

Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 12 AND PART OF SHEET 6 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

INCLUDING THE

COUNTRY AROUND LIMAVADY.

BY

JOSEPH NOLAN, M.R.I.A., AND F. W. EGAN, B.A.

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THE
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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.

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P R E F A C E.

THE district included in Geological Map, Sheet 12, has been geologically surveyed by Messrs. Nolan and Egan, the work of the former having extended over the western portion, that of the latter over the eastern. It is very fully described in Portlock's "Geological Report on Londonderry," &c., and its structure illustrated by sections drawn from Lough Foyle across into the basaltic plateau, which rises conspicuously along the eastern margin of the sheet. The Map of the Geological Survey agrees in all essential points with that of the late General Portlock—though somewhat differing in details. The grand escarpment of Benevenagh, which overlooks Lough Foyle at an altitude of 1,260 feet above its surface, is a special feature; together with the enormous landslips which form the broken ground at its base and flanks. This escarpment constitutes the north-western edge of the great basaltic table-land of co. Antrim, and is underlaid by strata belonging to the Cretaceous, Ljassic, Triassic, and Carboniferous systems; the foundation of the whole being the series of Metamorphic beds which occupies the greater part of the hilly country extending westward to the shores of the Atlantic.

EDWARD HULL,

Director.

Geological Survey Office, Dublin,

April, 1885.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 12 AND PART OF SHEET 6 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

INTRODUCTION.

THE district included within the limits of this portion of the Geological Map of Ireland lies entirely in the county Londonderry, except a small area to the north-west of Lough Foyle which belongs to the county Donegal. The only important town is Limavady,* on the river Roe. There are also the smaller towns of Articlave in the extreme north-east, Ballykelly, Muff or Eglinton, and Castlerock, all in county Derry; and the village of Carrowkeel, in county Donegal.

The greater part of this district has been described by General Portlock in his "Geological Report on Londonderry and parts of Tyrone and Fermanagh," 1843.

CHAPTER I.

PHYSICAL GEOGRAPHY AND GEOLOGY.

Lough Foyle occupies a considerable area in the central and western parts of this district, dividing the portion in county Donegal from that in county Londonderry. The former, which is very small, is part of the peninsula of Innishowen, and is composed chiefly of schists with a narrow strip of Carboniferous sandstones along the shores of the Lough. The ground slopes from a height of 500 feet to the level of the sea, and is drained by several small streams running in a south-easterly direction, the largest of which, called the Cabry river, enters the Lough at Carrowkeel.

The county Derry portion of the district is characterised by the extensive plains that border Lough Foyle; the lowest of which is a raised beach bounded on the seaside by large tracts of reclaimed land or intakes, and on the inner side by terraces of gravel that extend to a considerable height inland. Southward the ground rises into hills of moderate elevation and gently rounded outlines, the chief summits of which are—Loughermore, 1,298 feet, Dunorock, 1,080 feet, and Sistrakeel Top, 930 feet.

These hills, with most of the country hereabouts, are composed of schists similar to those that occur in county Donegal, while

* Formerly called Newtownlimavady.

near the shores of the Lough are bays occupied by sandstones of Carboniferous age, which in the low-lying country about Limavady have a considerable extension. As Carboniferous rocks are thus found more or less continuously along the shores of Lough Foyle, it seems probable that they once occupied the greater part of its area, presenting conditions favourable to the eroding action of the sea and river currents, while the harder rocks of Innishowen at the N.W., and the basaltic cliffs at Magilligan, render the entrance to the ocean narrow, and thus almost convert Lough Foyle into an inland lake.

The drainage of this part of the district is effected by the river Roe and a number of smaller streams that also run northwards into Lough Foyle.

J. N.

The high ground in the east of sheet 12, with its continuation in sheet 6, is underlaid by the basalt which forms the great Tertiary plateau of the counties Antrim and Derry. The boundary of this volcanic area is here, as in other parts of the district, often characterised by bold, precipitous cliffs, which towards the north assume magnificent proportions, and are accompanied by huge landslips of comparatively recent date. The rugged masses thus torn away rise sometimes in sharp pinnaced forms in front of the steep face of solid rock, and are separated from it by a gap strewn with blocks that have fallen in large numbers on either side. The general features, and the aspect they present when viewed from the neighbouring low ground, are well described in the following extract from General Portlock's Report:—*

"Turning from the Magilligan shore towards the north and western faces of Ben Evenagh, the scene acquires new grandeur, and still higher interest. Looking up from below, the face of Ben Evenagh appears encumbered by ponderous and shapeless masses, which in successive stages rise to the base of the steep basaltic summit, and there break into pinnacles and precipitous cliffs.

Standing on one of these, and looking along the face of the mountain, the successive lines of rudely formed hillocks, the steep basaltic face they present to the great mountain precipice, and the various beds of basalt and ochre which occur in each—together with the isolated pinnacles which yet remain on some of them—attest their former position; and explain the nature of these vast landslips, and of this undercliff of surpassing magnificence, connected as it is with the basaltic summit of Ben Evenagh rising to the height of 1,260 feet above the sea."

The bold outline which thus denotes the boundary between the Secondary and Tertiary formations passes northward and eastward with a wide sweep into sheet 6, accompanied by a gradual descent towards the coast. Here, at the east of Umbra, it consists of a steeply-receding cliff of chalk and basalt, about five hundred feet in height, supporting a mass of boulder-clay which stands piled up against the escarpment for a height of nearly three hundred feet.†

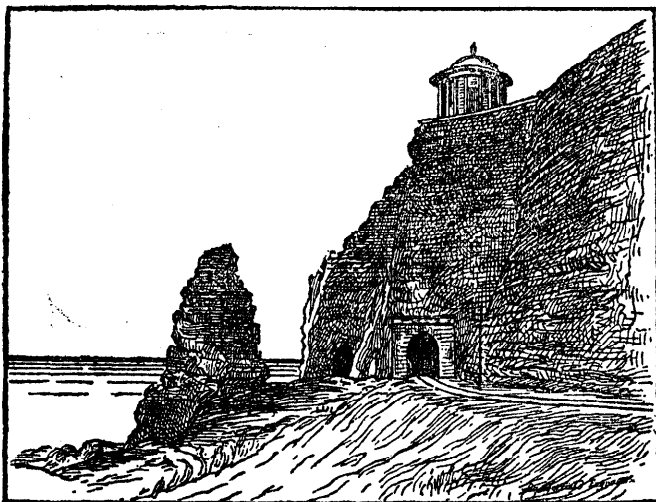
* Report of the Geology of the County of Londonderry, &c., page 103.

† See page 25.

East of Umbra the boundary of the basalt follows the coast line for a short distance, bending out below the sea within a mile of Downhill; while beyond this point, and as far eastward as the locality just named, nearly perpendicular crags, composed of basalt with some beds of ash, overhang the shore, skirted for half their height by an accumulation of blown sand resting on boulder-clay, and in some parts barely upholding ponderous semi-detached masses of rock which seem ready to fall from their position.

From Downhill eastward to Castlerock, the cliffs directly overlook the sea, having a more irregular and rugged outline, owing to the constant, and frequently violent, action of the waves, which are at the present day hollowing out caves in the basalt. Similar openings, standing at a somewhat higher level, and dating back to the period of the adjacent raised beach, occur in the Chalk between Downhill and Umbra; while in some instances, as at Backaunaboe (the Tether Stake), a little east of Downhill railway station, the conditions seem to point to a continuous drilling action carried on from that day to the present. The above name is given to a sharp sea-stack, composed of amygdaloidal basalt, standing out from the cliff at the western end of the Temple tunnel—a remnant of the northern wall of a spacious cave, the eastern portion of which is still to be seen penetrating the rock for a short distance (See fig. 1).

Fig. 1.—View of Sea-stack at Downhill.



