

Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 41, 53, AND 64 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

INCLUDING THE

COUNTRY AROUND BALLINA, CROSSMOLINA, KILLALA,
FOXFORD AND BALLYCASTLE;

BY

RICHARD GLASCOTT SYMES, M.A., F.G.S.

WITH

PALÆONTOLOGICAL NOTES BY W. H. BAILY, F.G.S.

(ACTING PALÆONTOLOGIST.)

Published by Order of the Lords Commissioners of Her Majesty's Treasury.



DUBLIN:

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE :

PUBLISHED BY

ALEXANDER THOM & CO., 87, 88 & 89, ABBEY-STREET,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY;

HODGES, FOSTER, & CO., 104, GRAFTON-STREET.

LONDON:

LONGMAN & Co., PATERNOSTER ROW; TRÜBNER & Co., LUDGATE HILL.

1879.



THE
GEOLOGICAL SURVEY OF THE UNITED KINGDOM

IS CONDUCTED UNDER THE POWERS OF THE

8TH & 9TH VICT., CHAP. 63.—31st JULY, 1845.

DIRECTOR-GENERAL OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM :

A. C. RAMSAY, LL.D., F.R.S.

Geological Survey Office and Museum of Practical Geology, Jermyn-street, London.

IRISH BRANCH.

Office, 14, Hume-street, Dublin.

DIRECTOR :

EDWARD HULL, M.A., LL.D., F.R.S.

DISTRICT SURVEYOR :

G. H. KINAHAN, M.R.I.A., &c.

SENIOR GEOLOGISTS :

W. H. BAILY, F.G.S. & L.S. (Acting Palæontologist); J. O'KELLY, M.A., M.R.I.A.;

R. G. SYMES, M.A., F.G.S.; S. B. N. WILKINSON.

ASSISTANT GEOLOGISTS :

J. NOLAN, M.R.I.A.; H. LEONARD, M.R.I.A.; R. J. CRUISE, M.R.I.A.,
W. A. TRAILL, B.A.; F. W. EGAN, B.A.; E. T. HARDMAN; J. R. KILROE;

W. F. MITCHELL; and A. M'HENRY.

FOSSIL COLLECTOR :

R. CLARK.

The observations made in the course of the Geological Survey, are entered, in the first instance, on the Maps of the Ordnance Townland Survey, which are on the scale of six inches to the mile. By means of marks, writing, and colours, the nature, extent, direction, and geological formation of all portions of rock visible at the surface are laid down on these maps, which are preserved as data maps and geological records in the office in Dublin.

The results of the Survey are published by means of coloured copies of the one-inch map of the Ordnance Survey, accompanied by printed explanations.

Longitudinal sections, on the scale of six inches to the mile, and vertical sections of coal-pits, &c., on the scale of forty feet to the inch, are also published, and in preparation.

Condensed memoirs on particular districts will also eventually appear.

The heights mentioned in these explanations are all taken from the Ordnance Maps.

AGENTS FOR THE SALE OF THE MAPS AND PUBLICATIONS :

Messrs. LONGMANS, GREEN, & Co., London ;

Messrs. HODGES, FOSTER, & Co., Grafton-street, Dublin ;

ALEXANDER THOM & Co., Printers and Publishers, Abbey-street, Dublin.

NOTICE.

IN the following Memoir by Mr. Symes, the nature of the various formations and rock masses and their stratigraphical and other relations to each other are so plainly expressed, that, in a broad way, any one at all conversant with geology cannot fail to understand the structure of the country. Having some years ago had the advantage of traversing part of the ground with the Director, Professor Hull, I can, to some extent, speak of it from personal experience.

ANDREW C. RAMSAY,
Director-General.

PREFACE.

The district embraced in this Memoir has been geologically surveyed by the author, Mr. Symes, Senior Geologist, and inspected by myself on several occasions while in progress in the years 1875-77. It is one of remarkable interest, owing to the relations of the Metamorphic group of rocks to the newer Carboniferous strata. The Metamorphic rocks are similar in character and in their stratigraphical relations to the overlying "Llandovery" conglomerates and Old Red Sandstone, to those of the district of Connemara and West Mayo, of which they are the evident prolongation, and may like them be considered to belong to the Lower Silurian series. The evidence for this determination has already been stated by the Director-General in his preface to the "Explanatory Memoir" to accompany Sheets 93 and 94 of the Geological Survey Map.

The evidences of glacial erosion, and of a movement of an ice-sheet in a north-westerly direction, are also remarkably striking, and will always make the shores of Lough Cullin and Lough Conn a favourite resort of the glacialist. Those who may examine the district with the aid of the Maps and Memoir will probably admit that its geological features have been very accurately laid down and described.

EDWARD HULL,
Director of the Geological Survey of Ireland.

Geological Survey Office, Dublin,
5th December, 1879.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 41, 53, AND 64

OF THE MAPS OF THE

GEOLOGICAL SURVEY OF IRELAND.

PART I.

PHYSICAL GEOGRAPHY.

THE area about to be described lies partly in the counties of Mayo and Sligo, but by far the larger portion in Mayo. It is bounded on the north by the Atlantic, and Killala Bay, on the east by that portion of the Ox mountains known as the Slieve Gamph hills, on the south by the Croaghmoyle and Pontoon hills, and on the west by Nephin and the Ballycastle mountains.

The chief towns are Ballina, Crossmolina, Killala, Foxford, and Ballycastle; there are also the small villages of Inishcrone* and Laherdaun.

Nephin mountain (2,646 feet in elevation), is the highest in Mayo, and lies on the south-west corner of Sheet 64. It is unconnected with any of the numerous mountains and hills which more or less form the western and southern boundary of the district. Tristia hill (1,067 feet), stands also in an isolated position about two miles north-west of Nephin. South-east of Nephin there lies the long narrow valley which extends to Newport (Sheet 74), and immediately to the east of this valley we have Croaghmoyle (1,196 feet), Beltra (1,080 feet), and Windy Gap (976 feet), which present very remarkable escarpments especially on the north-west slopes. To the east of the last-mentioned hills rise Lagan (1,298 feet), and Greenans (992 feet), which occupy the centre of a bold and mountainous district, gradually sloping to the shores of Loughs Conn and Cullin, which are only about 40 feet above the level of the sea. East of the lakes, and in the neighbourhood of Foxford, the ground gradually rises, and although cut up by numerous valleys, which more or less run at right angles to the general direction of the high ground, it extends into the long narrow range of hills which in this portion are termed the Slieve Gamph, and finally into that range known as the Ox mountains, which extend as far as the town of Sligo. The only other hills worth mentioning are those which lie west of Ballycastle (Sheet 53), and which rise with gentle slopes to six and seven hundred feet not far from the town, but increasing as we go west-

* Although marked Inishcrone on the map, it is always called Einniscrone.

ward, until 848 feet is attained just at the margin of Sheet 53. To the north of Ballycastle the coast section extending from Benmore (which lies west of Bunatrahir Bay), by Downpatrick Head, and as far as Kilcummin Head (which is to the east of Lackan Bay), shows in almost vertical cliffs the gently undulating beds of the yellow sandstones of the Lower Carboniferous series. It also shows the gradual eating away of the land along certain lines of fault and jointage by the action of the powerful waves of the Atlantic. Arguing on this supposition, we take it for granted that it was by this process that both Bunatrahir and Lackan Bays were formed; but, practically speaking, evidence is afforded of the rapid demolition of the cliffs by observing the action of the waves along the very numerous caverns in, and about, the headlands.*

Within the area just described, which is more or less surrounded by high ground, there lies a low undulating tract, having very few well-marked physical features, and in this the Carboniferous limestone lies; the town of Ballina being, as it were, in the centre of the basin.

Drainage.—There are four distinct catchment basins in this large district—I. The Moy. II. The Crumpaun or Newport. III. The Cloonaghmore or Palmerstown. IV. The Ballinglen or Ballycastle—that of the Moy occupying considerably more than three-fourths of the entire.

The river Moy, as it enters the district from the south, below Foxford, receives all the waters on the eastern side, and from the west those of the Deel and Addergoole rivers, which pass through Lough Conn, as well as the waters of the Claddagh and Castlebar rivers, which pass through Lough Cullin. It is separated from the catchment basin of the Crumpaun and Newport rivers by the watershed passing over Croaghmoyle, Nephin, and Tristia, in the south-west of Sheet 64. It is also separated from the catchment basins of the Cloonaghmore or Palmerston river, and the Ballinglen or Ballycastle river, by the watershed entering the district on the west side of Sheet 53, and passing over the comparatively low ground by Glenmore, Millbrook, Ballybroony, Broadlands, &c. The drainage of the Moy and Palmerston rivers passes into Killylala Bay; that of the Ballycastle river into the Atlantic west of Downpatrick Head, while that of the Crumpaun river goes into Clew Bay.

Loughs Conn and Cullin, occupying a very large portion of Sheet 64, are connected by the waters which pass under Pontoon Bridge,† and present good examples of rock-basins, probably scooped out by ice. To the east and west of Pontoon Bridge are low granitic hills, most beautifully carved, rounded and striated by ice action, which in this immediate locality passed from the south in a direction slightly west of north.

* Of the cliffs above mentioned, none of them exceed the height of 120 feet above the level of the sea.

† It is a curious fact that although the Moy receives the waters from Loughs Conn and Cullin, yet after incessant rain the reverse takes place, owing to the Moy not being able to discharge such an increased body of water through the confined channel in the neighbourhood of Foxford.

PART II.

ROCK FORMATIONS AND DIVISIONS.

Aqueous Rocks.

Name.	Colour on Map.
Recent and Post-Glacial.	Blown Sand when forming dunes, <i>Uncoloured.</i>
	Alluvium and Bog, <i>Pale Sepia.</i>
Post-Pliocene.	Drift, sand, gravel, and boulder clay, <i>Engraved dots.</i>
Carboniferous.	d ^{2'} Lower Limestone, oolitic at base, { <i>Prussian blue, red dots on the blue.</i>
	d ^{1'} Lower Carboniferous Sandstone, with bands of Limestone, { <i>Prussian blue and Indian ink, with yellow dots.</i>
Old Red Sandstone.	c Sandstones and shales, <i>Indian Red.</i>
Silurian.	b Conglomerate and Sandstone (probably of "Upper Llandovery" age), <i>Light Purple.</i>

Metamorphic Sedimentary Rocks.

μ	Mica schist,	<i>Pale pink.</i>
Q.	Quartzite,	{ <i>Do. washed with chrome yellow.</i>
λ.	Crystalline Limestone in schist,	<i>Cobalt.</i>
Δ.	Hornblende rock,	<i>Crimson Lake.</i>
Gf.	Granite, foliated,	<i>Light carmine.</i>
Gp.	" " porphyritic,	<i>Do.</i>

Igneous Rocks.

B.	Dolerite and Basalt,	<i>Burnt carmine.</i>
Bp.	" when porphyritic,	<i>Do.</i>
F.	Felstone,	<i>Light Vermilion.</i>

METAMORPHIC SEDIMENTARY ROCKS.

Foliated Granite.—This rock is to be found in the S.W. of the district, in the neighbourhood of the town of Foxford, and extending N.E. and S.W. from thence; it margins the shores of Loughs Conn and Cullin, and forms the highest peaks of the Slieve Gamph hills. It extends into the districts E. and S. of this, and a description has already been published in the Explanations to accompany Sheet 75, p. 26.

Although called a granite, it is, strictly speaking, rather a gneiss, formed *in situ*; and although the metamorphism may have been great, the foliation still follows the original planes of bedding.

