Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 7 AND 8 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

BY

RICHARD G. SYMES, M.A., F.G.S., F. W. EGAN, B.A., AND ALEX. M'HENRY, M.R.I.A.

WITH

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

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PREFACE.

THE district described in this Memoir, and included in Sheets 7 and 8, extends along the coast of Antrim and Derry, and for a short distance inland; it also includes the Island of Rathlin. It is one of exceptional interest to students of Tertiary volcanic phenomena, owing not only to the variety of the products of volcanic action, but also to the opportunities afforded along the coast cliffs of studying the nature and conditions of these products, and their relations to the older formations. In this district also are representatives of the Liassic and Cretaceous systems. The Carboniferous series is represented in the Ballycastle coal district, the strata of which are laid open in the fine coast sections extending from the town of that name to Murlough Bay on the east, where the base of the whole series, in the form of conglomerate, may be observed resting on the metamorphic schists which are the fundamental beds of the whole geological series of the north-east of Ireland.

The relations of the Tertiary volcanic rocks to the Cretaceous and Liassic series, and of these latter to the Carboniferous strata and more ancient schists, suggest long intervals of geological time—during which disturbances and successive denudations caused the disappearance of enormous masses of material.

The district has been the subject of numerous geological memoirs, amongst which may be specially mentioned those of Sir R. Griffith "on the Ballycastle Coal District"; of Dr. J. Bryce, "on the Geological Structure of the North-Eastern part of Co. Antrim;" of General Portlock, "Notes on the Basaltic District of the North-East of Ireland;" and "Geological Report on Londonderry, &c." (1843); Dr. Berger's Memoir on the Geological features of the N.E. counties of Ireland, together with the outline sections of the coasts of Antrim and Derry, by the Rev. W. Conybeare, in Trans. Geol. Soc., Lond., Vol. III., and many others, some of which are referred to in the text.

The tract of country included in Sheets 7 and 8 was geologically surveyed during the years 1883–85, by the Authors of this Memoir, and the Maps were published last year.

Mr. Symes surveyed the district between Portrush and White Park Bay; Mr. Egan the portion of the district in Co. Londonderry; Mr. M'Henry the country lying to the S.E. of Ballycastle, and the coast between Ballycastle and Ballintoy; while the survey of Rathlin Island was the joint work of Messrs. Symes and M'Henry. Each of the officers describes his own ground.

EDWARD HULL,

Director of the Geological Survey of Ireland.

THE

GEOLOGICAL SURVEY OF THE UNITED KINGDOM

IS CONDUCTED UNDER THE POWERS OF THE

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

IRISH BRANCH.

Office, 14, *Hume-street, Dublin.*

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EDWARD HULL, LL.D., F.R.S., F G,S.

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S. B. WILKINSON; J. NOLAN, M.R.I.A.

ASSISTANT GEOLOGISTS:
R. J. CRUISE, M.R.I.A.; F. W. EGAN, B.A.; J. R. KILROE; W. F. MITCHELL;
A. McHENRY, M.R.I.A.;
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EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 7 AND 8 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

CHAPTER I.

Physical Geography.

The area about to be described includes all the northern and north-eastern portions of the county Antrim and adjoining part of Londonderry, together with Rathlin Island, four miles N. from the coast of Ballycastle, and the Skerries, about one mile N.E. from that of Portrush; situated in this district are the towns of Ballycastle, Bushmills, Portrush and Port Stewart.

The shore line from Portrush to Fair Head, east of Ballycastle, composed for the most part of cliffs formed of successive tiers of basalt resting on chalk, is generally bold, often inaccessible, more especially in the neighbourhood of Bengore Head, which rises to a height of 367 feet above the waters of the sea, where the celebrated Giant's Causeway makes an interesting geological feature. Striking as is the appearance of Bengore Head, it is completely surpassed by that of Benmore or Fair Head, rising 636 feet, or nearly double the height of the former. This latter has a cap composed of a massive sheet of dolerite, which on the sea-face is broken up into great polygonal monoliths over 250 feet in length. At the base of this lofty cliff broken columns of basalt are confusedly strewn over the slopes to the water's edge, covering the underlying Carboniferous beds, and presenting great obstacles to a proper examination of the position of the coal-seams, as well as increasing the risk of going round the base of the cliff.

Inland the country slopes downwards from the coast-line, corresponding to the general inclination of the tabular basalt which dips always in a southerly direction; this portion of the district is usually overspread by peat-bog or boulder clay.

The only remarkable elevation in the district is Knocklayd, a hill about two miles S. of Ballycastle, rising 1,685 feet above Ordnance Datum. This dome-shaped mass consists of Upper and Lower Basalt and Chalk resting on a platform of mica-schist.

The peninsula of Portrush lies in the extreme N.W. corner of the county Antrim, and is fenced on its western side by perpendicular cliffs composed of a sheet of dolerite some seventy feet in thickness. The most westerly promontory is called Ramore

Head. At a distance of half a mile north-east from Ramore Head, a chain of islands, sixteen in number, called "The Skerries," commences, and extends in an easterly direction for about a mile and a half, forming a natural breakwater to the North Atlantic waves, which even in comparatively calm weather may often be observed breaking over the sea-ward faces of the Skerries, and throwing the spray high into the air.

The coast line at and west of Portrush consists chiefly of cliffs of basalt and dolerite, bounded at the base by a narrow uneven margin of the same rocks, indented by numerous small irregular creeks and bays. The surface at the top of these cliffs stands generally at a height of twenty-five to forty feet above the sea; reaching, however, about one-hundred feet in the vicinity of Island Doo. This island is one of a number of outliers belonging to the basalt, which lie at short distances out from the shore, some being separated from the mainland merely by narrow necks of water at full tide. The rocks are often traversed by fissures, some of them being open up to the surface, so as to form "puffing holes" or "blow-holes," through which the air, accompanied by spray, is projected with more or less force by the waves rushing into the cavities below. One of these occurs at Blackcastle Rock, close to Portstewart; the fissure here communicating with a cave which runs southward between the rock itself and the mainland. Another is found on an island south-west of Black Rock. Of the few caves that occur on this part of the coast, none are of large dimensions. Close to the ruins of Ballyreagh Castle, an opening of this nature runs in for about eighteen yards, being seven yards wide at the entrance, and at most seven feet in height.

The surface of the ground, here contained within the limits of the county Londonderry, is generally uneven, but not marked by any striking features, except where it takes a somewhat rapid rise eastward along the boundary of the Upper and Lower Basalt. This change of level is accompanied by escarpments in the columnar basalt which lies at the base of the upper division of the volcanic series. The higher ground in this locality attains, at Drumsull, an elevation of 434 feet. To the north it becomes denuded of Drift, the rock appearing in many projecting bosses at the surface, and disappearing below a deepening deposit of boulder-clay where the ground slopes away southward towards Cloyfin. Generally throughout the south-western part of Sheet 7, the covering of Drift gives a smooth aspect to the surface, which is, however, broken in various places by prominent bosses of basalt, some of them bearing clear traces of ice-action, both in their rounded forms and, also, in the delicately chiselled striæ which become apparent upon close examination.

The district lying to the south and south-east of the Ballycastle coal-field, is bounded on the north and east by the North Channel, along the shores of which it terminates in bold and precipitous sea-cliffs, the most prominent being Torr and Runabay Headlands. Generally the country is rough and hilly, containing picturesque glens and valleys, the high ground being invariably covered by thick and extensive accumulations of peat bog and Glacial Drift.

The tract lying between Ballycastle Bay and White Park Bay is of a gently undulating character, ending off in steep and often vertical sea-cliffs of basalt and chalk, averaging 300 feet in height.

Rathlin Island.—Although so close to the mainland, Rathlin Island is very difficult of access, owing to want of proper harbour accommodation, and the liability to dangerous seas due to tidal currents between the island and the mainland. In plan it represents two sides of a triangle, the lighthouse being at the apex, and Church Bay in the angle. From the lighthouse to Bull Point, in the extreme west, the distance is four and a half miles, and from the lighthouse to Rue Point in the south, three miles; the entire area of the island being about five and a quarter square miles.

Its physical features are very much the same as on the mainland. The northern face, consisting of tabular and columnar basalt resting on chalk, is formed of bold, often inaccessible cliffs, between three and four hundred feet in height, while along the opposite side of the island the sheets slope towards the south, and along their seaward faces, show a similar superposition of the basaltic and Cretaceous beds.

Numerous small shallow tarns are to be met with, probably excavated in the basaltic sheets by former ice-action, of which there is abundant evidence.

River Basins and Drainage.

The western portion of the district is drained by the Lower Bann, which rises in Lough Neagh, and enters the Atlantic near Port Stewart. It is here a navigable river about one hundred yards in breadth. Besides this the only rivers of any consequence are the Bush and Glenshesk. The former flows northwards, passing through Bushmills; the latter, having received the Carey and Ballycastle streams as tributaries from the east and west, also flows northwards and enters the sea a little to the east of Ballycastle. Both these streams have their source in the district comprised in Sheet 14.

The district included in Culfeitrim Parish is drained principally by the Carey River and its tributary streams, which flow in a general north-west direction into the sea at Ballycastle Bay.

A few small burns rise in the hills on the east, and flow eastwards into the North Channel.

CHAPTER II.

Rock Formations and Divisions.

Name.	—	Sign and Colour on Map.
	Aqueous Rocks.	
Recent, . .	Blown sand, . . .	Red dots on white ground.
„ . .	Bog and alluvium, . . .	Chalons brown and gamboge.
„ . .	Raised beach, . . .	Chalons brown and gamboge.
Post Pliocene (Drift).	Boulder clay, . . . } Sand and gravel, . . }	Engraved dots.
	Tertiary Volcanic Rocks.	
Basalt and Dolerite.	Upper Basaltic sheets, . .	B. Burnt carmine (deep).
	Iron Ore with Lithomarge, .	Light reddish brown and gold dots.
	Lower Basaltic sheets, .	B. Burnt carmine (light).
	Volcanic Ash, . . .	Bs. Burnt carmine with white dots.
	Intrusive Rocks and Dykes, .	B. Carmine and burnt carmine.
	Aqueous Rocks—continued.	
Cretaceous, .	Upper Chalk with Flints, .	h^5. Emerald green (light).
„ . .	„ Greensand . . .	h^4. „ „ (dark).
Liassic, . .	Lower Lias, ...	g^1. Chalons brown and gamboge.
Triassic, . .	Keuper Marl, ...	f^5. Venetian red (light).
Lower Carboniferous.	Sandstone, Limestone, and Beds of Coal.	d^2. Prussian blue.
	Metamorphic Sedimentary Rocks.	
	Mica schist, Hornblende schist, &c.	μ. Pale pink.
	Crystalline Limestone, . .	λ Cobalt.
	Intrusive Igneous Rocks of pre-Triassic age.	
	Quartziferous Porphyry, . .	E. Carmine (deep).
	Diorite, ...	D. Burnt carmine (deep).
	Felstone, ...	$F.\tau$ Vermilion (light).

Metamorphic Rocks.

Schists.—These consist chiefly of micaceous and quartzose schists, and are the oldest rocks in the Co. Antrim, forming locally the floor both to the Carboniferous, Triassic, Cretaceous and Tertiary strata.

For three miles south of Ballycastle they occupy a considerable area, and several exposures are met with on the east side of the railway, as well as in the plateau from which rises the isolated mass of Knocklayd. In the town of Ballycastle the railway cutting lays open beds of micaceous schist and quartzite dipping N. 30°W. at about 25°; these beds have an ochreous appearance.

Dr. Geikie has found staurolite in these silvery sericitic schists, and tourmaline has also been noted.

These rocks south of Fair Head and Ballycastle consist generally of micaceous and felspathic schists, which, in many instances, have become highly gneissose in character; the prevailing colour of the whole series being grey.

To the east of Murlough Bay, the schists are of greenish and grey colours, chloritic and micaceous, and contain abundance of vein-quartz. As we approach Torr Head the rocks become very hornblendic, while at Torr itself, and in its vicinity, they almost wholly consist of massive dark green compact hornblende schist, containing numerous lenticular beds of coarsely crystalline grey limestone. These limestones are of a very striking and unusual character; some beds, a little to the south-west of the village of Torr, being almost entirely composed of largely crystalline black calcite, which, at first sight, gives the rock the appearance of a dolerite.

Tracing the schists still to the southward of Torr, they maintain their highly hornblendic composition, but become gneissose in parts, notably at Altmore Bridge and Loughan Bay, where masses of reddish and grey gneiss occur, interbedded with the greenish hornblende schist.

To the east of Knocklayd Mountain the schists are very similar in composition to those at Murlough, as also are the rocks met with in the vicinity of Torteige, Carneighaneigh Mountain, and south of Loughaveema.

These strata are well seen in all the stream cuttings and on the sea coast, and in every case exhibit a highly contorted structure, the average inclination of the beds being about 30° below the horizon, and the general strike north-east and south-west.

Numerous quartz lodes and veins occur throughout the series. A little south of Glenshesk Bridge, in the stream, a thin vein of nephrite of a pale green colour, and containing small crystals of iron pyrites, was noted.

In general character the metamorphic rocks of this part of the country resemble closely those in some portions of Co. Donegal, so that we may safely assume that the north-east corner of Co. Antrim is a portion of the old ridge of metamorphosed beds which extended from the Co. Galway, through Mayo, Sligo, and Donegal into the western and northern highlands of Scotland in Devonian and Carboniferous times.

Aqueous Rocks—Carboniferous.

Lower Carboniferous Series.—The representatives of this series comprising thick sandstones, shales, thin limestones, coal-seams, and iron-stones, are to be found to the east and south-east of Ballycastle. The Lower Carboniferous limestone of the central plain of Ireland thins out to the north, and in this district is represented by only six to eight feet of bluish grey fossiliferous limestone, separated into two bands by thin shale partings.

In the shore section, east of Ballycastle, the limestone is first met with in the North Star Colliery at about forty feet above the level of the sea, dipping S., and as we proceed eastwards on approaching the North Star dyke, the beds descend, dipping eastwards. East of the North Star dyke the outcrop is well seen in the cliff a few feet above the level of the sea as far as the Carrickmore dyke, beyond which there is a considerable displacement of the strata, and we find the bed about 250 feet above the level of the sea; further east, in a pit sunk north of Craigfad, the limestone was found about 350 feet above the sea. The same bed apparently is found at the same height in Murlough Bay, but differs in colour; in the latter case being purple, instead of blue or gray as at Ballycastle Bay.

In the valley of the Carey River a boring was stopped in bluish-gray limestone (see Appendix section No. VII., Barnish), similar to that on Ballycastle shore, and Sir R. Griffith observes* "It is remarkable that the trial was discontinued in bluish-gray limestone, but the strata overlying the limestone at Barnish do not correspond with those on the sea shore, the former being through shale, and the latter through sandstone," from which he assumes that the limestones are not of the same age.

If, however, we assume that the limestone in Murlough Bay is of the same age as that on the Ballycastle shore, we have good data for inferring that the lowest Carboniferous beds are to be found in Murlough Bay; the limestone being at the bottom of the section in the former and at the top in the latter.

The Ballycastle coal district has been described in more or less detail by Dr. Berger,† Dr. Bryce,‡ and very fully by Sir R. Griffith, in his well-known Report, drawn up for the Royal Dublin Society.§

Coal-bearing series.—Sir Richard Griffith, in his Mining Report, notes that the Antrim coal district, in point of geological position, is by much the most remarkable in Ireland, and the workings for coal are amongst the most ancient in the British Islands. In 1770, when an adit was being pushed forward, the miners came upon a gallery which had been driven forward many hundred yards into the bed of coal; it branched out into thirty-six chambers where miners had carried forward their works. The great antiquity of these adits was shown by the decayed primitive tools, as well as by sparry incrustations on the sides and pillars of the mine.

As to the type of these coal-bearing beds, several authors have expressed their opinion that they are referable to those of the West of Scotland. Professor Hull writes, "I am struck by several features of resemblance which the rocks present to those

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*Griffith, "Geological and Mining Surveys of the Coal Districts, counties Tyrone and Antrim," page 74. Dublin, 1829.

† "On the Geological Features of the Northern Counties of Ireland." Trans. Geol. Soc., London, 1st ser., vol. iii.

‡ "On the Geological Structure of the North-east part of County Antrim." *Ibid.* 2nd ser., vol. v.

§ Report, *loc. cit.*, p. 47, *et seq.*

of the Lower Carboniferous district of the West of Scotland";* and John Kelly in an exhaustive paper remarks that they have a likeness to the colliery at Burdie House, near Edinburgh, in which the limestone has coal above it and coal below it in a similar way.

As the coal-measures extend from the E. of Ballycastle, round Fair Head and Murlough Bay, and occupy the valley of the Glenshesk and Carey Rivers, and as they possess different characteristics, it is as well to divide the tract into three districts.

1st. That of Colliery Bay, extending from Ballycastle to Carrickmore dyke.

2nd. That of Fair Head and Murlough Bay.

3rd. The tract in the vicinity of the Glenshesk and Carey Rivers.

The boundary between the first and third coal-district is formed by the Great Gaw dyke, which extends from Bath Lodge in an easterly direction as far as Murlough Bay, where its outcrop was noted on the shore south of Drumnakill Point. The Carrickmore dyke, on the shore three miles E. of Ballycastle, and the fault seen in the cliff, running in the same direction as the dyke, form a convenient boundary between the first and second districts.