In addition to Benevenagh, the following elevations are reached at various distances eastward from the margin of the plateau, constituting the principal culminating points of the surface, which commences to rise somewhat rapidly westward in the adjacent sheet not far from its western boundary:—

Donald's Hill, 1,318 feet above sea level; Craiggore, 1,277 feet, with the chain of hills stretching thence three miles to the north, including Boyd's Mountain, 1,077 feet, and an intervening height of 1,248 feet; Gortnamoyagh Hill, in the south-east, 903

feet; Keady Mountain, 1,101 feet, forming part of a range that extends eastward to the "Three Taghmores," nearly 1,000 feet in height; Round Knowe, a little over 1,100 feet, with a hill to the west, 1,157 feet, and another at $1\frac{1}{4}$ mile to the south, 1077 feet; Sconce Hill, 800 feet, with its neighbours to the west, Bratwell Hill and Windy Hill, somewhat higher. In the area west of Articlave, the following heights, figured on the map, denote hills of inferior size; 855 feet, 920 feet, 728 feet, and 305 feet.

On the north, west, and south of Benevenagh there is a rapid fall in the Cretaceous and Triassic ground below the basalt escarpment to the low-lying area skirting Lough Foyle. South of this the slope is more gradual, the surface becoming comparatively flat in the ground occupied by Carboniferous strata, with a slight rise to the level of the mica-schist in the south.

The escarpment is occasionally cut into by small channels worn by the mountain streams, which descend with considerable violence after heavy rains, in some instances creating narrow waterfalls which, from a distance, appear as white lines across the dark face of the basalt. Legavannon Pot is one of the deeper cavities of this kind; another runs out due north to the sea a little east of Downhill; and others of smaller dimensions occur one on each side of the railway station.

The course of the basaltic escarpment can be easily followed with the eye along the mountain flank north of Donald's Hill, the rock itself appearing in the streams, which further down contain sections showing that the lower ground is thickly overspread with boulder-clay.

This deposit lies deeply over the greater part of the Carboniferous and Triassic areas, and to a large extent over the basalt. Traces of it exist within short distances of the highest points in the mountain district; the rock, when laid bare, presenting the appearance of having been worn by ice moving towards the N.N.W.

As we ascend the Three Taghmores from the south, and pass out of the Drift, rugged cliffs of basalt soon meet the view, traversing the surface irregularly for short lengths, and trending in different directions, principally towards east and west. Some, running more nearly north and south, are caused by the wearing action of streams, while the others are escarpments along the outcrops of the sheets of basalt. They vary in height from about five feet in minor cases to forty feet in those of more extensive range.

Thick deposits of peat overspread the larger areas so coloured on the map, while shallow patches occur in small depressions; and a covering of upland bog gradually thins out up along the mountain slopes. The lower ground between the principal elevations consists of dreary expanses of flat boggy land bearing heath and short grass, and affording pasture for herds of cattle in summer.

The raised beach, traces of which exist at various places around the coasts of Derry, Antrim, and Donegal, and which represents the twenty-five feet terrace of the western coast of Scotland, here extends inland as far as the margin of drift composing the sloping ground west of the basalt escarpment. The beach itself is for the

most part covered with blown sand, either forming a flat surface at a level of about fifteen to twenty-five feet above the Ordnance zero plane,* or else rising into dunes, or less prominent mounds, arranged somewhat uniformly in accordance with the direction of the originating winds blowing from the west and north-west.

With the exception of about two and a half square miles west of Articlave all the Tertiary area is drained by streams flowing eastward on the one hand to the river Bann, which is reached by various channels in Sheet 13, or westward to Lough Foyle, principally by the Castle River and the River Roe. West of Articlave, a few small streams flow northward to the sea, into which they fall at intervals along a line of coast extending three miles west of the river Bann.

The watershed between the two principal drainage areas just now referred to, passes over Gortnamoyagh Hill in the south-east, by Craiggore, Boyd's Mountain, west of Three Taghmores, across Windy Hill, and thence N.N.W. to about $6^{\circ} 51'$ west long.

F. W. E.

CHAPTER II.

ROCK FORMATIONS AND DIVISIONS.

Aqueous and Volcanic Rocks.

		Colour and Sign on Map.	
Recent,	{ Blown Sand,	.	{ Fine dots showing dunes.
	{ Bog and Alluvium,	.	{ Chalons brown and gamboge.
Post-Glacial,	Raised Beach,	.	Burnt Sienna.
Post-Pliocene (Drift).	{ Sand and Gravel,	.	{ Engraved dots.
	{ Boulder Clay,	.	
Miocene (Tertiary Volcanic).	{ Lower Basaltic Sheets, with beds of amygdaloid,		{ B, Burnt Carmine.
	{ Volcanic Ash,		{ Burnt Carmine with white dots.
	{ Intrusive Basalt and Dolerite,		{ B γ , Burnt Carmine (deep tint).
Cretaceous,	{ Upper Chalk with Flints,	.	h ⁵ , Emerald green.
	{ Upper Greensand,	.	h ⁴ , Do. darker.
Rhætic,	.	.	f g, Chalons brown.
Triassic,	{ Keuper Marl,	.	f ⁶ , Venetian red.
	{ Lower Keuper Sandstone,	.	{ f ⁵ , Venetian red with wash of Indian ink.
Carboniferous,	Upper Calciferous Sandstone,	.	{ d ¹ , Prussian blue with wash of Indian ink and yellow dots.

Metamorphic Rocks.

Metamorphic Rocks, (<i>Probably of Lower Silurian age</i>).	{ Mica Schist with beds of chloritic and talcose schists, &c.,		{ β^1 to β^2 , Light crimson lake.
	{ Quartz Schists,		{ q, Light crimson lake with wash of gamboge.
	{ Limestone beds and schists,		{ λ , Cobalt blue.

* This plane is about eight feet (8.094) below the mean level of the sea round Ireland, and is that to which the heights of hills, &c., are referred throughout this memoir.

METAMORPHIC ROCKS.

The rocks of this division consist of schists, usually micaceous, but occasionally chloritic or quartzose, passing into quartz schist; and calcareous, developing into good beds of workable limestone. In the north-western portion of Sheet 12—the part included in county Donegal—they appear on the shore at Black-rock, where they are green mica schists overlaid by hard micacised quartzose grits and quartzites, with subordinate beds of thin schist. Sections may also be seen in the numerous streams that descend from the high ground to the north-west. The river that enters the Lough at Vance's Point cuts a deep ravine through massive chloritic schists of light green colour, usually very hard and gritty; and close to the Roman Catholic Chapel of Drung they form a ledge over which the waters are precipitated, forming a considerable waterfall. Westward of this, about Mullaghard and Roosky, many outcrops of similar beds appear on the hill, and sections were observed in the streams. Farther west, at the limits of the map, close to the Mearingland river, is a peculiar dark green rock, part of which is massive and apparently structureless, much resembling igneous rock, but for the pebbles of quartz that occur, while in other parts it merges into a schist. A rock of this kind, near the Ness, in county Derry, has been described at p. 12 in the Memoir to accompany Sheet 18, and several others were observed in the district included in the adjoining Sheet 11, and will be referred to in the description of that portion of the country. In the Cabry river, south-south-east of this, the deeply cut valley exposes beds of chloritic and micaceous schists, in part calcareous; and on the shore at Three Trees are thin-bedded quartzitic grits, somewhat like those at Black Point. This latter section is remarkable from the apparent similarity of the thin yellow quartzitic beds to those of like colour in the adjoining Carboniferous series, a peculiarity also observed in the same class of rocks at Craigboy, near Vance's Point, and in other localities.

The rocks of this series in the county Derry portion of the map, or that south of Lough Foyle, are in general like those just described. A good section may be seen in the stream that flows northward past the village of Muff* in the southern part of the district. There close to the roadside, about a quarter of a mile N.E. of Foyle Park, are talcose schists with a dyke of pyroxenic rock. Farther south, in the picturesquely wooded Muff Glen, schists, usually micaceous and chloritic, appear in many places; and in the bank of the stream about 300 yards S.E. of the old Templemoyle Agricultural Seminary† a very small outlier of Carboniferous sandstone was noted resting in a hollow of the schist. At the upper end of the glen there is limestone schist on

* This village is sometimes called Eglinton to distinguish it from another village called Muff in county Donegal.