I think it may be inferred from the uniform position, lie, and thickness of the schists which are regularly overlying the granite on the N.W. and S.E. slopes, that the mass may be considered as a

great anticlinal, and that originally the schists capped the granites, and over, the schists the Carboniferous beds; the "lie" of all being identical, yet the foliation, as now seen in the granite, does not warrant such an idea; however, if we had a great break, or fault in its centre, it would easily account for the constant vertical foliation which is parallel to the axis of the range of hills just mentioned. At the eastern margin of Sheet 64, there are examples of faults traversing the granite along the line of foliation.

The best localities for examining this rock, are those about the western shores of Lough Cullin, and in the low hills at the Pontoon, as the rocks there are not much broken up, but retain their petrological condition subsequent to their metamorphism.

Although the rocks at the Pontoon have not been much affected by the enormous breaks and faults which affect the granites a few miles E. and W. of this locality, yet they show clearly that it was there the great icefield found its outlet in conveying its great burden from an immense area to the south of the district. The low mammilated and hummocky hills at the Pontoon, show almost every stage of the action of a great ice sheet on a rock so highly crystalline, and devoid of joints as this foliated granite.

Roches moutonnées, and *blacs perchées*, are extremely frequent: in the former the *crag* is well shown by vertical cliffs, as the passage of the ice was at right angles to the line of foliation. Striations and grooves are met with over all the rocks from the Pontoon Bridge to the Police Barracks; but owing to the highly crystalline nature of the rocks, the grooves are more frequent than the striations—the latter can only be seen on the quartz veins which traverse the granite along the foliation.

In general composition, the rock consists of two felspars, one mica (black), and quartz. The crystals varying in size throughout the entire of the exposure; and the degrees of weathering vary in proportion to the rock being fine or coarse grained. Crystals of tourmaline are met with in the granites at the railway bridge on the E. side of Lough Cullin. On the shores of Loughs Conn and Cullin, where any hollow surface is capable of holding water, the rock weathers very rapidly, probably owing to frost, and, by degrees, a small rock basin is formed.

General bearing of foliation here is N, 60° to N. 70° E., but gradually changes to the N.E., as we get into the hills to the east.

West of the Pontoon, as well as at Glendaduff, on the east margin of Sheet 64, where the rocks are very much broken up, and the general condition of the rocks changed, subsequent to metamorphism, the proportion of the minerals are different to those of the main mass, such as at Foxford, and from that to Pontoon. The great change from fine-grained granite at Pontoon to a porphyritic rock, where the rocks are so much displaced, is very well marked; the colour, as well as composition, also changing. The colour of the granite at Pontoon is always gray; whereas, that at Terryduff, and to the north of it, is nearly always pink—mica being frequently absent.

Where these changes exist, fault rock is very abundant, composed almost entirely of *kaolin* of a pale flesh colour.

A notable but thin band of quartzite is to be met with among the granites of the Pontoon, which gradually dies out towards the east.

Schists.—These rocks are very well seen in the S.W. of the district, resting on the slopes of the granite hills, and in the hills E. and W. of Nephin, in the S.W.

Plenty of evidence is afforded in examining these rocks, but they do not differ in any very material point over the area which they cover. In all cases, the foliation follows the bedding, so by this means the different beds have been well traced out, especially in the Nephin range, where they alternate with the quartzites.

As already expressed, the metamorphism was not very great, and to this may be added that it was partial in its effects. As an example of the latter, beds are found in the valley between Nephin mountain and Tristia mountain, in which no trace of foliation was discernible, the rock being a coarse grit.

The ordinary class of schists, such as black and white micaceous schists, are most common; but, in some places, hornblendic, talcose, and chloritic schists were found. However, by following the strike of these rocks, it was always found that their respective characters died out, and that they gradually merged into mica schist. Regular beds of mica schist were met with in the granite very close to the boundary, and being so narrow, could not be inserted in the map where a well-defined boundary between these two classes of rocks was traced out.

Quartzite.—Nephin Mountain is composed almost entirely of this rock, but it is so broken up, and the bedding so irregular, that no estimate can be formed of its thickness, consequently it is to the hills south-west of Nephin, that we must look for evidence. On Knockaffertagh, which is immediately outside the western margin of Sheet 64, the bedding of the quartzites is so regular that the limits can be well defined, and from this mountain we are able to draw the inference that the quartzites of Nephin are not so thick as the observer would imagine by looking at the large area on the map coloured as quartzite. From careful examination we are also able to prove that the quartzites of Nephin form a great anticlinal, the axis being a fault ranging in a N.N.E. direction, with the beds dipping towards the N.W. and S.E. respectively; also that there is a repetition of the beds on the E. side of Nephin, similar to those in Tristia, two miles N.W. of Nephin.

On Nephin there are several kinds of quartzites, as on the top they mostly consist of an amorphous granulated compound of quartz and felspar (which is traversed in all directions by innumerable veins of quartz), and in which the felspar weathers rapidly out; this rock is devoid of foliation. Overlying the amorphous rock on the E. and W. flank, we have thick-bedded conglomerates, which are denuded from the summit of the mountain, composed of large blocks of thinly foliated pink and white quartzite, and coarse mica schist, imbedded in a matrix, also devoid of foliation, and underneath the amorphous rock there is flaggy quartzite and quartz schist, in which the foliation is well discerned; yet in some cases owing to the compactness of the rock and the

smallness of the flakes of mica, we require the aid of the glass to detect the lines which are so minute.

In the district west of this we have an exact repetition of the Nephin quartzite and the schists that alternate with it, the different beds being most clearly traceable by steady rolls and undulations over a large tract of country, and as far as Curraun Achill.

Independent of the quartzites of Nephin, there are others in connexion with the granites south of Foxford, as well as adjoining the granite at Terryduff.

These two are outcrops of apparently the same beds, but on either slope of the granite anticlinal; in the case of the Terryduff quartzite, the rocks there are so broken and displaced, that the direction of the foliation would lead the observer to conclude they had no relation to the beds S. of Foxford, which alternate with the granite, and which are shown to become thin towards the east, and end against a fault.

Sections of the granite, schists, and quartzite in a vertical position are well seen S. of Lough Muck.

Crystalline Limestone in Schist.—Although several examples are met with of crystalline limestones occurring in the metamorphic rocks, it is very doubtful whether we can accept these limestones as being contemporaneous with the schists and quartzites, in which they are found. Against the theory of their being metamorphosed, we rarely find any schistose limestone, save along the wall or junction of the beds along which they lie; we also seldom find these limestones following the foliation of the beds, and we only find them close to the Carboniferous limestone boundary, and along lines of great fault, such as the fault between the Silurian and Metamorphic rocks E. of Burrin Hill (1,299), on the S. margin of Sheet 64, and in the large fault three miles S.S.W. of Laherdaun, which separates the quartzite and schist from the Old Red Sandstone.

From such evidence it may be assumed that this crystallized limestone, with but one exception, has been formed by infiltration or percolation of bi-carbonate of lime, from the once overlying Carboniferous rocks, into joints or cracks in the now Metamorphic series.

The one exception where the limestone was found in a schistose state, and following the foliation, which in this district includes the bedding, is in the small conical hill south of Ballycong Lake, about five miles N. of Foxford, there the limestone is capped by a bed of quartzite, but even these facts are not evidence why the limestone was not formed in a similar manner to those already described.*

Hornblende Rock.—Four or five large exposures are met with in the granite and schists N. and S. of Foxford, one especially about a mile S. of Foxford, containing large crystals of hornblende, white felspar, brown and black mica, quartz veins, and a few small crystals of iron pyrites; this rock is foliated, and has the same

* I do not agree in Mr. Symes's view of the origin of these limestones—which I consider to belong to the group of strata in which they are found, just as they do in the West Galway District.—E. H.

direction as that of the granite in conjunction, but a well-marked boundary separates them. In the exposures four miles north of Foxford, the hornblende is highly crystalline, and the foliation very distinct, and being such a tough rock, weathers less than the schists in which it is found.

SILURIAN ROCKS OF BELTRA.

The rocks forming this group are but indifferently represented in this district, not from quantity (as considering the very small area which they occupy in the southern margin of Sheet 64, there are plenty of bold escarpments, cliffs, and river sections, which show their nature), but from the description of the rocks, and the absence of palæontological evidence it has been found difficult to place them with any exactness in their true position. Notwithstanding this difficulty, they have been placed among the "Upper Llandovery" beds from their lithological character, and from their close resemblance to the rocks which cover a large area lying to the west of Lough Mask (Sheet 85), in which fossils were found, thereby establishing their age.*

As to the thickness of the formation, no reliable data can be obtained. This is due in many cases to the constant absence of bedding, but the main cause is the great amount of crumpling to which the mass has been subjected in connexion with the enormous faults which present such marked features in that locality. A rough calculation as to the thickness of these beds was made when preparing the "Explanation" to accompany Sheet 75, in which this formation is much more largely developed, and the conclusion arrived at was, that they did not exceed 2,000 feet, but this can only be considered as approximate.

The beds of this formation consist of massive conglomerates, having blocks and pebbles of schist and quartzite very frequent, with a slight admixture of pebbles of vein quartz, granite, sandstone, and limestone.

Any sandstones found in this series occur under an enormous thickness of massive conglomerate, forming the almost perpendicular escarpment at Burrin (1,299 feet), at the southern margin of the district, and also at the base of the escarpments south of Levally Lough, where they consist of thin-bedded red and purple sandstones, alternating with green mottled shales.

OLD RED SANDSTONE.

The beds of this formation are to be found at the south-west portion of the district, and are a prolongation of the larger area which extends all along the northern portion of Clew Bay, and as far as Curraun Achill (Sheet 74).

They are to be found flanking Nephin, and they form the hill of Tonacrock (430 feet), two miles west of the village of Lahardaun, which presents a vertical cliff on its western side, showing an excellent section of the beds. They are also to be found in an isolated patch on the south of the valley at Levally Lough.

* Not only do these conglomerates resemble those of Lough Mask, but they occupy a position intermediate between the metamorphic beds (which are probably of Lower Silurian age) and the Old Red Sandstone of the district, to both of which formations they are unconformable. They are, therefore, in the position of the Upper Silurian beds.—E. H.

The sandstones and conglomerates rest unconformably on the quartzites and schists on the southern slopes of Nephin and the mountains to the west, but do not lie in the valleys which separate these mountains. On the south side of Levally the beds rest unconformably on the Silurian beds and quartzites, and are separated from the yellow sandstone and limestones of Carboniferous age in that locality by a large fault.

Vertical sections of the beds, as well as horizontal sections, showing the relation of these beds to the metamorphic series, as well as to the yellow sandstones and limestones which rest conformably on them, are to be met with, one of which is the following:—

Vertical Section at Tonacrock.

	Ft.
Well-rounded pebbly conglomerate, containing felstone and quartz porphyry pebbles, with sandy matrix,	97
Angular breccia, with gravelly matrix and large blocks,	100
Very thick-bedded red sandstones and shales,	50
	247

By far the largest portion of these beds is composed of conglomerates; at same time, in other sections, the sandstones and shales are to be found alternating with the conglomerates, and in some cases form the passage rocks from the Lower Carboniferous, to the Old Red Sandstones.

The composition of some of these conglomerates is rather curious. From one specimen on south side of Tonacrock the following pebbles were noted:—schist and quartzite (very abundant); vein quartz (scarce); granite, red hæmatite, jasper, and quartz-porphry (all very scarce).