Each of these coal districts has its peculiar lithological characters. The first is characterized by yellow and yellowish white sandstones, black shales, a coal-seam four feet six inches thick, two bands of limestone, each about four feet in thickness, and a small capping of dolerite. The second is characterized by thick red sandstones, several beds of coal, a bed of purple limestone, and a considerable capping of dolerite. In the third, beds of shale, very thin seams of coal and limestone are prevalent, with a base of massive sandstone; a considerable thickness of Drift obscures the Carboniferous strata over this tract.

The basal beds of the series are to be found in the second district on the southern shore of Murlough Bay, and are composed of conglomerates and red sandstones, resting on mica-schist.

1. *Colliery Bay District.*—In this district the workable coal is met with at different elevations in the sea-cliff, which is composed, throughout nearly three-fourths of its face, of sandstone. Owing to the existence of transverse faults and dykes of trap in-

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* "On the Geological Age of the Ballycastle Coal-field, with Palæontological notes by Mr. W. H. Baily." Journ. Roy. Geol. Soc., Ireland, vol. ii., new ser., 1871.

On visiting this district in 1871, and examining the fine sections along the coast of Ballycastle Bay, I was struck by the resemblance of the series of strata to those of the "lower coal and ironstone series" of Lanarkshire and Ayrshire, with which I had become familiar, and I came to the conclusion that they were representative beds. The series in county Antrim belongs, in all probability, in part to those of the "Upper Calciferous," the "Carboniferous Limestone," and "the Yoredale" stages of Scotland and the north of England; and amongst the points of analogy are the occurrence of thick beds of red and yellow sandstone, of black-band ironstone, and of earthy limestone in thin beds, containing marine fossils. These beds, only a few feet in thickness as stated above, are the meagre calcareous representatives of the great limestone formation of the Central Plain of Ireland, which has undergone a remarkable change in mineral characters and thickness in this direction, in keeping with the general change which the formation undergoes throughout the British Islands.

E. H.

† Proceed. Roy. Irish. Acad., vol. x., part. iii., p. 241.

tersecting the strata, the coal-seams have been separated into distinct blocks, or collieries, parted from one another either by dykes or faults.*

The following is a list of the several collieries comprised in this district, showing how they are separated from one another, and the position of the "main coal" above level of sea:—

GOING FROM WEST TO EAST.

NAME.	Separated from adjoining Colliery by	Main Coal thrown up or down.	Average height of Main Coal above level of sea.
Salt Pans,	Fault,	Up to E.,	165 feet.
White Mine,	Dyke,	Up to E.,	180 „
Fallbane,	Fault,	Down 30 fathoms to E.,	—
Doon,	Fault,	Up 30 fathoms to E.,	—
North Star,	Dyke,	Up 6 fathoms to E.,	100 feet.
West Mine,	Dyke,	Slight up E.,	200 „
Lagglass,	Fault,	15 fathoms up E.,	170 „
Goldnamuck,	Dyke,	8 or 10 fathoms up E.,	—
Colliery Port,	Fault,	12 or 15 fathoms up E.,	265 feet.
Pollard,	Dyke,	Down on E.,	152 „
Griffin,	Fault,	20 fathoms up E.,	180 „
Gobb,	Fault,	10 or 12 fathoms down E.,	200 „
Portnagee,	—	Carrickmore dyke,	—

The Gobb, Pollard, Goldnamuck, Lagglass, and West Mine, were worked as early as the year 1724.

In the Salt Pans Colliery, between 1749 and 1760, four pits were sunk near Bath Lodge, a little above sea level, and coal varying in thickness from six to nine feet was found about forty yards below the sea level; and in 1850 fresh bores were made to a depth of 596 feet, and at 260 feet a coal seam six feet thick was penetrated, and the bore passed through the old workings made by the proprietors.† About the same year a second bed was discovered by Mr. Dinsmore in the cliff about thirty feet above the sea, two feet four inches thick, and it is assumed from the thickness of the main coal in this mine and in the White Mine adjoining, where the coal also is found at a considerable depth below the sea, that these "collieries" are different from those eastwards, where the main coal is four feet six inches in thickness.

In driving the incline in the White Mine at about fifteen feet above the sea level, the rate of slope was one foot in the yard, and the miners went only seventy-two fathoms‡ before they caught the coal, showing that the inclination of the beds was at a very high angle, in fact about 50°.

In the North Star Colliery the rocks have an anticlinal position, those on the west dipping west, and those on the east dipping east, the coal being easily worked by adits.

In the Gobb Colliery the dolerite is first met with capping the stratified rocks to a depth of fifty-one feet (see Section I.,

* The local term used by the miners for a "fault" is "gravelly dyke" or "stop."
† Information received from Charles Darragh, miner, Ballycastle.
‡ Information received from James Darragh, Ballycastle.

Appendix); and 156 feet below the dolerite the main coal is met with, and 148 feet below the main coal is the limestone bed. The entire thickness of strata measured was 373½ feet, of which there are about sixty feet of shale, and 248 of sandstone.

2. *Fair Head and Murlough Bay District.*—The only coal worked in this district to the west of Fair Head was at the Nelson Colliery, about fifty perches to the east of Carrickmore dyke, and nearly on the level of high-water mark (see Section III., Appendix), and Sir R. Griffith mentions* that this was the only example in the Antrim coal district of a bed of bituminous coal being found beneath a stratum of non-flaming coal.

To the south of Fair Head coal was worked extensively; but transit by land or water being so precarious, prevented the beds being worked to the same extent as in the Ballycastle shore division.

The Murlough Colliery (see Section 4, Appendix) contains six beds of coal, four of which are bituminous, and two anthracitic; the latter being in proximity to the seventy-foot sheet of dolerite. Two of the bituminous beds are two feet six inches thick each: the upper called the "white mine," and the lower the "good man's vein." The upper bed of "blind" coal is also two feet six, and is only two feet above the dolerite; it also was worked extensively in 1790.

To the east of Murlough Colliery there is a large fault with a downthrow to the north, and to the east of the fault, N. of Portdoo, a bed of coal was worked below the sea-level, but was abandoned on account of flooding. This bed is probably the same as the "white mine" bed in the Murlough Colliery, which was about 350 feet above the sea.

3. *Glenshesk and Carey River District.*—This tract, about three square miles in area, has been repeatedly bored for coals, especially in the townlands of Barnish, Drumahitt, and Brackney, and with very poor results. In all the sections (see Sections VI. to XV., Appendix) thin coals are met with, but not one worth working; the only thin coal ever worked was by a labouring man in the townland of Barnish.

Blackband Ironstone.—The occurrence of blackband ironstone in this formation is adduced as a further point of analogy between the coal-series of Ballycastle and those of the Lower Coal and Ironstone Series of Scotland. In the Ballycastle Collieries ironstone was worked extensively in the Goldnamuck, Pollard, and Gobb Collieries, but in the collieries west of these, none has been worked although the blackband was struck in a bore made by Engledue at Doon, east of Fallbane.

The band worked in the collieries before-named varied from 11 to 15 inches in thickness; it was very pure and free from dirt, but would not calcine without a little coal being used

* Report *sup. cit.*, p. 76.

with it in the heap. A fresh band has been met with in the same locality, outcropping at sea level, but it has not been worked.*

Many thousands of tons of calcined ore are at present on the bank, waiting for export until the market is somewhat better than it is at present.

Sandstones and Conglomerates.—As before mentioned, white and light yellowish sandstones predominate in the Ballycastle shore section; red sandstones in Murlough Bay, while in the Carey River section sandstones are scarce, except in the bottom beds. Some of the sandstones prove very good building stones, but the majority are so soft that they are of no economic value. As evidence of the quality of some of the stone, the condition of the Boyd Church, Ballycastle, built in 1756, also of the R. C. Chapel, indicates the durability. Recently new quarries, in pink and yellow fine-grained stone, suitable for cornices and mouldings, have been opened by Mr. M'Gildowney; also a coarse pink stone suitable for bridge and rubble work.

In the Murlough Bay division there are several beds of good building stone, but the difficulty of transit places them out of reach of a proper market. Mr. J. Kelly remarks that in the Carey River district the proportion of sandstone to shale is 1 to 7; in Murlough Bay, 8 to 5; and on Ballycastle shore, 4 to 1.†

The junction of the sandstones and the underlying mica-schists can be seen in the townland boundary of Mullarts, a little over a mile S.S.E. of Ballycastle; also on the shore to the south of Murlough Bay, and John Kelly mentions having seen the junction in the Carey River about a mile S.E. of Carey Mill.‡ This latter junction cannot now be seen, being probably covered by shingle brought down by the stream. The junction beds S.S.E. of Ballycastle consist of brownish grey flaggy soft sandstone, white sandstone and greyish marl, resting on schists and thin quartzites, the sandstones dipping N.E. at about 20°, and the schists to the N.W. at a much higher angle. The junction in Murlough Bay consists of white and yellow sandstone and coarse conglomerate, dipping N. at 15°, resting in a basin of very crumpled and finely foliated mica-schist. Dr. Geikie considers this isolated patch to be faulted down to its present position, which is more than probable, as nearly all the beds in Murlough Bay, up to the Tertiary rocks, have been either faulted or have slipped.

Triassic Beds.

Keuper Marls.—These occupy but a very small area in the entire district, and are to be found in Murlough Bay, under the great escarpment of chalk, which, along with the overlying

* Information received from J. M'Gildowney, Esq., Clare Park, Ballycastle.
† Proceed. Roy. Ir. Acad., vol. x., pt. iii.
‡ Proceed. Roy. Ir. Acad., vol. x., pt. iii., p. 249.

dolerite, encircles this secluded amphitheatre. The best sections are seen in the townland of Torglass, as recent slips have exposed a face of the escarpment, showing beds of the Cretaceous and Triassic series in their relative positions, resting on the metamorphic sedimentary rocks.

The Triassic beds are not more than sixty feet thick, and consist of deep red sandstones and marls immediately under the Greensand; while lower down, and near the junction with the metamorphic rocks, there occur beds of breccia, composed of angular pieces of schist, vein quartz, and quartzite, derived from the older rocks. In some parts of the bay it would appear as if the New Red marl was of much greater thickness than really is the case, but this is owing to successive landslips.

Between Murlough Bay and the north-east slope of Carnanmore Mountain, these beds are entirely absent; but at the latter place, a limited lenticular deposit of soft brick-red, yellow, and brown sandstone exists, dipping towards the hill, south-west, at 5° to 10°. Its estimated greatest thickness here is about sixty feet, and it evidently thins away rapidly north and south from that point.

Just south of the Green Hill, another deposit of soft red sandstone and breccia, a few feet in thickness, is seen resting on the red and grey schists, and immediately under the Chalk; it dips 15° N.E.

Lower Liassic Beds.

The beds belonging to the Lower Lias are only found at Ballintoy, Portrush, and the Skerries Islands; in Murlough Bay where the Cretaceous and the Triassic beds are found, the Lias is absent, as the representative of the Greensand is found resting on the Keuper marls. At Portrush the Lias, in a highly indurated state, is found in several places along the eastern peninsula, and was many years ago the subject of much scientific discussion. Portlock observes that in 1799, "the discovery of organic remains in a rock, considered a species of basalt, naturally excited attention, and was appealed to by the advocates of aqueous deposition as a powerful argument in their favour."* Dr. Bryce writing of "the celebrated Portrush rock," says:—"A rock occurs on the sea shore near Portrush resembling basalt very closely, but containing fossil shells."† He also quotes the views of the following authors:—Dr. Richardson writes:—"The nature of this stone is not yet ascertained; an eminent geologist who visited the spot last summer asserts it to be chert, petrosilex, or schistus."‡ Professor Pictet, of Geneva, considered it to be basalt containing a greater portion of silex than usual. Mr. Playfair examined some specimens forwarded to Edinburgh, and was of opinion that the stones which contained the shells were no part of the real basalt. Mr. Conybeare notes in an appendix to Dr. Berger's

* Report on Londonderry, p. 37, *et seq.*
† Geol. Soc. Jour. Dub., Vol. I., p. 166.
‡ Trans. Royal Irish Acad., Vol. IX., p. 28.

paper on the N.E. of Ireland, that it is exactly similar to the indurated slate clay (carboniferous) which forms the wall of the Carrickmore dyke in the Ballycastle collieries, and feels convinced that the rock was no other than the slate clay of the Lias formation in an indurated state." *

Dr. Bryce in his paper alludes to the "Portrush rock as capping the basalt over the entire of the eastern peninsula occupied by Portrush;" this, however, is not the case, as the Lias is only to be found in isolated patches, chiefly on the shore of the eastern peninsula, one patch opposite the harbour and one on road S. of Reviggerly Point.

The rock consists of a dark, or bluish-gray, highly indurated shale, with a laminated cross section, and breaking with a conchoidal fracture, generally across the planes of lamination; the stone is also hard, flinty, and very compact. Fossils, chiefly *Ammonites*, are numerous along certain zones, but are difficult to obtain in their entirety, owing to the brittle nature of the rock. The beds of Lower Lias on the Skerries Islands coincide in character with those at Portrush, except that the formation is much thicker on the Skerries than on the mainland; in the latter the maximum thickness is about five feet, while on the Skerries it is at least double that amount, yet it is difficult to estimate the absolute thickness. In the Portrush locality the Lias along the shore N. of the Bath House dips a little N. of E. at angles varying from 10° to 15°, conforming to the inclination of the surface on which it is placed; but opposite Bath-terrace it is crumpled, and no definite inclination was recorded. At the Ladies' Bathing-place it is only a few inches thick, and has a similar dip to that N. of the Bath House. On the Skerries the dip is to the south, conformable to the inclination of the great dolerite sheets.

Recently, excavations have been made over Portrush for sewerage purposes, in some cases to a depth of fifteen feet through the dolerite, and in no case was the Lias met with.

In the neighbourhood of Ballycastle numerous Liassic fragments containing fossils are constantly found when excavations are being made, but no outcrop of Lias *in situ* has as yet been discovered.†

It may be observed that only the lower beds of the Lower Lias are present in this part of county Antrim, and their preservation from the denudation, owing to which the once overlying beds have been swept away, is attributable to their induration, from contact with the intruded sheets of dolerite.

At White Park Bay dark blue Lias clay and shale are well shown in a small stream, and immediately at the foot of the Chalk escarpment, a little north of the road between Ballintoy and the Causeway, dipping south south-east at 20° and overlain, unconformably, by the Cretaceous beds. A little lower down, towards the sea in the same stream, is to be seen

* Geo. Trans., Vol. III., p. 212.
† See Brit. Assoc. Report, 1874, p. 88.

a slipping mass of stiff blue Lias clay, containing an abundance of fine fossils and calcareous fossiliferous nodules.

The thickness of the Lias cannot be with certainty estimated at this locality, but as the topmost exposure of it is at the 150 feet contour line, and traces of it are to be found down to the sea level, we may assume it to be at least 150 feet in thickness.

In consequence of the soft clayey nature of this deposit, the superincumbent hard Cretaceous rocks have slipped to a considerable degree all round the escarpment of White Park Bay.

A little south-west of Ballintoy Harbour traces of Lias are to be met with in the vicinity of a north-east and south-west fault. At Fortnakillew, a little south of Kinbane or White Head, similar beds are exposed to view under the Chalk, the whole of which have been carried up from a deeper seat, and rest on the upper portion of a large intrusive mass of basalt. Fossils were noticed in these two localities

Upper Cretaceous Beds.

Upper Greensand.—From the lowest beds of the Lias we ascend at one step in this part of Ireland into those of the Upper Cretaceous Series. A vast interval of unrepresented geological time separates the epochs of these two formations. The beds of Upper Greensand consisting of conglomerate are but sparingly represented in the entire district, in consequence of the base of the Chalk not being exposed.

The only locality at which the outcrop of the Greensand is seen is in Murlough Bay, where the rock occurs under the Chalk escarpment, and rests apparently conformably on the New Red Marls. It corresponds with a similar bed described in the district of Cushendall.*

This conglomerate is about twelve inches thick, and composed of well-rounded pebbles of vein-quartz, quartzite, red sandstone, and Lias nodules, cemented by a calcareous, glauconitic, paste. It is remarkable for containing Lias fossils, while there is no exposure of Lias rock within several miles of Murlough Bay.

Upper Chalk.— In the N. and N.E. coast of the Co. Antrim this formation presents a striking appearance in the cliff sections, on account of the contrast which its whiteness presents to the dark masses of basalt, generally surmounting it. The formation is well exposed in Murlough Bay, Knocklayd Mountain, Ballycastle, Ballintoy, Portbradden, the mouth of the Bush, and in the cliffs between Dunluce and Portrush. It is similar to the Chalk of the remainder of the Co. Antrim, being a hard, white, compact limestone, separated into beds by bands of flints about four feet apart. It is used extensively for agricultural purposes; the chief quarries in it being at White Rocks, Portrush, Knocklayd, Ballycastle, and in the low ground N. of Armoy.

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* See "Explanatory Memoir to accompany Sheet 14," p. 15.

The Chalk formation occurs in greatest thickness along the northern shore west of Ballycastle, where it is probably 150 feet thick; but as the base is not visible in the sections, the thickness may actually be greater. On Knocklayd, at a height of about 870 feet above the sea, the Chalk resting on mica-schist, forms a ring round the mountain, and is estimated to be there, about seventy feet thick; while a couple of miles to the westward at Balleny, near Armoy, its position is only 270 feet above the sea, showing that there is a considerable fault with a downthrow on the north between these two localities. At Balleny the thickness is only thirty feet.

