyllum zone has not been defined, and the absence of Cyrtina carbonaria which marks the base of the S_2 zone in the North-West Province, or of forms typical of this zone, has rendered it impossible to fix an upper limit to the C_2S_1 zone.

Lithostrotion junceum has been regarded as typifiying D in limestone further east, in Co. Tyrone. This form is abundant in the Dartry Limestone, but the absence of other corals characteristically occurring in the D zone is perplexing.

The C_2S_1 fauna is closely similar to that of the Upper Caninia Zone of Pembrokeshire, in the South-West Province, but the persistence of the Caninia phase upwards into the D zone is in striking contrast with the Visean successions in Britain.

The lithological subdivisions adopted by the Geological Survey in Ireland allowed widespread correlation of the strata to be made with little regard to the contained faunal assemblage; but difficulties and confusion arise when (as near Manorhamilton) the lithological grouping breaks down.

In Ireland, correlation of the north-western area with other areas reveals at once a striking difference, for not only is the total thickness great but the development of the Calp is on a scale not seen elsewhere.

During this research a visit was made to the Carboniferous of Co. Clare which was described and zoned by Douglas. This is an area as far removed from the South-West Province as the Sligo area is from the North-West Province.

The Clare succession was shown, by Douglas, to compare closely with the Avon Gorge section, there being apparently a continuous sequence from the Old Red Sandstone to D_3.

The Calp subdivision of the Carboniferous was not recognised in South-West Ireland, and while the Ballyshannon has been correlated (by the Geological Survey) with a lower shale and overlying limestone

of the Z-zone, its faunal equivalent appears to lie between a massive limestone, containing a Waulsortian phasal fauna, and cherty limestones with overlying oolites of S-age.

Distinction between S_1 and S_2 is not well marked in Clare, where these zones together attain a thickness of some 450 feet. The lower beds of the Seminula Zone are dark grey limestones with an abundance of chert, and are succeeded by black crinoidal limestones and oolitic beds, with crystalline limestone at the top.

The Dartry Limestone has been correlated (by the Geological Survey) with the Seminula Zone and the overlying Dibunophyllum Zone. The latter zone, as defined by Douglas, is argillaceous at the base, but its upper part is much purer and chert is rare except in the uppermost beds. It attains a thickness of 1500 feet in Clare, of which 1000 feet is assigned to the D_1 sub-zone.

Some 4000 feet in the Sligo area is, therefore, represented by less than 2000 feet in Clare, the lithologies and faunal assemblages being markedly different.

6. STRUCTURE.

The Carboniferous strata of the north-west of Ireland were deposited across the axis of the Ox Mountains chain, whose anticlinal effect has been noticed in the reduced thickness of the lower members of the succession in the Eastern Region. The post-Carboniferous movements have folded these strata into a broad syncline between the Dalradian of the Ox Mountains chain and those further north.

A major fault, the Ox Mountains Fault, forms the southern boundary between the Carboniferous and the Dalradian. Its nature is not evident, though it may be a reversed fault. It enters the area in Ballisodare Bay, in the south-west, and extends to the Garrison river, in the north-east, bringing various members of the Carboniferous into faulted contact with the Dalradian rocks.

Near Lurganboy a small area of Carboniferous rocks is enclosed between the Ox Mountains Fault and the Dalradian; within it the strata, apparently much broken, rest in faulted contact with the metamorphic rocks except north of the village, where the local base of the Carboniferous is exposed resting unconformably on the Dalradian. South of Shanvaus

Cross the Carboniferous rocks are faulted against the Dalradian of Benbo, by a branch fault which joins the Ox Mountains Fault about two miles further south.

On the south-east side of the Ox Mountains chain the Manorhamilton Fault, which forms the striking escarpment of O'Donnell's Rock, diminishes northwards and is abruptly terminated by a cross fault, south of Saddle Hill, which brings down the Dartry Limestone on the northern side.

East of Saddle Hill the Yoredale Series occurs in a faulted outlier separated by a small valley from the main outcrop on Dough Hill further east.

The Carboniferous rocks are folded into an anticline in the Rosses Point promontory, and to the north and south are broken by three major faults.

The Sligo Fault, south of the promontory, brings down the Glencar Limestone against the Ballyshannon Limestone, and north of Knocknarea makes a marked feature where the Glencar Limestone rises above the dip slope of the Ballyshannon Limestone.

North of the promontory, the Castlegal Fault forms a marked topographic feature from Drumcliffe Bay to below Castlegal Mountain, where the Mullaghmore Sandstone can be seen almost in contact with the Reef

Limestone.

The Glencar Fault, which extends from the mouth of the Drumcliffe river eastwards near to Shanvaus Cross, is marked by much irregularity of dip in the strata along its course. It brings the junction of the Glencar Limestone and the Benbulben Shale to a lower level on the south side of the valley than on the north.

At the western end of the promontory, a small area of disturbed rocks is exposed on the shore. A cliff face, apparently a fault plane, rises above a thin small thickness of shales overlain by some 30 feet of yellow quartzo-felspathic sandstone and argillaceous limestone. The shales may well be of Bundoran Shale age and the associated sandstone and limestone belong to the passage beds below the Mullaghmore Sandstone. If this is correct, a fault of considerable magnitude is present. The evidence available is not, however, sufficient to place these strata more accurately.

The Ballyshannon Limestone of the Lissadell peninsula occupies a syncline between Streedagh Point and Serpent Rock. A more detailed knowledge of the structure in this large area has not been obtained, the relationship of the synclinal structure west of

Lissadell to the structures occurring on the coastal section being obscure.

North of Grange the Mullaghmore Sandstone is folded into an anticline trending north-east/south-west. It is broken by a fault in the estuary of the Grange river, between the mainland and Conors and Dernish Islands, so that the Bundoran Shale, which appears in the core of the anticline, is seen only on the mainland. The anticline is truncated by the Grange Fault in the south, which also truncates both the fault in the estuary of the Grange river and the Kinlough Fault. It brings Ballyshannon Limestone against Bundoran Shale and Mullaghmore Sandstone north of Grange, where exposures in the Ballyshannon Limestone show that the structure is complicated, though details are obscure.

The throw of the Grange Fault, about 1000 feet north of Grange, decreases to the south-east where the sandstone/shale junction is only slightly displaced; farther east it may be equated with a fracture observed in the scarp east of Benbulben.

The Kinlough Fault, a major fault with a throw of over 1000 feet, is beleived to pass through the low-lying and bog-covered ground between Moneygold

and Kinlough, with the Bundoran Shale to the south-east and the Mullaghmore faulted down to the north-west. The width of outcrop of the sandstone is doubled at the western end of Lough Melvin, and south of Kinlough a small area of Bundoran Shale is inferred between the town and the fault; similarily an area of Ballyshannon Limestone has been marked further south.

North of Lough Melvin the Carboniferous strata dip gently southwards from the Dalradian against which they rest in faulted contact at Ballyshannon, where the Basal Beds, exposed a mile west of the town, are cut out by a small fault entering the sea at the mouth of the River Erne.

Throughout the coastal section many small faults occur, and the thin-bedded limestone and shales often show much imcompetent folding. This is especially well seen on Coney Island and south-west of Streedagh Point. In Bundoran Bay the thin shales have acted in the same way.

