Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 102 AND 112 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

ILLUSTRATING PART OF THE

COUNTIES OF DUBLIN AND MEATH.

SECOND EDITION.

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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 own 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 Explanatory Memoirs.

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 TO SECOND EDITION.

In preparing a new edition of this Explanatory Memoir for the Press, I have only made such alterations as recent investigations have rendered necessary.

The original Memoir was drawn up by Messrs. Jukes and Du Noyer, from their own observations, and the notes of Mr. W. L. Wilson and A. Wyley, while the palæontological portion was prepared by Mr. Baily, who has now revised it.

EDWARD HULL.

12th January, 1875.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEETS 102 AND 112 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

General Description.

The district included in these two sheets comprises a large part of the county Dublin, with some bordering portions of the county Meath on the north and east. The city of Dublin is in the centre of Sheet 112, and Malahide, Swords, and Skerries, are the chief places in Sheet 102.

1. *Form of the Ground.*

The southern part of the district is high mountainous ground, rising up to 1,763 feet above the sea, at a point called Fairy Castle. There is another summit called Tibradden Mountain, which is 1,540 feet; and the better known Three Rock Mountain, everywhere visible from the neighbourhood of Dublin, is 1,479 feet high. A hill called Slievenabawnoge, at the extreme S.W. corner is 1,265 feet. Of the lower hills, Killiney Hill has a height of 480 feet, while the summit of that of Dalkey is 472 feet high, within a quarter of a mile of the sea. The mountains, like all granite mountains, have heavy-looking, gently sweeping summit outlines, their flanks descending gradually, but rather steeply, from them on the east towards the sea, and on the north to the plain traversed by the valley of the Liffey.

This plain spreads from the foot of these hills to the north with gentle undulations of between 100 and 200 feet above the sea, few eminences rising above the greater height, and much land, especially that near the sea or on the margin of brooks and rivers, being below the lesser altitude. It forms a portion of the central plain of Ireland.

In the northern part of the district, however, N. of Ballyboghill, some of the land rises to heights exceeding 500 feet; while the rocky promontory of Howth has a summit of 560 feet in height, and Lambay Island one of 418 feet.

All the inland drainage of the southern hilly ground is received by the river Dodder, which issues from the narrow and wild-looking glen of Ismole, a little S. of Tallaght, on to the plain which it traverses to the mouth of the Liffey. This river, which has a level of less than 40 feet where it enters the district, brings the drainage from the plains of Kildare into the head of Dublin Bay, into which also, the lesser river Tolka runs. In the northern half of the district the sandy estuary of Malahide receives the united waters of several brooks, which a little above Swords, are called Broad Meadow Water, while the muddier estuary between Donabate and Rush, receives several other brooks which appear to have no special designation.

J. B. J.

2. *Formations or Groups of Rocks entering into the Structure of this District.*

Aqueous Rocks.

		Name.	Colour on Map.
Recent.		Bog, Alluvium, or other superficial covering.	*Pale sepia.*
Pleistocene.		Drift, limestone gravel and boulder clay.	*Engraved dots.*
Upper Palæozoic.	*Carboniferous.*	d^3. Upper Shale series.	*Indian ink.*
		$d^{2'''}$. Upper Limestone. $d^{2''}$. Calp or Middle Limestone. (*not separable in this district.*)	*Prussian blue (dark).*
		d^2. Lower Limestone.	*Prussian blue (light).*
		d^1. Lower Limestone Shale.	*Prussian blue and Indian ink.*
		m is added to any of the above when they are magnesian.	*Olive green.*
		μ δ. When the dolomitization is evidently metamorphic.	*Ditto with dots.*
		c Old Red Sandstone.	*Indian Red.*
Lower Palæozoic.	*Lower Silurian*	b^2. Bala or Caradoc beds.	*Pale Purple.*
		ls. Limestone in the above.	*Cobalt blue.*
		β. When metamorphosed into Mica Schist.	*Pink purple.*
	Cambrian.	a. Purple and green Grits and Slates, &c.	*Gray purple.*
		q. Quartz Rock in the above.	*Yellow.*

Igneous Rocks.

D.	Diorite—Greenstone.	*Dark purplish red.*
Fp.	Felstone Porphyry.	*Orange chrome.*
Ds.	Trappean Ash.	*Light ditto dotted.*
G.	Granite.	*Carmine.*

Lower Palæozoic Formations.

Cambrian Rocks.—These consist of chiefly massive greenish and purplish grits and slates, frequently interstratified with brownish and yellowish quartz rocks. In some places the colours of the slate become brighter, so as to be strikingly red or green; in others they pass into dull liver colour, or brown. The thickness of this group is certainly great, but it is impossible to determine it, since neither the base nor the top of the formation is seen. The only fossils found in it hitherto, in this district, were some specimens of *Oldhamia*, discovered at Howth by Dr. Kinahan.

Lower Silurian Rocks.—The Lower Silurian beds consist of thin bedded black and gray, sometimes greenish, clay slates, and fine greenish grits. As these beds approach the granite they become more and more micaceous; and close to their junction with that rock they assume all the characters of mica schist.

In the northern portion of the district about Skerries, these rocks are more arenaceous, of a clear grayish green colour, with well defined bedding. At Portraine they are in some places black, in others of a pale yellowish gray colour, soft and close-grained, the slates occurring as bands between the grits, while about the middle of the group a highly fossiliferous, pale gray or dove-coloured limestone, thin bedded, and often nodular, is to be found. On Lambay Island they consist of dark gray argillaceous slaty shale, often containing graptolites, with fossiliferous limestone, which in some places passes into a coarse conglomerate, containing pebbles of similar limestone.

Upper Palæozoic Formations.

c. *Old Red Sandstone.*—The beds assigned to this formation in this district, are some local accumulations of red sandstone and conglomerate. They nowhere exceed 350 feet in thickness.

d^1. *The Lower Limestone Shale* consists of dark shales and thin flaggy limestones. They generally contain an abundance of broken fragments of *Fenestella*, and a few other fossils, which make a characteristic assemblage. They do not exceed a probable thickness of 200 feet.

d^2. *Lower Limestone.*—Pale gray crystalline limestone, sometimes regularly bedded, sometimes in amorphous masses. This being the usual character of the group, in districts where its position can be certainly determined, it has been assumed, whenever limestones of this lithological character are found in this district, that they belong to this group. If this assumption be correct, it will follow that the Lower Limestone of this district varies greatly in thickness, and somewhat in lithological character within the county Dublin. It will also follow that the conglomerates containing Lower Silurian pebbles in the limestone on the S. of Skerries belong to the Lower Limestone.

d^3 and d^4. *The Calp or Middle Limestone, and the Upper Limestone.*—If the black shales in the high ground S. of the Naul and Bog of the Ring be truly the bottom beds of the Upper Shale series, it follows that somewhere below them is the upper boundary of the Carboniferous Limestone. Hitherto, these black shales and the beds between them and those assigned to the Lower Limestone, have been mapped and spoken of as "Calp," both by Sir Richard Griffith and in the Index Map of the county Dublin, published by the Geological Survey, in 1851. Calp seems to be a local provincial term for black earthy stone or shale, and in that lithological sense it is perfectly applicable to all those upper beds, so much so, that it is impossible to separate the dark earthy limestones which overlie the Lower Limestone into two groups of beds, differing either in lithological or palæontological characters. Assuming then that the beds S. of the Naul be the Upper Shales, we arrive at the conclusion that all the upper part of the Carboniferous Limestone in the county Dublin and neighbourhood has acquired that "calpy," or dark earthy and shaly character, which in Carlow and Kilkenny on the S. and, as is believed, still more markedly in Fermanagh on the N. is confined to the middle part of the limestone series. It is easy to find a reason for this earthy character on the probable supposition that during the formation of these beds, islands of dark Lower Silurian

slate rose hereabouts from the Carboniferous sea, a supposition greatly supported by the fact of beds of conglomerate derived from those older formations being found in the Carboniferous limestone.

If the method of grouping the limestones suggested above, be approximately correct, we may then describe the Upper (and Middle) Limestone of this district, as consisting generally of dark earthy limestones interstratified with dark gray shales and with frequent layers or irregular nodules of black chert. Sometimes beds of good pale limestone, more or less free from argillaceous matter, occur in it, but these are partial and local exceptions to its general character. These more purely calcareous patches sometimes abound in fossils, such as large *Producti*, which are characteristic of the Upper rather than the Lower Limestone.

Local beds of conglomerate occur near Rush, containing pebbles and blocks of Lower Silurian slate, grit, and trap, some the blocks being as much as eighteen inches in diameter; and diminishing from that to a mere sand. (See pp. 63 to 65.)

In the uppermost part of the Limestone series there sometimes occur beds of calcareous grit or sandstone; and these may be taken, perhaps, as the topmost limit of the group.

It is not attempted to deny that there is still a good deal of uncertainty about the grouping and classification of the Carboniferous rocks of this district, and that many of the minor details are open to dispute. After a careful examination, however, of all the ascertainable facts—an examination in some cases many times repeated—the version now adopted in our maps and in this memoir, is the one at which we have arrived as the most probable and consistent interpretation of those facts.

d[s]. *Upper Shale Series.*—These beds were formerly known as "Coal Measures." The bottom beds only of the group occur in the district, so that it is highly improbable that they will be found to contain any coal. They consist of hard dark splintery shales, interstratified in some places with thin grits and flagstones.

They contain a very characteristic assemblage of fossils, among which are *Goniatites sphæricus, Aviculo-pecten papyraceus, Posidonomya Becheri,* and *P. membranacea,* with fragments of plants.

The thickness found in this district does not probably exceed 500 feet, while in Kilkenny, the lowest bed of coal has below it a thickness of 1,200 feet of gritstones and shales.

The *Drift** and *Alluvium* do not require a separate description from that which will be found at the end of the Detailed Descriptions.

Igneous Rocks.

The Granite of the Dublin Mountains has been fully described by Professor Haughton (see Memoir of Palæozoic Rocks of South-east of Ireland, &c., *Trans. R. I. Acad.*, vol. XXIII.) He there gives the following two analyses of that of the Three Rock Mountain:—

* The Drift has recently been recognised in this district as divisible into three members, similar to those of the N.W. of England, viz.:—1. Lower Boulder Clay; 2. Middle sands and gravels; and 3. Upper Boulder Clay. The upper member is seldom present owing to denudation, but is well seen in the cliffs of Killiney Bay.—E.H.

	No. 1.	No. 2.
Silica,	70·28	70·32
Allumina,	16·44	16·12
Peroxide of iron,	2·60	3·20
Lime,	2·04	1·34
Potash,	5·79	4·65
Soda,	2·82	3·39
Loss of ignition,	—	0·96
	99·97	99·98

He also shows the average constitution of the Dublin and Wicklow granite to be

Quartz,	27·66
Feldspar (Tersilicate),	52·94
White Mica (Margarodite),	14·18
Black Mica (Lepidomelane),	5·27
	100·05

Thin slices of the granite of Killiney, Blessington, &c., when examined under the microscope, show that there are always two felspars, Orthoclase, and another of the triclinic group, probably Albite. A crystal of this mineral has also been recognised in the granite of Killiney, by Dr. Westropp.*

The granite is generally of a dull gray colour, with dark spots. Ferruginous brown stains soon appear on it, and it generally weathers very rapidly, and in some places very deeply, so as to be a perfectly incoherent mass to a depth of several feet.

The character of the rock varies somewhat in grain and appearance in different places, and its power of resisting the weather seems to be equally various. The quarries are usually opened in the parts which most easily decompose, and are consequently most worthless—cheapness and easiness of working being preferred to durability in the material; the consequence is that some of the granite buildings in Dublin are in a state of constant decay.

It often contains veins of a white fine-grained variety, in which the mica becomes evanescent, and which, in the following pages, is spoken of as Eurite. Sometimes these white fine-grained portions assume larger dimensions than that of mere veins.

Other veins may be found in which the constituent minerals crystallize out still more largely than in the mass of the rock.

Felstone Porphyry.—This rock occurs in large masses at Donabate and Lambay Island. It was formerly described as a hornblendic greenstone—the dark appearance of the base being supposed to be due to the presence of this mineral. The examination of thin slices under the microscope, taken from both the mainland and Lambay Island, have led Mr. Hull to the conclusion that the rock is a felstone porphyry, and that hornblende if present at all, is only rarely so.

The rock presents a marked porphyritic structure, consisting of a dark green base, with numerous well formed crystals of orthoclase felspar of light green and straw colours. Under the microscope the base is seen to consist of felspar, densely charged with black grains and crystals of magnetite (magnetic iron ore), and with strings and veins of chlorite. It is these minerals which impart to the rock its

* Journal Royal Geological Society, Ireland, vol. ii., 213.—E. H.

dense aspect, and dark greenish tint. Cells filled in with calcite are also numerous; this mineral having probably been derived from the once overlying beds of Carboniferous limestone. Crystals of iron pyrites are not uncommon in this rock; and strings, as well as small, irregular, segregations of chalcedony, occur in it at Lambay, where it also contains epidote. This rock takes a fine polish.

Basalt.—The Cambrian rocks of Howth are traversed by dykes, some of which at least are composed of basalt; others may be diorites (or greenstones), into the composition of which hornblende enters. The dyke at the Baily lighthouse is an example of the former.

Another trappean district occurs on both sides of the valley of the Dodder and its tributaries, at the S.W. corner of Sheet 112. The rocks are of two principal varieties—first, felstones and felstone porphyries, interbedded with the Silurian slates and grits; and secondly, basalts, and dolerites, sometimes porphyritic, which are probably intrusive, though generally running parallel to the strike of the beds. It is probable however, that the felstone porphyries are of Lower Silurian age.

J. B. J., G. V. D., and E. H.

3. *Palæontological Notes.*

For the determination of the following list of species found within this district, 3,500 specimens were examined by Mr. Baily. Of these 600 were from the Lower Silurian rocks of Portraine and Lambay, the remainder, or 2,900 specimens, having been procured from the Carboniferous rocks, chiefly collected before the year 1850.

The shore of the Portraine peninsula and the western side of Lambay Island, especially the part a little N. of Kiln Point, are the localities where the principal part of the Lower Silurian fossils were found.

The Carboniferous fossils are, however, much more widely disseminated, those examined having been procured from sixty-eight different places, some of them a little outside the exact limits of our district in Sheets 101 and 111.

A list has been made of these localities, and a number assigned to each, commencing in the N. near Garristown. Those numbered as 1, 2, 3, 6, 7, 8, 9, 9*a*, 10, and part of 16, are in areas which are considered to belong to the Upper Shale series. The fossils found in these shales are almost peculiar to them, the species commonly occurring there in great abundance, while they are very rare in other localities; and even when they are found elsewhere, the beds are mostly such as, from lithological character and stratigraphical position, may belong to the upper part of the limestone, and may, in some cases, be scarcely below the beds of the upper shale series. The following are the species alluded to, in alphabetical order:—

Aviculopecten papyraceus, in 1, 6, 7, (Upper Shales), and in 18,* (Limestone).
Aviculopecten variabilis, in 6 and 10, (Upper Shales), and 25, (Limestones).
Calamites cannæformis? in 6, Upper Shales.
Dithyrocaris? in 6, Upper Shales.
Fish scales and defence spine, in 3, 6, 7, 9, 10, (Upper Shales), and 46, (Limestone).
Goniatites sphæricus, in 1, 2, 3, 6, 7, 8, 9, 9*a*, 16, (Upper Shales, and 11, 25, 31, 36, 42, 43, 46, 47, 59, 64, (Limestone).
Lunulacardium, *sp.* in 6, Upper Shales.
Orthoceras scalare, *Goldf.* in 6, Upper Shales.
Orthoceras Steinhauerii, in 1, 3, 7, 16, (Upper Shales), and 31, 36, 38, (Limestone).

* The specific identification, however, of the single specimen found in this locality is rather doubtful.

Orthoceras, large smooth species undetermined, in 1, 3, 6, 9*a*, (Upper Shales), and 8, 39, (Limestone).
Plant stems, in 4*a*, 6, 7, 16, (Upper Shales), and 19, 34, 42, 43, (Limestone).
Posidonomya Becheri, in 2, 4*a*, 8, 9, 10, 16, (Upper Shales), and 11, 50, (Limestone).
Posidonomya membranacea, in 1, 3, 6, 7, 10, Upper Shales, never in Limestone.

The peculiar assemblage of these species, their abundance in the localities above named as Upper Shales, their scarcity when they occur in other localities, and the absence of all other species from the beds believed to be above the limestone, confirms the correctness of the view which regards these beds as a distinct subdivision of the Carboniferous system, and identifies them with the basal shales of the Coal Measures of Kilkenny, Queen's County, Tipperary, Limerick, and Clare, in which exactly the same peculiarity and assemblage of species occurs.

This identification by palæontological evidence, worked out by Mr. Baily, is then in harmony with that made by myself on lithological and stratigraphical evidence only (see Journal of Geological Society, Dublin, vol. 8, p. 164.)*

Of the other localities, those numbered 4, 12, 13, 14, 17, 18, 19, 21, 22, 23, 24, 25, 25*a*, 26, 27, 28, 30, 31, 32, 35, 36, 37, and 38, are within areas which are supposed to belong to the Lower Limestone, while all the other localities fall in spaces coloured dark blue, and supposed to be above the Lower Limestone, but beneath the Upper Shales, and therefore considered as Upper Limestone.

An inspection of the lists of fossils, and a comparison of the localities where the most abundant species are found, will at once show that there is no palæontological evidence whatever in favour of this subdivision of the limestone.

As the Geological Survey of Ireland has, until recently, been almost entirely deprived of any palæontological assistance, the subdivision of the limestone was carried out entirely on lithological grounds.

The examination of the fossils just concluded by Mr. Baily has confirmed me in the belief I previously entertained of the small geological value of this subdivision.

I believe that some of the pale gray limestone, even when it occurs near the boundary of the formation, may in reality have been formed subsequently to some of the dark shaly limestone, which is ordinarily supposed to lie above it; and that any evidence derived from the mere colour, aspect, or mineral character of the rock, is even of less value in this district than usual. Every experienced geologist knows how apparent identity in the lithological character of beds is apt to lead him astray, unless it is continually checked and corrected by palæontological, or still better, by stratigraphical evidence. The latter is unfortunately not obtainable in the Dublin district; and it now appears that the former goes against, rather than in favour of, the conclusions based on the lithological characters. J. B. J.

List of Lower Silurian Fossils.

The mark × indicates the abundance of the species.

	Localities.
Hydrozoa; *Graptolites.*	
Diplograpsus pristis, *His.*	Portraine and Lambay.
Actinozoa; *Corals.*	
Cyathophyllum, sp.	Portraine and Lambay.
Favosites (polymorpha) cristatus, *Blum.* × . .	Portraine.
——— (alveolaris) asper, *Blum.*	Portraine.
——— (Stenopora) fibrosus, *Goldfs.* × . . .	Portraine and Lambay.
Halysites catenularius, *Linn.* ××	Portraine and Lambay.
Heliolites interstinctus, *Wahl.* ×	Portraine.
Syringophyllum (Sarcinula) organum, *Linn.* × . .	Portraine.

* It is due to Mr. J. Kelly to state that he had previously published his opinion that the hill immediately S. of the Naul was Coal Measures, in the Journal of the Geological Society, vol. vii., p. 253.