At Portbradden, on the western side of White Park Bay, the small fishing harbour has for its northern protection a natural wall of upper basalt some eighty feet in height, while the southern wall is a cliff of chalk about the same height. Between these points, also, there is a fault with a downthrow to the N. of several hundred feet, being the combined thickness of the lower basalt, the iron-ore beds, and some part of the upper basalt. The same beds of the Chalk which are represented at Portbradden occur further west amongst the sandhills at the mouth of the River Bush about a mile to the north of Bushmills; but their continuity here is broken by a downthrow fault on the W. bringing the lower basalt into conjunction with the Chalk. The next westward outcrop of the Chalk is to be found at low water on either side of Dunluce Castle; whence the rock gradually rises and forms a cliff at the "White Rocks" of about 150 feet. This cliff as seen from the sea presents a varied aspect owing to the numerous caverns and fantastic forms into which the rock has been carved by the erosion of the sea; a process which is still going on. The upper surface of the Chalk has also been eroded, chiefly prior to the outpouring of the basalts, and a very remarkable valley, or V-shaped cutting, of about sixty feet is seen in the chalk quarry which is now being worked. This cavity is filled with spheroids of basalt, and some geologists have considered it to be the old neck of a crater. Portlock* notes the unevenness of the surface of the chalk here and attributes it to erosion prior to the outflow of basalt. Dr. Geikie suggests the solution of the limestone subsequent to the outpouring of the basalts, and then the falling in of the roof, and the weathering of the basalt into the agglomerate-like blocks which are found in this funnel-shaped cavity. West of the White Rocks the outcrop of the Chalk is not again seen, but the underlying banks against which the sandhills have been heaped up, and which extend for about two miles, may possibly be formed of this rock. To the south of the town of Portrush, and at a distance of half a mile, at Carneybawn, there is an old quarry containing chalk-rubble, from which the presence of the rock *in situ* is inferred. The outcrop here is in a line with that of the coast-cliff near Dunluce Castle.

Carneighaneigh and Carnanmore Mountains, south and south-

* Report, *sup. cit.*, p. 148.

east of Fair Head, are both capped with a continuation of the Murlough Cretaceous beds and overlain by the lower basalt.

In all cases where the lowest portion of this formation is visible the basal pebble bed is to be traced resting on either the old schists or on Triassic strata. And in no instance does it exceed a foot in thickness.

The Green Hill, south of Torr Head, is capped by a limited outlying deposit of chalk limestone, the eastern portion of which has been thrown down on the east by three parallel north and south faults. On the coast, between Ballycastle and Ballintoy, the Chalk is visible in many places, and in all cases it is overlain by the lower basalt.

Rathlin Island.—The Chalk formation is the foundation rock of the Island of Rathlin. On the east side of Church Bay, for some distance there is a continuous section of the beds, in which they have a steady dip all through at about 13° to the North; this when measured gives about 220 feet as the thickness of the formation, and represents the greatest thickness of the Chalk either in Rathlin or the mainland. Immediately S. of this is a gap in the section, and then the beds dip S. at high angles and are much broken up by numerous faults.

A section of Chalk, seventy to eighty feet thick, with a constant dip north-west at 10° to 20°, is visible under the lower basalt, along the south shore of the northern portion of the Island from Church Bay to Sroanderrig, and from Cooraghy Bay to Bull Point, where the beds undulate from horizontal to north-west at 10° to 20°. The upper surface is also visible in three places just above low-water mark, between Bull Point and Derginan. On the north coast, along Altachuile Bay the formation also occurs, thirty to forty feet of nearly flat beds being visible above the sea level. In the southern portion of the island, and along its west shore, the highest beds of the Chalk crop up a few feet above high-water level, and extend for half a mile or so from Porternin to Inandrian.

Like the same formation on the mainland the chalk of Rathlin contains parallel layers of flint.

Tertiary Volcanic Rocks.

Nearly the whole of the western part of the district under consideration is capped with great sheets of basalt, which generally speaking, incline at low angles to the south, and are separated into an upper and lower division by thick ochreous beds, the miners' terms for which are "pavement," "lithomarge," &c. Both the upper and lower divisions have peculiar characteristics, the former being usually massive, hard, and columnar, while the latter is amygdaloidal, scoriaceous, and vesicular, with thin bands of red earth (or bole) separating the different sheets. But this difference between the two divisions does not appear to hold good to the same degree in the remainder of the Co. Antrim.

Lower Basalt.—The best sections are met with along the cliffs from Portrush to Bushmills, as well as at the base of the almost inaccessible cliffs round Bengore Head and on Knocklayd Mountain, where the lower basalt is found capping the Chalk. In the cliff, a short distance east of Dunluce Castle, a characteristic section shows alternations of almost every variety of basalt except columnar, and similar sections are to be met with as far as the mouth of the Bush River, where a fault throws down the basalt in proximity to the Chalk. For the most part these basaltic sheets incline slightly to the south, with the exception of the beds east of Port Ballintrae, which incline to the S.W.; this is probably due to the fault which has been recognised at that locality.

Similar sheets are met with from Runkerry Point to Bengore Head. The mass of lower basalt on which Dunluce Castle is built is remarkable for the wonderful disintegration of the sheets into spheroids. The first impression made by this section is that the whole mass is an aggregate of volcanic bombs forming the neck of some old crater; but on closer observation the original bedding is indicated by thin bands of bole, which are somewhat regular and continuous. A similar mass of spheroidal basalt fills up the funnel-shaped cavity in the chalk at the White Rocks, but no bole bands occur. Leaving the coast, we find the lower basalt occupying the S.E. portion of Sheet 7, about Moss-side. Near Killen Vale House the Chalk is exposed; but the position of the boundary fault drawn on the map between the two divisions of the basaltic series is conjectural in consequence of the district having such a thick coating of bog and boulder Drift as to obscure the underlying rocks. The northern boundary of the lower basalt between Portrush and Ballycastle is very well defined. Not only are the bands of tuff, ochre, and sometimes iron-ore, exposed to view in the cliffs, but inland their presence has been proved by bore-holes driven through the upper columnar sheets into the lower basalt.

The thickness of the lower basalt along the northern coast of the County Antrim is not easily estimated, but we must assume that it is less than that in some of the southern parts of the county where the average thickness may be taken at 450 feet.

The whole of the area included in Londonderry, is underlaid by Lower Basalt, with the exception of the small portion in the east, which is occupied by members of the upper division. These rocks come extensively into view in the sections already referred to, on the coast between Portrush and the River Bann, where they form sheets sloping at low angles in various directions. The precipitous cliffs opposite Island Doo, with the rugged marginal floor of rock, expose to view alternate sheets of basalt and amygdaloid with occasional beds of bole. Sometimes a spheroidal structure is developed in the basalt, as may be seen in the weathered rock laid bare in the adjacent railway cuttings, and southward in the neighbourhood of Moss Side. At Rinagree Point there occurs in the cliff massive rudely columnar dolerite, also weathering spheroidally, and below it beds of bole and amygdaloid, which continue throughout the underlying rocks out

to the edge of the water. South-west of the same point massive fine dolerite rests on an irregular bed, about six feet thick, of amygdaloidal basalt merging into bole, and partly into yellowish bole and a dark coloured rock like lithomarge. Cavities in this bed contain calcareous nodular masses, up to four inches in diameter, some consisting of pure white granular carbonate of lime, together with aragonite. Other cavities are lined with minute crystals of calcite.

Black Rock is a rugged outlier composed of regularly jointed massive basalt underlying a soft rock allied in character to lithomarge. The promontory at Port Stewart consists of massive finely crystalline dolerite in distinct sheets, dipping at low angles towards the north-west, and on the west side overlying, for a depth of thirty feet, a bed of fine amygdaloid.

In a north and south escarpmemt running immediately east of the main street north of the church at Port Stewart, there occurs, at top, a thickness of twelve feet of massive basalt above fourteen feet of amygdaloid, the latter containing many large cavities lined with zeolites. This overlies hard red bole, which again appears along the shore to the west.

The basalt in the cliffs south of Port Stewart is, like that already described, arranged for the most part in clearly defined sheets, with beds of amygdaloid at intervals, and some of bole. The basalt itself sometimes contains, as at Low Rock Castle, strings and geodes composed of different kinds of zeolite; also a little aragonite and vesicles filled with calcite.

On the north bank of the River Bann, at a point S.S.W. of Carnalbanagh, where stone was quarried for the construction of the pier near Castlerock, very massive basalt, twenty feet thick, overlies a layer of red bole, containing small grains of red hematite.

Good sections of this division of the basalt are exposed to view in the steep sea-cliff faces between Ballycastle and Ballintoy, in which latter direction it thins out to not more than a hundred feet or so; while in the vicinity of Ballycastle, the mass cannot be less than 350 feet thick. It is of the usual tabular, spheroidal, and amygdaloidal variety; sometimes, but very rarely, rudely columnar, the several beds or flows being separated from each other by grey ash or tuff and red and brown bole beds. One of the ash beds in particular, is of considerable thickness and extends regularly from the old volcanic vent at Carrick-a-raide eastward, in the direction of Ballycastle, where it thins out altogether at Doon Point. It is of a grey colour and highly calcareous, being largely composed of chalk debris, also burnt chalk flints and basalt fragments. Close to Carrick-a-raide this ash bed is between seventy and eighty feet thick.

South and south-east of Fair Head there is an outlying area of the lower basalt overlying the Chalk, and forming the higher elevations of Carnanmore and Carneighbareigh Mountains. In this district the basalt is 300 feet in thickness.

To the west of Carrick-a-raide another thick bed of ash occurs, but its position is between the lower basalt and the Chalk,

This bed extends westward for about three miles from Carrick-a-raide—which is the site of the volcanic vent—to south of White Park Bay, where it thins out altogether. South of Ballintoy good sections of the ash may be seen in the streams, consisting of grey, red and brown material containing a large proportion of chalk debris and occasionally basalt fragments. In many respects it is similar to the bed east of Carrick-a-raide, so that there can be no doubt but that it is part of the same deposit, although not interbedded with the basalt. At Ballintoy this bed is between sixty and seventy feet thick, but thins out gradually towards the west.

Iron-ore deposits.—As before mentioned the division between the upper and lower basalt is marked by a considerable thickness of beds of tuff or ash, together with bole, lithomarge, and pisolitic iron-ore which always occur below the upper basalt. This ore consists of small grains of hematite, from the size of a pea to $\frac{1}{4}$ of an inch in diameter, cemented together by a red or purple ochreous paste. Underneath the ore bed, which varies in thickness up to fourteen inches, are found red and variegated clays, and decomposing ash, called "bole." Formerly, owing to great demand and high price, this ore was worked more extensively than it is at present; the only mine now working being at Ballycraig, two miles S.E. of Portrush. Trials have been made all along the outcrop of the ochre-beds extending from Portrush to Bengore Head, and in most of them ore has been found, but of a poor quality. Lately, however, rich deposits have been opened south of Dunluce Castle as well as to the north of Killygreen hamlet S.E. of Portrush. Around the Giant's Causeway and on to Bengore Head, the cliffs exhibit good sections of these deposits at different elevations, with an average thickness of about forty feet, the workable bed not being more than a few inches thick. Ochreous beds without the pisolitic ore, and of no economic value, have also been traced in the upper basalt, one of them nine feet thick being met with in the section at Bengore Head, about 237 feet above the ochre beds which form the boundary of the two basalts; similarly at Croaghmore Mountain, four miles east of Bushmills, there are beds of ochreous tuff high up in the upper basalt. To the S. of White Park Bay the pisolitic iron-ore is replaced by a thick aluminous clay called "bauxite," which has been worked extensively by the Eglinton Chemical Company; an analysis of this bauxite as well as some foreign bauxites is given in the Explanatory Memoir to accompany Sheet 20. Bauxite was also worked in the mine at Killygreen, but the works are now abandoned.

The outcrop of the lithomarge and pisolitic iron-ore deposits is very clearly traceable along the escarpment of the upper basalt from White Park Bay, and along by Ballintoy towards Ballycastle. The quality of the ore, however, was found so poor that it was never worked to any great extent. In the hill to the south of Ballintoy the ore bed has been replaced, over a considerable area, by a thick lignite deposit, about two feet in thickness, which was worked as coal some eighty years ago.

Upper Basalt.—Although most of the district is capped with sheets of upper basalt, the only good sections are to be

found in the almost inaccessible cliffs east and west of Bengore Head. Here they form successive tiers of columns varying in size and sometimes in position; and at others, though very rarely, separated by thin bands of red ochre or decomposed ash. These tiers indicate successive outflowings of lava. The most remarkable of them is the lowest of the series which caps the iron-ore deposits and forms the Giant's Causeway. This bed is first met with as we descend the path at the back of the Causeway Hotel, at an elevation of about 100 feet above the sea, and its wall is there in conjunction with a wall of tuff brought down by a small fault to the east; the sheet then inclines northwards and extends into the sea for about 210 yards, the latter portion forming the Causeway. In plan the surface of this great sheet presents a polygonal tesselated floor, formed by the ends of the columns of very compact basalt firmly packed together. These columns are intersected horizontally by concavo-convex joints, and their sides vary from four to nine in number, the larger proportion being six-sided. East of the Causeway the sheet rises in the cliff, and its section is seen at the "Organ," which consists of numerous vertical columns about forty feet high, and which, at a distance resemble the pipes of an organ. Further eastward this sheet can be traced as far as the Spaniard Rock, where the "Chimney Tops," isolated columns of the same sheet, stand out in bold relief high up on the edge of the cliff. (Fig. 2.) Eastward of the "Amphitheatre," the splendid section of Plaiskin and Benbane Head can only be properly seen from the sea; but as one descends the path at Portmoon, east of Bengore Head, we pass over the beds of the upper basalt, iron-ore deposits, and lower basalt.

To the S.E. of Portrush the upper basalt occupies high ground, and the inclination of the sheets toward the south is distinctly marked. Here, also, as at the Causeway, the lowest sheet of the upper basalt forms a very striking feature all around the high ground; the quarries at Craigahulliar and Crossreagh being remarkable for the uniformity and height of the columns; in the latter quarry the columnar basalt passes upwards into tabular basalt of a coarser texture, no junction between the two sheets being perceptible.

Associated with the upper basalt are beds of lignite, which have been extensively worked for fuel. At the Causeway, in a cliff above "the organ," a bed upwards of six feet was worked, and Professor Harkness alluding to it in his paper writes—

"The lignite retains its woody nature to a great extent, and exhibits sufficient of its original structure to admit of the determination of the forms of vegetables to which this substance owes its origin"*

Other authors make special mention of this bed.†

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* 26th Report British Association, p. 66. See Mr. Baily's note, p. 49

† J. Kelly, *sup. cit.*, p. 320. Portlock, "Geol. Londonderry, &c.," p. 147. Dubourdieu's Statistical Survey, Co. Antrim, p. 87. W. Gray, "Tenth Annual Rep. Belfast Field Club." J. S. Gardner, "Monog. of Eocene Flora," Palæontographical Society, vol. xxxviii., p. 81.

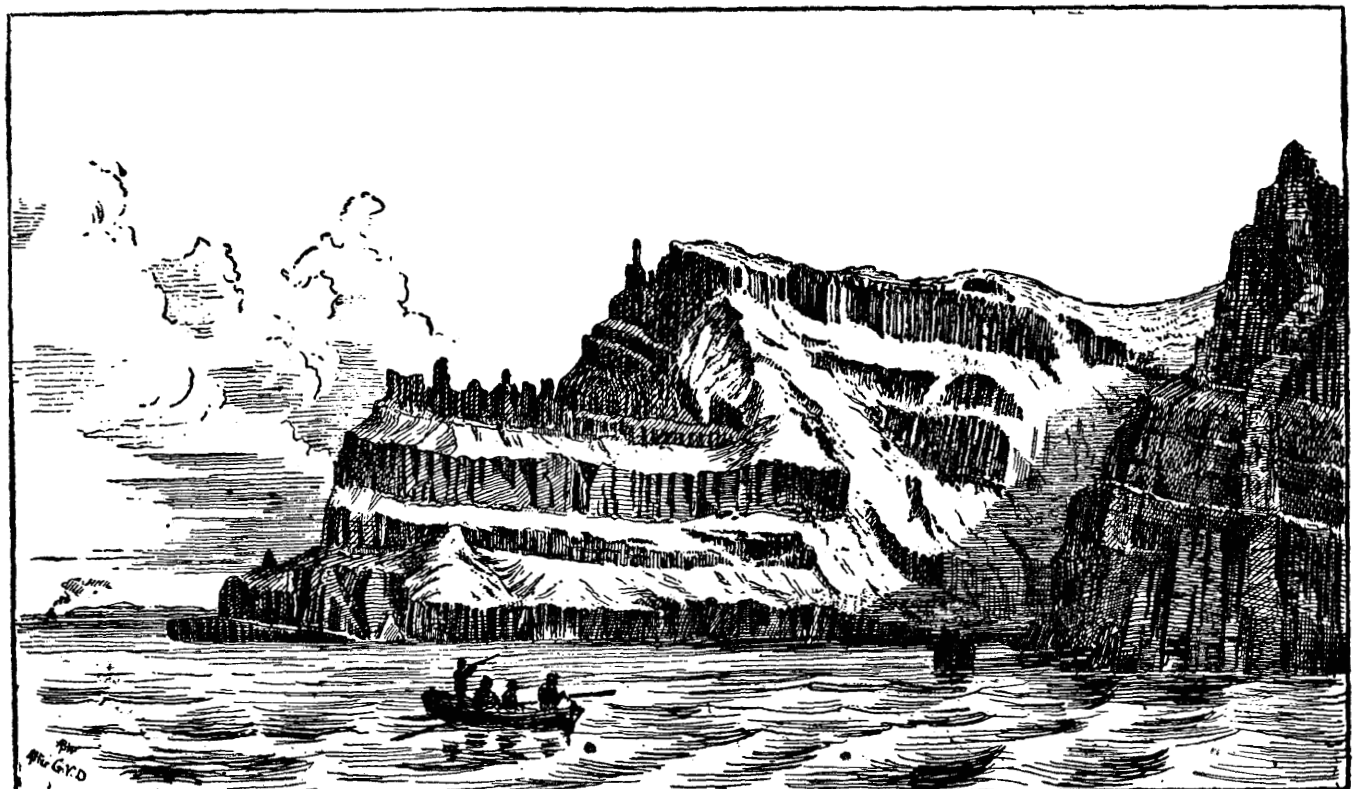

Fig. 1. View of the coast-cliffs forming part of "the Amphitheatre" near the Giant's Causeway, showing successive sheets of columnar basalt separated by bands of ochreous clay ("bole") and volcanic ash.