7. PALAEONTOLOGY.

The strata of the area described in this paper are very fossiliferous, especially the shales and argillaceous limestones. At Streedagh Point and Fairies Bridge, in the Ballyshannon Limestone, and Aughrus Point and in Bundoran Bay, in the Bundoran Shale, brachiopods and corals are exceedingly abundant. Many of the brachiopods are silicified and after etching, the internal structure is clearly seen; some of these forms are described below.

Tylothyris laminosa (M'Coy) Plate III, Figs. 1-4.

Tylothyris laminosa is very abundant in the Ballyshannon Limestone, especially at Streedagh Point. It has been found in the overlying beds up to the base of the Reef Limestone.

The specimens figured in Plate III and described and figured in the text were mostly collected at Streedagh Point. Silicified specimens from Streedagh Point have been etched and reveal the internal structure. The pedicle valve is most commonly found fossil; no brachial valve has been found which is in a good enough state of preservation for accurate

measurements to be made. The anterior margin of the pedicle valve is commonly broken away.

Description: Shell widest at the hinge line, breadth almost twice length. Cardinal extremities extremely acute (Plate III, Fig. 1). Width and height of cardinal area very variable:

		1.	2.	3.	4.	5.	6.	7.	8.
Width at hinge line	mm.	33	49	59	46	27	29	24	30
Height of cardinal area	mm.	11	8	10	11	12	9	6	8

Cardinal area slightly concave or strongly so. Beak slightly or strongly incurved:

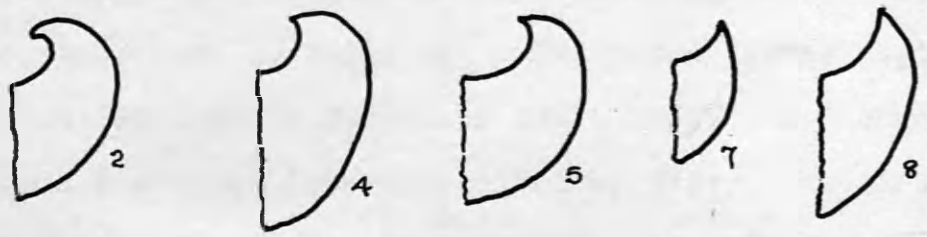


Fig. 3. Profile of beak of pedicle valve showing variation in elevation of cardinal area. Numbers refer to same specimens as those in table above; Nos. 7 and 8 are North's T. laminosa mut. β and mut. γ respectively.

Height of Delthyrium/Width of Delthyrium = 0·7-0·8. In two specimens (Nos. 1 and 5 above) with very high cardinal area the ratio is 0·4. Delthyrial angle about 38°.

The lateral slopes of both valves are ornamented by 12-14 laminose costae. At 1·5 mm. from the umbo there are 3 costae in 5 mm. Six or eight costae radiate from the umbo and the remainder do not reach the umbo. In large specimens the lateral slope at the cardinal extremity bears no costae. The lateral slopes are gently convex , umbonal slopes strongly so.

A mesial sinus is well developed in the pedicle valve and a corrosponding fold in the brachial valve. The costae diminish gradually, those near the cardinal extremity being weakly developed, and those bounding the sinus most strongly so. The sinus widens rapidly, a specimen from the Benbulben Shale shows the 'tongue-shaped flattened lobe' described by M'Coy, the sinus being over 2 cm. wide at a distance of 4·5 cm from the umbo. (Plate III, Fig. 2). The median fold of the brachial valve, which is elevated above the general level of the valve, expands correspondingly to the sinus of the pedicle valve.

Shell fibrous and impunctate.

Internal. Pedicle valve. The internal structure is well seen in the silicified specimen (Plate III, Fig. 3) and compares closely with North's description of the type specimen. The apical callosity which he describes and figures (North. Plate XIII, Fig. 13.) rises higher into the delthyrial opening than in specimens from Streedagh Point. The callosity is well developed covering the early formed part of the median septum and forms two gently curved ridges, between the base of the delthyrial supporting-plates and the base of the median septum, to form a strongly developed pit-like depression. The median septum is thickened at the base and reaches nearly half way between the umbo and the anterior margin. Close to the apical callosity the septum rises from the floor of the valve to a little less than half the height of the delthyrial supporting plates.

The internal structure of the brachial valve has not been observed.

T. laminosa occurs commonly from the Ballyshannon Limestone to the base of the Reef Limestone, the specimens showing no external difference at either horizon. The specimens described are larger than those from the South-

West Province---North's mut. γ being typical of Z_2, and larger forms occur in C_1. Specimens figured by Garwood from the lower S_2 of the North-West Province are more rounded at the cardinal extremities than the Sligo forms and are also much smaller. The forms described from Hook Head, Co. Wexford, where the species ranges from Z_2 to C_2 with no external difference, are closely similar to the Sligo forms.

Leptaena cf. analoga. (Phillips) Plate III, Figs. 5-8.

Leptaena cf. analoga occurs from the base of the Ballyshannon Limestone to the base of the Reef Limestone. Much variation in size is seen in specimens from the same locality, measurements are not included here because the imperfect preservation of the margins and of the cardinal extremities renders accurate comparison impossible. The specimens described below and figured in Plate III are from Streedagh Point.

Description. Shell transversely semicircular or sub-quadrate. Breadth greater than twice length. Cardinal extremities (seldom preserved fossil) extremely acute. (Plate III, Figs. 5 & 6). Cardinal area narrow,

less than 4 mm. at the delthyrial opening, tapering evenly to the cardinal extremities. Area flat, smooth or faintly marked by transverse lines. Height of Delthyrium/Width of Delthyrium = 2.5. Delthyrial angle about 108°. Both valves are strongly geniculated, the pedicle valve more than the brachial. The valves are ornamented by fine radiating rugae which, on the flatter part, are crossed by 14-20 coarse concentric wrinkles which turn towards the cardinal extremities close to the area. The rugose ornament is more closely spaced near the umbo; 3 in 5 mm. at 2 cm. from the umbo, 4 in 5 mm. at 1.1 cm. from the umbo. 19-20 rugae occupy 1 cm. at 2 cm. distance from the umbo.

Internal. Pedicle Valve. Teeth strong, divergent, with two or three fine vertical crenulations (Plate III, Fig. 7.) Muscle impressions bounded by a ridge rising to nearly 3 mm. above the floor of the valve extending from the short dental plates anteriorly to form a semi-circular area (Plate III, Figs. 7 & 8)---"saucer-shaped depression" Davidson. This depression extends to a distance of 14 mm. from the umbo and the enclosed muscle scars are divided by a median ridge which diverges anteriorly and passes over the margin of the

depression to extend for a further 6-7 mm. towards the anterior margin. The adductor muscles form two small scars on the lateral flanks of the median ridge. The divaricator muscle-scars fill the semicircular area anteriorly. No trace of the scars of the pedicle muscles exists, for the posterior part of the muscular depression is filled with a small apical callosity which may conceal the scars formed in the young animal; the pedicle not being functional in later life. In the area close to the muscular depression the surface is covered by irregularily disposed delicate papillae. The internal surface of the geniculated region and the adjacent flat part bear few papillae and are marked only by the vascular impressions.

The internal structure of the brachial valve has not been observed.

Vaughan's form from the South-Western Province is "as interpreted by Davidson", but the latter considered L. analoga as a variety of L. rhomboidalis, and his description is very general. He describes the cardinal angles as being rounded which is never the case in the forms described above. In the interior Davidson shows the spoon-like depression which

closely resembles the forms from Streedagh Point, but, in contrast, the papillate area is shown to be sharply demarcated from that bearing the vascular impressions.