At a section where the beds are to be seen resting on the quartzites of Nephin, all are composed of a very coarse angular breccia, in which the blocks are schists and quartzites.

In summing up these few remarks on a formation so indifferently represented in the north-west of Ireland, it must be borne in mind that, although these beds have been classed under a separate formation, the reason why they are not put under the head of Lower Carboniferous Sandstone is chiefly lithological. At the same time it is to be observed that these beds are absent below the Lower Carboniferous Sandstone at its junction with the metamorphic rocks in north Mayo.

In favour of such an idea we have the remarkably small thickness of the Carboniferous Sandstones and Old Red in this locality in comparison with the great thickness of the well-recognised Lower Carboniferous Sandstones in the north-west of the district, but against this view we have the total absence of any palæontological evidence in these older beds, combined with the very great variance in their lithological characters.*

LOWER CARBONIFEROUS SANDSTONE.

A very large portion of the district, especially to the north-west, is composed of rocks forming a group conformable to the Lower Carboniferous Limestone, and corresponding to the Carboniferous

* Gray friable sandstones are characteristic of the Lower Carboniferous Sandstones, while soft red sandstones are so of the Old Red Sandstone.—E. H.

Slate series of the south of Ireland, as well as the Calciferous Sandstones of Scotland.

Although they occupy such a large area, and are a prolongation of the beds to the west, their thickness is not nearly so great as that of the same series in the south of Ireland, and if we measure from the oolitic limestone (which has been placed as the basal bed of the Lower Carboniferous Limestone), to the conglomeritic bands which are to be found resting unconformably on quartzites and schists west of this district, it will be found that the total thickness does not exceed 1,000 feet.*

Occupying, as they do, such a large tract, it would be supposed that their thickness would be much greater; but considering that they roll so frequently, and for the most part lie at low angles, the above calculation may be taken as approximate. Coupled with their low inclinations, there must also be taken into account the numerous faults which traverse them, more especially those at Ballycastle and Lackan Bay, where the faults lie along the strike of the beds, and produce a repetition of the strata.

East of the fault at Ballycastle, which gives a downthrow to the west, beds are met with very similar to those above the basal beds outside the district, so that the series may be estimated from Ballycastle eastwards.

Sections of the gradation of the beds are well seen in the vertical cliffs extending from Downpatrick Head to Creevagh Head, and along by Kilcummin Head, but in the south this series thins out very much, whilst in the east of the district it is questionable whether it is there at all represented; the beds coloured as such being possibly shore beds in the Carboniferous limestone.

At the shore to the north of Ballycastle it has been assumed that the lowest beds are found, and that they crop out towards the west along the line of the great north and south fault; they consist of red micaceous sandstones, capped by red and gray sandstones, dipping east at 30°. North-east of these, the beds commence to roll and dip at low angles generally towards the north-west, and are composed of red beds containing nodules of purple limestone, some three inches in diameter, resting on red sandstone, and capped by massive yellow sandstones. The section then towards Downpatrick Head shows an almost regular succession and repetition (due to small faults) of flaggy sandstones obliquely laminated, and jointed vertically, with bands of impure limestone and shales. At Downpatrick Head, the almost vertical cliffs consist of calcareous sandstones, black rotten shales, black impure limestone, and sometimes a thin band of light gray brittle limestone; most of the beds contain fossils, especially plants,† and lie at low angles, dipping towards the north. Immediately north of Downpatrick Head is Doonbristy Island, where there is apparently a similar section, with this exception, that in the middle of all there is a bed about thirty

* Archdeacon Verschoyle estimates the thickness of these beds as between 1,700 and 1,800 feet.—*Transac. Geological Society, London, 2nd Series, Vol. V.*

† On the occurrence of Exogenous Wood in the Arenaceous Limestone of the Yellow Sandstone Series of the North Coast of Mayo, by the Rev. Samuel Houghton, M.D., F.R.S. *Journal Geological Society of Dublin, Vol. X., p. 122.*

feet thick of gray sandstone. East of Downpatrick Head, and as far as Creevagh Head, the cliffs which rarely exceed 100 feet in height present a succession of beds lying at low angles towards the east, and consisting of hard flaggy quartzose sandstones, thin bands of lignite at Pollnamuck, limestones and shales (one bed of limestone seven feet thick), micaceous slates and flags, ripple-marked, and impure fossiliferous limestones.

Fig. 1.



Doonbristy Island and Downpatrick Head, from the West.

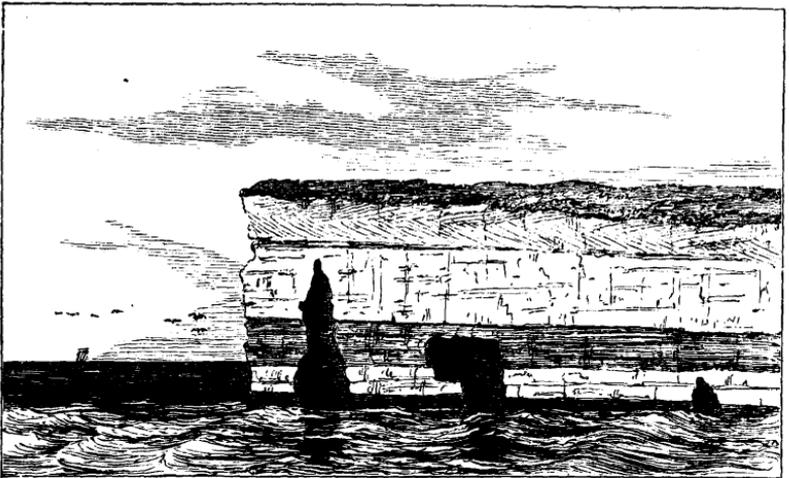
height present a succession of beds lying at low angles towards the east, and consisting of hard flaggy quartzose sandstones, thin bands of lignite at Pollnamuck, limestones and shales (one bed of limestone seven feet thick), micaceous slates and flags, ripple-marked, and impure fossiliferous limestones.

Section at Creevagh Head.

	Feet.
Thin flaggy calcareous sandstones obliquely laminated,	30
Thick-bedded compact brown quartzose sandstone,	30
Thin-bedded shales and limestones,	30
	90

East of Creevagh Head, the cliffs present almost horizontal beds of ripple-marked micaceous flags and shales, interstratified with hard quartzose sandstones.

Fig. 2.



Creevagh Head, from the West.

At Kilcummin Head a good section can be traversed, commencing on the east side of Lackan Bay, where the lowest beds consisting

of ripple-marked sandstones, interstratified with impure limestones dip at 5° to the east; above these are thin limestones, shales, and calcareous sandstones much weathered, and capping all a good thickness of shales.*

In the neighbourhood of Ross and Killala, rising as we do higher up in the series, very little change takes place, the only remarkable point being the constant alternation of the several beds. According to Archdeacon Verschoyle,† a section at Ross gives twenty-two different beds in sixty-two feet vertical section, while at Moyne, where the oolitic limestone rests on this formation, the section of fifty-two feet vertical, comprises twelve distinct beds, of which the oolitic occupies thirty-five feet.

At Moyne and to the N.E. of the abbey, I noted the following section :—

	Feet.
Earthy sandstones exfoliating,	3
Thick earthy and ferruginous black brown and gray shales, with a bed of sandstone occurring about half way,	10
Gray and brown sandstones with shale partings and well defined oblique lamination, which thin out towards the north,	7
Black muddy shales with silicified fossils,	5
	25

Above the measured section are soft arenaceous limestones, not of any great thickness, over these are intensely hard yellowish brown quartzose sandstones with peculiar wavy lines of lamination, and capping all are the oolitic limestones, which form, as already mentioned, the boundary of the Carboniferous limestone series.

Sections of the oolitic limestone and slate series are also to be met with in the islands of the estuary of the River Moy.

The sections that are seen west of Ballycastle large fault, are almost precisely the same as those described as between Downpatrick Head and Creevagh Head, with the exception that in the former the limestones occur only in bands, whereas in the latter the limestone forms a well recognised feature, more especially at Carrowmacshane Hill, two miles east of Ballycastle, where the limestones alone are about sixty feet thick, and at Ballinglen, along east side of the large fault, where the limestones in the hill lie horizontal, except in the neighbourhood of the fault, where the beds are drawn towards the west at high angles.

In the neighbourhood of Ballycastle numerous quarries have been opened where flags and slates are raised.

In the south-west of the district this formation thins out to a certain extent, and can be seen in several places resting on the Old Red Sandstone, but its junction with the overlying Carboniferous limestone is not so well defined; it almost invariably consists of white and yellowish brown coarse quartzose sandstones, devoid of shales, but having a band of calcareous conglomerate as a capping between them and the limestones. Similar beds occur on

* On the east of Kilcummin Head enormous caverns have been excavated by the sea in the impure limestones, a thick-bedded quartzose sandstone forming the roof of all.

† Trans. Geol. Soc. London, 2nd series, Vol. V., pp. 156, 157.

the S.E. side of the metamorphic hills S. of Foxford, but here they do not rest on Old Red Sandstone which is absent. They are also to be found in the shore beds of the Carboniferous limestone on the N. side of the Metamorphic hills, forming the Slieve Gamp range.*

LOWER LIMESTONE.

Oolitic Limestone.—This limestone, as previously mentioned, occupies the floor of the Lower Carboniferous limestone, and forms the boundary between it and the Calciferous series; it is very limited in thickness, and the area it covers, or where it has been found, is also confined; at same time, many miles outside this district, we have the exact beds in a position similar to those now under description.

In the neighbourhood of Killala, Moyne, Cartoon, and Castle-reagh, the best evidence can be obtained, and actual sections of the overlying and underlying rocks occur at the shore at Moyne, and under the round tower at Killala.

The beds, which rarely exceed two feet in thickness, are composed of minute spherical particles of carbonate of lime, embedded in a matrix in which silica has occasionally crystallized out in elongated crystals. In some cases fossils were found, but so comminuted as to defy classification. The total thickness of these beds is only about eighty feet, and the beds are separated one from another by minute black shaly layers. For the microscopic examination of the oolite, by Professor Hull, see page 28.†

Lower Limestone.—Although there are about 100 square miles of the district covered with Carboniferous limestone, we have been unable to make any divisions in it, and have classed all under the heading of Lower Limestone, merely from lithological characters. This want of division can be easily accounted for by the fact, that although the area is large, throughout the entire of it, the beds lie at very low angles, and there is a constant recurrence of anticlinals and synclinals, so that any attempt to calculate the thickness was found impossible; however, it may be assumed, that this formation does not exceed 600 feet.

The town of Ballina is situated somewhere about the highest beds in the district, and the town of Killala near the lowest, so sections of the different beds can be traversed along the shore on the west side of the river Moy. On the east side of the Moy, and along the shore extending northwards from Inishcrone, similar sections can be traversed; and throughout the entire district where the Lower Limestone exists, the same uniformity of character is always observable, consequently a single description will be quite sufficient.

* To the south of Laherdaun there is strong evidence of an unconformability between the Lower Carboniferous sandstone and the Old Red sandstone, as we find a considerable thickness of Old Red sandstone between the carboniferous sandstones and schists near the Addergoole river, which are entirely absent further north.—E. H.

† No better building stone than this oolite can be found anywhere; as examples of its lasting powers, we have the abbeys of Moyne and Rosserk, and the round tower of Killala; but it is greatly to be regretted that when quarries have been opened, no attempt was made to get to the heart, as after each excavation the quarry gets choked with debris.