To the S. of White Park Bay, and above the bed of bauxite a lignite band, first brought into notice in 1750, was worked, the spoil bank of which may at present be seen.*

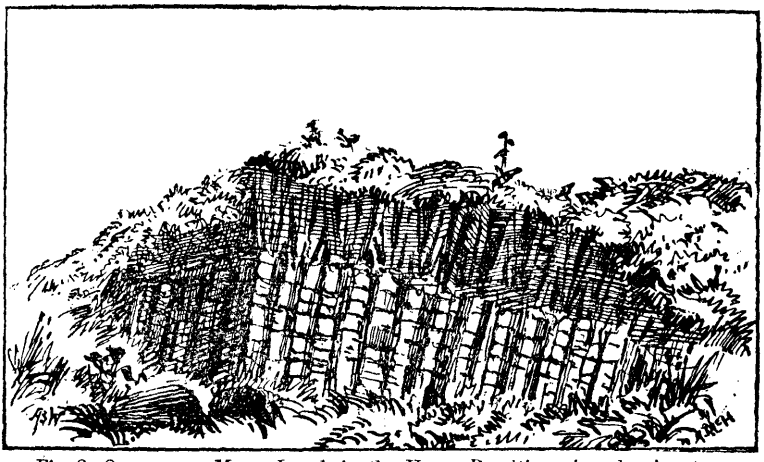

Fig. 2. Quarry near Magra Lough in the Upper Basaltic series, showing two varieties of columnar structure.

The upper division of the series to the north-west of Ballycastle and in the vicinity of Ballintoy is very distinct in character from the lower—being fine-grained and compact in texture, and invariably columnar. In these localities the columnar structure assumes two distinct forms—one having the regularly-polygonal structure, and the other a more irregular, and much smaller prismatic form. On the roadside, a little south-east of Glenstaghy, there is a quarry showing both varieties very distinctly. (See fig. 2.)

Rathlin Island.—The Tertiary volcanic rocks here are well represented, and present very much the same section as they do about Bengore Head on the mainland. The lower basalt consists of almost horizontal sheets of amygdaloidal basalt and anamesite, separated by thin beds of bole and decomposed basalt, and may be roughly estimated at about 300 feet thick, having on the top lithomarge, "pavement,"† and pisolitic iron-ore, over which are successive sheets of amygdaloidal and compact basalt of the upper series, sometimes columnar for a thickness of about eighty feet, and then another stratum of lithomarge and iron-ore. The best sections are seen from the sea, in the cliffs on the north side, from Bull Point to the Lighthouse. Towards the southern portion of the island the upper basalt occupies but a small area to the east of Ushet Lough, where it caps a rich deposit of black pisolitic iron-ore. The same deposit when exposed near Doon Point appears, in its decomposed state, in the escarpment, as a red friable mass of ochre. At Doon Point there occurs a causeway in the lower basalt,‡ and the longitudinal section shows vertically

* "On Geology of Co. Antrim, &c.," John Kelly, Trans. Roy. Irish Academy, Vol. X., part 3, p. 321.

† Pavement is the miners' term for the ochreous bed immediately beneath the pisolitic ore-band, and contains about 25 per cent. iron.

‡ Described and figured by Rev. Dr. Haughton in 1851. Journ. Geol. Soc., Dublin, Vol. V., p. 130, *et seq.*

columnar basalt, having fan-shaped and radiating columns of smaller dimensions blended into it from the top, showing that the two sheets amalgamated before cooling. Dr. Haughton notes of the rocks at Doon, as follows:—

"The curvature of some of the pillars is continuous through 90°, and they pass from the vertical to the horizontal position, exhibiting, however, a tendency to break at the point of greatest flexure, which has caused most of them to be broken off by the action of the sea."

The same observer also alludes to a bed of lignite, six to ten inches thick, between two thick beds of columnar basalt, in the cliff on the N. side of the island.

Mr. M'Henry notes in the north of the island a second and distinct iron-ore bed, thirty to forty feet above the regular deposit. It is a black, ashy, and pisolitic bed, from six inches to a foot in thickness, and is interposed between spheroidal and amygdaloidal flows of trap, occurring at Slieveanaille and Skerriagh.

Dykes and Intrusive Sheets.—Besides the Tertiary sheets of basalt there occur in this district others of intrusive origin, and of uncertain age, in contact with Carboniferous, Liassic, and Cretaceous strata. The most remarkable of these are the dolerites that were irrupted into the Lias shales of the Skerries and Portrush, and the great sheet which caps the Cretaceous and Carboniferous rocks at Fair Head. The dolerite of the Skerries is identical in character with that of Portrush, being highly crystalline, and having a large proportion of olivine, which weathers rapidly, leaving the rock honeycombed, and of a reddish brown colour.*

Mr. Griffith,† writing of this rock, infers that there are reasonable grounds for supposing it either to be of prior origin to the trap of the mainland, or that it is a projection from some great dyke which has intruded itself into the Liassic strata. He also notices that the "greenstone" (dolerite) changes materially when in contact with the flinty slate (*i.e.*, the Lias shales), and from very coarse-grained, crystalline, becomes comparatively fine-grained and compact, and in some places almost assumes the appearance of an homogenous rock. The dolerite of Fair Head is probably of the same age as that at Portrush, but does not weather so rapidly; in both are veins of segregation of highly crystalline augite and felspar, along lines parallel to the inclination of the sheets passing gradually into the surrounding mass. The Fair Head sheet is remarkable for its enormous thickness, presenting as it does an unbroken columnar face to the sea, near the "Grey Man's Path" of 250 feet. Landwards it thins out, and its surface is deeply eroded by ice-action. In the dolerite at the Salmon House, Portrush, there are numerous subordinate tongues of basalt running vertically through the mass, and near the Bath House veins of fibrous mesotype and crystals of calcite were noted.

At the base of the basaltic cliff at Fair Head an intrusive sheet of columnar basalt seventy feet thick occurs, and in its ex-

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* See p. 40 for description by Dr. Hatch.

† Quoted by Portlock, Report, *loc. cit.*, p. 43.

tension it is met with at Drumnakill Point to the south, where the columns are scattered in all directions.

S.E. of Portrush, between Cloughorr and the main road, the outcrop of a highly crystalline dolerite is seen in close proximity to decomposed amygdaloidal basalt, but its area is very limited in comparison with that of the other sheets.

Dykes are numerous on the coast line between Port Ballintrae and Bengore Head, also on the shore line east of Ballycastle. A careful account of the dykes on the North coast of Antrim has been drawn up by Dr. Richardson in Dubourdieu's Statistical Survey of the Co. Antrim. A dyke was measured at the Causeway twenty feet thick; one at Port-na-Spania, twelve feet; the two dykes dividing the Causeway into the Grand, Middle, and Little Causeways are eight and fifteen feet wide; and a dyke at the west end of White Rocks one and a half inches. In proportion to the width of the dykes the greater is the tendency to columnar structure which is always at right angles to the walls of the dyke.

Nearly all the dykes in this district run in a N. and S. direction,

Dr. Haughton in his paper* endeavours to prove a relation between the dykes on the Ballycastle shore and those in Rathlin Island, and cites the following bearings:—

Carrickmore dyke	. .	N. 10° E.
Pollard „	. . .	N. 15° W.
West Mine „	. .	N. 10° W.
North Star „	. .	N. 5 W.

which, if extended, would penetrate Rathlin.

Dr. Berger in writing of the dykes E. of Ballycastle, notes that the North Star dyke is twenty-four feet wide, and reduces the coal to cinders nine feet on either side of the dyke. The Salt Pans dyke is twenty-four feet, and the Carrickmore twelve feet.†

A remarkable dyke occurs on the roadside a mile E. of Dunluce Castle, and consists of the blending of two dykes into one, some fifty feet in united thickness. In the lower portion the columns are very perfect, while the upper has an irregular columnar and wavy structure.

The only dyke having an E. and W. bearing is the Great Gaw, E. of Ballycastle. It is of unusual thickness, being about thirty feet thick near the Salt Pans; and although the outcrop is not met with on the high ground E. of this spot, it was struck several times in driving adits in the various collieries, and Capt. James failed to pierce it in the North Star Colliery.

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* Dub. Geo. Soc. Jour., Vol. V., p. 132.
† Trans. Geo. Soc., Lond., Vol. III., p. 228.

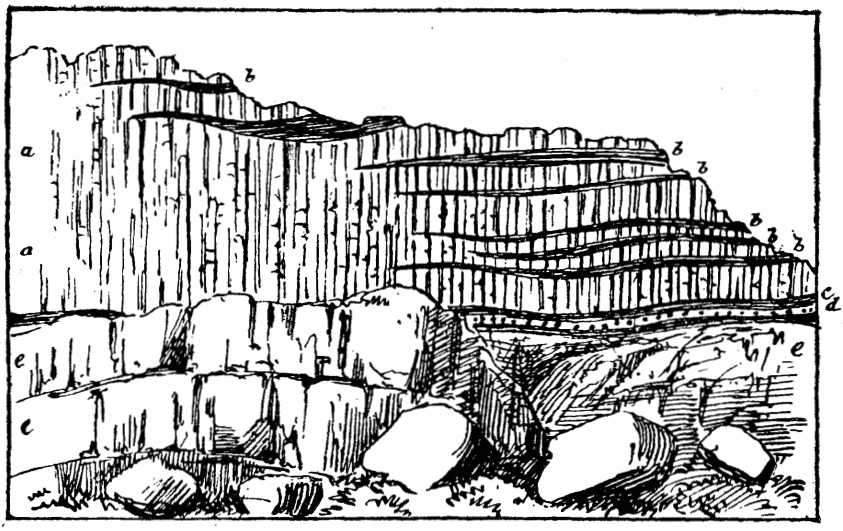

Fig. 3. Cliff of columnar dolerite, off Fair Head; dolerite protruding into Lower Carboniferous strata.
a, *a*, Massive dolerite; *b*, dark indurated Carboniferous shales; *c*, olive shale; *d*, grit-bed; *e*, *e*, thick-bedded grey sandstone.

On the south-west side of Fair Head the cliff face immediately under Doon shows a fine section of the massive Fair Head rock intruding horizontally amongst the coal-measures, which

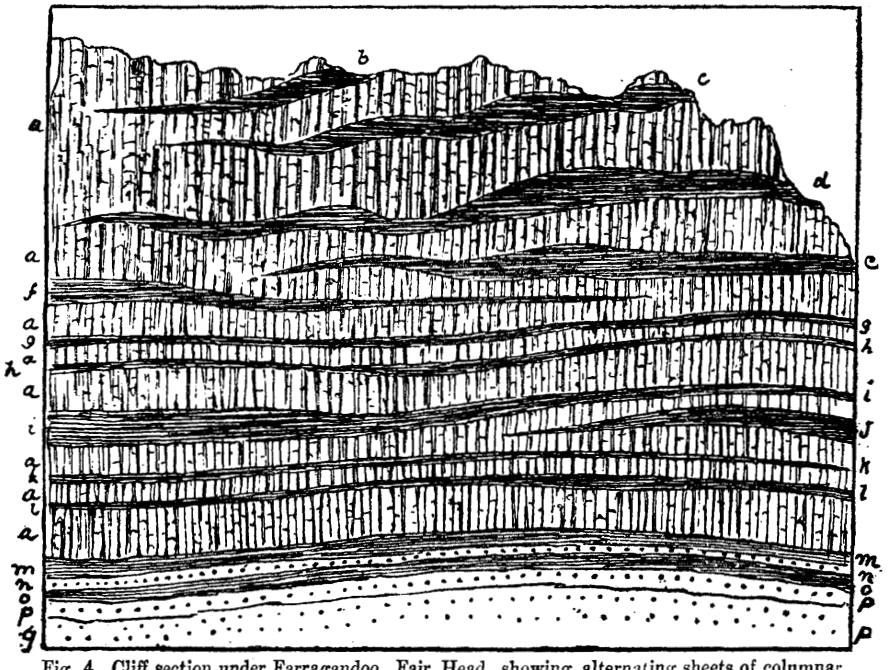

Fig. 4. Cliff section under Farragandoo, Fair Head, showing alternating sheets of columnar dolerite intruded into Carboniferous strata.
a, *a*, &c., Dolerite and basalt; *b*, *c*, *d*, *e*, &c., shales; *n*, *p*, *q*, sandstones.

it highly indurates (see figs. 3 & 4). To the east of the headland a large sheet, seventy feet thick, offshoots from the main trap a little to the west of the Grey Man's Path, and runs regularly, and almost horizontally, along the bedding of the coal shales to Murlough Bay, where it appears to end off abruptly against one of the north-east colliery faults.

Several minor and parallel dykes are also to be seen in the sections below the Grey Man's Path.

Mr. Symes regards the dolerite of Fair Head as possibly the latest volcanic protrusion in the Co. Antrim. A little to the east of the village of Ballintoy, is an intrusive dolerite mass from which paving setts are being manufactured by the Eglinton Company. This rock is more compact than the Fair Head trap, but is possibly contemporaneous with it.*

Sheep Island and Stackaboy are also formed of similar intrusive basalts, as well as the boss on which the coastguard house is erected, close to Ballintoy Harbour.

On the north-west side of Portnakillew, a mass of black compact basalt, 500 feet across, has carried up the Lias and Chalk on its upper surface above 100 feet or so from its original position. All those intrusive masses have a more or less rudely columnar structure.

Basalt dykes occur numerously along the coast between White Park Bay and Ballycastle, varying in thickness from one to thirty feet. In the vicinity of Kinbane Head the larger dykes are more frequent.

Volcanic Vents.—One of the most remarkable volcanic vents in the Co. Antrim is situated at the well known island of Carrick-a-raide and the adjacent coast, a fine view of which can be had from the celebrated "Swinging Bridge." This old neck cannot be less than ten to twelve hundred feet in diameter, and is filled up with massive coarse and tough greyish volcanic agglomerate, enclosing large irregular masses and smaller fragments of basalt, basalt bombs of all sizes, and chalk pieces occasionally.

Numerous veins and irregular dykes of compact black basalt penetrate the ash in all directions, some of them being columnar in structure. East and west from this large vent proceed the thick ash-beds already described.

VII.—Pre-Triassic Igneous Rocks.

Diorite.—At Ruebane Point, on the east side of Murlough Bay, three almost parallel dykes of brown and reddish diorite, varying in thickness from one to eight feet, are seen penetrating the schistose beds. The same rock is again visible in Greenanmore Hill, a little to the south, and intrusive through the older rocks.

At this place the eroded surface of the diorite exhibits fissures filled with the material of the basal Cretaceous bed enclosing fragments of the diorite.† (See fig. 5.)

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* See p. 39 for description of the Ballintoy dolerite by F. W. Rudler.

† See Trans. Geol. Society, Second Series, Vol. V., page 179.

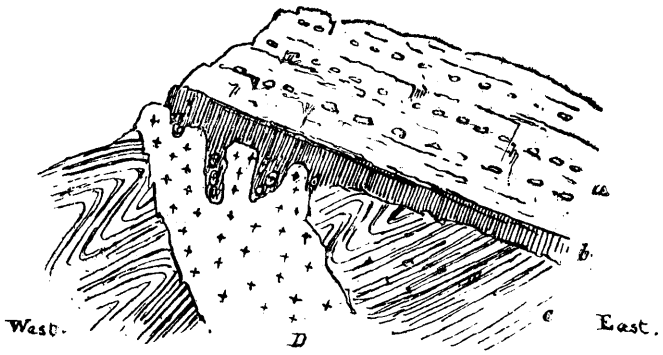

Fig. 5. Section on S. side of Greenanmore Hill, Murlough Bay.
a, Chalk with flint-layers; *b*, basal-bed of Cretaceous series; *c*, metamorphic rocks; *D*, diorite dyke.