† A very detailed account of this useful institution is given in Portlock's Report, already referred to. It has unfortunately been long since abandoned, and is now a private farm.

which a large quarry has been opened. It is here, as usually happens in this and the adjoining districts, associated with talcose schists.

In the Castle river east of Muff glen schists also occur, and in its upper part, about a mile east from Coolnavaddy bridge is a hard quartzose rock with specks of magnetite. Over it is a peculiar bed that has externally much the look of a trap dyke, and appears to have been considered such by Portlock. It is however a compact micaceous schist.

In the country east of this, and on the hills to the south-east, rocks crop out in several places, as may be seen by the dip arrows on the map, and there is nothing worthy of special notice except the occurrence of two limestone beds, one on the Faughanvale or Sheskin river, the other in the hill country at Baranailt. The former of these is a schist extending in an E.N.E. direction from the river bank to the road, where the beds are more compact, and quarries have been opened. At Baranailt there is a thick flaggy limestone on which a quarry has also been opened. The beds here are as usual associated with talcose and reddish mica-schists.

In the vicinity of Carrickhugh, at nearly a mile S.W. from the Railway station, a very remarkable section occurs in the river. There the schists are associated with Carboniferous sandstones forming in one place a singularly sharp ridge round which the latter were deposited. This is referred to by Portlock as a striking example of the very considerable denudation these schists were subjected to before the deposition of strata of the Carboniferous system. (See Geol. Report, p. 169, and Plate C, fig. 3.)

Eastward and south-eastward from this stream schists are again met with in the Ballykelly river and its tributary, where they are associated with Carboniferous rocks; and in the vicinity is a small bed of limestone. Farther eastward, at the bifurcation of the Burnfoot river, is an igneous augitic rock resembling those described on page 12 in the Memoir to accompany the sheet to the south (Sh. 18). Like them, it has in great part a structure resembling foliation parallel to the planes of bedding which here vary in direction a good deal. The rocks over it are talcose schists, with subordinate beds of pebbly schistose grit.

Some of the best sections in these metamorphic rocks may be seen in the river Roe adjoining. In the Deerpark wood, south of Roe Park, the rocky channel of the river from the Dog's Leap is cut through alternating beds of massive chloritic and micaceous schists, sometimes containing much glassy quartz and specks of biotite. They are more or less calcareous, and there are beds having a pseudo-porphyrific appearance from enclosed semiangular fragments of felspar. Near Roe House is a peculiar rock of this class containing pieces of felspar of a beautiful light-green colour. On the left bank of the river here is a limestone schist, and another, on which a quarry was opened, occurs in the wood, half a mile to the south; and farther still, a less important bed is seen in the river bank, north of the alluvial flat. South of this latter the river cuts another deep channel through massive schists,

forming a striking and picturesque ravine, having steep and lofty sides covered with dense foliage, through which on the right side the pretty church and parsonage of Carrick agreeably diversify the view.

J. N.

In the stream, west of the road at Lislane bridge, four miles south-east of Limavady, and in a quarry close at hand, mica-schist occurs, with thin layers of clay-slate. Again, at about four hundred yards north of the road, at the east side of the Castle river, there is a boss composed of the same rock, partly broken up, and appearing in the river within three or four yards of the Carboniferous sandstone, which, lying on a line of fault, dips down against it at an angle of 45° . At the cross roads, a mile to the north-west, a quarry opened in the mica-schist for the construction of railway bridges contains beds of various character and thickness, often somewhat gneissose, the thicker beds being hard and enclosing crystalline particles of reddish felspar, with but little mica; also layers of softer rock, more highly micaceous, of dark gray colour, and varying in character between ordinary mica-schist and gneiss. These beds, and those near Lislane bridge, contain quartz veins with iron pyrites, and are traversed by small fissures filled with red ferruginous earth, the presence of iron causing the rock itself in many parts to weather with deep red stains.

F. W. E.

CARBONIFEROUS ROCKS.

Upper Calciferous Series.—This formation, as before remarked, occupies a narrow strip on the north-west shore of Lough Foyle, in county Donegal, several places on the southern shore of that Lough, and around Limavady, in county Londonderry. It consists of red or reddish brown and yellow sandstones and shales with quartzose conglomerates, and is evidently the same formation as that found at Dungiven. It differs from it in the greater prevalence of the red friable sandstones and conglomerates and the scarcity of the whitish and yellow sandstones so characteristic of the rocks at Bovevagh, Altmore Glen, &c., from which it is probable that these beds are lower in the series. In county Donegal they first appear to the north at Craigboy, where there is clear evidence of the fault-boundary separating them from the schists; they are pebbly and whitish-grey calcareous sandstones, some of which are indurated, and closely resemble the adjacent rocks of the metamorphic series, which appear close to the sea wall. A prominent dyke of dark compact basalt cuts across the beds.

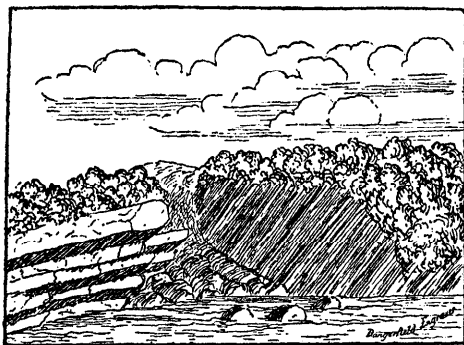
Farther on, pebbly sandstones and conglomerates appear in many places on the shore about Shandy Hall, White Castle, and Quigley's Point, as also in the adjacent streams, where they are seen in close proximity to the metamorphic rocks. South of this, red conglomerates and coarse yellow pebbly sandstones again appear on the shore east of Three Trees, where they are affected by a nearly N. and S. fault bringing down the metamorphic

rocks, which latter extend along the shore for over a quarter of a mile to the southern portion of the N.E. boundary fault, which again brings in the Carboniferous rocks that occupy the ground about Aught bridge, and continue into the adjoining district.

On the southern or Derry side of Lough Foyle this formation seems to occupy much of the flat country about Muff, though no rock is visible at the surface. Eastward from that village, where they form a similar bay in the Metamorphic series, red, friable pebbly sandstones were observed in the little wooded glen south-east of Tullybrisland, and also on the Sheskin or Faughanvale river near the old church,* and half a mile higher up, close to the elevated ground occupied by the Metamorphic rocks. East of Faughanvale bridge is the place already referred to where the schists extend as a spur or sharp ridge into a small bay of Carboniferous beds which are deposited around it. They are red sandstones with shales, quartzose conglomerates, and beds of greenish shale.

South of Ballykelly, reddish-brown friable sandstones appear in the prettily-wooded glen through which flows the river of the same name, and in a branch stream, at a mile's distance from the village, they are faulted against schists, as shown in sketch.

Fig 2.—Fault between Carboniferous beds and schists on river south of Ballykelly.



At a quarter of a mile farther south they reappear, being portion of a triangular area of these beds brought in by faults, of which there is abundant evidence from the direction of the dips, as shown on the map. A longer, but quite similar section is also seen in the main stream to the west.

Eastward of Ballykelly, and about Limavady, the country, too, appears to be occupied by these Carboniferous beds, though there is little rock seen, owing to a thick covering of drift, but sufficient evidence of its presence is afforded by the *débris* and character of the superficial deposit, while rock *in situ* crops out to the east, and will presently be described.

J. N.

* Faughanvale old church (Nuachongbail), which Colgan translates as "nova habitatio." Sketches of this church, and scenes on the adjacent river, by G. V. Du Noyer, are to be found in the "Oblong book of Londonderry sketches, Vol. II., pp. 92 to 95." The church is associated with the name of St. Fachtna, who is called a bishop. See O'Hanlon's Lives of the Irish Saints, Vol. I. p. 333.