Demanet describes forms from Cq of Tournai which, like those from Streedagh Point have acute cardinal extremities and similar internal structure.

Schelwienella sp. Plate IV, Figs. 1-10.

Several specimens of Schelwienella which show variations from described forms were collected at Streedagh Point. The specimens are silicified and the internal structure is well seen after etching.

Description. Shell wider than long, greatest width at hinge-line, cardinal extremities acute.

	1.	2.
Width at hinge-line mm.	59	28
Length of brachial valve mm.	53	23

Specimen No. 1 in the table above (Plate IV, Figs. 1-4) is a well preserved brachial valve. It is strongly convex close to the umbo and moderately so anteriorly. Cardinal area about 2 mm. high at the

centre, tapering evenly to the extremities and ornamented with costae and costellae. The former extend from the umbo to the anterior margin, and between each pair 5-7 costellae are present; the costellae do not reach the umbo. At a distance of 3 cm. from the umbo the costae are 3 cm. apart, while at 5 cm. distance they are 4 mm. apart.

Internal. Strongly developed bifid cardinal process (Plate IV, Figs. 3 & 4), with elongate oval depressions on the posterior surface, anteriorly the dividing slit gives rise to a fine median ridge about 5 mm. long. Strongly developed dental sockets bound the cardinal process laterally, the plates of these uniting with the cardinal process below. A chilidium is weakly developed. The muscle impressions form a deep depression bounded by the cardinal process posteriorly and laterally by a low ridge which enters the depression anteriorly to give a bilobed appearance to the muscle scars. The depression is confined to the extreme posterior (strongly convex) part of the valve. The internal ornament is partly obscured by pyritisation, but there is a suggestion of papillae with, at the anterior margin, radial ribbing.

Specimen No. 2 in the table above (Plate IV, Figs. 9 & 10) is partly broken in the umbonal region. The shell has a gently convex brachial valve and the preserved (anterior) part of the pedicle valve is flat. The external ornament is of radiating costae and costellae. The ornament is not well differentiated near the umbo, but anteriorly the costellae occur in groups of 1-4 (2 or 3 being most common). The ornamentation becomes stronger towards the margin where the costae are spaced about 2 or 3 mm. apart.

The internal surface is ornamented with fine papillae, other internal structures are not visible.

A pedicle valve (Plate IV, Figs. 7 & 8) whose margins are broken measures about 42 mm. at the hinge-line, and 36 mm. in length (restored). The valve is slightly convex near the umbo and flat near the anterior margin. The external ornament is of costae and costellae, the latter occurring in groups from 3 to 8 between the costae. The coarse ribs are therefore very variable in their spacing: at 2 cm. from the umbo the costae are 3 mm. apart where 4 costellae are present, while the adjacent space

between two costae, occupied by 8 costellae, is 5 mm. wide. Cardinal area about 6 mm. high with a wide delthyrium whose angle is about 63.

Internal. Strong teeth supported by dental plates diverging at 75-80°. Muscle scars in fan-shaped depression extending 11 mm. from the umbo enclosing laterally two pear-shaped diductors separated by a low median ridge bearing the impression of the adductor scars. There is an internal ornament of delicate papillae.

The Sligo forms differ from both the mutations described by Vaughan from the Bristol Area. In his mutation Z "the alteration of the ribs is made out with difficulty", and in mutation C, while this character is very distinct, "there is often a medial depression in the brachial valve" a feature not present in the Sligo forms.

The radialis type of ornament and the acute character of the cardinal extremities are features which the specimens described above have in common with Schelwienella aspis mut. radialformis Demanet. The proportions are similar, and one specimen figured by Demanet (Plate VII, Fig. 10) closely resembles

Specimen No. 2 above. The ornamentation of the specimens from Streedagh Point differs from that of any described form in the distribution of costae and costellae. They are, however, probably closely related to Demanet's species which occurs in C_1 near Tournai.

Pustula cf. nodopustulosa. Parkinson. (Plate V, Figs 1-5).

Four silicified specimens from Streedagh Point (Nos. 1-4) and one specimen from Ballyshannon (No. 5) are described. The exterior of the pedicle valve alone is visible in the last mentioned specimen, while the silicified specimens show the interior of the pedicle valve and in two specimens the external part of the brachial valve together with the cardinal process.

Description: Shell globose, longer than wide, greatest width mid-way between the umbo and the anterior margin. Hinge-line with prominent ears and incurved umbo. Pedicle valve strongly convex with median sinus commencing close to umbo and widening anteriorly. Anterior and lateral margins of both valves thickened and reflexed. (Fig. 4).

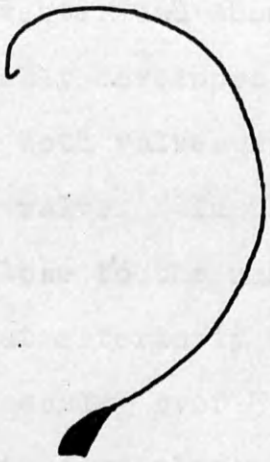


Fig. 4. Profile of specimen (Plate V, Figs. 2 & 4. No. 1 in Table below) showing reflexed and thickened margin. Natural size.

The thickened margin is not included in the measurements of width in the table below.

Dimensions (Brachial Valve):-

	1.	2.	3.	4.	5.
Width at hinge-line mm.	104	116	92	108	142
Maximum width mm.	65	60	52	57	83
Length mm.	52	×46	×40	×42	71
Depth mm.	35	37	23	26	40

× Restored.

The surface of both valves is ornamented by ribs and spine bases. The ribs are weakly developed except on the cardinal and umbonal flanks. On the cardinal flanks 7 ribs occupy 1 cm. but when traced across the

venter they become indistinct and are broad and flattened on the mid-venter and absent from the trail. The ribs are more feebly developed on the brachial valve. Spine bases cover both valves except on the cardinal flanks of the pedicle valve. In the pedicle valve they arise on the ribs; close to the umbo they are small and almost circular, but anteriorly they are more elongate and prominent reaching over 5 mm. in length and sometimes coalescing to form elongate ridges close to the margin. The spine bases are never seen to coalesce on the brachial valve, otherwise the ornamentation is similar.

Internal. Pedicle Valve. Well developed flabelliform divaricator muscle-scars form two depressions up to 20 mm. long, their apices directed posteriorly. They are marked by strong longtitudinal ridges. A strong median septum divides the scars, expanding anteriorly from 7 to 11 mm. in width it extends for a distance of approximately 30 mm. from the umbo where it terminates level with the scars. It is sometimes divided posteriorly / longtitudinally by a narrow deep groove. The narrow adductor scars are situated on the posterior part of the median septum. The interior surface of the valve is marked by a pitted ornamentation and delicate longtitudinal wrinkles.

Brachial Valve. A strong trifid cardinal process (Plate V, Fig. 1) is developed rising about 5 mm. above the hinge line. When observed from the interior of the valve, the cardinal process is seen to bear a strong knob-like protuberance which anteriorly gives rise to a median septum, The nature of the muscle-scars and other internal structures have not been observed.

