Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 60, 61, AND PART OF 71 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

INCLUDING

THE COUNTRY AROUND NEWRY, RATHFRYLAND, AND ROSTREVOR, IN THE COUNTY OF DOWN; AND THE MOURNE MOUNTAINS.

BY

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

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

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

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

Condensed memoirs on particular districts will also eventually appear.

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

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PREFACE.

THE district described in this Memoir was geologically surveyed by Mr. W. A. Traill, M.A., during the years 1870–73, but having resigned his appointment on the Geological Survey before he had prepared the Explanatory Memoir of the district, it became necessary that I should undertake the task with such materials as I could command. These consisted of the 6-inch Maps, containing the detailed observations made in the field, two sheets of Horizontal Sections (Nos. 23 and 24), the published 1-inch Maps and a few notes drawn up by Mr. Traill himself.

I had also derived a considerable amount of knowledge of the district from several visits made to it during the time that it was being surveyed, and since; the observations made on these occasions are recorded in my own note books. Mr. Traill's work has been ably executed.

EDWARD HULL.

13*th June*, 1881.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 60, 61, AND PART OF 71 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

PART I.

General Description.

The district described in the following pages lies wholly in the county of Down, and is one of singular interest from the variety of its physical features, as well as from the remarkable abundance of geological phenomena which are presented to the observer over almost its whole extent.

It includes two ranges of granite mountains; that of Mourne being the more lofty and striking; and that of Slieve Croob, which lies to the northward of the former, and is separated from its northern base by a wide depression of Lower Silurian rocks, which extend in a slightly curved line from Dundrum Bay to the head of Carlingford Lough. This depression is crossed by the watershed, which throws off on either side the streams flowing into the River Bann towards the north from those flowing into the Newry River towards the west and south.

The principal towns and villages in the district are—Newry to the westward, Hilltown about the centre, Rathfryland to the northward, and Castlewellan and Bryansford in the north-east, Newcastle, lying at the foot of Slieve Donard, also Maghera and Annalong. Rostrevor and Warrenpoint lie at the head of Carlingford Lough, and Kilkeel in Mourne is situated near the coast.

Carlingford Lough is a land-locked bay, forming a large and commodious natural harbour; it is however difficult of access from the low reef of limestone rocks which stretches across its entrance from the Louth shore, and the tongue of clayey-gravel (drift) which extends southward from Cranfield Point on the county Down side.

There exists no true bar, but an entrance passage has been dredged through this tongue of drift, whereby there is now a deep water channel at all times of the tide.

This passage is however at present inconveniently narrow, but if once completed there would be little danger of its being silted up, the scour from the lough being quite sufficient to keep it clear.

The lough for the most part is shallow, abounding with shoals and esker-like ridges of shingle and gravel. A few deep places

occur; "The Pool" off Kilowen Point attains, according to the Admiralty Chart, a depth of sixteen fathoms.*

At Warrenpoint there is a quay and tidal dock, capable of large extension, having many natural advantages.

Newry has also docks which are connected with the lough by the Newry Canal.

At Kilkeel and Annalong are small tidal harbours, but they are much exposed and liable to be silted up.

At Newcastle the harbour has been destroyed; a more suitable situation for it would, in the opinion of Mr. W. A. Traill, have been some short distance to the south of its present position.

"Capabilities for the construction of a pier or docks which should be utilized, may be found near Greencastle Point at the mouth of Carlingford Lough; adjacent to which a large portion of Mill Bay could readily and advantageously be reclaimed.

"Along this coast the mean tide level is 8·094 feet above the Ordnance Survey datum plane; from which the heights on the maps are figured.

"At Carlingford Bar,† spring tides rise seventeen feet and neap tides thirteen feet, consequently high water mark stands at about the seventeen feet contour level on the maps.

"The average rain-fall at Newry is thirty-six inches, at Lough Island Reavy forty-six inches.

"The magnetic variation is 25° W."‡

The district is bounded on the west by the deep depression of the Newry Canal and Carlingford Bay, by which it is separated from the rugged ranges of Carlingford, Fathom, and Slieve Gullion, described in previous Memoirs;§ on the south and east by the sea including Dundrum Bay, and it extends northwards, to the margin of the map where it joins that of sheet 48 already described.‖ The geological structure of the Ardglass district has also been described by Mr. Traill.¶

The mountains of Mourne, extending about 15 miles from east to west, form a connected group of elevations, culminating in Slieve Donard, which rises to an height of 2,796 feet,** at its eastern extremity. Several of the other elevations, lying in the eastern part of the group, fall but little short of the height attained by Slieve Donard. Thus Slieve Bingian attains an elevation of 2,449 feet, Slieve Bernagh, 2,394 feet, Slievelamagan, 2,306, feet, and Slievemeel More, 2,237 feet, while in the western portion, Eagle mountain has an elevation of 2,084 feet. Several of these elevations are isolated and dome-shaped, Slieve Donard

* In "The Physical Geology of Ireland" (1878) p. 240, I have pointed out the evident connexion of the depression of Carlingford Lough with the direction of the ice-movement of the glacial period, showing that the lough is a true "rock-basin," and that by an elevation of four fathoms it would be converted into an inland lake with a depth of twelve fathoms near the centre.

† Admiralty Chart, Manx Almanac.

‡ The portions under quotation marks are from Mr. Traill's M.S.

§ Expl. Mem. sheet 59, by F. W. Egan; Expl. Mem. part of sheets 60 and 71, by W A. Traill, and Expl. Mem. sheet 70 by J. Nolan.

‖ Expl. Mem. sheet 48 by F. W. Egan.

¶ Expl. Mem. sheets 49 and part of 61.

** These and the following heights are taken from the Ordnance Survey Maps.

being a conspicuous example of this form; others are in the form of ridges, sometimes rocky and serrated, such as Bingian, Cove mountain and Ben Crom. In general, however, a slope of greater steepness than 45° to 50° is of rare occurrence, except for small descents.*

One of the best land-views of the eastern portion of the group is obtained from the flanks of Slieve Croob, behind Castlewellan Park. From this point the view extends across the richly wooded plain, which separates the two mountain ranges, Slieve Donard and its neighbouring heights being directly in front. To the left the waters of the sea are seen stretching away from the base of the mountains, and sweeping inwards around the shore of Dundrum Bay. But a still more extended view is obtained from the neighbourhood of Hilltown. Here the prospect stretches from the Pigeon Rock Mountain to Slieve Bingian, and includes the conical hill of Slieve Muck, the dome-shaped Slievemeel More and Slievemeel Beg, the castellated height of Slieve Bearnagh, the flat doom of Slieve-na-glough, and the craggy ridge of Slieve Bingian; in the foreground is the undulating Silurian plain with its numerous farmsteads, rocky knowls and water-courses. (See Frontispiece.)

"A different, and perhaps, a more beautiful, panorama is presented by the Mourne Mountains when viewed from the neighbourhood of Kilkeel.

"Slieve Bingian stands out prominent in the centre, rising with a sharp and rugged peak to a height of 2,449 feet; when it is seen however, from either side, it reveals its ridge-like form, with the five large granite bosses, projecting from its crest, which give to it the bold and broken outline for which it is remarkable.

"Away to the northward may be distinguished the dome-shaped summit of Slieve Donard, almost hid amongst the numerous peaks and ridges which intervene."†

The district of the Mourne Mountains has attracted the attention of numerous observers, including Griffith,‡ Berger§, Bryce,‖ and Haughton.¶ Both in its physical features, and geological structure, it bears a striking resemblance to those of the Island of Arran in Scotland. In both districts the mountains rise abruptly from the waters of the sea to nearly the same elevation; they are formed of granitic and plutonic rocks, and present numerous remarkable illustrations of igneous action. Lastly, in both cases, the geological age of the granite itself is a point of conjecture and is incapable of actual demonstration.

Owing to the fact, that the group rises almost directly from the level of the Irish sea or its branches, and that its base is

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* See horizontal sections, Geol. Survey, sheets 23 and 24.

† Mr. Traill's M.S.

‡ Geol. Map of Ireland, 1839.

§ On the Geol. features of the N.E. of Ireland. Trans. Geol. Soc. Lond. vol. i. (first series).

‖ On the Geol. structure of the counties of Down and Antrim. Rep. Brit. Assoc. 1852, p. 42.

¶ Quart. Journ. Geol. Soc. Lond. vol. xii. and xiv.

bathed by the waters on three sides—the Mourne Mountains present a bold and striking appearance from long distances, and in clear weather, are visible from the heights of Killiney and Bray, south of Dublin, and from the deck of the Kingstown and Holyhead mail steamboat. On such occasions, Slieve Donard's cone-like form will be observed at the extreme right, towering by a head and shoulders above the neighbouring heights.

The group is penetrated by several long and remarkably picturesque valleys, extending inwards towards the central heights, both from the north and from the south. Amongst these may be mentioned, the valley of the Annalong River, which rises on the western flanks of Slieve Donard, and runs in a nearly southerly direction, till it enters the sea at the village of the same name. Next is that of the Kilkee River, which receives numerous tributaries from the slopes of Carn Mountain, Slieve Bearnagh and Slieve-na-glough—one of the streams issuing from Lough Shannagh; next, the valley of the White River, which upon entering the mountains, branches in several directions. On the northern side, are the valleys of the Rocky River, that of the Bann which rises on Carn Mountain, and the valley of the Shimna River, which, rising on the northern slope of Carn Mountain, flows in a northerly and easterly direction, through the wooded glens of Tollymore Park into Dundrum Bay, north of Ballycastle.

Of the streams above mentioned, the most important is the River Bann, which after descending from the slopes of Pigeon Rock, and Slieve Muck, at an elevation of 1,467 feet, as determined by Mr Traill, unites with the Rocky River, and passing by Hilltown, takes a northerly and westerly course, towards the head of Lough Neagh, which it enters below Portadown. At Muddock Bridge, it receives the waters of the stream of that name, descending from the artificial reservoir of Lough Island Reavy, which according to Mr. John Smyth, stands at an elevation of 430 feet above the sea,* and has been constructed to meet the requirements of the numerous mills which are built along the course of the Bann.

Watershed.—The higher ridges and elevations of the Mourne Mountains, throw off the waters which flow into the Bann, and the Shimna on the north, and those which flow into the sea, either through Carlingford Lough, or directly along the south-eastern coast. This watershed leaves the northern edge of the map, (sheet 60) at Knockiveagh, a hill 785 feet high, and passes southwards through Rathfryland, to the road W. of Hilltown R.C. Chapel; here it turns westward, keeping the course of the road to the trig. point 801, thence southward to the trig. point 1190 south of Mullaghmore House. From this point the watershed follows the summit of the ridge, by Gruggandoo, (1,252 feet), Crotlieve, Tievedockaragh (1,552 feet), to Shanlieve (2,055 feet), afterwards it takes a north-easterly course, following the crests of Eagle Mountain, Slievemaganmore, Pigeon Rock, Carn, Slieve

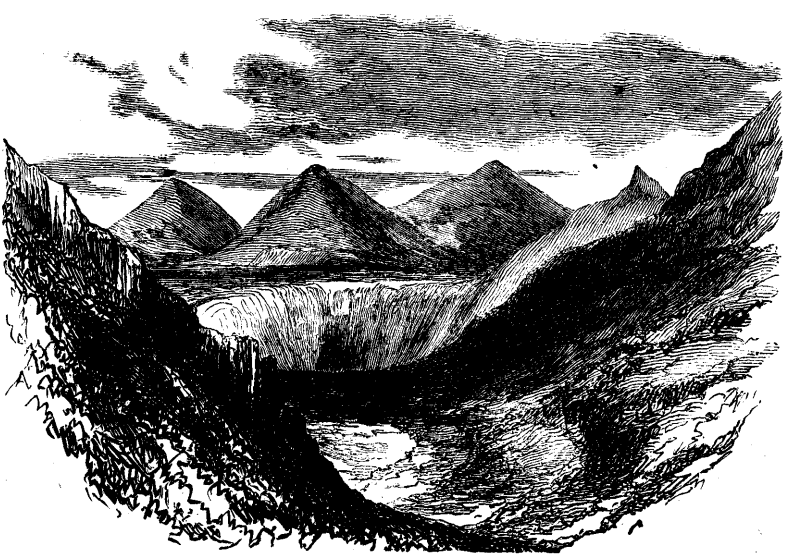
* This Reservoir was designed by the late Sir. W. Fairbairn and Mr. Bateman, C.E. and its construction and uses are fully described by Mr. Smyth, in his paper on "The industrial uses of the Upper Bann River." Brit. Assoc. Rep. 1874, p. 139.

Lough Shannagh, Slieve Bearnagh, and Slieve-na-glough to the Great Carn of Slieve Donard, from which it descends to the sea-coast about a mile south of Newcastle.*

Valleys.—Several fine valleys open from the south, and ascend into the recesses of the mountains. Amongst these that of the White Water, Kilkeel River, and Annalong River are the most remarkable. Several valleys lie along lines of faulting—such as those of the Kilbroney, the Ghann, the Leitrim, the Shanky, the Kilkeel, and the Mill Rivers. It is not to be understood, that the faults produce the valleys, or originate the physical features on either side; but only that the streams which have scooped out the valleys have eroded the rocks along the fault-lines—the material having become more or less broken by reason of the faulting—and masses or beds of different degrees of hardness having been brought into contact by displacement.

Looking up the Kilkeel River, there is at the head of the valley the appearance of a remarkable terrace—at an altitude of about 1,200 feet above the sea-level—upon which Bencrom, Slieve Lough Shannagh are planted (see Fig. 1). Upon reaching the position of the apparent terrace it is scarcely to be recognised. Similar terraces which only are recognisable from a distance have been observed in several other mountainous districts, such as that of the Joyce country at the head of Killary Harbour; and they not improbably indicate old sea margins.

Fig. 1.



View looking up the valley of the Kilkeel River, showing the position of the Terrace at its head.

The manner in which the drift deposits run far up into the principal valleys is sufficient evidence that the valleys have been

* Through part of its course this watershed divides the baronies of Upper Iveagh (lower half) from that of Mourne.

formed before the Drift or Glacial Epoch. Such is the case with those of the White Water, Kilkeel, Annalong, and Bloody Bridge Rivers.* The drift deposits rest in nearly horizontal positions against the flanks of the valleys—gradually ascending with the valley up to considerable elevations, but are absent off the higher altitudes. Thus these deposits, consisting of sand, gravel, and clay, are found rising :—†

In the Bloody Bridge River Valley, to about	.	.	1,500 feet.
In the Annalong R. Valley	,,	.	1,200 ,,
In the Shannagh R. Valley	,,	.	1,300 ,,
In the Miner's Hole R. Valley	,,	.	1,550 ,,

On the northern slope, the elevation attained is somewhat less, but it is probable that the original limit of the glacial drift deposits was considerably over the highest figure above given—as these deposits have been washed off the slopes by rains and streams.

Loughs.—As compared with many mountain ranges of similar extent in the British Isles, the number of loughs amongst the mountains of Mourne is small, in fact only six in number, including two very small loughlets—those of the Castle bog, and Lough Cove at the southern base of Cove mountain. All the loughs lie in the granite district.

The largest is Lough Shannagh, lying at the southern base of the elevation of that name, and bounded by the steep slopes of Carn mountain on the west. It is probably a shallow lake, and its eastern shore, about half a mile in length, is banked up by a peat-moss resting on drift pebbly clay.‡ Mr. Traill writes to say that he considers Lough Shannagh to be a true rock-basin.

The Blue Lough and Bingian Lough, which send off streamlets into the Annalong River, are partially bounded by granite, and have the appearance of true rock-basins with moraine banks. Bingian Lough lies at an elevation of 1,347 feet.§ The elevation of Blue Lough is not as great (1,080 feet by aneroid measurement), but below the former there is a steep descent for a depth of 400 feet down which the stream draining the lough falls to its junction with the stream coming from its neighbouring loughlet. The origin of these loughs is associated with the former glaciation of the district.