POLYZOA.	
Ptilodictya dichotoma, *Portl.* ×	Portraine.
——— acuta, *Hall.* ×	Portraine.
BRACHIOPODA.	
Atrypa marginalis, *Dalm.*	Portraine and Lambay.
Discina, small sp.	Portraine.
Leptæna quinquecostata, *M'Coy*,	Portraine.
——— sericea, *Sowerby*,	Portraine and Lambay.
——— tenuicincta, *M'Coy*,	Portraine.
Lingula, small sp.	Portraine.
Orthis biforata, *Schloth.* ×	Portraine.
——— calligramma, *Dalm.* ××	Portraine and Lambay.
——— elegantula, *Dalm.* ××	Portraine and Lambay.
——— insularis, *Eichw.* ××	Portraine and Lambay.
——— porcata, *M'Coy*,	Portraine.
——— testudinaria, *Dalm.* ××	Portraine and Lambay.
——— vespertilio, *Sow.*	Portraine.
Strophomena alternata,* *Conr.* ×××	Portraine and Lambay.
——— (depressa) rhomboidalis, *Wilck.* ×	Portraine.
——— expansa? *Sow.* ×	Portraine and Lambay.
CONCHIFERA.	
Ctenodonta, sp.	Portraine.
Modiolopsis, sp.	Lambay.
GASTEROPODA.	
Cyclonema crebristria? *M'Coy*, ×	Lambay.
——— rupestris? *Eichw.*	Portraine.
Euomphalus, sp. and n.s.	Portraine and Lambay.
Holopæa concinna, *M'Coy*, ×	Portraine and Lambay.
Murchisonia (large and small sp.).	Portraine and Lambay.
Raphistoma, n.s.	Portraine.
NUCLEOBRANCHIATA (*Heteropoda*).	
Bellerophon subdecussatus, *M'Coy*,	Lambay.
——— n.s., allied to acutus, *Sow.* (Sil. Syst.).	Portraine.
CEPHALOPODA.	
Orthoceras remotum, *Salter*, m.s.	Portraine.
——— sp.	Portraine.
——— tenuicinctum? *Portl.*	Portraine.
ANNELIDA.	
Tentaculites anglicus, *Salt.*	Portraine.
CRUSTACEA.	
Agnostus trinodus, *Salt.*	Portraine.
Æglina mirabilis, *Forbes*,	Portraine.
Calymene (Otarion) obtusa, *M'Coy*, ××	Portraine and Lambay.
Cheirurus clavifrons, *Dalm.* ×	Portraine.
——— bimucronatus, *Murchison*,	Portraine and Lambay.
Cybele verrucosa, *Dalm.* ××	Portraine and Lambay.
Cythere, sp.	Portraine.
Illænus Bowmanni, *Salter*, ×××	Portraine and Lambay.
Lichas Hibernicus, *Portl.* sp.	Portraine and Lambay.
—— laxatus, *M'Coy*,	Portraine.
Remopleurides, longicostatus, *Portl.*	Portraine and Lambay.
Spærexochus mirus, *Beyrich*, ×	Portraine and Lambay.
Stygina latifrons *Portl.*	Portraine and Lambay.
Trinucleus seticornis, *Hisinger*, ×	Portraine and Lambay.

The evidence derived from an examination of the fossils included in the foregoing list, shows that the beds of Portraine and Lambay are as precisely similar with respect to their organic contents as they are lithologically.

* Orthis Hirnantensis, *M'Coy*, Pal. Foss. t. 1, Hf. 11, is most probably a synonym of this species.

There is a difference in lithological character between them and those of the chair of Kildare, with a corresponding difference in species; all appear, however to be of Carradoc or Bala age. In the dark compact limestone of these deposits fossils are very abundant, Trilobites being the most numerous; amongst which Cybele verrucosa, Lichas Hibernicus, Calymene obtusa, and Illænus Bowmanni, are the prevailing forms. Corals are also abundant, particularly the Chain coral, Halysites catenularius. Of Mollusca, the Brachiopodous Bivalves are as usual in Lower Silurian strata the most numerous, at Lambay the rock is full of Strophomena alternata, which is, however, not so numerous at Portraine, Strophomena rhomboidalis there appearing to take its place, but not having yet been found at Lambay. The Orthidæ are particularly abundant at both localities: The rarer forms of Brachiopoda, Lingula, and Discina, of which the species are not yet determined, were only found at Portraine. Very few Conchifera, or ordinary Bivalves, occur at either locality. Of Gasteropoda there are several, the most abundant being Holopea concinna, also common at the chair of Kildare, with species of Murchisonia and Cyclonema. The Cephalopoda are confined to the genus Orthoceras, of which there are three species.

LIST of the LOCALITIES from which the CARBONIFEROUS FOSSILS have been collected.

No.	*Quarter Sheet of the 6-inch Maps.	Townland.	Situation, Geological Formation, and Sheet of the One-inch Map.
1	3/3	Garristown,	A little N. of the village. Upper Shales. Sheet 101.
2	3/3	Tobergreggan,	Three quarters of a mile S. of Garristown. Junction beds of Upper Shales and Upper Limestone. Sheet 101.
3	3/3	Tobergreggan,	One and a half miles W.S.W. of Garristown. Upper Shales. Sheet 101.
4	3/3	Newtown,	The Hoare Rock, one and three quarter miles W. of Garristown. Lower Limestone. Sheet 101.
5	4/1	Westown,	In bed of River Delvin, at Ford of Fine. Upper Limestone. Sheet 102.
6	4/3	Westown,	Quarry just S. of wood on top of hill. Upper Shales. Sheet 102.
7	4/4	Knockbrack,	Small quarry in the glen. Upper Shales. Sheet 102.
8	4/4	Kitchenstown,	In a ditch S. of the road. Upper Shales. Sheet 102.
9	4/4	Belgee,	Quarry a little S. of the cross reads. Upper Shales. Sheet 102.
9a	4/4	Balrickard,	Quarry by roadside, half-a-mile S. of Bog of the Ring. Junction beds of Upper Shales and Upper Limestone. Sheet 102.
10	5/3	Courtlough,	Quarry close to road, about three-quarters of a mile N.W. of Man-of-War. Upper part Upper Shales. Sheet 102.
11	5/3	Courtlough,	Lower part of the same quarry as No. 10. Top of Upper Limestone. Sheet 102.
12	5/4	Holmpatrick,	On shore, a little N. of townland boundary. Lower Limestone. Sheet 102.
13	7/1	Oldtown,	In the village. Lower Limestone. Sheet 102.

* The sheets of the Six-inch Maps are divided into quarters, for convenience sake, the N.W. quarter being called No. 1, the N.E. 2, the S.W. 3, and the S.E. 4.

LIST of the LOCALITIES from which the CARBONIFEROUS FOSSILS have been collected—*continued.*

No.	Quarter Sheet of the 6-inch Maps.	Townland.	Situation, Geological Formation, and Sheet of the One-inch Map.
14	7/3	Wolganstown, . .	One mile and a-half S.W. of Oldtown. Quarries in fields in middle of townland. Lower Limestone. Sheet 102.
15	8/2	Loughshinny, . .	On the shore at the village. Upper Limestone. Sheet 102.
16	8/2	Loughshinny,* . .	On the shore, about a furlong S. of the village. Upper Shales and Upper Limestone. Sheet 102.
17	12/1	Corballis, . .	On the shore, about a furlong W.N.W. of Corballis House. Lower Limestone. Sheet 102.
18	12/3	Malahide, . .	Seamount quarries. Lower Limestone. Sheet 102.
19	12/4 and 15/3	Robbs walls and Carrick Hill, .	The Malahide shore. Lower Limestone. Sheet 102.
20	13/4	Blanchardstown, .	Quarries and cuttings E. and S. of the village Upper Limestone. Sheet 112.
21	14/1	Mitchelstown, . .	Quarries in the townland, three miles N.N.W. of Finglas. Lower Limestone. Sheet 102.
22	14/2	Cloghran, . .	Quarries at the village. Lower Limestone. Sheet 102.
23	14/3	Dunsink, . . .	By River Tolka, a quarter of a mile E. of Hillbrook. Lower Limestone. Sheet 112.
24	14/3	Dunsink, . . .	In a field E. of last locality. Lower Limestone. Sheet 112.
25	14/3	Dunsink, . . .	Near the Observatory. Lower Limestone. Sheet 112.
25a	14/3	Cappoge, . . .	Near Cappoge House. Lower Limestone. Sheet 112.
26	15/1	St. Doolagh's, . .	The large quarries near St. Doolagh's. Lower Limestone. Sheet 102.
27	15/4	Quarry, . . .	On the shore, near Howth Lodge, and in the Deer Park to S. of it. Lower Limestone. Sheet 112.
28	16/1	Howth, . . .	On the shore of Balscaddan Bay. Lower Limestone. Sheet 112.
29	17/1	Tobermaclugg, . .	One mile and a-half S.W. of Lucan, by roadside. Upper Limestone. Sheet 111.
30	17/	Woodlands, . .	In demesne on river bank, a little S. of gate lodge. Lower Limestone. Sheet 111.
31	17/2	Woodlands, . .	On river a little farther S. than last locality. Lower Limestone. Sheet 111.
32	17/2	Woodlands, . .	Do. do. Lower Limestone. Sheet 111.
33	17/2	Woodville, . .	A field S.E. of Woodville farm-yard. Lower Limestone. Sheet 111.
34	17/2	Irishtown, . .	Cursis stream quarry. Upper Limestone. Sheet 111.
35	17/2	Astagob, . . .	Close to River Liffey. Lower Limestone. Sheet 111.
36	17/2	Woodlands, . .	S. side of Liffey, near Hermitage. Lower Limestone. Sheet 111.
37	17/3	Woodville, . .	S.W. of Woodville farm-yard. Lower Limestone. Sheet 111.
38	17/3	Castleknock, . .	Quarries S. of the village. Lower Limestone. Sheet 112.
39	17/4	Clondalkin, . .	In river, a little N. of village. Upper Limestone. Sheet 111.
40	18/1	Pelletstown, . .	Quarry between road and Tolka River, a quarter of a mile W. of Finglas Wood Bridge. Upper Limestone. Sheet 112.
41	18/3	Butcher's Arms, .	The only quarry in the townland. Upper Limestone. Sheet 112.

* In this locality a small portion of the Upper Shale series are exposed in the cliff, consequently fossils such as Posidonomya Becheri, are here mentioned as associated in the same locality with others that are not usually found with them.

LIST of the LOCALITIES from which the CARBONIFEROUS FOSSILS have been collected—*continued.*

No.	Quarter Sheet of the 6-inch Maps.	Townland.	Situation, Geological Formation, and Sheet of the One-inch Map.
42	18/3	Golden Bridge, S., .	Quarry near Blackhorse Bridge. Upper Limestone. Sheet 112.
43	19/1	Killester, . . .	Railway cutting and quarry. Upper Limestone. Sheet 112.
44	21/1	Greenoge, . .	Quarries S. of road. Upper Limestone. Sheet 111.
45	21/1	Monsenalion Commons, Upper.	About one mile S.E. of Castle Bagot. Upper Limestone. Sheet 111.
46	21/2	Brownsbarn, . .	Road cutting and quarries S. of Corkagh. Upper Limestone. Sheet 111.
47	21/2	Bedlesshill, . .	Between Corkagh Mills and Belgard Castle. Upper Limestone. Sheet 111.
48	21/2	Newlands Demesne, .	About a quarter of a mile N.W. of Belgard Castle. Upper Limestone. Sheet 111.
49	21/2	Garranstown, . .	About a furlong W. of Kilnamanagh House. Upper Limestone. Sheet 112.
50	21/2	Kilnamanagh, . .	One field S.E. of Kilnamanagh House. Upper Limestone. Sheet 112.
51	21/2	Clondalkin, . .	Quarries S. of Mount St. Joseph's Monastery. Upper Limestone. Sheet 112.
52	21/2	Bushelloaf, . .	A little E. of last locality. Upper Limestone. Sheet 112.
53	21/2	Fox and Geese, . .	Quarries near the Red Cow. Upper Limestone. Sheet 112.
54	21/2	Red Cow and Ballymount Great.	On boundary of townlands near the Red Cow. Upper Limestone. Sheet 112.
55	22/1	Kilnamanagh, . .	Near Ballymount Little. Upper Limestone. Sheet 112.
56	22/1	Kilnamanagh, . .	Between last locality and Air Mount. Upper Limestone. Sheet 112.
57	22/1	Roebuck and part of Crumlin.	Quarries S.E. of Cromwell's Fort. Upper Limestone. Sheet 112.
58	22/1	Kimmage, . .	Quarries on both sides of road S. of village. Upper Limestone. Sheet 112.
59	22/1	Greenhills, . .	Old quarries between this townland and that of Limekiln Farm. Upper Limestone. Sheet 112.
60	22/1	Terenure, . . .	In River Dodder, and at old quarry at Rusina Ville. Upper Limestone. Sheet 112.
61	22/1	Crumlin, . . .	Quarries S.E. of Roman Catholic Chapel. Upper Limestone. Sheet 112.
62	22/2	Donnybrook E., .	Quarry by Methodist Chapel. Upper Limestone. Sheet 112.
63	22/2	Roebuck, . . .	In River Dodder, near Milltown. Upper Limestone. Sheet 112.
64	22/2	Rathgar, . . .	Large quarry at West Hamptown, N. of Roundtown. Upper Limestone. Sheet 112.
65	22/2	Roebuck, . . .	In River Dodder, S. side, near Donnybrook. Upper Limestone. Sheet 112.
66	22/2	Rathmines, Great, .	Quarry on N. side of River Dodder, opposite Cloth mill. Upper Limestone. Sheet 112.

List of the species collected from the preceding localities, with the numbers of these localities attached to each :—

PLANTÆ.

Calamites cannæformis?	6
Fucoid?	16
Plant stems, ×	6, 7, 9a, 16, 19, 34, 42, 43

Cœlenterata.

Actinozoa: *Corals.*

Amplexus coralloides, × × × . . . 18, 25, 26, 29, 30, 35, 37, 38, 46, 61
Aulopora gigas, *M'Coy*, sp. 31
Cladochonus crassus, ... 16
Chætetes tumidus, ... 11, 46, 66
Cyathophyllum Stutchburyi, × . . . 19? 28
——— undetermined species, . . . 37, 44, 46, 51, 52, 57, 58, 62, 64
Gorgonia Lonsdaliana (*M'Coy*), . . . 18
Lithodendron affinis, ... 27
——— junceum, ... 18, 19, 28, 58
Lithostrotion striatum, ... 5, 12
Michelinia favosa, ... 28
Zaphrentis patula, ... 19, 28
——— Phillipsi, ... 19, 31, 32, 33

Mollusca: *Polyzoa.*

Ceriopora interporosa, and others undetermined, . 28
Ceriopora rhombifera, ... 15, 16, 19
——— n.s.? 18
——— 65
Fenestella antiqua,* × × × . . . 11, 15, 16, 18, 19, 22, 25, 26, 27, 28, 29, 30, 35, 36, 37, 38, 47, 63
——— membranacea, ... 13, 18, 26, 29, 35
——— multiporata,† 30, 38
——— oculata, ...
——— undulata,‡ 18, 30
——— varicosa? 30
——— sp., ... 33
Glauconome bipinnata, × × . . . 18, 26
——— gracilis, ... 19
——— pulcherrima, ... 16
Ichthyorachis Newenhami, ... 19
Polypora fastuosa, ... 11, 16, 27
——— verrucosa, ... 18, 35
Ptylopora flustriformis, ... 18
——— pluma, ... 25
Vincularia dichotoma,§ × × × . . . 11, 18, 25, 26, 30, 35, 37, 38
——— multangularis, ... 26, 35

Brachiopoda.

Athyris ambigua, ... 18, 19
——— lamellosa, ... 19
——— planosulcata, ... 25, 30, 38
——— Royssii, ... 24
——— sp., ... 31
Chonetes Hardrensis, × 16, 21, 25, 30, 31, 39, 42, 46, 51, 52, 54, 59, 65
——— papilionacea, × × . . . 12, 46, 47, 48, 51, 52, 54, 55, 56 57, 63, 64, 65, 66
——— tuberculata, ... 26
——— sp., ... 30
Discina nitida, ... 11, 15, 18, 57
Lingula mytiloides, ... 31, 44.
Orthis resupinata, × × × 4, 11, 12, 15, 16, 18, 19, 25, 26, 30, 32, 35, 38, 40, 41, 44, 46, 47, 51, 52, 54, 55, 56, 57, 58, 60, 61, 62, 63, 65, 66
Productus aculeatus, × × × . . . 13, 17, 18, 21, 22, 25, 26, 30, 35, 38, 46, 51, 54, 56, 59, 61, 65, 66
——— Cora, ... 12, 26, 35, 38, 57
——— giganteus, ... 12, 25, 38, 46, 57, 58
——— longispinus, ... 19, 57, 64

* Syn.: Fenestella (Retspora) flabellata, *Phil.* G. Y., and F. plebeia *M'Coy* Synop. Carb. Foss.
† Syn. F. quadridecimalis, *M'Coy.*
‡ F. formosa, *M'Coy*, is probably a synonym of this species.
§ Vincularia raricosta, *M'Coy*, Sulcoretepora *D'Orbigny* in Morris's Catalogue is most probably the rounded side of *V.* dichotoma

Productus margaritaceus, ... 12, 15, 38, 64
——— mesolobus, ... 18, 25, 26, 30, 38
——— plicatilis, ... 29, 30
——— punctatus, ... 11, 15, 21, 54, 56, 59, 65
——— scabriculus, × × × . . . 4, 11, 12, 15, 16, 18, 19, 25, 26, 27, 29, 35, 37, 38, 44, 45, 46, 47, 51, 52, 53, 56, 57, 65
——— semi-reticulatus, × × × . . 4, 5, 11, 12, 13, 15, 16, 17, 18, 19, 21, 22, 25, 26, 27, 29, 30, 35, 37, 38, 40, 44, 46, 47, 49, 51, 52, 53, 54, 56, 58, 59, 63, 64, 65, 66
——— striatus, ... 16
——— undatus, ... 35, 38
——— species undetermined, . . . 36, 39, 50
Retzia radialis? 18
Rhynchonella pleurodon, × × × . . . 4, 11, 13, 15, 16, 17, 18, 19, 25, 27, 38, 43, 45, 46, 52, 62, 63, 64
——— pugnus, × . . . 15, 18, 25, 26, 30, 37
Spirifera convoluta, ... 11
——— cuspidata, × 19
——— duplicostata, ... 30
——— glabra, × × × . . . . 2? 11, 12, 15, 16, 18, 19, 23, 25, 26, 27, 28, 30, 38, 44, 49, 52, 54
——— laminosa, ... 19, 28, 57
——— lineata, × × × . . . 11, 12, 13, 15, 16, 18, 19, 25, 26, 27, 35, 37, 38, 44, 46, 47, 57, 59, 64, 65, 66
——— pinguis, × × . . . 19, 22, 25, 26, 27, 29, 30, 38, 46
——— rhomboidea? 30
——— striata, × × × . . . 13, 16, 18, 19, 25, 26, 27, 29, 30, 35, 37, 38, 51, 57, 62
——— trigonalis, ... 4, 11, 12, 15, 18, 30, 46, 57, 64
——— triradialis, ... 18, 27, 30, 35, 56
——— species undetermined, . . . 36, 39
Spiriferina cristata, ... 18
——— insculpta, ... 16
Streptorhynchus (Strophomena) crenistria, × × × . . 11, 15, 16, 18, 19, 25, 26, 30, 35, 38, 47, 50, 52, 55, 57, 58, 64, 66
Strophomena analoga, ... 15, 16, 18, 19
Terebratula hastata, × × × . . . 4, 11, 12, 13, 15, 18, 21, 22, 25, 26, 27, 30, 31, 35, 38, 46, 59, 61, 66
——— sacculus, ... 15
——— vesicularis, ... 63

Conchifera.

Arca semicostata, ... 30? 31, 33
Avicula lævigata, ... 35
——— lunulata, ... 18, 26, 30
Aviculopecten clathratus, ... 18
——— concentricostriatus, . . . 18, 38
——— dissimilis? 27
——— fallax? 35
——— flabellulus, ... 18, 26, 35
——— flexuosus, ... 13
——— Forbesii, ... 18, 25, 26, 30, 58
——— granosus, ... 18, 26, 30
——— lævigatus, ... 18, 26, 38
——— papyraceus, × × . . . 1, 6, 7 (18?)
——— planicostatus, ... 30
——— quinquelineatus, ... 21
——— rigida, ... 18, 38
——— Sowerbii, ... 22,* 25, 26, 38
——— tessellatus, ... 18, 26
——— variabilis, ... 6, 10, 25
——— sp. undetermined, . . . 30, 57
Cardiomorpha oblonga, ... 18, 26, 35, 38

* The specimen from loc. 22 shows zig-zag lines of colour

Cucullæa obtusa, ... 25
Cypricardia, sp., ... 66
Donax? primigenius, ... 40
Edmondia quadrata? 21
——— sulcata? 35
——— oblonga, ... 25*a*
——— sp., ... 25
Leda, n.s.? 32, 36
Leptodomus fragilis, ... 18
Lima lævigata? 26
Lithodomus dactyloides, ... ? 18, 30, 38, 50
——— sp., ... 18
Lunulacardium, sp., ... 6
Myacites? Omaliana, ... 35
Pleurorhynchus aliformis, ... 18, 27
——— armatus, ... 38
——— fusiformis, ... 19, 28
——— Koninckii, n.s., *Baily*, . . . 28
——— Hibernicus, ... 18, 38
Posidonomya . . . . . .
——— Becheri,* × × × 2, 8, 9, 9*a*, 10, 11, 16, 50
——— membranacea,† × × × . . . 1, 3, 6, 7, 10, 39
——— small, ... 39
Sanguinolites plicatus, ... 18, 25
——— sp., ... 25*a*, 30
Pullastra bistriata, ... 18, 26
——— scalaris, ... 18

GASTEROPODA.