This form bears a close resemblance to Parkinson's species, especially in the nature of the cardinal process and the median sinus, also the well developed ears are a common feature between the two forms. The weak development of the ribs distinguishes it from P. nodopustulosa which is characterised by strong ribs. The thickening of the margins is probably a gerontic feature in the forms described. All the specimens described are very much larger than Parkinson's and do not compare in relative proportions, the width being in all specimens about 0·6 of the length, while in P. nodopustulosa the width is equal to, or exceeds the length.

Caninia cf. cylindrica (Scouler). Plate VI, Figs. 1-6.

Gigenteid Caninias occur abundantly in the Ballyshannon Limestone and Benbulben Shale, they have been found in the Dartry Limestone up to its highest beds. The specimens show so much variation that a description of a specimen from any one of these horizons would not be typical of the assemblage at that horizon or sufficient to distinguish it from a specimen from another horizon. Excepting characters caused by the mode of preservation, a single specimen from the Ballyshannon Limestone would not be distinguishable from one from the Benbulben Shale or from the overlying Dartry Limestone. The description given below is based on the characters typical of the group and concerns the varying morphological structures observed. The specimens are compared with described forms.

Text Figures 3 and 4 are frequency curves of variation observed in the assemblage at two localities in the Ballyshannon Limestone and one locality in the Benbulben Shale.

Description: External characters. All specimens examined are adult forms, the corallum being

cylindrical throughout its length, except for a small part near the base in some specimens, and in those specimens showing rejuvenescence. The largest specimens observed were found at Streedagh Point--- one almost 27 inches in length while another with a calyx over 3½ inches diameter.

Corallum simple, regularily cylindrical throughout most of its length, small conical neanic stage not found fossil, (Lewis has suggested that the early formed portion was dissolved during the lifetime of the coral thus accounting for its absence in the fossil state. This seems unlikely, and other small conical corals occur complete in the same bed showing no signs of resorption of their base). Corallum marked by annular growth-swellings, occurring approximately 5 in every 4 cms., crossed by fine longtitudinal striations. Corallum frequently rejuvenated. Calyx about 3·5 cm. deep, with major septa forming ridges about 3 mm. high at the margin and tapering towards the centre which is not radiated by the septa, being a free tabulate area about 1·5 cm. across. Cardinal fossula open, well marked by shortened cardinal septum and (frequently) adjacent septa. Counter fossula seldom well marked in calyx. Number

of major septa very variable.

Internal Characters.

(a) Transverse Section. Sections at different stages show that while the interthecal zone is of nearly constant thickness there is much variation in the external diameter caused by a widening and narrowing of the dissepimental region. The dissepiments reach a thickness of 1·0 - 1·5 cm. and often show variation in thickness on opposite sides of the corallum. When the dissepiments are of uniform thickness around the corallum they are of the "concentric" (Lewis) type and are characteristically radiated by the septa throughout. Thickening of the dissepimental area usually introduces widely spaced curved dissepiments in the outer region---"petaloid" dissepiments. The petaloid type is not uniformly distributed around the corallum and is not radiated by the septa, which only form small tooth-like projections on the inner surface of the dissepiments. (This character is typical of Vaughan's mutation γ.)

In specimens from all localities major and minor septa occur, though many speciméns show no development of minor septa. The major septa are continuous from the outer thecal wall to near the centre of the coral, being radially disposed and leaving a free tabulate c

central area of about 1·5 cm. across. The major septa are frequently thickened by stereoplasm especially close to the inner thecal wall; the thickening may be developed in all the septa or confined to the cardinal and adjacent septa, or confined to those of one quadrant. (Plate VI, Figs. 2, 3 & 4). The septa taper to a point, extending about 1cm. inside the dissepimental zone, and are often sinuous within the interthecal region.

The minor septa exist as small projections on the inner thecal wall about 2 mm. long, they are not continuous to the outer thecal wall existing only as tooth-like projections on the inner side of the dissepimental rings of the concentric zone and rarely being present in the petaloid zone.

Two or three tabulae are typically intersected by the section, and form a curved area at the cardinal fossula.

(b) Vertical Section. The dissepiments are steeply inclined to the inner thecal wall forming a sharp division between the dissepimental and the tabulate areas. The tabulae turn down at the thecal wall and are frequently gently depressed in the mid-region. In sections through the fossula, the deep siphonal

depression of the tabulae, which gave rise to the generic name, is always clearly seen. (Plate VI, Fig. 5). There are usually about 10 tabulae in 3 cm., but these are increased by the introduction of tabulae which arise in a mid-position so that a further 25 tabulae may exist within 3 cm. which do not extend completely across the interthecal zone.

In a broken specimen the coral is generally seen to be filled with clear crystalline calcite. On the upper surface of the tabulae the major septa are seen to extend towards the centre, their lower surface being in contact with the tabulae throughout their length but their upper surface only in contact with the overlying tabulae close to the inner thecal wall.

Smyth's description of the Holotype of Caninia cylindrica (Scouler) (Smyth in Lewis 1927) corresponds closely to the characters of the specimens described above. The holotype posseses 'minor septa projecting inwards about 2 mm. from the theca' like the specimens from the Sligo area which possess minor septa; but minor septa are not always present even in specimens from the same bed. It possesses about 56 major septa (the corallum is a weathered adult portion)

at a diameter of about 3.5 cm. of the interthecal zone. Specimens from the Ballyshannon Limestone with an interthecal zone of 3.4-3.6 cm. diameter have from 52-72 septa, while those from other horizons show a similar wide range though with fewer than 70 septa.

Caninia cf. cylindrica (Scouler) described by Lewis (1927) differs only from the type form in the absence of minor septa and the possession of a greater number of septa (70) at about the same diameter (3.5 cm.). It is therefore similar to specimens found in the Ballyshannon Limestone, and it is from beds of, probably, this horizon that it was obtained. (The locality is the 'Lower Carboniferous Limestone, Carrowgarry, Co. Sligo', which is about 20 miles west of Ballisodare.)

A collection of 30 specimens from both Streedagh Point and Serpent Rock, together with a similar number from the top of the Benbulben Shale was made and statistical measurements taken to study variation. The characters used in this study of variation are:- (i) The number of septa; (ii) The diameter of the interthecal zone: characters which remain constant, or nearly so, in the adult growth stage.

In Fig. 5 the number of septa is the character

plotted, and this shows a close grouping of the peaks of the curves for specimens from the Ballyshannon Limestone; the peak for those from the Benbulben Shale being well separated.

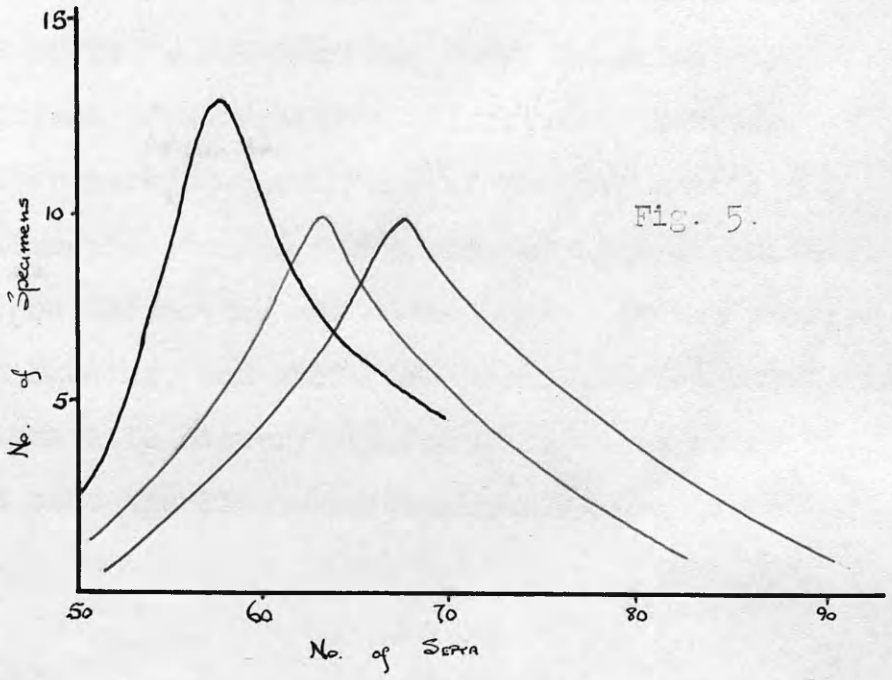


Fig. 5.

