

Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 17 AND S.E. PORTION OF SHEET 11

OF THE MAPS OF THE

GEOLOGICAL SURVEY OF IRELAND,

By G. H. KINAHAN, M.R.I.A.; S. B. WILKINSON;
J. NOLAN, M.R.I.A.; AND F. W. EGAN, B.A.;

WITH

PETROGRAPHICAL NOTES,

By J. S. HYLAND, M.A., PH.D.

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THE
GEOLOGICAL SURVEY OF THE UNITED KINGDOM

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

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P R E F A C E.

THE District described in this Memoir is composed nearly altogether of rocks more or less metamorphosed, and, as far as observation has hitherto extended, unfossiliferous. It forms a section of the great tract of altered strata consisting of various crystalline schists, quartzites, limestones, and trappean sheets which extends from the volcanic plateau of Co. Antrim westward through Tyrone and Derry into Donegal. The geological age of these rocks is still uncertain; as all attempts to discover definite forms of past life have failed; though there are sufficient indications that such forms originally existed, but have been obliterated, or rendered obscure, by metamorphic action.

The Memoir is the work of several contributors who have each geologically surveyed portions of the Map and the small riparian tract in Sheet 11, lying outside the north-eastern margin. Mr. Kinahan surveyed the north-western tract lying on both sides of the estuary of the River Swilly; Mr. Nolan the adjoining portion along the northern half of the Map; Mr. Wilkinson the south-eastern portion, and Mr. Egan the south-western. The introductory pages of this Memoir have been written by myself.

The geological literature of this tract is exceedingly scanty, except so far as it is included in the general description of the rocks of the Counties of Londonderry, Tyrone, and Fermanagh, by General Portlock, in his well-known work, to which reference will be found in the text.

EDWARD HULL, *Director.*

Geological Survey Office, Dublin,

January, 1889.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 17 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

CHAPTER I.

PHYSICAL GEOGRAPHY.*

THE area included within the limits of Sheet 17, and described in this Memoir, belongs to three counties—those of Donegal, Londonderry, and Tyrone. The first named county includes almost the whole of the district lying to the west of the river Foyle, which traverses the sheet from south to north and divides it into two nearly equal portions; while the counties of Londonderry and Tyrone divide the eastern portion between them. The whole tract is undulating; in some places almost mountainous; but its special feature is the broad valley of the Foyle, which below St. Johnstown becomes a deep and noble river, opening out into the wide estuary of the same name at the City of Londonderry, a few miles beyond the northern margin of the Map. The principal towns and villages are Strabane on the Tyrone side of the river Foyle, and the assize town of Lifford on the opposite side; Raphoe, Convoys, St. Johnstown, Carrigans, and Dunnamanagh.

The river Foyle is tidal as far as its junction with the Finn at Lifford, at which point it changes its name and is known as “the Mourne.” In its course it receives several other tributaries; those entering at the left bank below the Finn, are the Dee and the Swilly Burn, while the Owenreagh and the Burdennet streams enter at the right bank of the main river. Above St. Johnstown, large tracts of alluvial ground follow the banks of the Foyle and of its tributaries, the Swilly, the Dee, and the Finn; but it may also be observed, that above and beyond the low tracts liable to floods at the present day there are terraces formed of river-gravel rising from ten to fifteen feet higher, which are never reached by the highest floods of the present day, and belong to an epoch when the whole country was relatively lower, as regards the ocean, by some feet, and when the waters of the estuary of the Foyle extended far beyond their present limits, and inundated the tracts occupied by these more ancient alluvial gravels.† At

* By Professor Hull.

† The evidences of the recent elevation of the land are found along the coast in the form of raised beaches with marine shells, for an account of which the reader is referred to the Explanatory Memoirs to illustrate Sheets 7, 8, p. 34, and 12 of the Geological Survey, p. 26.

the north-west corner of the Map the estuary of the river Swilly traverses the district for about two miles, and receives several small streams coming in from the south.

The highest elevations in the district are found in the north-eastern portion of the Map, on the borders of Londonderry and Tyrone. They may be considered as the western shoulders of the mountainous region which stretches eastward towards the basin of Lough Neagh, and in the Sperrin range reaches an elevation of 2,236 feet. The following are the more important elevations:—Balix Hill, 1,333 feet, and Slievekirk, 1,219 feet; these are on the east of the Foyle valley; on the west, where the ground does not rise so high, we have Croghan Hill, 724 feet, Buinion, 630 feet, and Dooish Mountain, 888 feet.*

CHAPTER II.†

ROCK FORMATIONS AND DIVISIONS.

Name.	Divisions on Map.	Sign and Colour on Map.
RECENT, . . .	Bog (Peat) and Alluvium, . . .	Chalons-brown and gamboge.
POST - PLEISTOCENE,	Drift Deposits—Boulder clay and sand and gravel.	Engraved dots.
LOWER CARBONIFEROUS.	Calciferous Sandstone, . . .	Prussian blue—dotted.
METAMORPHIC ROCKS.	Clay-slate and phyllite, passing into mica-schist.	μ. Light crimson lake.
	Quartzite and quartz-schist, . . .	q. Gamboge over crimson lake.
	Schistose conglomerate, . . .	Light crimson lake with yellow dots.
	Limestone (crystalline), . . .	λ Cobalt blue over crimson lake.
INTRUSIVE ROCKS (Dykes and intrusive sheets).	Hornblende Rock passing into schist.	Δ Burnt carmine.
	Basalt,	B. Burnt carmine and carmine.
	Diorite,	D. Burnt carmine.
	Felstone,	F. Orange-chrome and carmine.
	Felstone Porphyry,	Fp. Ditto.

METAMORPHIC ROCKS.

General Characters.—The whole of the area included in this sheet, with the exception of small tracts of intrusive rocks of later date, is formed of strata belonging to the Metamorphic series of the north-west of Ireland. This series includes a great variety of beds, of which mica-schist passing gradually into sericitic-phyllite, and this again into roofing-slate, forms the larger area; but with these are interstratified varieties of quartzite, quartz-schist, crystalline limestone, and hornblende sheets of intrusive

* The elevations are taken from the Ordnance Map.

† By Professor Hull.

origin, which have subsequently undergone alteration along with the rocks with which they are associated.

The old necks, or volcanic throats, from which some of these sheets were probably extruded, also occur in the form of irregular bosses of hornblendic diorite, breaking through the stratified deposits transversely to the bedding. Of these the most remarkable mass is that which forms the ridge a short distance west of St. Johnstown; other similar masses occur to the north of Raphoe, which are largely crystalline-granular in structure.

Crystalline Limestone.—The south-western portion of the sheet near Raphoe is largely composed of crystalline limestone which here swells out into thick masses, interstratified with schist, hornblende rock, and quartzite, of which the Convoy limestone is the most important. This great mass illustrates remarkably the inconstant character of the limestones of the metamorphic series; for, after having been displaced by transverse faults, it finally thins out on the banks of the river Finn about two miles above Lifford towards the south-east,* and in the opposite direction disappears within a distance of about three miles of the village of Convoy.† These remarkable beds of limestone, from their inconstant character, suggest the idea that they were originally banks of coral-rock formed in the sea of the period to which the strata belong; but unfortunately, such has been the effect of the metamorphic action to which they have been subjected since their formation, that no unquestionable organic forms have yet been discovered in them, notwithstanding repeated and careful search.

Tracts of slight Metamorphism.—Some portions of the area in Sheet 17 appear to have undergone but very slight alteration during the epoch of metamorphism, so that the schistose beds are only slightly micacised, and consist of glossy slates (sericitic phyllites) which have been worked for roofing purposes. These beds are found along a tract of country crossing the river Foyle in a north-west and south-east direction at the bend below St. Johnstown. It was hoped that these slates, which have a strong resemblance to some of the fossiliferous beds of Lower Silurian age in North Wales, might have afforded some traces of organic bodies (such as *graptolites*), and careful search was made by the officers of the Survey on several occasions, but without result. As far, therefore, as fossil evidence has gone, both in this immediate district and those adjoining, no light has yet been thrown on the geological age of this great series of metamorphosed and sub-metamorphosed strata. Amongst the slaty beds of the tract just described there occur occasional beds of fine conglomerate and coarse grit, called on the map "schistose conglomerate." These are regarded as being very high up in the series, and are found again amongst the hills between Londonderry and Bun-crana in Sheet 11.

Intrusive Rocks of later date.—Besides the hornblendic sheets

* See Geological Survey Map, Sheet 25.

† In Sheet 16.

and bosses above referred to, there are a few dykes and bosses of igneous rock belonging to an epoch more recent than that of the metamorphism. They are easily distinguishable from the older series, both by their structure and composition, as well as by their relations to the strata which they penetrate. These rocks consist chiefly of felstone, and felstone porphyry, of which the most remarkable example is the dyke which breaks out along the banks of the Burndennet near the south-eastern corner of the map. Several smaller dykes and bosses occur near Raphoe, of which details will be given in connection with the structure of that district. Besides the felspathic masses, there also are found at rare intervals dykes of basalt, which are not improbably of Tertiary age.

General structure of the Rocks of the District.—The general arrangement of the strata within the limits of the map appears to be sufficiently simple. The highest beds, consisting of slate, sericite-schist, and coarse grit, occupy a tract of country of which the Dooish mountains to the west of the valley of the Foyle, and those called Gortmonly, Killymallaght, and Slievekirk to the east of this valley, are a portion. These beds have a general dip northwards of about 35° – 40° , but are occasionally subjected to gentle foldings, as a southerly dip has been noted in a few localities. From beneath this upper schistose series rises, towards the south-west, a great calcareo-quartzite series, near the centre of which lies the little town of Raphoe. The general dip of these beds is towards the north-east at angles of 20° – 25° , and they are traversed by a remarkable system of transverse faults (ranging in a mean N.N.E. direction) which displace the beds on either side. Seven or eight faults referable to this system occur in the Raphoe district, and they are continued necessarily into the tracts included in the adjoining maps to the west and south.* From the parallelism of these faults to the great lines of fracture and disturbance of western Donegal we may conclude that they are referable to the same epoch or epochs of disturbance, in which the latter have been originated.

General Distribution of Drift Deposits.—These deposits, consisting of boulder clay, sometimes overlain by stratified sand and gravel, are largely spread over the lower parts of the valleys leading down into the central depression of the river Foyle, and bordering the estuary of the Swilly. From beneath these drift-covered valleys and slopes rise numerous rocky eminences almost devoid of drift deposits. In the adjoining district to the north, and lying amongst the hills bordering the shores of Lough Foyle, are certain calcareous clays containing marine shells, which have been described by General Portlock,† the principal forms being those of *Turritella terebra*, *Cyprina Islandica* and *Nucula oblonga* (*Leda pernula*). Portlock considered these to be of later Tertiary age; but Mr. Nolan regards them as belonging to the age of the boulder clay—and therefore Post-Tertiary—which

* Sheets 16, 24, and 25.