In the northern part of the district there are several natural loughlets situated in hollows amongst the hills of drift clay, and gravel, which is there so extensively distributed. Amongst these may be mentioned Lough Orme, Hunshigo Lough, and Ballyward Lough. The origin of these loughs is associated with the irregular accumulation of the drift-deposits. Many of the adjoining flats, now filled in with peat, were at one time occupied by water which has been replaced by the vegetable matter derived from the accumulation of the remains of aquatic plants—a phenomenon of constant recurrence over large portions of Ireland. Castlewellan Lake is only partly artificial.

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* The margin of the drift is engraved on the Geological Survey Map, and the ground overspread by the drift deposits is shown by engraved dots.

† See Hor. Sec. sheets 23 and 24.

‡ See Hor. Sec. sheet 23, No. 2 ; and map, sheet 60.

§ As determined by Mr. Traill's section, sheet 24.

PART II.

Formations, or Groups of Rocks, entering into the Structure of the District.

1. AQUEOUS ROCKS AND DEPOSITS.

Recent and Post-Pliocene, or Drift.

Name.	Colour on Map.
Bog, and Alluvium of River Valleys,	*Brown.*
Shingle (marine),	*Engraved dots.*
Estuarine Deposits and Raised Beaches,	*Pale sepia.*
Drift, { Middle Sands and Gravel, / Lower Boulder-clay,	*Engraved dots.*

Carboniferous.

d^2 Lower Limestone,	*Prussian blue.*

Silurian.

b^2 Lower Silurian Rocks (Bala Beds),	*Light crimson lake and Indigo.*

2. METAMORPHIC ROCKS.

β. Altered Lower Silurian, Mica-schist, &c.,	*Same as unaltered, with wash of carmine.*
G. Granite of Newry and Slievanaslat,	*Light carmine.*
Gf. Do., when foliated,	*Do.*

3. IGNEOUS ROCKS.

B. Basalt, Dolerite, Melaphyre, &c.,	*Crimson lake and burnt carmine.*
Bp. Basalt Porphyry,	*Do.*
Bm. Do., when micaceous,	*Do.*
T. Pitchstone,	*Deep orange chrome.*
D. Diorite (Greenstone),	*Crimson lake and burnt carmine.*
E. Quartziferous Porphyry (Elvanite),	*Deep carmine.*
F. Felstone,	*Orange chrome and carmine.*
Fp. Felstone Porphyry,	*Do.*
Fm. Mica-trap,	*Do.*
G. Granite of Mourne Mountains,	*Light carmine.*
Gp. Do., when Porphyritic,	*Do.*

LOWER SILURIAN ROCKS.

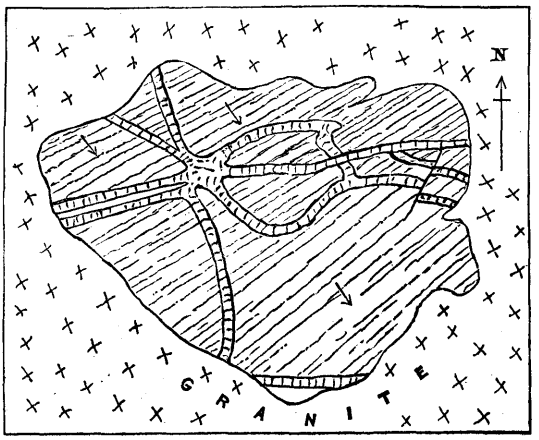
The rocks of this formation belong to the great mass which forms so large a portion of the north-east of Ireland, south of Belfast Lough, and the valley of the Lagan. They are the oldest in the district under description; and as far as can be determined, neither their basement or uppermost beds are present.

They consist of alternations of hard, greenish, or grey grits, coarse to fine-grained, rarely conglomeritic, alternating with rough green, purple or grey slates—seldom so fine, or evenly cleaved, as to form a good material for roofing purposes; and it may also be added that owing to their colour, hardness, and

splintery fracture, the grits cannot be considered as of value for building purposes, except those of the most ordinary description.

The Lower Silurian beds occupy three separate areas in the district under description; first, that lying to the north of the granite of Newry near Drumantine House; second, the district intervening between the two granite districts of Newry and Rathfryland on the one side, and of the Mourne mountains on the other; and third, the district extending along the coast from the northern shore of Carlingford Lough to the eastern base of Slieve Donard.

Fig. 2.



Cap of Lower Silurian Beds with basalt dykes on the top of the granitic elevation of Slievemaganmore—1,837 feet.—(Taken from the field 6-inch map).

It will be observed from the map, that all along the coast, a narrow band of Silurian beds skirts the flanks of the mountains, so that the granite is never actually washed by the waters of Dundrum Bay. A few outlying patches of the same formation, occur amongst the granite of Mourne as at Finlieve, Slievemaganmore (Fig. 2), and east of the Eagle Rock on the northern slopes of Slieve Donard.* In these cases the grits and slates form a capping to the granite, and indicate that at a period subsequent to the formation of the granite, the Silurian Rocks were spread over a much larger area than at present, and formed the surface where the granite now only exists.

On looking at the Geological Map, sheet 61, a narrow band of Silurian rock will be observed, skirting the flanks of the mountains for a distance of nearly two miles from north to south, and separated from the main mass which lines the coast by a granitic tract about 100 yards in width. This band is laid open in the section of the Bloody Bridge River, and seems to occupy an old depression in the original surface of the granite, at its contact with the Silurian beds, which owing to denudation has been dissevered from the main mass with which it was originally connected.

* Hor. Section, sheet 24, No. 1.

Throughout the whole district, the Silurian rocks preserve, with few exceptions, a remarkable persistency in the strike or direction of the beds—the normal direction being E.N.E. and W.S.W.—while the dip is at right angles thereto, that is, E.S.E. or W.N.W. This is the general direction throughout the region occupied by these rocks in Down, Armagh, and Monaghan. It is the more remarkable in the district of Mourne, where the granite has been intruded amongst these beds at a later period; in consequence of which, it might have been supposed, the strike of the strata would have been frequently deflected from its normal bearing.

The angle of dip is exceedingly varied; it is generally high and seldom lower than 30°; in a few cases the beds are vertical. No attempt to estimate the thickness of these beds from the dip in any locality would be successful, because they have been forced by lateral pressure into numerous folds, so that they are sometimes doubled back on each other; and it would be impossible to know when an apparent superposition of strata was a reality. Any one who examines the section along the eastern coast south of Newcastle, will easily convince himself of this fact; for he will observe, that while there is an apparently steady dip towards the S.E., the beds sometimes become completely inverted, and we pass from an ascending to a descending series, or *vice versa*. At the same time, the general inclination of the beds, that is exclusive of foldings and minor flexures, has been to some extent influenced by the intrusion of the granitic mass which lies below, probably at no great depth.

The Silurian beds often rise to high levels on the flanks of the granitic heights of Mourne—in several instances crowning the summits of the ridges, or hill tops. Thus we find them on the summit of Finlieve at an elevation of 1,888 feet, capping the granite slopes; again in a similar position on Slievemaganmore, 1,837 feet as already stated, and at a somewhat less elevation on the northern slopes of Slieve Lough Shannagh and Slieve Donard (Thomas' mountain) at an elevation of nearly 2,000 feet. In all these cases, the Silurian beds occur in detached outliers, dissevered by granitic tracts from the main mass of the formation, and indicating their former extension over large portions of the existing granitic surface. But it is along the northern margin of the main mass itself that they rise into the highest and most conspicuous positions. Thus along the escarpment of Pigeon Rock (Fig. 3), Slieve Muck, and Carn mountain, the hardened splintery Silurian slates and grits, impinging on the surface of the underlying granite at high angles (from 50°–80°) may be traced throughout a distance of over three miles, forming the crest of the ridge, penetrated by dykes of porphyry shooting out from the supporting granite, and also by dykes of basalt and dolerite which terminate at the margin of the granite itself. Here the Silurian beds attain

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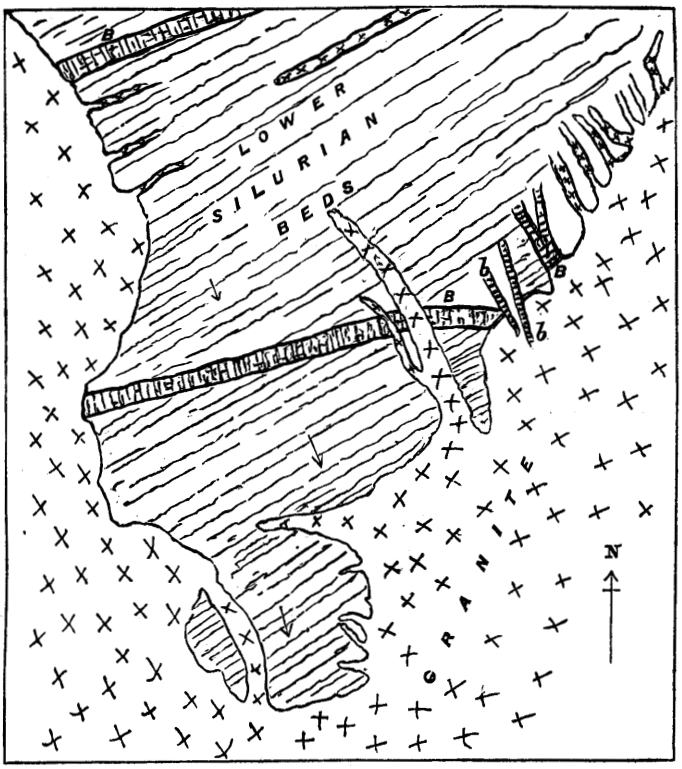
* All the above phenomena are very clearly laid down in the Geological map as far as the scale permits, and are more fully represented in section No. 2, sheet 23, which crosses Slieve Muck at the highest point. On reaching the summit of Slieve Muck on 1st June, 1871, in company with Mr. Traill, we determined the elevation with the anaroid, and found it to be exactly 2,198 feet, the height given on the Ordnance map.

an elevation of 2,198 feet, which is their culminating level in this part of the country,* and are traversed by two sets of joint planes, one ranging N.N.W. and another ranging N.W. along some of which there are slight displacements or faults.

Fig. 3.



Plan of portion of Pigeon Rock Mountain showing Lower Silurian Beds capping granite—and dykes of the "Older Basalt" (B.B.) terminated at the granite margin—while both rocks are traversed by more recent dykes, (*b.b.*)—Plan taken from the 6-inch field-map.

That the tilting and flexuring of the Lower Silurian beds was produced antecedently to, and independently of, the protrusion of the granite is evident from an examination of the section along the escarpment of Slieve Muck. Had the dip and strike of the beds been regulated by the circumstances of the granite protrusion they would have been found dripping away from the granite boundary. But such is not the case; and an inspection of the map will show that the beds are more frequently found dipping towards the granite margin than from it, while the strike varies but little from the normal E.N.E. direction.

Induration of the Silurian Rocks.—All along the margin of the Mourne granite—and extending to varying distances—the Silurian grits and slates are indurated or "baked," and break with a

splintery fracture. This is due to the contact with the granite when in a highly heated state; but beyond this, the process of alteration does not extend, and in remarkable contrast to the condition of the same group of rocks when in contact with the Newry granite to the north—the beds are not metamorphosed even to the extent of being micacised. To this subject I will have to return when I come to describe the granite itself.

Metamorphism of the Silurian Rocks.—It is otherwise when we examine the condition of the Silurian beds in contact with, or proximity to, the granite of Newry, Rathfryland, and Castlewellan. All along the margin for a distance of about a mile, the beds are more or less metamorphosed, and converted into mica-schist. The gradual process may often be traced, as for instance at Slieveacarnane, Loughanlea Hill, near Hilltown, or north of Castlewellan. The incipient stage is that of the formation of small black specks of mica along the planes of bedding; then, as we approach the granite, these become larger and more numerous, and quartz and granite veins are found ramifying through the beds.

A little further and the rock becomes converted into an ordinary mica-schist, and then there is a sudden change into a true granite or gneiss, where the heat has been developed sufficient to melt the original rocks and allow the molecules to enter into new crystalline forms. The difference in the condition of the Silurian rocks along the margins of the two granitic masses points to essential differences in the original mode of formation of the granites themselves, to which I shall advert in the sequel.

2. Lower Carboniferous Rocks.

Only one member of the Carboniferous series is represented in the district now being described, namely, the Lower Limestone. Though the only member present, this is not the real base of the Carboniferous formation, but the subordinate Lower Sandstone and conglomerate usually forming the basement beds being absent, the Limestone rests directly, and unconformably, on the Lower Silurian rocks.

The Limestone occupies a small area at Soldier's Point and the adjoining islands, called Haulbowline Rock, on which the light-house is built, and Green Island, at the entrance to Carlingford Lough. It also forms the southern and western shore, and the entire low-lying tract about Carlingford, Greenore, and Grange to the base of the mountains. On both sides it is traversed by numerous basaltic dykes.

The general succession of beds at Soldier's Point, from the lowest upwards, is as follows:—

	Feet.
(*a.*) *Lowest beds.*—Sandy brecciated limestone with black shales, .	20 to 50
(*b.*) *Middle beds.*—Limestone with black shaley beds; fossils abundant, about, ...	200
(*c.*) *Upper beds.*—Beds of blue limestone, from one to three feet thick, interstratified with shale—fossils also abundant, about, ...	700*

* These thicknesses are taken from the Hor. section, No. 1, sheet 24.

On the mainland the limestone is generally concealed by the gravels of a raised beach, occupying the flat terrace about Soldier's Point, or by drift deposits which occur under Cranfield House.*

3. Drift, or Post Pliocene, Deposits.

These are represented by at least two members—the Lower Boulder Clay and the Middle Gravels, sometimes called the "Interglacial Gravels." I am not aware of the presence in this district of the Upper Boulder Clay which elsewhere occurs and has been described by the author† and other officers of the Survey. These deposits cover by far the larger portions of the low-lying grounds bordering the sea about Kilkeel, and also the depression to the north of the Mourne Mountains. They ascend the valleys for long distances, and cover the flanks of the hills and ridges where not very steep, climbing up to elevation of 1,200 to 1,400 feet as on the side of Slieve Muck, which is an exceptional level. They also overspread the district to the north and N.E. of Newry to a large extent—forming rounded hummocky hills—easily to be recognized—as they are smooth, rockless, and destitute of marked features. The thickness of these drift deposits is generally about forty to fifty feet, but they doubtless attain in some places to greater thickness than these—the most persistent member is the Lower Boulder Clay—the overlying sands and gravels of the next division being only occasionally present—and through this covering the underlying rock, whether granite, Silurian grit, or other material, sometimes juts forth in rugged knowls, sharp cliffs, or steep banks, while the higher elevations of the mountains are destitute of the covering altogether.

(*a.*) *Lower Boulder Clay.*—This formation consists of stiff reddish brown, or dark-blue clay, destitute of stratification (except of a very rude and irregular kind), and enclosing stones and boulders often of large size and of many varieties. The stones often present glaciated surfaces, and are scored by lines and groovings due to glacial erosion.‡ It attains a thickness of thirty to fifty feet—thinning out towards the slopes. This deposit is now recognised by geologists as owing its formation to an ice-sheet—the stones and boulders it contains indicating the direction from whence the ice-sheet moved. In this district the general direction of the ice-movement seems to have been from the north, or north-west, parallel in fact to that of Carlingford Lough. The boulder clay ascends to a high level on the slopes of Slieve Donard and its neighbouring heights. The valley of the Bloody Bridge River has been filled in with this material, out of which the existing channel of the river has been excavated. Ascending this valley, we find the stony clay, with

* A list of fossils collected about Greenore from the Carboniferous Limestone will be found in the Explanatory Memoir to sheets 60 and 71, p. 24, prepared by Mr. Baily.

† Hardman, Expl. Mem., sheet 35 (Tyrone), p. 14.