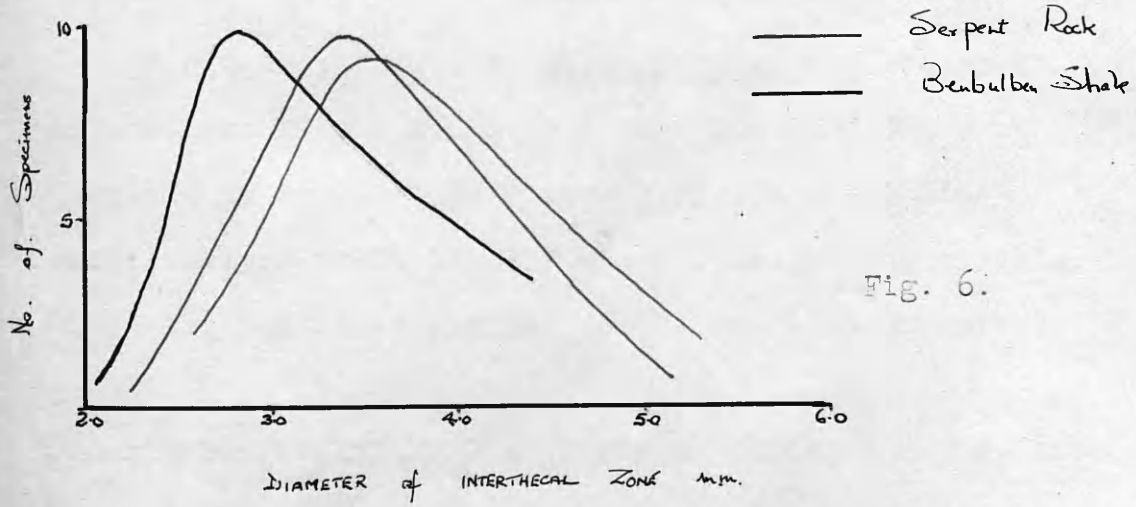


Fig. 6.

The diameter of the interthecal zone, the character plotted in Fig. 6, shows a similar grouping of the peaks, except that the position of the peaks for the specimens from the Ballyshannon Limestone is reversed.

The frequency curves suggest that more than one species is present, and that the large Caninias may provide a means of sub-zonal subdivision. However, until further work has been done on the nature of the concentric and petaloid dissepiments and the septal changes associated with them, and on the nature and distribution of the stereoplasmic thickening, and while the early developmental stages of the life history are unknown, it is not considered that the limits of the species can be defined.

Dibunophyllum sp. Plate V, Fig. 6 a-c.

A single specimen of Dibunophyllum was obtained at the base of the Dough Hill Reef Knoll. The specimen is embedded in a pure grey crinoidal limestone, only a small area of the epitheca being visible. Only half the adult portion of the coral is preserved.

Description: External Characters. Simple. Turbinate. Epitheca bears fine longtitudinal striations and gentle transverse wrinkles. Calyx unknown.

Internal Characters.

(a) Transverse Section. (Plate V, Figs. 6a & 6c.)

In the adult stage at a diameter of 2·9 cm. the specimen contains 23 major septa, this appears to be more than half the total number of major septa--- probably 42-44. The major septa are 12-13 mm. long, slightly sinuous in the 2-3 mm. inside the dissepimental zone, and show slight thickening in the mid-distance of their length. The septa do not reach the centre but taper into the mesial area. (Plate V, Fig. 6a).

The minor septa alternate with the major septa. They are rudimentary, extending from 2-3 mm. inwards from the thecal wall and being of even thickness throughout their length.

A section near the base, at a diameter of 1.3 cm. shows a complete cross section. (Plate V, Fig. 6c). There is a well marked cardinal fossula, with shortened cardinal septum, bounded by almost parallel septa, a counter fossula is also evident. There are 31 major septa meeting in the centre in a mass of stereoplasm. Minor septa are absent. The median plate is not apparent at this stage. The dissepimental area, which is not of uniform thickness around the coral, varies from 1·0-1·5 mm. in width.

In the adult part of the coral the cardinal fossula is not preserved, a very slight shortening of the septum in line with the median plate can be observed. The cardinal fossula lies on the convex side of the corallum.

The horizontal section is divisible into three zones: (i) An external area of loose vesicular dissepimental tissue, 7-8 mm. wide, extending from the outer thecal wall to an area of closely spaced vesicles 4 or 5 in number, 3-4 mm. wide. The total width of this area is about 11 mm. and is radiated entirely by major septa. (ii) A mesial area, 4-5 mm. wide, radiated by major septa to a distance of 2-3 mm. (iii) A central area containing a plate-like columella, (probably) 6-7 mm. long, of even thickness throughout, surrounded by a spiders-web, 4 mm. wide, of tabellae and radiating lamellae.

(b) Longtitudinal Section. Plate V, Fig. 6b.

The dissepiments are steeply inclined to the thecal wall and are well spaced especially in the outer part. The tabulae occupy the mesial area. They are incomplete, forming arched brackets, convex upwards, two or three of which bridge the mesial area. The central area occupies one quarter of the width of the coral in

the adult stage, being formed of steeply inclined tabellae making an angle of about 35 with the median plate.

The dissepimental tissue occupies a smaller area than in D. bourtonense and in this respect it resembles D. bristolense, but this latter form has a larger and more sharply defined central area and a well defined inner wall. The described specimen, like D. bourtonense, lacks a well defined inner wall, but the lamellae are much more pronounced than those of D. bourtonense. The wide area between the ends of the major septa and the central area is a distinctive feature in this specimen from Dough Hill.

8. SUMMARY.

The Carboniferous rocks considered in this paper are shown to be Visean to the base; the Ballyshannon Limestone containing a fauna closely comparable with that of the Upper Caninia Zone of Pembrokeshire. The succession reaches up to D_1 in the limestone, consisting of a Caninia facies throughout. The overlying Yoredale Series contains goniatites characteristic of P_2: it should be referred to the Pendleside and not the Yoredale Series. The absence of forms diagnostic of S_2 has led to this zone not being separately recognised.

The presence of a reef-limestone is one of the most interesting features of the area. Reef-limestones of Tournasian age have been recorded in eastern Ireland, Clare and Cork; and reef-knolls from the Dublin area have been described. Reef-limestone has not previously been recorded from the north-west of Ireland: this reef together with the Knoll development at Dough Hill and their relationship to the overlying Yoredales provides a task for extensive study which lies outside the scope of the present paper.