Acroculia neritoides, ... 35
——— vetusta, ... 18, 26, 30
Dentalium ornatum, ? De Koninck, . . . 18
Euomphalus Dionysii, ... 38, 56
——— pentangulatus, ... 5, 18, 19, 25, 26, 29, 30, 38
——— pileopsideus, ... 18, 46, 47, 56 57, 56, 66
——— serpula, ... 12
——— tabulatus, ... 18, 30, 38
——— sp. undetermined, ... 36, 53
Loxonema Lefebvrei, *De Kon.*‡ 27
——— sp., ... 18, 47, 53, 56, 66
Macrocheilus ovalis, ... 25, 30
——— (Litorina) pusilla, *M'Coy*, . . . 19
——— sp. undetermined, ... 13, 18, 53, 59
Natica elliptica, ... 18, 26
——— plicistria, ... 11, 18, 19
Patella mucronata, ... 18
——— sp., ... 35
Pleurotomaria, sp. undetermined, . . . 19, 57, 66
Trochella prisca, ... 18, 26
Turritella spiralis, ... 13, 56
——— tenuistriata, ... 15

NUCLEOBRANCHIATA (HETEROPODA).

Bellerophon hiulcus, ... 56
——— tangentialis, ... 18, 26

CEPHALOPODA.

Actinoceras giganteum, ... ? 26, 27
§Goniatites crenistria, var. of sphæricus, × . . 7, 8, 9, 1
——— cyclobus, ... 14

* Syn. P. lateralis, P. tuberculata, *Sow.*, and P. acuticostata, *Sandberger*.
† Syn. P. costata, which appears to be only a more wrinkled variety.
‡ Syn. Loxonema pulcherrima, *M'Coy*, Carb. Foss. t. 7, f. 7.
§ A revision of the genus Goniatites is much wanted. After an examination of numerous specimens from the Carboniferous Limestone and shales, I feel disposed to consider the following as synonyms of Goniatites sphæricus, viz., Ellipsolithes ovatus, *Sowerby*; G. carbonarius, *Sow.*; G. crenistria, *Phil.*; G. granosus, *Portl.*; G. obtusus, *Phil.*; G. spiralis, *Phil.*; G. truncatus, *Phil.*; also G. subsulcatus, undulatus, intermedius, and dorsalis, *Brown*. (*See Explanation to Sheet* 142.)

Goniatites, furcatus, × × 20, 21, 23, 24, 25, 32, 33, 36
——— obtucus, var. of sphæricus, . . 30
——— sphæricus, × × × . . . 1, 2, 3, 6, 7, 8, 9, 9*a*, 11, 16, 25, 31, 36, 42, 43, 46, 47, 59, 64
——— truncatus, var. of sphæricus, . . 25
——— sp. undetermined, . . . 52, 65
Nautilus biangulatus,* 26, 38
——— De Koninckii, *D'Orb.* . . . 11
——— (Discites) discors, ... 27
——— dorsalis, ... 25, 26, 27, 38
——— (*Discites*) sulcatus, ... 11
Orthoceras cinctum, ... 30
——— Goldfussianum ?† . . . 25, 26, 29, 31, 32, 33, 35, 37, 38
——— allied to polygonum ? *Sandberger*, . 1
——— scalare, *Goldf.* 6
——— Steinhauerii, ... 1, 3, 7, 16, 31, 36, 38
——— sp. undetermined, . . . 1, 3, 6, 8, 9*a*, 10, 11, 18, 27, 30, 39, 40, 52, 59

ANNULOSA.

ECHINODERMATA.

Actinocrinus, stems, &c. 13
——— polydactylus, ... 19
Archæocidaris Urii, plates of, . . . 16
Crinoidea, stems, joints and heads, × × × . 6, 7, 11, 16, 19, 20, 21, 23, 25, 26, 27, 28, 29, 30, 32, 35, 38, 39, 40, 43, 45, 47, 51, 52, 53, 55, 56, 57, 59, 60, 62, 63, 64, 65, 66
Platycrinus lævis, ... 19
——— pileatus, ... 30

ANNELIDA.

Spirorbis globosus, ... 18
——— intermedius, ... 18

CRUSTACEA.

Brachymetopus MacCoyi, ... 30, 38
Cythere costata, ... 38
——— inflata, ... 13
——— several undetermined species, . . 18, 65
Dithyrocaris? 6
Entomoconchus Scouleri, ... 25, 26, 38
Griffithides globiceps, × × 12, 13, 16, 18, 44, 45, 46, 66
Phillipsia Brongniartii, ... 27, 45.
——— Derbiensis, × × × . . . 12, 15, 30, 31, 32, 33, 36, 47, 54, 55, 56, 64
——— pustulata, × × × . . . 5, 18, 21, 26, 30, 33, 35, 38, 46, 51, 57
——— sp., ... 65

PISCES.

Chomatodus, palatal tooth, ... 12
Cochliodus? palatal tooth, ... 19, 57
Fish bones and scales, × × . . . 3, 6, 7, 9
Fish defence spine? 10
Fish scales? 46
Psammodus? palatal teeth, . . . 18, 19

W. H. B.

* Syn. N. carinatus, *Sow.*
† Orthoceras, Goldfussianum, and Steinhauerii, may possibly prove to be identical.

4. *Relations between the External Form of the Ground, and its Internal Structure, and General Description of latter.*

All the ground that can be called mountainous, meaning by that term not only height but steepness and ruggedness of outline, is composed of the older Palæozoic formations and their associated igneous rocks.

The newer Palæozoic rocks form in this district either low plains, or hills that rise with very smooth and gentle slopes, and are mostly flat-topped or broadly rounded.

The Carboniferous limestone in the centre and south of Ireland rarely presents any of the high land with torrs and scaurs, and deep picturesque ravines, or long lines of lofty cliffs, which are the general characteristics of the formation in England. The English term of "Mountain limestone," therefore, though adopted by the Germans and the French, cannot be applied to it generally in Ireland without manifest inconsistency.

The hills indeed, in the Carboniferous part of the present district are usually formed, not of the hard limestone, but of the series of dark shales, which rest upon the limestone. The surface of the limestone underneath these hills descends even lower than usual, so as to form a rude basin-shaped depression, or hollow, in which the shales repose, the hills being formed by a greater or less thickness of the shale, which has been left there, while it has been removed from all the surface round about. They are, therefore, strictly, *hills of circumdenudation*, and not the result of any local upheaval of the beds below. We may suppose, perhaps, that the shales in these places have been comparatively protected from the denuding action, partly by their inward dip, by which the edges only of the beds were presented to the surrounding water, and partly by unknown circumstances modifying the direction of the currents of the sea, which was the chief denuding agent.

If we examine the general boundary of the Carboniferous country, either on the N. about Skerries and Bog of the Ring, on the east about Portraine and Howth, or on the south from Booterstown to the Glen of Ismole, we shall find that, although the evidence is not perfectly clear in any one situation, yet it is sufficient on the whole to prove, that there is no connexion at all between the rocks of the Carboniferous group and any of those below.

On the north, the rocks which come out from beneath the limestones are Lower Silurian slates and grits. About Donabate and Portraine beds of Old Red Sandstone make their appearance from beneath the limestone, while Lower Silurian slates, with calcareous bands and traps and ash beds rise from beneath the Old Red Sandstone. At Howth the limestones repose directly on the Cambrian rocks. About Blackrock and Dundrum nothing is visible between the limestone and the granite; while farther west, the beds of limestone must pass from the granite on to the Lower Silurian slates and trap rocks the strike of which is directly towards the Carboniferous boundary. This proves to us that the Carboniferous rocks, taken as a whole, must rest upon a very various and, probably, a very uneven surface, composed of different Lower Palæozoic formations, and different parts of the same formation. It is clear, that where the lower rocks rise immediately out from underneath the limestone, that part of their surface, which is just uncovered by limestone, is only a continuation of the surface that is still covered by that formation; and we may reasonably argue directly from the form of the one to that of the other. As we recede from the limestone boundary, however, the surface may have been more and more altered since the limestone was stripped off it, so that its present form probably differs to a greater or less extent from that which it possessed just before the limestone was deposited upon it. Still the difference must be comparatively a slight one, since it never goes to the extent of exposing a formation different from that on which the limestone reposes in the immediate neighbourhood.

Before the commencement of the Carboniferous period vast changes, both from disturbance and elevation, and from denudation, must have taken place. We can hardly doubt that the whole area was once covered by nearly horizontal beds of Lower Silurian rock, resting everywhere upon Cambrian (or some still earlier) rocks, either conformably or unconformably. As the thickness of the Lower Silurian rocks is certainly many thousand feet, all the Cambrian rocks now at the surface must then have been many thousand feet below it.

The granite was then intruded from below upwards towards the surface, and must have apparently passed through the whole of the Cambrian, and any older or lower rocks, and penetrated to a greater or less extent into the mass of the Lower Silurian rocks, sending veins in among the slate rocks, and causing a metamorphism of the clay slate into micaceous schist, through a thickness of several hundred feet round the upper surface of the granite.*

If, as we have every reason to think certain, the molten mass could only consolidate into granite at a great depth, and would have formed felstone or some other rock, if it had ever reached the surface while still uncrystallized, it follows, that the upper surface of the granite after it was consolidated, was still covered by a great thickness of Lower Silurian rocks. We have no means of determining whether this upward intrusion of the granite was accompanied by any elevation or disturbance of the beds over it; but it seems most probable that these beds would be at least bent and arched, and more or less disturbed by it. If elevation of the original surface of the Lower Silurian rocks commenced with the intrusion of the granite below, it was subsequently carried on to a still greater extent, so that the beds were greatly tilted and variously contorted, and sometimes left almost vertical. Contemporaneously with this disturbing action, or subsequently to it, probably both one and the other, the erosive action of the sea began to remove portions of the upper surface of the Lower Silurian rocks, and as the rocks continued to rise gradually and continuously, it wore their upper surface down, until

* There are certain appearances about the Leinster granite which indicate that portions of it, at least, are of metamorphic origin, for example, the foliated structure seen at Killiney Park, as represented in the sketch (fig. 8) by Mr. Du Noyer. For my part, I regard it as in some places intrusive, in others metamorphic.—E. H.

it bared the once deep-seated granite, and re-exposed parts of the Cambrian rocks.

We have good reason for believing that these old Cambrian rocks had themselves suffered much, both from disturbance and denudation, previously to the deposition of the Lower Silurian rocks. Any fractures and contortions previously existing in them would of course be still farther complicated by the disturbing action, which gradually threw the Lower Silurian rocks into such high and variously inclined positions. We can, therefore, easily understand how difficult it must be now to unravel such complications of position, more especially when we recollect that all have been again acted upon by all the disturbances that have taken place subsequently to the Carboniferous period.

It was obviously before the commencement of that period, however, that the denudation had proceeded to the extent of laying bare much of the granite, much of the Cambrian rocks, and of the lower parts of the Lower Silurian rocks, since the Carboniferous rocks rest upon all these different groups in different places; just as recent deposits would now rest upon them, if the whole country were again to sink beneath the sea, and deposition of earthy matter to ensue.

It seems highly probable that this great amount of denudation could not have taken place, and the irregularities of the surface could not have been formed, unless the surface had been dry land for a vast period of time; so that the planing action of the breakers of the sea might have been aided by the subsequent grooving and graving which is the result of the atmospheric action of rains, and storms, and rivers.*

This hypothesis would agree well with what would appear to be the structure and character of the Carboniferous rocks, since we must then suppose that these rocks were deposited during a subsequent period of slow and gradual depression, by which the uneven land surface was again lowered step by step beneath the waters of the sea.

We may imagine that the country about Portraine and Lambay Island was first brought below the sea-level, and those beds of sand and gravel formed in the shallow water, which now compose the little patches of Old Red Sandstone to be found there.

As the depression continued, the black shales and flaggy limestones forming the Lower Limestone shale would be deposited over the central part of the district about Swords and Malahide; while the neighbourhood of Howth Hill, the slope of the Dublin Mountains, and the country about Skerries still remained dry land,

* Even if we suppose that the present surface of the Lower Palæozoic rocks and granite is in some places exactly, and in others approximately, the same identical surface which they had, immediately preceding the commencement of the Carboniferous period, it by no means follows, that if we stripped off the Carboniferous rocks, we should reproduce the exact *form of ground* which existed before the Carboniferous period. That surface might have sloped in different directions, and at different angles from what it does now; its hills and valleys may have been very different in form, and even in position. The movements of elevation and depression that have occurred since the Carboniferous period, necessarily involve equal movements both of curvature and fracture in the old surface on which the Carboniferous rocks were deposited.

and could, therefore, receive no deposits during this part of the period.

The depression of the area, however, still proceeding, and the sea ever becoming wider and wider, by spreading farther and farther over the sinking land, the beds of limestone formed in that sea would likewise spread wider and wider, overlapping those that lay below them, and resting upon and against the slopes or cliffs of Lower Silurian, Cambrian, or granite rock, according to the place in which they were deposited. It seems that for some time after the deposition of the Lower Limestone shales this sea was a tolerably clear one, and the beds of limestone formed in it were, therefore, nearly pure carbonate of lime, derived from the debris of the shells, corals, or other hard parts of the marine animals that lived in it.

The Hill of Howth seems to have had nearly its present form then, but to have been probably beneath the sea during the time when the Lower Limestone was deposited, so that those beds rested upon and against its cliffs.

Some pinnacle of Lower Silurian rock, however, containing both slates and traps, must have been above the level of the water a little north of Loughshinny, from the waste of which the pebbles must have been derived that enter into the composition of the conglomerates there, if, as Mr. Du Noyer believes, they belong to the group of the Lower Limestone.

Subsequently, as the depression continued, the sea became generally, or periodically, invaded by floods of dark earthy mud or silt, so that during the deposition of the Upper Limestone group, all the rocks acquired this dark earthy character, and many beds of actual black shale were thrown down. This may, perhaps, have been the consequence of some of the darker and earthier parts of the Lower Silurian ground having been now reached by the sea, or the matter may have been derived from other sources, to which the sea had now gained access, or which, perhaps, if rivers, had now gained access to it. These upper beds appear to have again overlapped the lower on the south, so as to repose directly on the granite and slates of the Dublin Mountains, and, probably, also on the Lower Silurian country west of Skerries, since the subsequent denudation has exposed but a very narrow border of limestone there, between the base of the upper shale series and the Lower Palæozoic rocks.

Eventually, all calcareous depositions ceased, and the sea had nothing brought down into it except black mud or dark silt, the deposition of which formed the shales lying below the Coal Measure series. These again in some places overlapped and spread beyond the whole of the limestones, since in the country east of the Naul, there seems to have been nothing interposed between these upper shales and the Lower Silurian slate rocks.

It seems most probable that these upper shales, if not also the higher coal-bearing Coal Measures themselves, once spread in level sheets over the whole county of Dublin, burying the whole of the Silurian ground on the north and east, the Cambrian rocks of Howth, and a large part, if not the whole, of the granite and Lower Silurian ground of the Dublin Mountains. This is probable from the

relations of the rocks to be observed at the present day, however different the present form of the ground and the dip of the beds may be from that which they had at the close of the Carboniferous period.

Since that time we know that the district has been again acted on by movements of disturbance and elevation, having their origin deep below the surface, and by the erosive power of moving water gradually and successively removing coat after coat from above, and thus producing many successive new surfaces. The result has been that the Carboniferous rocks have been tilted and bent in various directions, and inclined at all kinds of angles, as well as fractured by large and extensive fissures, producing dislocation of the beds; and that large parts, in some places even the whole mass, of the Carboniferous rocks have been swept away from areas once covered by them, and the older subjacent rocks again exposed to view. These actions of disturbance and denudation have had the whole Secondary and Tertiary Epochs in which to produce their total effect; but it is probable, from the examination of the rest of Ireland and England, that the chief amount of change was produced at a comparatively early period, namely, before the deposition of the New Red Sandstone.

There is, however, in this immediate district, no evidence of the geological period in which any part of the effect was produced, until we come down to that very recent one, known as the Post-Pliocene period, during part of which the land was more or less covered by glaciers, and surrounded by seas incumbered by many ice-floes and icebergs. During some part of this period the land, with almost precisely its present form, stood at a lower level by several hundred feet. Many blocks of rock were then scattered over the bed of the sea, in consequence of being dropped by melting icebergs that had carried them from the neighbouring land. These are now found scattered over our present lands, and even on the tops of some of the hills. Much clay, sand, and gravel were also strewed over the bed of these shallow seas, and variously arranged and re-arranged by the currents that traversed them, especially during the time that the land was slowly rising again above the sea-level. It was probably during this time of final elevation that the Esker ridges were formed, being the result of the piling action of currents and eddies traversing the shallow water.

The present surface of the ground then is composed partly of the older surfaces formed previously to the Carboniferous period, partly of the newer surface produced on the Carboniferous rocks by the actions just alluded to, and partly of the more recent Drift sands, and gravels, as they were left on the last elevation of the ground above the waters of the Post-Pliocene or Glacial sea.

The general position of the rocks below the surface may be sketched as follows:—A line of anticlinal elevation is believed to stretch from the neighbourhood of Lambay and Portraine towards the S.W. for some distance beyond Swords. The Old Red Sandstone is brought up to the surface along this line about Portraine and Donabate, and the Lower Limestone shale is made visible at Swords, and two miles to the S.E. of it. Outside of this again the Lower Limestone is

supposed to range, dipping N.W. and S.E. on each side respectively, under the Upper Limestone. On the S.E. side this S.E. dip may possibly be aided by faults with a downthrow to the S.E., one of which is especially well seen in the cutting of the railway a little south of Malahide. North of this central anticlinal ridge is a synclinal trough of Upper Limestone, with a nearly parallel axis, but spreading out northwards, so as to include a shallow basin of the Upper Shales, of which beds Walshestown Hill is formed. Local undulations bring up the Lower Limestone again, both about Oldtown and Donoughmore, and Baldwinstown, and also, as is believed by Mr. Du Noyer, south of Skerries, by Milverton, and thence to Dennis Bridge. Similar local undulations of the beds bring down the Upper Shale series into the ground under Baldongan Hill, and in three or four sharp synclinal curves on the shore between Skerries and Rush. The Carboniferous rocks are remarkably contorted about that shore.

The Lower Limestone is also brought up to the surface in several local undulations to the south of Malahide; and, as is believed, in all the country about St. Doulough's, Baldoyle, and Raheny, and round the north-western foot of Howth Hill. In all the Dublin district, however, the beds are supposed to belong to the upper dark "calpy" division of the limestone series, including some more purely calcareous and fossiliferous beds, stretching east and west near Crumlin. Over all the southern district, between the Liffey and the foot of the Dublin hills, the prevailing dip of the beds, which are sometimes, however, slightly contorted, seems to be everywhere southwards. Scarcely anything can be seen of the limestones within a mile or more of the foot of the hills; but all that is to be seen, taken in conjunction with the almost invariable southerly dip of the beds about Donnybrook, Rathgar, Crumlin, and the Green Hills, leads us necessarily to conclude, that the uppermost beds of the limestone series are those nearest to its boundary. This apparent anomaly can only be made intelligible on the hypothesis of an original overlap in the Carboniferous series, or the wider and wider spread of the upper beds beyond the limits within which the lower were deposited; so that the upper passed over the lower on to whatever rock it might be that formed the margin of the water in which the Carboniferous rocks were deposited.

Still the great breadth of the band of country over which this steady southerly dip is to be observed, would lead us to suppose the thickness of the group to be much greater than its known thickness anywhere else, unless we assume the existence of concealed inclinations in the contrary direction, or of east and west dislocations causing frequent repetitions of the same beds as we traverse the ground from north to south.

J. B. J.

Detailed Description.