Quartziferous Porphyry.—Several dykes of this rock are to be met with intruding through the metamorphic rocks in the eastern portion of the district, notably west and south of Runabay Head. It is reddish in colour, highly felspathic, and contains large crystals of red orthoclase, also smaller crystals of transparent and white plagioclase, quartz blebs, and mica (black, bronze, and white).

Felstone.—But one example of felstone was noticed in the whole area. It occurs as a dyke four feet wide, penetrating the older schist rocks in a branch of the Carey River, a mile E. of Torteige, and is dark-blue in colour and compact in texture.

Post Pliocene.

Boulder Clay.—The Drift accumulations are divisable into boulder clay, sand and gravel. The boulder-clay throughout the district is composed chiefly of striated blocks of basalt in ochreous clay. Near the sea there is seldom any accumulation of Drift; but, inland, along the valleys of the Bush and Carey Rivers, there occurs a thick coating of boulder-clay containing blocks of basalt and chalk. Sections are seldom seen; but about three miles S.E. of Ballycastle, the Carey River cuts through a thick bank of boulder clay resting on mica-schist. Here large angular blocks of chalk are more abundant than those of basalt or of schistose rocks, yet the nearest chalk out-crop is two miles distant.

A section on the north bank of the River Bann, south-west of Carnalbanagh, shows boulder-clay overlying the basalt for a depth of fifteen feet. This deposit exhibits, more or less clearly, traces of a bedded structure in the arrangement of its gravelly constituents. It also contains unimportant seams and lenticular beds of comparatively pure clay, free from stones, marked with brown laminæ of various shades. For an average depth of eight feet from the top the general mass consists of brown stiff clay, in which, besides the gravel, are contained many large blocks of basalt, and occasionally chalk, some of them being angular,

others rounded or glaciated. This passes below into a more compact bluish clay, with numerous chips of chalk and flint, and enclosing sandy seams near its base. The pebbles of the gravel throughout consist chiefly of basalt, with others of quartz, a few of clay-ironstone, and occasionally mica-schist.

Several of the railway cuttings pass through boulder-clay, exhibiting sections up to about fourteen feet deep, but they are of no special importance.

Sand and Gravel.—Generally speaking, the boulder-clay is capped by stratified sand and gravel, and good sections of the latter are to be seen in the valley of the Bush, S. of Bushmills; also in the railway cutting near Ballycastle, and in the very conspicuous terraces in the Carey River, E. of Ballycastle. In Ballylough townland, which is S. of Bushmills, all the high ground is composed of stratified sand and gravel, the stratification being very irregular; the oblique lamination being well seen in the sands; the gravels are generally of a light bluish-grey colour; they contain a large proportion of chalk and flint pebbles, and are devoid of any intermixture of clay. All the pebbles have a mineralized gloss on them, and some of the chalk have dendritic markings.

The railway section, close to Ballycastle, shows about thirty feet of sand and gravel, the former being composed of minute particles of basalt, while the gravel is made up of pebbles and blocks of chalk, flint, basalt, and metamorphic rocks, some of them being four inches in diameter. In the Carey River section the first terrace on the boulder clay is about 250 feet above the sea, and from that up to 600 feet there are several terraces; the gravel is mostly composed of mica-schist, chalk, and flints in small chips. The beds of gravel of the Carey River are overlaid by an upper boulder-clay deposit.

Erratics.—These are frequent, especially in the country to the west and south-west of Fair Head, the blocks of the Fair Head trap being very hard and easily recognized. On Rathlin Island which is composed only of basalt and chalk, erratics are very numerous, and are chiefly formed of gneiss and schist. Two of the most remarkable are called, "Macateery or the Two Wolves." They consist of mica schist, much weathered, and oscillate under great pressure; the basalt floor on which they rest retains the most delicately traced glacial striations. These erratics appear to have come from the Mull of Cantyre, a view confirmed by the direction of the glacial striæ which point E. and W.

Lower boulder clay is very generally distributed over the south-east portion of the district. In the low ground it sometimes attains considerable thickness, particularly in the valleys south of Torr and Green Hill. In the Carey River valley, near Torteige, immense boulders of Fair Head trap are to be seen imbedded in it, some measuring up to 1,600 cubic feet. In the same valley, as well as in Glenmakeeran and Glenshesk, thick accumulations of stratified sand and gravel are found resting on the boulder drift. Fragments of marine shells, of existing species, have been found in the gravels in the neighbourhood of Calhame.

CHAPTER III.

Recent Accumulations.

Ochre deposited from Spa Wells.—Water strongly charged with iron, and depositing a large quantity of reddish brown ochre, issues from a perennial well in the flat ground west of the road, at about half a mile north of Ballysally. It appears also at other places in the same area, and again in the flat south of Dundooan House. Spa water occurs in drains at the eastern extremity of the sand-hills north of the River Bann. These waters, no doubt, derive the iron from ferriferous beds which occur higher up in the basalt.

Peat bogs and alluvial flats.—A deposit of peat projects from beneath the blown sand, and follows the slope of the strand for a short distance seaward, at the point where the county boundary terminates a little south of Portrush. It is partly covered at high water, during which, in rough weather, masses of it are torn away and carried out to sea. This deposit occurs in layers, some of which are composed of pure compact peat, while the greater part is of a flaky texture, and is more or less mixed with sand. There are also contained in it occasional thin layers of brown ferruginous sand. The peat contains hazel nuts, portions of small branches, leaves, and the elytra of beetles. The presence of this peat within range of the sea action may indicate a subsidence of the land within very recent times. Similar instances are to be observed at various points of the Irish coast.

Mountain Bog.—The high ground in the eastern portion of the district is invariably covered by extensive and thick peat bogs, which extend also over the hill tops in unbroken sheets. Between Ballycastle and Ballintoy deep accumulations of it also exist on the upper basalt sheets.

Alluvium.—Limited deposits of alluvium occur along the Carey and Glenshesk Rivers, south and east of Ballycastle, as well as by the sides of the other streams. They consist of beds of gravel, clay, and loam.

Raised Beaches occur at Portrush, Port Ballintrae, Rathlin Island, and the Giant's Causeway. The Portrush beach was first noticed by Mr. James Smith of Jordan Hill; it contains a great variety of shells. This observer, alluding to it,* says, "this shelly deposit seems to have been a sheltered bay into which the shells have been drifted with a small admixture of land shells washed down by floods; none of the bivalves have both valves together, but they have been but little injured by the sea. I never met with such a variety in so small a space either in recent or ancient beds." Professor Hull has recognized the raised beaches of county Antrim as the representatives of the "20-feet beach" of the opposite coast of Scotland.†

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* See Portlock's Report, p. 163.

† "Phys. Geography and Geology of Ireland," p. 107.

The shores of White Park Bay and coast line north-west of Ballintoy exhibit examples of the raised beaches and their associated old sea caves and sea stacks. (See fig. 7). A detailed description of the caves and of the bones, &c., that were found in them, is contained in the British Association Report for 1834.*

The inner margin of the raised beach north of the Bann River would be indicated by a slightly curved line drawn from the edge of the flat west of Carnalbanagh, through the sandhills, to the Spa Well south of Low Rock House. This is not shown on the map, however, as the original surface is wholly concealed below the accumulated sand. A section in this beach is referred to by Portlock, thus:—"In Dunboe parish, on the boundary of Grange (More and Beg), is a bed of blue silt, full of recent shells, *Mytilus*, *Turbo*, &c., in the banks of the stream, covered by seven feet of fine sand (rabbit warren), the clay itself being two feet six inches thick, and also resting on fine sand." This section is still to be seen, and the blue shelly silt has been dug up in different places in the vicinity, on both sides of the river.

A narrow portion of the raised beach appears to underlie the village of Portstewart, extending eastward from the vicinity of the castle to a point near the church; thence northward along the road as far as Blackcastle Rock, where it again bends eastward, cutting through the promontory of Portstewart Point, which is thus seen to have at one time formed an island. Eastward from this the inner edge closely follows the road as far as the little bay south-east of Black Rock. Here and at the village the raised beach is to some extent covered over by blown sand, below which occurs blue shelly silt with coarse sand. Its level, as indicated by these remains, is about six to seven feet above ordnance datum.

Pre-historic remains have been found in abundance on the raised beach platform of White Park Bay, consisting of worked flints, stone hammers, corn crushers, fire hearths, pottery, &c., and the bones of various animals; also "kitchen middens" of shells and ashes.

Caverns.—The Chalk at the White Rocks is penetrated by numerous caves at different elevations, but none of them extending any great distance. Under Dunluce Castle a cave runs through the entire rock; this is probably artificial, and could easily have been excavated, owing to the spheroidal nature of the rock. At the Giant's Causeway are two caves in the lower basalt at the sea level, and in Rathlin Island four have been noted by Mr. Andrews, the length varying from 150 to 250 feet.

Blown Sand.—A considerable extent of the coast line is occupied by sand hills, ever changing in their external features, and especially during prevalent north westerly gales. At Portrush the dunes extend for two miles along the shore to the east, and for some distance inland; at the mouth of the Bush about a mile;†

* Fourth Report Britt. Association (1834), pp. 658 and 660.

† Recent excavations in these sand-hills for the Electric Tramway prove that the blown sand rests on a considerable thickness of sand and gravel similar to that near Ballinlough.

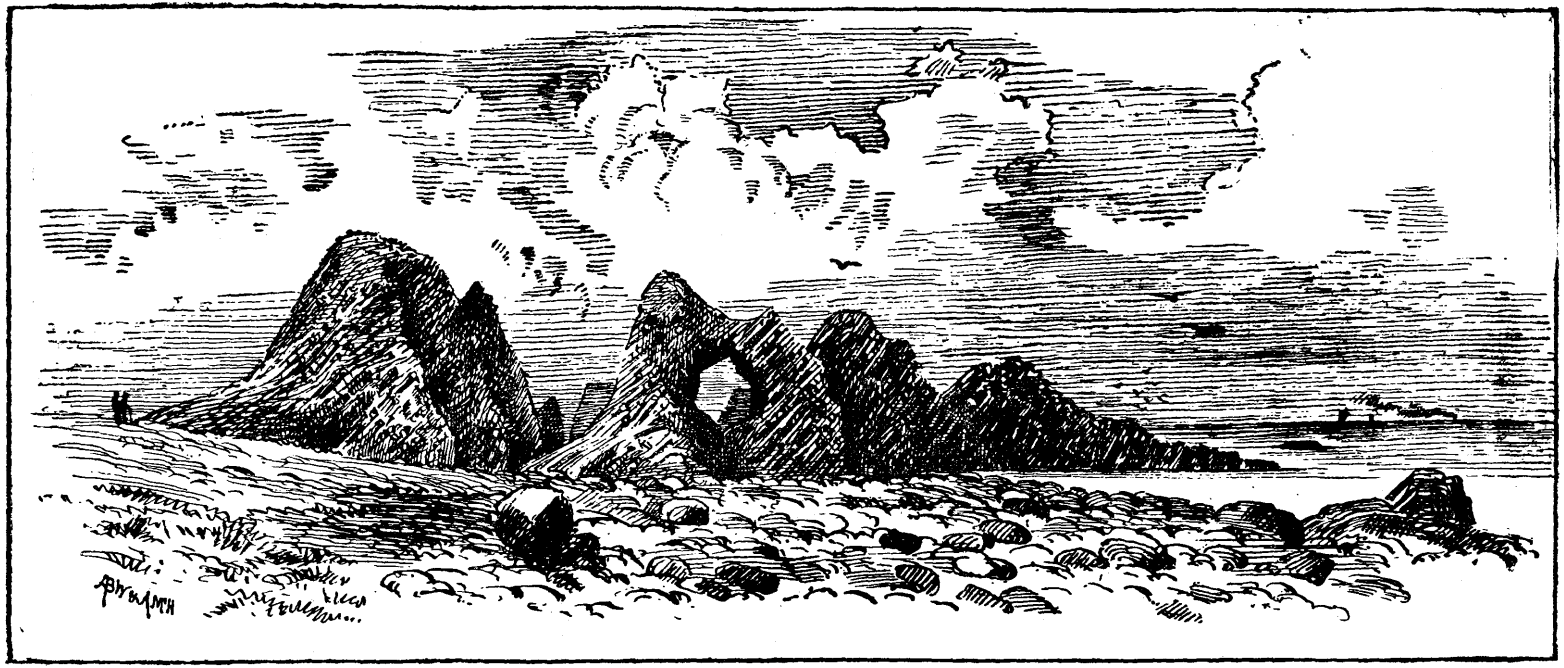


Fig. 6.—Sea-stacks and caves in basalt along raised coast at Dunshamrir near Ballintoy.

at White Park Bay for two miles; and at Ballycastle for about half a mile; the width, generally speaking, being proportional to the length—the greater the length the greater the width. Among the sand hills, in the town of Portrush, a gale recently exposed a pre-historic hearth in which were pieces of pottery, numerous flakes and cores of flint, and a few bones. The flakes are remarkable for their freshness; wherever else found the majority of them are porcelainized or weathered.

The blown sand, besides forming dunes, as already mentioned, lies more evenly over the Drift or basalt for various distances in from the coast between Dooey and Black Rock. Remains of ancient pottery, worked flints, bones, glass beads, brass ornaments, &c., have from time to time been dug out from amongst the sand-hills north of the River Bann.

CHAPTER IV.

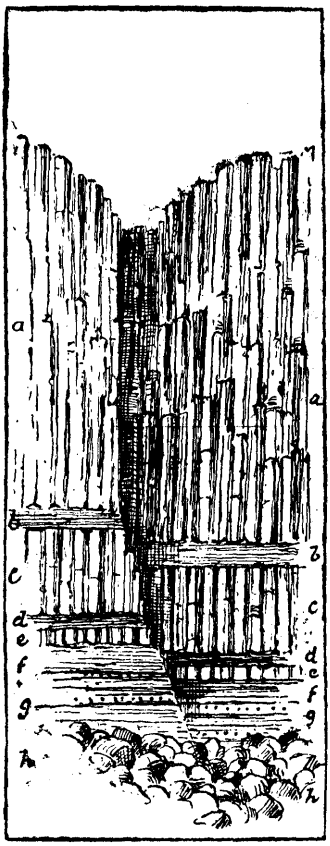
I.—Principal Faults.

The largest fault in the district is that which traverses the valley S.W. of Ballycastle, and throws down the basalts and Chalk on the N.W., a measured distance of 700 feet: the Chalk in Ballycastle being about seventy-five feet above the level of the sea, while on Knoklayd Mountain, a distance of one and a half miles, it is almost horizontal, and is 775 feet above the sea. A fault branching from this one, and running in a W.S.W. direction for a long distance, accounts for the relative positions of the two basaltic series, both in this district and that to the south in Sheet 13; and another almost parallel to that last mentioned is visible, extending from White Park Bay on the E. to the mouth of the Bush river on the W., throwing down on the north a great, but unknown, thickness of upper and lower basalt against the Cretaceous beds on the south.

Numerous small faults or slips occur along the outcrop of the pisolitic ore bed, and this was especially noted on Rathlin Island, where there are a number of N. and S. faults disturbing the strata, and distinctly visible in the cliff sections. In the Ballycastle Colliery district there are numerous small faults, but these have been already alluded to (*ante* p. 14) as separating the entire coal-field into distinct "collieries or sections."

A number of small faults are to be observed along the coast line, and adjacent to it, between Ballycastle and White Park Bay, and also between Murlough Bay and Runabay Head. None of them, however, are of much importance, as they do not materially affect the position of the strata.

The celebrated Grey Man's Path, which leads from the top of Fair Head down to the sea, is formed along a line of fault which dislocates both the coal-measures and the overlying trap, and throws the beds down on the west side twenty feet. (Fig. 7.)



a. Main trap of Fair Head, columnar, ... 250 feet high.
b. Black shale of coal measures, ... 10 to 15 ,, thick.
c. Rude columnar trap bed, ... 70 ,, ,,
d. Brown and grey coal measure shale, . . . 3 ,, ,,
e. ,, rotten trap bed, ... 3 to 4 ,, ,,
f. Black and grey shales, ... 6 ,, ,,
g. Olive and brown grits and shale over red and brown sandstone.
h. Slope of Basalt boulders.

Fig. 7.—Fault in cliff at the "Grey Man's Path," Fair Head.

II.—Glaciation.

Glaciation:—Of the glacial striæ which occur so plentifully in the south-west of the Sheet 7, the greater number follow a N.N.E. and S.S.W. direction. In those places in which the rock projects above the surface in rounded bosses, as, for example, on the highly glaciated hill at Ballygelagh and Craigtown, the course of the ice seems to have been from the N.N.E.

There is also a second set of striæ which, in the localities south of Port Stewart, point E.S.E. and W.N.W., and farther east approach more nearly to N.N.W. and S.S.E. The two distinct sets were seen together on the very smooth artificially stripped surface of the basalt above the quarry S.S.W. of Carnalbanagh. Where the markings were observed to cross each other, it appeared tolerably clear in some cases that those coming from the N.N.E. were of the more recent date.