Reef sedimentation in the Western Region ceased before the end of Dartry Limestone times, the cherty limestone of the latter being found overlying the Reef Limestone

on Benbulben and Castlegal Mountain, and occurring as deposits beleived to be the infillings of channels in the reef. In the Eastern Region the Yoredale Sandstone is seen resting unconformably on the reef-knoll and to be, apparently, in a similar disposition to the Kilroosk Reef and to the reefs in the Saddle Hill area.

Apart from the area surrounding the north-east end of the Ox Mountains Chain, the thickness of the strata is uniform and points to the north-west Irish area being one of quiet continued subsidence throughout Visean times.

In post-Carboniferous times the area was raised above the sea and folded into a gentle syncline with a north-east/south-west axis. Faulting parallel to this axis took place, the major fracture being the Ox Mountains Fault in the south.

No post-Carboniferous sediments, except Glacial and Recent superficial deposits, occur within the area.

9. ACKNOWLEDGEMENTS.

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10. LIST OF WORKS TO WHICH REFERENCE IS MADE.

Anderson J.G.C. 1946 The occurrence of Moine Schists in Ireland. Geol. Mag. Vol. lxxxiii.

Apjohn J. 1842 Presidential Address. J.G.S.D. Vol. ii.

Bisat W.S. 1934 The Goniatites of the Beyrichoceras Zone in the North of England. Proc. Yorks. Geol. Soc. Vol. xx., Part iv.

Carruthers R.G. 1919 A remarkable Carboniferous Coral. Geol. Mag. D. vi, Vol. vi.

Cole G.A.J. 1913 The Geology of the Mallaranny and Sligo Districts. P.G.A. Vol xxiv.

" & Hallisey T. 1924 Handbook of the Geology of Ireland.

Davidson T. 1851-1858 British Fossil Brachiopoda.

Demanet F. 1934 Les Brachiopodes du Dinantien de la Belgique.

Dixon E.E.L. and Vaughan A. 1911 The Carboniferous Succession in Gower (Glamorganshire), with Notes on its Fauna and Conditions of Deposition. Q.J.G.S. Vol. lxvii.

Douglas J.A. 1909 The Carboniferous Limestone of County Clare (Ireland). Q.J.G.S. Vol. lxv.

Garwood E.J. 1912 The Lower Carboniferous Succession in the North-West of England. Q.J.G.S. Vol. lxviii

Geological Survey of Ireland 1878-1888. One inch Geological Maps and accompanying Memoirs Nos. 31,32. 42, 43, 44 & 55.

Griffith R. 1818 Geological and Mining Survey of the Connaught Coal District of Ireland.

" 1835 Report of the British Association for the Advancement of Science.

" 1836 Presidential Address J.G.S.D. Vol. 1

" 1837 Second Report of the Railway Commission. Appendix No. 1.

" 1837 & 1855 Geological Map of Ireland.

Hind W. 1897 The Yoredale Series. Geol. Mag. D. iv, Vol. iv.

" & Howe J.A. 1901 The Pendleside Group at Pendle Hill. Q.J.G.S. Vol. lvii.

Hull E. 1878 Geological Map of Ireland.

Jukes J.B. 1868 Geological Map of Ireland.

Kelly J. 1857 The Sub-Division of the Carboniferous Rocks of Ireland. J.G.S.D. Vol. vii.

Lewis H.P. 1924 Corals of the genus Caninia. Q.J.G.S. Vol. lxxx.

" 1927 Caninia cylindrica (Scouler) and other large Caninias from the Carboniferous Limestone of Ireland. Sci. Proc. R.D.S. Vol. xviii N.S.

M'Coy F. 1844 A synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland.

Muir-Wood H.M. 1928 British Carboniferous Producti, Mem. Geol. Surv. G.B./Vol iii, Palaeontology. Pt. I.

North F.J. 1920 On Syringothyris Winchell, and certain Carboniferous Brachiopoda referred to Spiriferina D'Orbigny. Q.J.G.S. Vol. lxxvi.

Padget P. 1952 Carboniferous Beds at Kildress, Co. Tyrone. Irish. Nat. Journal Vol. x.

Parkinson D. 1926 The Faunal Succession in the Carboniferous Limestone and Bowland Shales at Clitheroe and Pendle Hill, Lancashire. Q.J.G.S. Vol. lxxii.

Smyth L.B. 1930 The Carboniferous Rocks of Hook Head, County Wexford. Proc. Roy. Irish Acad. Vol. xxxix.

Thomas I. 1914 British Carboniferous Producti. Mem. Geol. Surv. G.B. Palaeontology, Vol i, Pt. 4.

Turner J.S. 1948 The Age of the Reef Limestones in Cork and Dublin. Trans. Leeds Geol. Assoc. Vol vi, Pt. 2.

Vaughan A. 1905 The Carboniferous Limestone Series (Avonian) of the Avon Gorge. Proc. Brist. Nat. Soc. Vol. i, Pt. II.

Wright W.B. 1913 The Lower Carboniferous Succession at Bundoran. P.G.A. Vol. xxiv.

Wynne A.B. 1863 The Geology of parts of Sligo. J.G.S.D. Vol. x.

EXPLANATION OF PLATES

Plate I

Geological Map of North-West Ireland. (Facing page 3).

Plate II

Figs. 1 & 2. Sandy Oolite. Ballyshannon Limestone, Twigspark Estate, Lurganboy. (x 140).

All specimens figured in Plates III-VI are natural size.

Plate III

Figs. 1-4 Tylothyris laminosa (M'Coy) Page 35.

1. Partially exfoliated specimen showing acute cardinal extremities. Ballyshannon Limestone.
2. Specimen showing 'tongue-shaped lobe'. Benbulben Shale.
3. Interior of pedicle valve showing apical callosity. Ballyshannon Limestone.
4. Exterior of same specimen.

Figs. 5-8. Leptaena cf. analoga (Phillips) Page 39.

5. Exterior of pedicle valve with acute cardinal extremities. Ballyshannon Limestone.

6. Interior of same specimen

7 & 8. Interior of pedicle valve showing muscle depression and papillate ornament.

Plate IV

Schellwienella sp. Streedagh Point.

Figs. 1-4 Brachial valve, specimen No. 1. Page 92.

1. Exterior, ornament partly obscured by pyritisation.

2. Interior showing muscle scars.

3 & 4. Cardinal process.

Figs. 5 & 6. Cardinal process of another specimen.

Figs. 7 & 8. Pedicle valve, Page 94.

7. Interior showing divergent dental plates.

8. Exterior showing radialis-type ornament

Figs. 9 & 10. Specimen No. 2. Page 94.

Plate V

Figs. 1-5 Pustula cf. nodopustulosa Parkinson. Streedagh Point.

1. Part of brachial valve with cardinal process.

2. Exterior of Specimen No 1, page 97

4. Interior of same specimen showing muscle scars.

3 & 5. Interior of specimen No. 2, page 97, showing muscle scars.

Figs. 6 a-c. Dibunophyllum sp

6a. Transverse Section of adult.

6b. Longtitudinal Section

6c. Transverse Section of young stage in same orientation as 6a.

Plate VI

Caninia cf. cylindrica (Scouler) Page 100

Fig. 1. Transverse Section showing petaloid and concentric dissepiments. Benbulben Shale.