[The Granitic and Lower Silurian district included in Sheet 112, was surveyed by Mr. W. L. Willson, now of the Geological Survey of India, and Mr. A. Wyley, late Government Geologist to the Cape Colony. The Cambrian rocks of Howth and the island of Ireland's Eye, by Messrs. A. Wyley and George V. Du Noyer. The whole of the Northern Sheet, No. 102, and the entire area of the Carboniferous limestones in both sheets were examined by Mr. George V. Du Noyer, by whom also, in conjunction with myself, the accompanying detailed description of the whole has been compiled from his own notes and those of the other observers.—J. B. J.]

5. *Position and Lie of the Rocks.*

In giving the detailed description of the country included in Sheets 102 and 112, it will be most convenient to divide it into the following districts;—I. The Dublin Mountain District; II. The Howth District; III. The Portraine and Lambay District; IV. The Skerries District; and V. The Central Carboniferous District.

I. *The Dublin Mountain District.*

The Granite.—The granite here has a superficial width of over six miles, measured from near the village of Dundrum on the N.W., to Cherrywood House on the S.E. The rock is well exposed along the coast from Blackrock on the N. to the shore under Victoria Castle on the S. It rises in many bosses over the low ground on the northern slope of the mountains, and many quarries have been opened in it over the same area, the most remarkable being that at Dalkey Hill, from which the materials to form the Harbour of Kingstown were obtained. This excavation extends for a quarter of a mile in a N.E. and S.W. direction, and its greatest depth is about seventy feet.* The granite obtained from this quarry is of a clear gray colour, and quartzose, the felspar being less abundant in it than on the eastern slope of the hill near Sorrento-terrace. The mica is well developed, and eurite occurring in veins of variable thickness is common through the mass, in which are to be found occasional nests of tourmaline crystals. The Sorrento granite, unlike that from Dalkey Hill, frequently contains plumose mica. The next most important quarry at present is that adjoining the new church of Dalkey on the west; and till lately, the large quarry in the town of Kingstown, to the W. of Windsor-terrace, was extensively worked for the latest additions to the harbour and piers of Kingstown and other works in the neighbourhood. Other extensive works of this

* The working of these quarries for the formation of Kingstown harbour commenced in 1817, and continued till about 1857. For many years the working was on the face of the hill, at nearly its highest part; and the material, which was obtained by blasting, was brought down on inclined planes worked in the usual way with endless chains. Subsequently a quarry was opened at the base of the hill. In the formation of the two breakwaters, which are in deep water, and about 3,000 yards in length, about 6,000,000 tons of rough stone, varying in weight from eight tons to small rubble, were consumed. In addition to this, a large portion of the superior ashlar blocks, of which the two circular pier-heads, the Queen's Wharf, the Trader's Wharf, and the Steam-packet Pier are constructed, were had from those quarries. In the working of these quarries it was not usual to have any very large blasts; but, on one occasion, when some experiments suggested by Sir John Burgoyne were made, with a view to obtain the maximum of large blocks fit for ashlars with a minimum of rubble, one mass of sound granite was separated, the cubic contents of which was 1,800 feet.—*From information kindly communicated by Sir R. Griffith, Bart.* An old quarryman informed us that the largest blast at the Dalkey quarries was from a common jumper hole of four and a half inches diameter, and twenty-two feet deep, the charge of powder having been sixty pounds; the amount of debris thus obtained required three weeks to remove, and was estimated to weigh about 3,000 tons.—G. V. D.

kind are carried on at the eastern flank of the Three-rock Mountain. In general character, the Killiney and Dalkey granite is rather quartzose, of a pale clear gray colour, and it is traversed by numerous veins of eurite. These frequently assume the magnitude of thick dykes, one of which, to the north of the rock called Black Castle, on the shore of Killiney Bay, measures forty yards across. The granite of Roche's Hill, as well as that at the Dalkey Hill quarries, has two sets of main joints running through it, which strike for the most part in a N.E. and S.W. direction, one set inclined to the N.W., and the other to the S.E., the maximum being 30°. These surfaces on Roche's Hill correspond somewhat to the inclination of the ground. The granite which appears on the western slope of Roche's Hill, in the townland of Kilbogget, is remarkably close-grained and quartzose; and is, perhaps, the best for building purposes which can be found in the neighbourhood. It is commonly veined with eurite, the general direction of these veins being W.N.W., inclined sometimes as much as 75° to the northwards.*

In the N.E. corner of this townland, adjoining Beechwood, a quarry exposes a massive dike of eurite, the strike of which is nearly N.W. and S.E. One-half the quarry is in the ordinary gray quartzose granite.

The large quarry in the town of Kingstown, to the west of Windsor-terrace, exposes granite, which in places is different in mineral structure from that of the neighbourhood. It is traversed by quartzose veins, occurring on the main joint lines, the surfaces of which are thickly coated with large and small well-developed crystals of schorl; these sometimes occur in such abundance, as to give the rocks a black mottled look. At the northern angle of the quarry there appears a well-defined dyke-like vein of pure quartz, which in its thickest portion measures two feet six inches from side to side. It inclines to the westward at an angle of about 60°, and extends about twenty feet above the ground; at this distance it widens suddenly, and ends abruptly, enclosing what appear to be three large angular fragments of the granite; though apparently detached from the mass, these are evidently nothing more than angular projections, the result of sudden parting in the rock after consolidation, the quartz having filled up the fissures by infiltration.

At the southern end of the same quarry there occurs a layer of dark gray quartz in the granite. Unlike the former, its structure is streaky, and its resemblance to gray flint, in its central portion, is remarkably striking. This vein is about twelve inches thick, thinning out at either end at the distance of about thirty feet. It has quite the aspect of a deposited layer in the rock.

Adjoining these quartz deposits the granite is speckled with small crystals of mica of a peculiarly silvery lustre. Thin veins of eurite are also common in it.

At the northern end of the quarry, where the granite has been long exposed to atmospheric action, and the heat and fumes of forges, it is observed to be much decomposed, and of a rich brown colour.

The quarry near Dalkey Church is now extensively worked for the better class of building materials, the dressed paving-stones for some of the streets of Dublin being procured at it.

Surfaces which exhibit slickenside striæ are not uncommon in the granite; some may be observed on the shore, under the houses of Burdett-

* The granite for O'Connell's Monument, erected in the Cemetery at Glasnevin, was procured from a quarry in the S.E. corner of this townland, on the recommendation of Mr. Jukes, who was requested by Mr. O'Kelly, of Rochestown House, to examine the neighbourhood for that purpose.

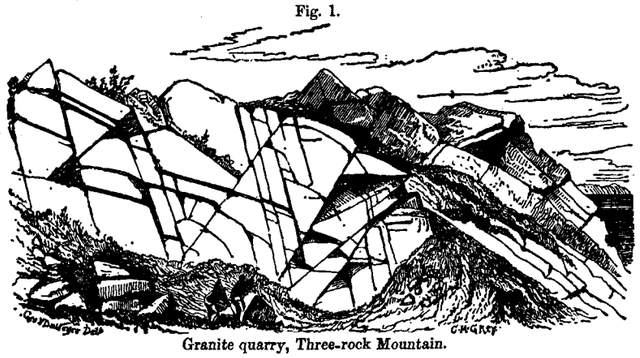
avenue, at Sandycove, the striated surface being coated with dark matter. Slickenside striæ also appear in the granite in the extreme N.E. corner of the townland of Ballybrack, where thin veins of eurite and quartz are also common.

The granite appears at the surface in the plantation attached to Grange House, in the townland of Deansgrange, and in the higher portion of the townland of Galloping Green, South, where it is felspathic and coarse-grained, and appears to decompose readily. In the same townland, at its northern extremity, and to the south of Stillorgan Brewery, the granite again comes to the surface, and is traceable along the road in the plantation for a considerable distance. The road to the east of Riddesdale is cut through the granite, which also appears in the adjoining townland of Kilmacud East. The Dublin and Wicklow Railway cuts through granite in several places to the south of the village of Dundrum, the rock being generally speaking, not as quartzose or hard as that in the Dalkey district. It is occasionally much decomposed, and seems sometimes to form a kind of impure kaolin.

The granite appears largely at the surface in the townland of Murphystown, it is coarse-grained in texture, felspathic, and contains large flakes of mica; hence it may be inferred that it is not so good for building purposes as it would be if finer in the texture, the excess of felspar and mica rendering it easy of decomposition. The granite of Foxrock and Cornel's court is closer in texture and more quartzose than the former, and yields a good building material from a new quarry close to and south of Cornel's-court.

The quarries on the east of the Three-rock Mountain are much sought after, and afford large quantities of granite for building stone. At the summit of the hill the joints are nearly horizontal, and close together; the rock has consequently weathered freely in these places, and the masses which there stand out so prominently above the surface have quite a bedded aspect, as may be seen on the right of the sketch given as fig. 1, the edges of the layers being unequally weathered and moulded into massive cornices.

Fig. 1.



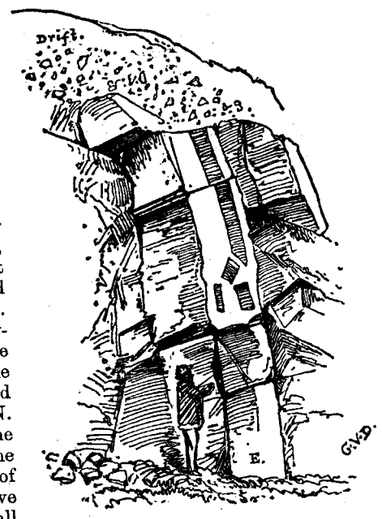
Granite quarry, Three-rock Mountain.

The same phenomenon may be observed on the summit of Two-rock Mountain, an elevation marked 1,699 feet, and lying to the south of the Three-rock, just out of the limit of the map.

The granite is well exposed over the summit of Kilmashogue Mountain, and many quarries have been opened in it. Tibradden Mountain is not so rocky as the former, the granite only appearing near the summit.

Black mica is not uncommon in the granite of the district. A remarkable plumose variety of white mica occurs in the townland of Ballybrack. In the Dalkey quarries, it is not unusual to find perfectly formed crystals of black quartz in the open and clay-filled joints of the rock.

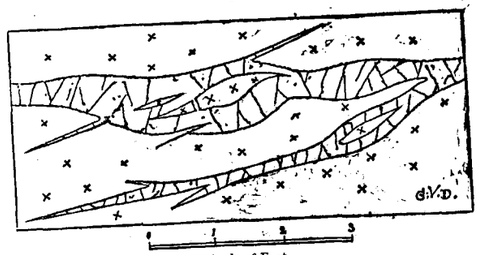
Fig. 2.



E. Eurite dyke enclosing angular fragments of the adjoining granite. Railway cutting N. side of Killiney Tunnel.

The dykes and veins of eurite, which are so abundant in the Dalkey granite, are evidently intrusive,* filling up what were either large and wide fissures or jagged cavities, or else thin cracks, so continuous and regular as at present to resemble dykes and thread-like strings in the rock. The most marked example, showing the intrusive nature of the eurite, is to be found in the dyke of that mineral which is exposed in the railway cutting on the N. side of Killiney Hill, close to the tunnel. The upper portion of the dyke contains angular fragments of the adjoining granite, which have evidently flaked off from the wall of the fissure during the injection of the eurite†; they are darker in colour and coarser in texture than the material in which they are enclosed (see fig. 2). There are many interesting examples of eurite veins traversing the granite in such a peculiar manner as to impress the belief that they have filled up what were open cracks and cavities, the result of sudden fracturing of the consolidated and crystallized granite; of these the accompanying sketch, fig. 3, is a most

Fig. 3.



Eurite veins in granite. Rochestown Hill. The × × portion is granite.

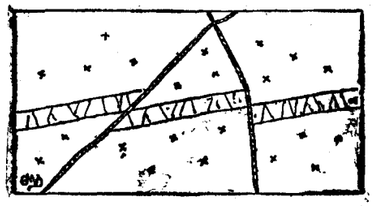
* Some of these eurite veins are of intrusive origin, subsequent to the mass in which they lie, but certainly some of them are not so. There is a large irregular mass of the pale, nearly compact variety of granite, which we have called eurite, on the railway cutting a little S. of the Dalkey tunnel, which has no appearance of being a dyke or intrusive mass, but seems to be a mere local variety in texture, produced by some local modifying circumstances during the consolidation of the mass.—J. B. J.

† According to the views of Dr. Sterry Hunt and some physicists, these "eurite" veins, together with others of quartz, &c., have been formed by aqueous infiltration after the consolidation of the granite which encloses them.—E. H.

striking example. It should be remarked that the portions of the granite which appear as isolated in the eurite are not, perhaps, really detached from the main mass, but may be sections of either small pinnacles or narrow connecting pillar-like portions of that rock, occurring in the midst of a large cavity, the section of which is now presented to us.

It frequently happens that the eurite veins are very regular in thickness for a considerable distance, and that they have been faulted or dislocated; the lines of dislocation having remained open for indefinite periods, and subsequently becoming filled by an infiltration of quartz. Of these an example is offered in fig. 4.

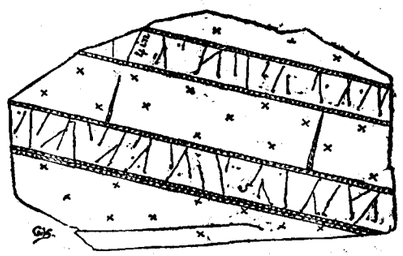
Fig. 4.



Eurite veins faulted, the fissures subsequently filled with infiltrated quartz. Thickness of veins, 2 inches. Killiney Hill. The × × parts are granite.

Very frequently these veins are quite parallel one to the other for considerable distances as may be observed in the road-cutting close to Victoria Castle, at Killiney Hill; and often it would appear that the eurite has shrunk from the sides of the fissures which it originally filled with the most singular regularity; the spaces thus formed having remained open and become filled with an infiltration of quartz. In the fissure thus formed and subsequently filled, and at the bottom of the lower eurite vein, the quartz consists of two films; thus appearing as if it crystallized simultaneously from the opposite walls of the fissure, the two sets of crystals meeting midway. Two small cracks in the granite itself, between these veins, and at right angles to them, are also filled with this infiltrated quartz, as shown in fig. 5. It is remarkable that the eurite veins are not

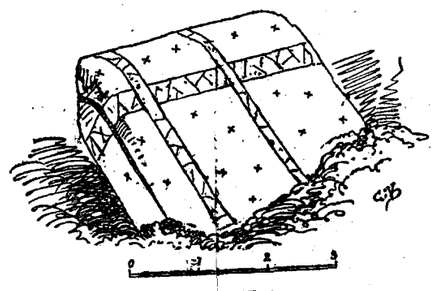
Fig. 5.



Eurite veins in granite, showing how they have shrunk after their injection into that rock, the spaces thus formed having been subsequently filled by an infiltration of quartz. The × × parts are granite.

all of the one period of injection, as is proved by the accompanying illustration, which shows one set of thin veins traversing the other (see fig. 6).

Fig. 6.



Scale of Feet.

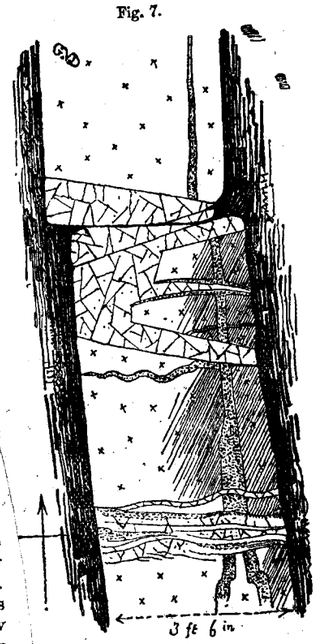
Block of granite on Killiney Shore showing eurite veins of two periods. The × × parts are granite.

I know of no example of a third vein of eurite crossing two sets of veins analogous to the illustration given above; and we may therefore, so far, suppose that there were but two periods for the injection of the eurite into the granite.

While alluding to this subject it may be well to direct attention to a dyke of granite which traverses the mica slate, on the southern flank of Roche's Hill, close to the garden wall of Killiney Park. A plan of this remarkable dyke is given in fig. 7.

The direction of the dyke is N. and S., and its width three feet six inches. In one portion, on its east side, the mica has been arranged in delicate strings, oblique to the wall of the dyke, and striking from it at an angle of about 32°, or in a N.E. and S.W. direction. The mass has been slightly faulted, and at the fractured part it is traversed by a thick transverse vein of eurite, which on the E. side divides into three portions. The central tongue of eurite appears to have shrunk in the cavity which received it and the spaces thus formed have subsequently been filled with an infiltration of quartz. A thin irregular vein of eurite strikes across the dyke at the distance of a few feet to the S. of the larger one. Prior to the injection of the eurite the granite vein shrunk in the direction of its length along its eastern wall, the cavity thus formed having been filled with infiltrated

Fig. 7.



Plan of granite dyke west of Killiney Park, traversed by veins of infiltrated quartz, and both cut through by eurite. The × × parts are granite; the dotted spaces are the quartz veins.

quartz. The structure of this dyke as explained by the facts which it presents to us is highly instructing, and the details relating to its formation may be thus summed up :—

1. The injection of the granite as a dyke into the slates, and the arrangement of the crystals of mica in a portion of it along its eastern wall.
2. Its consolidation, and consequent shrinking in cooling and crystallizing whereby it was fractured along its eastern side.
3. The fissure thus formed becoming filled with an infiltration of quartz.
4. The dyke and quartz vein shattered in one place, and broken clean across in another, and eurite injected into the fissures, the local broken fragment of the granite having been either removed or used up from this particular portion.
5. The consolidation of the eurite and the dyke at this portion of it being broken across and slightly faulted.
6. The shrinking of the eurite and consequent fissuring, the spaces thus formed being subsequently filled by an infiltration of quartz.*

The illustration, fig 8, is given as affording an interesting example of the manner in which a certain amount of difference in the arrangement of the particles has been sometimes produced in the granite when in contact with the slates. This sketch is taken from the quarry close to the garden wall of Killiney Park, on the flank of Roche's Hill. The mica in the granite when in immediate contact with the mica slate has segregated into distinct blotches for the depth of eighteen inches into the rock, thus giving it a mottled look, which is, perhaps allowably, slightly exaggerated in the wood-cut.

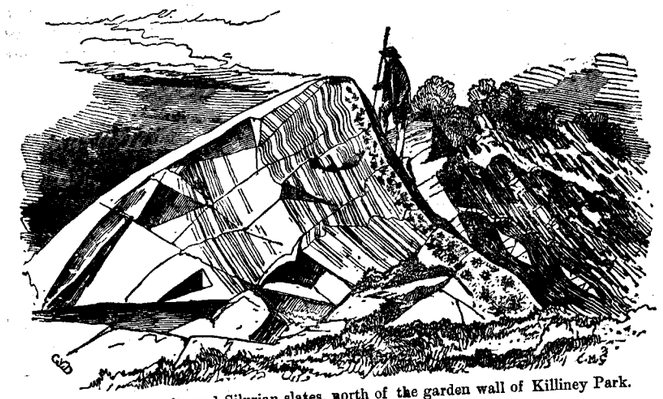
Beyond this part, a different result has been produced, the crystals of black mica being arranged in delicate wavy layers parallel to the junction of the two rocks, thus giving to the granite quite a gneissose appearance. This alteration is traceable for the distance of from ten to fourteen feet, becoming less and less apparent as it passes into the body of the granite.†

The joints in the granite, especially in the western portion of the large quarry at Dalkey Hill, and, indeed, wherever the rock can be clearly studied over a considerable space, have been arranged in groups of parallel lines, often giving to the mass quite a stratified appearance. After a time, however, these parallel joints die out and give place to another set which have a direction quite the opposite to the former. These, again, soon cease, to be crossed likewise by other joints which have no relation in compass bearing to either of the other two. When all these, as well as other sets of

* As Mr. Du Noyer wishes the explanation given above to stand, I allow it to do so, but must here record my dissent from it. It seems impossible that the original granite vein could have cooled and solidified so as to allow of a quartz vein being infiltrated into it, and then that a subsequent vein of granite or eurite should be intruded into the original vein, and yet be confined to it and not penetrate the adjacent slate rocks. The euritic part of this granite vein must have differed from the rest originally, in consequence of a difference assumed on the first cooling of the mass. The quartz may have been subsequently introduced into fissures, or may possibly have been the result of original segregation. With regard, however, to the veins of close-grained, almost compact granite rock, for which we have chosen the name of eurite, which traverse not only the coarse-grained granite, but continue sometimes into the adjacent slate rocks, it has occurred to me to think it possible that these veins may have been intruded during the cooling of the granite. If we can suppose that the upper part of the granite cooled first, sufficiently to become consolidated, although still retaining a high absolute temperature, while a lower and deeper part of the original molten mass retained sufficient fluidity or plasticity to be injected into fissures, it seems likely that such fissures would be caused in the upper part of the mass in consequence of the contraction on consolidation, and that some of these fissures might be filled by injection from the lower part. These veins would then cool down to the temperature of their walls much more rapidly than the mass of the granite cooled down to it, and therefore perhaps be less coarsely crystalline than it. It is, of course, assumed that during the process the whole was deeply buried under great masses of Lower Silurian rocks.—J. B. J.