At Walk Mills, three miles E.S.E. of Limavady, the Carboniferous strata consist of thinly-bedded sandstones of pinkish and brownish gray colours. Large flags, three to five inches thick, are procured in a quarry east of the road, where the beds are of dull purple and brown shades, occasionally stained black, and sometimes contain flat pebbles of red shale. All are finely micaceous, and none calcareous.

White and reddish-coloured Carboniferous sandstone was uncovered in a railway cutting east of Whitehill Cottage, below five feet of drift.

A little east of Drummond bridge (a mile east of Limavady), purple and light-brown and reddish grits occur south of the old church; and again at the sharp bend of the river to the east. Some of the lighter portions contain quartz pebbles, and many of the beds are finely and obliquely laminated. The Carboniferous rocks come in again a little farther east, owing to a sharp bend in the Triassic boundary, and continue to appear till the boundary crosses the stream again half a mile higher up.

They consist of soft purple shale and whitish shaly sandstone, with pink and yellow sandstones and micaceous shales. Beds generally similar appear in the bank of the confluent stream to the south, at nearly half a mile west of the Triassic boundary.

TRIASSIC BEDS.

Lower Keuper Sandstone.—Sections in this division of the upper group of the Triassic rocks occur in the Curly river north-east of Limavady, and in the stream which joins it a little north of Streeve House. These two sections are mentioned by Portlock,* who, in alluding to the former locality, records some details extracted from "The Itinerary, 1802," as "the first notice of one of the most interesting fossil localities of the country"—a reference specially to the Rhætic beds noticed farther on. Other sections are found at intervals along the stream passing westward from the south of Keady Mountain to Drummond Bridge.

As we ascend the latter stream, having passed the Carboniferous beds south of the old church, the basal beds of the Lower Keuper Sandstone appear on the south side, consisting of loose pebbly grit of a dull red colour, a short distance above which a quarry contains red sandstones with whitish seams, and bands of red and purplish shale. These rocks come to view at several points farther up, within a distance of three hundred yards from the lowest beds, and often include dark red finely laminated sandstones.

After the short interval occupied by Carboniferous beds, the Triassic sandstone re-appears in the stream, accompanied by shales of a deep red colour.

The basal beds are again seen in the stream west of St. Lowry's Well, consisting of rather dark reddish sandstone enclosing many pebbles of quartz and quartzite, and partings and lenticular

layers of red shale. Higher up in this stream the beds are of a brighter red colour and more shaly; and in the stream, nine hundred yards south of St. Lowry's Well, just below the Greensand, sandstone flags occur, some soft and marly and of a deep red tint, others hard and light in colour, and occasionally ripple marked. The basal beds appear a short way east of Drumagosker, and again half a mile farther east, along the line of fault.

In the stream that flows by Artikelly bridge, mentioned by Portlock, under the name of the Lyn-burn, as containing interesting sections, the Triassic beds appear first at about a mile up from the bridge, in the form of thin-bedded red sandstones. North of this, along a thickly wooded ravine, red sandstone flags form the bed of the stream, the sandy character prevailing as far northward as the bend of the stream immediately south of the road, east of which layers of shale become common, all being variegated with light greenish coloured stripes, and containing subordinate beds of white and greenish sandstone. Some of the red sandstone beds here contain cavities lined with calcespar crystals, the rock itself being frequently calcareous, and sometimes enclosing small pebbles of quartz, quartzite, and red granite. North of the bridge under the Limavady and Coleraine road, mixed beds of sandstone and shale, or marl, continue for a distance of about nine hundred yards, up to the boundary of the Keuper Marl.

The lowest beds seen in the Curley river are bright red sandstones with marly layers, and irregular beds of whitish sandstone marked with thin laminæ containing small quartz pebbles. These occur at about seven hundred yards east of the Presbyterian Meeting House, and they appear in various places along the stream farther north, till the Keuper Marl comes in near the narrow public road.

The Keuper Sandstone is slightly exposed along the escarpment east of Drumagosker; while at Donald's Hill, and between it and Legavannon, it is more extensively seen. In a section at about eight hundred yards south-east of the summit of this hill the beds are seen for a height of twelve feet, consisting of variegated red and light brown marly sandstone with strings of calcite, merging upwards into harder sandstone of a more uniform light brown colour; and at the same distance north-west of the summit, in a section along the mountain road, similar beds overlie deep red marly sandstone, which farther down along the road passes into red and purplish marl and sandstone. Large masses of hard sandstone occur on the slope west of Donald's Pot, having evidently slipped from a higher position, and probably belonging to the uppermost beds in the section last referred to. One of these blocks, known by the name of "The Giant's Mill," consists of whitish sandstone mottled with light red markings.

Keuper Marl.—In proceeding up the Curly river from the boundary of the Keuper marl, the beds of this division are found

in several places up to within about two hundred yards of the basalt boundary. They consist of red and green marls with occasional beds of light gray sandstone. In the upper part of the section the marls are cut through by a dyke of basalt, in contact with which they are indurated and turned almost black for a depth of a few inches, the portions immediately adjacent to the basalt assuming a structure resembling fine lamination.

In the Lyn-burn, referred to on page 15, the red and green marls are met with at intervals, especially near the southern boundary of the area, and to a small extent a little below the point where the Rhætic beds appear. Finally, they come slightly to view on the southern slope of Keady Mountain, being in some parts changed in colour to a dusky yellowish brown.

RHÆTIC BEDS.

The lowest beds of this series occur, as above stated, over the red and green Keuper marl at a point in the stream one mile and a half east of Aghanloo Rectory. They consist of light greenish gray slightly calcareous marl, as seen a short distance east of the stream; and a little higher up a section ten feet deep appears in the bank, containing beds generally similar, and weathering out in small rudely concentric nodules. These appear to contain no fossils. At about seventy yards farther up, a section, which was particularly noticed by Portlock,* shows black and brown shales containing *Avicula contorta* and other fossils, with thin fissile bands in which the fossil named especially abounds. The visible section is in detail as follows, the lowest bed disappearing in the stream.

	Fect.	Inches.
1. Friable black and brownish fossiliferous shales,	4	3
2. Calcareous shale of dull gray colour, containing <i>Avicula contorta</i> , &c.,	-	4
3. Same as 1,	-	8
4. Light gray calcareous grit containing broken fragments of spines, &c., with more perfect fragments and impressions of shells and spines on surface, also some iron pyrites,	-	$\frac{1}{2}$
5. Friable black and brownish gray shales,	-	9
6. Harder dark gray shale containing <i>Avicula contorta</i> and other fossils,	-	8
7. Friable black shales with fossils,	2	10
8. Brown and black friable shales, more highly fossiliferous, with <i>Avicula contorta</i> ,	-	6

A little west of this section the continuation of these beds and of other shales, less fossiliferous, and apparently overlying them, is indicated by fragments of the shales and a peculiar soft slippery clay at the surface; and in the vicinity of the stream half a mile east of the Rectory masses of decomposed grit and soft shale are laid bare in places where they have evidently slipped somewhat out of place. In the stream itself a small section exhibits shales generally similar to those mentioned in the details above, and at a short distance below them are hard shales with a calcareous grit. These seem also to be portions of the rock that have been displaced by slips.

About five hundred yards up the stream from the corn-mill

* Report, p. 107.

east of Roe bridge fragments of the underlying rock consist of hard finely granular limestone containing iron pyrites, with dark gray more earthy limestone, all somewhat arenaceous and containing fossils. A little to the south are arenaceous shales and limestone, also fossiliferous; and at a short distance to the south-east the debris of blue and brown shales lies in bulged-out masses below the Chalk. These shales and limestone are no doubt the representatives of the White Lias—the uppermost member of the Rhætic series.

In the Tircreven burn, N.N.E. of Benevenagh, are found some disturbed portions of the Rhætic shales, and of beds which belong to the Lias, some of the latter consisting of brown fossiliferous sandstone, and blue arenaceous limestone containing *Gryphæa incurva*. These, however, are so associated with masses of the Greensand as to leave no doubt that all have been dislodged from their true position, and it seems likely that the Liassic strata do not crop out below the base of the Greensand.