As a rule, the limestones are almost dark gray in colour, and, generally speaking, rarely exceed one foot in thickness. In places they are evenly bedded, as in the shore sections previously alluded to; but in the large area, east of Killala Bay, the limestones assume a wavy form of bedding, probably due to the unequal decomposition of the beds. Great zones of characteristic fossils of the Lower Limestone period, such as *Producta gigantea*, and *Zaphrentis cylindrica*, are frequently met with in these beds. Between the beds of limestone there are always bands of shales, which, in places, as at Castleconnor, on the east side of the river Moy, attains a thickness of some feet. From these shales there issues a constant supply of water which is highly charged with bi-carbonate of lime derived from the limestones, and this water redeposits its lime in the form of petrefactions along the shore line, and in the brooks in a similar way to that at Auvergne.

The texture of the limestones is very similar throughout the district, inasmuch as they are always finely crystalline—in no case have we highly crystalline rocks. The brittleness is also remarkable, as the beds are traversed by numerous well-defined joints, and also by an infinite number of invisible joints, locally called “watery joints,” which are only observable when the rock has been reduced by pressure. On this account, it may be inferred that for external purposes, there could be no worse building stone.

Thick flags, five feet long, and four inches thick, have been raised at Inishcrone; and are suitable for door sills and underground for covering sewers.

IGNEOUS ROCKS.

Dolerite.—Abundance of evidence of the nature of this rock is to be found in this district, more especially about three miles north of Killala, in the Carboniferous slate series, and in the shore sections in the Carboniferous limestones on the east side of Killala Bay.

At Mullaghnacross, at the cross roads between Killala, Kilcummin, Summerhill, and Ballycastle, the dolerite is very highly crystalline. Some of the crystals of labradorite (?) are more than half an inch long, and are of a pale bluish gray colour, but the augite is not so well developed. In this locality it was inferred that the irruption of the igneous matter took place, and that it spread its sheets or dykes in all directions from this as a centre. For microscopical examination of this rock see page 27.

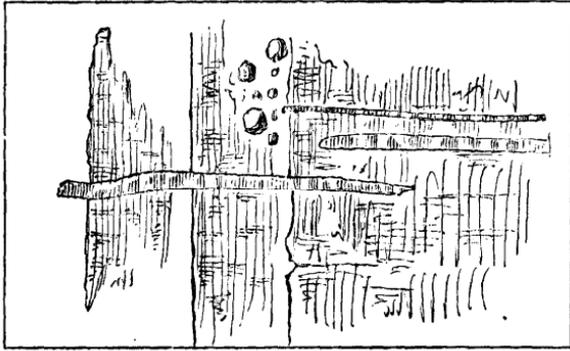
In no other part of the district have we so highly a crystalline dolerite as the boss at Mullaghnacross, but in several of the dykes which are so numerous on the Inishcrone shore, it is found that in proportion to the width, so is the crystallization. In the case of the dykes the augite is more highly crystalline than the feldspar.

On the shore, to the north of Inishcrone, no less than thirty-six dykes of basalt and dolerite were noted and measured. These range in width from six inches to three hundred feet, but the most of them are from five to fifteen feet. None of these dykes occur

along the bedding of the limestones, but appear in vertical dykes at right angles to the strike of the limestones, which along this shore is in a N. and S. direction, and the dip at a low angle.

In all these dykes there are vertical joints along their direction, which probably are planes of cooling, and at right angles to these

Fig. 3.



Dyke of dolerite (basalt) in limestone N. of Inishcrone.

planes are smaller joints, along which the rock exfoliates, and produces the rhomb so peculiar to weathered dolerite. The presence of these dykes can always be ascertained prior to actual observation, as a system of vertical parallel joints is given to the limestones in connexion with the dyke, and the jointage is greater in proportion to the size of the dyke. The joints in connexion are so fine that the limestone appears as if it had been cleaved, but in proportion as you recede from the dyke the joints extend from inches to feet. Another phenomena with regard to these dykes is the alteration of the limestones, which has been described by my colleague, Mr. Hardman.* The alteration, however, does not affect the rock so much as to preclude the idea of obtaining fossil evidence.

On the east side of the headland known as Kilcummin promontory, there are five dykes having somewhat of an E. and W. direction, the largest being twenty-one feet across. These dykes have all the same characteristics as those at Inishcrone, and contain some yellowish brown mineral, probably olivine. At Downpatrick Head there are some three or four dykes, but one only of any consequence, which occurs in the sandstones and shales to the south of Portnahally. This dyke is well shown in the vertical section of the beds, and affects the sandstones in the same way as the shales, giving the peculiar parallel jointing to both.

In a paper read by Archdeacon Verschoyle, an attempt is made to show that all these dykes are parallel to one another, and the author by this means comes to the conclusion that a certain dyke—say the dyke known as the Boat Harbour at Inishcrone—can be traced along a certain E. and W. line, and that from Sligo on the E. to Belmullet on the W., which is over 60 miles, the one dyke is continuous. This argument however, will

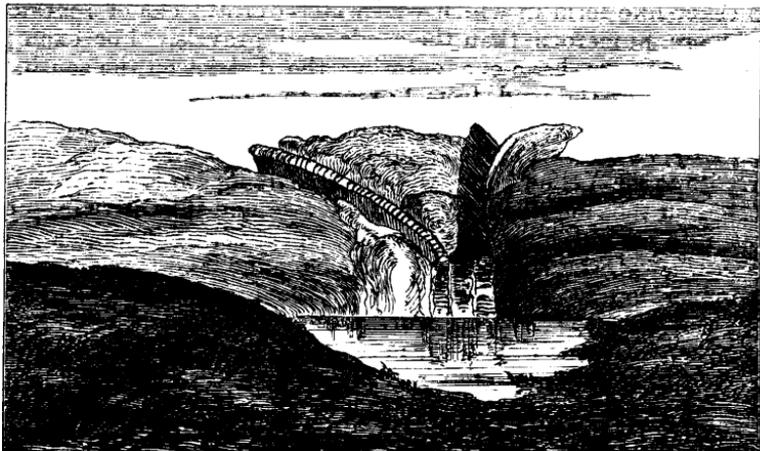
* Journal Geological Society, Ireland, Vol. III. (New Series).

not hold good, as the subsequent examination of the district has proved that these dykes have no specified direction over any continuous area.

The weathering of the dolerites is very peculiar, and there are no data to go upon which would guide one as to why one dyke should weather more than another. Generally speaking, the higher the crystallization the more rapid the disintegration, but this is not so in the case we are now treating, for the highly crystalline rocks at Mullaghnacross do not weather so rapidly as some of the dykes along the Sligo coast line on the E. side of Killala Bay, and these again differ very materially in their weathering. For an example of rapid weathering we have the natural "Boat Harbour" at Inishcrone, which is nothing more than a fifteen-foot dyke, weathered and washed out.

In connexion with the large mass of dolerite, where well-exposed along the Rathfran estuary, there are minor dykes of micro-crystalline basalt, cutting up the older and more highly crystalline rock.

Fig. 4.



Newer dykes of basalt, cutting up the dolerite on Ross shore.

Having thus treated of the dolerites in the northern portion of the district, there must not be forgotten a remarkable boss of dolerite which makes its appearance in the extreme S.E. portion of the district, and which occurs between the Lower Carboniferous Limestones and Sandstones. This outcrop is continuous in the district to the south, and has already been referred to in the "Explanation" to accompany Sheet 75, page 32.

The age of these two so widely-separated masses of igneous rock may fairly be put down as of later date than the deposition of the Lower Carboniferous limestone, consequently they rank as the newest rocks in the district.

Felstone.—Although felstones have been noted, yet the only evidence lies in narrow dykes; as, for example, in the Ballykinletteragh river, about four miles S.S.W. of Ballycastle, there is an eight-foot dyke of light bluish gray compact felstone, which does not indurate the shales in conjunction. There is another similar dyke on the shore at Ross, which is of little consequence.

POST PLIOCENE (DRIFT).

Boulder Clay.—The various members of the Post-Pliocene cover nine-tenths of the district. The boulder clay is composed chiefly of well-rounded and striated blocks and boulders of dark-blue limestone, embedded in a dark-blue pasty clay.

The external form of this deposit is generally that of a ridge or saddle-backed hill, with the axis parallel to the direction of the ice striæ. For vertical sections of boulder clay, the ballast hill at the quay at Ballina is a good example; also the vertical cliffs north of Kilcummin coast-guard station, in which there is a bed of sandstone much broken up. In other places, such as at Castleconnor, on road-side, and in shore sections along the Inishcroone coast, sheets of limestone, moved bodily from out of the underlying rock, can be traced near the bottom of the boulder clay.

Sand and Gravel.—Resting on the boulder clay, in places there are beds of sand and gravel, but no actual junction could be ascertained; to the east of the district the sand and gravel assume an esker-like form in which well water-worn blocks of limestone are more numerous than the sands and gravels. For example of an *esker*, we have one entering the district on the south, on the E. side of the road from Foxford to Barrowfield, and which extends in a northerly direction more or less along the valley of the Moy, as far as Foxford; it is again met with resting on the granite at the Yellow river, where its contents are the same as if it rested on the limestone; north of this we find it as it were spread out into several hummocky ridges, and covering a large area on both sides of the River Moy at Coolcronaun, and through which the river has cut its course close to the graveyard, which is on top of one of the ridges. Further north, it is found in isolated patches, with the trend still north, when it bifurcates into two distinct ridges immediately south-east of Ballina; and north-east of this it blends into the enormous sheets of sand and gravel which occupy the north-western slopes of the Ox mountains, as high as 600 feet above the level of the sea.

In the west of the district, small esker-like detached ridges are met with on either side of the road from Crossmolina to Bangor, and about six miles from the former town.

In the north of the district, gravel hills and stratified sands are met with close to the sea-coast, along the margins of the Glencullin and Glenulra rivers; but these sands and gravels I consider were carried down by the rivers and re-arranged under different circumstances, and at a much later period than the esker gravels.

Erratic Blocks.—In no part of Ireland, probably, is there such an abundance of erratics as in one portion of this district, viz. :—that lying to the north of the granitic hills at Pontoon and the Slieve Gamph hills; blocks of every shape and of enormous size, are met with, studding acres upon acres of hill and dale. Nearly all these blocks are of granite, and they are to be found resting not only on the sand, gravel, and boulder clay, but also on the local rock. For an example of the latter, we have abun-

dance of evidence at the Pontoon, especially "the rolling stone" west of the bridge.

Fig. 5.



Granite erratic on W. of road at the junction of the Castlebar, Ballina, and Foxford roads, east of Pontoon.

The limit of the area of these enormous blocks of granite is not confined to this district (with the exception of that small portion coloured as Carboniferous, in the S.E. of the district), because, at the extreme north of the district, erratics of granite from the Ox mountains and Pontoon are frequent, but in proportion to the distance from which they were originally transported, so does their size grow less the further we proceed in a northerly direction.

About two and a half miles S.W. of Ballina, and a little to the N.W. of Carrowmore, there is a remarkable erratic of foliated granite, the weight of which has been calculated to exceed 415 tons; this erratic is more than six miles from any granite *in situ*.

It must not be assumed that all the erratics are granite, for schistose blocks in places are common; so also in certain localities are there blocks of carboniferous grit and conglomerate, but by far the largest proportion are granite, the locality from whence it came being unmistakably known, owing to their composition and foliation.

Many years ago these blocks attracted the notice of many able writers—as, for example, Sir Richard Griffith and Archdeacon Verschoyle, have written on them.*

* On the distribution of erratic blocks in Ireland, particularly those of the north coasts of Sligo and Mayo, by Sir Richard Griffith, Thirteenth Report, British Association, 1843.