† The boss of granite figured in p. 33 appears to me to be simply a case of foliation, and an evidence that this portion of the granite is of metamorphic origin.—E. H.

Fig 8



Junction of granite and Silurian slates, north of the garden wall of Killiney Park.

minor joint planes come together the rock has a decided amorphous appearance, as shown in the left-hand part of fig. 1. Joints which are strictly horizontal are of rare occurrence indeed, the only good example of them with which I am acquainted occurring in the masses of granite on the top of Three-Rock and Two-Rock Mountains. Many of these joint surfaces are coated with a pale yellowish green mineral, soapy to the touch, and resembling chlorite.

Mica Schist. Altered Lower Silurian Slate.—The manner in which the granite is brought into junction with the Lower Silurian slates, and their metamorphism into mica schist, for probably the distance of over half a mile from the exposed junction of the two rocks, is remarkably interesting. The absolute contact of the slates and granite can be distinctly seen in many places along the shore of Killiney Hill, as well as in the road and railway cuttings of the neighbourhood, but especially over the rugged ground of Roche's Hill, and that lying to the west of Killiney Park. The first place where the two rocks can be observed together on the eastern side of the district is on the shore, just 500 yards S.W. of Sorrento Cottage, where a tongue of mica schist is wedged into the granite, its width being about forty or fifty yards, and probable length 200 feet.

At the distance of about 300 yards to the south of this is a second tongue of mica schist resting in a hollow of the granite. This is traceable inland for the distance of 200 yards up the southern slope of Mount Malpas Hill, where it has a maximum width of 200 yards. As it is traced southwards down to the shore it rapidly narrows to about fifty or sixty yards, and further south, under Mount Eagle, it terminates as a narrow wedge in the granite. Its total observed length from north to south is about 525 yards.

This mass of slate consists of beds of gray mica slate, with bands of gray close-grained grits usually not micaceous but very compact; the dip of all being invariably to the S.E. at from 40° to 60°. This high steady inclination of the beds gives them the appearance of dipping down into the granite, and on a level surface would make them seem as if they were interstratified with it. The fall of the ground, however, and exposure in the cliffs, show that the beds are cut off by the granite below, and that they rest in wedge-shaped troughs of that rock, the outline of which has no relation to the

dip or strike of the beds.* Crystals of andalusite, and some that resemble chiastolite, the former often arranged in a beautiful stellated form, are very abundant in the mica slate here, especially where the granite approaches to it, either as a mass or in thick dykes or veins. This is remarkably evident on the shore under Mount Malpas, and in the slate quarries north of Killiney Park.

Fig. 9.

Junction of granite and Silurian slates: shore of Killiney Hill.

The manner in which the granite has wedged itself into the slates, penetrated them in veins, and taken up and included large and small angular blocks of those rocks in which the original bedding is well seen, is illustrated in fig. 9. At this locality eurite veins of two different periods of injection or formation are seen traversing the slates and cutting across each other, and the mass of the slates are veined in various directions by the thinnest strings of this rock.

The shore immediately south of Mount Eagle is occupied by granite, which is believed to extend along it for the distance of 250 yards, when the slates ought again to come in; their junction is, however, concealed by a thick deposit of sand and gravel; but the slates show themselves to the northward of this place, along the road N.E. of Victoria Castle. They do not, however, extend for more than thirty yards up the slope of the hill, when the granite again rises from beneath them. The beds of this patch of schist dip easterly at 50°, and rest in a hollow of the granite in the same way as those described as appearing along the shore to the north. This tongue of slate may be about 200 yards in width.

The granite now appears on the west, forming superficially a long spur, which extends southwards from the northern limit of the slates for the distance of 350 yards, having a maximum width of 130 yards. To the west of this the slates appear in great force, and extend northwards into the granite under the village of Killiney, and close to the elevation marked 480 on the map, having, however, a long narrow tongue of granite stretching into them for the distance of 350 yards, between Killiney and the elevation just named. The maximum width of this mass of slate is over 500 yards. To the south of Killiney village the dip of these beds is S. at 70° to 80°, inclined from the granite, or they are vertical, with an E. and W. strike. As they are followed southwards, towards Ballybrack, they dip to the S.E. at various angles; sometimes as low as 25°, and between Killiney Lodge and Killiney Park they seem as if interstratified with lenticular dykes of granite, adjoining which they become full of crystals of andalusite.

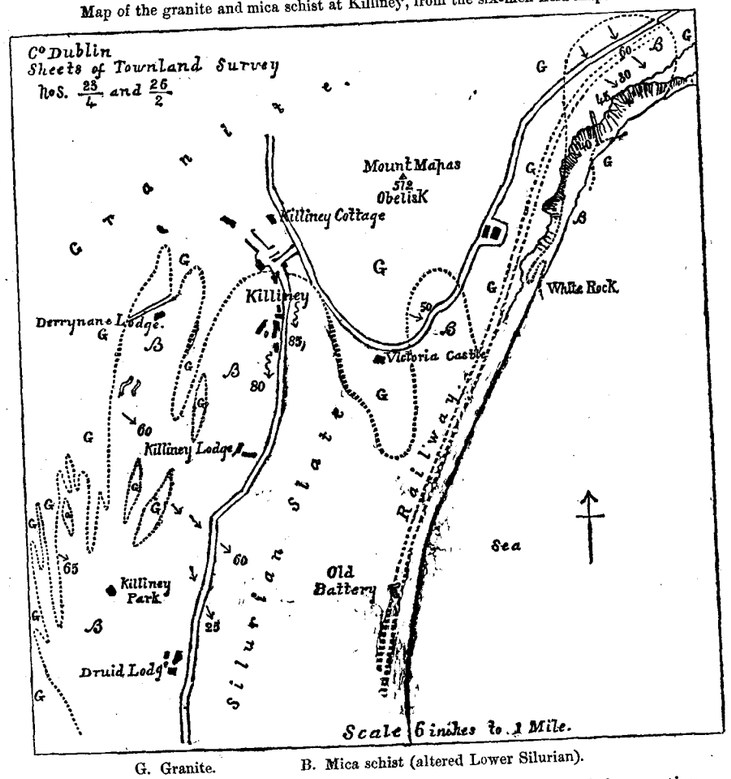
The boundary of the slate and granite, as it is observed to the west of Killiney Park, is very intricate, one rock entering the other in long dykes

* It was in studying this locality that I first became fully aware of the nature of the relations between the mica schist and granite, as explained above. The stellated crystals of andalusite (or staurolite), occur only in certain layers of about an inch in thickness, separated from each other by layers of ordinary mica schist of some inches in width.—J.B.J.

and tongues, as may be seen by reference to the S.W. corner of the sketch map given in fig. 10. The first mentioned tongue of mica schist in the preceding description, that 500 yards S.W. of Sorrento Cottage, is not included

Fig. 10.

Map of the granite and mica schist at Killiney, from the six-inch field maps.



G. Granite. B. Mica schist (altered Lower Silurian).

in fig. 10, but all the other features are included. The remaining portion of the boundary between the slates and granite, southwards from Ballybrack cross-roads to the edge of the map, a distance of a mile and a quarter, is quite concealed by a thick deposit of drift, so that the boundary line between them is a rather hypothetical one, being drawn from the form of the ground only.

On the west side of the granite range, the boundary between it and the metamorphosed slate is, for the most part, a supposed one, the absolute junction of the two rocks being observed but at three localities:—First, in the mountain stream east of Anne Mount, near the south margin of the map, where reddish brown micaceous grits and gneissose slates, with compact gray quartz veins, rest on the granite with a dip of 50° to the W.; secondly, in a quarry N.E. of and close to Mount Venus, nearly three miles distant from the former locality, where a few layers of mica slate may be

observed to overlie felspathic granite, which contains black mica;* and thirdly, on the road near Laurel Hill, at the distance of about three-quarters of a mile northwards from this quarry, where the mere surface of each rock is visible for a few yards from their boundary. If this line of junction was well exposed, there is but little doubt that the slates and granite would be seen to meet under the same conditions as those observed along the boundary of these rocks at the shore of Killiney and on the flanks of Roche's Hill.

Unaltered Lower Silurian Rocks.—The line on the map between the micaceous or metamorphic portion of the Lower Silurian slates and that which is unaltered is a perfectly arbitrary one, intended merely to limit the colourer of the maps in his application of the tint which is intended to denote mica schist. It would, in fact, be impossible to draw any definite boundary, since the unaltered passes quite gradually into the altered portion of the slates.

Over the small triangular space on the map to the south of Killiney, supposed to be occupied by the unaltered Silurian slates, there is no exposure of these rocks—their presence here is, therefore, merely inferred from data appearing in the country to the south of Sheet 112.

When the unaltered Silurian slates appear in the S.W. corner of the map they are plentifully associated with finely crystalline trap-rock, which is sometimes porphyritic, occurring in large and small lenticular masses, as well as in dykes and veins of various dimensions, and along with these are equally numerous beds of compact gray ash. As the general strike of the trap-rocks and porphyries agrees with that of the slates, and the latter rock does not appear to have undergone any very marked alteration in their neighbourhood, these igneous rocks are all supposed to have been more or less contemporaneous with the deposition of the slates.

The localities where the unaltered Silurian slates and the trap-rocks can best be seen in Sheet 112 are on the eastern flanks of the range of hills which run along the extreme south-west margin of the map, and terminate in the eminence called Slievenabawnoge, the north-western flank of Mount Pelier Hill, and in the little ravine through which a small stream flows and joins the River Dodder at Fort Bridge.

The description of these slates and trappean beds may be given in a few words. The former are for the most part dark bluish gray—sometimes changing to a yellowish brown colour; near Mount Pelier they are occasionally of a greenish hue, and in the N.W. corner of that townland they are observed to be black and argillaceous. Very frequently these beds are micaceous, though apparently far removed from the granite. This is the case in the section afforded by the small stream-course S. of Fort Bridge, on the Dodder river, where they are also unusually felspathic.

The porphyry when freshly broken often closely resembles an ordinary basalt in its compactness of texture, and its porphyritic structure is not apparent till it has become slightly decomposed by weathering. This is especially the case with that rock where it appears at the gap of Ballinascarney, in the townland of Belgard Deer-park. To the west of Ballinascarney House, at either bank of the small stream-course, this rock is stated to be micaceous. An excellent section of the basalt, sometimes porphyritic, occurs along the small stream-course which runs into the River Dodder, south of Fort Bridge. The stone would make excellent road material for the streets of Dublin.

The older Palæozoic rocks, now described as forming the Dublin mountain district, all sink down and terminate in low ground, along a gently curved line running from Glenville, south of Tallaght, a little north of Dundrum, to the shore between Williamstown and Blackrock. North of this line no rock *in situ* is to be seen, except the Carboniferous limestone. No junction, however, of the Upper and Lower Palæozoic rocks is anywhere to be seen, nor indeed any exposure of the two within any short distance of each other. The limestone may be seen indeed on the shore at Booterstown, within a distance of less than half a mile from the granite; and from that and from the form of the ground the boundary between them has been drawn. This boundary runs directly across the strike of the Lower rocks, and cuts off equally the northern extension of the granite and the Silurian rocks both altered and unaltered. This of itself would be good proof of the entire unconformability of the two groups of rocks to each other, and shows us that the granite had not only been intruded into the Lower Silurian rocks, but denuded and laid bare before the deposition of the Upper Palæozoics. Farther proof of this fact will be seen presently in the occurrence of lumps of granite, and lines of granite sand, occasionally found in the Carboniferous limestone.

* See Rev. Professor Haughton's remarks and analysis of "Black Mica."—*Transactions Royal Irish Academy*, vol. xxiii.

II.—*The Howth District.*

Cambrian Rocks.—The coast of Howth affords such clear and well-defined sections in the Cambrian rocks, and is, for the most part, so accessible that we naturally refer to it for an explanation of the geological structure of the greater part of the Peninsula. I shall commence its examination on the western shore, where these beds first make their appearance at the distance of 200 yards north of Bottle-quay, near Sutton, and follow the section southwards round the hill. The first beds of the Cambrian formation which are here presented to us are massive quartz rocks, dipping to the W. at 60°, and gradually curving round to the S.W. at a similar angle. As they are followed southwards, they are found to be separated from each other by bands of greenish gray slate, and are observable along the shore for the distance of 300 yards; they disappear beneath a thick series of greenish gray slates and grits veined with quartz, all dipping to the S.W. at from 30° to 40°, which are farther traceable for the distance of 350 yards, where in their upper portion they contain some red slates and grits, very much crushed and squeezed. Adjoining them is a massive bed of quartz rock, a longitudinal section of which appears to be given by the coast. It extends for a distance of 350 yards S.E. from the Martello Tower, where it terminates in a sharp fold, being overlaid by irregular bands of red grit and green clay-slate, which dip at an angle of 60° to the S. Between this point and "Red Rock," a distance of 140 yards, beds of green and red grit and slate and bands of quartz rock appear. A second and much more massive bed of quartz rock then presents itself. This can be traced southwards for a distance of 360 yards, its continuity being broken near its central portion by two small and not continuous bands of red and green gritty slate, which look as if they formed part of the beds on which the quartz rock rested, it being in this particular place sharply bent into an anticlinal fold. At the southern termination of this massive quartz bed, it is overlaid by green and red gritty slates, which appear for a distance of about 165 yards, having a dip to the S.E. of 60°. We now reach a point called "The Cliffs," and here again we find another massive bed of quartz rock split up in the central portion by a band of greenish grits and slates, which, at the southern extremity of the quartz rock, are much contorted, but as a mass dip to the east at from 30° to 80°. In the upper portion of these beds there are two trap-dykes; that to the south is inclined to the S.E. at 30°, and is rotten and ochreous at the surface; but

when the central or undecomposed part is reached, it is found to be dark green, augitic, or hornblendic, and slightly porphyritic. This dyke underlies a fourth great bed of quartz rock, which forms the cliffs at a place called "The Sheep-hole." Directly to the S.E. of this spot at "Worne-hole" the quartz rock terminates, and two greenstone dykes may be observed in contact with it—the strike of both being about N.W. and S.E. It is just possible that those dykes may be the extension of those first observed, but bent back in such a way as to enclose the quartz rock bed of "The Sheep-hole." From the trap-dyke N. of "Sheep-hole" to beyond Drumleck point, a distance of over 450 yards, the cliffs are formed of quartz rock; the central portion encloses some green slates, in which respect it resembles the bed S. of "Red Rock." Here, however, the enclosed slates appear to be portion of the upper beds, showing that the quartz rock has been bent into sharp synclinal folds, in which respect it differs from the former; the quartz bed may be 400 feet in thickness. At Drumleck Point we have reached the extreme southern end of Howth, and as we follow the coast section which now strikes N.E., it is probable that along it we have a repetition of some of the slate beds which appear to the north and south of "The Cliffs," but which here exhibit a greater development of quartz rock layers amongst them than before. A dyke of compact trap cuts obliquely across the slates near their junction with the quartzite of Drumleck Point, from which place to "The Needles," a distance of 260 yards, the invariable dip of the slates is to the S.W. at 60°; there they are often stained red, green, and yellow, but becoming gray as we reach their termination on the north. The pinnacles called "The Needles" are formed of the end of a massive quartz bed, probably 100 yards in thickness, which can be traced inland from this spot for a distance of 900 yards in the W.N.W. direction. It is possible, perhaps, that this is a thickening out of a quartz bed which appears in the centre of the slates to the north of "The Cliffs," a distance of two-thirds of a mile west of "The Needles." At the base of the cliff over "The Needles" the quartz rock and slates are cut across by a double branching dyke of green porphyry, which has a N.E. and a S.W. direction; it thins out on its western extremity, but ends against a fault on its eastern, by which means also the quartz rock is abruptly terminated in that direction. The pinnacle called "The Needles" is formed out of that portion of the quartz rock which rests on the trap-rock (see fig. 11).

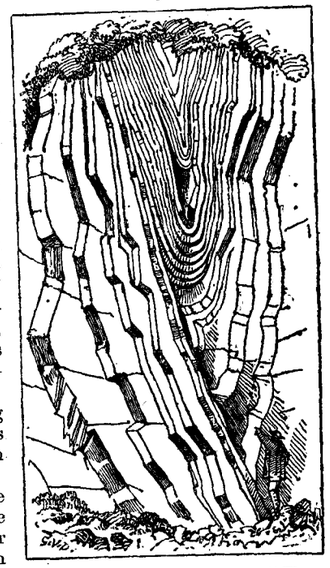
Fig. 11.

Sketch of the Needle Rocks, at Howth. Quartz rock resting on porphyritic trap.

North of this the shore for the distance of 400 yards forms a cliff section of brightly variegated slates, the same rocks when seen below high water-mark presenting merely a light greenish or gray colour. At first these

beds dip with regularity to the S.W. at 60° to 70°; but beyond the distance of 100 yards or so they become much contorted, and eventually curve round so as to incline to the N.E., at from 50° to 65°, a dip which they retain for less than 100 yards, when another massive bed of quartz rock appears. If in a district so contorted as the one which we are describing we can argue as to position of beds from dips, I should say that here we have a repetition of the quartz rock of "The Needles." The band of this rock which now appears on the shore is fully 100 yards in width, but I am inclined to suppose that one-half of this would represent the real thickness of the bed, which is, I believe, sharply doubled back upon itself. This band of quartz rock can be traced inland for the distance of fully 560 yards to the turn of the road E. of Carrick-brack House. On the shore facing this bed there is a trap dyke which is slightly porphyritic. The shore now strikes nearly due east towards the Baily Head, and for the distance of 300 yards exposes a cliff section of bluish and greenish gray grits and slates all much contorted, some of the grits being very massive. At the distance named the slates are abruptly cut off by a north and south fault, which on the east side lets in a thick bed of quartz rock jutting into the sea, and known as "The Lion's Head." Beneath this and dipping south appears a branching dyke of trap-rock, which penetrates some gray slates lying below it, and also dips southwards at 45°.

Fig. 12.



Fault in Cambrian rocks east o "The Needles," Howth.

Some of the faults observable along this shore are remarkable, and one is especially so. A sketch of it is given in fig. 12.

If the upper portion only of the cliff section had been exposed, the existence of this fault would never have been suspected, as the dislocation of the beds has here taken place on the line of their bedding, and the only indication for the displacement at this part might possibly be a surface covered with vertical slickenside striæ.

From this to the Baily* Lighthouse the cliff section is about 800 yards in extent, exposing at either extremity pale greenish gray slates traversed by very numerous dykes of dark porphyry, the middle portion being occupied by beds of quartz rock. So far as we are aided by the dip of the beds it would appear that as we near the Baily Point we get into higher and higher beds.

The extreme end of the point consists of massive beds of quartz rock which dip apparently to the southwards at 40°, being separated from the mass of the slates on the north by a thick dyke of porphyritic basalt.†

* The word should be Bally, signifying a fort—G. V. D.

† Mr. Wyley has the following note on the Cambrian rocks of Howth:—All the smaller beds of quartz rock on the south coast of Howth, as at Drumleck Bay, Lion's Head, &c., are only coarse sandstones not cemented into a compact, nearly uniform mass like those of the county Wicklow, or even those at "Red Rock," or "Carrigbrack," or "Kilrock," on the

The east side of the Baily promontory affords a precipitous coast section of fully 700 yards in extent, along which the same slate beds appear as those on the opposite side; but the dykes of porphyritic trap here appear to be much more numerous than before, probably because the rocks are better exposed. Mr. Wyley notices one large dyke which cuts across the bedding of the slates and grits, which are much hardened and twisted. Other dykes adjoining this one are smaller, and want its porphyritic structure. North of the "Cave" there is a large dyke of green porphyry seventy feet above the sea level, and twenty to thirty feet thick. And to the north of this, at "Whitewater Brook," red, yellow, and gray, gritty slates and coarse sandstones are cut through by a dyke of fine-grained bluish gray trap. The most usual dip in all these beds is southwards from 40° to 60°; but in the neighbourhood of the "Cave," this order of arrangement is reversed, and the beds are contorted so as to dip to the E., and afterwards to the N. The slates close to the porphyritic dykes are more or less baked and hardened. One of these dykes is also visible inland, on the road to the Baily Lighthouse, a little W. of the narrow isthmus that connects the Baily peninsula with the main.