Fig. 2. Transverse Section showing stereoplasmic thickening in lateral quadrant. Streedagh Point.

Fig. 3. Transverse Section showing stereoplasmic thickening in cardinal and counter-cardinal quadrants. Benbulben Calp, O'Donnell's Rock.

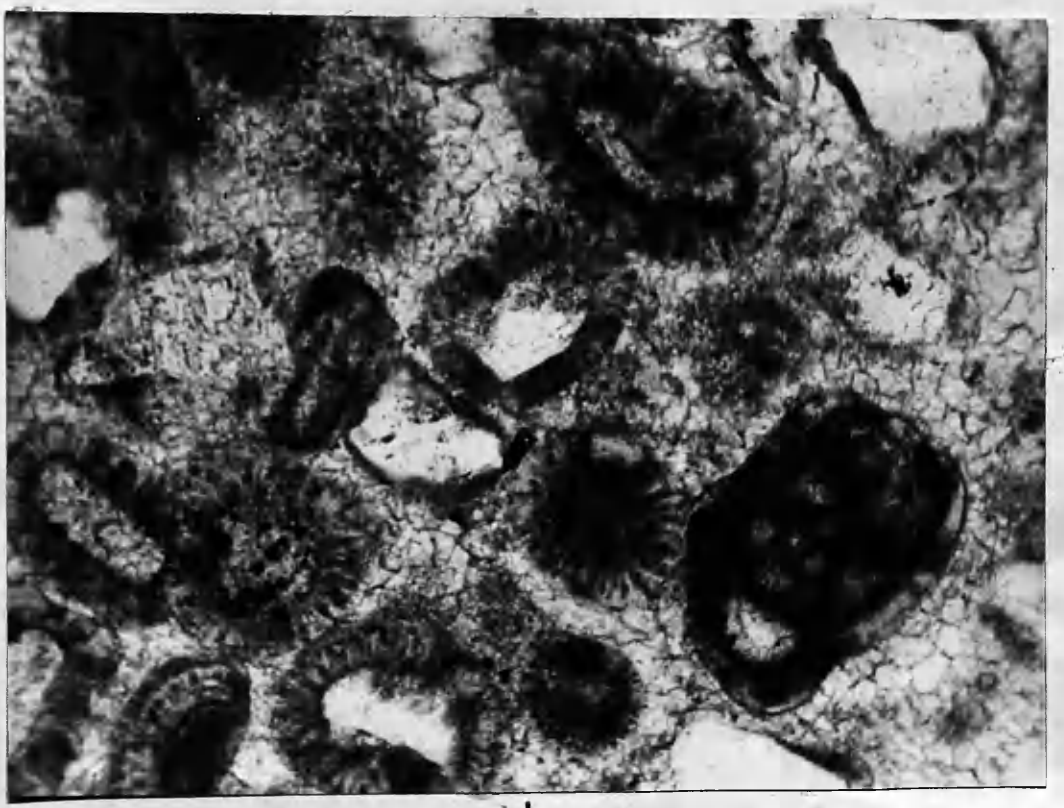
Fig. 4. Transverse Section showing stereoplasmic thickening in nearly all septa. Benbulben Shale.

Fig. 6. Longtitudinal Section of same specimen.

Fig. 5. Longtitudinal Section close to fossula, showing siphonal depression of tabulae. Streedagh Point.

Plate VII

Stratigraphical table showing regional correlation.



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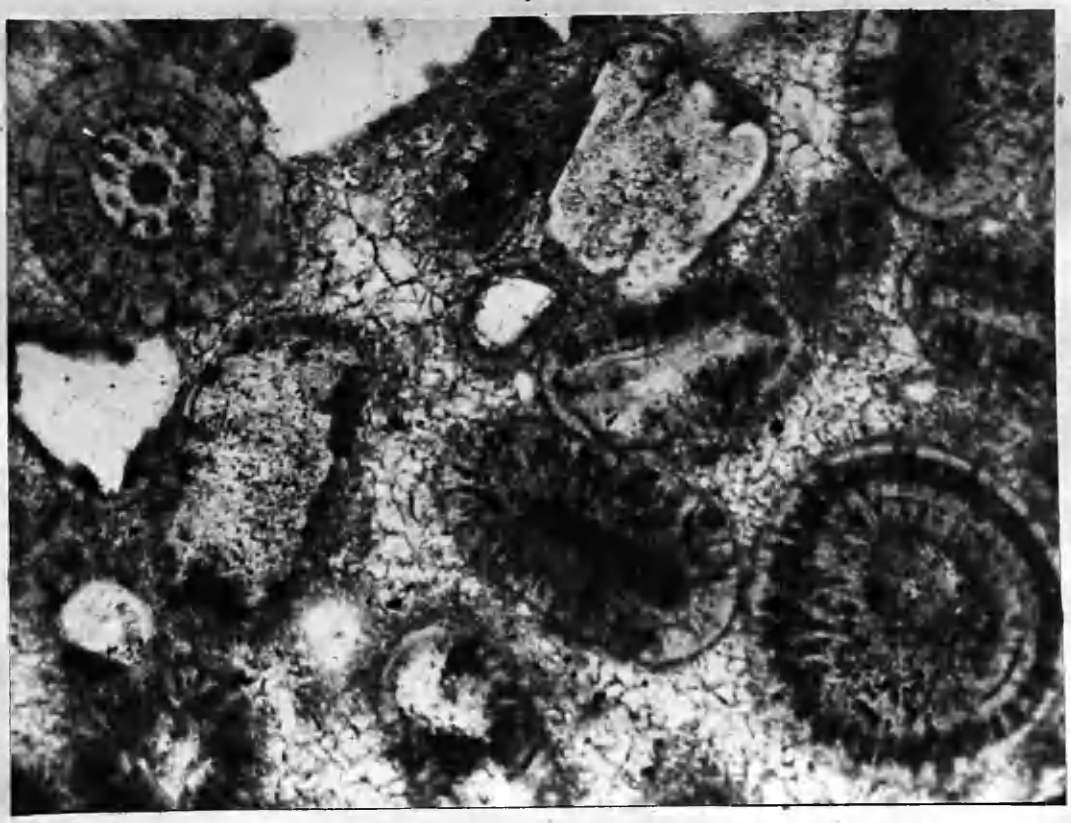

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PLATE V

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PLATE VI.