† "Report, Geology of Londonderry," &c., pp. 157–159.

extends into the district here described. As Portlock has observed, the shelly clays are frequently overlain by stratified sand and gravel of the middle drift-division, and they have been traced to levels of nearly 600 feet above the present surface of the sea, at which they become unfossiliferous. As the formation of the lower boulder clay is generally considered to have been brought about during an epoch of elevation, rather than of depression, as regards the present sea level, the question arises whether these shells have not been ploughed up from the sea-bed and pushed up the slopes of the adjoining land by the great ice-sheet which, as we now know, invaded the north of Ireland from the Scottish Highlands.* The shells occurring in the clay are often fragmental, but occasionally it is otherwise, as in the case of the delicate *Nucula*; and Portlock appears to have satisfied himself that in general the shells were formed *in situ*, or in the position in which they are found. On the other hand, the beds of sand and gravel which overlie the shell clays and rise up to levels of nearly 1,000 feet, clearly indicate a period of great depression of the land, during which only the higher parts of the existing surface in the north of Ireland were unsubmerged. The latest period of submersion, to a depth of perhaps 20 or 25 feet relatively to the present sea-level, is represented by the terraces of gravel along the banks of the Foyle, and by the old raised beaches along the coast, which contain numerous marine shells.

CHAPTER III.

METAMORPHIC ROCKS.

DETAILED DESCRIPTION.

Manorcunningham District.†

The tract to be described lies at the north-west of Sheet 17; in it the villages of most importance are Manorcunningham and Pluck. The geology is obscure on account of the paucity of rock exposures, and also owing to the strata being very much faulted and otherwise disturbed.

The latest rocks in the area may be called the *Manorcunningham Series*. They occur at that village, and in the country to the north-eastward and eastward of it. They consist for the most part of argillaceous beds associated with irregular grits, often pebbly, and subordinate limestones.

The Manorcunningham rocks are more or less reconstructed; this appears in the following description of the section at the S.E. beach of the Swilly estuary, communicated by the Director

* J. R. Kilroe, "Directions of Ice-flow in the North of Ireland," *Quart. Jour., Geol. Soc.*, Nov., 1888, p. 828.

† By Mr. Kinahan, with note by Dr. Geikie.

General, Dr. Geikie, from the notes made by him when inspecting the area with me in March, 1885:—

Section on Coast N. of Manorcunningham.

A. GEIKIE, March 23rd, 1885.

“At the south end of the section where the rocks are first seen they seem to be dipping in a general northerly direction, but with cross joints or cross fractures obscuring the dip.

“A little further north, however, the meaning of this apparent confusion is explained. It is there seen that the phyllites with their limestone bands are really inclined at high angles in a general easterly direction, and that the apparent northerly dip is really cleavage. The bedding is perfectly distinct, being revealed not merely by colour bands, which are sharply defined, but by layers of different mineral texture. It is quite regular, but wavy and sometimes puckered, the long axis of the puckers running with the dip. The beds in many places split up along the bedding planes into bands, from an inch to several inches thick, each of which is cleaved.

“The cleavage presents some remarkable changes, traced along the strike, even of the same bed. While their general northerly dip, at angles of from 20° – 40° , is preserved, the cleavage-planes vary in angle, and even in direction, from bed to bed. After the production of the cleavage, there would seem to have been a subsequent series of movements whereby the cleavage-planes were crumpled into little anticlines and sinclines, the axes of which were determined by the lines of bedding between the phyllite-bands. Specimens can be obtained showing crumpled cleavage across the bedding.

“Everywhere the cleavage is accompanied with foliation. A fine sericitic mica has been developed along the cleavage planes; sometimes in such abundance that the phyllites pass into true sericite-schists. Hand-specimens of these schists, where foliation is unquestionably across the true bedding, could not be distinguished from the sericitic-schists of N. Scotland. There could hardly be a more instructive example of the way in which bedding is gradually effaced and is replaced by a totally different structure induced by cleavage, but which so resembles bedding that no one would be likely to take it for anything else. There may also be a minor foliation along some of the bedding-planes, but this question must be referred to microscopic examination.

“The amount of shearing due to cleavage cannot here be great, for the lines of bedding cross those of cleavage with apparently little distortion. Some of the minor curvatures or puckerings may possibly be due to shearing. But if so, this shearing must have been so singularly alternate and equable in maxima and minima that this explanation of the structure appears extremely improbable.

“A few hundred yards inland from the beach (which running in a general N.N.E. direction corresponds on the whole with the strike of the bedding) there occur massive bands of a coarse pebbly grit or fine conglomerate. These bands range with the phyllites among which they are intercalated, that is, in a general N. and S. direction, but their foliation is inclined, like that of the phyllites, in a prevailing northerly direction. No one, from a crag of this conglomerate, would probably form any other idea of its structure than that the rock is well-bedded, with a general northerly dip at angles varying probably from 25° or 30°

up to 50° or 60°. But, as in the case of the phyllites on the beach, this apparent dip is entirely deceptive. The rock is really inclined to the eastward like the phyllites among which it lies, and what is mistaken for bedding is a structure due to cleavage with foliation along the cleavage-planes. Originally the pebbles of white quartz, constituting the main portion of this mass, were probably imbedded in an argillaceous matrix. The fine mud or muddy sand forming this matrix has been converted mainly into sericite which now wraps round the pebbles as a kind of glaze. It is the presence of this argillaceous matrix which has permitted the rough cleavage that the rock has undergone. The quartz-pebbles have been in some measure re-arranged with their long axes parallel to the planes of cleavage, but the re-arrangement is not so well-marked as in other examples, though further search might disclose better illustrations of this structure, and even of the elongation of the pebbles in the same prevalent direction.

"There can, I think, be no doubt that this section affords the key to the structure of the more highly mineralized tracts further south and west. We here see that what on cursory inspection might be taken for a continuous section of many thousands of feet of rock dipping steadily northward for several miles, may not be more than a few hundred feet thick, and that instead of passing many successive horizons, along the coast section, we remain for several miles practically on the same beds, the line of coast and true strike of the rocks being nearly coincident."

Elsewhere the phyllites that come to the surface have characters in general like those above described. Some, however, as in Bank Hill, partake more of the nature of slate; but no band suitable for roofing slate has been discovered in the district here described.

The included grits vary in texture from fine to pebbly. In all of them the most conspicuous structure is the cleavage which dips northward, and strikes nearly E. and W. (W. 15 N. to W. 5 S.) In the fine varieties the cleavage may be so close and regular as to give the rock an appearance as if it were a pile of paper. Some of the coarse grits can be raised in blocks of considerable size; many of the finer kind are suitable for the chisel and for dressed work; and those that are thinly cleaved, as they rise in flat bedded slabs, are suitable for walling, and when large enough, for flags.

The grits and conglomerates occur in beds of irregular width, and apparently are more or less in lenticular masses. To the N.E. these beds strike about N. 15 E., but at Manorcunningham, and to the S. and S.W., they range about N. 20 to 30 W. Outlying masses occur at Listellian; due west of Pluck; at the margin of the area; and to the S.W. and S. at Trean, Kinraigy, Roosky Lower, and Rockstown. In the sandstones there are very black sericite partings that should be mentioned, as they have given rise to a belief that there is plenty of coal in the County Donegal.*

The beds of limestone occurring with the sandstone were

* This, although impossible, is an old tradition, as it is mentioned by Dr. M'Pharlan in his Statistical History of the county, written at the beginning of the century.

observed at the S.W. end of the beach section, in two places near Manorcunningham, N.W. of Ballyboe, where they are pebbly, and in the Listellian outlyer to the west of Pluck. In all these places the stone was worked a little for lime burning, but was found not to be of much value.

The principal limestone exposures are in Sallybrook, two miles east of Manorcunningham; south of that village, in two places in the townland of Raymoghy; in Labbadish (Leslie Hill), one mile to the S.W., and further S.W. in Lisclamerty. In these places the stone has been more or less worked for lime burning, and for road metal. For the latter it is not very well suited, because although in dry weather the roads mended with this stone are dry and good, yet in wet weather they become plastic. These limestones are generally associated with sericitic or micaceous schist.

The exact position of these limestones in the series is obscure. All the exposures seem to be portions of one set of beds that have been broken up, and displaced by thrusts and faults; the Sallybrook limestone being altogether forced out of the regular lie of the others.

In connection with the Sallybrook limestone pieces of the rare mineral phosgenite (*corneous lead ore*) were found in the townland of Monclink, while in the upper portions of those in Labbadish is a bed of pyrophyllite (cam-stone).

In the small tract at Castlewray, to the north of the estuary of the Swilly, the rocks are principally grits, with subordinate beds of schist, limestone, and diabase. In the grit the most conspicuous structure is an irregular cleavage that dips northward, and strikes from E. and W., or W. 15 N. Some of the grits are very little altered, and in them the cleavage seems to be replaced by oblique lamination. Their usual colour is a light greenish grey or blue, but they weather to great depths into rusty brown. This suggests that the colouring matter is carbonate or silicate of iron.

The older rocks are principally mica-schists and sericitic schists, many being quartzitic, while some pass into phyllite and pyrophyllite. Some of the cam-stones are locally used for lining fireplaces, and for hearths; while the clay or decomposed outcrop is used to make hearths, and for lining the furnace at the Lurgy iron foundry.

Associated with the older schists, limestones occur at Magheraboy west of Pluck, at Treanavinny nearly two miles to the south, and in Mondooy over two miles S.E. of Pluck. The Magheraboy stone is white and crystalline, and appears as if it could be raised in blocks suitable for chisel work; it seems worth looking after, because at the present time such a stone is much required in Letterkenny.

At Treanavinny and Mondooy, Upper, the limestones are schistose, and are interstratified with micaceous or sericitic schists. In both localities they are quarried, principally for road metal, for which they are ill suited.

*Strabane District.**

Schistose beds.—Nearly the whole area is occupied by metamorphic schists with bands of limestone. The schists vary in character but slightly, passing from mica schist to chloritic schist or quartzose schist, the change being so gradual that it is difficult to draw any decided boundary between these varieties. In some few places, however, the beds are decidedly quartzose, as at Loughan Hill, S.E. of Dunnamanagh, and at Craignagore E. of Strabane; at Black Park, between Strabane and Dunnamanagh also, there is a small outcrop of quartzose schist; as also N.E. of Ballindrait, where there are two narrow bands.

In the Strabane Glen beds of schistose conglomerate are seen, and on the north side south of Killymallaght a bed of conglomeritic schist crops out from under the Drift deposits.

In the neighbourhood of Strabane the dip of the schists is very low, but further N. the dip increases in a N. or N.N.E. direction; this is also the direction of the dip of the strata S. of Dunnamanagh, where beds of micaceous schist, dipping from 15° to 40° in a N.N.E. direction, may be observed in the channels of all the streams.

Knockavoe Hill, E. of Strabane, is formed of mica schist, evenly bedded, dipping N. 10 E. at from 3° to 5° . In the Workhouse wood a large quarry has been opened and is now being worked, where the beds are seen to be very even, dipping N.N.E. at 5° ; here they are slightly more quartzose. At Hollyhill the mineral called zoisite (a lime-epidote) has been recognised by Portlock as occurring in "greenstone slate."[†]

Half way between Tullyard and Castletown, in a large quarry, beds of brilliant mica schist are seen to be nearly horizontal, as is the case with those in the Evish burn.

In the stream of Artigarvan, E. of Ballymagorey, the beds are tilted up at high angles varying from 30° to 50° in a N.W. direction owing to a slight fault. Other cases of change of dip might be instanced, but will best be understood by reference to the map itself.