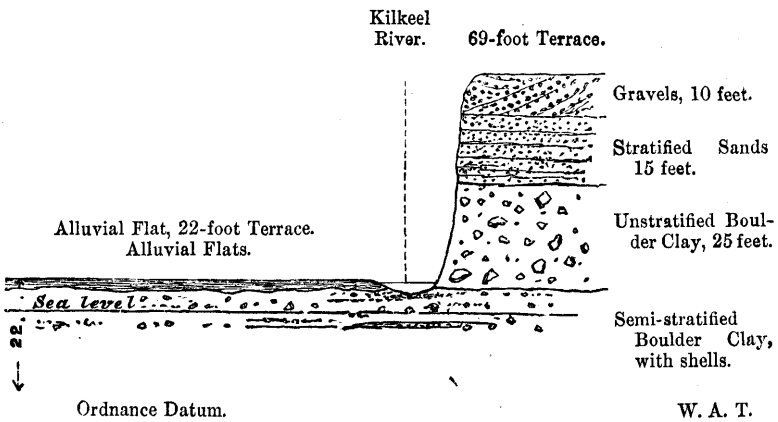
‡ On the question of the origin of this remarkable deposit the reader is referred to "The Physical Geology of Ireland," pp. 80, 82, and 224.

large boulders, assuming the character of moraine matter, and stretching up to the base of the steep slope to a level of about 1,500 feet above the sea. Mr. Traill with myself determined the upper limit of the deposit on Slieve Muck to be about 1,570 feet by aneroid observation—so that we may assume that only the highest elevations of the Mourne Mountains were left uncovered by the ice-sheet, if, indeed, there were any such.*

In a pit above the watermill in the valley N. of Warrenpoint the pebbles found in the boulder-clay clearly pointed to a northern source, and included (along with some of a local origin) fragments of flint from the chalk, red quartzite, and reddish granite from the district east of Newry. Again, in the road cutting S. of Bloody Bridge, the boulder-clay contains numerous blocks of Silurian grit and slate, and of granite from the Castlewellan district to the north—some of these blocks are glaciated. Additional evidence of the direction of the ice-movement will be offered when I come to describe the erratic blocks of the district.

(*b.*) *Middle or Interglacial Gravel.*—This deposit is found frequently surmounting the Lower Boulder-clay, from which it differs in being truly stratified, and formed of sands and gravel of water-worn pebbles. Sections may be observed in some of the river valleys—such as those of the Whitewater and Kilkeel rivers (Fig. 4). In the dell running up from the coast, three miles N. of Newcastle, the two divisions of the drift may be observed gradually ascending with the rise of the ground. The gravel is about forty feet thick, and the boulder-clay over ten feet in thickness. Flint fragments were observed in the gravel.

Fig. 4.



Along the coast S. of Newcastle the solid rock is generally surmounted by banks of sand and gravel resting on the boulder-clay—these rise inward to higher levels on the slopes of the mountains.

One of the best sections in the district is that shown in the valley

* "The Physical Geology of Ireland," p. 260.

of the Whitewater below Mourne Park. Here the bank is formed of beds of drift, consisting in the upper part of stratified sands and gravel, with *Turritella* and fragments of other marine shells, resting, with a clearly marked boundary, on the boulder-clay of a reddish-brown colour—containing angular blocks, sometimes standing on end. In addition to these are some patches of river-gravel occupying depressions in the drift; showing that the river-channel has been cut down much below its former level.

Another good section is shown in the Kilkeel river (see Fig. 4) about a quarter of a mile below the Newcastle road. Here beds of sand and gravel, twenty-five feet thick, are seen resting on stiff reddish boulder-clay, with blocks of Silurian grit and granite. Towards the mountains the boulder-clay emerges from beneath the gravel beds and forms sloping terraces.

4.—Raised Beaches.

There are numerous indications around the coast, that the land has been raised in recent times. These indications occur in the form of terraces, consisting of stratified sands and gravels often containing marine shells of the species now inhabiting the neighbouring seas—with possibly a few forms which may have disappeared. These terraces were clearly old sea-beds, and they have since been raised into land-surfaces beyond the reach of the highest tides.*

Such terraces are found skirting the northern shores of Dundrum Bay, partially covered and concealed by sand-hills, and extending to the foot of the high ground at Newcastle. They again appear forming a very narrow strip along the coast at Annalong, where they have been subjected to the wasting effects of the waves, but on both sides of the entrance to Carlingford Lough, at Soldier's Point and Greenore Point, they form considerable tracts of level land and may be conveniently examined.

Of those terraces, which may be properly called "raised beaches," there appear to be two; the lower, rising from three to seven feet above high-water of spring tides; the second, from ten to fifteen feet above the same datum. Mr. Traill has described these terraces as they occur at Greenore,† where, in the stratified gravels of which they are formed, there are bands of oyster-shells, together with shells of the genera *Mytilas, Pecten, Natica, Littorina,* &c. At Killowen near Rostrevor, similar shells were found in shingle ten feet above high-water mark. The two terraces on the opposite shore are similar in formation.

On the lower terrace, that of about ten to fifteen feet above high-water, is built the town of Warrenpoint; together with the old keep of Narrowwater, on the estuary of the Newry river. Beside the Presbyterian Church, and outside the park of Narrowwater, beds of oyster-shells were found.

At Annalong Harbour, the terrace is at forty feet elevation

* The Ordnance Survey datum plane is 8·64 feet below mean tide level, it is from this plane that the heights marked on the map are measured.

† Expl. Mem. to sheets 60 and 71 (in part) pp. 19, 20.

above Ordnance datum, or a little over twenty-two feet above high-water line—this is therefore the upper terrace. The terrace bordering the coast near Dundrum, is referable to the first or lower level. Other remains of raised beaches are to be found at intervals along the shore of Carlingford Lough to Warrenpoint, from ten to twelve feet above the water line.

In addition to the raised beaches, clear indications of terraces, formed out of the drift deposits, are to be observed at several levels, viz., at those of 50, 75, and 150 feet. These are often more easily to be recognised, when viewed at some little distance, than when standing upon them. One of these, with a distinct inland bank, borders the coast from Cranfield Point to the mouth of the Kilkeel River; and I have already referred to another, at a much higher elevation, at the head of the same river valley.

The terraces of this class are of more ancient date, than those described above, and are probably referable to the period when the land was emerging from the sea, towards the close of the glacial epoch, the terraces having been formed during long pauses.

River terraces and alluvial flats.—These are not of any great importance in the district under description, they consist sometimes of gravel, and where of estuarine origin of mud, such as that of the Newry River.* Along the course of the Whitewater and Kilkeel Rivers, the alluvial tracts are composed of fine sand, silt, and peat inter-stratified, and are somewhat wide; and the section in the bank below Mourne Park shows that at least one of these streams has deserted its old bed, and now runs in a lower course.

Old Lake Beds.—The level flat of the Kilkeel valley is probably an old lake-bed, covered by water before the river had cut down its channel to its present depth. It would require but a small embankment to restore its former lacustrine condition.

Another old lake bed occurs in the upper part of the Annalong valley, where the river bends to the northwards towards the foot of Slieve Donard. Here a large moraine was thrown across the valley by a glacier which descended from the snowfields of Slieve Donard and its neighbouring heights, and converted (on the disappearance of the glacier) the valley into a lake. The fine sand and silts which formed the lake-bed may be observed forming a level-terrace just above the moraine. Ultimately the lake was drained and its bed laid dry when the river cut down the present deep channel through the moraine.

Peat Bogs.—The number and extent of peat-bogs amongst the Mourne Mountains is small, compared with many other mountain districts of Ireland. This is probably due to the extreme porosity

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* The narrow strip of slob-land, from Narrowwater to Newry, a distance of about five miles, is fast reclaiming itself by the alluvial deposits brought down by the river. A part was artificially reclaimed, and it is now some five or six feet below the level of the alluvial deposit outside the embankment, which extra height has accumulated in a period of about twenty-five years.

These, together with a large portion of the ground on which the town of Newry is built, must be considered the representation of the lower raised beach. The B. M. at Margaret-square is marked twenty feet.

W. A. Traill.

of the rocks, which prevent the stagnation of water so necessary to the growth of marsh and aquatic plants; and partly to the small number of places where the slope of the ground approaches the horizontal position. There are, therefore, only four peat-bogs of any importance—those called on the map Deer's Meadow bog (from 1,100 to 1,150 feet in elevation), Castle bog (1,500 feet), and those lying on either side of Slieve L. Shannagh. In some places these bogs are being rapidly cut away, particularly the last mentioned, for the requirements of the inhabitants.

Another district in which there are considerable tracts of bog-land, is that lying to the north and east of Rathfryland. Below the peat there is generally found a fine alluvial sandy deposit. These tracts lie amongst a group of drift hills, and are connected with the drainage of the Bann and its tributary streamlets, and are liable to floods. Stems of pine trees occur in the peat, the roots being imbedded in the underlying alluvial soil. In this district are several little lakes, with borders of peat of vegetable origin, which probably occupy flats originally under water. Of these loughs the largest are those of Hunshigo and Ballyward.

5. Metamorphic Rocks.

(*a.*) *Granite of Newry.*—The tract of granite which ranges in a north-easterly direction through the district, is a portion of a larger area, extending from the flanks of Slieve Gullion (sheet 59) by Newry and Rathfryland to Slieve Croob (sheet 48), which rises to an elevation 1,755 feet, and is the culminating point of this range.* This granitic tract nowhere comes into actual contact with that of Mourne—hence the question of the relative ages of the two granites (those of Slive Croob and Mourne) is not capable of actual demonstration. Nevertheless, it is almost certain that the Slieve Croob granite is the more ancient of the two, while, as will presently be shown, it also differs in composition and mode of formation.

In a paper read before the British Association at the Edinburgh meeting (1871), by Mr. Traill and myself, we adduced evidence in favour of this view. It is founded on the characters and relations of the dykes of igneous rock to the granites and to themselves, and the argument may be briefly thus stated:—

The granite of Mourne at its margin in some places, particularly along its northern margin, passes into quartziferous porphyry, and sends offshoots of this rock in the form of dykes into the surrounding Silurian strata, as may be very clearly determined by several examples in the vicinity of Newcastle. Hence it may be inferred that the dykes of quartz-porphyry which traverse the granite of Slieve Croob, are referable to the age of the granite of Mourne, and if this be so, the greater antiquity of the granite of Slieve Croob is determined.†

There is also another point of evidence which may be observed from a study of the geological maps (sheets 48, 59, and 60). It

* Egan, Expl. Mem., sheet 48, pp. 5 and 8. The summit of Slieve Croob is capped by schist.—See map, sheet 48.

† Brit. Assoc. Rep., 1871. Trans. of Sections, p. 102.

will be seen that numerous dykes of basalt or dolerite terminate at the margin of the Mourne granite; hence they are inferred to be of older date as regards their origin than the granite itself; but in the case of the Slieve Croob granite we have no similar instance of the abrupt termination of a basalt dyke at its margin, and it is exceedingly probable (to say the least) that some of the basalt dykes traversing the Slieve Croob granite are contemporaneous with those which are terminated by, and are therefore older than, the granite of Mourne.

Composition of the Granite.—As shown by the Rev. Professor Haughton, the granite of Slieve Croob consists of quartz orthoclase, and black mica, in varying proportions. In some places the felspar is pink or reddish, as at Greenan, near Newry, giving a "warm" tint to the rock when polished. Towards the margin it changes (as already stated) into mica schist, and sometimes patches and bands of this rock are found enveloped in the granite itself. The analysis of the granite from Goragh Wood station shows an unusally low per-centage of silica. The rock is generally finely crystalline granular, uniform in texture, though sometimes inclined to be porphyritic; is capable of being delicately wrought, and produces a stone well adapted for building and decorative purposes. From a quarry near Castlewellan, large blocks were extracted and sent to London for the base and pedestal of the Prince Albert memorial in Hyde Park, the stone having been selected from amongst others by The Queen herself.*

The rock is largely quarried at Newry, Goragh Wood station, and a few other places, where it is cut into headstones, columns, and blocks for buildings and paving. Its composition has been determined by Dr. Haughton from specimens taken from Newry quarry (No. 1) and Goragh Wood (Nos. 2 and 3), to be as follows:—†

Chemical Composition of Newry Granite.

	I.	II.	III.
Silica,	54·60	62·08	66·56
Alumina,	14·64	15·92	13·52
Peroxide of Iron,	6·04	7·72	6·76
Lime,	3·16	5·52	1·20
Magnesia,	2·80	2·16	1·32
Potash,	3·15	2·19	2.73
Soda,	4·02	3·34	3·75
Peroxide of Iron,	—	—	0·18
Loss by ignition (water),	1·13	0·89	2·19
	99·54	99·83	98·21

The finest exposure of Newry granite is that of Goragh Wood where an active business is carried on in quarrying and shaping the stone.‡ Large quantities of good paving sets are here made and are sent to Belfast, Dublin, and other towns. The section extends for about 280 or 300 yards, with a vertical face of about eighty feet, and shows several bands of granite rock, alternating

* "Building and Ornamental Stones, &c." (1872), p. 44, &c. North of Castlewellan, on the flanks of Slieve Garran the granite contains bronze, mica, and crystals of hornblende.

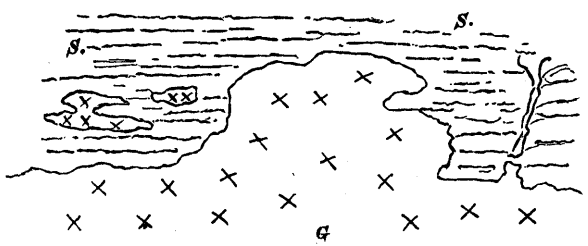
† Quart. Journ. Geol. Soc., vol. xiv., p. 303.

‡ This section lies in sheet 59, just outside the margin of sheet 60, but being so close, and of such importance it is referred to here.—See Expl. Mem., sheet 59.

with irregular masses of metamorphosed Silurian schist, highly micacised. Several granite veins are also visible, and the whole mass is penetrated by a pair of basaltic dykes.

The junction with the Silurian schist may generally be very clearly traced all along the southern margin from the banks of the Newry Canal, near Greenan Lodge, to Castlewellan (Fig. 5). In some places the granite passes into quartz-porphyry and sends out dykes into the adjoining schist. The most remarkable instance of this kind is the dyke which crosses the hill called Craignamona from Lisaslieve, traversing the Silurian beds for upwards of a mile. At Bannvale, near Hilltown, a remarkable dyke of felstone-porphyry starts from the side of a fault, and runs for upwards of four miles parallel to the boundary of the granite, and only separated from it by a band of schist from a quarter to half a mile in breadth. It can scarcely be doubted that this dyke originates in the granite underneath. Other cases will be observed on consulting the maps.

Fig 5.



Plan of granite at junction with the Metamorphic Silurian beds, N. of Castlewellan Park. G. Granite. S. Lower Silurian beds.

It has been already stated that all the evidence goes to show that the Newry granite is of metamorphic origin, and in a previous page I have given an account of the process by which the Lower Silurian grits and slates have been converted—first, into micaceous schist, and then into granite or gneiss. This process arises from the developement of a high temperature from below in presence of aqueous vapour, gradually extended upwards and outwards, and causing the original molecules of the rock to enter into new combinations. In this way the mica and felspar were developed, and the excess of silica is left free.

The presence of aqueous vapour is proved by the existence of fluid cavities in the silica of the granite which I have examined from specimens both of the red and grey varieties taken from near Newry.

(*b.*) The mica-schist in contact with the granite of Slieve-Croob and Newry has already been sufficiently described (p. 17).

Microscopic Structure.—I have examined thin sections of this granite from Greenan, near Newry. With a low magnifying power (two-inch object glass) the following minerals were observed: (1) orthoclase—clouded—not well developed; (2) plagioclase in small quantities as compared with orthoclase; (3) quartz, amorphous, shown by the polariscope to occur in distinct grains bounded by a light-coloured fringe, each polarizing differently;

(4) green mica in small flakes, deeply scarred; (5) magnetite in black grains, not numerous; (6) iron-oxide; and (7) chlorite.

Plagioclase, although not usually recognised in the Newry granite, is undoubtedly present in small quantities. From the large proportion of soda and lime shown by the analysis, this may be presumed to be oligoclase.