Six-inch Map.	Townland.	Position.	Striæ.
Antrim.	Ballygill, Middle,	At cross roads,	N. 10° E. N. 27° W.
„	Do.,	West of hamlet,	E. and W.
„	Ballynagard,	On extreme west of townland,	N. 45° E.
„	Craigmacagan,	Under "the Two Wolves,"	E. and W.
„	Carravinally,	N.W. of Ushet Lough,	E. and W.
„	Bushfoot,	Sea shore,	N. 25° W.
„	Ballynastraid,	In roadway,	N. 10° E.
„	Lemanaghmore,	S. of Low Carn hamlet,	N. 27° W.
„	Cross,	E. of Lough na Crannagh,	N. 60° to 70° E.
„	Craig,	S. of Turfahan hamlet,	N. and S.
„	Billy,	East of Glebe,	N. 27° W.
„	Ballyrock, Scotch,	Between the bog and road,	N. 27° W.
„	Kebble,	Under boulder drift, top of cliff, Bull Point, Rathlin Island,	W.N.W.
„	Knockans,	Near edge of cliffs, north coast of Rathlin Island,	N. 30° W.
„	Drumacullin,	N.E. of Glenshesk Bridge,	S.W.

NOTE on the BALLINTOY DOLERITE, by Mr. F. W. RUDLER, F.G.S.

C. 76. *Olivine-Dolerite from Ballintoy.*

This is a dark bluish-black slightly mottled rock, of rather coarse-grained texture, with porphyritic crystals of felspar and vitreous grains of dark bottle-green olivine. A thin section shows the felspar in crowds of lath-shaped crystals, mostly binary twins, penetrating the augite and giving a well-marked ophitic structure to the rock. There are a few larger crystals of plagioclase, with polysynthetic twining, measuring in some cases upwards of a millimetre in length and about 0·12 mm. in breadth. The extinction-angles of adjacent lamellæ in relation to the plane of twining are on an average about 30°, suggesting a basic felspar approaching to anorthite.

The pyroxene occurs in broad crystalline masses, much broken into by the felspars, and traversed by well-marked cleavage planes and irregular fissures. It presents, in thin sections, a pale brown colour, with very feeble dichroism. Olivine is abundant, principally in large crystals, some of which reach a size of 2·5 mm. × 1·2 mm. It is almost colourless in thin sections, and on the whole remarkably fresh, though a tendency to serpentinization is evident along the irregular cleavage cracks. The olivine also occurs in small crystalline grains, from 0·04 mm. to 0·2 mm. in diameter. An opaque black iron-ore, presumably magnetite, occurs in crystalline plates, some of the rectangular sections measuring as much as 0·4 mm. in the side. There are also opaque grains, probably of magnetite, embedded in the olivine, especially along the lines of fissure. Brown iron-ore is sparingly present, as a product of alteration of the magnetite, and the slide carries some patches of serpentinous matter. Apatite is present, but not abundant.

The rock is a typical ophitic dolerite, quite holocrystalline, no trace of interstitial matter being present in the section under examination. The boldly crystalline structure of the rock suggests that the magma must have been subjected to very slow cooling. It is evident that of the principal constituents the olivine must have been the first to crystallize, inasmuch as it is not penetrated by any other mineral, save the included

grains of magnetite. The felspars must have crystallized after the olivine and before the augite, for they are always seen to accommodate themselves to the contours of the olivine, while they boldly intrude into the areas occupied by the pyroxene. The augite must have been the last mineral to consolidate, since it everywhere conforms to the outlines of the pre-existing crystals, and fills up the intervening spaces.

NOTES on the MICROSCOPIC STRUCTURE of some specimens from the District, by Dr. F. H. HATCH.

Dolerite (Diabase).

Intrusive in Lias: Portrush, County Antrim.

This section consists mainly of continuous plates of augite which are penetrated by a few lath-shaped crystals of plagioclase, producing the so-called ophitic structure. The augite is perfectly fresh, and of a pale brown colour, with a slight tinge of green.

Magnetite in isolated crystalline grains.

Typical Olivine Dolerite (Olivine Diabase).

Portrush, co. Antrim.

Ophitic plates of fresh augite, penetrated by needles of plagioclase felspar. Numerous grains of olivine, beginning to alter to serpentine along the cleavage cracks, but otherwise quite fresh. A few grains of magnetite. Isolated patches of serpentinous matter derived from the alteration of the olivine.

Here and there, wedged in between the crystalline grains, are small portions of interstitial glassy base which have been devitrified, and, in some cases, changed into masses of fine interwoven fibres.

1369. Dolerite (Diabase). Portrush.

Coarse-grained rock, consisting in section of plates of augite, penetrated by lath-shaped crystals of plagioclase felspar, showing well-marked twin striation. Olivine is not present. Magnetite in grains of moderate dimensions. A cavity in the rock is filled with zeolitic alteration products, a portion of which possesses a fibrous radiating structure, probably mesotype (natrolite).

1379. Fine-grained Olivine-dolerite (Diabase). Ballygally Head, Antrim.

Ophitic plates of augite, showing optic continuity over considerable areas, and penetrated by needles of plagioclase.

The olivine grains are much altered to serpentine, which has also been carried to other portions of the rock mass, and has given rise to green-coloured patches wedged in between the felspar needles. These patches probably consisted originally of interstitial glassy base.

1380. Intrusive medium-grained Olivine-dolerite (Diabase). Portrush.

Consisting of ophitic augite, lath-shaped plagioclase crystals, showing twin striation, fresh olivine, and a little magnetite.

1373. Fine-grained Basalt. Portmoon.

Confused aggregate of microlites of plagioclase felspar, minute granules of augite and some magnetite, together with some interstitial devitrified glass, often stained with serpentinous decomposition products.

Apparently, there is no fresh olivine; certain semi-opaque grains of a blood-red colour, however, are probably the residual products of alteration of this mineral.

Cavities in the rock are lined with serpentine or fibrous calcedony.

Geological Survey Office, London,
April 27, 1887.

CHAPTER V.

Palæontological Notes to Sheets 7 and 8.

Localities from which Fossils were collected.

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation and Geological Formation.
			Sheet 8.
		Co. of Antrim.	Lower Carboniferous.
1	5/3	Broughanlea, .	A little east of Bath Lodge, on shore, one and a half miles north-east of Ballycastle; pinkish and grey sandstone.
2	5/3	Do., . .	Rocks on shore and road, a quarter mile east of Bath Lodge, and one and a half miles north-east of Ballycastle; dark grey shales.
3	5/3	Do., . .	On shore road, a little east of Bath Lodge, one and a quarter miles north-east of Ballycastle; dark grey shales.
4	5/3	Tornaroan, . .	On shore a little west of North Star Dyke, nearly two miles east-north-east of Ballycastle; grey shales.
5	5/3	Ballyvoy, . .	Bands of limestone in cliffs over shore road, about half a mile south-west of Carrickmore, and two and a half miles north-east of Ballycastle; light grey limestone.
6	5/3	Barnish, . .	Bands of limestone in cliff, a little west of Pier at Colliery Bay, two miles east-north-east of Ballycastle; light grey limestone.
7	5/4	Ballyreagh, Upper,	Rocks in stream, south-east of Carrickmore, nearly three miles east-north-east of Ballycastle; light grey limestone.
8	5/4	Cross, . . .	Shales on shore under Fair head, about a quarter of a mile north-east of Carrickmore, three miles north-east of Ballycastle; dark grey shale.
9	5/4	Do., . . .	Rocks face of cliff (Fair Head), about 400 feet above sea level; yellow ochreous sandstone.
10	5/4	Do., . . .	East side of Fair Head, about a quarter of a mile west of Portdoo, 500 feet over sea level; red shales.
11	5/4	Big House, . .	Rocks on face of hill, a little east of Islandoo, Murlough Bay, five miles east of Ballycastle, Coal measures; black and grey shales.
12	5/4	Cross, . . .	Face of cliff, western side of Fair Head, a little east of Carrickmore; dark shales.
13	9/1	Drumeeny, . .	Small quarry on bank of stream, crossing old road from Ballycastle to Glenshesk Bridge, about one and a half miles south of Ballycastle quay; grey micaceous sandstone.
			Sheet 7.
			Jurassic—Lower Lias.
14	2/3	Portrush, . .	Rocks on shore under Bath Terrace, Portrush; indurated dark grey shale.
15	2/3	Do., . . .	A little north of Baths, Portrush; indurated dark grey shale.
16	2/3	Do., . . .	Rocks on shore at Blue Pool, Portrush; indurated dark grey shale.
17	2/4	Skerries, . .	Rocks on large Skerries Island, about one and a half miles north-east of Portrush; indurated dark grey shale.
18	4/1–3	White Park, . .	Rocks in small stream at White Park Bay, one and a half miles east of village of Ballintoy; bluish grey clay.
19	4/3	Do., . . .	Pebbles cast up on shore of White Park Bay; light grey fossiliferous limestone.

Palæontological Notes to Sheets 7 and 8.

Localities from which Fossils were collected—*continued.*

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation and Geological Formation.
		Co. of Antrim.	Sheet 8.
20	4/4	Cregganboy, . .	At Planting, a little south-east of Kinbane Head, three miles north-west of Ballycastle; dark grey micaceous shale.
			Upper Cretaceous.
21	9/2	Goodlands, . .	Bed between Chalk and New Red Sandstone, half a mile south-west of Ruebane Point, six miles east of Ballycastle; Chloritic conglomerate.
22	5/3	Town Parks, . .	Cliffs on shore, a little north-west of Ballycastle quay; White chalk and flint.
23	4/4	Coolmaghra, . .	Cliffs at Kenbane Head, three miles north-west of Ballycastle; White chalk and flint.
24	9/2	Ballyvennaght, .	Quarry, west side of Carnanmore Mountain, three quarters of a mile east-north-east of Flughery Bridge, eight miles east of Ballycastle; White chalk.
25	10/1	East Torr, . .	Quarry, half a mile east of Carnanmore Mountain, a little south of road from Ballycastle to Torr, seven miles east of Ballycastle; White chalk.
26	10/1	Do., . . .	About one mile south-west of Torr, and a little south of road from Ballycastle to Torr; White chalk.
27	9/4	Ballypatrick, .	Old quarry at Carneighaneigh Mountain, three quarters of a mile west of road from Ballycastle to Cushendall, six miles south of Ballycastle; White chalk.
28	9/4	Glenmakeeran, .	Outcrop of chalk in stream or drain at Carneighaneigh Mountain, nearly six miles south-east of Ballycastle on Cushendall road; White chalk.
29	10/1	West Torr, . .	Rocks at Greenanmore Hill, six miles east of Ballycastle; Chloritic and White chalk.
30	9/2	Goodlands, . .	Chalk slipping from cliffs at Murlough Bay, six miles east of Ballycastle; White chalk.
31	9/4	Ballypatrick, . .	A little south-east of Altadreen Bridge on road from Ballycastle to Cushendun; Chloritic conglomerate.
32	4/4	Town Parks, .	Bed between chalk and basalt on shore, a little north-west of Ballycastle quay; pinkish marly conglomerate.
			Sheet 7.
			Upper Cretaceous.
33	3/2	Lemnaghbeg, .	Cliffs on sea shore, half a mile east of Portbradden, about two miles west of Ballintoy; White chalk and flint.
34	4/1	Magheraboy, . .	Cliffs on sea shore, half a mile west of Ballintoy Harbour; White chalk and flint.
35	4/1	Ballintoy, . .	Large quarry at Ballintoy Harbour, three quarters of a mile north-west of Ballintoy; White chalk.
36	4/4	Glenstaghey, .	Cliffs on shore, quarter of a mile south-west of Carrick-a-raide Island, half a mile north-east of Ballintoy; White chalk.

Palæontological Notes to Sheets 7 and 8.

Localities from which Fossils were collected—*continued.*

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation and Geological Formation.
		Co. of Antrim,	Upper Cretaceous—*continued.*
37	2/4	Tanderagee, . .	Large quarry, two miles east of Portrush on coast road to Bushmills; White chalk.
38	2/4	Do., . .	Cliffs at White Rocks under coast road, about two miles east of Portrush; White chalk.
39	2/4	Magheracross, .	Cliffs under road from Portrush to Bushmills, about two and a half miles east of former; White chalk and flint.
40	2/4	Ballynacrea, Lower,	Rocks on shore, about two miles east of Portrush, and a little west of Slidderycove Point; White chalk.

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 × placed before some of them is intended to denote their comparative abundance.

LOWER CARBONIFEROUS LIMESTONE, SHALE, AND SANDSTONE.

Plantæ.

	Localities.
Sagenaria dichotomælegans (Lepidodendron Sternbergii), ...	1, 12.
Sphenopteris flabellata, n.s. (fig. 9, *a*, *b*, *c*), . .	9.
Sigillaria, sp. leaves, ...	××11.
„ (Stigmaria ficoides) rootlets, . .	1, 9, 11, 13.
Plant stems longitudinally striated, some branching, 1 inch diameter, ...	13.

Actinozoa.

Chætetes tumidus, ...	×4.

Echinodermata: *Crinoidea.*

Actinocrinus lævis, ...	5, 10.
„ sp. stems and joints, . . .	4, 7.
Poteriocrinus crassus, ...	5.

Echinoidea.

Archæocidaris glabrispina, ...	6, 7.
„ Urii, ...	6.

Crustacea: *Ostracoda.*

Leperditia Okeni, ...	××.××8.

Polyzoa.

Fenestella antiqua, ...	6.

Brachiopoda.

	Localities.
Athyris planosulcata,	5, 6.
Lingula squamiformis,	1, ××3.
Productus aculeatus,	5.
,, giganteus,	5, ×6, 10.
,, punctatus,	5.
,, scabriculus,	4.
,, semireticulatus,	5, ×6, ××××10.
Rhynchonella pleurodon,	4, 6.
Spirifera bisulcata,	5, 6.
,, lineata,	5, 6.
,, striata,	6.
Streptorhynchus crenistria,	10.

Lamellibranchiata.

Aviculopecten alternata,	10.
,, flabellata,	10.
,, hemisphæricus,	×××2.
,, plicatus?	2.
,, rigida?	10.
,, Sowerbyi,	5, 6.
,, variabilis,	6.
Axinus deltoideus,	4, 10.
Edmondia crassistria,	××4.
,, sulcata,	2.
Leda attenuata,	1, ××4, 10.
Myalina (Mytilus) comptus,	10.
Nucula radiata,	10.
Sanguinolites (Myacites) primæva,	10.
,, sp.,	2.

Gasteropoda.

Euomphalus pentangulatus,	6.
Loxonema (Murchisonia) Larcomi,	7.

Heteropoda.

Bellerophon decussatus,	4, 5.
,, Urii,	4.

Cephalopoda.

Orthoceras dactyliophorum,	×4, 10
,, Steinhauerii,	4.

Pisces.

Fish remains,	3, 10.

JURASSIC: *Lower Lias.*

PLANTÆ.

Fossil wood,	19.

Annelida.

Serpula lævis?	18.

Brachiopoda.

Lingula Voltzii,	19.
Rhynchonella furcata,	20.
,, rimosa,	×20.
,, sp.,	16.
Terebratula obovata,	16, 18.
,, sp.,	20.

Lamellibranchiata.

	Localities.
Anatina sp.,	18.
Arca truncata,	20.
Astarte consobrina,	15.
Avicula inæquivalvis,	17, 18.
Cardinia crassiusculus,	15.
Cardium truncatum,	18.
Cucullæa cucullata,	18.
„ Heltingiensis,	18.
Goniomya rhombifera,	18, 20.
Leda sp.,	15.
Lima acuticosta,	×14, ×15, ×16, ××17, 18.
„ pectinoides	××20.
Modiola sp.,	18.
Myacites unionides,	18.
„ sp.,	15, 18, 20.
Nucula sp.,	15, 18.
Ostrea irregularis,	18, 19.
„ (Gryphæa) Maccullochi,	18, 19.
Panopæa elongata,	18.
Pecten calvus,	×14, ×15, ×16, ××17, 18.
„ cingulatus,	×18, 20.
„ lunulatus,	18.
„ sublævis,	18, 19.
„ textorius,	14, 15, ×16, 18, 19.
„ vimineus,	17.
Perna sp.,	20.
Unicardium (Corbis) ovalis,	18.

Gasteropoda.

Small univalves?—Eulima,	18.

Cephalopoda.

Ammonites armatus,	18.
„ Conybearei (intermedius),	×18.
„ Johnstoni,	14, ××15, ××16, 17.
„ læviusculus,	18.
„ planorbis,	×18.
„ raricostatus,	18.
Belemnites acutus,	18.
„ longissimus?	16.
„ sp.,	20.

UPPER CRETACEOUS: *Upper Chalk.*

AMORPHOZOA: *Spongida.*

Amorphospongia globularis,	22, 26, 27, 28, 30, 33, 34, 36, 37.
Cliona cretacea,	22, 25.
Coscinopora infundibuliformis,	26, 30, 38, 39.
Ventriculites radiatus,	30, 39.

Actinozoa.

Parasmilia centralis,	23, 28, 38.

Echinodermata.

Cidaris vesiculosa?	32, 38, 39.
Echinochonus (Galerites) abbreviatus,	22, 23, 28.
„ (G. albo-galerus.) conicus,	36, 39.
Echinocorys (Ananchytes ovatus) vulgaris,	22, 23, 36, 39.
Holaster pillula,	22.
Micraster cor-anguinum,	34.

Annelida.

Serpula ilium,	32, 36.
„ plexus,	38.
„ lævis,	32.
Vermilia ampullacea,	31.

Crustacea.

	Localities.
Valve of Cirrhipede? Verruca prisca,	32.

Polyzoa.