Shales, most probably belonging to the Rhætic series, were bored through in searching for coal a number of years ago close to the Robbers' cave, where the basalt boundary reaches the coast between Downhill and Magilligan Point. According to information obtained from a labourer who assisted at the boring, dark friable shale was met with under the Chalk and a small thickness of what appears to have been the Greensand, and below this a considerable depth of softer bluish gray shale. The total depth of the boring is stated to have been about 150 feet, the greater part of which was in the soft shale; but there appears to have been no accurate record kept.

CRETACEOUS BEDS.

Upper Greensand.—Beds belonging to this division of the Cretaceous rocks crop out at several places below the Chalk, forming a band of small dimensions between it and the Rhætic strata. It was met with at some depth below the surface in the quarries south-east of Donald's hill. Farther north these beds are slightly exposed to view almost in contact with the Keuper sandstone in the stream which flows down the escarpment of the basalt south-west of Boyd's mountain. It consists of a somewhat compact sandstone finely speckled with dark green particles of silicate of iron, and here possesses a light reddish tint, due probably to the oxidation of this mineral.

The Greensand is stated by Portlock to reach a thickness of thirty-six feet at the west of Keady mountain, where it is indurated, the bottom portion becoming more loose, green in colour, and sandy. These beds are at present covered up by a large heap of debris from the adjacent quarries.

In the stream crossed by the basalt dyke north of Keady mountain, the Greensand occurs not far above the uppermost exposure of the Keuper marl, and it again appears at a short distance up the smaller stream which here flows from the south-east. It is also uncovered in an excavation below the Chalk on

the north side of the main stream at about five hundred yards west of this.

Many traces of the Greensand are observed along the southern and western slopes of Benevenagh; but owing to the disturbed condition of the ground it is but seldom seen *in situ*, as, for example, in a well nearly a mile E.N.E. of the Rectory. North of this the debris occurs plentifully, in common with that of other rocks, large solid masses occupying the ground south of Duncrum, and affording evidence of the great landslips which took place at a period when the escarpment extended considerably to the west of its present position. In one place, east of the ruined abbey, the following section is to be seen:—

	Fect.	Inches.
Debris of Chalk and flints,	3	6
Dark gray shale,	2	0
Greensand, hard at top—softer and of darker green colour below,	3	0

The Greensand in Tircreven burn (S. of Tircreven bridge) occurs *in situ* just below the basalt, with a small intervening thickness of Chalk. There is a large detached portion at about two hundred and fifty yards farther north containing part of a bed nineteen inches thick, highly fossiliferous, and overlaid by a more arenaceous bed also enclosing fossils.

The boring at the Robber's cave (see page 17), west of Downhill, is said to have passed through the Greensand, this deposit being described as a sandy rock, three or four feet thick, lying between the Chalk and the Rhætic shale.

Upper Chalk.—The white limestone which so persistently underlies the basalt in this country is seen cropping out below it in beds which form a band of varying thickness at several points on the line of the escarpment across the sheet from north to south. The rock is a compact and hard perfectly white limestone, more or less fossiliferous, and abounding in flints, which, lying in the planes of bedding, indicate the general dip in cases where the stratification is otherwise obscure.

Between Donald's hill and Legavannon the Chalk is well exposed in quarried sections, either in contact with the basalt and its accompanying beds of bole or ash, or separated from them by a bed of hard flinty breccia. It is here greatly shattered, and broken up into innumerable small roughly cuboidal pieces. In the quarries south-east of Donald's hill the thickness of the Chalk has been proved to be from about twelve to thirty feet.

The fragmental bed above the Chalk varies here in thickness from three to five feet, and consists of a hard non-calcareous mass, generally of a pink colour, but sometimes white, crowded with reddened flints, which are mixed up without any arrangement, are either whole or broken into angular pieces, and all closely cemented together. This appears to be a product of meteoric agency, formed out of the harder and less destructible constituents of the Cretaceous strata, and locally deposited in irregular beds at the time when the Chalk formed a land-surface previous to the outburst of the basaltic lava.

In a section west of Keady mountain, where columnar basalt rests on the Chalk, the latter is greatly indurated and deprived of its carbonic acid for a depth of about three inches from the point of contact, being quite discoloured for half that distance, and marked with blackish and dark gray streaks that probably correspond to a finely-laminated structure which is undistinguishable in the less altered portions of the rock. At the southern end of the quarried space, the basalt is seen bursting up, as it were, below a mass of chalk debris and flints, which it seems to have carried up with it, and through which it has not completely penetrated. Close at hand is a layer of similar materials which appear to have been deposited in an uneven bed, and then overflowed by the basalt. This encloses a three-inch layer of hard ferruginous matter, in the upper portion resembling the limonite below the basalt at Craignashoke,* but harder, and in the lower part becoming extremely hard and merging obscurely into the equally indurated mass of mixed flints and chalk. The thickness of the Chalk at Keady is stated by Portlock to be about thirty-three feet.

Old quarries in the Chalk exist in the angle north of Keady mountain, and the rock is now covered up. It may be seen, however, above the beds of Greensand in the main stream, and a little south of it; and again some five hundred yards to the west, on the northern slope, where it is pierced by a dyke of basalt.

The Chalk is slightly exposed in old quarries above where the Rhætic beds are seen, on the west side of Benevenagh, and to a very small extent below the basalt in Tircreven burn; and the debris is constantly found associated with that of the Greensand in the lower ground. It next comes to view a little east of Umbra bridge, in sheet 6, appearing with a very uneven surface below the basalt eastward along the escarpment. The junction of the two rocks occurs in some places at a considerable height, being at one point on a level with the top of the blown sand at about fifty feet above the road. There is a large depression in the surface of the Chalk, filled with basalt, a short distance east of the basalt dyke; and here, as in many other places, the junction is marked by a red, earthy layer full of broken and baked flints, many of which also are imbedded in the bottom of the basalt.

The Chalk boundary can be approximately traced along the strand by the projecting masses of rock which are exposed to view at low water.

TERTIARY BASALTIC SERIES.

Lower Basalt.—The basalt occurs in successive sheets overlying the older rocks at depths which vary according to the amount of denudation that has taken place on its own surface, and that which formerly affected the surface of the chalk, which

* See Memoir, Sheet 18, pp. 22, 26.

was greatly eroded during the period preceding the outburst* and overflow of the basalt. At intervals among these sheets are found beds of amygdaloidal trap,—a vesicular variety containing zeolites and carbonates—and thin bands of red indurated ochreous earth, or bole; but these varieties of rock are not of frequent occurrence here, and are less common among the upper sheets, which compose the higher ground, than among those that mark the earlier stages of the Volcanic period, as seen in sections along the escarpment.

In the quarries between Donald's Hill and Legavannon, the basalt is seen above the Chalk, separated from it by a soft ashy-looking bed of light-brown colour, changing below to a hard red ferruginous bed, in both cases containing small vesicles filled either with greenish-coloured zeolite, or with brown oxide of iron. The basalt is greatly decomposed, and seems to merge gradually into this bed.

The quarries on the escarpment west of Keady mountain show the basalt resting on the Chalk for a depth of about thirty feet, possessing a columnar structure, and passing up into ten feet additional of decomposed amorphous trap containing cavities with zeolites and large crystals of calc-spar. Some of the former occur in well-developed, short square whitish prisms, having the angles replaced by planes, the mineral swelling up before the blow-pipe into a white glass (probably Apophyllite).

On "Three Taghmores," and a mile to the north of its summit, the basaltic rocks are extensively seen running in broken escarpments, which follow pretty closely the contour lines of the hill. In a quarry at the latter place there is exposed, below massive basalt, a bed of bole of purplish-gray colour merging into red, in part highly vesicular, the cavities containing brown iron oxide. This rock affects the magnet very sensibly, some parts of it plainly exhibiting polarity.

Farther north, the hills lying to the east of Benevenagh are composed of tabular basalt and dolerite, with bands of red bole. These rocks rise up in scarped masses at various levels around the summits, as is most conspicuously seen on the top of Sconce Hill, which consists of a mass of rock about one hundred yards across, surrounded by a rugged and steep escarpment from thirty to forty feet in height.