Metamorphic Limestone.—Bands of metamorphic limestone are rather numerous in this district. To the E. of the River Foyle the principal band can be traced from near Artigarvan along the road to Dunnamanagh, dipping north at angles varying from 30° to 40° . About half a mile south of the village the beds bend round gradually and dip in a N.E. direction at 25° to 30° ; south of Loughan Hill they are lost sight of, owing to the overspread of Drift deposits. This band consists of blue highly crystalline limestone making good road metal, and when burnt excellent lime. Immediately N. of Dunnamanagh a band of limestone, about 45 feet wide, is seen in the bed of the stream, but nothing more is seen of it owing to the deep deposits of gravel by which it is concealed from view; it is a bright blue limestone and makes excellent road metal. Besides the above there are several other

* By Mr. Wilkinson.

† "Geology of Londonderry," p. 209, also p. 212 where zoisite is stated to be associated with albite.

thin bands of limestone in the neighbourhood of Lough Ash ; and S.E. of Old Glen, on the boundary between counties Londonderry and Tyrone a good band of limestone, much waterworn, appears at the junction of the mountain bog and Drift, dipping N.N.W. at 10° .

At the back of Newtown House, in the town of Strabane, a narrow bed of very crystalline blue limestone is being quarried, and is said to make excellent lime when burnt: the beds dip N.N.E. at 5° .

West of the River Foyle, at Ratteen Upper, a broad band of similar limestone is seen at the base of Binnion, dipping N. at 10° , and a small exposure, of probably the same band, occurs at the top of the hill, and a little further W. it appears to be cut out on the west and east by a fault.

We have now to refer to the Longvale limestone quarry, which appears to be the most largely used in this district. The beds dip N.E. at 40° , and consist of fine crystalline blue limestone, with numerous veins of white calcite. When burnt it makes excellent lime, and is said to be far superior to that made from the Castle-caldwell (co. Fermanagh) limestone. The Londonderry Gas Company appear to be the chief consumers of the lime taken from this quarry.

A small outcrop is seen at Drunleene, dipping N.E. at 25° ; also S. of Cavan a small quarry has been opened, the beds dipping N.E. at 20° .

On the N. slope of Croaghan Hill a narrow bed of limestone dips at 25° E., and south of the Hill Head of Castletown another small band of this rock occurs.

Clay Slate.—A large slate quarry has been opened at Tamnasolus, about half way between Strabane and Londonderry, above the right bank of the Foyle. The beds consist of grey slate and tilestone, dipping from 40° to 60° in a northerly direction. An enormous amount of quarry rubbish has accumulated. The rock breaks easily along the cleavage planes into large flags, and in places appears to be very slightly metamorphosed.

*St. Johnstown District.**

Mica Schist.—Coarse schists, weathering white, passing into quartzose grits, are seen on the roadside half a mile south of Castledowey, three miles N.N.E. of Raphoe, and similar rocks make up the low hill at the cross roads close to the village. To the north much rock of the same character appears at Stoneyfall and Galdonagh, but shows less alteration, consisting in many places of micacized slates (phyllites). These are affected by cleavage, the direction and dip of which seem, in general, nearly to coincide with the bedding; but near Galdonagh Lower it is almost at right angles to it, and similarly this may also be said of the beds in the railway section to the north, where the schists

* By Mr. Nolan.

are interstratified with limestones. Farther north coarse grits and flaggy schists form a rugged knoll at Craig—whence the name—and to the west, about the road, they are associated with several beds of limestone. At Gortnacross the slaty beds were formerly quarried for roofing purposes.* To the north-east much rock may be observed in the railway cuttings and stream sections about Gortree and Glensmill. In the vicinity of the former are coarse micaceous flags overlying dark schists, which pass into shining slates, to be referred to subsequently. At Glensmill the stream descending the hill from the village of Dooish cuts through schists and hard green grits, very slightly altered, with earthy-looking limestone beds.

The country between this and the River Foyle is thickly covered with Drift, but rocks crop out in a few localities. At Listicall and Churchtown are schistose grits, some of which are calcareous, with cleaved, striped or banded schists. The cleavage in the latter has the same strike as the beds, but the dip is lower and in the opposite direction. Between Cloon and Kildrum there is much rocky ground composed of schist and schistose grit. The latter is compact and fine-grained, making very fair building stone. Coarse quartzose grits or schistose conglomerates make up the Hill of Ballougry near the River Foyle, and on the road from Letterkenny to Londonderry, near Milton Lodge, coarse schists or phyllites occur.

The district to the east of the River Foyle is occupied by rocks of similar character to those just described. In the south-eastern part of Sheet 11 schists and grits slightly altered are laid bare in the railway cutting north-east from Rosses Bay, and a remarkable section occurs close to the road on the left of the River Faughan, a little below Mobuoy Bridge. Here are chloritic-looking schists, with peculiar coarse gritty beds, containing semi-crystalline fragments of glassy quartz and felspar, giving a somewhat crystalline appearance to the mass. Rock of this kind will be again referred to when describing the country to the south, where "porphyry dyke" is marked on Portlock's map. A similar description is given of a rock at Rosses Bay, about a mile westward of Mobuoy Bridge; but the quarry where it was probably seen is now filled up. To the north of the River Faughan coarse chloritic-looking slates were obtained at Gorticross, and to the southward in the glen south-west of Gortree Hill.

At the Waterside, that part of the city of Londonderry on the right bank of the Foyle, rocks crop out in several places, and large quarries for building purposes have been opened near the bridge. The rocks here are shining slates (phyllites) and grits, many of which are calcareous. On the surfaces of some of the slates are black crystals, like nail heads, probably altered iron-pyrites.†

* Portlock says that slates from the Gortnacross (Gorticross) quarry have been used for roofing the offices of the Templemoyle Agricultural Seminary. They are "thick and heavy, requiring a strong roof, and though wearing tolerably well, have a tendency to absorb moisture and induce vegetation. . . . Some of the harder varieties are well fitted for tombstones, flagging, and gate-posts."—"Report on Londonderry," &c., p. 670.

† See "Petrographical Notes," pp. 38 & 39.

Schistose beds are visible in the right bank of the Foyle, at Prehen, and farther south they are associated with limestones. Eastward are several quarries in coarse slates and flags, the dip of the beds being southerly, while the cleavage dips at 50° to the N.N.W.

The ridge west of Hollymount and Glebe Town is composed of coarse schists, and to the south of it limestone is again met with in a quarry close to the road. Here the beds are much contorted, and are penetrated by a dyke of dense green diorite. At the west end of the quarry is a well-marked slickensided surface, due no doubt to the fault that shifts the dyke to the south, as shown on the map. Westward and southward from this place the country is mostly under cultivation, and little rock is seen; but massive quartzose grits compose a low fuzè-covered hill to the west of the road a little below Rushyland; and on the opposite side of the valley of the Burngibbagh, at the road half a mile from the county boundary, is a hard massive grit full of glassy quartz and felspar, having a general resemblance to a porphyry, and described as such on Portlock's map. On a little examination the mechanical origin of the constituents is quite apparent.

The hilly ground, called Killymallaght, immediately east of this locality, and that to the northeast, beyond the road leading to Dunnamanagh, comprising Curryfree Hill and Ned's Top, is mostly composed of coarse greenish schists, often of the quartzose pebbly character before described. Farther northeast, in the valley of the Faughan, a remarkable section may be observed in the river at the bend in its course due east of Ashbrook. There the slaty schists have weathered into peculiar forms, somewhat resembling monumental slabs, and are traversed by two wide dykes of diorite. Under this series, at the south, is a thick bed of limestone, being one of the many instances where limestone is associated with basic dykes or intrusive sheets of trap.

In the Berry Burn, and the other streams that cut deeply through the hilly ground southwest of the Faughan, schists are again seen, and in some places are interstratified with limestone, as noted on the map. On the top of Slieve Kirk, close to the county boundary, coarse schists crop out in several places, and a bed of quartzite appears at the margin of the peat bog to the east. On the southern flanks of the mountain are coarse schists forming massive crags overlooking the valley, the upper part of that which in the district to the east, included in sheet 18, is called Bond's Glen. This valley is remarkable for the very frequent association of schist with limestone, as described in the Memoir to accompany that map,* as also for the example it affords of an ancient river course. Evidence of this, in the form of terraces about 12 feet above the present stream, occurs in the lower part of the glen, and has been cited in the Memoir just referred to (p. 9), while here, the very remarkable isolated mass west of the hamlet called Rock, is another instance of the same kind.† The

* Explanatory Memoir to sheet 18, p. 13.

† These old river terraces, now left high and dry, probably belong to the period when the land was somewhat lower as regards the sea-level than at present. They are, in fact, the alluvial representatives of the raised beaches of the coast.—E. H.

schists in this valley are often of a fine-grained quartzitic variety, passing almost into quartzite. Some of them, too, are slaty, and according to Portlock, would probably prove of economic importance if properly worked. (See reference to Kildoag quarry, situated in this glen, in the "Report on Londonderry," &c., p. 670.)

Clay-slate passing into Phyllite.—In some parts of this district the rocks are very slightly metamorphosed, the schists passing into shining slates, and these into a variety differing very little from ordinary clay-slate. To the west of St. Johnstown these slightly altered beds occupy a tract of about three miles from east to west, and about two miles from north to south. The chief locality is at Glentown, where extensive quarries have been opened in slates, chiefly for roofing purposes.* The quarries, however, had to be abandoned, the slates proving so thick and heavy that, even at a comparatively low price, they were unable to compete successfully with others in the market. The bedding planes here, as indicated by bands of colour and of lamination, indicate a dip to N.N.W., with some undulations, while the more prominent planes of cleavage dip E.N.E. and E. at 25° ; there are other planes, which may be joints, that dip S.W. at 80° . It is remarkable that while the cleavage surfaces show scarcely any trace of micacization, this character is well developed on those of bedding, and to this circumstance the absence of fossils is probably due. Similar slates also showing a cleavage dip to E.N.E. crop out in many places on the hill to the east of Glentown, in the vicinity of the large tract of diorite, and also on Dooish mountain, to the north. Here are several quarries, the principal being that on the north-east part of the mountain, close to Ballycushion. The slates are quite similar to those at Glentown, and like them show banded structure and dip to N.N.W., the cleavage dipping at 25° to E.N.E. There is also a remarkable system of joints bearing N.W., and inclining to N.E. at 60° . As at the Glentown quarry, the slates here also proved unsuited for economic purposes.

In the railway cutting to the north-east at Gortree, slates also appear, but they are somewhat more micacized than those just described, and pass into the ordinary mica schist of the district at both ends of the section. Similar transitions from slate to schist were observed near Londonderry, on the elevated ground immediately south of the Waterside.

Coarse Quartzose Grit (Schistose Conglomerate).—Associated with the slates, as with the schists, are numerous beds of coarse quartzose grit, which in some places may be termed a conglomerate. The presence of these rocks here is important, as proving the schists and slates to be portions of one system, and accordingly we find the schistose conglomerates, when traced into the slate area, are little, if at all, micacized. At Kinnacally, on the margin of the slate area, W.S.W. of St. Johnstown, greenish gray, quartzose,

* For microscopic description of these slates, see "Petrographical Notes," p. 88.

micacized grits occur, but at a little distance to the west, close to the diorite, the grit is not at all micacized. North of the trap, micacized grits occur in a tongue of schist among the slates, and again in a similar tongue of schist south of the Glentown quarry, where they are very coarse, and have a well-marked schistose structure. Where they occur in the slate district on Dooish Mountain they are cleaved like the adjacent beds, and not micacized, but on the north-east slope of the hill, where they are found among the schists, they have a well-marked micacized base.