GLACIAL STRIÆ observed in this DISTRICT.

County and Quarter Sheet.	Townland.	Direction.	Remarks.
Mayo.			
7/1	Doonfeeny, Upper,	N. 65 W.	On shore.
"	Do,	N. 35 W.	W. side, Bunatrahin Bay'on shore.
"	Ballymachugh,	N. 35 W.	E. side, do. do.
"	Knockaun,	N. 10 W.	do. do.
"	Killeen,	{ N. 75 W. } N. 55 W. }	Newer E. of Pollnagowna do.
7/2	Moyny,	N. 75 W.	do.
"	Do.,	N. 77 W.	At Moyny Point do.
"	Creevagh,	N. 15 W.	E. of Creevagh Castle.
7/3	Killerduff,	N. 40 W.	On road to Coast Guard Station.
"	Lisbrin,	N. 35 W.	On shore.
8/	Rathlackan,	N. & S.	Do.
"	Carrowstellagh,	N. 25 W.	Do.
"	Kilcummin,	N. 10 E.	On W. of headland on shore.
14/2	Barnhill, Upper,	N. 15 E.	—
15/	Cashel,	N. & S.	On old road.
39/1	Cloontalty,	{ N. 10 W. } N. 27 W. }	Newer on Lough Conn shore.
39/3	Cloghans,	N. 15 W.	Do.
40/3	Ballymore,	N. 35 W.	On schists.
"	Boyhollagh,	N. 45 W.	On schists "roches moutonnées."
46/2	Tristia,	N. 30 W.	On schists.
47/3	Prughlish,	N. & S.	On quartzite "roches moutonnées."
"	Derrymartin,	N. 15 E.	On red sandstone.
"	Doonaroia,	N. & S.	On quartzite.
47/4	Tobernaven,	N. & S.	Do.
48/1	Rinmore,	N. 15 W.	On shore of Lough Conn.
"	Brackwanshagh,	N. 15 W.	Do.
48/2	Coolcronaun,	N. 10 W.	Schists east of road.
"	Bunnafinglass,	N. & S.	Schists on hill side.
"	Drumscoba,	N. & S.	Schists top of hill.
"	Do.,	N. & S.	On hornblende rock E. of Swinforl-road.
"	Sraheen,	N. & S.	On schists in railway cutting.
"	Do,	N. & S.	On granite do.
48/3	Terrybaun,	N. 35 W.	Do. "roches moutonnées."
"	Illaunaglashy,	N. & S.	On schists in Island in Lough Conn.
"	Burnt Island,	N. 27 W.	On granite do.
"	Cuingmore,	N. 10 W.	At Pontoon Bridge.
48/4	Tawnaghmore,	N. 10 W.	On schists.
"	Do.,	N. & S.	On granite.
"	Do.,	N. 12 W.	Do.
"	Cuingbeg,	N. & S.	"Roches moutonnées."
"	Gorteenamuck,	N. 5 W.	On granite.
"	Shannasmore,	N. & S.	Do.
"	Sraheen,	N. 5 E.	Do.
"	Do.,	N. 10 E.	On schists.
"	Do.,	N. 15 E.	On granite.
"	Clossaghroe,	N. 5 W.	Do.
49/1	Drumscob,	N. & S.	On hornblende rock.
"	Do.,	N. 10 E.	On schists.
"	Derryvicneill,	N. 10 E.	Do.
49/3	Coollagagh,	N. 35 W.	On granite.
"		{ N. 55 W. } N. 27 W. }	Newer on schists
49/4	Carrowneden,		
59/2	Shanvoley,	N. 12 W.	On quartzite.
"	Ballyknock,	N. 35 W.	Do.
"	Massbrook, South,	N. 15 W.	On vein quartz in schists.
59/4	Sheeans,	N. 12 W.	On schists.
"	Shanvoley,	N. 12 W.	Do.
60/1	Terryduff,	N. & S.	On granite.
"	Knockaglana,	N. 12 W.	On vein quartz in granite.

GLACIAL STRIÆ observed in this DISTRICT—*continued.*

County and Quarter Sheet.	Townland.	Dir. ction.	Remarks.
60/1	Knockaglana, . . .	N. 5 W.	On granite "roches moutonnées."
"	Do., . . .	N. 10 W.	Do.
"	Do., . . .	N. 12 W.	Do.
60/2	Leckee, . . .	N. & S.	On hornblende rock.
61/1	Do., . . .	N. & S.	On quartzite.
"	Cashel, . . .	N. & S.	Do.
"	Do, . . .	N. 10 W.	On schists.
"	Cuillonaghtan, . . .	N. & S.	On quartz lode.
"	Do., . . .	N. 25 E.	On schists.
"	Do., . . .	N. 45 W.	Do.
Sligo.			
10/1 & 2	Carrowmacbryan, .	{ N. 5 E. } { N. 15 W. }	Newer on shore.
16/2	Lackan, . . .	N. & S.	Do.
"	Carrowhubbuck, North,	N. & S.	Do.
"	Do. South,	N. & S.	Do. close to village of Inish-crone.

RECENT AND POST-GLACIAL.

Alluvium.—Immense alluvial flats bordering the River Moy occur to the north and south of Foxford, the thickness of which cannot readily be ascertained, but in places they must at least be over twenty feet; these flats each winter receive additions from the torrents from the Ox mountains, and owing to such irrigation their value is yearly enhanced.

Under the alluvium, blue clay is often found, and in some parts of these flats, as to the north of Mount Falcon, and about Cool-cronaun, where the alluvium is light, good bricks could be made.

In the town of Ballina the blue clay has been worked for bricks, but owing to the abundance of mica, the brick after burning becomes brittle. Brick clays have also been worked to the W. of Ballina in the neighbourhood of Cooleran.

Bogs.—Peat bogs are common throughout the district, not only filling up the hollows and extending for a considerable distance in the low ground, but forming a good thickness on the mountain tops, as well as resting on the slopes sometimes at high angles.

At the bottom of the bogs, and on the marl or drift, as the case may be, great stools of oak, yew, fir, and hazel, are met with; in most cases the nuts of the hazel are also to be found.

The following is a section of a small bog to the N.E. of Carrow-keribly Lough, showing evidence of two distinct growths.

Stools of oak, fir, and hazel, resting on boulder clay, then bog consolidated into two feet in thickness, then stools of fir and hazel branches, and over this three feet of spongy bog.

At Pollacheeny, on the E. shore of Killala Bay, there is a large bog which is covered at high water, which shows that the land there must be gradually subsiding.

Blown Sands.—At the mouths of many of the rivers flowing into Killala Bay or the Atlantic, great sand hills have been formed by the action of the winds, which often change their character from dome-shaped mounds to a flat surface, after a succession of storms.

The most remarkable of these sand hills is that which extends in an almost E. and W. direction for a distance of four miles from

Inishrone on the east, to Killala on the west. This great ridge has two outlets in it, one on the Killala side, and one in the centre, the latter being the main outlet through which the River Moy shapes its course. Formerly we may assume that the Moy had only one outlet, and that it was on the Killala side, but from the tendency of the river to now eat along its eastern banks, more than the western, the bulk of the water consequently takes the east side, and has cut its present course in what may have been a weak point in the ridge.

Although these sand hills have a ridge-shaped appearance from a distance, on closer examination we find they are composed of a series of small hills and hollows, the sides of the former often sloping at an angle of 35° , and these are constantly changing their position and shape; in consequence of which, means have been adopted by sowing grasses, to prevent, if possible, the sands being blown over the good grass lands lying to the S.E.

At the present outlet of the Moy we have, in the centre of the sand hill, boulder clay resting on oolitic limestone, so we may assume that this ridge has a nucleus of either boulder clay or limestone, and that around this nucleus the sands will always be changing their peculiar appearance.

Tuffose Limestone.—In many places in this district the springs flowing from the Lower Carboniferous limestone, and from the slate series, carry in solution an enormous quantity of carbonate of lime, which, when exposed to the atmosphere, is precipitated in a stalagmitic form, and adheres to anything it may pass over; in this way reeds, brambles, stones, shells, &c., get covered with this precipitate and present a very remarkable appearance.

All along the E. shore of the Moy estuary from Ballina to Inishrone, where the numerous small brooks discharge themselves, this deposit can be seen covering the rocks, &c.; at Ballycastle also there is a great accumulation of it in the glen, and in the valley west of Bonneconlan there is a similar deposit; these accumulations are going on at the present time, and are similar to the remarkable springs in the Puy de Dome district at the town of Clermont.

PART III.

ACCOUNT OF MINES, MINERALS, AND PRINCIPAL FAULTS.

Mines.—Very little evidence of minerals was obtained, and throughout the entire district there have been no mining operations carried on.

To the E. of Downpatrick Head copper is found in some fault rock on the shore, in the townland of Doonadoba, and under my superintendence trials were made, but the copper only occurred in occasional crystals; both copper pyrites and malachite were got, but in very small quantities. These lodes could not be examined far, owing to the great head of drift, but there is no reason why they should not extend further, and join in with the lodes which are on the shore section in the district to the west.

West of Doonadoba, in the townland of Moy, very thin bands

of lignite were found in the Carboniferous sandstone, but they do not extend for any distance, but gradually die out.

Principal Faults.—The oldest faults in the district are those about Nephin mountain, and probably the most extensive one is that in the valley between Nephin and Knockaffertagh, which displaces the bands of quartzite and schist to a considerable distance, but which, from their regularity in bedding, are easily recognizable. This fault does not affect the Old Red sandstone which rests on the quartzites and schists.

The newest faults are those which form part of the main fault, extending from the Newport valley in the district to the S.W., in a north-easterly direction to Lough Conn by Lough Beltra, Croaghmoyle, and Levally Lough. By this large fault, which has a down-throw to the N.W., the limestones and sandstones of the Carboniferous age, which must have capped Croaghmoyle and all the other hills in that immediate locality, are depressed, and are now found preserved in the valley by Massbrook, Addergoole, and Levally. There is another large fault, probably of the same age as the Newport valley fault, which extends in an E. and W. direction, with a down-throw to the north, on the north side of Nephin; by this down-throw the great thickness of the Lower Carboniferous sandstones, as found in the northern portion of the district, has been concealed, and we find the Carboniferous limestone separated from the schists and quartzites of Nephin by a considerable thickness of fault rock.

The granites, schists, and quartzites W. of Pontoon, have been very much broken up by repeated upheavals; the age of some of these disturbances was probably prior to the deposition of the Carboniferous series.

Numerous small faults are met with among the Carboniferous rocks, the only ones of any note being those in the Lower Carboniferous sandstones at Ballycastle and at Palmerstown bridge, which, as already explained, give a repetition of the beds, and thereby reduce what at first sight might strike the observer as an enormous thickness of this Lower Carboniferous Sandstone.

NOTES ON THE MICROSCOPIC STRUCTURE OF SOME ROCKS IN THE DISTRICT round Ballina, Co. Mayo, by Professor HULL, M.A., F.R.S.

DOLERITE.—Large dyke on the W. shore of Killala Bay. This is an unusually largely-crystalline rock, and a thin section forms a very beautiful object under the microscope, especially when viewed with the aid of polarized light. With a low power it is seen to consist of long plates or prisms of plagioclase (Labradorite?), embedded in a brownish augitic paste, which also contains crystalline grains of magnetite (or titano-ferrite) and olivine. A little chortite fills in the interstices of the other minerals.