Bratwell Hill and Formoyle Hill, especially the latter, afford good illustrations of the stepped conformation of the surface so frequently caused by the successive sheets of trap rock, the otherwise generally smooth outline of the slopes being broken by small more or less continuous escarpments. The basalt and dolerite sometimes here weather spheroidally, and very often with dimpled surfaces, the latter fact being, at least to some extent, due to the weathering-out of crystals of felspar and augite, as

* The basalt of Benevenagh probably reaches a thickness of about 850 feet, and is certainly not much below that. Part of this may possibly belong to the upper division of the series; but in the absence of the zone of iron ore, &c. which in so many places separates the two divisions, no boundary can be here recognised with any degree of certainty.

may be readily seen on Formoyle Hill and Sconce Hill. A small quantity of aragonite occurs in dark spheroidal dolerite at Carn Top, north-west of Windy Hill.

Several varieties of basalt and amygdaloid occur along the ravines and gullies on the slopes of Benevenagh, either forming the bed of the stream between deep banks of boulder-clay, or in rugged sections up the steep sides. Of these some are given in detail by General Portlock,* and among them is furnished a list of beds composing the mass that has fallen from the great cliff west of the mountain, as also a section taken from the cliff itself. The latter is as follows, the detailed descriptions being somewhat condensed for the sake of brevity :—

	Feet.	Inches.
1. Ridge at top removed from the precipice in detached outlying masses.		
2. Hard basalt, slightly amygdaloidal, spherical concretionary, the lower portion irregularly cellular.		
3. Reddish amygdaloid, very vesicular. 13 inches of top decomposed, and subsequently indurated,	5	0
4. Hard, brittle, decomposed basalt, slightly columnar at top,	24	0
5. Amygdaloid, surface red, interior dark vesicular, minerals abundant (zeolites, aragonite, &c.),	4	6
6. Rudely columnar vesicular basalt,	38	0
7. Amygdaloid, red at top, almost pure clay or bole,	5	6
8. Vesicular basalt; becomes occasionally an amygdaloid, with lenticular hard masses involved in its substance; contains zeolites, semi-opal, &c.,	40	0
9. Hard columnar basalt, with conchoidal fracture,	8	0
10. Red amygdaloid, indurated at top,	4	0
11. Dark vesicular basalt, of variable hardness—very like pumice stone,	20	0
12. Hard basalt,	6	0
13. Seam of red ochre and amygdaloid, abounding in zeolites and carbonate of lime.		
14. Hard basalt, with micaceous iron ore, and a seam of minerals principally stilbite.		

Thin bands of volcanic ash and bole may be traced along the face of the cliff west of Downhill, and a thicker and more conspicuous bed of the former rock occurs among the sheets of basalt and amygdaloid crossed by the dyke one mile east of Umbra. It is of a dull purplish-gray colour, with laminæ of a redder tint, or mixed red and white, and consists apparently of the pulverised materials of the amygdaloid and basalt, enclosing a few angular fragments of the chalk and basalt.

The vesicular beds contain various forms of zeolite, with calcite and aragonite, and more rarely quartz, this last mineral occurring in beautifully grouped small crystals, to which adhere tufts formed of slender glassy prisms of zeolite.

Farther east there appear whitish streaks and small patches on the face of the basalt, due to the presence of a rather uncommon mineral which fills many of the crevices in the rock. This seems to be the “curious mineral” mentioned by Portlock† as occurring here, and thus described by him :—

“It is oolitic in structure, consisting of spheroids, cemented either by pure white carbonate of lime, or by green earth. In the latter case it has much the appearance of puddingstone. The spheroids are

* Report, p. 142, &c.

† Report, page 215.

yellow, whitish, or greenish, and appear to be a mixture of the hydrocarbonates of lime and magnesia; the small cavities are lined with drusy crystals of pure white carbonate of lime; where exposed the cement yielding first, it assumes a mammillated appearance."

This mineral is associated with largely crystalline aragonite, fragments of which, when broken across, sometimes reveal cavities from the sides of which project beautifully formed tapering transparent crystals, reaching an inch or more in length.

Upon careful comparison of specimens of this mineral there is observed a change from the typical form of the aragonite to a crystalline granular texture, the prismatic structure disappearing, and the mass becoming in some places like a close-grained, perfectly white marble. This again becomes compact, the change being accompanied by the separation of some of the constituents into globular masses, closely united together in a less calcareous matrix, and thus giving rise to the oolitic structure alluded to in the above quotation.

An examination of various specimens of this mineral, submitted to Professor O'Reilly for analysis, led him to the conclusion that it is "constituted of oolitic aragonite, in a matrix which presents to a greater or less extent the character of dolomite." The analysis yielded the following result:—*

CaO,	.	.	.	.	.	54.69
MgO,	.	.	.	.	.	0.55
Al ₂ O ₃ and Fe ₂ O ₃,	.	.	.	.	.	0.87
Insoluble matter,	.	.	.	.	.	0.54
CO ₂,	.	.	.	.	.	43.54
Moisture,	.	.	.	.	.	0.31

The same mineral is found along with calcite and calcedony forming veins in basalt at Craigatempin, near Ballymoney, in this county;† and again in Sheet 12, at about five hundred yards above the basalt boundary on the Curly river, three and a half miles south-east of the top of Benevenagh. In the latter place it is so associated with variously-altered masses of flint and chalk contained in the basalt as to suggest that this mineral is a product resulting from the envelopment of those materials in the molten rock.

Among the numerous water-worn masses of basalt which strew the shore near the tunnel east of Downhill station, one very large block is traversed by veins of the same mineral. It here possesses a distinctly globular structure which, as is the case also in the neighbouring locality to the west, is lost to view by larger development, so that a fracture presents a smooth, uniform surface, having various whitish-yellow tints. Here it is extremely hard, and though quite calcareous, it resembles in this respect, in its conchoidal fracture and in colour, many of the hardened flints at the bottom of the basalt. It is found again *in situ* near the base of the cliff not far from the tunnel, along with aragonite in its

ordinary radiating form. There are here also thin strips of satin-spar (finely fibrous calc-spar), which are more numerous a short distance up the road that runs south from the station.

The sea-stack near the tunnel, already alluded to under the name of "the tether-stake," has near its base a band of reddish-coloured amygdaloid passing into hard, compact, bright red bole, which can be traced in its extension in the adjacent cliff, as well as another equally well marked bed higher up in the cliff, above the horizon reached by the pinnacle of the outlying mass.

At the base of the jagged cliff which lines the coast outside the tunnels there is in some parts a narrow, projecting margin, composed of rudely columnar basalt, which is overlaid directly by beds of amygdaloid and bole, and vesicular basalt, with aragonite, &c.; and over them comes a variety of more or less disintegrated beds of trap, including one of hard basalt more perfectly columnar than that below. In the more accessible portions near Castlerock the vesicular beds contain beautiful snow-white crystals of natrolite, lining or filling flat cavities of very irregular shape, and sometimes reaching a length of nine inches, having an arrangement to a great extent parallel to the surfaces of the beds. Nearly transparent trapezohedral crystals of zeolite are occasionally found along with these; and in a few places there are strings of white calcite, with well-developed, transparent crystals of the same.

Dark, coarse-grained, rudely-columnar basalt, or dolerite, overlies beds of amygdaloid at Castlerock, and a little to the west, as seen in the coast section. The amygdaloid passes at the top into an uneven bed which presents a variety of composition and texture, being in part a hard, reddish-coloured rock, apparently derived from dark vesicular trap by a process of metamorphism and weathering, this again changing to a uniformly red, hard bole containing in some parts pisolitic grains of red hæmatite.

The coarser descriptions of the basaltic rocks are not of frequent occurrence in this district, being occasionally met with along the escarpment, as already seen, and now and then appearing at the surface in the higher ground, as, for example, on the top of Keady mountain and in other localities.