From "Whitewater Brook," past the cliffs called "Gaskin's Leap," for the distance of about 300 yards, the coast is quite precipitous, and all but inaccessible. The rocks exposed along it are the ordinary greenish gray grits and slates, their apparent dip being to the S.S.E,, with tolerable regularity. At "Lough Levin," however, Mr. Wyley detected a band of black or dark gray slate, thirty feet thick, which, he says, resembles the dark slates on the east side of Ireland's Eye. Directly below these beds, and conformable to them, we again find the quartz rock bands associated with the ordinary red, yellow, and gray slates. These are well seen in the cliffs over a point of rock called "Highroom Bed," the dip being to the S.E. at 60°. At the distance of 250 yards north of this place, the thin eastern extension of a group of quartz rock beds appear, which as they are traced inland, form a considerable feature on the outline, as well as geological structure of the hill. North of this place we have a cave called "Fox Hole," and beyond it a precipitous excavation in the cliff called "Piper's Gut," and north of that again a cliff called "Green Ivy." The total extent of coast just mentioned is about 750 yards, and its section exposes massive greenish gray grits and slates, the former often scarcely distinguishable from a greenstone in outward aspect; while the quartzite beds are becoming less and less frequent and decided in their character. The dip of all the beds is southwards or east of south at angles varying from 35° to 50°. In the neighbourhood of "Piper's Gut" these beds are cut through, transversely to their strike by dykes of dark basalt

north coast of Howth, which are all true quartz rocks. They resemble a red or yellow sandstone much more than quartz rock. The slates in Drumleck Bay associated with these sandstone beds are striped with innumerable thin cherty-looking layers of grit, and in other respects are quite of a conglomeritic look, being full of small grains and lenticular nodules of a gritty texture, which give them when weathered a rough surface, very like that produced by fragments of fossils. It is not easy to say whether these are grains originally deposited or of the nature of siliceous segregations from the mass of the slates. The same appearance is presented by many of the slates about the north-east point. The grit, sandstones, or quartz rock beds (whatever they may be called) of Drumleck Bay, strike out just clear of the Lighthouse; they are much more regular than the grit beds of the rest of the south coast, which are exceedingly nodular and lumpy, and utterly unlike any rock seen in the Cambrian formation of the county Wicklow. Taking Howth as a whole, it presents hardly a feature in common with the Cambrian rocks of Wicklow or Wexford, with the exception of some of the quartz rock masses, and the occurrence of green grits and slates at some points. Whether Cambrian or Silurian, it seems to me to occupy a horizon distinct from any rocks hitherto examined on the east coast.—A. W.

I have myself no doubt that the Howth rocks belong to the Cambrian period, an opinion confirmed by the fact that the Oldhamia was found in them at Puck's rocks by Dr. Kinahan.—J. B. J.

porphyry, and inland at "Green Ivy" cliff there is a very extensive, though irregular, protrusion of greenstone, or basalt, measuring 160 yards from east to west, by about 125 feet in thickness. From "Green Ivy" northwards to the indentation in the coast north of "Cassana Rock," a distance of 250 yards, there are three well-marked dykes which cut across the bedding of the slates. The central one is observed to traverse the cliff obliquely from its summit to near the base. The dip of the slates and grits is here southwards at from 50° to 70°. The third dyke appears on the north face of the cliff at "Cassana Rock," but is not so marked as that previously described; and beyond it, to the north, the Cambrian beds are free from trap-rock.

From the spot last described northward to the point called "The Nose of Howth," a distance of nearly 800 yards, the greenish slates and hard quartz grit bands have a steady dip to the southward at high angles, the average being 70°. The upper half of the beds are far from true quartz rocks, which, however, become developed in the central part and die out as the lowermost beds are reached.* If we attempt to trace the beds which appear along the cliffs alluded to inland, we soon find ourselves among beds of true quartz rock, the position of which has not the least relation to that of the rocks on the coast section which we have left. Mr. Wyley, therefore, suggests the occurrence of a fault, which would start northwards from the innermost part of the indentation of the coast north of "Cassana Rock," and come out on the north shore to the west of "Puck's Rocks." This, however, is incapable of proof, and, therefore, it has not been inserted on the map. The high knolls which surround "Kilrock," marked 271 feet on the map, and the cliffs near the quarries, are mostly formed of quartz rock, which here occurs as a very massive and singularly irregular-shaped bed. Its upper boundary is not so well defined as its lower, but it must have an average thickness of 150 feet. In this quartz rock I formerly detected singular, smooth, pear-shaped nodules of quartz rock, the nature of which has not been determined. The slates on which this bed appears to rest are clearly seen along the cliffs, as well as in some quarries, and on the road leading to the village of Howth. They consist of pale gray slates, usually brown stained, with many quartz nodules and beds. At the foot of the hill slope there are a few thin beds of quartz rock, which, with the associated slates are contorted; and further to the west other quartz rock beds appear along the coast, and are similarly bent; and finally, in the cliffs over Balscadden Bay, the Cambrian rocks become concealed by a thick accumulation of drift, sand, gravel, and clay. Along the base of the cliffs at Balscadden there is a coarse, brecciated, conglomerate, formed of quartz rock materials, red and yellow stained, and from its proximity to the Carboniferous limestone, it is possible that we have here the representative of the Old Red Sandstone.

Having thus described the geological structure of the coast section in the Cambrian rocks of Howth, a few words will explain their mode of occurrence in the interior of the peninsula. The highest elevation is 563 feet above the sea, and is called "Black Linn;" it is formed of thick beds of quartz rock, with thin bands of slate running through them in a N.W. and S.E. direction. To the north of this are the Loughoreen Hills, and to the west of them, Dung Hill, on which is the old Post Office signal post. S.W. of this is the knoll called Shelmartin Hill, 350 feet in elevation, with the "Flat Rocks" and the Cromlech Hill to the north of it, and "Middle Mountain" still further to the west, and lastly "Carrickbrack Hill," 503 feet high, distant half a mile S.E. of the latter. All these well-marked physical features are formed of massive beds of quartz-rock, the best

* At the extreme end of the cliff north of the "Nose of Howth," Dr. J. R. Kinahan discovered "*Oldhamia antiqua*" in the summer of 1857.

marked examples of which are to be found in the hills of Shelmartin and Carrickbrack, the former a boss of quartz rock measuring about 400 yards from N.W. to S.E., with a width of 240 yards, and the latter about 300 by 150 yards, both being completely surrounded by gray slates and greenish gray grits. In a district like this, where the only prominent features are masses of quartz rock, the intervening slates forming intermediate lower grounds, and being mostly concealed by soil or vegetation; and where we know by observation of the coast section, that all the rocks have been subjected to every conceivable amount and kind of contortion, it is frequently difficult to determine even the limits of the quartz rock beds. Any person looking at the geological map of Howth, especially that on the six-inch scale, would hesitate to pronounce which were the lower and which the upper beds of the whole group. We may venture a conjecture, however, suggested by the observed dips, that those which are on the north of the peninsula, and which contain *Oldhamia*, are lower than those on the south shore which are traversed by the dykes of trap, unless we suppose a total "bouleversement" of the beds, a supposition for which there is no occasion.

The island of Ireland's Eye lies less than one mile due north from the village of Howth, and presents a rough, wedge-shaped outline, the base being to the north, and the apex to the south, its greatest length is three-quarters of a mile, and its maximum width 700 yards. The peculiar form of the island is due to the existence of a massive bed of quartzite, 200 yards thick, which stretches across it at its northern extremity, forming the cliffs there, which reach a height of 330 feet. This bed rests on the gray slates and greenish gray grits of the Cambrian series, which may be observed from the sea at the base of the cliffs, dipping southwards at an average of 60° underneath the quartzite. On the west side of the island red and yellow slates and quartzose grits are seen coming in over the great quartzite bed, the average dip being to the south at 65°. On the opposite or southern side of Carrigeen Bay the same red and green beds again appear, but with a dip the reverse of that just stated, all of them rising to the south and the extreme south end of the island, and are formed of a thick bed of quartz rock over which are greenish and dull gray slates, dipping northwards at 70°, and passing up into some quartzose grits. Along the eastern part of the island the beds are entirely different from those now described, and consist of bluish and blackish gray slates, greatly twisted and crumpled, with irregular grit beds and nodules. As a mass, these appear to dip to the south at an average angle of 50°, though in many places they are rolled and contorted, especially in their middle portion. It is probable, if they could be seen farther south, that they would be found dipping to the northward like the Cambrian rocks; and that Ireland's Eye is in fact part of a trough, the same bed of quartz rock appearing at either end of it, with variegated slates over it, the contorted edges of which are covered unconformably by black Silurian slates.*

* These dark gray slates are similar in character and appearance to the Lower Silurian rocks of Wicklow and Wexford, and appear like them to rest unconformably on the red and green slates and quartz rocks of the Cambrian series. In Ireland's Eye, when standing, at low water, on the western shore of the island, the observer looks at the contorted Cambrian rocks below him, and at the quartz rocks which rise from underneath them both to the north and to the south; and then carries his eye towards the east, he may see an obvious contour line defining a roundish mass forming the central and eastern part of the island. This is composed of the dark slaty rocks before spoken of, evidently stretching as a mass across the edges of the Cambrian rocks, and reposing upon their denuded surface.

Mr. Wyley observed this when making a fresh examination of the Howth district in the year 1853, after he had re-examined the northern part of Wicklow, and mapped it in accordance with the fact of the wide unconformability of the Lower Silurian to the Cambrian rocks, which I showed him to be their relations in the neighbourhood of Ashford.—J. B. J.

The Cambrian rocks of Howth are girdled by the Carboniferous limestone towards the north and west from the Harbour of Howth round to the southern part of the Sutton shore. These beds are compact, thick-bedded limestone, frequently magnesian, and sometimes a perfect dolomite. About 200 yards north of Bottle-quay, on the Sutton shore, the limestone may be seen resting against a mass of quartz rock, from which at first sight it is scarcely distinguishable. The dolomite here dips to the westward, but at a distance of 250 yards to the north it curves round so as to dip to the S.W. at 40°. As we approach the old Manganese works, the beds are reversed so as to dip to the N.N.W. at 30°. Beyond this they do not exhibit any bedding, but are an amorphous dolomite.

The shore at Howth Lodge exposes a short section in the light gray Lower Limestones, the general dip of the beds being to the W.N.W. at from 25° to 45°, and in places the rock changes to a dull brown dolomite, a dyke-like mass of which traverses it in an east and west direction on the shore at the point east of Howth Lodge, where the beds are more massive than usual. As we approach the harbour of Howth the dolomite may be seen at low water occupying the entire S.E. portion of the harbour, and presenting a decided dip to the north. At the base of the Eastern Pier the limestone becomes very dark gray, with black carbonaceous-looking shales, the general dip being to the westward at angles of 5° to 10°. These beds may possibly be the representatives of the Lower Limestone shale; but it is equally possible, that they may belong to a much higher horizon in the limestone series.*

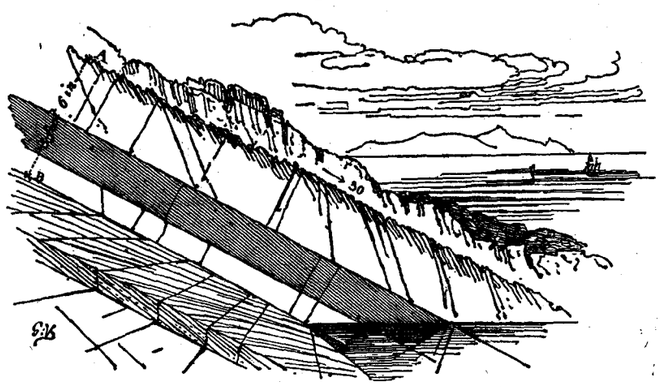
III.—*The Portraine and Lambay District.*

Portraine Lower Silurian Rocks.—The rocky projection of the coast at Portraine, two miles and a half due west of Lambay, is formed of Lower Silurian rocks, but they differ in many respects from those which we have previously described. If we commence the examination of the Portraine section on the north we first find a thick mass of dark-green felstone in places porphyritic, and exhibiting thick and irregular veins of dull-coloured jasper. Above this, and apparently dipping southward, are beds of coarse ashy conglomerate, the pebbles of which are rounded fragments of grit and trap, the base being green flaky ash. Then follow two bands of dark gray slaty shales and black slates, separated by ashy conglomerates, all dipping S. 40° E. at 40°. The slates contain Graptolites. A fault now breaks the continuity of the section, and the beds are reversed in their dip. We now find greenish ashy slates and conglomerates, a band of Graptolite slates, succeeded in descending order by ashes and fine conglomerates, and lastly by a dyke of trap-rock, when a second fault breaks the section. We have now approached close to the Martello tower, and we find that on the south of the fault the gray Lower Silurian limestone comes to view, occupying, however, only 150 feet of the cliff section, when it is cut off by a third fault, and on the sea-side, or east, it is overlaid by the ashes, conglomerates, and slate layers, which have curved round from the north with a dip of 45°. We have now reached the small sandy bay to the south of the tower, and this we find to be formed in dark

* Howth Hill having been an island in the Carboniferous sea, was surrounded by beds of limestone deposited against its shores, higher and higher beds touching those shores as the island sank in the sea, until it was possibly entirely entombed in the limestone. It has since been re-elevated and partially exhumed by denudation; but there is no evidence to show that the contour line now at the sea level was the original base of the old island, or that the beds of limestone shown on the north-west side of it were the lowest beds of limestone originally deposited against it. Neither, if they were, can we be sure that these belonged to the lowest portion of the Carboniferous series, since the old hill may have stood upon dry land during the time when those lowest beds were being deposited in the adjacent sea.—J. B. J.

gray slates, which as we follow the coast southwards, dip to the E. at 40°, but are much contorted, and terminate in a N. and S. fault, supposed to be a downthrow to the east. On the west side of this dislocation we find light gray, compact, thin-bedded, limestone, containing *Halysites catenularius*, along with Brachiopod shells and Trilobites. In some places these beds are amazingly contorted, often completely folded and crumpled about each other; but as a mass they dip to the sea, or eastward, at low angles, and occupy about a quarter of a mile of the coast section. Nodular layers are common throughout the limestone. Near the top of the cliff, at "Chinkwill," the limestone is nodular, and greenish gray earthy and slaty shales become mixed up with it. These are evidently the basal beds of a thick deposit of pale greenish gray, fine-grained grits and slates, which overlie the limestone, and form the remaining portion of the cliff section to the southward. These beds also dip eastward at angles of from 20° to 30°; and a well-defined cleavage traverses the more silty layers, though it appears only on the upper surface of the grits, or else to have not affected them at all; this cleavage dips S. 25°, E. at 40° (see fig. 13). In some of these lower layers at

Fig. 13.



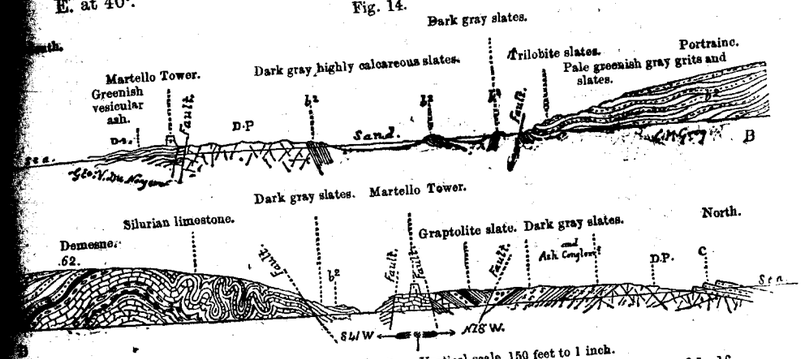
Gray Silurian grits, with cleaved slate beds between. Dip, S. 45°, E. 30°.
Dip of cleavage, S. 25°, E. 40°.

the south end of the section these slates contain Trilobites. We have now reached the sandy bay south of the old chapel, where these beds disappear; and we immediately come on a set of dark gray, almost black, highly calcareous slates, which dip E. at 30°, so directly in the strike of the other rocks on the shore as to lead to the supposition of their having been brought into their present position by a fault (see section fig. 14). Similar slates to these appear on the south shore of the sandy bay with the same strike, but dipping at 65°, and in this way they rest on a mass of green porphyry which now forms the coast line. At first this rock when it appears close to the slate is of a light green colour and flaky; but as the central portion of the mass is reached it becomes highly porphyritic and vesicular, the cavities filled with pink coloured carbonate of lime. The porphyritic portion exhibits crystals of pale green felspar. Adjoining the southern Martello tower on the N.E. the porphyry is faulted, and comes against the edges of a series of purplish green and greenish gray ash beds, which dip to the S.E. and S. at about 45°. As the ends of these beds come against the porphyry they are baked and hardened, the original bedded and ashy aspect being thoroughly

obliterated. At the Martello tower these ashes are quite unaltered; they are felspathic and vesicular, the small cavities being filled with carbonate of lime. Small crystals of iron pyrites are common through these beds.

A decided cleavage is observable in these ashes, its planes dip about S. 35°, E. at 40°.

Fig. 14.



Horizontal scale 6 inches to 1 mile. Vertical scale, 150 feet to 1 inch.

The porphyry just alluded to can be traced inland for the distance of half a mile, having a width of 450 yards appearing over the surface in large bosses, especially around Balcarrick House.

The slates and limestone may be traced inland over the higher portions of Portraine Demesne, especially the latter rock, a boss of which forms the highest level of the ground, and the Round Tower Mausoleum has been erected on it. Fragments of the overlying greenish gray slates generally show themselves in the vicinity of the protrusions of limestone, and have mainly suggested their boundaries as shown on the map.

Through the northern portion of the Deer Park the ash and ash conglomerates, with their associated bands of slate, described as forming the northern end of the shore section are but imperfectly seen.

At the distance of nearly a mile and a half due west of Balcarrick House the Dublin and Drogheda Railway has a north and south cutting through the middle portion of the Portraine peninsula, exposing for the distance of 200 yards south of Donabate Station, a mass of bright green porphyry, the embedded crystals of pale yellow felspar being unusually large and well developed. This rock can be traced westerward from the railway station into Newbridge Demesne for a distance of 400 yards, when it becomes covered by the Old Red Sandstone conglomerate. It soon again appears from beneath that rock, and forms a pear-shaped boss which measures about 350 yards from east to west, and possibly 160 yards from north to south, being completely surrounded by the conglomerates of the Old Red Sandstone.

The last locality where these trappean rocks appear in this district is in a deep ditch cutting which runs nearly east and west or parallel to the shore, between the southern end of the railway cutting at Donabate and Corballis House. Here we find superficial evidence for compact as well as slaty and vesicular green ash; but its dip or general relation to the Silurian rocks is not in the least apparent. These layers are cut off on the south by an east and west fault, which brings the limestone in contact with the Old Red Sandstone in the manner shown on the map.