Alecto ramea,	36.
Diastopora ramosa,	22.
Escharina intricata?	37.
Flustra inelegans,	22.
Holostoma contingens,	36, 38, 39, 40.

Brachiopoda.

Crania Ignabergensis,	23, 32.
Megerlia lima,	×22, 23, ××24, ××25, ××26, 28, ×30, 31, 32, 33, ×34, 35, 36, ××37, 39, 40.
Rhynchonella Cuvieri,	22.
„ octoplicata,	21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 33, ×35, 36, ×37, 38, 39, 40.
„ „ var. limbata,	22, 24.
„ „ var. plicatilis,	26.
Terebratula biplicata,	22, 25, 28, 36, 37.
„ carnea,	22, 23, 24, 26, 28, 30, 35, 36, ××37, 39, 40.
Terebratulina gracilis,	×32.
„ striata,	22, 24, 29, 30, 34, 35, 36, ×37, 40.

Lamellibranchiata.

Cyprina sp.,	21.
Inoceramus Cripsii and sp.,	22, 29, 30, 34, 38.
Lima elegans,	24, 37.
Ostrea vesicularis,	24, 25, 27, 29.
Pecten nitidus,	30, 38, 39.
„ quinquecostatus,	22, 38.
Spondylus spinosus,	23, 29, 40.

Gasteropoda.

Pleurotomaria perspectiva,	21, 29, ? 32.
Turbo sp.,	29.

Cephalopoda.

Ammonites radians,	21.
„ sp.,	29.
Belemnites minimus,	24, 30, 33.
Belemnitella mucronata,	×22, 23, 25, 26, 27, 28, 33, 35, 36, 40.

Pisces.

Chimera? sp.,	21.
Lamna acuminata,	25, 36, 39.
Otodus appendiculatus,	21.
Fish remains,	23, 36, 37.

Remarks on the Fossils.

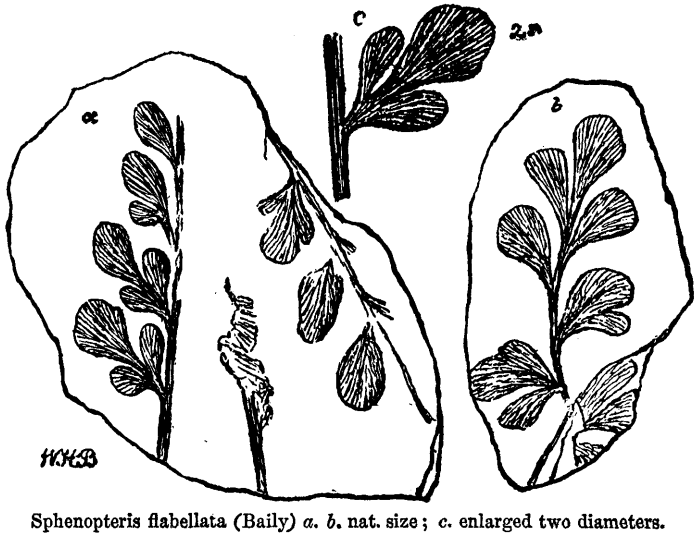
The fossils obtained within the area included by these sheets of the Map consisted of at least 1,300 specimens, and are from the following formations; Carboniferous, Lias, and Upper Cretaceous. Many of them are of much interest, and evidence great diligence and discrimination in their collection by Mr. Richard Clark.

As remarked in the paper by the Director of this Survey "On the Geological age of the Ballycastle Coal-field," etc,* this coal-field with its "Palæontological evidence fully bears out the view of the identification of the whole coal series with the Lower Carboniferous rocks of Scotland." In my appendix to that paper, *ibid.*, p. 270, etc., I have supplied a list of the fossils, and with respect to them, more especially in regard to the Plants, observe "that the absence of Ferns and Calamites and the presence of Sagenaria (of which Lepidodendron and Knorria are synonyms), is a remarkable feature in this series of Fossil Plants from the Ballycastle Collieries offering considerable support to their alliance with the Flora of the Carboniferous Limestone and Culm. This, together with the absence of certain characteristic Upper Carboniferous or true Coal measure Molluscan shells and the occurrence of so many species of Carboniferous Limestone fossils, some of them being peculiarly Lower Limestone forms, tends to confirm the opinion as to their belonging to the lower division, or Carboniferous Limestone series."

In addition to the species given in the preceding list, the following are included in the appendix to Mr. Hull's paper.

Plantæ—Aspidaria quadrangularis, Lepidostrobus variabilis, Sagenaria rimosa, Sigillaria reniformis.
Crustacea-Trilobita—Phillipsia Derbiensis, Griffithides longiceps.
Polyzoa—Ceriopora gracilis.
Brachiopoda—Chonetes Hardrensis, Productus longispinus.
Lamellibranchiata—Cypricardia cuneata? Sanguinolites discors?
Gasteropoda—Macrocheilus ovalis. Murchisonia angulata.
Pisces—Amblypterus sp. Ctenacanthus sp. Helodus planus?

Fig. 9.



Sphenopteris flabellata (Baily) *a. b.* nat. size; *c.* enlarged two diameters.

The remarks already quoted as to the position of these Carboniferous strata, in the series, are also confirmed by the collection of fossils from this district now recently made. Amongst the Plants are the remains of a Fossil Fern, in good preservation, impressed upon a fine grained ochrey sandstone. I believe it to be a new species, and have named it *Sphenopteris flabellata*, fig. 9, *a*, *b*, *c*, its principal characters are the

* Journ. Roy. Geol. Soc. of Ireland, Vol. 2, part 3, new series, pp. 260, etc.

trifoliate, rounded, and fan-shaped leaflets. This species bears a close resemblance to a fossil collected by Mr. A. B. Wynne from rocks in the river Bunnow, at Killavilla, about three and a quarter miles N.E. of Roscrea.* I referred this fossil fern to the same genus, but did not specifically name it. Mr. Wynne describes the deposit from which it was obtained as Old Red Sandstone, but as the characteristic associated fossil, found in its vicinity, is, as at this place *Leda attenuata* (figured in same Explanation, fig. 2, p. 9), no doubt they are both in corresponding strata, *i.e.*, Lower Carboniferous.

The Jurassic formation occurring in the district under consideration is represented by Lower and probably Middle Lias. The localities are, with one exception, on Sheet 7. The indurated Lias at Portrush and its vicinity (localities 14, 15, 16, and 17), is principally remarkable for the altered condition of the rock in which its fossils are imbedded, which is of a cherty character, sharp in its fracture, and resembling very much the basalt with which it is in close proximity. Mr. R. Tate, F.G.S., &c., includes these strata in the Zone of *Ammonites planorbis*.† Ammonites are the principal fossils, more especially the species named *Ammonites Johnstoni*. At White Park, Ballintoy (loc. 18), zone of *Belemnites acutus* (Tate),‡ fossils are abundant in a bluish clay. On the shore in White Park Bay many fossils are obtained from water-worn pebbles, believed by Mr. Tate to be of similar age, they include Fossil Wood and a small Brachiopod, which I have referred to *Lingula Voltzii*. The only Lias locality on Sheet 8 is situated at Planting, a little S.E. of Kinbane Head, about three miles N.W. of Ballycastle (loc. 20 on list); the peculiarly marked bivalve, *Goniophora rhombifera* was found here as also at loc. 18, White Park, Ballintoy. The Cephalopod fossil which characterizes this division of the Lias, *Belemnites acutus*, occurs in the same locality (No. 18).

I have extracted from Professor Tate's paper the following lists of fossils mentioned by him as occurring at Portrush and Ballintoy, also a list of those from what he considers Middle Lias (Drift), found near Ballintoy, by Wm. Gray, Esq., of Belfast, which he believes to be "contemporaneous, if not conterminous, with the Pabba shales."

"TABLE of the FOSSILS of the ZONE of AMMONITES PLANORBIS" occurring at Portrush, according to Mr. R. Tate, Journ. Geol. Soc., London, Vol. 23, p. 301.

Ammonites angulatus, A. armatus? A. Johnstoni, P. vimineus? Lima acuticosta. L. rustica? Avicula inæquivalvis? Mytilus minimus. Cardinia ovalis. Pholadomya ventricosa. Panopæa elongata.

"TABLE of FOSSILS of the ZONE of BELEMNITES ACUTUS," occurring in the small Bay of Ballintoy, as enumerated by Mr. R. Tate (*ibid.*), p. 304.

Ammonites armatus. A. Bucklandi. A. Conybearei. A. elegans. A. hastatus A. læviusculus. A. rotiformis. A. striatulus. A. subradiatus. {Belemnites acutus, B. abbreviatus, Portl.} B. penicillatus. {Pleurotomaria similis Trochus Anglicus, Portl.} Phasianella Pattersoni, Turritella percincta. {Ostrea Maccullochi, Gryphæa cymbium, Portl.} Plicatula spinosa. Lima {acuticosta, L. alternans, Portl.} L. punctata. {Arca sp. Cucullæa cucullata, Portl.} Astarte {consobrina. A. tetragona, Portl.} Avicula inæquivalvis. Leda tenuistriata. L. oxynoti? Mytilus lamellosus, Pecten Hehlii, P. æqualis,

* Explanation to Sheet 127 (1st edition), fig. 1, p. 8 (July, 1862).
† Journ. Geol. Soc. of London, Vol. 23, p. 30.
‡ *Ibid.*, p. 304.

Hippopodium ponderosum, Cardinia Nilssoni, Goniomya rhombifera, Corbis? ovalis, Pholadomya longirostris, P. ventricosa, Panopæa elongata, Sanguinolaria undulata, Terebratula obovata, Waldheimia perforata, Rhynchonella ranina, Montlivaltia Haimei?

"List of Fossils from Middle Lias (from the Drift)" found near Ballintoy and determined by Mr. R. Tate, Journ. Geol. Soc. of London, Vol. 26, p. 324, etc.

"Ammonites margaritatus, A. Henleyi, Belemnites umbilicatus, Pitonillus turbinatus Pecten liasinus, P. acutiradiatus, Plicatula spinosa, Cypricardia cucullata, Isocardia cingulata, Limæa acuticosta, Avicula novemcostæ, Rhynchonella acuta, R. variabilis, Waldheimia numismalis, Pentacrinus sp. Hybodus reticulatus."

"The close similarity in lithological composition and, in part, in fossiliferous contents between the Pabba shales and the blocks containing these fossils, found at Ballintoy, suggests the probability of the latter having been transferred during glacial times from the Hebrides."

The following fossils, included in the Portlock collection, Jermyn street, London, and Geological Survey, Royal College of Science, Dublin, from Portrush and Ballintoy, are not included in the preceding lists.

Portrush—Pecten vitreus, (Roemer) Lima alternans.

White Park, Ballintoy—Ammonites planicostatus, A. armatus, Nautilus striatus, Lima Hermanni, L. rustica, L. cardiiformis, Modiola scalprum, Pholadomya ventricosa, P. longirostris { Pleuromya liasina. / Pholadomya myacites Portl: } Unicardium (Corbis?) ovalis.

In the Upper Cretaceous Formation a chloritic conglomerate (loc. 21) containing pebbles of quartz, a deposit between the Chalk and New Red Sandstone is interesting notwithstanding its lithological character for containing well preserved fossils, including Brachiopoda, Mollusca, and Fish remains.

Of the Amorphozoa; the small rounded fossil sponge *Amorphospongia globularis*, was found at nine localities. One of the valves of a cirrhipede, probably *Verruca prisca* was collected from a remarkable deposit, a bed between the Chalk and Basalt, a pinkish marly conglomerate, occurring on the shore a little north-west of Ballycastle Quay; this bed contained, besides some rare Brachiopoda, such as *Carnia Ignbergensis*, and *Terebratulina gracilis*, *Megerlia lima*, a fossil very abundant in the White Chalk (White Limestone) of Ireland, having been collected at no less than sixteen localities in this district. *Rhynchonella octoplicata*, including its synonym *R. plicatilis* and its young form *R. limbata* was found at twenty localities, *Terebratula carnea* at eleven, *T. biplicata* at five, and *Terebratulina striata* at nine localities. Mollusca, both bivalves and univalves, were not nearly so frequent. Of Cephalopoda, Ammonites were few, one species only having been identified. *Belemnitella mucronata* occurred at ten localities, *Belemnites minimus* at three. Remains of fish were not abundant, having been collected only at seven localities.

In the Tertiary lignite and marl deposits at Ballintoy, plant remains occur in the marl; and in connection with the lignite, fossil leaves, one of which, presented to us by Mr. William Gray, I have identified as *M'Clintockia trinervis* (Heer).

William Hellier Baily.

June 18th, 1887.

APPENDIX.

SECTION I.

BALLYCASTLE SHORE DIVISION.

Table of the Strata at Gobb Mine, from top downwards.

	Feet.	Inches.
1. Trap imperfectly columnar,	51	0
2. Shale,	18	0
3. Yellowish-white sandstone,	42	0
4. Black shale with thin seams of coal,	15	0
5. Hard grey and yellowish-white sandstone,	81	0
6. Main bed of *coal*,	4	0
7. Shale with thin beds of fire clay,	2	0
8. Impure *coal*,	2	0
9. Black shale,	16	0
10. White-sandstone,	33	0
11. *Coal* and black shale,	2	0
12. Grey sandstone,	36	0
13. Grey sandstone slate,	21	0
14. Black shale,	6	0
15. Yellowish-white sandstone,	30	0
16. Yellowish-grey limestone,	5	0
17. *Coal*,	1	6
18. White sandstone,	5	0
19. Bluish-grey sandy slate,	3	0
	373	6

SECTION II.

SALT PANS COLLIERY.

	Feet	Inches.
Coal forty yards below the level of the sea, bed irregular, being from six to nine feet thick,	6	0
Coal, upper bed at Bath Lodge,	2	4
	8	4

SECTION III.

NELSON COLLIERY.

Fifty perches east of Carrickmore Dyke, nearly on the level of high-water mark.

	Feet	Inches.
Black shale forming the roof of the coal,	6	0
Carbonaceous or non-flaming coal,	1	8
Black slate clay,	6	0
Blazing coal,	1	4
	15	0

SECTION IV.

MURLOUGH BAY DIVISION, commencing from top of cliff.

	Feet	Inches.
1. Columnar greenstone,	100	0
2. Brownish-red sandstone,	20	0
3. Bituminous *coal*,	1	0
4. Red sandstone,	80	0
5. Black shale,	6	0
6. *Coal*, highly bituminous (White Mine),	2	6
7. Brownish-red sandstone,	40	0
8. *Coal*, highly bituminous,	0	6
9. Red sandstone,	20	0
10. Black shale,	10	0
11. *Coal*, bituminous (Goodman's Vein),	2	6
Carried forward,	282	6

	Feet	Inches.
Brought forward,	282	6
12. Black shale,	60	0
13. *Coal*, carbonaceous, uninflammable,	2	6
14. Black shale, passing into flinty slate,	2	0
15. Greenstone, second columnar range,	70	0
16. Black shale,	2	0
17. *Coal*, non-flaming, with alternations of black shale,	8	6
18. Black shale,	10	0
	437	6

SECTION V.

Murlough Bay Division.

In face of Cliff, about 300 yards to the south-east of the Greyman's Path, commencing from top.

	Feet	Inches.
1. Columnar greenstone,	200	0
2. Black shale,	50	0
3. Non-flaming carbonaceous *coal*,	2	6
4. Black shale, highly indurated,	3	0
5. Columnar greenstone,	50	0
6. Indurated black and grey shale,	4	0
7. Rudely columnar greenstone,	3	0
8. Indurated black shale with thin beds of non-flaming *coal*,	8	0
9. Impure non-flaming *coal*,	5	0
10. Black shale,	10	0
11. Yellowish-grey shale,	30	0
12. Black shale,	20	0
	385	6

SECTION VI.

Carey Mill River Sections.

99 perches west of Carey Mill, Townland of Drumahilt.

	Feet	Inches.
1. Surface soil,	1	0
2. Drift,	12	6
3. Dark blue indurated clay,	10	0
4. *Coal* splint,	0	1
5. Dark grey shale,	10	4
6. Strong dark grey freestone,	2	6
7. Black bituminous shale, with three thin layers of coal,	3	0
8. Dark grey shale, with thin bands of dark freestone,	13	6
9. Grey shale,	16	8
10. Black shale, with coal smelt through it,	4	0
11. Bluish-grey sandstone, with partings of brown shale,	14	5
	88	0

English, 80 perches east of Carey Mill.

	Feet	Inches.
1. Grey freestone,	5	0
2. Dark shale,	1	1
3. Grey freestone,	3	9
4. Dark grey shale,	1	5
5. Grey freestone,	1	6
6. Dark grey shale,	1	8
Carried forward,	14	5

	Feet	Inches.
Brought forward,	14	5
7. Grey firestone,	1	11
8. Grey shale,	2	11
9. Black slate,	3	6
10. *Coal*,	1	5
11. Dark grey shale,	14	0
12. Black slate,	6	3
13. Dark grey shale,	6	0
14. *Coal*,	0	7
15. Dark grey shale,	1	11
16. Grey freestone,	1	3
17. Dark grey shale,	19	6
18. Grey freestone,	0	4
19. Dark grey shale,	7	8
20. *Coal*,	0	10
21. Dark shale parting,	0	2½
22. *Coal*, soft,	0	9
23. Dark grey shale,	3	2
24. Black shale,	1	6
25. Blue shale,	1	8
26. *Coal*,	1	10½
27. Fireclay,	3	4
	95	0

SECTION VII.