Intrusive basalt and dolerite.—The upper part of Donald's hill is composed of intrusive dolerite, which has burst up through the sheets of basalt and amygdaloid that here form the steep and rugged side of the hill. Its intrusive character may be well observed at the north side of Donald's Pot—a hollow caused by the slipping of a large portion of the rock at some distant period. Here the sheets of basalt, surmounted by a thick bed of decomposing porous amygdaloid (reddened in some parts in contact with the heated mass), are seen to be cut through by hard crystalline dolerite, the junction being also traceable by the eye for a short distance to the south-east, where the rocks are well exposed. The dolerite, weathering with a rougher surface and with rounder forms than the adjacent basalt, is distinguished also by numerous joints traversing it in all directions, and near the junction exhibiting a rude approach to a columnar arrangement. It contains a

few small fissures partly filled or lined with calcedony, in some parts forming a vein two inches wide.

The dyke known as Lady O'Cahan's bridge, crossing the stream in the angle north of Keady mountain, is seven feet wide. It consists of hard basalt, in some parts finely porphyritic, breaking up into cuboidal fragments, owing to a series of transverse fractures combined with more regular divisional planes running parallel to its course. The crystals consist of augite and glassy felspar, and it contains very thin strings of satin spar, and a few small vesicles filled with calcite. It can be traced for a distance of about sixty yards, including a break for the channel of the stream. The basalt which cuts through the chalk at three hundred yards to the north-west, is, no doubt, either the continuation of this dyke, or a smaller vein connected with it.

Three conspicuous dykes penetrate the sheets of basalt that compose the cliffs in the vicinity of Downhill. The most westerly of these is about fourteen feet wide, and cuts up through the basalt, amygdaloid, and ash, in a nearly vertical direction, being visible from the top of the grassy slope to the highest part of the escarpment. It consists of dense, dark-coloured basalt, having a faint reddish tinge, and containing numerous minute iridescent particles which appear to be labradorite; also small crystals of augite, and vesicles containing calcite.

Another dyke cuts up with a winding course through the dolerite and basalt immediately west of Downhill station. It is eleven feet wide at the base of the cliff, diminishes to five feet at about half way up, above which it becomes narrower, and maintains a more uniform thickness to the top of the cliff. This is also compact basalt, and abounds in minute shining crystals of felspar.

At the western end of the longer tunnel a basalt dyke ten feet wide can be traced upwards to a little height above the masonry, and thence in a narrowing mass with a sudden bend to the south, where it soon thins out, and disappears from view.

POST PLIOCENE. (DRIFT DEPOSITS).

Lower Boulder-Clay.—Sections in the lower boulder-clay occur in the banks of some of the streams that flow westward to the river Roe and Lough Foyle. It consists of a dense mass of clayey material varying in colour and composition according to the nature of the rocks from which in each locality it has been principally derived.

Among the largest sections are those in the ground below St. Lowry's well, on the western slope of Boyd's mountain. Here the boulder-clay, which is seen for a depth of thirty feet, encloses a few sandy seams, and contains scattered pebbles of chalk, quartz, and flint, with sub-angular basalt blocks and small gravel. A similar deposit overlies the rocks in the Tircreven burn, and extends over the escarpment, partly filling up the depression traversed by the branch streams coming from the south. Worked flints were picked up from a gravelly portion of the drift at the

gully which cuts into the escarpment a short distance to the north of this burn.

Traces of boulder-clay, containing pieces of mica-schist, and of the more local rocks, appear over the disturbed ground west of Benevenagh; and farther north, to the east of Umbra, in sheet 6, there is, as previously stated, a mass of boulder clay, containing blocks and small fragments, chiefly of basalt, piled up at the base of the escarpment, where it was, no doubt, thrown down over the cliff during the glacial period, upon the advance of the ice-sheet from the S.S.E.

Boulder-clay containing marine shells is found in some localities, as, for example, in a section along a stream flowing south, at one and a quarter mile due east of Fruit Hill, near Limavady; also in the southern bank of the Curly river, just inside the Triassic area. Here it underlies sandy and gravelly clay, and the same deposit is covered by stratified sand and gravel where two streams unite at half a mile E.S.E. of Drummond bridge. The clay is light brownish gray in colour, is more or less calcareous (sometimes highly so), and is greatly compressed, the shells being found only in fragments, so far as was observed in the places here referred to. Near the flax-mill, E.S.E. of Drummond bridge, there is a section showing about twenty feet of boulder-clay, the lower part of which is very compact, and all containing blocks of basalt, some scratched by ice. The same compact clay is found a little to the east, below stratified gravel and clayey sand, and from this were obtained small fragments of shells.

F. W. E.

Boulder-clay is pretty widely spread over the central and western parts of this district, and in some places is of considerable thickness. To the north-west the Cabry and Bogstown rivers and contiguous streams cut deeply through it, and similar sections may be seen in county Derry, on the Faughanvale river below the waterfall, and on the numerous streams that flow from the hills to the south, particularly the Ballykelly river, where a thickness of from sixty to eighty feet of it is seen.

Marine shells in chocolate-coloured boulder-clay were found in the glen through which the Castle river flows, near Muff, about a mile S.S.E. from that village, and also in the stream sections south of Ballykelly. Their occurrence in the Dungiven district has already been noticed in the memoir for that sheet. This deposit, though undoubtedly a boulder-clay, has been referred by Portlock to the "Tertiary" period.

In his description of the shells from these two localities, he mentions the following species:—*Turritella terebra*, *Cyprina Islandica*, and *Nucula oblonga*.*

Sand and Gravel.—Large tracts covered by these deposits also occur, and generally assume the form of terraces, which extend to the hill tops, gravel pits having been opened on Sistrakeel Top. The most remarkable are those extensive flats that spread over most of the district around Limavady, and westward by Ballykelly and Muff. Of these the lowest, from its position and great extent, has been

* Report, pp. 157-159.

sometimes regarded as a recent raised beach. A little examination, however, shows that this is not the case, as its contents are precisely similar to the gravel terraces above it, and differ widely from those in the raised beach presently to be described. Among other characteristics a peculiar gravel conglomerate, resembling that at Glenismole, county Dublin, and many similar deposits of glacial age, has been observed.

RECENT DEPOSITS.

Raised Beach.—An extensive raised beach, at an average height of about twenty-five feet, fringes the southern and eastern shores of Lough Foyle, extending to Bellarena and Magilligan, where it has a width of from two to four miles. It is also seen on the north-western shore in Donegal, where, owing to the nature of the ground, it is much narrower, being only a quarter of a mile wide at Quigley's Point. The road from Londonderry to Moville is in several places carried over this raised beach, and in the vicinity of Drung Chapel, at Vance's Point, and below Carrowkeel, the ancient sea cliffs, in some places rock, in others sand and gravel, are plainly discernible. This beach appears to consist chiefly of sand and silty alluvium, with fragments of shells.

J. N.

Openings made in that part of this area which lies north of Limavady, are rarely of sufficient depth to reach below the covering of sand, mixed with earthy and peaty matter, that to so great an extent overspreads the more level portions in sheet 12. An excavation at nearly a mile south of Roe bridge was found to reach blue sandy and shelly silt below two feet of alluvial sand, a second layer, containing more numerous shells, being said to exist at a depth of six feet. A similar deposit is spoken of by the people in the neighbourhood as occurring in the ground north-west of Bellarena station; and we have further evidence of its extent in the following quotation from letters of the Rev. Robert Innes, rector of Magilligan, written in the year 1732, and referred to by General Portlock on page 24 of his Report:—

“That this land was formerly sea I think there is sufficient reason to believe, for along at the foot of the mountain, and all the coast, is the old bank to be seen, to which the sea hath formerly flowed, at the foot of which everywhere is sea sand and shells to be dug up.”

The writer further alludes to the occurrence of water-worn stones, with shells and sand, under his own house, and in other places not far from the mouth of the river Roe. *Turritellæ* exist in large numbers below the blown sand near the river on the east side of the railway; and they occur also, with a few other shells, in beds of sand and shingle exposed in section along the adjacent north bank of the river.