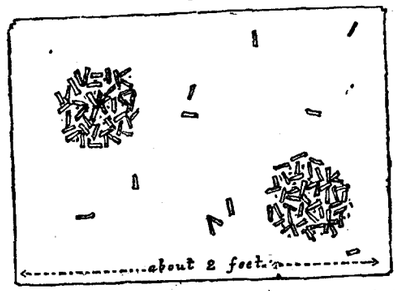
Old Red Sandstone, Lower Limestone Shale, and Lower Limestone.—The Old Red Sandstone beds occurring in this district may be seen in the

eastern half of Newbridge Demesne, and in the railway cutting both north and south of the porphyry at Donabate. The lowest beds consist of bright salmon-coloured conglomerates, consisting chiefly of well-rounded pebbles of quartz and purple grits. At Donabate these beds have been deposited on the porphyry, and at present rest on it at angles varying from 5° to 10°. Where it is exposed by the railway cutting, however, the angle of dip is 30°. In no instance has the porphyry been injected into these sandstones, but merely forms bosses belonging to the Lower Silurian rocks below, on which the Old Red beds were deposited. The thickness of the conglomerates at the bottom of these beds is very trifling, and it soon becomes overlaid by soft dark red shales, marls, and sandstones; these pass up into dark gray nodular shales with thin impure limestones and gray calcareous flags, the basal beds of the Carboniferous Limestone, and the probable representatives of the Lower Limestone shale. Many of these layers contain fossils of well-known Carboniferous forms. The section thus described occurs in the railway cutting, and the beds appear to lie in the form of two shallow troughs, the upper or calcareous beds appearing in their proper line of strike to the east in two places in the townland of Corbalstown. They may, however, be still better seen in the wood on the south side of the road leading N.W. from Donabate, where there is much dark gray, earthy, slightly micaceous shale, with nodular, calcareous concretions, between the Old Red Sandstone, which appears in Newbridge Demesne, just on the south, and a quarry of compact limestone on the other side of the road, the beds of which dip N. (with a contortion) at 15°. The occurrence of these beds makes it probable that a small band of them surrounds the Old Red Sandstone here. Near the shore, just west of the railway, dark crystalline limestone, with black shale, dips N. at from 20° to 40°; while limestone may be seen in Newbridge Demesne on the S.W., and at other places further south. In the high road south of Turvey Bridge, dark purplish gray crinoidal limestone dips N.N.W. at 15°. Similar limestone is to be seen near the shore just north of Kilcrea House, dipping S. at 10°, and within seventy yards to the north of one small quarry the Old Red is seen dipping to the north. This renders it probable that a fault runs between the two, a supposition supported by the appearance of limestone from underneath the slob on each side of the railway farther east; while immediately beyond, greenish vesicular ash is to be seen almost in contact with the limestone, and with no Old Red Sandstone between them, nor any Lower Limestone shale.

A few beds of the Old Red conglomerate may be seen resting on the green porphyry which forms the extreme northern end of the Portraine section.

Lambay Island. Lower Silurian Rocks.—The island of Lambay now claims our attention. Here, as at Howth, the coast affords the best sections to be found; and, therefore, gives the best explanation of the general geological structure of the island. I shall, therefore, first describe it, commencing at the small Boat Harbour and following the line of the coast southwards. The shore directly under the coast-guard station, and south of the harbour, exposes a mass of pale greenish gray amygdaloidal and epidotic trap-rock containing numerous small hollows and irregularly shaped cavities, filled with chalcedony and carbonate of lime. Throughout the rock are small greenish gray glistening crystals of hornblende (?), and here and there are wedge-shaped masses and squeezed layers of pale yellowish gray, soapy, and slaty, ash, which has been caught up and enclosed by the trap. Under the garden wall of the coast-guard station the trap undergoes a considerable modification in its structure, being observed to change suddenly from a homogeneous rock to a well-developed porphyry. The base of this rock is a bright greenish gray colour, and the embedded crystals of felspar are a pale yellowish green or straw colour, and sometimes assuming the arrangement shown in fig. 15. The line of distinction beween these two varieties of greenstone is so sudden and well-defined that a hand specimen might be procured which would exhibit both. Along this shore further south the porphyry contains abundant, though minute, crystals of iron pyrites, frequently occuring along what appear as main joints in the rock, and weathering so as to make the greenstone soft and rusty looking.

Fig. 15.



Groups of Felspar crystals, assuming a pophyritic arrangement, in greenish gray felstone, detached crystals of Felspar appearing in the mass.

At the extreme western point of the island, opposite the Burren rocks, the felstone presents the same variableness in its mineral structure, presenting the appearance of a highly vesicular porphyry, the cavities filled most usually with carbonate of lime, and rarely with chalcedony.

As we approach the point west of Talbot's Bay, the felstone becomes dark gray in colour and compact, and we find two small wedge-shaped masses of purple slate embedded in it. On the west side of this bay we find a band of gray slates resting on gray grits, dipping W.S.W. at 65°, having the porphyry both above and below them. These beds have been baked and thus hardened by the contact of the trap-rock; and the slates which are finely laminated, are so cut up by cleavage and close jointing as to break into small splintery fragments or "pencil slate." At the termination of the porphyry (which as it follows the bedding of the slates here assumes the appearance of a dyke about 100 feet thick), we find another band of gray slate, eight feet thick, having the same dip as the former and resting on an equally thick bed of fine brecciated conglomerate, formed of slate fragments; this again rests on a band of black slates, which are much cleaved in planes striking nearly W.N.W. and E.S.E. vertical. We now have reached the extreme indentation of Talbot's Bay, and the shore for the distance of about 400 feet exposes gray and dark gray slates with thin gritty bands, all so much contorted that both bedding and cleavage is in many instances obliterated. In one respect this fact is interesting, as it shows that the contortion is subsequent to the formation of the cleavage.

On the east side of the bay, these slates are observed to rest on greenish gray ash, which rapidly passes down into the ordinary porphyry, which again comes into the section and appears along the shore for the distance of 450 yards, as far as the west side of Carnoon Bay. The middle portion of this porphyry becomes ashy, and dips seaward in a gentle curve. We have, therefore, reached its basal portion; and if more perfectly exposed, it would be seen to form a thick band which would curve round to the south. This supposition, I think, is proved by the fact that, at Carnoon Bay, we again

find dark gray slates and thin gray grit bands with a bed of conglomerate, similar to those of Talbot's Bay; and resting on this, porphyry that dips to the S.E. at 80°, or in the opposite direction to the Talbot's Bay beds. As in the former instance, the slates which occupy the central portion of the shore of Carnoon Bay have been subjected to a great amount of contortion, and on their southern limits they have been hardened and baked by coming into contact with the porphyry.

From Carnoon Bay to the centre of Bishop's Bay, a distance of 500 yards in a straight line, the coast is formed of greenish gray porphyry. Here, at the mouth of Thornchase Valley, this rock is cut through by a massive dyke of dark greenish gray hornblendic greenstone, having fragments of the porphyry embedded in it. The strike of this dyke is apparently N. 15° E. vertical.

To the east of Bishop's Bay, is Sunk Island Bay, and north-east from that Kiln Point; the coast throughout being formed of porphyry. At Kiln Point we come abruptly upon some gray Silurian limestone, occurring as a wedge-shaped mass of lumpy layers, with thin bands of dark gray earthy shales between them, all very much contorted and resting on the porphyry, which has evidently come up under them, while in a pasty condition from heat, as it sends veins and strings into the lower bed of the limestone, and often enclosing fragments derived from it. The limestone nearest to the porphyry appears not to have undergone much chemical change from the heat, being merely made harder and more siliceous-looking. The total thickness of these limestone beds may not be much over twenty feet. The trap at its junction with the limestones is stained with green, as if from carbonate of copper.

North from Kiln Point to Seal Hole, a distance of over 400 yards, the cliff section exposes a coarse conglomerate, composed chiefly of rounded pebbles and boulders of gray Silurian limestone, sometimes fossiliferous, with fragments of black cleaved slate, gray grit, and greenish gray trap and ash; in one instance a boulder of an older Silurian conglomerate was discovered, in which were rolled pebbles of dark green close-grained greenstone, the paste being a limestone containing Silurian fossils.* The matrix of the Kiln Point conglomerate is a black mud, and throughout the deposit are irregular slaty layers: those predominate on the top of the cliff section; when we get lower into the mass, and as we trace it inland, we lose the conglomerate and find nothing but pure dark gray slates, which near Raven's Well are found to contain *Graptolites* and thin calcareous fossiliferous bands.

The outline of this deposit in its extent inland will be at once apparent by reference to the map. North of Seal Hole the porphyry again forms the coast section, and here it is cut back by the sea-action so as to form a lofty and almost perpendicular cliff, following the line of a fault, against the face of which we can yet see large flakes and patches of the Silurian conglomerate adhering. Hence it follows that the porphyry was ejected against the conglomerate while in a molten condition, and thus it caught and retained on its surface a flake or film from off that deposit.

On the top and at the very edge of the cliff, which is formed by this conglomerate, and directly south of the Seal Hole, there is an isolated patch of porphyry about 400 feet in length, by 125 in width, and possibly fifty feet thick. In mineral character it is exactly the same as the porphyries which

* Some of the Silurian corals were attached by their bases to the pebbles, showing that they had grown on them, just as corals may now be seen growing on pebbles and fragments of rock along tropical shores.– J. B. J.

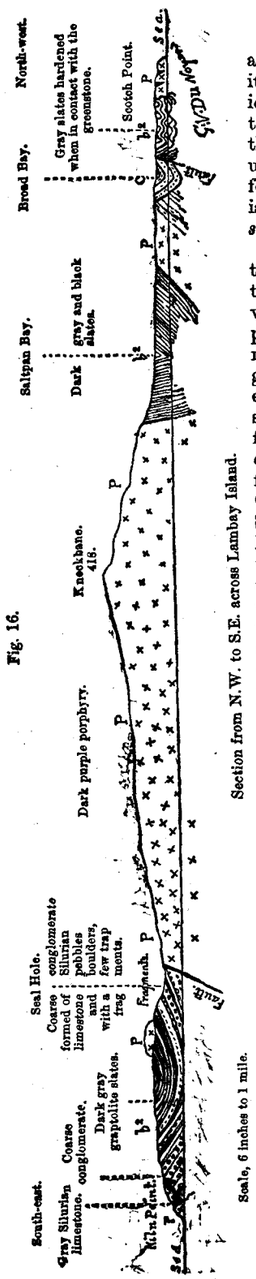


Fig. 16.

are to be seen over the rest of the island; but its position is interesting, as it suggests the idea that the Silurian conglomerate and graptolite slates were once all entirely embedded in the porphyry, and that this is a fragment of the upper crust of that rock which has survived the forces of denudation which swept over the island and moulded it to its present form. (*See section*, fig. 16).

From Seal Hole to Lambay Head, which is the extreme eastern point of the island, a distance of three-quarters of a mile, and from thence westerly along the northern shore to the precipice over Saltpan Bay, a further distance of one mile, the cliffs are entirely formed of greenish gray and dark purple porphyry. Here, however, we lose this rock, and again find dark gray slates resting on it at a high angle. These slates form the inner coast-line of Saltpan Bay for the distance of about 360 yards, when we again find the porphyry to rise from beneath them at Gouge Point, the dip of the slates here being S.E. at 60°. We find, therefore, that these beds have been bent into a synclinal curve, and when we trace them inland, they are observed to extend in a S.W. direction past the castle, where they have a width of about 200 yards, to near the old grave-yard (a distance of half a mile), and end in a scoop-shaped form. Though evidently a portion of the same Silurian slates, they are not connected superficially with those beds which appear in the line of their strike on the coast of Talbot's Bay.

The width of the trap at Gouge Point is but 252 feet, where it terminates in a thick ash, which dips southwards at 50°, and encloses a small wedge-shaped mass of reddish purple slate. On the west face of this point, which forms the south shore of Broad Bay, the ash has been denuded and red salmon-coloured quartz conglomerates (part of the Old Red sandstone) has been deposited on its edges.

On the other side of this little patch of Old Red sandstone, slates are seen for 100 yards along the west side of Broad Bay. They are very much contorted, and the cleavage which pervaded them has been also affected by the disturbing forces. As a mass they dip to the eastward at 80°.

On the north of these slates is the green porphyry of Scotch Point, which has hardened and baked them close to the line of contact with it, and it has intruded itself into this mass in lumpy projections. As we follow the line of the coast, we find that these slates extend across the short peninsula of Scotch Point, from shore to shore, but on that to the west, they have a di-

rectly opposite dip to where they were first observed, and at an angle of only 35°. We are now nearing the harbour of Lambay, and find that the ash which underlaid the Old Red conglomerate extends also across the base of the small peninsula. Here it is a pale greenish gray colour, and is full of large, irregular-shaped cavities, and numerous veins and strings filled with gray crystallized carbonate of lime. So very prominent are these calcareous segregations, that at a hasty glance the rock resembles a conglomerate. Above this we find the ordinary massive pale greenish gray porphyry, in places epidotic and amygdaloidal, the cavities being filled with carbonate of lime. This completes the circuit of the coast of the island.

The whole of the interior, with one exception, is formed of the green porphyry, to which allusion has been so frequently made. The spot alluded to is on the hill side to the west of Trinity Well, where some dark gray fissile slates appear. It is possible that they are a mass wedged into the porphyry, like as we see at Saltpan Bay, and not, as at first sight it might be supposed, any portion of the lower beds, contorted so as to have come under the influence of the denudation, and thus to be exposed at the present surface of the ground.

Old Red Sandstone.—On the S. side of Broad Bay there is a singular little patch of Old Red Sandstone, consisting of salmon-coloured sandstones above, and a conglomerate below, resting unconformably on the Lower Silurian ash and slates. The base of the conglomerate may be well seen. There seems at one time to have been a little trough or basin of Old Red here, now broken on the north. At their outcrop the beds dip north at 60°, but they flatten on the dip, so that at their western termination they are inclined at a much less angle; their aggregate thickness is not over fifty feet. On their northern extension, these conglomerates are cut off by a small east and west upthrow fault, by which means some Silurian slates are brought to the surface, and the conglomerate made to abut against them. (*See section*, fig. 16.)

Drift.—It now remains to mention the facts relating to the drift. This deposit exists merely on the low ground which extends along the western margin of the island, and in no respect differs from the ordinary brown drift gravelly clay, containing boulders and rounded lumps of the Carboniferous limestone, which is so common over Ireland. Here, however, as we would naturally expect, this clay contains a large per-centage of rounded fragments of the local porphyries, but nothing to stamp it as a local deposit. It is, however, evident that at the period of its deposition, Lambay Island formed a portion of the mainland. This clay does not extend more than 100 feet, if so much, up the flanks of the more elevated portions of the island, and beneath it the rock surfaces are rounded, smoothed, and scratched, the direction of the striæ being north-west and south-east.*

IV.—*The Skerries District.*

At the extreme northern limit of Sheet 102, the Lower Silurian rocks again make their appearance. If we commence their examination here on Shennick's Island, which is formed of them, we find that they consist of a series of green, purple, and dark gray grits and slates, with interstratified

* On the occasion of my first visit to Lambay, in the month of June, 1857, I was accompanied by my friend Professor W. K. Sullivan, from whom I derived much information in the mineralogical structure of the porphyries, and during our mutual examination of the island he directed my attention to lumps of hæmatite which occur in great abundance around a knoll marked 281 feet in elevation, and distant 200 yards, S.W. from the Raven's Well. These were supposed to occur on the line of fault or fracture, the direction of which may possibly be determined by the strike of the dyke of intrusive greenstone, described as appearing in the cliff of porphyry E. end of Bishop's Bay, and at the mouth of Thornchase Valley. Professor Sullivan suspects that a copper lode may here be present.—G. V. D.

Fig. 17.
Martello Tower.

1 1 1 Gray, dark gray, and green slates, and their grits, with purple slates, at the S. of the island.
2 2 2 Green felspathic trap, frequently passing into a green ash.
3 Thin flake of dark red conglomerate, the pebbles being chiefly derived from the Silurian rocks; the lower portion is dull reddish purple sandstone, the representation of the "Old Red Sandstone."
4 Recent brown gravelly clay containing limestone pebbles.

Scale—6 inches to 1 mile horizontal. 150 feet to 1 inch vertical.

Section through Shennick's Island.

contemporaneous beds of green trap, which is often porphyritic, and its associated ash. All the beds dip to the S.S.E. at from 40° to 50°, with remarkable regularity, and some of the trappean rocks attain a thickness of several hundred feet. The section thus briefly described is one of much geological interest, and at low water can be conveniently examined (see fig. 17).

On the shore, N. of the village of Skerries, there are beds of green grits and gray slates, all much contorted, and in many places veined with quartz, the dips being to the N.N.W. and S.S.E. from 45° to 75°. The grits are very compact and smoothly bedded, and the slates thin-bedded, and hard. These beds are clearly lower than those described as occurring on Shennick's Island.

The district to the west of Skerries, which is coloured as Lower Silurian, is for the most part covered with drift and under cultivation. The rock is rarely seen at the surface, and then merely as shingly fragments. The evidence, such as it is, may be best studied in the northern portion of the townland of Grange, about two miles to the W. of the village of Skerries, where the drift lies but thinly over the surface; and by traversing the country past the "Cross of the Cage" on to Cullen Hill townland, and from thence to the "Bog of the Ring," the nature of the Lower Silurian rocks may be guessed at by the fragments of purple and green slates and grits which are exposed in the deeper ditch cuttings and along the roads. The boundary of these rocks has been, for the most part, suggested by the form of the ground; but to the E. and N. of the Bog of the Ring, by the fragmentary evidence just alluded to.

On the S.E. shore of Shennick's Island, the edges of the Silurian slates, traps, and ashes, are overlaid by a thin deposit of dark red coarse-grained sandstones and coarse conglomerates, the pebbles of which are made of Silurian debris. On the N. this conglomerate, which most probably belongs to the Old Red Sandstone, dips to the south at 10°, becoming horizontal in its middle portion, and disappearing in the sea on the S. of the island.* G. V. D.

* The boundary of the Skerries Lower Palæozoic district, like that of the Dublin Mountain district, is formed by the edge of the unconformable beds of the Carboniferous rocks, which sweeps directly across the strike of the beds below.

As in the case of the Howth and Dublin Mountain districts, there is nothing to show that the lowest beds of the Carboniferous series appear along this boundary, or were ever deposited in that immediate neighbourhood. On the contrary, near Bog of the Ring, the first beds met S. of the Silurian ground, and within less than a quarter of a mile of it, are black shales belonging to the group of beds which are certainly the highest Carboniferous group in the district, and which, we believe to belong to the Coal Measures.

Eastward of this indeed, limestone appears a little S. of the Lower Silurian boundary, some of which is believed to be Upper and some Lower Limestone. I must, however, here record my conviction of the very uncertain value of these hypothetical distinctions in the limestone of this district, resting as they do on mere lithological evidence, and being rather opposed than supported by stratigraphical grounds of reasoning.

In any case, the same reasoning as to the exact geological horizon occupied by the beds

V.—*The Central Carboniferous District.*

V. *a.*—*The part S. of the Liffey.*—If we commence the description of this district on the south, the first fact that strikes us is, that no Carboniferous rock is to be seen south of the River Dodder, with the exception of some black limestone lying apparently in a horizonal position, which was formerly to be seen in the cutting of the drainage pond near the Booterstown Station of the Kingstown Railway.

In descending the bed of the Dodder, limestone first makes its appearance just S. of Bushy Park, near Rathfarnham. It consists of thin flaggy dark gray limestone, in some places dolomitized, and dipping at low angles in several directions, chiefly towards the S. Similar rocks just show themselves S. of Rathgar House. Dark gray compact limestones, with shale partings, were also quarried near the viaduct of the railway just above Milltown, dipping W. at 8°; and near the bridge a little above that, there are several old quarries in similar beds, dipping both E. and W. at 5°. The beds hereabouts seem to be all contorted. In a wall built of limestone, near the viaduct, were formerly to be seen blocks of limestone containing fragments of granite as large as a man's fist. They were probably quarried close by.

Just above the old Milltown Bridge limestone, quite dolomitized, is to be seen in the river bed, and beds of dark limestone, with shale partings, are visible thence for some distance down the river, either horizontal or dipping S. at 20°. Much lenticular bedding may be observed in it hereabouts, and it is now being rather largely quarried just N. of the river.* Below Clonskeagh Bridge, and thence to Donnybrook Bridge, similar rocks are largely exposed in the river bed, dipping generally S. at 10° or 15°, but frequently contorted, and showing lenticular bedding on a large scale. Just S. of Donnybrook Bridge is a large quarry in these beds, the dark limestone being generally regular, separated by black shale partings, but in some places showing thick beds, thinning out rapidly, and others setting in in their place, in the fashion spoken of as lenticular bedding.† No rock is to be seen in the bed of the river, or near it, below this point. Few or no fossils have ever been found in the beds now described.

Coming north of the Dodder to Rathgar there were very large quarries formerly opened in black, earthy, flaggy limestone there, and also north of Roundtown, the dip being steady to the south at 20° or 25°, and the beds destitute of fossils.

Precisely similar beds, with the same southerly dip, are also largely quarried to the south of Kimmage; but here there come in over the black earthy limestone some beds of pale gray crystalline limestone, in some places dolomitized. These beds are largely quarried S. of Crumlin House, and a long line of quarries is now open in them, stretching to the W. and S.W. along the line of a field road running in the direction of Airmount.

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which form the local boundary of the Carboniferous series, that was applied to those abutting against the Cambrian rocks of Howth (pp. 22 & 43 note), is equally applicable to those which occur near the boundary of the Skerries Lower Silurian district.