Limestone.—West and north-west of Mullaghsawny Hill, three miles N.E. of Raphoe, pale gray schistose limestone is seen in the stream between the hamlet of Momeen and the road from St. Johnstown to Raphoe. As these beds dip constantly eastward, the limestone appears to have a considerable thickness, but it rapidly thins away to the north and south. Impure schistose limestone appears on the roadside at Slievebuck, westward of this locality, and to the northward are many similar beds that pass into crystalline limestones. Still northwards, thick limestones, alternating with dark steatitic schists, are seen in the railway cutting north-east of Monclink, and many small impersistent beds of limestone schist crop out in the vicinity of Dundaff's Fort, and Drumbarnet Middle. Here, too, the limestone is associated with the dark steatitic schists noticed at the railway section.

In the country east of this to the Foyle there is very little limestone, the only beds noted being one at Coxtown, west of Carrigans, where there is a quarry in thick beds of compact schistose limestone; another east of the same village, near White House, where it is associated with a dyke of diorite; a small one at a mile to the N.E., and several at Monglass, two miles north of Carrigans, where several quarries have been opened in massive blue crystalline limestone.

In the country east of the Foyle thick blue limestones are quarried at New Buildings, and a little north of the village, towards Prehen, are similar quarries. South-west from the village, are two localities marked on the map where limestone was formerly raised, but none is obtained there now. Half a mile south of Tullybridge, in this vicinity, a quarry was opened in blue crystalline limestone.* The beds are cut across on the west by a dyke, which will be noticed further on, and a similar association of limestone with basic dykes is seen to the north-east, close to the Burngibbagh stream, and further north-east, in the valley of the Faughan, near Ashbrook, as already stated.

In the small stream that flows into the Burngibbagh, west of Curryfree Hill, are calcareous schists, passing into blue schistose limestone, and associated with dark talcose-looking schist, like that before noted in other localities. On the east part of the top of Slievekirk, eastwards of "Old Glen," is a quarry in crystalline limestone, in great part schistose, with lines of pebbles of quartz. Large veins of white quartz traverse the beds, and contrast forcibly with the dark blue limestone. Several beds of

* For a petrographic description of this limestone see p. 38.

flaggy and schistose limestone also occur in Bond's Glen, in the valley south-east of this mountain. This district has been already referred to in the Memoir to accompany the adjoining Sheet 18.

*Raphoe District.**

Mica-Schist.—Amongst the lowest beds in the sheet are certain black and dark-bluish fissile schists, which occupy a small area in the extreme S.W. corner. These form a portion of a well-marked band which strikes in a N.N.W. direction into the adjoining sheet (No. 16), in which they are intersected by faults. In some places they contain a quantity of iron pyrites, which, by decomposition, causes the percolating water to be highly charged with iron. In the area lying immediately to the north and east, including Convoy, Raphoe, and Ballindrait, the mica-schist which underlies so large a portion of the district is greatly concealed from view by the Drift deposits. It is found, however, in several places, associated with subordinate bands or larger masses of limestone, and is generally rather dark in colour, but more silicious and less fissile than that last described. A few beds of dark argillaceous schist occur with the harder beds that overlie the limestone at the roadside a little west of Raphoe.

Layers of dark ferruginous and fissile schist occur among the more quartzose beds which extend N.W. of Raphoe by Mongorrry Hill, and also at intervals among those to the east, on Mullafin, &c., and it is likely that the intervening lower ground is chiefly occupied by the same rocks. A chalybeate spring issues from black schists on the eastern flank of Mongorrry Hill, and the occurrence of these beds, partly stained with iron, has led some of the inhabitants to believe that coal exists in the locality.

Dark gray mica-schist, containing slender needle-like crystals of actinolite, occurs in conjunction with a mass of schistose diorite on the hill north of Raphoe. Examples of the same mineral in metamorphic limestone under similar conditions will be referred to further on.†

Quartzite—Quartz-schist. — A conspicuous mass of white bedded quartzite, known as the "White Rock," occurs in the flat ground E.S.E. of Loughery's Town, in the S.W. of the sheet; and rocks of the same character, occasionally interstratified with other quartzitic beds, distinguished by the presence of a foliated structure, are numerous developed throughout the elevated ground that extends northward by Findrum and Carrickbrack. Beautiful examples of minute and sometimes sharply-crumpled foliation occur, accompanied by the development of small flakes of mica, in planes which may either be distinctly marked, or else pass into merely a high condition of micacising, hardly apparent

* By Mr Egan.

† Beds of greenish-coloured earthy mica-schist, W.N.W. of Leight, have been quarried to a small extent for hearthstones, sides and backs of grates, &c., as they stand intense heat without injury, and can be sawn into convenient slabs.

Soft glossy schist, also greenish in colour, abounding in scales of dark mica, and having a very soapy feel, occurs among other beds along the stream at the place called "Black Repentance."

except when the rock is fractured in a favourable direction. It is not easy, in general, to determine the planes of bedding, except by the occurrence of an occasional layer of mica-schist.

The quartzose rocks at Leckan, to the S.E., are similar to those of Findrum and Carrickbrack, and in each locality they are traversed by veins of white quartz.

Interstratified beds of quartzite and quartz-schist (the foliated varieties being here distinguished by the latter term) come extensively into view in the area lying to the N.W. of Raphoe. The bedding is here easily distinguishable, and throughout these rocks also there are found bands and layers of dark gray and fissile black schist.

The lowest beds of quartz-schist pass, to the N.W. of Figart Lower, (S.W. of Raphoe), into a coarse grit, resembling the finer descriptions of schistose conglomerate which is found in many other places in this sheet. Here, and on Mongorry Hill, and to the west of Raphoe, veins of white quartz also penetrate the quartzose beds.

Limestone.—This rock is generally fine-grained and highly crystalline, the texture occasionally becoming somewhat coarse. It is generally of a bluish gray colour, and more or less schistose, with frequently a delicately banded structure showing lines of lamination in different shades of blue and gray. Sometimes, also, it is white, and in part would be sufficiently compact to constitute a marble, were it not that in this case it is often sharply crumpled into curved and zig-zag foldings, rendered very conspicuous by dark irregular micaceous bands, along which the rock easily breaks. On account of these bands the rock cannot be advantageously worked as marble.

South and east of Convoiy, in the river Dee, there are thin beds of blue micaceous crystalline limestone, containing veins of quartz and calcite, and scattered grains of iron pyrites. These beds are sharply folded in a few places, and are similar to those in the river close to Convoiy House. They often contain pot-holes, worn into them by the action of water on pebbles, or small boulders, which may sometimes be found in the holes. These hollows are circular, or nearly so, ranging in diameter from two inches to nine inches, some of the larger size being one foot deep. Immediately west of the porphyry dyke are crumpled beds, partly white and highly crystalline, with dark partings and thin laminæ. Some are hard and very fine-grained, and if quarried would probably yield small blocks of comparatively good and solid marble. In some cases the darker laminæ are arenaceous, and exhibit a structure resembling oblique lamination. Beds of the same general character occur in the river at Kiltole, a little below Convoiy. Here some of the dark seams, which form beautiful miniature contortions, contain small crystals of actinolite and specks of iron pyrites. The limestone at Kiltole rests on dark mica-schist, subordinate bands of which, as well as of quartz-schist, occur higher up in the section and in other localities in the district. Actinolite is even more plentiful in indurated limestone in the river Dee, at Damback, 150 yards east of the bridge, south

of Convoy. These beds are evidently the same as those at Kintole, but are more hardened, probably through contact with a mass of hornblendic trap, blocks of which lie at the surface of a boss a little to the eastward.

The presence of actinolite, and the accompanying high degree of induration which has converted the limestone into a rock differing considerably from the ordinary limestones of the district, are conditions evidently dependent on the proximity of hornblendic rocks, which have themselves been subsequently metamorphosed. Similar examples were observed as follows:—At M'Caul's Town, on the south margin, a few yards east of the main road, a rocky boss contains a clear section through greatly crumpled thin beds of schist and limestone, ranging from half an inch in thickness to nine inches. Some of the thinner beds are composed of a white very hard rock, slightly calcareous, and abounding in slender prisms of black and greenish actinolite. Here, also, quartzite containing a few similar crystals occurs, and dark gray mica-schist in which they are more sparingly developed. Some of the beds are clearly affected by cross cleavage. These beds are in immediate conjunction with a mass of schistose hornblendic trap rock. The harder among them, in which actinolite is most abundant, are slightly calcareous, and are evidently highly metamorphosed forms of the limestone. Less altered portions, from which that mineral is absent, occur among them as distinct laminae.

Actinolite occurs in indurated limestone in contact with schistose diorite, lying in the same general strike, to the N.W. of M'Caul's Town, at a point N. of Rockfield; again, a little higher up on Carnowen Hill to the N.E.; and, again, in a boss of white crystalline and crumpled limestone on the south margin of the map at longitude $7^{\circ} 38' 25''$. This contains dark partings, which, being harder and less weathered, bring out in fine relief the sharp foldings of the beds. Beneath an exposed face is a mass of dark schistose trap, close to which actinolite occurs in the limestone.

Another locality where actinolite occurs is in the lane which runs S.S.W. from Powderly, a little S. of the cross roads at Leaght. Here, in a slight excavation, a mass of dark trap has been found in contact with indurated white limestone containing prisms of actinolite.

The white limestone of Carnowen Hill, a short distance N.W. of Breagy, where it is associated with sheets of schistose diorite, is quarried for road metal, for which, however, most of it is not well adapted, owing to its softness. Some beds are harder, and would be suitable for statuary marble but for the presence of micaceous bands.

Thin, crumpled, and hardened beds of limestone and quartzite occur in a small plantation at Knocklee, nearly two miles S. of Convoy, and here also they are contiguous to a mass of metamorphosed diorite; similar beds occur again S.W. of Ballindrait.

The lime produced in this district is generally of good quality, the best being obtained from the bluish gray crystalline rock.

For this purpose many small openings have, from time to time, been made by the farmers in their own lands. Some larger quarries exist, as, for example, at Powderly, where the rock comes out in fine flags, one of which measured on the ground 6 feet by 4, and 4 inches thick. Above and below a band of purer limestone, are mixed beds of quartz-schist and schistose limestone. These beds contain a few veins of quartz and calcite.

In a quarry at the cross-roads, S.W. of Kilmonaster, the limestone dips in various directions, and consists, in the lower part, of thick beds of blue, finely-crystalline rock, above which come thinner beds, whitish, and variable in texture, with darker layers as thin partings; and also thin fissile layers of mica-schist.

Very good limestone is quarried at half a mile S.W. of Raphoe. It is highly schistose, and exhibits a foliated texture in very distinct lines of white and dark gray, as is common in this and some other localities, (as at Green Hills, S.E. of Convoys, &c.)

At Magherasollus, a little N.E. of Raphoe, a quarry to the west of the road contains beds of delicately-marked, fine-grained, blue and white marble below blue limestone.

The lowest beds of limestone near Gortaquigley are light coloured, and more or less schistose. At Dromore these are in part succeeded by compact and darker coloured limestone, some beds of which exhibit a finely-crumpled foliation, others being very delicately laminated, apparently along planes of deposition. These beds contain strings of white calcite, often associated with quartz.