BASALT-DYKE.—traversing older dyke of largely crystalline dolerite. This is an ordinary basalt under the microscope, appearing to consist of brownish augitic paste, containing long prisms of plagioclase (Labradorite?), and numerous crystalline grains of titano-ferrite—this latter embedded exclusively in the augite. There is no appearance of olivine in the rock, which is in a very fresh or unaltered condition.

Plagioclase.—The felspar prisms are generally arranged side by side, in parallel groups. They are colourless, fissured, and in places fleckered. The fine parallel lines indicative of the triclinic system are very distinct, and the terminal angles obtuse. With the polariscope, these crystals show a vivid parallel banding in shades of blue, gray, yellow, purple, pink, and light green, and the changes of colour on rotating the analyzer may be described as sometimes gorgeous.

Augite.—The augite is less in quantity than the felspar, and occurs in irregularly shaped masses, taking the forms caused by the indentation of the felspar prisms. It was clearly later in consolidating than these latter, around which it forms a paste. With polarized light and crossed Nicol's prisms, the augite assumes a dark bronze colour, with delicate shades of green, &c., changing into light brown.

Olivine.—At least one large olivine grain—imperfectly crystalline in form—occurs in the section here described. It is enclosed by augite, from which it is separated by a distinct band, filled with chlorite. The polarization is perfect, giving, on rotating the analyzer, the changes from green to pink, which are characteristic of this mineral, and which show that it remains in its unaltered condition. This is remarkable, considering the probably high antiquity of this dyke.

Magnetite.—This mineral, or its representative, titano-ferrite, occurs in the form of a few large black grains imperfectly crystalline in form. They are, however, sufficiently numerous to cause the rock to be strongly magnetic, and which, when applied to the N. pole of the needle, repels it.

Chlorite.—The mineral which I have designated by this name is of a sap green colour, and either lines the edges of the other minerals, or fills cells and cavities. It is clearly of "secondary" formation, and as such differs from those minerals previously described.

The above description shows that this rock, though so peculiar on account of its structure, really differs little in composition from ordinary dolerites and basalts of the north of Ireland.

Oolitic Limestone of Killala.—The thin section of this rock is very well seen with a 1-inch objective, magnifying 55 diameters. It is seen to consist of dark brown, round or oval, granules enclosed in a colorless mass of calcite, the crystals of the latter radiating outwards from the sides of the granules.

The granules have generally (not always) a concentric structure, and a faintly-radiating series of fine lines resembling "medullary rays." They are sometimes worn or broken off along the sides, as if they had been subjected to attrition after having been formed.* The centres are generally solid, and formed of the same material as the mass; in other cases they are filled with clear calcite, but I did not observe any particle or fragment of extraneous matter which could have acted as a nucleus of attraction for the calcareous matter. Such nuclei have been observed by Professor Phillips and others in the case of the oolitic limestones of the centre of England.

Amongst the granules was observed a perfectly-formed minute crystal of quartz, with a pyramidal apex. As it seems to traverse several of the granules, it must have been formed earlier than themselves. It polarizes vividly, and with a very high power is seen to be full of minute cells.

The origin of such oolitic limestones is not very clearly understood; but it is known that they are in course of formation at the present day

* Professor E. Reynolds, M.D., to whom I showed the section, considers that the apparent wearing of some of the edges is probably due to the granules not being spherules, so that their major axes are oblique to the plane of the section.

in the warm seas of the tropics, and in waters highly charged with carbonate of lime.

Quartzite in Nephin.—Gray compact quartzite, slightly foliated, with minute gray mica scales. The section is cut at an angle of 25° to the plane of foliation. With 2-inch objective, the section shows a colorless translucent field, throughout which small colorless, or slightly shaded, crystals, are scattered in the form of short prisms, preserving a nearly parallel direction. Subsequent examination with higher powers showed these to be mica flakes cut at oblique angles.

Viewed with a one-fifth objective, these prisms are seen to be distinctly scarred, and striated parallel to the sides, and to contain minute cavities. Sometimes the terminations are rounded, jagged, or sharply truncated.

With the polariscope the whole field becomes variegated like that of a kaleidoscope. Each separate grain of siliceous matter, of which the rock is made up, becomes individualized and polarizes differently from its neighbours, and the little crystals of mica are seen in some places to be imbedded in distinct grains; in others to traverse two or more grains of silica. This is unusual and unexpected; and shows that the silica must have become gelatinous or soft during the process of metamorphosis. Still, its powers of polarization show that it occurs, not as gelatinous or colloid, but as a crystalline, silica, or rock crystal.

The colours vary according to the positions of the Nicol's prisms. With parallel prisms they appear as light yellow, light blue, and very pale pink or rose colour. With crossed prisms, as deep purple, blue, and yellow, of various shades.

In addition to the quartz and mica, very little extraneous matter was visible, except a few specks of iron oxide.

Hornblende Rock, Ox Mountain.—In section this appears to consist of groups and bundles of imperfect crystals of hornblende, of a sap green colour, arranged more or less in the planes of foliation. Some crystals are, however, placed transversely to this. The hornblende is surrounded by quartz, and occasionally a little felspar. Black grains of magnetite of irregular forms are abundant, and there is also a little bronzy material, which is probably iron oxide.

With the polariscope the quartz appears broken up into distinct grains, polarizing differently from one another, as in the case of the quartzite of Nephin, previously described. The hornblende polarizes but faintly.

Under a high power (from 400–860 diameters), the quartz is seen to contain great numbers of exceedingly minute fluid cavities, varying from $\frac{1}{500}$ to $\frac{1}{800}$ m. m. in size. Each little cell contains a gas or vacuum bubble, which may be observed to change its position when the slide is turned. Hence we may infer that vapour of water or steam was present during the metamorphic process, as in the case of most granites, owing to which the silica was maintained in a gelatinous or soft condition until after the consolidation of the hornblende and magnetite.

Another section of hornblende schist from the same district affords similar results.

PALEONTOLOGICAL NOTES, SHEETS 41, 53, and 64.

LOCALITIES from which FOSSILS were collected.

No. of Locality.	Quarter Sheet of 6-inch Map	County and Townland.	Situation, Geological Formation, and Sheet of 1-inch Map.
1	7/2	County of MAYO. Moyny, . . .	CARBONIFEROUS LIMESTONE AND SANDSTONE, SHEET 41. On seashore, a little south of Pollnamuck, one mile south-east of Downpatrick Head Sandstone and Limestone.
2	8/	Lackan, . . .	On seashore, at Lackacappal, entrance of Lackan Bay; dark gray micaceous shale.
3	8/	Do., . . .	On seashore, south of preceding locality, and a little north of coastguard station; dark gray micaceous shale.
4	8/	Kilcummin, . . .	On seashore, a little south-east of Benwee or Kilcummin Head; dark gray earthy shales.
5	7/4	Carrowmore, . . .	Half a mile south of Ballintemple, two miles north-east of Ballycastle; Lower Limestone.
6	10/1 & 2	County of SLIGO. Carrowmacbryan, . . .	On seashore, half a mile south of Lenadon Point, east side of Killala Bay; Lower Limestone, dark gray earthy limestone.
7	7/4	County of MAYO. Castletown, . . .	SHEET 53. A little south of Castletown village, four miles east of Ballycastle; dark gray sandstone.
8	7/4	Castlelackan, . . .	About a quarter of a mile west of preceding locality; yellowish sandstone.
9	8/	Kilcummin, . . .	About a quarter of a mile south-west of Kilcummin Head; brown micaceous sandstone and shales.
10	13/2	Glencullin, . . .	In river a little south of House, two miles south-west of Ballycastle; brown sandstone.
11	14/1	Ballinglen, . . .	A little east of Toorboy, two miles south of Ballycastle; Carboniferous Limestone (Lower), light and dark gray crinoidal limestone.
12	15/1	Ballinlena, . . .	On west shore of Killala Bay, a little south of coastguard station, and about five miles north of Killala; dark gray micaceous sandy shale.
13	15/1	Ballingarry, . . .	On seashore, half a mile south of preceding locality; brown micaceous sandstone.
14	15/1	Castlenageeha, . . .	On seashore, one mile east of Cashel, three miles north of Killala; dark gray micaceous and arenaceous shale.
15	15/1	Tooreen, . . .	A little east of Tooreen, three miles north of Killala; compact gray sandstone.
16	15/3	Ross, . . .	On seashore, half a mile north-east of coastguard station, about two miles north-east of Killala; dark gray arenaceous shales.
17	15/3	Do., . . .	On seashore, half a mile north-east of coastguard station, two miles north-east of Killala; gray sandstone.
18	21/1	Ratheskin, . . .	A little south west of Ballyruddy, five miles south of Ballycastle; brown sandstone.
19	21/2	Ballygowan, . . .	In stream close to road, about two miles south of Palmerstown, three miles south-west of Killala; dark gray earthy limestone.
20	21/3	Garranard, . . .	In river half a mile north of Faltabrack, six miles south-west of Killala; dark gray earthy limestone.

PALEONTOLOGICAL NOTES.

LOCALITIES from which FOSSILS were collected—*continued.*

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation, Geological Formation, and Sheet of 1-inch Map.
21	22/1	Killala, . . .	Close to south boundary, half a mile south of Killala; light gray oolitic limestone.
22	22/1	Kilroe, . . .	Three-quarters of a mile south of Killala; dark gray oolitic limestone.
23	22/1	Meelick, . . .	Several localities, one mile south-east of Killala; Carboniferous Sandstone and Limestone.
24	22/1	Moyne, . . .	A little south of Kilroe church, one and a quarter miles south-east of Killala; oolitic gray limestone.
25	22/1	Mullafarry, . . .	At Glebe, close to road, one and a half miles south of Killala; dark gray compact limestone.
26	22/2	Abbeylands, . . .	On shore, a little east of Moyne Abbey, two miles south-east of Killala; dark gray earthy shale and arenaceous limestone.
27	22/2	Rusheens, . . .	On seashore, two and a half miles south-east of Killala; brown oolitic limestone and dark earthy shales.
28	22/2	—	At Goose Island, south-east side of Killala Bay, mouth of River Moy; brown and oolitic sandstone.
29	22/3	Cooncalcunan, . . .	Quarry close to road, three and a half miles south of Killala; black earthy limestone.
30	22/4	Newtownwhite, . . .	Quarry at Cross-roads, two and a half miles south-east of Killala; black earthy limestone.
31	22/4	Roserk, . . .	On west shore of River Moy, half a mile north of Roserk Abbey, three and a half miles south-east of Killala; dark gray compact limestone.
32	22/4	Do., . . .	On west shore of River Moy, a little south-east of Roserk Abbey, four miles south-east of Killala; dark gray compact limestone.
33	29/1	Forren, . . .	A little west of Millbrook House in river, about seven miles south-west of Killala; dark gray compact limestone.
34	30/2	Farranos, . . .	Quarry on road, half a mile north of Belleek Abbey, two miles north of Ballina; dark gray limestone.
35	30/2	Do., . . .	On bank of River Moy, about half a mile east of preceding locality; black earthy limestone.
36	30/2	Garrankeel, . . .	On shore of River Moy, a little east of Belleek Abbey, one mile north of Ballina; black limestone.
37	30/3	Deelcastle, . . .	In river a little north of Deel Castle, four miles west of Ballina; black earthy and compact limestone.
38	30/4	Ballina, . . .	A little north-west of Ballina, close to workhouse; dark gray earthy limestone.
39	10/1 & 2	County of SLIGO. Cabraghkeel, . . .	On seashore, a little north of Pollacheeny Harbour; dark gray earthy limestone.
40	10/3 & 4	Carranduff, . . .	On seashore, one mile south of Pollacheeny Harbour; dark gray compact limestone.
41	16/2	Lackan, . . .	On seashore, a little north of road; dark gray compact limestone.
42	16/2	Carrowhubbock Sth.	On seashore, about half a mile north of Inishrone; dark gray earthy limestone.