The Robbers' Cave and the Piper's Cave, which penetrate the chalk at about one and two hundred yards, respectively, east of the stream that joins the sea a little east of Umbra, in sheet 6, standing at about the twenty five feet contour line, belong, no doubt, to the period of this raised beach. These openings were occasion-

ally within reach of the waves during the prevalence of storms, till the construction of the railway presented a barrier; and the floors are now strewn with rolled blocks and pebbles of basalt and broken shells.

In a place where the basalt is laid bare among the sand dunes, four hundred yards east of Castlerock, at about the level of the twenty-five feet contour line, the surface of the rock bears clear evidence of the rounding action of the sea, and the crevices are filled with sand and shell fragments—probably remnants of the old beach. On the south side of this, at a higher level, the overlying boulder-clay is seen covered by sand; and on the east side a section, reaching nine feet in height, shows boulder-clay full of sub-angular basalt blocks, and mixed with gravel and coarse sand, overlaid by two feet six inches of fine sea sand with shells. This is covered by eighteen inches of gravel and shingle and sand, full of broken shells, and this again by a similar depth of sand—the upper part, at least, being blown sand, which, a few yards to the east of the section, rises into dunes.

The arrangement of these deposits is in accordance with what frequently happens during stormy weather on the more exposed parts of our own sandy coasts. The boulder-clay appears to have been first covered by sand washed up from the sea, and this by blown sand; these were then partly denuded, and the shingle bed spread over them, by exceptionally high tides; and over this was deposited sand, in part probably by the sea, while the upper portion consists of blown sand containing land shells.

The blown sand here, as in many other places, contains a few thin dark-coloured layers, composed partly of black oxide of iron, derived from the basalt, which can be readily separated by the application of a magnet. Some layers, however, owe their dark colour more to the presence of grains of the basalt itself.

The hollows between the sand dunes, which latter cover the raised beach very thickly along its northern margin, often contain patches covered with water-worn pieces of basalt, and sometimes chalk and flint, with which are mingled various shells, such as the whelk, cockle, &c., including occasionally valves of *Cyprina islandica*. Accumulations of the last-named shells, in perfect condition, and not to be confounded with those belonging to the age of the raised beach, are sometimes found among the dunes, near the shore. These are the refuse from quantities of the animals which have been in recent times, and are up to the present day, opened here and carried away for food.

Peat Bogs.—The large bogs lying east of Benevenagh and south of Articlave consist of deep deposits of peat, which supply fuel to the people in the adjacent districts. They occupy extensive depressions caused by denudation, the peat probably lying to a great extent on the rock surface, without the interposition of the drift.

F. W. E.

Alluvium and Peat Bog.—A strip of alluvial land borders the river Roe from the south, where it enters this district, to Limavady, interrupted only by the rocky gorges at Carrick and the Dog's Leap at the entrance to the Deer Park wood. North of Limavady

it widens into a plain, which extends for some distance along the streams towards Drummond bridge and Artikelly, and to the north merges into the raised beach before described. The flat bogs are unimportant, but much peat is cut on the hills to the south.

Intakes.—Much of the shallow sea-bed on the southern and eastern shores of Lough Foyle has been reclaimed, and forms excellent arable land, but a good deal remains to be done in this direction, particularly between Longfield bridge and Ballykelly railway station, where thousands of acres might be made available.

CHAPTER III.

PRINCIPAL FAULTS AND GLACIATION.

To the north-west of Lough Foyle the Carboniferous rocks are bounded by a N.E. and S.W. fault, with downthrow to the south-east, interrupted in one place by a small northerly and southerly cross fault. The evidence for this is very clear, as at Craigboy the strike of the Carboniferous sandstone is directly against the schists, and although it regains the normal direction south of this, yet the amount of dip is unusually high, exceeding that of the older rocks, and in some places, as in the Cabry river section, slickensides and other evidences of disturbance were observed. The cross fault is visible on the shore east of Three Trees, particularly at low water.

The Carboniferous beds near Ballykelly are also affected by faults. Visible evidence of that which cuts off these beds in the river section one mile south of the town has already been referred to at page 13 (fig 2). This fault appears to extend north-eastwards towards Limavady, and also to the south-west, where evidence of its presence exists in the Ballykelly river. The fault bounding the triangular area of Carboniferous strata towards the N.E. is also proved by the dips in both these stream sections, by the disturbance of the limestone schists in the river Roe, and farther east, as will be described by Mr. Egan; while the fault forming the southern boundary of this small tract is also clearly manifest from the direction of the dips as seen on the map.

J. N.

The fault at Lislane bridge, already referred to on page 12, brings down the Carboniferous beds on the north against the mica-schist, as seen in the Castle river, and displaces the boundary for a distance of about half a mile from east to west. Another fault, passing by Drumagoser, causes a decided break in the Triassic boundary, the basal beds occurring there with an abnormal dip to the south, and again 1,100 yards to the east, where they dip at higher angles in the same direction. That this latter fault extends farther west, with a northern downthrow, may be looked upon as tolerably certain, from the following consideration, namely, that the Carboniferous beds are found east of White Hill Cottage, as already stated (page 14), and that eastward along the fault line shown on the map there is, so far as can be judged from the nature of the ground and from the debris, an abrupt passage from the mica-schist on the south to Carboniferous sandstone on the north.

Glaciation.—Evidences of glacial action are in some places clearly seen, as on Eagle Hill, near Umbra in sheet 6, where the rocks, extensively exposed at the surface, bear unmistakeable indications of having been ground down by ice proceeding in a N.N.W. direction. The rocks on Boyd's mountain and Three Taghmores afford also many though less striking examples.

South-west of Articlave fine striae and small furrows are well preserved on the rock surface which forms the bed of the stream; and remarkably so in the locality east of Benevenagh. Striae occur on the north-east slope of Sconce hill, and at one and a half mile south-east of it, where the rock is laid bare along the stream flowing north-east.

F. W. E.

NOTE ON THE FOSSILS.

The Ordnance Survey collection (such as remains in charge of the Geological Survey of Ireland), together with some additional species mentioned in Portlock's "Report," contains the following Cretaceous fossils as having been collected in parishes situated on this sheet of the one inch Map, (12).

No Palæontological inspection or collection of fossils have since been made by the Geological Survey from the district included in this sheet, as the extent of the fossiliferous beds is very small. It is intended to insert any further notice of species with those of the adjoining sheet to the North, (6); those of the Dungiven district to the south have been described in the Memoir to Sheet 18, p. 27.

List of CRETACEOUS ("Upper Chalk") Fossils, in Ordnance Survey collection (Ireland) and from Portlock's "Report on Geology of Londonderry," &c., as occurring in parishes situated on this sheet of the Geological Survey Map.

County of LONDONDERRY.

PROTOZOA—*Spongiæ*.

Amorphospongia (Achilleum) per-reticulatum,		
"White limestone,"	Parish Magilligan,	. Portl. sp.
Ventriculites alternans, "Chloritic chalk,"	" Drumachose,	. Roem. sp.
radiatus	" "	.
Cliona "Entobia" cretacea, chalk flint and	" "	.
"White limestone," Townland Umbra,	" Magilligan,	. Portl.

ECHINODERMATA.

Echinocorys (Ananchytes) sulcatus, "White limestone,"	Drumachose,	. Goldf.
Echinoconus (Galerites) abbreviatus	" Magilligan,	. Lamk.
" conicus (Galerites albo-galerus)	" "	. Breynius.
" (Galerites) subrotundus	" "	. Mant.

MOLLUSCA—*Lamellibranchiata*.

Ostrea vesicularis++	White Limestone, Keady Hill, Drumachose,	Lamk.
Pholadomya Esmarkii	" "	. Nilo, sp.

Cephalopoda.

Belemnitella mucronata—"White limestone," Townland Umbra,		
Parish Magilligan,		. Schlot, sp.

February 27th, 1885.

WM. HELLIER BAILY.

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