Hornblende Rock passing into Schist.—A large irregular mass of highly schistose diorite occurs on the hill north of Raphoe. It is of a dull greenish gray colour, becoming lighter by weathering, and consists of felspar intimately mixed with a large amount of hornblende. This mineral crystallizes out also indistinctly, and occasionally appears in large broken crystals an inch or more in length, which often project and give a rough aspect to the weathered surfaces. This mass of trap, which is clearly intrusive into the quartzite and mica-schist, probably forms one of the principal volcanic necks already mentioned in the General Description. The smaller mass of trap east of Raphoe is similar in character to that on the hill, and, no doubt, represents a minor outburst from the same source. Other examples occur to the west of this, as at Tullydonnell, N. of Convoys, and, again, to the N. at Cornagillagh and Flemingstown.*

The schistose diorite of Carnowen Hill, S. of Raphoe, occurs in large masses, probably intruded in lenticular sheets among the beds of schist and limestone. That composing the wide irregular band immediately S. and W. of the highest point, comes to view in many bosses, showing a conspicuous structure suggestive of bedding, which corresponds in direction with that of the limestone above and below. It consists of a dark greenish gray foliated rock,

* The masses here described near Raphoe and Convoys are referred to by Dr. Hyland as forming exceptions to the generality of the hornblende rocks of this district as regards their original constitution. See Petrographical Notes, p. 34.

in which the hornblende is in general easily distinguishable. The planes of foliation present a glistening appearance, no doubt the result of the great shearing force, to which the whole of the rocks here, as in many other localities, seem to have been subjected. Similar rocks are met with on Croaghan Hill, S. of Ballindrait, on the western flank, forming a succession of bands of altered limestone, black mica-schist (some of which contain hornblende), and hornblendic schist.

Several minor examples of these altered sheets of trap occur, which are indicated on the map, and to which it is unnecessary specially to refer.

On the very edge of the map, and S.W. of Leaght, there has been quarried a dull greenish-gray schistose rock, known locally as "cam-stone," soft and earthy, and having a greasy feel. In some parts it has a fine fibrous texture, from the presence of some hornblendic mineral; and it is speckled with small cavities containing red ferruginous powder, due to the decomposition of iron pyrites. Enclosed within this rock, and chiefly occurring, so far as it was observed, in the form of a coating round small irregular nuclei of the harder mass, is occasionally found light greenish asbestos, also quite greasy to the touch. This rock, as a whole, may perhaps be best described as an actinolite schist, having combined with it a large quantity of magnesian silicate. A structure resembling rude bedding causes it to break off in irregular slabs, not, however, lying parallel to the beds of limestone, which occur a little above it to the east. In the same quarry was excavated the *débris* of a highly schistose and fissile mineral, having a minute fibrous structure, with the same greasy touch, and evidently another and less pure form of the asbestos, produced probably by shearing motion within the mass.

The rock just described is used in this district for the purpose of lining kilns and fire-places, for hearth-stones, &c., as it is uninjured by contact with fire. A somewhat similar rock, and used for the same purposes, occurs at Camus, close to the edge of the sheet, three miles west of Strabane. It is composed of dark hard hornblendic trap, slightly schistose, and weathering to a softer mass, the latter being the more highly valued, not only because it resists the heat better (that is, without cracking), but also because, like that near Leaght, it can be easily sawn into any required shape.

Portions of the schistose trap-rock before referred to in connection with the altered limestone at M'Caul's Town, have also been used for lining kilns, and prove to be well-suited for the purpose. They remain quite hard after years of use, having turned red through the action of the fire.

The argillaceous schist N.W. of the "cam-stone" at Leaght, already mentioned as being put to similar uses, is also locally known as cam-stone. It answers very well;—intense heat rendering it hard, and firmly uniting portions which would otherwise separate along planes of foliation.

CHAPTER IV.

LOWER CARBONIFEROUS ROCKS.*

A very small tract of Carboniferous rocks comes within the limits of that part of Sheet 11 described in this Memoir, viz. :— at Coolkeeragh, about four miles N.E. of Londonderry. The beds appear on the shore and in a quarry which has been opened for building purposes close to the railway station. They consist of red, pebbly, and in part friable, sandstones with soft shales, and belong probably to the Calciferous Sandstone group, being a portion of the large tract of that formation extending to the east, in the district included in Sheet 12.

CHAPTER V.

IGNEOUS ROCKS.

*Strabane District.**

Felspathic Dykes.—At Claggan a dyke of felstone-porphry is seen in the bed of the stream, and can be traced for about a mile and a half to the eastwards. It consists of a chocolate-coloured felspathic paste, with distinct crystals of brownish felspar, which on the surface weather pinkish white. At the back of Newtown House, Strabane, a small dyke of pale greenish felstone occurs; and on the roadside, between Lifford and St. Johnstown, is a dyke of similar rock.

South of Lough Ash, on the roadside, a very small dyke occurs; it appears to be *in situ*, and to be a dark greenish hornblende rock.

*St. Johnstown District.**

Diorites (Epi-diorites) of Dooish Mountain and St. Johnstown.†
—To the west and north-west of St. Johnstown, chiefly in the area occupied by the slates, are several intrusive masses of hornblendic rock. Their trend for the most part coincides with that of the associated slates and grits, but their intrusive character is abundantly proved in many places. The largest of these masses is that which forms the low rocky eminence north of Treantagh, and extends for a mile and a half to the north-east, where it has the greatest width. Though apparently conformable to the bedded rocks in its narrower portion to the south-west, it cuts directly across them northward of Kinnacally. It consists of a dark green finely-crystalline aggregate of plagioclase and hornblende, crystalline in the centre but schistose at the margin, this change being especially noted in the south-west portion, where there is a transition into hornblende-schist. To the north-west five dykes of similar character, but

* By Mr. Nolan.

† Petrographical Notes, p. 33.

of smaller size, traverse the slates at the wild tract called Dooish Mountain. Like the larger mass, these sheets are usually conformable to the bedding of the slates, but cut directly across them in some places, as at the quarry west of Ballycushion, and towards the south-west, a little to the left of the road that crosses the hill.

Dykes, probably of same age as above.—To the east of Carrigans, a dyke of very dark green diorite was observed in a limestone quarry, and on the opposite side of the Foyle, in a similar quarry, is another dyke full of beautiful crystals of asbestiform actinolite.* Still eastwards, in the vicinity of the stream called Burngibbagh, diorite is again found in connection with limestone, and in the Valley of the Faughan, near Ashbrook—also associated with limestone—are two thick dykes of similar rock. Many of these diorites are schistose at the margin, so that it is not improbable they are of the same age as the larger masses just described.

Raphoe District.†

Basalt.—Of the basalt dykes, which, as previously stated, are probably of Tertiary age, a well-marked example occurs at Breagy, three and a half miles S. of Raphoe. It consists of finely-crystalline basalt, and has a width of three yards, cutting due N. and S. across the beds of limestone. It appears a little further S. in a limestone quarry, west of the road.

A narrow dyke of fine basalt enters the map from the south, near the S.W. corner, having been traced across the limestone district, by Cloghcor,‡ northward to a point near Leckan. Possibly the same dyke extends one mile and a quarter further north, being slightly exposed at the surface a little south of Green Hills.

Immediately west of Bogagh, two miles south of Raphoe, fissile beds of quartz-schist are crossed by a four-feet dyke of hard basalt, bearing N. and S.

Diorite.—A sheet or flat dyke of diorite, of later age than the altered trap rocks already described, forms a ridge seventeen yards wide, running parallel to the road east of Loughery's Town (S.W. corner of the map). It is principally finely granular, of a dark gray colour, and is composed of felspar and hornblende, thickly crowded in many parts with small prisms of the latter mineral. It weathers reddish, and felspar not unfrequently occurs in minute crystals, distinct from the general mass. Thin beds of schist and limestone are seen in contact with the trap where it bends westward from the road.

West of Carrickbrack a large dyke of diorite passes into the map, cutting through beds of quartz-schist and a band of lime-

* See Petrographical Notes, p. 25.

† By Mr. Egan.

‡ Memoir, Sheet 25, p. 17

stone, and reaching a width of thirty-five yards in one part. It consists of a dark gray and bluish felspathic base, breaking with a rough fracture, and abounding in black crystals of hornblende. Occasionally these are absent, and the mass becomes more compact, and inclined to break with a conchoidal fracture. A narrow dyke of similar trap rock traverses the extensive area of quartz-schist immediately to the S.E., in widths of one to four yards. Here it contains caught-up pieces of quartz.

Felstone.—Most of the felstone dykes in the Raphoe district present one general character as to composition and texture, differing in both in slight degrees—in the former chiefly on account of variable amounts of hornblende, which mineral is generally present in some quantity. These varieties exist sometimes in different parts of the same dyke. The rock occurs, as a rule, not in highly-inclined dykes, but rather in intrusive sheets or flat dykes, possibly intruded sometimes for short distances along the planes of bedding, which have to a great extent determined the course of these eruptive masses.

Among the felstone dykes worthy of notice may be mentioned those to the W. of Raphoe. On, and close to, the old road from Convoys to that town there occurs a red granular felstone, abounding in small prisms of black and greenish hornblende. Here it forms a mass about 180 yards in width, measured at the surface. Further north, in the small plantation at Ardvarnock, the same rock appears, with a decidedly columnar structure. To the east of Bawn this trap comes to view in two separate masses, about eight feet and five feet thick respectively, cutting up clearly at low angles through beds of limestone and calcareous schist, and partly intruded between them.

The felstone dyke of Carnagillagh occurs in continuous masses or low bosses, which attain a width of twelve yards. This rock consists chiefly of a bluish compact felspathic base, with many hornblende prisms, which are easily detected in the lighter weathered portions. Small specks of iron pyrites are also found.

A well-marked dyke of felstone forms a ridge 15 yards wide, close to the stream between Cooladerry and Coolaghy, S.E. of Raphoe. It consists of a compact red felspathic base with obscure specks of hornblende. Another is found a little to the north, partly of the same character, but generally coarser in texture, of a gray colour, and containing very distinct black crystals of hornblende. The jointing is regular, especially in the former case, and there is a marked tendency, as in many of these felstones, to assume a columnar structure.

Crystalline-granular felstone, hard and extremely tough, of bluish-gray colour and containing hornblende, forms a dyke 15 yards wide S.W. of Tullyrap, E. of Raphoe. It cuts through beds of dark micaceous and quartzose schist. In some parts it passes into a fine porphyry. A boss of similar trap occurs at a short distance to the south.

On the E.S.E. part of "Tops" hill (S. of Raphoe) an intrusive sheet of felstone 10 feet thick is exposed in a quarried face, lying

partly in the planes of bedding of mica-schist. It consists mainly of a dark reddish-coloured hard felspathic base, finely porphyritic with lighter-coloured felspar crystals. The rock has a platy structure, which causes it to come out in rough slabs when quarried. In part it passes to a compact felstone, of a decidedly bluish colour. It furnishes a good hard material for road metal.

Felstone-Porphry.—A ridge composed of this rock enters the map on the southern margin, and can be traced, with a course interrupted by faults, for about three miles in a north-westerly direction towards Convoy. West of M'Caul's Town it reaches a width of 25 yards, having a steep face about twelve feet high on the west side, and exhibiting a closely-jointed rude columnar structure. To the south, in Sheet 25, its position as an intrusive sheet among beds of limestone is seen. Here the actual thickness of the sheet is approximately represented by the scarped face just now mentioned. At 500 yards S.E. of Rockfield this mass is seen at the east side of the road cutting up obliquely through beds of quartz-schist and dark glossy mica-schist, specimens being obtainable with portions of these rocks adhering to it, which show the planes of foliation abruptly cut off by the intrusive mass.