With a magnifying power of 400 diameters the silica is seen to contain very small fluid-cavities, generally arranged in lines (that is, in planes cut transversely by the plane of the section), but occasionally sporadically scattered throughout the mass. Some of these cavities have angular termini. Along with these are slightly coloured angular bodies (probably small mica flakes), and long curved needle-like, opaque bodies, of whose nature I have no idea, but which come under the vague category of crystallites known as "trichites." There are also a few colourless prisms (or tube-like bodies) with blunt or rounded termini, which would be identified as apatite were it possible to make out the hexagonal form of cross-section, but this I am unable to do;—so I refrain from hazarding an opinion regarding their nature.

6. Igneous Rocks.

Granite of Mourne.—The granite of the Mourne mountains is remarkably different in appearance and composition from that of Newry and Slieve Croob.* It varies in colour from the prevalent grey to reddish-brown—or light purple, and consists essentially of four distinct minerals, determined by Rev. Dr. Haughton to be quartz, orthoclase, albite, and green or black mica.

The quartz is generally of a brown colour, approaching the variety known as "smoke quartz." It sometimes crystallizes out in hexagonal prisms in the little "druses" or cavities which often occur in the granitic mass.

The orthoclase occurs in large opaque white crystals, with well-formed faces, or else in short well-formed prisms with truncated terminations lining the cavities of the rock. Dr. Haughton has determined its composition as follows from three specimens.

Analysis of Orthoclase.

	I.	II.	III.	Mean.
Silica,	66·32	66·33	66·10	66·25
Alumina,	17·56	17·47	17·01	17·35
Lime,	1·36	1·15	1·26	1·25
Magnesia,	0·17	—	—	0·17
Potash,	10·60	12·10	10·95	11·22
Soda,	2·33	2·67	4·14	3·05
Loss by ignition,	0·90	—	—	0·30
	99·24	99·72	99·46	99·47

The specific gravity = 2·557.

The albite is less distinct than the orthoclase in ordinary specimens; it occurs in twin crystals, incrusting the interstices of the orthoclase and quartz, and may be traced by its translucent

* The granite of this district has been described as "pegmatite," but as Dr. Haughton observes, the destinction between this variety of granite and the ordinary fine grained granites, does not appear of sufficient importance to be worthy of a separate name. Quart. Jour., Geol. Soc., vol. xii., p. 189.

appearance in the body of the rock itself in small quantities.* The albite gave the following analysis:—

Analysis of Albite.

Silicia,	68·97	per cent.
Alumina,	19·23	,,
Lime,	1·21	,,
Magnesia,	0·24	,,
Potash,	1·54	,,
Soda,	8·71	,,
	99·92	,,

The general composition of the Mourne granite has been determined by Rev. Dr. Haughton as follows:—†

Silica,	71·41	per cent.
Alumina,	13·24	,,
Oxides of iron,	2·52	,,
Lime,	0·69	,,
Magnesia,	—	,,
Potash,	4·33	,,
Soda,	3·07	,,
Loss by ignition,	0·80	,,
	99·65	,,

The specimen above analysed was taken from Slieve Corragh, of which the specific gravity was 2·595.

Thin sections show under the microscope that the quartz contains fluid cavities, as is usual with true granites, and Professor Hartley has noticed that sometimes the cavities have a crystalline form.‡ In general the orthoclase and mica are well crystallized out, the albite less so, and the quartz (except when crystallized along the sides of cavities) is amorphous, or occurs in small grains (or "blebs").

Besides the above minerals, the Mourne granite contains others of rarer occurrence, such as the topaz (with the varieties of aquamarine and emerald), peridot, and fluor-spar (octohedral).§ Along with these, occur beautiful dark crystals of smoke-quartz. The rarer minerals are found only in the drusy cavities of the granite, and chiefly in Slieve Bingian and Slieve Corragh. On Carn mountain the granite is highly cellular, the cells being lined by crystals of quartz, orthoclase, and albite.

The cellular character of the Mourne granite is one of its peculiarities, owing to which it has given origin to the numerous crystalline minerals above referred to. These cells or "geods" were probably originally filled by gas or steam at a high pressure and temperature.

Tabular Structure.—On the flanks of Slieve Donard, as also on Chimney rock, Ben Crom, Slieve Muck, and along the valley of the Annalong river the granite assumes a flaggy structure, corres-

* Haughton. Quart. Jour. Geol. Soc., vol xii., p. 190.

† Journ. Chem. Soc., March, 1877, p. 7.

‡ Beautiful examples of these will be found in the mineral collection of the Royal College of Science, Dublin.

§ Haughton, p. 191.

ponding in some degree to the slope or sides of the hills themselves. This structure will be observed very clearly on ascending Slieve Donard along the Bloody Bridge valley, and might at first sight be taken for bedding. Such is, however, not the case. The structure is one originating during the cooling down of the rock under its formerly superincumbent mass of Silurian strata. The planes giving rise to the flaggy structure are those of shrinkage on cooling, and are approximately parallel to the original surface of contact with the enveloping mass. Other shrinkage or joint-planes traverse the granite in vertical, or highly inclined directions.

The granite changes into quartz porphyry.—The granite at its junction with the Silurian rocks, and for some distance downwards, tends to assume the petrological conditions of a quartz porphyry or elvanite; that is to say, a rock with a felsitic paste enclosing crystals of felspar, mica, and grains of quartz. This (as will be seen on looking at the map, sheet 60) characterizes the marginal portion all along the northern boundary from Shanslieve to Slievemaganmore, and also generally along the western margin of the granite from Cruggandoo to Finlieve. It will also be observed that the dykes which protrude into the Silurian rocks from the granite, generally assume the form of quartz porphyry, of which there is a remarkable example in the case of the large dyke which traverses, in a N.W. direction, the Silurian rocks of Slievenabrock, near Newcastle.

This change in mineral character is doubtless due to the greater rapidity with which the granite cooled down and solidified when in contact with the enveloping Silurian rocks, than where more deeply seated. Instead of a paste of silica, one of felspar has been formed, and the rock loses its characteristic form of granite. It is not easy clearly to see how the change has been brought about, but the cause is evident enough.

Microscopic Structure.—Specimens from Annalong, near Slieve Donard, and from the neighbourhood of Rostrevor, give the following results when seen under the microscope :—

(1.) Granite of Annalong (two sections). The rock is slightly flesh-coloured, consisting of white and pinkish orthoclase, a little plagioclase (albite), quartz in distinct grains, and a very little black mica.

(*a.*) All the above minerals are clearly shown under a low microscopic power. The orthoclase seldom shows the angles of crystallization, but its strong cleavage planes are brought out under the magnifier. With the polariscope the play of colours, on rotating the analyzer, is rich and varied, and with a higher power (one-inch) the orthoclase is seen to be cellular, but no fluid cavities could be observed.

(*b.*) *Plagioclase.*—In one of the thin sections there is a large crystal of plagioclase, showing the parallel lines and bands of colour extremely well under the polariscope. The walls of the crystal are well formed, but with this exception there is very little plagioclase in the observed sections.

(*c.*) *Mica.*—The mica is sometimes almost opaque, at other times

it crystallizes in small flakes, traversed by cleavage planes, and polarizes strongly.

(*d.*) *Silica.*—The silica is abundant, next in quantity to the felspar. It occurs in numerous grains, each polarizing differently, sometimes enclosing felsper grains or mica flakes, but generally tending to form distinct sub-crystalline grains. With the one-fifth object-glass, cells containing fluid bubbles are seen to be extremely numerous; along with which are gas—and stone—cavities. Professor Hartley has observed, along with water-cavities in the granite of Mourne, others containing carbon dioxide, but of rare occurrence.* He also observes that some of the cavities take the form of the crystal in which they are enclosed, and from this deduces the temperature at which crystallisation took place (about 150° C.)

(*e.*) *Magnetite.*—With a magnifying power of 400 diameters and upwards, very minute black grains of magnetite, come into view. They occur imbedded both in the felspar and mica. As oxide of iron has been detected by chemical analysis (see p. 24) the existence of magnetite was to be anticipated.

(2.) *Granite of Rostrevor.*—The thin section from Rostrevor gives nearly similar results to those stated above, except that it does not happen to contain plagioclase. With polarized light the play of colours both of the quartz and orthoclase is very rich, and the quartz contains numerous fluid cavities.

On the whole, it cannot be said that the granite of Mourne differs materially in microscopic structure from that of most other granites. The occurrence of the fluid cavities in the quartz in such large numbers identifies the rock as a true granite; the only slight difference being, that the quartz is less in the condition of a paste enclosing the other minerals than is usual with this class of rocks.

In a previous page I have stated, that the Silurian rocks at their contact with the Mourne granite (unlike those in contact with the Newry granite) are not metamorphosed, but only indurated or "baked." This points to a difference in the original condition of the two masses. In fact it may be supposed, that the Mourne granite was not intruded in a condition of very intense heat, but in a viscous state, and in temperature below that of fluidity. The temperature appears to have been below that necessary to melt the enveloping masses of rock;—but in the case of the Newry granite, it was otherwise. Here the heat was sufficiently intense, not only to metamorphose the enclosing sedimentary rocks to a considerable distance from their margin of contact, but even to melt down, and convert into crystalline granite, these rocks themselves. It has also been shown that the epochs of formation of these to granite masses are different. From all of which it appears, that they are different from each other in three essential particulars: first in age, second in composition, and third in mode of formation.

Geological age of the Mourne Granite.—In the paper read

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* Journ. Chemical Society, March, 1877, p. 4.

before the British Association, above referred to, the authors recorded their opinion that the granite of Mourne, is of Mesozoic age.* On the other hand, the late Professor Harkness suggested to one of the authors that it was irrupted during the interval between the Carboniferous and Permian period.† All that can be confidently affirmed from the available evidence is, that the Mourne granite is Post-Carboniferous on the one hand, and older than the Miocene period on the other; as the numerous basaltic dykes by which it is penetrated are doubtless referable to that epoch of volcanic activity. On the other hand, the basaltic dykes, which terminate at the margin of the granite, and are therefore more ancient, are probably identical in age with those which on the south side of Carlingford Lough, and near Greenore and Grange, pierce through the Carboniferous Limestone.

The actual epoch of irruption is therefore very uncertain, and its possible limits are bounded by such wide margins in time that the question must ever remain in uncertainty. Such is also the case as regards the age of the granite of Arran, with which it has been compared.

It is probable that the granite of Mourne is contemporaneous with, and in some measure represented by, the felspathic rocks which form such a large portion of the region lying south of the Newry River and Carlingford Lough, about Clermont Carn, Slievetrasna, and Fathom Mountain (sheets 59, 60, and 71). As Mr. Traill has shown, the same mass in this district appears at different points under very different forms, depending chiefly upon the conditions of cooling, so that the simple felstone of one tract passes by slight changes into felstone porphyry, quartziferous porphyry or elvanite, and ultimately into granite.‡ On the other hand we have seen, that the granite of Mourne has a tendency to pass into quartziferous porphyry around its margin. Hence the chain of variations from felstone to Mourne granite is connected throughout. The only points remaining to be determined in order to establish the representative characters of the two masses—those east and west of Carlingford Lough—are those of geological age and chemical composition. And as regards the former the evidence goes to show that in both cases the felstone and quartz-porphyry of the western region are Post-Carboniferous,§ as I have shown to be the case with the granite of the Mourne district,‖ and in reference to the chemical composition of the two sets of rocks, we have the investigations of Rev. Dr. Haughton, which show that there is a remarkable similarity between typical specimens taken from each. Thus the composition of a specimen taken from Slieve Naglogh, characteristic of the entire mass of the felspathic rocks of Carlingford district is as follows :—¶

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* Hull and Traill, Brit. Assoc. Rep. 1871. Trans. of Sections, p. 102.

† *Ibid.*, note to p. 102.

‡ Expl. Mem., sheets 60 and 71 (in part), p. 10.

§ Mr. Traill has shown that the felspathic rocks have converted the Carboniferous Limestone on the flanks of Barnavane, Slieve Foye, and Slieve Naglogh into white saccharine marble. *Supra. Cit.*, p. 18.

‖ *Supra.*, p. 29.

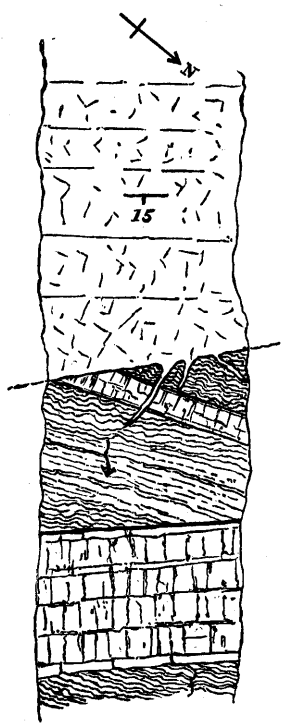
¶ Quart. Journ. Geol. Soc., vol. xiv., p. 300.

Silica,	70·48
Alumina,	14·24
Peroxide of iron,	3·72
Lime,	1·48
Magnesia,	0·40
Potash,	4·26
Soda,	3·66
Loss by ignition,	1·59
	99·83
Specific gravity,	2·593

If the above be compared with the analysis of the specimen from Slieve Corragh (p. 26), it will be found that the differences are exceedingly slight in the case of the silica, alumina, oxide of iron, and lime, while the proportions of magnesia, potash, and soda are almost identical. The specific gravities of both specimens only differ by $\frac{1}{200}$ part.

The boundar of the granite with the Lower Silurian rocks may be traced with certainty along the northern, western, and eastern margins by means of the sections visible in the streams, on the hillsides, and escarpments. The phenomena observable are ever varying and very interesting, such as when the granite sends off dykes into the schists, or when it cuts off a dyke of basalt or trap of older date than itself. A very interesting section of this kind is visible in the Glen River, in Newcastle Park, of which a plan (Fig. 6) made by Mr. Traill is annexed.

Fig. 6.



Granite (Mourne) composed of Quartz, Orthoclase, Albite and green Mica, in thin sheets inclined 15° N.E.

Junction of granite with schists bearing W. 35 N nearly vertical or highly inclined N.E.

Basalt dyke (pre-granitic) N.N.W., penetrating the schists and cut off by the granite.

Indurated schists, crumbled dip N.E.

Basalt dyke penetrating the schists, bearing W. 35 N., 20 feet wide, a finely crystalline Melaphyre.

Along the southern margin of the granite—between the Annalong and White Rivers, the boundary is generally obscured by drift deposits of boulder-clay and gravel, and the surface is strewn with granite boulders. No rock is found *in situ* between Crockanroe and Carrick Little (both formed of granite), and the sea-coast over three miles distant, near Danes Bridge Point, where Silurian beds occur. On this account, the boundary between the granite and Silurian marked on the map is drawn conjecturally and chiefly from the form of the ground.

7. Igneous Rocks other than Granitic.

The trap-rocks of the Mourne district, like those of the adjoining districts of Carlingford and Slieve Gullion are remarkable both for number and variety. They are chiefly abundant amongst the Silurian beds in proximity to the granite of the Mourne Mountains, and of rarer occurrence in the granite itself. Dykes are also numerous in the Newry granite, particularly on the west side of the Newry River valley, and they may be advantageously studied along the cuttings of the Dublin and Belfast Railway in sheet 59.* Dykes of trap are also not uncommon in the granitic and schistose district S.E. of Newry and about Castlewellan. Along the coast between Newcastle and Ballymartin the dykes of trap present a remarkable spectacle from their number and variety. Although within a few hundred yards of the margin of the granite, in scarcely a single instance, are they found to traverse that rock.† Doubtless there are many more than those shown on the geological maps, but undiscoverable owing to the overspread of the drift deposits.

Composition.—The trap rocks of the district are divisible into three groups as regards composition :—

(1.) *The felspathic,* including felstone, porphyrite, felstone porphyry, quartziferous porphyry or elvanite, and syenite.

(2.) *The pyroxenic,* including those of which augite or hornblende are essential components, such as basalt, dolerite, melaphyre, and diorite.