PALEONTOLOGICAL NOTES.

LOCALITIES from which FOSSILS were collected—*continued*.

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation, Geological Formation, and Sheet of 1-inch Map.
43	16/3	Scurmore, . . .	On seashore, a little south-west of Scurmore, one mile and a half south-west of Inisherone; dark gray compact limestone.
44	22/1	Lecarrowaveagh, . . .	About one mile north-east of Castleconor; black earthy limestone and shale.
45	22/2	Rathglass, . . .	One mile north-east of Corbally South, close to north boundary; dark gray limestone.
46	22/2	Bunnailra, . . .	Close to road, one mile north-west of Corbally South; dark gray earthy limestone and shale.
47	22/3	Farrangarode, . . .	Close to River Moy, about half a mile north of Crocket's Town; dark gray earthy limestone.
48	22/4	Quignalegan, . . .	One mile east of Crocket's Town, and two miles north-east of Ballina; dark gray earthy and compact limestone.
49	29/1	Quignalecka, . . .	About one mile north-east of Ballina; black earthy limestone and shale.
50	29/1	Bunree and Downhill, . . .	At boundary, in Bunree river, half a mile north-east of Ballina; dark gray compact limestone.
			SHEET 64.
51	29/4	Breaghwy, . . .	A little south-west of Corrower Lake, about three miles south-east of Ballina; light gray limestone.
			County of MAYO.
52	38/1	Kildaree, . . .	In river a little south of Rathglass Fort, two miles south-west of Crossmolina; dark gray earthy limestone.
53	38/1	Kinard, . . .	In river about two and a half miles south-west of Crossmolina; dark gray earthy limestone.
54	39/3	Cloghan, . . .	On east shore of Lough Conn, a little north-west of Cloghan's Castle, five miles south-west of Ballina; dark gray earthy limestone.
55	40/3	Ballymore, . . .	A little south of Cartron Lough, four and a half miles south-east of Ballina; arenaceous and micaceous sandstone.
56	40/3	Mullaghawn, . . .	About one mile north-east of Carrowkeribly Lough; gray arenaceous limestone.
57	47/1	Derryhillagh, . . .	In stream close to boundary, five miles south-west of Crossmolina; gray micaceous sandstone.
58	47/2	Knockmaria, . . .	On west shore of Lough Conn, five miles south of Crossmolina; dark earthy limestone.
59	48/1	Brackwansha, . . .	On east shore of Lough Conn, six miles north-west of Ballina; dark gray compact limestone.
60	48/1	Carrowgarve, . . .	On east shore of Lough Conn, one mile south-east of preceding locality; compact gray limestone.

LIST of the FOSSILS collected from the LOCALITIES mentioned in the preceding TABLE.

The numbers opposite each species refer to the places at which they were collected, and the \times placed before some of them is intended to denote their comparative abundance.

CARBONIFEROUS LIMESTONE AND SANDSTONE.

PLANTÆ.		Localities.
? Fucoids,		9, 27.
Plant fragments,		3, 4, 7, $\times \times \times 57$.
" " some branching,		2.
" " grass and reed-like,		$\times \times \times 2, 5, 16$.
" " coarsely ribbed longitudinally—one and one and a half inch diameter,	}	7, 17, 23.
" " longitudinally striated,		5, 14.
ACTINOZOA: <i>Zoantharia</i> .		
Alveolites depressus,		49.
Aulopora campanulata,		58.
Chætetes tumidus,		6, 28, 42, 44, 47, 48, 51.
Cyathophyllum ceratites,		35, 42.
" " turbinatum,		50.
" " sp. indet.,		33, 40.
Lithodendron affinis,		6, 20, 23, 25, 30, $\times \times 32$, $\times \times \times 33, 34, \times \times 37, 38$, $\times 39, 40, 41, 42, 43, 45, 46$, 47, 48, 50, 51, 54, $\times \times \times 58$, $\times 59$.
" " junceum,		19, 38, 49, 53.
Syringopora geniculata,		20.
" " ramulosa,		38, 47, $\times \times 54$.
Zaphrentis cylindrica,		$\times 6, 20, 23, 30, 31, \times \times 33, 35$, $\times \times 38, \times \times 39, 40, 41, \times \times 42$, 43, 46, $\times \times 47, 49, \times 50$.
" " Enniskilleni,		4.
" " Griffithii,		? 38.
Zaphrentis or Cyathophyllum,		20, 23, 44, 52, 56.
MOLLUSCA: <i>Polyzoa</i> .		
Ceripora interporosa,		44.
" " rhombifera,		42.
Fenestella antiqua,		4, 6, 18, 25, 37, 40, 46, 49, 52.
" " formosa,		6.
" " membranacea,		19, 31, 35, 48.
" " Morrisii,		56.
Glauconome pluma,		4.
Sulcoretepora parallela,		4, 39.
Vincularia, sp. indet.,		25.
<i>Brachiopoda</i> .		
Athyris ambigua,		9, 10, 13, 18, 35, 45.
" " planosulcata,		8, 11, 15, 21, 35, 36, 37, 38, 39, 40, 44, 46, 47, 48, 52, 53, 55, 56.
" " Royssii,		32, 47, 51, 56.
" " sp. indet.,		9, 60.
Chonetes Hardrensis,		45, 52, 53.
" " papilionacea,		31, 39, 41, 45, 47, 48, 51, 52, 54, 56.
Lingula sp. indet.,		1.
Orthis Michelini,		4, $\times \times 27$.
" " resupinata,		6, 8, 11, 19, 21, 24, 29, 31, 38, 39, 41, 43, 44, 46, 47, 55.
Productus aculeatus,		6, 29, 36, $\times \times \times 37, 51$.
" " fimbriatus,		35, 38, 39, 40, 56.
" " giganteus,		$\times 6, 11, 20, 29, 31, 35, \times \times \times 37$, 38, 39, 40, 43, 45, 47, 48, 49, 50, 52, $\times \times 53, 54, 58$.

MOLLUSCA: *Brachiopoda*—continued.

	Localities.
<i>Productus punctatus</i> ,	6, 19, 25, 29, 31, × × 32, × 35, 36, 37, 38, 39, 40, 41, 43, 45, 46, × × × 47, 49, × 50, 51, 52, × × 53, 56, 58.
" <i>pustulosus</i> ,	11, 38, 47.
" <i>scabriculus</i> ,	11, 12, 25, 29, 38, 40, 45, 46, × × × 47, 49, 50, 52, 56.
" <i>semireticulatus</i> ,	4, 6, 11, 18, × 19, 23, 24, 25, 31, 32, × × × 33, 36, 37, 38, 39, 40, × 41, 43, 44, 45, 46, × × × 47, 48, 49, 50, 51, 52, 53, 55, 56, 58, 59, 60.
" <i>undatus</i> ,	38.
<i>Rhynchonella pleurodon</i> ,	4, 9, 21, 23, 47, 51, 52, 56
<i>Spirifera bisulcata</i> ,	35, 47.
" <i>laminosa</i> ,	? 9, 11.
" <i>striata</i> ,	4, 15, 35, 37, 39, 41, 47, × × 55.
" <i>sp. indet.</i> ,	7, 9, 52.
<i>Spiriferina cristata</i> ,	× × 10, 11, × × 13, 15, × × × 18, 28, 35, 46.
<i>Streptorhynchus crenistria</i> ,	× × 4, 6, 8, 12, 13, 18, 19, 20, 24, 25, 29, 35, 38, 40, 43, 44, 45, 46, 47, 48, 50, 52, 55.
<i>Strophomena rhomboidalis</i> ,	50, 55.
<i>Terebratula hastata</i> ,	20, 29, 37, 38, 39, 41, 43, 46, 47, 49.
" " <i>var. sacculus</i> ,	35, 47.
<i>Lamellibranchiata.</i>	
<i>Avicula lunulata</i> ,	48.
" <i>sp. indet.</i> ,	31.
<i>Aviculopecten interstitialis</i> ,	47.
" <i>micropterus</i> ,	47.
" <i>planicostatus</i> ,	49.
" <i>plicatus</i> ,	29, ? 41, 47.
" <i>Sowerbii</i> ,	45, 46, 52.
" <i>variabilis</i> ,	39.
" <i>sp. indet.</i> ,	11, 20, 22, 24, 25, 29, 35, 36, 37, 40, 41, 47.
<i>Axinus axiniformis</i> ,	9.
" (<i>Anatina</i>) <i>deltoides</i> ,	1, 47.
" <i>obliquus</i> ,	1.
" <i>orbicularis</i> ?,	52.
" (<i>Dolabra</i>) <i>securiformis</i> ,	36.
" <i>sp. indet.</i> ,	8, 23, 36, 37, 38, 46, 47.
<i>Cypricardia cylindrica</i> ,	40.
" <i>quadrata</i> ?,	11.
" <i>sinuata</i> ,	39, 40, 41.
" <i>tumida</i> ,	40.
" <i>sp. indet.</i> ,	27, 39, 40, 43, 47, 52.*
? <i>Cyprina</i> ,	35.
<i>Edmondia crassistria</i> ,	32, 41.
" <i>sp. indet.</i> ,	1, 25, 31, 32, 40, 41, 46, 47.
<i>Leda</i> (<i>Nucula</i>) <i>carinata</i> ,	39.
" <i>sp. indet.</i> ,	6.
? <i>Lunulacardium</i> — <i>sp. indet.</i> ,	47.
<i>Modiola Macadami</i> ,	× 8, 45.
" <i>megaloba</i> ,	47.
" <i>sp. indet.</i> ,	11, 36.
<i>Myacites sulcatus</i> ,	46.
<i>Myalina Verneuilii</i> ,	47.
" <i>sp.</i> ,	27.
<i>Mytilus Flemingi</i> ,	21, 40.
" <i>sp.</i> ,	6.
<i>Pinna flabelliformis</i> ,*	23, 35, 46, 56.

* *P. dexcicostata* McCoy is most probably a synonym of this species.

MOLLUSCA: Lamellibranchiata—continued.

	Localities.
Pteronites (Modiola) divisa,	36.
" sulcatus,	40.
Pullastra bistrata,	33.
" scalaris,	1, 20.
Sanguinolites attenuatus,	35.
" discors,	41, 46, 47.
" plicatus,	25, 29, 35, 50.
" sp. indet.,	6, 26, 35, 36, 37, 39, 40, 46, 47, 52.
Sedgwickia corrugata,	1.
" sp.,	43.

Gasteropoda.

Dentalium inornatum,	29, 31, 34, 39, 40, 41.
" ornatum,	40.
Euomphalus Dionysii,	34, 35.
" pileopoideus,	11, 23, 25, 29, 31, 34, × 35, 36, 39, 40, 43, 45, 46, × × 47, 49, 56.
" pugilus,	39, 47.
" tabulatus,	46.
" sp. indet.,	1, 6, 11, 26, 40, 45, 47, 49.
Loxonema impendens,	34, 40.
" rugifera,	35, 40, 55.
" tumida,	35, 45, 50.
" sp. indet.,	6, 26, 32, 36, 39, 40, 45, 46, 47, 49, 54.
Macrocheilus imbricatus,	47.
" ovatus,	43.
" (Litorina) pusilla,	47.
" semisulcatus,	43.
" sp. indet.,	6, 22, 26, 36, 46, 47, 56.
Murchisonia angulata,	45.
" sp. indet.,	1, 6.
Natica elliptica,	35, 47.
" plicistria,	25, 43, 46.
" sp.,	11.
Platyschisma sp.,	45.
Pleurotomaria sp.,	25, 26, 35, 40, 43.
Turritella spiralis,	35.