In a fresh fracture where the porphyry has not been discoloured throughout by weathering, it has a bluish-gray colour, and contains distinct crystals of white felspar, which occasionally reach an inch in diameter, but are generally not more than one-tenth of an inch. These incline to a pinkish colour in weathering. Hornblende exists in very variable quantity, sometimes abundant in black or dark-greenish broken prisms, at other times nearly absent; and now and then forming nests of small prisms crowded together. Iron pyrites also appears in small specks, and occasionally a little silvery mica coating the felspar, and to a very small extent in separate scales.

The course of this mass of felstone-porphry is easily followed by the east of Holmes Town, north of which it is seen clearly to have been displaced by the fault which passes in a N.E. direction. At one mile S.E. of Convoy this sheet of trap crosses the main road, and appears on each side of it, having a width of about 10 yards.

The dyke of felstone-porphry crossing the river Dee at Convoy is in character generally similar to that just now described, but rather harder and more uniform in texture, consisting of a close, compact, dark-gray base with numerous small whitish crystals of felspar, and a very small quantity of quartz occurring in blebs.

Two miles S.W. of Ballindrait two intrusive sheets of porphyry traverse beds of schist, having widths at the surface ranging from 2 to 25 yards. This rock is readily distinguishable by the light colour with which it weathers. It is variable in texture, and in the manner of distribution of hornblende and mica, which are sometimes present; and is precisely similar in some parts to the rock already described S.E. of Convoy. A sheet of porphyry of the same description traverses the limestone and quartz-schist on Croaghan Hill, to the east.

CHAPTER VI.

GLACIATION.

*St. Johnstown District.**

Ice striae.—A little north of New Buildings, on the right bank of the Foyle, striae bearing W. 35° S. occur at a height of 250 feet; and on the opposite side of the river, near St. Johnstown, several striae having a similar direction, and at elevations up to 380 feet, were noticed on the ridge of igneous rocks, west of that village. These appear to indicate a movement of the ice sheet towards the W.S.W., and are probably due to ice from the Scottish area, as has been already stated in the General Description (page 9).

Erratic Blocks.—Numerous boulders of granite resembling that of Barnesmore have been found on Dooish Mountain, and to the north-east of it at Creeve Upper. Blocks of granite and of a largely crystalline hornblende rock, foreign to this district, occur as standing stones, probably remains of an ancient circle, at three-quarters of a mile W.S.W. of Carrigans, and were perhaps erratic blocks found on the spot or in the vicinity, and utilized by the ancient inhabitants. As the blocks are never imbedded in boulder clay, but are found on the surface, sometimes on bare rock, they were most probably deposited from floating ice during the latest period of glaciation.

Raphoe District.†

The S.W. part of the district is, except in a few localities, overspread by a deposit of boulder-clay, from below which, as it thins out in the more elevated spots, the underlying rock appears, forming bosses and craggy masses which sometimes furnish evidence of glacial action.

Rounded blocks of granite, apparently identical with that of Barnesmore, fifteen miles to the S.W., are met with occasionally; but as these occur either on the surface of the Drift, or close below its surface, and as other observations seem rather to indicate a great movement of land ice from the east, it is more probable that these blocks were deposited from *floating* ice coming from the S.W., at a later stage of the Glacial period than that of the boulder-clay, as suggested by Mr. Nolan.

A large rounded block of granite lies imbedded in the surface of the drift at Cooladerry, S. of Raphoe, and another a little S.E. of this, by the side of a lane close to the plantation. The former measured 12 × 9 × 8 feet, and the latter 5 feet in diameter. A block, 6 feet in diameter, stands by the stream, S. of Daisy Hill, near Tullyrap; and well-rounded granite boulders are dug out close to the surface of the Drift at Drummucklagh, N. of Tullyrap. East of Tullydonnell large boulders rest on the Drift clay, one of granite, measuring 7½ × 7½ × 5 feet; one of quartzschist, 12 × 8 × 5 feet; and a smaller block of hornblendic trap also occurs here.

* By Mr. Nolan.

† By Mr. Egan.

Ice Striæ and Grooves cut by Ice going north-eastward and eastward down the Valley of the Swilly and into (?) the Valley of the Foyle.

NORTH OF RIVER SWILLY.

Rough Park, striæ ranging N. 25° E.
Camblestown, striæ ranging N. 25° E.
Bogay, crags dressed by ice going N.N.E.

SOUTH OF RIVER SWILLY.

Trimragh, N. 60° E. grooves on several surfaces. The rocks all ice-dressed, but now much weathered.

Manorcunningham Church Land, grooves ranging N. 35° E.

Manorcunningham, grooves ranging N. 35° E.

Ballyboe, striæ ranging N. E.

Tullybogly, grooves ranging N. 35° E.

Magheraboy, grooves ranging N. 80° E.

Kincraigy, N. 70° E. striæ on several crags.

N.E., striæ in several places on the eastern slope of the crags.

Roosky, Lower, the crags dressed by ice going N.E.

Eden, striæ ranging N. and S.

Findrum and Leckan, ice-moulded rocks.

Mullafin, N. of Raphoe, striæ and grooves ranging N. 40° E. and S. 40° W.

Flemingstown, striæ ranging nearly N. and S.

CHAPTER VII.

DRIFT DEPOSITS, RAISED BEACHES, AND TERRACES, AND RECENT ACCUMULATIONS.

*Manorcunningham District.**

Sand and gravel occur, resting on the Glacial Drift, as seen in the railway cuttings, townland of Monclink. These were extensively used during the construction of the Lough Swilly Railway for ballast and in the mixing of mortar. Beds of sand also occur in the Ballyboe ravine where the railway crosses it, a little west of the R. C. Church.

Erratic blocks are rather scarce, owing probably to their having been broken up and used for farm purposes, many of the prehistoric megalithic structures having been similarly treated. At Trimragh, near the margin of the "Isles," is an assembly of blocks, the largest being called the "Giant's Rock," from the ancient

* By Mr. Kinahan.

markings on it. These blocks are interesting as they illustrate the lasting qualities of some of the sandstones, and the great size in which they might be raised. The large granite erratic, S.W. of Pluck, has already been mentioned. Many of the long ice-worked grits have been placed as standing stones (*dallan*) in prehistoric times.

Raised Beaches occur in places along the Swilly estuary and lough. In this area only one was observed, about half a mile S.W. of Balleeghan Abbey. It consists of a shelly coarse gravel, below the 25 feet contour line, and about 10 feet above high-water mark of spring tides. At this locality there is also one of the ancient *Shell Heaps*. The new road from Letterkenny to Strabane traverses a very deep bog on the watershed between the valleys of the Swilly and the Foyle.

The Isles lie along the margin the estuary of the Swilly. We learn from Dr. M'Pharlan that at the beginning of the century they were "salt marsh" and "slob land," and that about then they were intaken from the sea. In places in these mud-lands there is good brick clay; none of what occurs in this area has been used of late years, but further westward, at "Milk isle," fair bricks have been made.

*Strabane District.**

Boulder Clay, Sand, and Gravel.—Light deposits of boulder clay occur on each side of the River Foyle, and are of no particular importance.

Gravel.—In the neighbourhood of Dunnamanagh the gravel and sand deposits are of great thickness. Here the Burdennet stream has cut its channel down through these deposits, showing in places beds of stratified sand and gravel sometimes 150 feet thick. These gravels have been deposited well up the hill sides, especially about Moor Lough. The pebbles consisting chiefly of quartzite and grit, are well rounded, and are in part derived from the Metamorphic beds and from the Lower Carboniferous Sandstones.

Old River Gravel.—A small area of old river gravel occurs opposite Strabane Workhouse, and is laid open in the railway cutting S. of Strabane station; it is about 20 feet higher than the present alluvium. The origin of these gravels is referred to in page 5.

Raised Beach.—A small portion of the 25-feet raised beach, which occupies so large an area to the east, comes just within the limits of that part of this district included in Sheet 11. It has already been described in the Memoir to accompany Sheet 12.

St. Johnstown District.†

Boulder Clay.—Most of the ground about St. Johnstown is covered with this deposit, which in the valleys frequently attains a

* By Mr. Wilkinson.

† By Mr. Nolan.

considerable thickness, and clothes the sides of the hills to a height of about 900 feet. It is a stiff, grayish, unstratified mass, full of angular and sub-angular pieces of local rocks, no blocks derived from distant localities having been observed. In the district to the east, shells are found, apparently in pockets of a peculiar chocolate-coloured clay, but nothing of the kind was noticed here. (For description of these peculiar deposits with the included shells see Memoirs to accompany Sheets 12 and 18.)

Sand and Gravel.—Terraces of sand and gravel occupy much of the country on the east of the Foyle, in that part of the area described included in Sheet 11. The lowest of these, which stands at an elevation of 50 feet, is a portion of the extensive plain that forms a peculiar feature further east in the vicinity of Eglinton (Muff) and Limavady, already described in the Memoir to accompany Sheet 12. Here it occupies most of the country from Coolkeeragh south-westwards to Rosses Bay, whence it extends in a rather narrow strip to the Waterside district of the city of Londonderry, the military barracks being built upon it. In this area, the terrace is chiefly remarkable for the great number of lakes and lakelets found on its surface, of which the Loughs Enagh, west of Mobuoy-bridge, are the largest. It is difficult to account for the existence of these lakes, as they have no visible inlet and scarcely any outlet, except that they are due to springs derived from the neighbouring heights.

Terraces are also found at an elevation of 75 feet and upwards; the highest, that to the south of Coolkeeragh, having a height of 130 feet. In the adjoining portion of Sheet 17 these deposits are not extensive, the drift being chiefly boulder clay; but sands and gravels were noticed at Slievekirk, on the slopes of which they occur at a height of 1,000 feet. The pebbles are almost always local, but a few of granite have been recorded.

Shell Marl.—A deposit of shell marl, containing a small delicate bivalve (*Cyclas*?), occurs below black peat along the stream at Meenahoney, on the south margin of the Sheet.

Ochre.—Small quantities of ochre are being deposited in various places by the water which traverses the ferruginous schists. Some of it finds its way in the south corner to the boggy land near Loughery's Town, and, further north, to the hollow E. of Findrum. A thin crust of bog iron ore has been deposited in the rising ground west of the bog, and more abundantly in the low ground about the place called Black Repentance.

Ochre is met with also in the following localities:—In the stream west of Leckan; in that to the E.S.E. of Sessiagh; at Tullydonnell, N. of Convoy; further N., among the schists of Roosky, Upper; and, as before referred to in connection with the supposed existence of coal, on the flank of Mongorry Hill.

Peat-bog, Alluvium.—A rather extensive peat-bog covers the northern flanks of Slievekirk, extending almost to the summit. It is for the greater part available for economic purposes, some portions of the peat being very dense and of excellent quality. The other peat bogs in the district are small and unimportant.

Some alluvium occurs on the banks of the river Faughan in the vicinity of the Oaks and Drumahoe, and there is also some on the Foyle at Prehen, which, however, call for no special notice.

CHAPTER VIII.

PRINCIPAL FAULTS.*

Of the several faults that enter the Sheet in the S.W., some are fully proved by local evidence, while others depend more on observations made in the adjoining Sheets.

The limestone two miles west of Ballindrait has been displaced by two faults, the amount of downthrow being uncertain. The relative positions and dips of the various rocks abundantly prove the existence and directions of these fractures, which probably unite near Swilly Burn. The extension of this break seems to pass by Mullasawny, where the beds are disturbed and appear to be cut off in the manner shown on the map.