(3.) *The micaceous,* including mica-trap.

I shall now give a description of some of these in the order above named, together with that of their microscopic structure.

1. The Felspathic Group.

Under this head are included those varieties in which the "paste" is felsitic or felspathic,‡ and which when containing crystals of felspar, become "porphyrites," or when containing crystals or grains of quartz, become porphyries, or of quartz and felspar—become quartziferous porphyries and elvanites in their coarsely granular condition. Dykes of these varieties are found all over the district under description. In many cases the Mourne

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* Nolan, Expl. Mem., sheet 59.

† These remarkable dykes are represented on Griffith's "Geological Map of Ireland," published in 1835. That Sir R. Griffith was aware that the dykes are cut off at the granite margin was stated by that eminent observer to the author a few years ago.

‡ The felsitic differ from the felspathic in being more highly silicated than the latter.

granite, in others the Newry or Slieve Croob granite, sends forth dykes of this class of rocks into the bordering Lower Silurian beds, and in a few cases the granites are traversed by dykes of more recent date than themselves.

(1.) *Craignamona Dyke.*—Amongst the more remarkable instances in the case of the Newry granite is that already referred to as occurring at Craignamona, about four miles N. of Warrenpoint. Here a dyke of granitoid quartz-porphyry about ten or twelve yards in width strikes southward from the edge of the granite for about a mile into the Silurian beds, till terminated by a fault. This dyke crosses the Hilltown road along which it is laterally displaced by a fault which runs parallel to the road itself. It is a finely crystalline granular rock, of a reddish colour, and consists of the following minerals as seen under the microscope:—

(*a.*) *Orthoclase.*—In well-formed short crystals—clouded and colourless.

(*b.*) *Plagioclase.*—Several well-formed prisms, showing clearly with the polariscope the parallel bands and lines of a triclinic felspar. From the occurrence of soda and lime in the granite of Newry (see p. 23), it may be inferred that this mineral is oligoclase.

(*c.*) *Mica.*—Small flakes, deeply scarred or fissured, and of a sap-green colour.

(*d.*) *Quartz.*—In small quantities filling interstices, and mixed with felsitic matter as a paste in which the felspars and mica are enclosed. With a high power the silica is seen to include fluid cavities, and others containing "dust."

(*e.*) *Chlorite.*—A few patches of a green colour, easily to be distinguished from the mica by its amorphous form, and absence of structure.

(*f.*) *Actinolite or Tremolite* (?).—Along with the above occurs a mineral in long prisms or flakes radiating from a centre. It polarizes vividly from green to ruby-red, and shows well with a high power. It seems to answer the description of actinolite as given by Rosenbusch,* but the absolute determination would require a series of investigations beyond my reach.

(*g.*) *Apatite* (?).—With one-inch object glass, numerous long slender colourless prisms are visible, with blunt terminations. They traverse the quartz and felsite paste in all directions. There can be little doubt but that these are crystals of apatite; at the same time, in order to be certain, one should be able to observe a hexagonal cross-section, which (except in one doubtful instance) I have been unable to do. The absence of phosphoric acid amongst the components, as determined by analysis, does not prove that the substance is not present, but that it had not been specially looked for and is in exceedingly minute quantities.

(2.) *Hilltown Dyke.*—The remarkable dyke, from six to eight

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* Mikros. Phys. d. mineralen, B. I., p. 307.

yards in breadth, which courses through the metamorphosed Lower Silurian rocks from Hilltown to the foot of Carn Hill, a distance of nearly five mile, has already been alluded to as being probabaly concealed offshoot of the granite itself, but is dissimilar in appearance from the former. Under the microscope, a thin section presents a very interesting subject of study. With the two-inch object-glass, the rock is seen to consist of a mottled brown or yellowish felsitic paste, with crystalline grains—sometimes quadrangular, sometimes hexagonal—of clear quartz, and long twin-crystals of orthoclase, which are well brought into view by the polariscope. The field of the felspathic paste is covered by patches of a radiating brownish mineral, evidently of secondry origin, which surrounds the crystals of quartz and felspar. It is properly iron-oxide which has been filtered in along the walls of the crystals. With a high magnifying power the grains of silica are seen to contain numerous fluid cavities, in which the little vacuum bubble is easily to be distinguished; while other cells are filled by gas,* or "dust." It is an unusual circumstance for the silica of trap dykes to contain fluid-cavities, and tends to confirm the view that in this instance the dyke is connected with the subterranean granitic mass.

(3.) *Felstone with epidote, Spelga, Mourne Mountains.*—Dark greenish-brown rock with numerous round cavities filled with epidote. This latter mineral is of a waxy-yellowish colour, crystallized in radiating prisms easily visible with an ordinary lens. The rock occurs in the form of a dyke, traversing the Lower Silurian beds, and is of older date than the granite of Mourne.

Under the microscope, the paste appears as a mottled grayish mass enclosing prisms of felspar, a few grains of quartz, and small specks of magnetite. There are also numerous round patches of yellowish secondary mineral, which polarizes vividly, and in this respect agrees with Rosenbusch's description of epidote.† The specimen from which the slice was made for the microscope does not appear to be the same as the hand specimen of the rock, and the supposed epidotic mineral is not so well crystallized in the former as in the latter.

(4.) *Felstone dykes and sheets of Sleve Muck.*—Regarding these Mr. Traill states that some are very similar in appearance to the Silurian grits, following the same strike and similarly inclined as the strata they penetrate, thus apparently resembling contemporaneous ash-beds or sheets. But, the fact that they occasionally bifurcate and cut across the Silurian strata, places their intrusive origin beyond doubt; though Mr. Traill considers that they originated at a very early period; in fact, previous to the period of the crushing and plication of the Lower Silurian rocks of this region.

(5.) *Slievenabrock Dyke.*—Numerous dykes of felstone, basalt, &c., are visible in the Shimna River which traverses Tollymore

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* They exactly resemble the "gas-poren" figured in Rosenbusch's "Mikros. Physiographic," vol. i., p. 22.

† *Ibid.*, vol. i., p. 336.

Park, and several of porphyry protrude from the granite into the Silurian schists. One of these ranges in a north-westerly direction along Slievenabrock, is from ten to fifteen yards across, and is remarkable for the occurrence of a narrow basaltic dyke in contact with its northern face. This dyke is crossed by one of the horizontal sections constructed by Mr. Traill.*

(5.) *Glasdrumman Port Dyke.*—One of the most remarkable dykes in the whole district is that which has been traced from the Annalong River, about a mile inland from the coast, and which, after ranging in a N.N.E. direction, enters the sea in two branches N. of Glasdrumman Port, five miles S. of Newcastle. This dyke is about thirty yards wide, and consists of a grayish felspathic paste, enclosing well-formed crystals of orthoclase, and small granular crystals of quartz, and a few of hornblende. It is a felstone porphyry, verging in places into quartz-porphyry. Exposures of this dyke occur in the River Annalong, near the spot where crossed by the Newcastle road, and on the coast cliffs.

At its northern end it bifurcates into two arms, and one of these is bounded on both sides by narrow dykes of compact basalt. There can be little doubt that this dyke is a subterranean offshoot of the granite, which is probably at no great depth under the bordering Silurian rocks.

At a point nearly two miles S. of Newcastle Harbour another dyke of felstone porphyry occurs. It is of large dimensions, including portions of Silurian rocks, and cuts across one of the older dykes of basalt.

(6.) *Felstone Porphyry amongst Silurian Rocks, Leckanmore Hill, above Rostrevor.*—This is a dark-grayish crystalline rock, with numerous small crystals of felspar well-formed. Under the microscope it is seen to consist of a colourless felsitic (or glass) paste, containing minute prisms of apatite—grains of magnetite—often well formed, and felspar crystals porphyritically distributed. Much green chloritic matter is diffused throughout the paste, and around the margins of the crystals there are also a few small grains of silica.

The felspar crystals are chiefly orthoclase, and show beautiful bands or lines of growth following the sides of the prisms; besides these there are others of plagioclase, showing the characteristic parallel hair-like lines. Some of these crystals are in twins and groups. This dyke, like nearly all those on Leckanmore, is older than the granite, and is cut off at its margin.

(7.) *Dyke of Felstone porphyry (or porphyrite), Dunmore Head, five miles S. of Newcastle.*—Amongst the numerous dykes along this coast there are none more remarkable than one near Dunmore Head—about sixty feet in width, containing numerous well-formed crystals of triclinic felspar, and a few of orthoclase. These are most numerous near the centre, and attain a length in some cases of three inches. Most of the crystals show the fine, hair-like parallel lines characteristic of the doubly oblique system. These crystals are set in a dark-greenish paste, which might be

* Horizontal Sections, Sheet 22.

taken for basalt; but an examination under the microscope shows that it is almost or entirely destitute of augite, and that the dark colour is due to the presence of a chloritic (?) mineral and of grains of magnetite in great abundance throughout the whole rock.

The paste consists of glass and small crystals of triclinic felspar with a green secondary mineral (chlorite ?), and small grains of black magnetite. There are also a few crystals—apparently of mica—of a dark green colour, and deeply scarred. The large crystals show the parallel bands and lines extremely well under polarized light.

(8.) *Granitoid Dyke traversing Lower Silurian Rocks on Craignamona Mountain, near Newry.*—This rock consists of a silicated paste, with brownish-mottled crystals of felspar, and flakes of light green mica. With polarized light a few of the crystals are seen to consist of plagioclase, but the majority are of orthoclase. The mica shows a fine play of colours—from leek green to the deep purple, with strong cleavage planes. With a high magnifying power the mica is seen to contain peculiar rhombic cavities, apparently filled with "dust," and having the forms of mica flakes themselves. One of these is elongated like crystal of quartz, with a double terminal pyramid. Professor Hartley has explained the origin of such cavities with crystalline form. ("Journal of the Chemical Society," March, 1877.) They are pale green in the centre, with darker sides. Chlorite is diffused abundantly through the mass, and the silica contains extremely minute fluid cavities. Colourless prisms of apatite, sometimes very long compared with their diameters, at other times short, are seen to penetrate both the silica and the felspar.

(9.) *Felstone Porphyry Dyke penetrating the Newry Granite in the Muddock River near Lough Island Reavy.*—This rock has a dark green base, with crystals of white felspar porphyritically developed. Vertically the rock passes into a quartz-porphyry.

Under the microscope it is seen to consist of a felsitic paste, containing numerous short, black needles ("belonites") and colourless minute prisms of apatite. Numerous grains and crystals of magnetite—the octohedral form well developed—are present, and also much greenish chlorite. There are also a few crystals of orthoclase, others of plagioclase, sometimes in twins, and round grains of silica.

This is one of those rocks which might be mistaken for a basalt porphyry, but which the microscopic examination shows to be destitute of augite.

(10.) *Reddish Felsite Dyke, Benagh, near Newry.*—This dyke penetrates the Newry granite in a northerly direction. Under the microscope it is seen to be composed of mottled reddish felsitic matter and silica in nearly equal proportions, throughout which are scattered flakes of greenish mica, and a few grains of black magnetite. With a high magnifying power a few short prisms of apatite become visible, and the silica is seen to contain cells, some with fluid bubbles, others with "dust."

(11.) *Felstone Porphyry, Slieve Bearnagh.*—This occurs as a

dyke traversing the granite of Mourne in an E.S.E. direction; it is the central dyke at the top of the mountain. It is of a light brown or gray colour, consisting of a felsitic paste enclosing crystals of felspar (often decomposed), and speckled by a greenish mineral.

Under the microscope the following minerals were observed—orthoclase, plagioclase, a few quartz grains, epidote, magnetite, and a translucent radiating fibrous mineral not well defined. It is, no doubt, of secondary origin, introduced by filteration.

The dykes on Slieve Bearnagh are very remarkable, and will be best understood by reference to the map. It will be seen that they are five in number, ranging in a somewhat crooked line in a general E.S.E. direction. Of these, three are basaltic, and two felspathic; and that one of these latter is twice crossed by one of the former. All, however, are newer than the granite, and may possibly be of Tertiary age.

Pitchstone Dyke, Newry.—For several years a specimen of pitchstone has been in the collection of the Geological Survey, stated to have been obtained from the neighbourhood of Newry.* The position of this rock *in situ* was with some difficulty determined by Mr. Traill to be at the north suburbs of Newry, and it is shown on the geological map in the form of a short dyke, ranging E. and W. across the main road. It is also shown on Sir R. Griffith's Geological Map of Ireland.†

The specimen before me leaves no doubt as to its true nature. It consists of a light blue or dark grey platey rock, traversed by parallel planes of jointage (or shrinkage), at a distance of about one-tenth of an inch apart, along which it splits easily. There are also numerous concealed jointage planes running perpendicular to these, along which it breaks less readily. The stone itself is hard, will scarcely scratch with the knife, and has a smooth, glossy surface as is usual with pitchstone. Scattered throughout the rock are a few grains of quartz and sanidine (?) crystals. There is every probability, judging from its character, that this rock is of Tertiary age, allied to the trachytes of Down and Antrim.

Under the microscope it exhibits some of the characteristics of pitchstones from Arran, Greenland, and other countries. It presents, with a low power, a light brownish field of uniform character, but somewhat cellular, and containing clear spaces filled with twisted or confusedly mixed matter. The cells are filled with dark pitchy material, or else with silica. There are also numerous grains of quartz, sometimes crystalline, at other times rounded, and the section of the hexagonal prism may be clearly made out in several cases. Along with these are a very few crystals of orthoclase (sanidine), one in twins polarizing differently, and a few black specks of magnetite.

With the polariscope the effect of the play of colours of the

* In the Gallery of the Royal College of Science, Dublin.

† Marked "xi., Pitchstone," amongst the newer trap protrusions. It is described also by the Right Hon. G. Knox in the Phil. Trans., No. cxii. Mr. Kinahan and Mr. Rutley have described a peculiar rock from Slievenalargy, Co. Down, under the name of "trachylite."—Jour. Roy. Geol. Soc., Ireland, vol. iv., p. 227.

quartz grains set in the brown vitrious paste is vivid, the colours consisting of shades of gold, purple, and bronze.

With a higher power (400 diams.) the characteristic feature of a pitchstone is seen. This consists in numerous stellate bodies (crystallites and trichites) shooting out from dark centres into the vitreous paste;* generally these rays are straight and terminate in sharp points, at other times, however, they consist of bent, twisted, and knotted "trichites," like those from the obsidian of Greenland figured by Rosenbusch,† or from that of Tokay described by Zirkel. The exact nature of these forms is uncertain; but they suggest the idea of radiating shrinkage fissures, rather than bodies of material differing from that of the surrounding vitreous paste.

2. Pyroxenic Group.

Though this name is more properly used to designate only those in which augite is an essential, it may be conveniently extended to include those which are hornblendic, and in this sense it is here used.

The dykes of trap of this group are exceedingly numerous in the district under description, especially amongst the Lower Silurian rocks surrounding the Mourne granite. Along the coast between Newcastle and Ballymartin about 150 of these have been determined by Mr. Traill, and are laid down on the six-inch field maps, and as far as possible on the published one-inch maps. These mostly belong to the augitic varieties, consisting of basalt, dolerite, and melaphyre, sometimes porphyritic.

It would be useless to attempt to describe these dykes in detail, as they to a great extent resemble each other, and only a few will be noticed as examples.

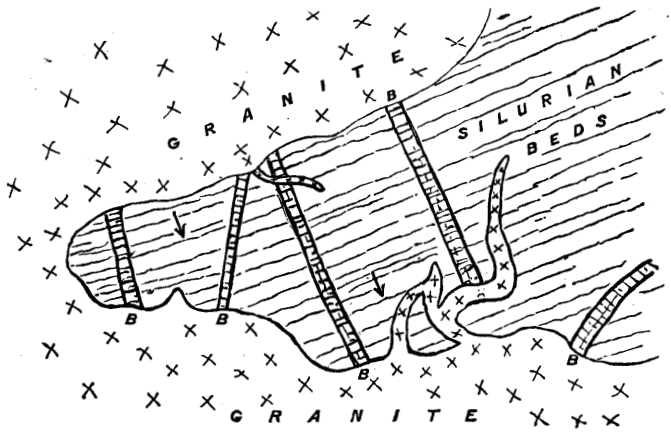
Dykes of at least two distinct epochs.—On referring to the geological maps it will be observed that the granite of Mourne, as well as that of Newry, is traversed by a few basaltic dykes. On the other hand, a considerable number—in fact the majority—are abruptly terminated upon reaching the margin of the granite, into which they do not extend. This is particularly observable in the district of Carn Mountain, Slievenaglough (Fig. 7), and Slieve Muck, along the ridge of which the sudden termination of the basaltic sheets in touching the granite is exceedingly remarkable.