At BARNISH, 207 perches east of Carey Mill.

	Feet	Inches.
1. Sand and gravel,	48	0
2. Brown strong clay,	1	4
3. Blue stone, very fine grit, with casts of plants,	0	3
4. Bluish-grey shale, with thin bands of post,	3	6
5. Bluish-grey freestone, with soft shale partings,	6	9
6. Dark grey shale,	2	6
7. Strong white freestone,	0	6
8. Bluish-grey shale, with thin layers of post,	2	3
9. Strong bluish-grey freestone,	5	0
10. Grey shale, with hard layers,	3	6
11. Bluish-grey freestone,	4	10
12. Dark grey shale,	6	3
13. Strong bluish-grey post,	0	6
14. Grey freestone, dark,	1	6
15. Bluish-grey freestone,	1	10
16. Black shale,	0	4
17. Grey shale,	0	4
18. Strong grey freestone,	2	1
19. Dark grey shale,	2	4
20. Grey freestone,	3	3
21. Grey shale,	0	4
22. Black shale,	1	3
23. Grey shale,	6	5
24. Grey freestone,	1	0
25. Grey shale,	1	5
26. Black shale, mixed with coal,	4	11
27. Dark grey shale,	1	2
28. Black shale, mixed with coal,	0	9
29. Dark grey shale,	4	4
30. Strong grey freestone,	0	6
31. Grey shale,	11	11
32. Dark grey shale,	7	8
Carried forward,	138	6

	Feet	Inches.
Brought forward,	138	6
33. Very dark shale,	3	6
34. Bluish-grey shale,	3	10
35. *Coal*,	0	4
36. Pavement (Coal seat—? ironstone),	0	11
37. Blue shale,	1	6
38. Grey shale,	5	6
39. Dark brown shale,	3	2
40. Strong grey freestone,	0	6
41. Dark brown shale,	3	9
42. Grey shale,	2	1
43. Dark grey shale,	0	9
44. Light grey shale,	4	7
45. Dark red shale,	2	0
46. White shale,	0	6
47. Dark grey shale,	0	6
48. Light grey shale, with spar of lime,	21	5
49. Dark red shale,	5	0
50. Light grey shale,	1	0
51. Light blue shale, mixed with spar,	8	11
52. Dark grey freestone,	2	6
53. Very strong light brown limestone,	0	9
54. Marl, dark parting,	1	2
55. Bluish-grey limestone,	1	0
	213	8

SECTION VIII.

Townland of DRIMADOWN, 1817.

	Feet	Inches.
1. Strong clay,	16	3
2. Grey freestone,	2	0
3. Dark grey shale,	16	0
4. Grey shale,	6	0
5. Grey shale,	1	6
6. *Coal*, very good,	0	10
7. Dark grey shale,	13	3
8. Black shale,	0	10
9. Dark grey shale,	2	5
10. *Coal*, soft,	0	11
11. Fireclay (pavement),	3	5
12. Light grey shale,	5	0
13. Light grey freestone,	1	10
14. Dark grey shale,	1	6
15. Light grey shale,	5	8
16. Black shale,	0	10
17. Dark grey shale,	4	11
18. Light grey shale,	2	0
19. Grey freestone,	1	4
20. Light grey shale,	1	7
21. Blue shale,	3	1
22. Blue slate, bituminous,	4	7
23. Dark blue shale,	1	10
24. Dark grey shale,	2	11
25. Brownish-grey shale,	2	0
26. Light grey freestone,	1	1
27. Dark grey shale,	2	6
28. Light grey freestone,	2	2
	108	3

SECTION IX.

Journals of Four Borings in the Townland of BRACKNEY, east of the Glenshesk River. November 9th, 1857.—No. 1.

	Feet	Inches
1. Surface drift,	24	0
2. Light grey shale,	10	9
3. Grey sandy shale,	7	6
4. Hard freestone,	1	0
5. Black shale,	1	0
6. Foul *coal*,	6	0
7. Fireclay,	0	6
8. Very black shale,	14	2
9. *Coal*,	0	2
10. Light grey shale,	18	0
11. *Coal*,	1	0
12. Fireclay,	2	0
13. Black shale and *coal* mixed,	2	0
14. *Coal*, burned,	4	6
15. Black shale mixed with *coal*,	3	0
	90	1

SECTION X.

Townland of BRACKNEY. December 3rd, 1857.—No. 2.

	Feet	Inches
1. Surface drift,	6	0
2. Grey sandy shale,	6	7
3. Light grey shale,	3	4
4. Grey sandy shale,	3	0
5. Black shale,	2	6
6. Brown shale,	2	4
7. Hard sandstone,	0	6
8. *Coal*,	1	1
9. Black shale,	10	9
10. Light grey shale,	3	0
11. Black shale,	21	0
12. Very black shale,	6	6
13. *Coal*,	1	6
14. Fireclay,	1	6
15. Black shale,	0	6
16. *Coal*,	1	0
17. Black shale mixed with *coal*,	2	0
18. *Coal*,	1	10
19. Black shale,	6	0
20. Light grey shale,	7	0
21. Grey sandy shale,	11	0
22. Hard sandstone,	1	0
23. Parting (black shale),	0	6
24. Very hard grey sandstone,	2	8
25. Black shale,	0	4
26. Grey sandstone,	5	3
27. Brown shale,	12	0
28. Grey sandy slate,	3	6
29. Brown shale,	3	6
30. Light grey shale,	2	3
31. Brown shale,	1	6
32. Dark grey shale,	5	0
33. Grey sandy shale,	4	8
	141	4

SECTION XI.

BRACKNEY. February 16, 1858.—No. 3.

	Feet	Inches.
1. Surface drift,	22	6
2. Blue clay,	8	3
3. Dark grey sandy shale,	10	1
4. Light grey shale,	8	6
5. Black shale mixed with ironstone balls,	19	6
6. *Coal*,	0	9½
7. Fireclay,	2	9
8. Black shale,	0	4
9. *Coal*,	1	1½
10. Dark grey shale mixed with *coal*,	1	4
11. Fireclay,	1	0
12. Dark grey shale,	4	3
13. Foul coal,	0	9
14. Grey sandy shale,	18	4
15. Brown sandy shale,	1	5
	100	11

SECTION XII.

BRACKNEY. February 16, 1858.—No. 4.

	Feet	Inches.
1. Drift composed of sand and gravel,	31	9
2. Soft sandstone,	12	8
3. Light grey sandy shale,	9	6
4. Brown shale,	3	0
5. Light grey soft shale,	5	0
6. Black shale,	1	0
7. *Coal*,	1	4
8. Fireclay,	0	2
9. Dark grey shale,	3	6
10. Black shale,	0	6
11. *Coal*,	0	3
12. Black shale,	9	3
	77	11

SECTION XIII.

Journal of Boring No. 6, Townland of BARNISH, and north of Carey River, by ENGLEDEN—COULSON, Superintendent.

	Fathom	Feet	Inches.
1. Soil,	0	1	6
2. Sand,	0	1	6
3. Gravel,	0	1	3
4. White freestone with water,	0	2	0
5. Blue metal,	0	4	7
6. Strong freestone,	0	0	11
7. Dark grey metal,	0	2	6
8. Black metal,	0	1	0
9. *Coal*,	0	1	1
10. Black metal,	0	1	2
11. Grey metal,	1	0	8
12. Blue do.,	1	3	8
13. Strong black metal with water,	1	1	5
14. Ironstone,	0	0	5
Carried forward,	6	5	8

	Fathoms	Feet	Inches.
Brought forward,	6	5	8
15. Dark grey metal,	0	2	2
16. *Coal*,	0	0	7
17. Dark grey metal,	3	1	6
18. Grey metal mixed with ironstone,	0	3	4
19. Blue metal,	0	3	11
20. Dark grey metal,	0	1	0
21. Ironstone,	0	0	9
22. Blue metal mixed with ironstone,	0	1	10
23. Dark grey metal,	0	4	11
24. *Coal*,	0	0	8
25. Grey metal,	0	0	5
26. Black metal mixed with coal,	0	0	6
27. Grey do. do.,	0	1	9
28. Grey metal,	0	1	7
29. *Coal*, strong and coarse, 1′ 4″; band grey metal, 7″, *coal* at bottom good and tender, 2′ 4″ =2′ 11″,	0	4	3
30. Blue metal,	0	2	6
31. Black sand approaching coal,	0	0	9
32. Brown metal,	0	0	7½
33. Black metal mixed with coal,	0	5	6½
34. Light blue metal,	0	0	11
35. White freestone with water,	0	0	8
36. Blue metal.	1	3	3
37. Green metal mixed with coal,	2	4	10½
38. Strong grey metal,	0	3	6½
39. *Coal*,	0	0	3
40. Grey metal stone, strong at bottom,	2	5	1
41. Grey stone with feeder of water immediately below it,	0	0	5½
42. Brown metal mixed with green,	0	4	6
43. Grey metal,	0	5	7
44. Green metal,	0	2	0
45. Dark grey metal,	0	5	10½
46. Green metal stone,	0	1	4½
47. Grey metal,	0	3	6
48. Green,	1	4	9½
49. Reddish brown metal,	0	1	10½
50. Green metal,	0	2	0½
51. Brown metal,	0	1	10½
52. Strong green metal,	0	5	3½
53. White freestone,	0	2	1½
54. Grey metal stone,	0	4	2
55. Brown metal,	0	2	10½
56. Green metal stone,	0	4	7
Total depth bored by Coulson,	34	1	9

SECTION XIV.

Journal of Boring No. 7, Townland of BARNISH, and north of Carey River, by ENGLEDEN—COULSON, Superintendent. 1849.

	Fathoms	Feet	Inches.
1. Dark grey metal,	0	4	0
2. Brown metal,	1	5	9
3. Dark grey metal with ironstone,	2	1	6
4. Blue metal with ironstone,	1	2	3
5. Dark grey do. do,	0	3	9
6. Brown metal do.,	0	2	10
Carried forward,	7	2	1

	Fathoms	Feet	Inches.
Brought forward,	7	2	1
7. Black metal with coal,	0	2	2
8. Grey metal do.,	0	1	4
9. Light blue metal,	0	0	6
10. Coal mixed with metal,	0	1	2
11. Grey metal, strong coal, dark grey metal,	0	1	2
12. *Coal*,	0	2	10
13. Grey metal,	0	1	9
14. Coal mixed with black metal,	0	1	5
15. Dark grey metal,	0	2	3½
16. Black metal mixed with coal,	0	2	5
17. Light grey metal,	0	0	3½
	10	1	5

SECTION XV.

No. 8 Boring, Townland of BALLYVOY, bank of Carey River.

	Fathoms	Feet	Inches.
1. Soil and sand,	0	1	6
2. Gravel,	0	3	0
3. Red freestone,	1	0	1
4. Brownish-red metal with post,	1	1	0
5. Blue metal,	0	5	5
6. Yellow freestone,	1	3	9
7. Blue metal,	0	1	2
8. Yellow freestone,	0	3	10
9. Blue metal,	0	2	3
10. White freestone,	0	4	7
11. Grey metal,	0	2	6
12. Green metal,	0	0	4
13. Grey metal mixed with ironstone,	0	1	4
14. Dark grey metal,	0	2	6
15. Black metal mixed with coal,	0	2	4
16. Dark grey metal,	1	1	0
17. Light grey metal,	0	3	6
18. Dark grey metal,	0	5	8
19. Black metal,	0	5	4
20 Dark grey metal,	3	4	10½
21. Light grey metal,	1	4	4
22. Dark grey metal,	0	3	8
23. Black metal mixed with coal,	0	2	9
24. Light grey metal,	0	3	6
25. Dark grey metal,	0	2	7
26. Black metal mixed with coal,	0	1	10
27. *Coal* 3″, bond 4″, *coal* 1′ 5½″,	0	2	0½
28. Light grey metal stone,	0	5	10½
29. White freestone,	0	3	2
30. Light grey metal,	0	4	0
31. Black metal,	1	4	0
32. Dark grey metal,	1	0	0
33. Light grey metal,	0	1	6
34. Dark grey metal,	1	4	2½
35 Green metal mixed with red,	0	4	7
36. Strong green metal stone,	0	3	0
37. Black metal,	0	0	9
38. Grey metal stone.	0	4	0
39. Green and red metal mixed,	3	1	8
40. Green metal stone,	3	3	7
41. Green metal	0	1	8
Carried forward,	36	4	9

	Fathoms	Feet	Inches.
Brought forward, . .	36	4	9
42. Strong green stone, . . .	0	3	5½
43. Grey metal stone, ...	2	0	9
44. Green metal mixed with brown, . .	0	2	9
45. Green metal stone, ...	0	4	4
46. Very strong green stone, . . .	0	2	2
47. Green metal mixed with brown, . .	1	3	0
	42	3	2½

SECTION XVI.

At BENGORE HEAD, east of Giant's Causeway.

			Feet.
Lower Basalt.	1. 2. 3.	Three thick layers of black tabular amorphous basalt, ...	80
	4. 5. 6.	Several layers of black tabular basalt and seams of ochre, ...	80
Pisolitic Iron Ore.	7.	Bole or red ochre, ...	22
Upper Basalt.	8.	Columnar basalt, ...	44
	9.	Irregular prismatic basalt, ...	54
	10.	Columnar basalt, ...	54
		From the top of Bengore Head, going eastward, other layers crop out as follows:—	
	11.	Coarsely columnar basalt, ...	10
	12.	Intermediate between bole and basalt, . .	8
	13.	Columnar basalt, ...	7
	14.	Basalt irregularly prismatic, ...	60
	15.	Red ochre or bole, ...	9
	16.	Basalt irregularly prismatic, ...	60
			488 feet.

ANALYSIS of a GAS COAL from BALLYCASTLE.

Specific gravity, 1·2787.

Moisture, ...	7·14
Volatile matter, ...	36·11
Sulphur, ...	0·85
Fixed carbon, ...	50·22
Ash, ...	5·68
	100·00

Five cubic feet of which burning per hour, had an illuminating power equal to 14 sperm candles.

ROBERT F. SMITH,
Glenpark Chemical Works, Glasgow.

	Sulphur.	Illuminating Power.
Wigan average, . . .	1·43	11½ candles.
Ballycastle ,, . .	0·85	14 ,,

INDEX.

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PUBLICATIONS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

UP TO DECEMBER, 1887.

MAPS.

The following One Hundred and Eighty-nine Sheets of the One-inch Map:—7, 8, 12, 13, 14, 18, 19, 20, 21, 24 to 29, 32 to 205, all inclusive.

SIX INCH SHEETS.

The following Sheets are published on the Six-inch Scale:—County of Antrim, Sheet 41; County Tyrone, Sheets 46, 47, 54 and 55; County Roscommon, Sheets 1 and 2; County Sligo, Sheet 35; County of Leitrim, Sheets 20 and 21.

EXPLANATORY MEMOIRS.

The following One Hundred and Eighty-six Sheets are described in the Explanations:—(6 partly), 7, 8, 12, 13, 14, 18, 19, 20, 21 with 28 and part of 29, 24, 25, 26, 27, 33, 34, 35, 36, 37 with 38 and part of 29, 39, 40, 41 with 53 and 64, 42 and 43, 44, 45, 46, 47, 48, 49 with 50, 51, and 52, 53 with 41, 54 and part of 42, 55, 56, 57, 58, 59 and part of 61, part of 60 and 71; parts of 60, 61 and 71; 62 with part of 73, 63 with part of 74, 64 with 41, 65, 66 with 67, 68 with 69, 70, 71 with 60, 75, 76 with 77, 78, 79, 80 with 78, 81 with 82, 83 with 84 and parts of 73 and 74, 85, part of, with 86, 87, 88 with 86, 89 with 90, 91 with 92, 93 with 94, 95, 96, and 97 with 96,—98, 99 with 98,—100, 101, 102, 104 with 113, 105, 106, and 107 with 96,—108 and 109 with 98,—110 with 100, 111, 112 with 102, 113 with 104,—114, 115, 116 with 115, 117, 118 with 117, 119, 120,—121 with 130,—122 and 123 with 114, 124, 125 partly with 124 partly with 126, 126, 127, 128—131, 132 with 131, 133, 134, 135, 136, 137,—140, 141 with 140, 142, 143, 144, 145, 146, 147, 148 with 149,—150, 151 with 150, 152, 153, 154, 155, 156, 157 with 147, 158 with 159,—160 with 161, 162, 163, 164, 165, 166, 167, 168 with 167,—169, 170 with 169, 171 with 160, 172 partly with 160 partly with 182, 173, 174 with 163 175, 176, 177 with 176, 178 with 167, 179 with 167,—180, 181 with 169, 182, 183 with 182, 184, 185, 186 with 185,—187, 188, 189 with 188, 190 with 182,—191 partly with 182, 192, 193, 194, 195 with 187, 196 with 187.—197, 198 with 197, 199 partly with 192 partly with 200, 200, 201 with 194, 202 with 194, 203 with 200. 204 with 200, 205 with 200.

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Longitudinal (New Series).—Sheets 1 to 26 inclusive.

Longitudinal (Old Series).—Sheets 1 to 4.

Plans and Sections of Ovoca Mines.—Sheet 1.

See Detailed and Priced List, to be had on application to the Office or to the Agents.