The fault at Powderly is continued from Sheet 25, and is here confirmed by the disturbance of the quartz-schist, and more clearly by that of the felstone-porphry, which has been shifted southward for a distance of 340 yards, the downthrow being on the west.

The Carrickbrack fault, passing through the low ground between that place and Findrum, has caused a slight displacement. The evidence for its presence is found chiefly in Sheet 16, where the mica-schist and quartz-schist meet, being brought into juxtaposition in the line of strike, along the line of fracture.

The band of limestone extending northward from Bawn has been slightly brought down between the fault there and that which passes by Treanavinny.

CHAPTER IX.

ECONOMIC PRODUCTS†.

Excellent *lime* either for farm or building purposes is burnt at Sallybrook near Monclink, at Raymoghly and at Lisclamerty. Besides these localities there are good limestones at Labbadish (Leslie Hill) and at Magheraboy. The latter ought also to be valuable as a *building stone*.

* By Mr. Egan.

† By Mr. Kinahan.

The *whinstone* in Roughpark ought to be valuable for cut-stone purposes. As already mentioned (p. 12) pieces of *Corneous lead ore* were found in the railway cutting, Monclink. In the north-east of Roosky there is a fair *cam-stone* locally used for hearths.

Bog-iron ore is exported from the Co. Donegal to be used in the purification of gas. It seems to be due to the decomposition of the iron pyrites of the rocks, especially the sandstones; and it comes up to the surface in springs. Iron spas are very numerous, while deposits of bog-iron ore were observed in Mondoorey, Upper, and other places; but none of it in this area appears to have been worked.

Coming from a N.W. fault at the western boundary of Drumoghill a strong spa, slightly *coppery*, breaks forth; while at the boundary of Mondoorey, Middle and Upper, another strong spa breaks out along a N.W. quartz vein.

CHAPTER X.

PETROGRAPHICAL NOTES

on some of the rocks referred to in the Memoir.*

The rocks selected for microscopic examination consist of :—

- I. Epi-diorites ;
- II. Schistose Limestones ;
- III. Micaceous Slates ;
- IV. Mica-schists ;
- V. Schistose Grits.

I. EPI-DIORITES.

The petrographical description is based upon specimens collected from the following localities :

- One mile N. of Raphoe ;
- Half mile N. of Raphoe ;
- Half mile N. of Convoiy ;
- Half mile S.E. of Drumahoe Bridge, two miles S.E. of Londonderry ;
- One and a half miles W. of St. Johnstown (Dooish Mountain) ;
- One and a half miles S.S.W. of New Buildings, and four miles S.S.W. of Derry.

The rocks are dark greenish-grey to light-grey in colour, and vary in grain from coarse to fine : those from Raphoe and Convoiy show on the weathered surface a yellowish tinge, due to the epidotisation to be mentioned later.

All these rocks have been subjected to regional-metamorphism, and are most probably the result of the alteration of plagioclase-pyroxene rocks. The field evidence is conclusive as to their eruptive nature and warrants their diagnosis as epi-diorites. This term is used according to Gumbel's† proposal to define an altered igneous rock, consisting of

* By J. Shearson Hyland, M.A., PH.D.

† Die paläolithischen Eruptivgesteine des Fichtelgebirges. München, 1874, p. 9.

"fibrous, pale-green, needle-shaped hornblende in large quantity (often much altered), plagioclase in small quantity, a chloritic mineral, and ilmenite or magnetite. Augite is absent or very subordinate in its occurrence." Such rocks probably form a stage in the metamorphosis of dolerites (Ger. Diabases) into amphibolites.* The name "pseudodiorites"† has been suggested as a field-term for rocks of this class.

Many of the specimens examined possess some degree of foliation. Where this structure is wanting, or but little developed, we must not assume that molecular re-arrangement has not taken place; for, as Mr. Teall‡ has demonstrated, a molecular re-arrangement may occur without such a structural development.

As a result of microscopical examination, it may be concluded with a great degree of certainty, that the rocks from the localities named above have, with two exceptions, been originally dolerites (diabases). The two exceptions are those represented by the specimens from one mile N. of Raphoe and half a mile N. of Convooy. These are coarse in grain, and have the aspect of altered gabbros. It is therefore not unlikely that the epi-diorites of this district are the products of the metamorphosis of both dolerites and gabbros. The transition of gabbros into amphibolites and similar masses has been known for a long time, and instances have of late years been microscopically described by Törnebohm,§ Lehmann,|| Traube,¶ and others. An intermediate stage between gabbros and amphibolites represented by epi-diorites, is conceivable.

Under the microscope, the most important constituent of these Irish epi-diorites is a monoclinic amphibole, which probably owes its origin to the paramorphism of pre-existing pyroxene. In appearance it is often "uralitic," although instances occur, where it is fairly compact. There is never any trace of the original pyroxene to afford positive proof of the alteration, but the mode of occurrence and the general characters of the hornblende leave no doubt as to its secondary nature. This constituent never shows decided crystallographic outlines, but mostly occurs in irregular patches, which at times present in vertical sections indications of terminal faces. The degree of pleochroism depends, of course, upon the colour of the mineral. Where the latter is pale-green, but little change in the absorption is to be noticed. Not infrequently the colour is deeper, and a decided pleochroism may then be recognised. The tints observed are pale-yellow, light-green, and dark-green. An almost colourless, tremolite-looking hornblende is also sometimes present.

In the more altered varieties, the hornblende becomes split up into fibrous aggregates, which through the twisting and movement they have undergone show under the microscope a decided foliation (*Flaser-structure*). Confused heaps of such aggregates are very common. Under such circumstances the hornblende becomes decidedly actinolitic in character, and forms long, green or bluish-green prisms, with no terminal

* Rosenbusch.—Massige Gesteine, p. 205.

† Lossen.—Sitzungsber. der Gesell. naturf. Fr. zu Berlin, 1885, No. 3, p. 34.

‡ "The metamorphosis of dolerite into hornblende-schist." Q. J. G. S., 1885, p. 139; and "The metamorphosis of the Lizard Gabbros." Geol. Mag. III., Vol. I., p. 487.

§ Om Sveriges vigtigare Diabas-och Gabbro-arter. Kon. Svenska Vetensk. Akad. Förhandl. XIV., No. 13, Stockholm, 1877.

|| Untersuchungen ü. d. Entstehung der altkryst. Schiefergest. Bonn, 1884, Kapitel XIII.

¶ Beiträge zur Kenntniss des niederchlesischen Gebirges. Greifswald. Inaug. Diss., 1884.

endings, but commonly showing lines of division at right angles to the axis. Many of the larger pale-coloured hornblende individuals possess actinolitic borders. As a general rule, the actinolitic nature of the hornblende becomes the more evident, the more decided the foliation.

One hand specimen from a mile S.S.W. of New Buildings appears to have come from a plane of movement or a joint, as one surface is coated with highly lustrous, amianthus-like, prismatic actinolite, which exhibits the following dichroism:

α =pale yellowish green.

γ =dark green.

This coated surface effervesces with acids, and an examination shows the presence of calcite and quartz. Quartz-veins with iron pyrites are also to be noticed in this specimen, but they show no albite.

The most careful examination of the rock-sections has not enabled me to detect primary hornblende, such as Liebe* has observed in similar rocks.

Chloritization of the hornblende is not uncommon, the chlorite being often drawn out into streaks, which encircle the secondary hornblende thus producing a sort of lenticular structure.

Biotite is also present in thin patches or flakes as a microscopic accessory in these rocks. It mostly presents irregularity of form, and often occurs wedged in the hornblende. It is probably largely secondary, as has already been described by various writers.† The pleochroism is strong:

α =pale straw yellow.

γ =brownish yellow to dark brown.

The alteration of the biotite leads to discolouration and the formation of a micaceous chlorite.

Epidote is frequent in irregularly angular, colourless grains and aggregates. Prismatic forms with fairly good contours are at times to be observed: the angle on some of those, between $\rho \infty$ (100) and $\rho \infty$ (101) was ascertained by measurement to be $129^{\circ} 30'$. Pleochroism is rare, but as usual, the high index of refraction causes the marginal total reflection and the unevenness of surface, referred to by Michel-Levy,‡ to be strongly marked. This mineral is secondary, and has chiefly been derived from the alteration of the felspar. Perhaps a small proportion owes its origin to the paramorphosis of pre-existing pyroxene.

The quantity of felspar present varies more or less, but is always subordinate to that of the hornblende. The felspar is much altered, the change having been both mechanical and chemical. In the former case the alteration shows itself by the granulation of the crystals, in the latter by the new products formed. Epidote has already been mentioned as one of these products; zoisite is another of equal frequency, in fact in some instances this mineral appears to predominate over the other. The zoisite is found in aggregates of columnar-shaped individuals and in sporadic grains. Crystallographic boundaries, when present, are only developed in the vertical zone. The prism-angle was measured on

* Uebersicht ueber den Schichtenaufbau Ost-thüringens. Abhandl. z. geol. Spezialkarte von Preussen u. d. Thüring. Staaten. Band V., Heft 4, p. 83.

† Tschermak.—Die porphyrgest. Oesterreichs, etc., 1869, p. 264. Götz.—Unters. einer Gesteinsuite aus der Gegend der Goldfelder von Morabastad, etc. Neues Jahrbuch. Beilage-Band IV., 169, also Blum.—Pseudomorphosen I. 31; III. 93.

‡ Note sur quelques ophites des Pyrénées. Bull. de la soc. géol de France, 3 sér. 6, No. 3, 156-176.

several grains and found to be 118° . Becke* gives 115° , 116.5° , 118° , 117.6° for the same angle, whilst Miller† recorded $116^{\circ} 18'$. In vertical sections there is a cleavage parallel to the greatest length, and, at right angles thereto, a transverse parting approximately parallel to a surface which would correspond to OP. The grains are colourless, strongly refractive, but non-pleochroic. The polarization colours are very weak, bluish grey, thereby showing a marked contrast to epidote. Luedecke‡ and Cathrein§ have, however, observed instances, where this contrast does not exist. The orientation is throughout that of a rhombic mineral, the extinction coinciding with the direction of the cleavage. Some of the aggregates are clouded, this condition being probably due to decomposition. Sauer|| mentions that zoisite decomposes into a finely fibrous, turbid substance.

The occurrence of zoisite in this district was known to Portlock.¶ He describes its presence in "greenstone slate" at Holly Hill near Strabane, and further on mentions its association at the same locality with fine crystals of "albite."***

The alteration of the felspar into epidote and zoisite may here and there be observed to be confined to the centre, the marginal portions remaining fresh and unattacked. Such instances are to be ascribed to the presence of an isomorphic felspar.

Some few well-developed felspar sections parallel to M. give an extinction of -30° , which would denote the presence of a felspar of the constitution Ab, An₃. These appear to be original constituents. The mass of the felspar is however characterised by the want of striation, by its granular condition, and by occurring in association with epidote and some quartz, thus forming in polarized light a quartz-felspar-mosaic. This condition recalls the metamorphism of Labradorite (Ab, An₂ according to Schilling††) into albite, as has been described by Lossen ‡‡ in the case of the Hartz diabases. If it resulted from the same process then the felspar-quartz-mosaic must of course be considered as secondary.

Felspar has frequently been observed as a secondary product on the veins in epi-diorites, and analysis has proved its composition to be that of albite.§§ Teall has, however, shown that the vein felspar in the Scourie Dyke is andesine, |||| but no attempt has apparently been made to isolate the secondary felspars from the ground mass of the rock itself.