Nucleobranchiata.

Bellerophon apertus,	6, × 35.
" hiulcus,	45.
" tangentialis,	46.
" Urii,	26.
" sp.,	27.

Cephalopoda.

Cyrtoceras Gesneri,	40.
Goniatites obtusus,	40.
" sphaericus,	25, 30, 39, 46, 47.
" sp.,	56.
Nautilus (Discites) sulcatus,	25, 31, 40.
" tetragonus,	39, 47.
Orthoceras cinctum,	6, ? 49.
" dentaleoideum,	30.
" Goldfussianum,	43, ? 49.
" mucronatum,	47.
" sp. indet.,	6, 21, 25, 29, 31, 36, 38, 41, 45, 46, 47, 52.

Echinodermata.

Actinocrinus sp.,	7.
Archæocidaris vetusta,	6.
" sp.,	4.

Echinodermata—continued.

	Localities.
Palæchinus elegans,	6, 56.
Platycrinus, ?	23.
Poteriocrinus crassus,	55.
" sp.,	
Crinoid stems and joints,	1, × > 4, 6, × × 7, 8, × × 9, × × 10, × × 11, 12, 13, × × 18, 19, 20, 22, × 24, 25, 28, 29, 33, 34, 35, × × 36, × × × 37, 38, × × 39, 41, 42, 43, 44, 45, × × 46, × × 47, 48, × × × 49, 50, × × 51, × × × 52, × × 55, 56, 58, 59, × × 60.

Annelida.

Serpula ? sp.,	50.
Tracks and burrows,	9, 14.

CRUSTACEA: Trilobita.

Griffithides globiceps,	41, 47.
" longiceps,	35.
" sp.,	36.
Phillipsia Derbiensis,	35, 41, 46, 50, 52.
" pustulata,	46, 47, 48.

Ostracoda.

Cypridina primæva,	39.
Leperditia Okeni,	1, × 6, 25, 31, 34, 35, × 39, 41, 43, 46, × × 47, × 59.
" " var tuberculata,	41.
Cypridea sp. indet.,	1, 33, 36, 47, 50, 58, 60.

PISCES.

Labodus prototypus,	41.
Petalodus Hastingsiæ,	38.

REMARKS ON THE FOSSILS.

The fossils sent to me for examination as having been collected from the district included in sheets 41, 53, and 64, numbered about 2,000, and are all from Carboniferous strata; those from rocks, described on the Maps as Lower Carboniferous Sandstone, &c., consist for the most part of plant remains, grass and reed-like forms, and larger coarsely-ribbed stems, amongst which the vegetable structure is apparent, although the classes to which they belong is uncertain.

Of the *Zoantharia* (corals) the compound form, *Lithodendron affinis* (occurring at 24 localities), and the large turbinated coral, *Zaphrentis cylindrica* (from 17 localities), so eminently characteristic of Lower Limestone shale, appears to have been remarkably abundant in this district, as were also some species of *Brachiopoda*, particularly *Athyris planosulcata*, *Orthis resupinata*, *Productus giganteus*, *P. punctatus*, *P. scabriculus* and *P. semireticulatus*. Bivalve and Univalve shells of Mollusca, although of small size, are also not unfrequent in the collection of fossils from this district.

WILLIAM HELLIER BAILY.

September 20th, 1879.

INDEX.

Addergoole, 27.
 " river, 8.
 Alluvium, 25.
 Anticlinal, 10, 11.
 Aqueous rocks, 9.
 Atlantic, 7, 8, 25.
 Augite, microscopic structure, 28.
 Auvergne, 19.

 Ballina town, 7, 8, 18, 22, 23, 26.
 " brick clay, 25.
 " quay, 22.
 Ballinglen river, 8.
 Ballybroony, 8.
 Ballycastle, 7, 19, 21, 26, 27.
 " catchment basin, 8.
 " coast section, 8.
 " fault, 15.
 " flags and slates, 17.
 " mountain, 7.
 Ballycong lake, 12.
 Ballykinletteragh river, 21.
 Bangor, 22.
 Barrowfield, 22.
 Basalt, 27.
 Belmullet, 20.
 Beltra, 13.
 " hill, 7.
 " lough, 27.
Blocs perchés, 10.
 Blown sands, 25.
 Blue clay, 25.
 Boat harbour at Inishcrone, 20, 21.
 Bogs, 25.
 Bonneconlan, 26.
 Boulder clay, 22.
 Broadlands, 8.
 Bunatrahair bay, 8.
 Burrin hill, 12, 13.

 Calciferous sandstones of Scotland, 15.
 Carrowkerribly lough, 25.
 Carrowmore erratic, 23.
 Cartoon, 18.
 Castlebar river, 8.
 Castleconnor, 19.
 Castlereagh, 18.
 Catchment basins, 8.
 Caverns in coast cliff, 8.
 Chlorite, microscopic structure, 28.
 Claddagh river, 8.
 Clermont, 26.
 Clew bay, 8, 13.
 Coolcran, 25.
 Coolcraunaun, 22, 25.
 Conn lough, 7, 8, 9, 10, 27.
Crag, 10.
 Creevagh head, 15, 16.
 Croaghmoyle hills, 7, 8, 27.
 Crossmolina, 7, 22.
 Crumpaun river, 8.
 Crystalline limestone in schist, 21.

Cullin lough, 7, 8, 9, 10.
 Curraun Achill, 12, 13.

 Deel river, 8.
 Dolerite, 19, 27.
 " age of, 21.
 " weathering, 21.
 Doonadoba, 26.
 Doonbristry Island, 15, 16.
 Downpatrick head, 8, 15, 16, 20, 26.
 Drainage, 8.
 Dykes of basalt, 19, 20.
 " parallel joints due to, 20.
 " affecting limestone in con-
 junction, 20

 Erratic blocks, 22.
 Esker, 22.

 Faults, along line of foliation, 10.
 " principal, 27.
 " rock, 10.
 Felspar, 10.
 " labradorite, 19.
 Felstone, 21.
 Foliated granite, 9.
 " " devoid of joints, 10.
 Foliation, 10.
 " general bearing of, 10.
 Fossils, evidence of, 13.
 " localities, 30, 31, 32.
 " remarks on, 36.
 Foxford, 7, 8, 9, 12, 22, 25.
 " quartzites, 12.

 Glacial striæ, 24, 25.
 Glencullen river, 22.
 Glendaduff, 10.
 Glenmore, 8.
 Glenulra river, 22.
 Granite, colour of, 10.
 " composition of, 10.
 " erratics, 23.
 " fine grained, 10.
 " formed *in situ*, 9.
 " highly crystalline, 10.
 " mica schist in, 11.
 " porphyritic, 10.
 " weathering of, 10.
 Grooves, 10.
 Greenans hill, 7.
 Griffith, the late Sir Richard, 23.

 Hornb'ende rock, 12.
 " " nature of.
 " " of Ox mountains, micro-
 scopic structure of, 29.

 Ice action, 8, 10.
 Icefield, outlet of, 10.
 Igneous rocks, 9, 19.
 Inishcrone, 7, 18, 20, 26.

- Inisherone, coast, 22.
 " flags, 19.
 " shore, 19.
- Kaolin*, 10.
 Kilcummin, 19, 20, 22.
 " head, 8, 15, 16.
 Killala, 7, 17, 18, 19, 26.
 " bay, 7, 8, 19, 21, 25.
 " round tower, 18.
 Knockaffertagh, 11, 27.
- Lackan bay, 8, 16.
 Lagan hill, 7.
 Laherdaun, 7, 12, 13.
 Levally, 14, 27.
 " lough, 13, 27.
 List of fossils, 33, 34, 35, 36.
 Localities from which fossils were collected
 30.
 Localities where glacial striæ was noted,
 24 25.
 Lower Carboniferous sandstone, 14.
 " " " section of the
 beds, 15, 17.
 " " " shore beds, 18.
 " " " thick limestone
 in, 17.
 " " " thickness of, 15.
 Lower limestone, 18.
 " " area of, 18.
 " " characteristic fossils in, 19.
 " " thickness of, 18.
- Magnetite, microscopic structure of, 28.
 Mask lough, 13.
 Massbrook, 27.
 Metamorphic sedimentary rocks, 9.
 Metamorphism, 10.
 Mica, 10.
 Microscopic structure of the rocks, 27.
 Millbrook, 8.
 Mines, minerals, and principal faults, 26.
 Mount Falcon, 25.
 Moy river, 8, 18, 19, 22, 25.
 " " catchment basin of, 8.
 " " outlet of, 26.
 " beds of lignite in townland of, 26.
 Moyne, 17, 18.
 " Abbey, 18.
 Muck lough, 12.
 Mullaghnacross, 19, 21.
- Nephin mountain, 7, 8, 13, 27.
 " " amorphous quartzite, 11.
 " " flaggy quartzite, 11.
 " " quartzite, 11, 12.
 " " " conglomerate,
 11.
 " " schists, 11, 12.
 " " thickness of quartzites, 11.
 Newport, 7.
 " catchment basin, 8.
 " valley, 27.
- Old Red sandstone, 12, 13.
 Olivine, microscopic structure, 28.
 Oolitic limestone, 18.
 " " microscopic structure, 28.
 " " sections, 17.
 " " thickness of, 18.
 Ox mountains, 7, 22, 23, 25.
- Palæontological notes, 30.
 Palmerstown bridge, 27.
 " river, catchment basin of, 8.
 Physical Geography, 7.
 Plagioclase, microscopic structure, 28.
 Pollacheeny, 25.
 Pollnamuck, 16.
 Pontoon, 23, 27.
 " bridge, 8, 10.
 " erratics, 22.
 " hills, 7, 10.
 " rolling stone, 23.
- Quartzite of Nephin mountain, microscopic
 structure, 29.
 Quartzite, thin band of, 11.
 Quartz veins, 10.
- Recent and post glacial, 25.
 Remarks on the fossils, 36.
Roches moutonnées, 10.
 Rock basins, 8, 10.
 " formations and divisions, 9.
 Ross, 17, 21.
 Rosserk Abbey, 18.
- Sand and gravel, 22.
 Section at Moyne, 17.
 " " Tonacrock, 14.
 " of granite, schist, and quartzite, 12.
 Schists, 11.
 " chloritic, 11.
 " hornblendic, 11.
 " micaceous, 11.
 " talcose, 11.
 Silurian rocks, 13.
 " " crumpling of, 13.
 " " thickness of, 13.
 Slieve Gamph hills, 7, 22.
 Sligo, 7, 20.
 " coast line, 21.
 Striations, 10.
 Summerhill, 19.
- Terryduff quartzite, 12.
 Tonacrock, 13.
 Tourmaline crystals, 10.
 Tristia hill, 7, 8, 11.
 Tuffose limestone, 26.
- Upper Llandoverly, 13.
- Verschoyle, Archdeacon, 15, 17, 20, 23.
- Watershed, 8.
 Windy Gap hill, 7.
- Yellow river, 22.

DUBLIN: Printed by A. THOM & Co., 87, 88, & 89, Abbey-street,
Printers to the Queen's Most Excellent Majesty.
For Her Majesty's Stationery Office.

170.—250.—10/79.