It is an easy inference that these dykes existed before the granite was intruded, and are therefore of older date; while it is also obvious that these dykes which penetrate the granite itself are of more recent date. Hence, we gather that there are two sets of dykes of very different ages, though of similar composition, one set older than, the other newer than, the granite of Mourne. In the communication to the British Association already quoted,‡ the authors express an opinion that the older dykes are referable to the Upper Carboniferous period, while those more recent than the granite are of Miocene age, having originated at

* Rutley, "Study of Rocks," p. 162.
† Mikroscop. Phys., vol. i., plate i., fig. 3.
‡ Report, 1871, Trans. of Sections, p. 103.

the period of the great outburst of volcanic rocks which invaded the north-east of Ireland at that time. The prevalent direction taken by the dykes of both ages is N.W. or W.N.W.

Fig. 7.



Plan of Escarpment of Slieve-na-glough, showing basaltic dykes terminating at the margin of the granite of Mourne.

In composition these rocks consist of plagioclase (labradorite), augite, magnetite (or titano-ferrite), and olivine or its pseudomorph. In some cases the rock has undergone considerable alteration, and chlorite has been introduced by percolation throughout the mass, while the olivine is replaced by this mineral. There is no essential difference between the basalts of the two epochs.

Having thus given a general account of the nature of the augitic trap rocks, I shall confine my description to those of which I have thin sections for examination under the microscope.

1. *Melaphyre Dyke, Slieve Muck* (*Older Series*).—This dyke penetrates the Silurian rocks but does not extend into the granite. It consists of a crystalline granular rock in which, with the lens, long thin prisms of triclinic felspar may be seen embedded in a dark augitic paste. With the 2-inch objective, and under polarized light, the rock shows a mottled augitic paste, enclosing long prisms of triclinic felspar, often in twins, while there are cavities of silica and chlorite. The felspar is sometimes much altered.

Under a power of 400–600 diameters, the section shows a colourless glass paste, enclosing numerous slender prisms of apatite (?), and enveloping the minerals above referred to. Chlorite is abundantly transfused throughout the whole mass. Along with the smaller felspar prisms are individuals and groups of much larger size, giving a porphyritic aspect to the rock. Magnetite occurs in irregular patches or long black bars. On the whole, this rock may be regarded as a typical melaphyre, much altered since its original solidification.

Basalt, Slieve Bearnagh.—This dyke penetrates the granite of

Mourne in an E.S.E. direction, and therefore belongs to the newer (possibly Tertiary) series of dykes.

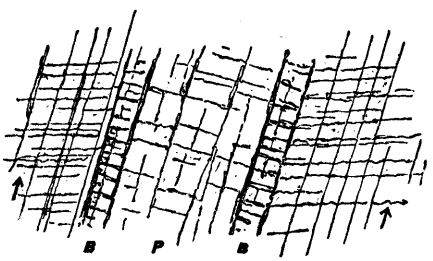
Under the microscope it is a beautiful object, the constituent minerals being well crystallized out and clearly defined. These consist of plagioclase (labradorite?) in long, slender, colourless prisms, as also some of a wider diameter; augite in light brown grains and crystals, often with well-defined sides and angles; large black crystalline grains of magnetite, the cubical form being often apparent; irregular grains of chlorite, generally cellular; and (as seen under a high magnifying power) long, slender, colourless prisms of apatite. It is probable a few grains of olivine may be present, but they are rare, and not discoverable by the aid of the polariscope in the section before me.

The rock is fresh, and except for the presence of chlorite (which is abundant in the Antrim basalts) is nearly unchanged.

A dyke of felstone porphyry adjoining this has been already described (p. 34).

Dykes of Murphy's Point, S. of Newcastle.—A sketch plan of these remarkable dykes is here given. Here the Silurian beds are traversed by parallel joints, in the line of which three dykes appear side by side. In the centre is one of greyish felstone porphyry (P.) about thirty-five feet wide, and this is flanked on either side by basalt dykes (B. B.) about eight feet in width respectively. It would be difficult to say which of these is the older, but it may be assumed that the centre dyke of felstone existed before those of basalt.

Fig. 8.



Dykes of basalt and porphyry traversing Lower Silurian Beds at Murphy's Point, South of Newcastle.

2. *Dyke of Melaphyre along coast, three miles S. of Newcastle.*—This is an exceedingly micro-crystalline rock, very dark, with a few round grains of a greenish mineral, probably chloritic. In a hand specimen, this rock might be taken for basalt, but from a microscopic examination I am led to doubt if it contains any pyroxenic mineral whatever. It is one of those rocks the real nature of which can only be determined by examination under the microscope. It is seen to consist of a glass paste with numerous little prisms of apatite, larger ones of triclinic felspar, and of magnetite, a few of a colourless mineral of secondary origin. No augite crystals are visible. The octrohedral forms of the magnetite

grains are often perfect, but it is evident that the rock has been much altered since its original formation.

3. The following description of the melaphyre or basaltic dykes of Slieve Muck and Pigeon Rock Mountains is from the MS. of Mr. Traill:—

"The third group of rocks here represented are the older basalts or melaphyres;—those pre-granitic dykes which penetrate the Silurian rocks but are all cut off at the margin of the granite. Numerous examples of these are to be found along the escarpment near the summit of the ridge on Slieve Muck, where some twelve or thirteen dykes penetrating the schists are all terminated at their margins with the granite, beyond which boundary they are not found, in fact do not exist. In several cases off-shoot veins from the granite cut across these dykes.

"Among these pre-granitic dykes there appear to be two systems, one set running approximately N. or N.N.W. and S., the other E. and W. As these dykes are apparently independent of the dip or contortions of the strata, they have possibly followed certain lines of weakness which may have existed as part of a system of conjugate joints in the Silurian rocks before the intrusion of the Mourne granite. The N. and S. dykes, which seem to be the older of the two, cut across the bedding of the schists and slates at nearly right angles. A specially marked one runs close along the summit of the ridge of Pidgeon Rock Mountain as a broad wall or causeway, in average width of about twenty feet, and vertical. It has a somewhat winding course, bearing S.E. and S.S.E., until it terminates at the margin of the granite, where it is cut off, and near which it is cut across by a broad granitic off-shoot.

"Lower down, on the eastern side of this mountain, where the rocks are greatly broken up, there are three more similar dykes, running nearly parallel in widths from four to ten feet; these are only traceable for a short distance but appear again to the southward, at the other side of the valley, on the western flanks of Slieve Muck. There are six dykes belonging to this system on this Pigeon Rock Mountain.

"Similarly, on Slieve Muck, there are also a number of dykes of this class, some of which are probably prolongations of those on Pigeon Rock Mountain; they mostly bear N.N.W. and S.S.E. and are of the following widths respectively, nine feet, fifteen feet, twenty-four feet, and the largest thirty-three feet. They are all traceable to the escarpment which forms the margin of the Silurian cap, and do not enter the granite.

"To the second system of these older dykes belong those having an E. and W. bearing, or more correctly E.N.E. and W.S.W. a direction which coincides with the average strike of the strata; the dykes are, however, not interbedded, for they are mostly vertical, while the grits and slates are inclined at various angles.

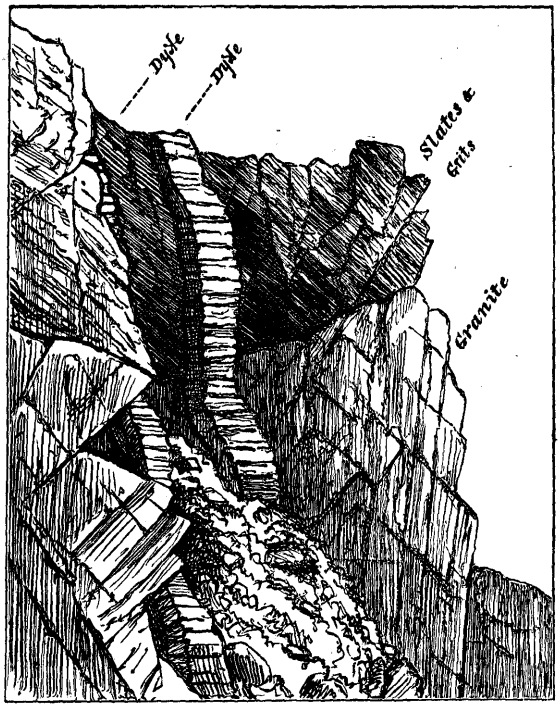
"There appear to be six dykes belonging to this class, which, so far as evidence is apparent, seem to cut across those dykes previously mentioned.

"Of these, one is of special interest (fig. 9), it is traceable across the southern flanks Pigeon Rock Mountain in an E.N.Ely. direction where where it is thirty feet wide, and projects at the edge of a steep precipice where the Silurian rocks are seen resting unconformably on the top of the granite (*Vide* Fig. 9).

"This dyke is found again at the opposite side of the valley on the flanks of Slieve Muck, where the Silurian beds have not been denuded away, following approximately the strike of the beds, but still vertical,

while they are inclined; it is traceable E. 30° N. with an average width of twenty-four feet, passing a little north of the summit (1,931 feet), and terminating at the escarpment which the Silurian beds form along the summit ridge of this mountain, where the underlying granite is brought to view.

Fig. 9.



Granite surmounted by schist; both penetrated by two vertical dykes of basalt. Pigeon Rock Mountain. (After a sketch by Mr. Traill.)

"A similar dyke of melaphyre, but somewhat more crystalline, runs nearly parallel, at a distance of about 2,000 feet to the southward, but only six feet wide. To the northward are three others, sixteen feet, fifteen feet, and twenty feet wide, respectively.

"At about 500 feet to the westward of the angle of the Townland Boundary wall on Pigeon Rock Mountain, there are several of these dykes crossing each other; this may possibly have been a centre of dispersion or old volcanic pipe of the older trappean period, similar to those in other places in this district.

"At the southern extremity of Pigeon Rock Mountain and immediately facing the road which comes up from Kilkeel, before it turns up the valley to the Deer's Meadow, there is a steep precipice on the side of the mountain, the lower portion of which is composed of the granite in large jointed masses, and resting unconformably on the top of it, with a clearly defined line of separation, are the contorted Silurian rocks. In these latter there occurs one of the older melaphyre dykes, ending off with the Silurian beds at the edge of the granite, while immediately adjacent, there are two of the newer (or post-granitic) dykes of basalt penetrating not only the Silurian beds but also the granite; thus clearly exemplifying the trap dykes of two geological periods.

"Slievemoughanmore is another mountain which supplies still further confirmatory evidence of the relations existing between the several rocks. It rises to a height of 1,837 feet, a little to the S.W. of Pigeon Rock mountain. The entire formation of the mountain is of granite which is found on every side forming the flanks of the hill; resting on top of it and forming the summit, is to be observed an isolated cap of hardened Silurian schists and grits, which have withstood the several denuding agencies to which they have been subjected.

Penetrating these beds there are a number of basalt (melaphyre) dykes which are all cut off at the margin of the granite, as shown on the Geological map. At one spot there seems to have existed an old volcanic pipe or vent of extrusion of pre-granitic trap, which may probably have so bound together the adjacent beds, while all were additionally indurated by the intrusion of the granite, that they were able to remain intact, when all the surrounding masses of Silurian rock were carried away."*

The dykes of diorite (hornblendic) and of mica-trap now about to be described, are less numerous than either the felspathic or augitic varieties. As the principal hornblendic dyke of the district cuts across several older, apparently augitic, dykes, there is no evidence in favour of the view of the greater antiquity of hornblendic varieties of trap. It is more probable that conditions of pressure, or other occult causes determined the form assumed by the pyroxenic mineral on cooling from a molten state.

(4.) *Diorite Dyke traversing Silurian Rocks at Rostrevor.*—This is a crystalline granular rock, consisting of dark-green, or nearly black, hornblende and white felspar, with a good deal of epidote diffused through the mass, both in patches and along the joints. It occurs under the village of Rostrevor, and taking a south-easterly course, ascends the hills, and can be traced for upwards of a mile, forming the cliffs west of the Cloghmore. It crosses several other dykes of basalt, and is itself dislocated by faults (*see* sheet 71), and all of these are probably of older date than the granite. The rock is laid open in a large quarry behind the Mourne Hotel.

Under the microscope it is seen to consist of long prisms of triclinic felspar, embedded in a brownish paste of hornblende, or mixed with sub-crystalline forms of that mineral. A sap green mineral (chlorite?) of secondary origin, and a slightly fibrous structure, is diffused amongst the other constituents, and also occurs in large patches. Magnetite is present in large sub-crystalline grains and groups of grains, and there are a few long, slender, colourless prisms of apatite.

With polarized light the section presents a gorgeous display of colours on rotating the analyzer, the hornblende varies from sap green, through pale brown, to a deep rose or pink colour, while the parallel lines and bands of the felspar are strongly defined—some of the crystals occur as twins.

The felspar is occasionally traversed in various directions by a few long, slender, colourless prisms of apatite, which are easily visible with a one-inch objective, but to be properly observed

* From MS. by Mr. W. A. Traill.

require a higher power. There are also a few grains of silica imbedded in the green chloritic portions. This rock, therefore, contains the following minerals: hornblende, felspar, chlorite or epidote, silica, magnetite, and apatite—the last named in least quantity.

3. Micaceous Group.

Mica-trap, Leckanmore Hill, above Rostrevor.—This is a finely crystalline-granular rock traversing the Silurian beds, but older than the granite. It consists of a felsitic paste, through which a greenish chloritic mineral is diffused, containing minute colourless long prisms of apatite; crystals (often in well-formed tubes) of magnetite; a few of triclinic felspar; and numerous mica flakes of light green, yellow, and brown colours. There are also a few crystalline grains of pyroxene, differing in form and structure from those of mica. It will thus be seen that the composition of this rock is highly varied; but the predominance of mica justifies its being placed under the head of mica-trap.

Under polarized light it produces a beautiful and strong play of colours on rotating the analyzer—rich green, pink, and bronze colours predominating. It is very slightly magnetic.

The mica-trap, like the other dykes on Leckanmore, is of older age than the granite.

The hill of Leckanmore presents a remarkable assemblage of trap rocks where they can be well studied, consisting of bedded intrusive felstone, felstone porphyry, mica-trap, basalt, sometimes micaceous, and basalt porphyry, &c. All these traverse the Lower Silurian rocks only, and are older than the granite. The felstones nearly coincide with the bedding, but in some places may be seen to cross the beds obliquely. They weather white, and are highly silicated. The basalts contain chlorite in fissures.

The Glaciation.

By W. A. TRAILL.

The glacial phenomena of this district are very interesting, and the evidences which still exist clearly unravel the movements of the main ice-flow.

The surfaces of the various rocks have, to a very different extent, retained the impressions of the ice-action. The granites as a rule have disintegrated so much that all striations and grooving have been obliterated; the rounded forms of the *roches moutonnées*, however, indicate the direction of the ice-flow. The Lower Silurian beds, especially in the more exposed situations, have retained the planed and rounded surfaces, and the striations are often beautifully clear and distinct; the covering of drift has probably preserved them from being obliterated until they became exposed by subsequent denudation.

The bearings of the rounded drift hills or "drumlins" have also an intimate relation, as regards direction to the adjacent striæ.

The glaciation of the rocks in this district must be viewed in connexion with the table of ice-striæ in the Memoir of sheets 62 and 71, p. 62, and with that in the Memoir of sheets 49 and 50, p. 62.