In order to do this, the rock from Convoy was taken, and after being finely powdered, was treated for a short time with weak acid in order to remove the small quantity of calcite present. The powder was then placed in a Sonstadt-solution having a specific gravity of 2.689, with

* "Gesteine der Halbinsel Chalcidice." Tschermak's Mitt. I., p. 249.

† *Des Cloizeaux*—Annales des Mines, T. XVI., Série V.

‡ "Der Glaukophan und die Glaukophanführenden Gesteine der Insel Syra," Zeits. d. deutschen geol. Gesell. XXVIII. 1876, p. 259.

§ "Ueber Saussurit." Zeits. f. Kryst VII., pp. 237-8.

|| Erläuterungen zur Geol. Spezialkarte Sachsens, Section Kupferberg, 1882, p. 25.

¶ Report of the Geology of the county of Londonderry, etc. Dublin, 1843, p. 209.

*** Op. cit., p. 212.

†† "Grünsteine des Harzes." Göttingen, 1869, and Teall, Brit. Petrography, p. 152.

‡‡ "Studien an metamorphischen Eruptiv- und Sedimentgest." Jahrbuch d. k. preuss. Geol. Landesanstalt für 1883: Berlin, pp. 619-640. Also, Erläuterungen zur geol. Spezialkarte von Preussen. Blatt Wippra, 1883, pp. 50 and 83.

§§ Gümbel, l. c., p. 14, and others.

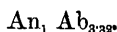
|||| "Metamorphosis of Dolerite into Hornblende-schist." Q. J. G. S., '85, Analysis, p. 105.

the result that the primary feldspar sank, whilst the secondary rose. The latter remained suspended at 2.645.

The analysis gave following result:—

			Orthoclase.	Albite.	Anorthite.
			2.11%	71.49%	22.18%
SiO ₂	. . . 62.86	= 62.74	= 1.36	+ 49.07	+ 9.61
Al ₂ O ₃	. . . 20.1	20.06			
Fe ₂ O ₃	. . . 2.6	2.59	0.39	13.96	8.08
CaO	. . . 4.5	4.49	—	—	4.49
K ₂ O	. . . 0.36	0.36	0.36		
Na ₂ O	. . . 8.48	8.46	—	8.46	—
H ₂ O	. . . 1.3	1.3	—	—	—
	100.20	100.00			

The 2.11 per cent. of orthoclase-substance is probably not present as an independent individual, hence the constitution of the secondary feldspar may be considered as:



The amount of Fe₂O₃ is certainly somewhat high, but the specific gravity of the powder (2.645) shows that it cannot be ascribed to the presence of epidote. 2.59 per cent. of Fe₂O₃ would be equivalent to an admixture of about 5.8 per cent. of epidote, which would demand a specific gravity of about 2.9.*

The result of the analysis demonstrates the fact, that the original Labradorite (Ab₁An₉) has been metamorphosed into granules of an unstriated feldspar allied to oligoclase (An₁Ab_{9.32}). A large proportion of lime thus became free, and epidote and zoisite were largely the result, calcite being also formed in small quantity. In the Hartz this alteration of the feldspar is peculiar to the district where regional metamorphism has acted with the greatest intensity, and this relation probably holds good in all cases.

The rocks are so altered, that the feldspar rarely exhibits the lath-shaped form so characteristic of ophitic dolerites. The aggregates of zoisite and epidote show that such a structure has been present, as they are found piercing in continuous lines the bi-silicate.

The amount of chlorite and quartz present is naturally in direct proportion to the degree of alteration the rock has undergone. The chlorite frequently encloses strongly refractive grains similar to those which Petersen† determined as identical with epidote, and rhombs of calcite, both by-products of the chloritization of the hornblende. The presence of chlorite in the altered feldspar of some of these rocks seems to indicate its position therein to be due to a certain extent to the alteration of this feldspar. This change is all the more probable from the known macroscopic pseudomorphism of pennine from feldspar.‡

Iron pyrites and ilmenite are present. Both are at times decomposed, the latter showing every stage in the alteration characteristic of this mineral. In the most altered specimens the ilmenite often completely disappears, but its original presence is suggested by the occurrence of

* Cf. *Cathrein*, l. c. pp. 241–242.

† *Mikroskopische und chem. Untersuch. am Enstatitporphyrit, etc.* Inaug. Diss. Kiel, 1884.

‡ *K. Vrba*.—Die Grünsteine des Pribramer Erzrevieres. Jahrbuch d. k. k. geol. Reichsanstalt, 1877, XXVII., p. 227. Also, *R. v. Drasche*, *Tschermak's Mitt.* 1873, 125, and *v. Zepharovich*, *ibid.* 1874, 7.

greyish-brown granular aggregates of titanomorphite. As A. von Lasaulx* observed in the "Diabaspophyrit" of Lambay, these aggregates appear mostly opaque, although at times they have a decided influence upon polarized light. Apatite is rare.

II. SCHISTOSE LIMESTONES.

One and a half mile S.S.W. of New Buildings, and four miles S.S.W. of Derry, the epi-diorite is found in contact with limestone which appears as a schistose, fine-grained rock of a dark bluish-grey colour and of crystalline texture. A section cut from this rock for microscopic examination shows to the naked eye a thin black band running through it, which is remarkably free from calcite, being mostly composed of carbonaceous matter.

The microscope exposes to view a decided parallelism in the directions of the constituent minerals. The carbonate of lime is represented by crystalline calcite, interbedded amongst which are granular aggregates of quartz and felspar. The twin-lamellæ, which the calcite shows, are most probably secondary, a result of pressure and strain.

Brown mica is present, and colourless mica is also not wanting.

Filamentous streaks of a dark substance—to a large extent found to be carbonaceous matter—show the direction of the schistosity. These streaks are at times bent up into folds, and bear witness to the compression which the rock has undergone.

The amount of calcite varies in a remarkable manner. This constituent here and there disappears, and the accessory constituents mentioned above then constitute the entire rock.

The limestone was found on chemical treatment to contain only a trace of dolomite.

Dr. Callaway† has noticed the occurrence of garnets in the limestones of this district, but this mineral is not a constituent of the specimens I have examined.

III. MICACEOUS SLATES.

The specimens examined were brought from the slate quarry of St. Johnstown. They are of a dark grey colour, with a sericitic lustre. A band of calcareous plumbago is present in one hand specimen.

The principal constituent under the microscope appears as a pale-green micaceous mineral, which lies along the planes of cleavage. It occurs in thin streaks, sweeping round the numerous quartz-grains, which form as usual a large proportion of the rock. Felspar can rarely be detected.

Acicular crystals of rutile and columnar crystals of tourmaline are common. The latter often show the well-known hemimorphism. Zircon is also often to be observed, whilst iron pyrites is frequent.

IV. MICA-SCHISTS.

The specimens of these rocks which I have examined come from the large quarry near Londonderry Bridge. The rock is of a dark bluish-grey colour, with a satin-like sericitic lustre, and bears ample evidence

* "Petrographische Skizzen aus Irland." Tschermak's Mitt. I., p. 424.

† Callaway.—On the granitic and schistose rocks of N. Donegal. Q. J. G. S., 1855, XLI, pp. 227 and 231.

of the crumpling to which it has been exposed. It is a part of the schistose series of this area, but is not garnetiferous.

The mica is seen under the microscope to be light green and uniaxial with very weak pleochroism. The field of vision is composed of a plexus of fibrous mica and minute grains of quartz, and exhibits a beautiful example of "strain-slip-cleavage," or the "Ausweichungscleavage" of Heim.*

Felspar could seldom be detected. Calcite grains of relatively large size are present in the rock, which consequently effervesces with acid. Where the fibrous mica encounters these grains it sweeps round them in graceful curves.

Rutile is present in small yellowish-brown needles, which often form the reticulate groups known as "sagenite." In conjunction with the latter tourmaline is also to be observed.

Small plates of hematite are also visible, while iron pyrites is common, and may be noticed macroscopically on the face of the rock, partly altered into hydrous peroxide of iron.

V. SCHISTOSE GRITS.

Specimens were examined from two places to the W. of St. Johnstown, and are both coarse and fine in grain. Schistosity is well marked in them, the grains having been re-arranged so that their greatest length is coincident with the direction of movement.

The grits consist mostly of "eyes" of quartz and felspar, the former being larger in quantity. The effects of the crushing to which the grits have been subjected are particularly noticeable under the microscope. The constituent grains have undergone more or less granulitization. Every stage is represented, from the molecular tension which shows itself optically by an undulose extinction to that physical condition known as "granulitization," or the resolution of a grain into smaller individuals, no longer in optical continuity with each other. In fact this granulitization often leads to the formation of a mosaic-like pseudo-ground-mass of minute felspar and quartz grains. Especially interesting is the occurrence of twin lamellæ in a few of the felspars. These lamellæ bear every evidence of being of secondary formation, and possess great similarity to those described and figured by v. Werveke,† Lehmann,‡ Judd,§ and Bergt.|| They are to be explained as the result of strain.

Both brown and colourless mica are found encircling the quartz and felspar grains. The mica is undoubtedly secondary, and has been developed at the expense of the original clastic material, for, as Lehmann¶ has shown, its formation takes place along planes of movement.

There is a little calcite present in some hand specimens that effervesce with acids.

* Mechanismus der Gebirgsbildung, Band II., p. 53.

† "Eigenthümliche Zwillingsbildung an Feldspath and Diallag." Neues Jahrbuch, 1883, II., 97.

‡ "Die Entstehung der altkryst. Schiefergest," p. 196, and Pl. C, fig. 4.

§ "On the Tertiary and other Peridotites of Scotland." Q. J. G. S., 1885, XLI., p. 365.

|| "Beitrag zur Petrographie der Sierra Nevada de Santa Marta," etc. Tschermak's Mitt., X. 383.

¶ Op. it., p. 248.‡

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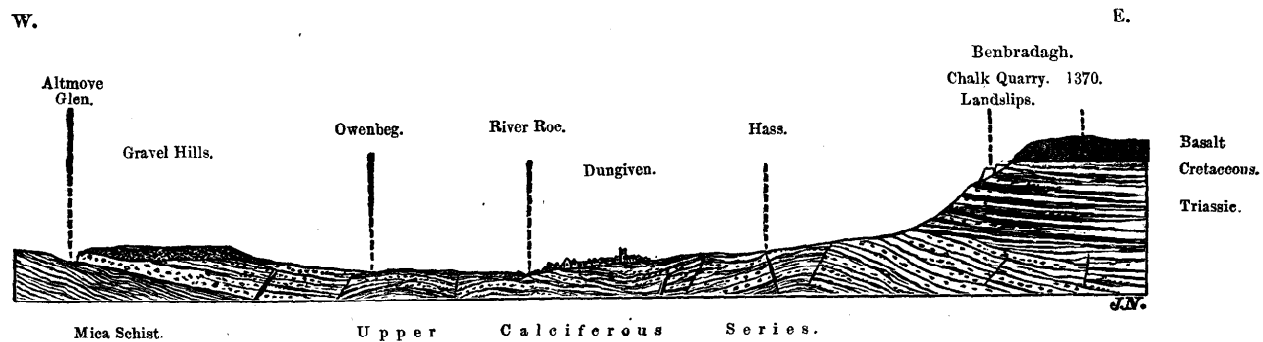
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Section from Benbradagh Mountain to southern end of Altmover Glen.



Scale, 1 inch to 1 mile horizontal—3 inches to 1 mile vertical.