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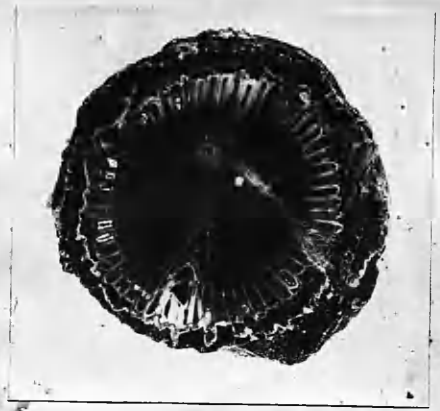

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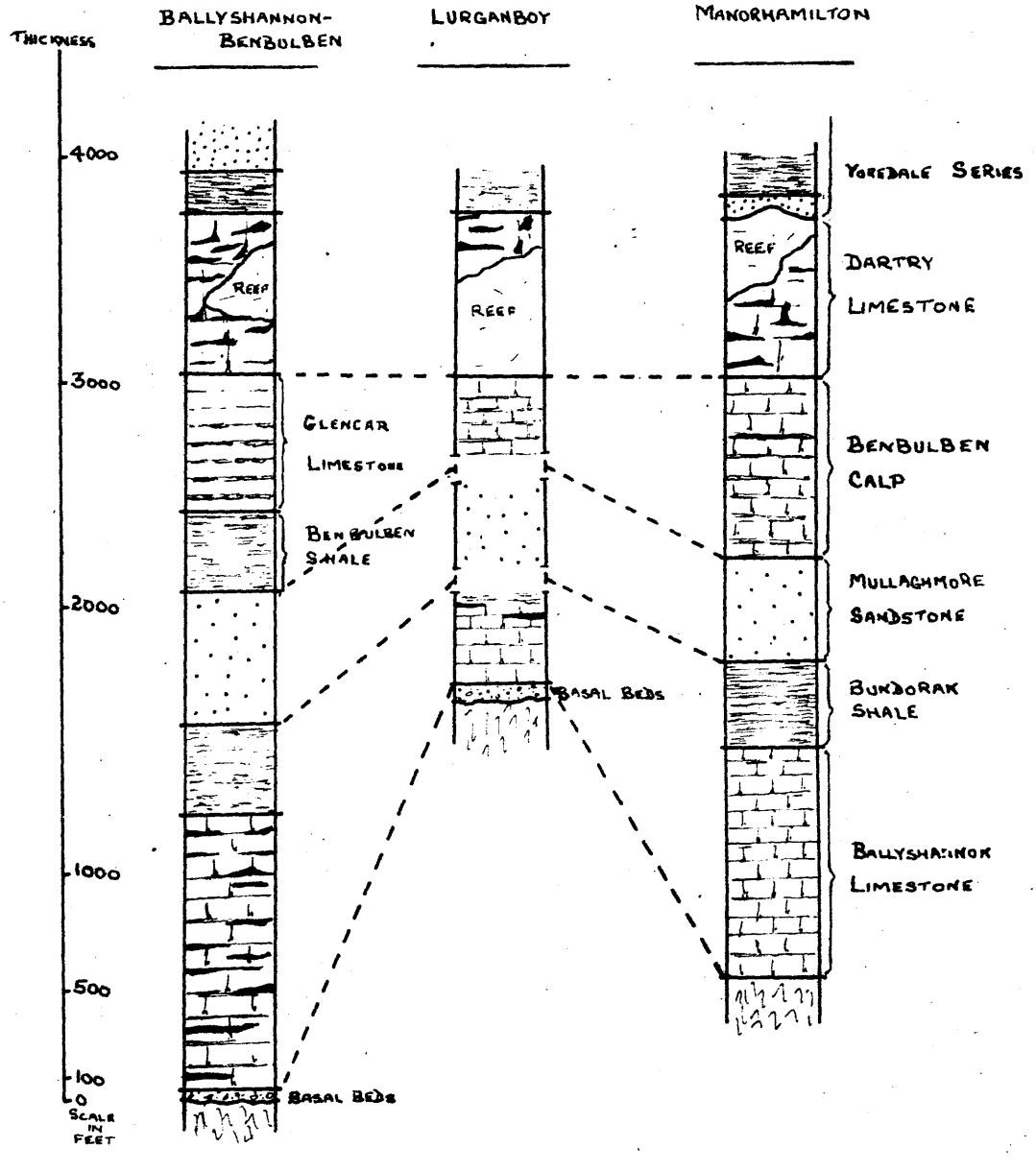
PLATE VII.

STRATIGRAPHICAL TABLE SHOWING REGIONAL CORRELATION



VERTICAL SCALE: ONE INCH TO 800 FEET.

THE CARBONIFEROUS ROCKS BETWEEN THE OX MOUNTAINS AND DONEGAL BAY.

N

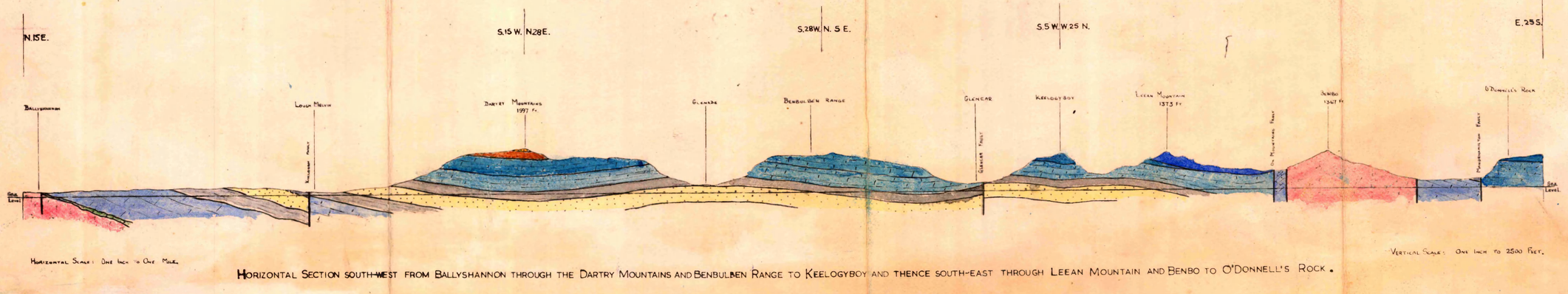
DONEGAL BAY

SLIGO BAY

- YOREDALE SANDSTONE
- YOREDALE SHALE
- REEF LIMESTONE
- DARTRY LIMESTONE
- GLENCAR LIMESTONE
- BENBULBEN SHALE
- MULLAGHMORE SANDSTONE
- BUNDORAN SHALE
- BALLYSHANNON LIMESTONE
- BASAL BEDS
- DALRADIAN

BALLYSHANNON, FAIRIES BRIDGE, AUGHRUS POINT, BUNDORAN, MULLAGHMORE HEAD, KINLOUGH, LOUGH MELVIN, KINLOUGH FAULT, CLIFFONY, INISHMURRAY, STREEDAGH POINT, MONEYDOOR, BALLAGHNATRILLICK, GRANGE, GRANGE FAULT, TRUSKBEG, TRUSKMORE, GLENIFF, GLENADE LOUGH, BENBULBEN, BENBULBEN RANGE, DARTRY MOUNTAINS, OX MOUNTAINS FAULT, KILTYCLOUGHER, SERPENT ROCK, LISSADELL, CARNEY, GLENCAR LOUGH, DRUMCLIFF BAY, GLENCAR FAULT, CASTLEGAL MT, CASTLEGAL FAULT, NORTH ROSSES FAULT, CONEY ISLAND, ROSSES POINT, KILROOSK, NURE, LURGANBOY, MANORHAMILTON, SHANYAUS CROSS, DOUGH HILL, LEEAN MOUNTAIN, KEELOGYBOY, BENBO, O'DONNELL'S ROCK, GIBRALTAR POINT, SLIGO, SLIGO FAULT, KNOCKNAREA, LOUGH GILL, BALLISODARE

SCALE
ONE INCH TO ONE MILE



HORIZONTAL SECTION SOUTH-WEST FROM BALLYSHANNON THROUGH THE DARTRY MOUNTAINS AND BENBULBEN RANGE TO KEELOGYBOY AND THENCE SOUTH-EAST THROUGH LEEAN MOUNTAIN AND BENBO TO O'DONNELL'S ROCK.