From the detailed examination of the following table of ice-striæ, and from their mode of occurrence, I consider that a comprehensive view of the ice movement in this district can be obtained.

In the N. and N.W. the ice-flow shows indications that its motion was from N.N.W. towards the S., impelled by some powerful agency—what that agency was is apart from the subject here*—and that it continued its course with little deviation, transporting the ground-down detritus of the Silurian rocks across the area of the granite, which extends from Newry to Slieve Croob; and the debris of the granite over the more southern band of Silurian strata.

To this movement of the ice in the normal direction, S.S.E. and S.E., the Mourne Mountains, from Newcastle to Rostrevor, presented an impediment to its further progress.

As the constantly accumulating ice increased in depth, but was unable to overtop the mountains, it became divided somewhere about the present locality of Hilltown; one portion being deflected to the eastward, was forced out across the low-lying tracts by Fofanny and Slievenaman, until the whole movement on that side was to the eastward, part being deflected even as much as E. 20 N.

On the other side the deflection of the ice-flow was to the S. and S.S.W., and even to S. 40° W., in the direction of the valleys of the Kilbroney, Ghann, and Moygannon rivers; these ice-streams, subsequently meeting with that down the Newry valley, accumulated at the head of Carlingford Lough.

The excessive divergences of the striæ in some localities are found only in low-lying tracts, for at the higher elevations there was always a tendency to return to the more normal direction, S.S.E.

As the thickness of the ice-sheet was augmented by additions from the N.W., and was confined by the Slieve Croob range on the E. and Slieve Gullion on the S.W.; the valleys were completely filled up, and the surface level ascended on the northern flanks of the Mourne mountains, until the intermediate heights were covered; and later still the higher elevations, and at last the tops of Finlieve, Slievemoughanmore, Pigeon Rock mountain, Slieve Muck, and Shanslieve, with elevations of 1,888 to 2,204 feet, were enveloped.

At the greater heights the striæ indicate that the average direction of the ice-flow was from the N.N.W.

From these and other striæ on the Silurian rocks to the southward, and from the general contour of the large mountains of granite, from Slievemeel More to Carn Mountain, together with

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* On this subject the reader may consult "The Physical Geology and Geography of Ireland," p. 227–249.

Shanlieve and Slievecommedagh, and even from the outline of Slieve Donard itself, there appears unmistakable evidence that the ice-sheet had moved across the whole range of the Mourne Mountains; and that only the very highest summits, if any, appeared above its general surface.

There are similar evidences of the passage of the ice-sheet across almost the highest elevations of the Carlingford mountains.*

The vast quantity of ice which must have accumulated in the N.W. of this district may account for the crushing back of the top surfaces of the Silurian rocks in the neighbourhood of Hilltown, and for the apparent retrograde movement of the sheet in that locality. It must have been over two thousand feet, at least, in thickness to have overtopped the mountains; and also to have acted with such force in passing over elevations of 2,000 feet, so as to have crushed over the surface of the Silurian beds at that height on the Rostrevor Mountains.

At the head of Carlingford Lough large quantities of ice must have collected by the junction of the several ice streams. It found an exit down the valley of the lough, till at length the mountains on both sides became covered, and it passed over their summits with but slight deflection.

On the breaking up of the ice-sheet the converse of the above description would have taken place; and for long after the higher levels were uncovered, it is probable that glaciers filled the valleys, and moved around the Mourne Mountains eastward by Bryansford, and southward into Carlingford Lough.

In addition to the evidence afforded by the transport of the drift and the ice-striæ, there is also that of perched blocks and erratic boulders which occur in remarkable groups. Among these may be mentioned the granite boulders which overlie the Silurian rocks along the northern flanks of the Mourne Mountains; the perched blocks of granite which overspread the Silurian cap of Slievemoughanmore, at elevations up to 1,837 feet; the perched blocks and boulders which occur in Leckanmore and Leckanbeg; and those numerous granite boulders which cover the Silurian rocks on the western flanks of the Rostrevor Mountains. The latter include many of large size and in conspicuous positions, such as "Cloghmore" (Fig. 10), on the ridge of the hill above Rostrevor quay, at an elevation (by aneroid) of 970 feet.

Fig. 10.

"The Cloghmore"—a boulder of Mourne Granite resting on Lower Silurian Slate.

* Memoir of Sheet 71, p. 59.

Coombs.—On the E. and N.W. sides of Slievecommedagh and Shan Slieve there occur two semi-cup-shaped hollows in the granite, surrounded on three sides by precipitous cliffs, called the Pot of Pulgarvie and the Pot of Legawherry. These seem to be *coombs* or *cirques* associated with the general glaciation and formed by ice erosion. The bottoms of these hollows have an elevation of about 1,400 to 1,500 feet. In Legawherry a small lake occasionally exists; but in Pulgarvie there is none.

On the northern flanks of Slieve Bingian there occurs Bingian Lough at an elevation of 1,347 feet, which seems to be another

TABLE of ICE-STRIÆ, and the

County.	No. of Ordnance Sheet.	Townland.	Locality.	Formation.
Down,	40 / 3·4	Corgarry,	Beside Schoolhouse,	Lower Silurian,
,,	,,	,,	Beside Newry & Belfast Road,	,,
,,	,,	Aughintober,	1,500 feet N.W. of Four Mile House.	,,
,,	41/7	Cargabane,	At Meeting House,	,,
,,	,,	Gransha,	E. of Ouley Hill,	,,
,,	41/2	Lisnacreevy,	At stream beside The Hard Hill.	,,
,,	,,	Edenagarry,	Knockiveagh,	,,
,,	,,	Imdel,	At National School,	,,
,,	,,	Ballynamagna,	W.S.W. of Flax Mill,	Granite,
,,	41/3	Lisserboy,	S.E. of Traymount,	Metamorphosed grits,
,,	42/1	Ballyroney,	Duggan's Hill,	Drift,
,,	,,	Lackan,	Kennedy's & Hamilton's Hill, Crabtree Hill.	,,
,,	,,	Drumadonnell,	Dodd's Hill, Dickson's Hill, Gibson's Hill.	,,
,,	42/2	Ballyward,	Parson's Hill, White Hill, The Island.	,,
,,	42/3	Lisnisk,	Forgy's Close,	,,
,,	,,	Ballynagappoge,	Adam's Hill,	,,
,,	42/4	Drumena,	S. of Lough Island Reavy,	Metamorphosed grits,
,,	43/1	Ballymaginaghy,	Slievenaslat, N.W.,	Granite
,,	,,	,,	Do., W.,	Lower Silurian,
,,	,,	Clarkill,	Near Play Rock,	Granite,
,,	,,	,,	,,	Lower Silurian,
,,	,,	,,	Curlets Mountain,	,, ,,
,,	,,	,,	Slievenaslat,	,, ,,
,,	,,	Ballymagreehan,	Ballymagreehan Planting,	Granite,
,,	,,	,,	,, ,,	Silurian schists,
,,	43/3	,,	S.W. of Planting,	Granite,

* The bearings of the striæ in the Table in Memoir of

coomb or lake of glacial excavation. Possibly also Blue Lough and Cove Lough may have been similarly formed.

Appended is a table of the localities where ice-stria and other glacial phenomena were more particularly observed, with their elevations, and the rocks on which they occurred.

The bearings of the striæ in this table show the directions in, or toward which, the ice-streams moved, and correspond with those in the Memoir of Sheet 71.* A large number of the glacial markings have been inserted on the one-inch map.

Localities where observed.

Elevation.	Direction of Ice Movement.			Remarks.
	Deflected.	Normal Striæ.	Deflected.	
250	—	S. 30 E.	—	Ice-planed surfaces, with "Roches Moutonnées," striæ rather obscure. Erratic granite boulders.
150	—	S. 25 E.	—	Striæ faintly visible.
150	—	S.S.E.	—	Striæ obliterated.
250	—	—	—	The top surface of the rock is broken back to the northward, by weight of ice, or movement from S.S.E.
400	—	—	—	Ditto.
400–450	—	—	—	Top surface crushed over to the N.W., apparently by ice movement from the S.E.
675–750	—	S. 25 E.	—	The N. and N.W. flanks are ice-planed, and the drift is banked up against them.
500	—	—	—	Top surface broken back to the northward.
450	—	S. 30 E.–N. 30 W.	—	Striæ on compact granite, direction doubtful.
300–325	—	S.S.E.	—	"Roches Moutonnées" surfaces weathered.
300–325	—	S.E.–N.W.	W.–E.	
363	—	—	W.–E.	
300–350	—	S.E.–N.W.	W.–E.	Adjoining the Ballyroney, Ballyward, and Hunshigo lakes, are extensive flats, surrounded by drift hills or "Drumlins," trending N.W.–S.E., and W.N.W.–E.S.E.
275–325	—	—	E.S.E.–W.N.W.	
325–353	—	—	—	
377	—	—	E.W.	
600–650	—	—	E.S.E.	"Roches Moutonnées."
600–700	—	—	E. 40 S.	Ditto, ditto, direction evident, striæ obliterated.
700–750	—	—	E. 40 S.	The Silurian rocks near the granite are greatly ice-worn and striated.
600–650	—	—	E.S.E.	The W. flanks of this ridge are much ice-shorn, the granite has not retained the striæ.
550–600	—	—	E. 20 S.	Ditto, ditto.
550–742	—	—	E. 25 S.	Along the N. and W. flanks the semi-metamorphosed grits are greatly glaciated. The ice-flow seems to have been deflected to the eastward.
600–902	—	—	S.E.–E. 30 S.	The N. and N.W. flanks of Slievenaslat are greatly ice-worn, and the S. and E. flanks cragged and broken. At the higher levels the ice-flow was S.E., but was deflected to E. 30 S. across the lower ground.
500–600	—	—	S.E.	"Roches Moutonnées" on the granite.
"	—	—	E. 35 S.	Ditto, ditto.
600–700	—	—	E. 30 S.	Ditto, ditto.

Sheet 49 indicate the direction *from* which the ice-flow came.

TABLE of ICE-STRIÆ, and the

County.	No. of Ordnance Sheet.	Townland.	Locality.	Formation.
Down,	43/3	Ballymagreehan, .	S.W. of Planting, . . .	Silurian schists, .
,,	,,	,, . .	N. of Altnaduah Lough, .	,, ,, . .
,,	,,	Drumena, . .	The Black Rock, . . .	,, ,, . .
,,	44/1	Dundrum, . .	Dundrum Castle, . . .	Lower Silurian, .
,,	46/12	Carnmeen, . .	Beside Millrace, . . .	Granite, . . .
,,	,,	Cloghanramer Damolly.	Eden Wood and Northward,	,, . . .
,,	46/34	Drumcashellone, .	Campbell's Quarry, . .	,, . . .
,,	47/1	Croreagh, . .	3,000 feet S.W. of Glenville, .	,, . . .
,,	,,	Cabragh, . . .	N. of Flax Mill, . . .	,, . . .
,,	47/2	Ballygorian Beg, .	On the Watershed, . .	Lower Silurian schists,
,,	47/4	Ballydulany, . .	W. of The Alt, . . .	Mica schists, . .
,,	,,	,, . .	At Kean's Bridge, . .	,, . .
,,	,,	,, . .	,, ,, . .	Granite, . . .
,,	,,	,, . .	,, ,, . .	Mica schists, . .
,,	,,	Edentrumly, . .	Carnadranna, . . .	Lower Silurian, .
,,	,,	Mullaghmore, . .	Grugganskeagh, . .	,, ,, . .
,,	,,	,, . .	Ditto, at Barony boundary,	,, ,, . .
,,	48/2	Ballykeel, . .	Loughanlea Hill, . . .	Silurian schists, .
,,	,,	Fofannybane, . .	Fofanny Planting, . .	Lower Silurian, .
,,	,,	,, . .	Craigdoo, N. flanks, . .	,, ,, . .
,,	,,	Moyad, . . .	Slievenaman, N. side, . .	,, ,, . .
,,	,,	,, . . .	Ditto, W. flanks, . .	,, ,, . .
,,	,,	,, . . .	Ditto, W. of summit, 1,053,	,, ,, . .
,,	,,	Fofannyreagh, .	Butter Mountain, . . .	,, ,, . .
,,	48/3	Corcullion, . .	Carrickalane, . . .	,, ,, . .
,,	,,	Leitrim, . . .	Sheep Hill, ...	,, ,, . .
,,	,,	Ballyaughian, Ballynanny.	Hen Mountain, . . .	Granite, . . .
,,	48/4	Moyad, . . .	Slievemeel Beg, . . .	Lower Silurian, .
,,	,,	Stang, . . .	Ott Mountain, . . .	,, ,, . .
,,	,,	,, . . .	Spelga, ...	,, ,, . .
,,	49/1	Tullyree, . .	Tullyree Hill, . . .	,, ,, .

Localities where observed—*continued.*

Elevation.	Direction of Ice Movement.			Remarks.
	Deflected.	Normal Striæ.	Deflected.	
600–700	—	—	E. 30 S.	The schistose beds have retained the striæ in several places.
350	—	—	E. 5 S.	At the bend of road, W. side of Crocknashellida.
650–700	—	—	E.S.E.	Hill on S. side of Lough Island Reavy.
75–125	—	S. 5 E.	—	The hill on which Dundrum Castle stands is a large "Roche Moutennée," planed and striated on its northern slopes. The ice-flow here had regained its normal direction.
50–75	—	S.S.E.	—	Bosses of granite ice rounded on N.N.W. side.
100–200	—	,,	—	Numerous rounded bosses of granite, mostly free from drift, showing evidences of glaciation from the N.N.W.
125–150	—	S. 15 E.	—	Striæ are discernable on the granite above the quarry.
275–325	—	—	—	Ice rounding from the N.W.
300–350	—	S.S.E.	—	Granite bosses ice-shorn from the N. and N.N.W.
506	—	S.S.E.	—	The top surfaces of the metamorphosed schists adjacent to the granite are ice-worn.
625–675	—	—	—	Apparently ice-shorn from the northward.
650	S. 25 W.	—	E. 35 N.-W. 35 S.	Double striations are distinctly seen on the schistose rock on the N. side of the granite boss.
,,	S. 10 W.	—	—	Glaciation on the granite boss, ice-flow to the southward.
,,	S. 10 W.	—	—	On mica schists, S. side of granite; striations clearly seen.
900–1000	S. 20 W.	—	—	The northern flanks of the mountain are ice-planed.
850–900	S.S.W.	—	—	The N.E. flanks are ice-shorn and free from drift.
1023	S. 40 W.	—	—	The ice-flow across Grugganskeagh seems to have been deflected to the westward, by the Mourne mountains; and to have been forced down the valleys toward Rosstrevor.
500	—	—	E.	The ice-flow was here deflected by the Mourne mountains, and moved due E. towards Dundrum Bay. Striæ are clearly visible on the schists adjacent to their junction with the granite.
700–750	—	—	E.	"Roches Moutonnées," by deflected ice-flow from the westward.
1000–1100	—	—	E. 10 N.	Ice-action is visible across the summit of Craigdoo, 1,317 feet high.
800–900	—	—	E. 5 N.	The N. and W. flanks of Slievenaman are ice-planed and striated. The W. slopes presented the chief obstruction to the deflected ice-flow moving eastward toward Dundrum Bay.
,,	—	—	E. 20 N.	
800–1053	—	—	E. 15 N.	
1000–1100	—	S.E.	—	The ice-flow seems here to have assumed its normal direction at the higher elevations, over 1,000 feet. and to have moved south-eastward across the Mourne mountains.
500–600	—	—	—	A large number of Silurian sub-angular boulders overspread the granite, immediately S. of Carrickalane.
650–846	—	S.S.E.	—	The ice-flow passed over the summit of this hill without apparent deviation.
1187	—	(S.E.)	—	Evidences of glacial action are traceable in the large bosses of granite which give this mountain its characteristic features.
1000–1700	—	—	—	Owing to the schistose nature of the Silurian rocks on these mountains, the striæ have not been retained. Glacial action is discernable over summits 1,700 feet high, with ice-flow apparently south-eastward.
1724	—	—	—	
1100–1600	—	—	—	
706	—	—	E. 5 N.	The top of this hill is furrowed from the westward.

TABLE of ICE-STRIÆ, and the

County.	No. of Ordnance Sheet.	Townland.	Locality.	Formation.
Down,	49/1	Cross,	On Bryansford Road,	Lower Silurian,
,,	,,	Clonachullion,	Slievenaglogh,	Granite,
,,	,,	,,	Lukes Mountain,	Lower Silurian,
,,	,,	Tullybranigan,	Slievenabrock, N.W.,	,, ,,
,,	,,	,,	Ditto, N. flanks,	,, ,,
,,	49/2	,,	Curraghard,	,, ,,
,,	,,	Ballagh,	Drinnahilly,	Silurian schists,
,,	,,	,,	Slievenamaddy,	,, ,,
,,	49/3	,,	Shan Slieve,	,, ,,
,,	49/4	,,	Slievenamaddy,	,, ,,
,,	50 / 1·2	Commons,	Lower Commons,	Granite,
,,	51/1	Greenan,	Greenan Mountain and southward.	Metamorphosed schists
,,	,,	Carrogs,	E. of Ryan's Close,	,, ,,
,,	,,	Aughnagon,	S. end of Townland,	,, ,,
,,	,,	Tamnaharry,	Craignamona,	,, ,,
,,	,,	Carrickmacstay,	High ground of Townland,	Lower Silurian,
,,	51/2	Clonta Fleece,	Slieveacarnane,	,, ,,
,,	,,	Ballyvally,	Ballyvally Mountain,	,, ,,
,,	,,	Cleomack,	Gruggandoo,	Metamorphosed schists
,,	,,	Knockbarragh,	Slieve Roe,	,, ,,
,,	,,	Ballyaghol,	,,	,, ,,
,,	,,	,,	,,	Basalt dyke,
,,	51/3	Greenan,	W. end of Old Road to Newry,	Lower Silurian,
,,	,,	Aghnamoira,	N. of Deer Park,	,, ,,
,,	,,	Carrickmacstay,	N. of Ballydesland Hill,	,, ,,
,,	51/4	Ballyaghol,	Knockbarragh Mountain,	,, ,,
,,	,,	Knockbarragh,	,, ,,	Basalt,

Localities where observed—*continued.*

Elevation.	Direction of Ice Movement.			Remarks.
	Deflected.	Normal Striæ.	Deflected.	
650	—	—	E. 20 N.	Striations distinct, ice-flow greatly deflected.
1200–1400	—	—	E.	"Roches Moutonnées" on granite, ice-flow eastward.
800–1238	—	—	E.	The N. and W. flanks of Lukes mountain are glaciated. At the lower levels, 500–700 feet, the Silurian beds are thickly overspread with granite (Mourne) boulders; so are also The White Plains.
750–807	—	—	E.	Indurated schists, overspread with perched boulders of granite.
800–1100	—	—	E.	"Roches Moutonnées" and striæ occur across the northern slopes of this mountain. Granite boulders are plentiful up to the 900 feet level, but scarce above it. Glaciation is evident to much higher elevations.
500	—	—	E. 15 S.	The ice-flow passed with considerable weight across the *col* between Curraghard and Slievenabrock.
700–807	—	—	E.–E.S.E.	This hill forms a large "Roche Moutonnée"; the striæ have mostly been obliterated. Ice-flow E. or E.S.E.
1000–1600	—	—	E.–S.E.	The higher elevations of this mountain show evidences of ice-action, apparently moving E. or S.E.
1500–2204	—	—	E.S.E.–S.E.	Glacial action is clearly traceable over the northern flanks of these mountains, with evidences up to near the summit of Shan Slieve, 2,204 feet high. The ice-flow was apparently moving south-eastward.
1400–1800	—	—		Two *Coombs* occur in the granite, called the Pot of Legawherry and the Pot of Pulgarvie.
200–250	S.	—	—	In the Newry district, granitic "Roches Moutonnées"; ice-flow apparently southward, along the Newry river and estuary.
350–416	—	S. 10–15 E.	—	The striæ are occasionally retained on the Silurian beds.
300–350	—	S. 5 E.	—	Striæ on schists well preserved; ice-flow southward.
575–600	S. 15 W.	—	—	The ice-flow was here further deflected to the westward.
600–946	S. 10 W.	—	—	The N. and W. flanks are greatly glaciated, and the striæ well preserved. The ice-flow was here deflected, and passed down the several valleys to the head of Carlingford Lough.
600–765	—	S. 5–10 E.	—	Rocky exposures here are glaciated.
800–861	—	S. 10 E.	—	—
850–981	S. 15 W.	—	—	The ice-flow had been deflected here to the westward.
1000–1257	—	—	—	On this ridge glacial action is apparent, but striæ defaced.
900–1196	S. 20 W.	—	—	Along the E. flanks of this mountain striations are abundant; the ice-flow was deflected, and moved down the valley of the Ghann river.
900–1000	S. 20 W.	—	—	Ice-stream deflected down the valley of the Moygannon river, impinging more strongly on the western flanks of Slieve Roe, which are greatly glaciated.
950	S. 20 W.	—	—	
350	—	S. 10 E.	—	—
325–373	—	S. 15 E.	—	"Roches Moutonnées," with occasional striations.
400–450	—	S. 20 E.	—	—
650	S. 10 W.	—	—	Ice-stream deflected down the valley of the Moygannon river.
850	S. 10 W.	—	—	The basaltic dykes have frequently retained the glacial markings better than the Silurian rocks.

TABLE of ICE-STRIÆ, and the

County.	No. of Ordnance Sheet.	Townland.	Locality.	Formation.
Down,	51/4	Drumreagh, Upper,	Leckan More,	Lower Silurian,
,,	,,	,, ,,	,, ,,	Basalt dykes,
,,	,,	Drumreagh,	N. of Thunder Hill,	Lower Silurian,
,,	,,	Kilbroney,	Leckan Beg,	,, ,,
,,	52/1	Carcullion,	Beside Hilltown Road,	Granite,
,,	,,	Ballyaughian,	Slievemoughanmore,*	Silurian schists,
,,	52/2	Mourne Mountains, Middle.	Pigeon Rock Mountain,	Do., and basalt dykes,
,,	,,	,, ,,	,, ,,	Lower Silurian,
,,	,,	,, ,,	Slieve Muck,	,, ,,
,,	52/3	Mourne Mountains, West.	Finlieve,	,, ,,
,,	52/4	Leitrim,	S. of Slievenagore,	Drift,
,,	53/1	Mourne Mountains, East.	Bingian Lough,	Granite,
,,	54/2	Rosstrevor, Upper,	Slievedermot,	Lower Silurian,
,,	,,	,, ,,	N. of Cloghmore,	Diorite,
,,	,,	,, ,,	On path to Cloghmore,	,,
,,	,,	,, ,,	S. of Cloghmore,	Basalt,
,,	,,	,, ,,	Slievemartin,	,,
,,	,,	,, ,,	Slievemeen,	,,
,,	,,	,, ,,	,,	Lower Silurian,
,,	54 / 54	Ballinran,	Killowen Coastguard Station,	,, ,,
,,	,,	,,	Maggy's Rock,	,,

* Slievemaganmore.

Localities where observed—*continued.*

Elevation.	Direction of Ice Movement.			Remarks.
	Deflected.	Normal Striæ.	Deflected.	
600–1161	S. 10 W.	—	—	The ice-stream down the Glann valley impinged more strongly on the eastern side, thus greatly glaciating the Silurian rocks on the W. side of Leckan More, even to the summit 1,161 feet high. The granite to the northward has retained the "Roche Moutonnée" forms, but not the striæ.
"	S. 10 W.	—	—	
550–650	S. 10 W.	—	—	Numerous granite boulders are piled up along the western slopes.
400–500	S. 10 W.	—	—	This hill forms a large "Roche Moutonnée," and is glaciated by the deflected current passing down the Kilbroney valley. Numerous granite boulders are collected around the eastern and southern slopes.
750–800	S. 10–15 W.	—	—	"Roches Moutonnées" on granite, from the deflected ice-current passing up the valley of the Leitrim river.
1700–1837	—	S.S.E.	—	The isolated Silurian cap, resting on the granite, which forms the summit of this mountain, 1,837 feet high, is glaciated from the N.N.W., and is overspread with numerous granite boulders, which must have been ice-borne from lower levels.
1450–1749	—	S. 30 E.	—	This mountain is free from drift, and glaciated.
1600	S.	—	—	Striæ are well preserved on the Silurian beds at the top of the steep granitic escarpment on the south-eastern side.
1400–2198	—	S.S.E.–S.E.	—	Glacial action is discernible on the W. and N.W. sides of Slieve Muck, and even over the summit, 2,198 feet high, apparently moving in its normal direction S.S.E.–S.E.
1600–1888	—	S.E.	E.S.E.	The isolated Silurian cap on Finlieve, 1,888 feet high, is glaciated.
600–200	—	—	—	The southern flanks of the Mourne Mountains have taluses of drift, and accumulations of granite boulders overlying the Silurian beds.
1440	—	—	—	Some very large ice-borne granite boulders occur to the S. of Bingian Lough.
1100–1442	S.	—	—	The "Roches Moutonnées" range N. and S. along the western flanks of Slievedermot. Erratic boulders of granite (Mourne) thickly overspread the Silurian beds which form these slopes.
850	S.	—	—	The ice-flow was deflected at the lower levels, round the western flanks of the Rosstrevor Mountains.
800	S. 10 E.–S.	—	—	Striæ seen on the diorite and basalt dykes.
1000	—	S. 20 E.	—	Striæ are visible on the basalt dykes S. of Cloghmore. Numerous erratic boulders of granite (Mourne) overspread the western and southern flanks of these mountains, of which Cloghmore is the most conspicuous.—*Vide* p. .
1550–1595	—	S. 20 E.	—	"Roches Moutonnées" and striæ are visible across the highest summits of Slievemartin, 1,595 feet high.
1350	—	S. 40 E.	—	The ice in the Cloghmore Glen moved up the natural slope of the ground.
1500–1543	S. 10 W.	S. 20 E.	—	Two sets of striations are visible here. The ice-flow seems to have bent and broken over the top surfaces of the Silurian rocks in a direction opposite to the dip.
10–25	—	—	E. 25 S.	The ice-flow at the lower levels was deflected down Carlingford Lough, while at the higher elevations it retained its normal bearing; these different movements may have occurred simultaneously.
10–25	—	—	E. 25 S.	

TABLE of ICE-STRIÆ, and the

County.	No. of Ordnance Sheet.	Townland.	Locality.	Formation.
Down,	54 / 3·4	Ballyedmond,	Ballyedmond Planting,	Granite,
„	55/1	Kilfeaghan, Upper,	The Rowans,	Lower Silurian,
„	„	Mourne Mountains, West.	Finlieve, S. side,	Silurian schists,
„	„	„ „	Rocky Mountain,	„ „
„	„	„ „	Formal,	„ „
„	55/2	Aughrim,	Aughrim Hill,	Lower Silurian,
„	55/3	Ballintur,	Knockshee,	„ „
„	„	Ballincurry,	Near R.C. Chapel,	„ „
„	57/1	Greencastle,	Lisgarron Point,	„ „
„	„	„	Green Island,	Carboniferous limestone.

Evidences of Local Glaciers.—The glacial striæ above recorded are referable to the erosive action of the general ice-sheet of the lower Boulder Clay period; but there are occasionally to be obtained evidences of local ice-action, in the form of moraines, which may be observed amongst the interior recesses of the mountains; and to which the formation of several mountain loughs, or tarns, is to be attributed. Till recently I was inclined to doubt the occurrence of such local ice-action, notwithstanding Mr. Traill's opinion in its favour; but a recent visit, paid for the first time, to the Annalong Valley and Blue Lough, has convinced me that Mr. Traill's opinion was correct, and that there are unmistakeable evidences of moraines due to the agency of glaciers, which descended the valleys from the snowfields which covered the higher portions of Slieve Donard and the neighbouring heights.

On ascending the valley of the Annalong River, two consecutive moraines may be recognized. The first, and lowest, occurs at the entrance to the granite district, where the valley opens out on the plain at the foot of Seefin. Here the rock is covered by a great accumulation of moraine matter, with boulders well shown on the east side of the river. The second occurs just under Rocky Mountain, where the valley closes in, and bends more to the northward. This moraine is laid open in a deep cutting of the river to a depth of fifty feet, and at one period, was clearly thrown right across the valley from side to side, at an elevation (by aneroid observation) of 900 feet above the sea. There is clear evidence that this moraine originally produced a lake, since laid dry by the deepening of the river channel. The old bed of the lake may be observed, in the form of a level terrace of fine sand and gravel, more or less stratified, which has been left on either side of the river channel, above the position of the moraine. This fine gravel may also be observed, banked up against the moraine, which sweeps round in a wide semicircle from the base of the granitic slopes on either side of the valley. This second moraine indicates a pause in the final retreat of the glacier, which filled the valley originally, down to its entrance under Seefin, at the time when the perennial snows were gradually melting away.

Localities where observed—*continued.*

Elevation.	Direction of Ice Movement.			Remarks.
	Deflected.	Normal Striæ.	Deflected.	
750 (?)	—	—	—	"Cloghgarran," a large granite boulder 32 feet in girth, and many others, are collected under the lee of the Rosstrevor mountains.
850–1000	—	S. 30 E.	—	The rocks over all this tract are glaciated, and frequently striated.
1500	—	—	E. 30 S.	Glaciation on south side of Silurian cap.
1000–1100	—	S.S.E.	—	Striæ mostly defaced, grooving occasionally retained.
550–886	—	S.S.E.	—	Rocks all more or less glaciated from the N.N.W.
650–830	—	S.S.E.	—	Glaciation evident, striæ obliterated.
900–1000	—	S.S.E – S.E.	—	At the higher levels the ice-flow seems to have returned to its normal direction.
100	—	—	E. 15 N.	The direction of the ice-flow had been greatly deflected here, spreading out fan-shaped over the low-lying tracts, after passing through the contracted neck of Carlingford Lough at Killowen Point.
20–50	—	S. 5 E.	—	The direction of the ice-flow is rather obscure here. On the south side of the entrance to Carlingford Lough the striations bear S. 30 E.
25	—	S.S.E.	—	This island shows the effect of the ice-flow down Carlingford Lough, but with a tendency to return to its normal direction.

The moraine which forms, at least, half the marginal enbankment of Blue Lough, is very cleary defined. On the north-east side of the lough, cliffs of granite, rapidly disintegrating in angular blocks along the joint planes, rise to a height of nearly 1,000 feet, and from their base a bank of moraine matter sweeps round from side to side, forming the basin in which the waters are held. It is possible at the same time, that with the moraine enbankment, there may co-exist a basin hollowed out of the solid granite in the deeper parts of the lough.

Another moraine, formed of loose gravel and boulders, may also be observed, below Bingian Lough, at the head of the cliff, over which the stream draining the lough is precipitated. This has been laid open to a depth of about fifteen feet, by the action of the stream itself, which lays bare the solid granite floor underneath. The moraine is bounded on either hand by prominent masses of granite, rising into precipitous cliffs overlooking the valley of the Annalong river.

List of Fossils obtained from Rocks on shore at and near Soldier's Point, entrance of Carlingford Lough, in dark gray compact and bluish limestone. Lower Carboniferous limestone.

Fucoids.

Crinoidea.

× × Crinoid stems.
Poteriocrinus crassus.

Actinozoa.

Zaphrentis, Enniskilleni or Phillipsia.
,, cylindrica.
Michelinea favosa.
Chætetes tumidus.
Syringopora reticulata,

Polyzoa.

Ceriopora rhombifera.
Fenestella antiqua.

Brachiopoda.

Athyris planosulcata.
× × × Productus giganteus.
Rhynchonella pleurodon,
Streptorhynchus crenistria.

W. H. Baily.

INDEX.

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