It will also apply to the limestone boundary of the Dublin Mountain district, though so little is known of the facts near that, that nothing definite can be said with respect to it.—J. B. J.

* This stone is sold in the quarry at 1*s.* 6*d.* to 1*s.* 8*d.* a ton for "wallers" or rough irregular blocks; at 2*s.* a ton for coigns, and about 2*s.* 4*d.* for large unworked thick slabs, fit for foundations. Dressed stones, such as paving stones for gardens, are delivered in Dublin for about 6*s.* a ton.

† In the walls of the new road running from Donnybrook Bridge to the Ranelagh road many blocks of dark limestone were to be seen containing angular and rounded fragments of granite, and some pieces of mica schist, from the size of a man's fist down to that of peas. I was not able to learn where that limestone was quarried.—J. B. J.

Large angular fragments of granite, some six or eight inches in diameter, were found embedded in the limestone in some of these quarries, as well as smaller chips and splinters and granite sand. Attention was first directed to this remarkable fact by Dr. Lentaigne, in a paper read before the Royal Dublin Society on January 31, 1851, and afterwards by the Rev. Professor Haughton, who brought it before the notice of the Geological Society, Dublin, in March of that year. Large specimens were sent by Dr. Lentaigne to the Great Exhibition of 1851.*

Pieces of granite and large slabs of black glistening mica schist in dark limestone have lately been presented to the Museum of Irish Industry by Mr. Carroll, jun., who procured them from the Milltown quarries.

Fossils, which begin to show themselves in the rocks at Kimmage, are more plentiful near Crumlin. Fenestellæ, Productæ, and Trilobites were formerly collected by Mr. Flanagan from these localities in tolerable abundance.

The dip of the beds is still steadily to the southward all along these quarries, sometimes curving a little to the S.E., and then again towards the S.W. The angle of inclination may be stated at a mean of 20°. The S.W. dip gives them of course a strike to the N.W., in which direction the beds are again visible in a line of quarries N.W. of Airmount, having the same lithological character, and the same dip of 20° to the S.W. nearly as far as Ballymount.

In a direction nearly due S.W. of this, and therefore above the beds just described, black earthy limestones, corresponding to those of the Donnybrook quarry, may be seen in the ground S. of Kilnamanagh House and White Hall. They are unfossiliferous, and dip S.W. at 8° or 10°.

North of Ballymount, on the ridge of Airfield, about the Red Cow and Mount St. Joseph's Monastery, there are numerous quarries in dark flaggy limestones, full of seams and nodules of black chert. These beds all strike E. and W., and dip steadily to the S. at angles varying from 15° to 35°. They are often fossiliferous, containing Brachiopoda and other molluscan shells, with Trilobites in considerable abundance. These beds must apparently lie below those of Crumlin, and they seem to strike off towards Dolphin's Barn, where large quarries formerly existed in beds which were apparently on the same horizon as the Airfield beds.

Between this line of strike and the River Liffey the rock is to be seen at only three places:—One near the canal bridge, called Blackhorse Bridge, where it dips S. 30° E. at 30°; another is an old quarry at the bend of the southern road, half a mile east of Ballyfermot Cottage, where the beds dip S.S.E. at 15°; and the third by the side of the road a little E. of Drumanagh Lodge, where they apparently dip N.W. at 20° to 30°. The rocks at these three places were all dark earthy limestone, similar to that seen in the country to the S. It is most remarkable that with the single exception of the last-named locality (and even that is a doubtful one, since the beds are irregular), and the few contorted beds in the Dodder, all the beds over the whole space between the Liffey and the foot of the granite hills, wherever a section is exposed in them, were observed to dip towards the S., or at the high country made of the Granite and Lower Palæozoic rocks. The same singular position of the beds may be observed in the country still further westward, all the beds almost invariably dipping S. as far as Newcastle and the neighbourhood of Celbridge. Confining ourselves to the limits of Sheet

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* It is possible that these fragments of granite may have adhered to the roots of the plants that were drifted down the watercourses from the neighbouring granite land into the sea of the Carboniferous period. It is well known that on some of the Coral Islands of the Pacific the only hard stones known to the natives are those they find in the roots of trees drifted from the rivers of Asia, and thus carried over thousands of miles across the ocean.—J. B. J.

112, there appears to be an upper earthy group of limestones, unfossiliferous, of which the Donnybrook beds are part, a middle fossiliferous, and more purely calcareous band running E. and W. through Crumlin, and a lower earthy unfossiliferous group between these and the Liffey. The surface width of this space, measured N. and S., is about four or five miles; and if we could suppose the beds to have an average inclination to the S. of only 15°, over half that space we should have a thickness of over 3,000 feet of black earthy limestone for this part of the series alone. It is very improbable that there can be any such thickness here, and we must therefore suppose either that there are many concealed undulations in the beds, or that there are a series of step-like faults running E. and W., by which the same beds are repeated over and over again. There is, however, no known direct evidence for either supposition.

V. *b.*—*The Country North of the Liffey.*—No rock *in situ* is to be seen at the surface between the lower parts of the Liffey and Tolka rivers, although the black earthy limestone must in many places have been reached through the heavy covering of gravel, by wells, and even in the foundations of buildings in the city of Dublin, and about the Phœnix Park. It first appears at the surface in the western part of the latter place, thin-bedded black earthy limestone having been just bared on the slope N. of Chapelizod, and two small quarries in similar beds, dipping S.E. by E. at 10°, having been opened a little to the N.E. of Mountjoy Barracks.

Two old quarries were formerly opened in dark earthy limestone on Clontarf Strand, and some others at Holybrook, and several cuttings were made through it on the Drogheda Railway between Clontarf and Raheny. The beds here are greatly contorted, dipping at angles of even 60° in several directions. Small exposures of similar rock are to be seen at Coolock, and in some old quarries near Tonlegee House.

There is a large quarry between Edenmore and Kilbarrack House in which beds of light gray compact limestone are seen dipping about S.E. at 40°. They have one bed of black shale, full of Fenestella interstratified with them. In consequence of their light colour, these beds are believed by Mr. Du Noyer to belong to the Lower Limestone, although the inclination of the beds would apparently place them above those of Coolock and Tonlegee.*

No rock is seen in the valley of the Tolka till we come above Glasnevin, when about Tolka Bridge there are several quarries in black earthy limestone and dark shale, the beds dipping both to the S.E. at 60° and to the N.W. at 30°. Similar beds may be seen in quarries between Tolka Bridge and Finglas, and for half-a-mile to the north of it, all dipping steadily to the S.E. at 10° or 15°. Occasional quarries, disclosing precisely similar facts are to be seen near Finglaswood House, Rosemount, and Scribblestown House, near the Dunsink Observatory, and at Ashtown and Hill-

* I am quite willing to admit that in many cases the lithological characters of beds have a remarkable constancy, so that conclusions based on those characters are sometimes found to be correct in opposition to evidence derived from what at first appeared to be the stratigraphical relation of beds. At the same time, lateral changes in the characters of beds are also common, beds on the same geological horizon often being exceedingly different at different places. The boundary line between the Lower and Upper Limestone in the Sheets 102 and 112 has been drawn chiefly from the lithological character of the beds which seems in many cases to be in accordance with their apparent stratigraphical relation, and sometimes, as in this instance, to be opposed to it. The difficulties in determining the exact relations of the rocks in many localities, and in making those of different localities in the county Dublin agree with each other, are very great. There is, however, this economical and practical advantage in the boundary we have now drawn in the limestone, that all those areas which are spoken of as Lower Limestone, and which are coloured of a paler blue in the maps than the Upper Limestone, will be found to afford good limestone fit for burning into lime, while the darker coloured areas are chiefly occupied by earthy limestones and shales, to which the provincial term "Calp" may be applied.—J. B. J.

brook. In all these places the inclination is towards the S.E. Fossils, especially Trilobites, are also found occasionally in all.

A little S. of Castleknock there are some large quarries in pale gray compact limestone, the beds of which certainly seem to form an oval anticlinal elevation, dipping at 30° towards the N.W. on one side, and S.E. on the other; and in every case passing under beds of dark earthy limestone and shale.

These, then, may be looked upon with little doubt as true Lower Limestone. Many fossils, Productus, Spirifer, Euomphalus, and Orthoceras, of ordinary Carboniferous species, are to be found here. In one place, the light gray limestone is traversed by a vertical dyke-like mass of dark brown crystalline dolomite, full of cells, coated with crystals of quartz. This dyke is about three feet wide, and runs N. 40° W. across the quarry.

Small quarries E. of this, about Ashfield, show beds of the black limestone dipping E. at from 10° to 30°; one at the Palmerston Mills, dipping S.E. at 30°; and these beds may also be seen on the west in the little glen of Knockmaroon, where, however, their inclination cannot be determined.

A still larger exposure of beds, which are believed to belong to the Lower Limestone, is to be seen further west, but chiefly beyond the limits of our district; and again to the N.N.E. of Castleknock, beds of pale gray limestone are to be seen, S. of Elm Green, just W. of the Observatory, at the old castle of Cappoge, and in quarries to the N. and N.W. of it; while in the valley of the Tolka, along Abbottstown Demesne, beds of hard black earthy limestone and black shale are exposed, undulating and dipping at low angles in almost every direction.

To the N.E. of Cappoge, light gray compact limestone is to be seen near the Old Red Lion, and S. of Huntstown House; but to the east of that, little or no rock is to be seen *in situ* for a distance of four miles, when we come to the quarries near St. Doulagh's.

V. *c.*—*The Country about Malahide.*—St. Doulagh's Hill is rather largely quarried, the rock being a light gray compact splintery limestone, the beds of which undulate on the S., but towards the north dip N.E., N., and N.W. at 30°. Similar pale gray limestone is to be seen N. of Kinsaley House, and again at Ruckarone and near Beechwood, places which lie one and two miles N.E. of St. Doulagh's.

The beds are not sufficiently disclosed at the two latter localities to enable us to determine the dip, but between them dark earthy shaly beds may be seen in one or two places in the railway cutting and elsewhere. About a mile N.N.W. of Kinsaley is Feltrim House just N. of which is another hill made of light gray splintery limestone, the beds of which dip in various directions. Similar limestone is seen at Cloghran, a mile W. by S. from Feltrim Hill, dipping S. at 40°; and again on a hill just N. of Corballis House, where the beds dip E. at 35°, in the direction of some dark shaly beds obscurely seen in several places to the S.W. of this.

In Malahide Demesne is an old quarry, in thick bedded gray limestone, dipping to the N.N.W.; and south of the Malahide station is a cutting in the railway more than half a mile in length, exposing a good section in the beds of that extent. For the first 700 yards S. of the station the rock is a darkish gray compact rather earthy limestone, with occasional shale partings, and breaking into concretionary lumps when weathered. It dips for this distance steadily to the N.N.W. at 25°, when just near the S.E. corner of the Malahide Demesne, and 100 yards N. of a bridge, a fault strikes N.W. and S.E., across the railway, having a hade or inclination to the S.W., and bringing down a set of dark earthy shales which dip S.W. at 30°, with one or two undulations towards the N.W., but finally, near Broomfield Cottage, dip S. at 15°.

The thickness of the beds seen N. of the fault cannot apparently be less than 750 feet; and as the fault is evidently a downthrow to the S.W., and since none of the beds to the southward appear in the section to the north, it is clear that the amount of the downthrow must be greater than 750 feet.*

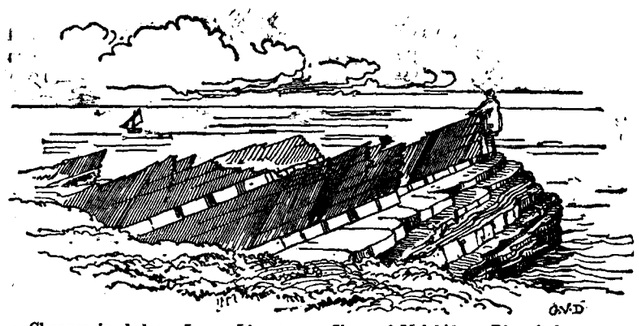
There is an interesting section also to be seen in the beds on the shore S. of Malahide, commencing just at the northern termination of the Velvet Strand.

The first and lowest rocks seen are some dark gray shales, with Fenestella, partly buried in sand, and dipping to the N.W. at about 15°. Just N. of these we find a set of dark gray flaggy concretionary limestones, interstratified with beds of black calcareous shale, dipping to the N. and N.W. at angles varying from 20° to 40°. These are precisely similar in lithological character to beds which are frequently found at the base of the limestone in the S. of Ireland (and also in S. Wales), and are called therefore the Lower Limestone shales. They are full of fossils, among which Mr. Baily determined the following species:—

Corals.—Cyathophyllum Stutchburyi.
Zaphrentis Phillipsii.
Polyzoa.—Fenestella antiqua.
Glauconome gracilis.
Ceriopora rhombifera.
Brachiopoda.—Spirifera pinguis, striata, and glabra.
Strophomena rhomboidalis (analoga).
Rhynchonella pleurodon.
Orthis resupinata.
Gasteropoda.—Pleurotomaria.?
Macrocheilus.

Just on the S. side of the Martello Tower here there is a sudden twist in the beds, beyond which there is an equally sudden change in their lithological character. It is supposed, therefore, that a fault traverses the limestone here, having probably a downthrow to the N., and being perhaps connected in some way with the one just described as to be observed in the railway, where however the throw is in the opposite direction. Some of the beds just about this dislocation are greatly dolomitized. North of this point we get dark gray compact rather earthy limestone, dipping gently to the N., but with one or two sweeping undulations towards the east. *Orthis resupinata* and *Spirifera glabra* (as determined by Mr. Baily), are very abundant here, and

Fig. 18.



Cleavage in shales. Lower Limestone. Shore of Malahide. Dip. of cleavage, N.W. at 60°.

* It is possible, as before stated, that many of the apparent anomalies met with in attempting to group the Carboniferous Limestones of county Dublin, may be the result of similar large dislocations to the one here proved to exist.—J. B. J.

a little further north many corals (*Lithodendron junceum*), make their appearance.

At one point the beds are traversed by cleavage planes, which dip N. 20°, W. at 60°, but do not affect the hard layers (see fig. 18).

The beds continue to undulate, dipping generally to the N.E., till we come near the point where the boundary of the townland of Robb's Walls comes out on the coast, and a field-road runs N.W. to a farm. Just here a large part of the limestone is suddenly changed into yellow and brown dolomite, very crystalline, and full of large cavities, which are lined with beautiful crystals of bitter spar. This is in the centre of an anticlinal curve, the beds sweeping round it from the S., and dipping from it on the N. The dip is then steadily to the N., at 25°, for more than 100 yards, when the beds curve up again, and dip to the S. at the same angle.

For more than 200 yards, however, N. of the mass of dolomite just mentioned, a narrow crack or fissure is observable running due N. along the shore, and cutting right across the beds. On the west of this fissure the beds are all dolomitized, while they are not at all so on the east side of it, although the same beds obviously run from one side to the other. N. of this, after dipping towards the S. for some distance, the beds again form an anticlinal curve, along the axis of which a dyke-like mass of dolomite runs out for some distance from the shore, and beyond this the dip of the beds is steady to the N. at angles of 15° or 20°, as far as they can be seen, or up to the Martello Tower of Robb's Walls. As far as the old castle the beds are probably only a repetition of those which have been described farther S., having the same abundance of Spirifera glabra and other fossils.

Beyond that point, however, higher beds come in, characterized by an abundance of large shells of *Pleurorhynchus fusiformis*, with corals, as *Lithodendron junceum*. In many cases the corals are attached to the broken *Pleurorhynchus* shells, having evidently grown upon them as corals do now upon shells and stones.

Mr. Baily determined the names of several fossils besides those previously mentioned, among which were *Spirifera striata* and *S. cuspidata*, and stems of *Actinocrinus*. Throughout the section the limestones are dark and often earthy, with beds of black shale occasionally, the latter becoming more numerous in the upper beds.

The exposed thickness of the beds, which are believed to be Lower Limestone shale, S. of the southern Martello Tower, is about 170 feet. If we suppose that for 800 yards N. of that the beds are all the same set repeated by the curves just now described, and therefore that the dolomitic limestone just under the S. Martello Tower, is nearly or quite on the same horizon as the northern dolomite which is seen 400 yards S.E. of the castle, we shall have, including that set and the beds above, an exposed thickness of about 650 feet. This makes a total of between 800 and 900 feet for the thickness of the beds actually seen in the Malahide coast section.

If the strike of the beds shown in the cutting of the railway be persistent out to the coast, they would reach it about the sandy tract north of Robb's Walls, Martello Tower, where no rock is to be seen, and will make, therefore, another 750 feet to be added to this section. Certainly the beds in the railway cutting are not the same as any of those in the exposed section, differing both in the character of the rock and in the apparent absence of fossils.

Fossiliferous limestones, however, the extension of some of those on the coast, are to be seen in several quarries about Sea Mount, dipping in various directions, but mostly to the N. or N.E.

V. *d.*—*The Country about Swords.*—Between Malahide and Swords no rock is to be seen, except some dark gray shaly limestone, dipping N. at 10°, and containing *Fenestella*, &c., in the brook just W. of Barrack Hill.

In the bed of the brook that runs through the village of Swords dark gray thin-bedded limestone is visible, with dark shales and abundance of Fenestella, dipping steadily N. at 20°, for a distance of 800 yards. This dip and distance would give a thickness of 850 feet.

Two miles S.W. of Swords, precisely similar beds may be seen at a place called Forrest. The beds here dip in some places W. or S. W., and seem to be curving round in each direction as if they ranged over the axis of an anticlinal, which itself inclined towards the W. In one quarry a fault may be seen running N.W. and S.E., with a downthrow to the S.W. To the northwards of these quarries dark gray earthy limestone may be seen by the road at the southern end of the demesne of Brackenstown, while in some quarries near Little Forrest House the beds dip E. and S.E. This arrangement of the beds suggested to Mr. Du Noyer the idea that this might be the termination of an anticlinal elevation of the Lower Limestone shale running down from Donabate, the beds seen in Swords lying on the northern flank of the anticlinal.

It is possible that this hypothesis may be in accordance with the general lie of the beds, so far as the existence of an anticlinal curve is concerned, but it seems very doubtful whether these beds with the thickness they seem to possess at Swords, can all belong to the Lower Limestone shale.

If indeed we proceed further to the S.W. beyond Forrest, we find scarcely anything but black shaly beds by Pass-if-you-can and Dunsoghly Castle, till we come to the pale gray splintery limestone near the Old Red Lion and Huntstown House, mentioned at p. 55.

No great reliance, therefore, can be placed on the boundaries between the different groups of the Carboniferous limestone series in this part of the map. They must be looked at merely as a result arrived at with much hesitation, and giving what appeared to us a probable or possible arrangement of a few scattered facts, the precise interpretation of which has no practical or important significance one way or other.

The brook running down from Broghaun Bridge to below Newpark House, exposes beds of dark gray shaly limestone striking along it, and dipping about N.W. at angles varying from 10° to 40°.

North of that nothing worthy of record is to be seen till we come to Kilsallaghan.

Both to the S.W. and S.E. of that place there may be seen here and there in the ditches, and occasionally in a little old quarry masses of grit-stone and conglomerate which appear to be interstratified with the limestones. The limestones are but obscurely seen, but appear to dip N.W. in some places and S.E. in others, at rather high angles. The grits are brown and ferruginous-looking, with fragments and pebbles of sandstone and quartz. They are seen also in the ditches a mile N.W. of Kilsallaghan and N. of Mountstuart, where the dark earthy limestones above and below them dip N.W. at 60° or 70°. These beds are probably similar to those seen on the shore at Rush. They are indicated by yellow dots on the map.

These beds bring us up to the valley of the Broad Meadow Water, north of which there is very little rock to be seen *in situ* for a distance of three or four miles.*

V. *e.—The N.W. Corner of the District.*—There is a small quarry at Greenoge showing regularly bedded dark gray limestone, and two of light gray limestone, in the parish of Clonmethen, in one of which the beds dip S.E. at 15°, and then curve over to N.W. at 80°, while in the northern one they dip N.W. at 40°.

* The limestone between the Malahide and Donabate estuaries have been already mentioned at p. 46.

A little further N., at Oldtown, there are larger quarries in light bluish gray compact limestone, with large *Spiriferæ* and *Encrinites* and *Fenestellæ*, dipping apparently S. at 10°, but contorted at one place. Mr. Du Noyer believes these to be the uppermost beds of the Lower Limestone, and the black shaly beds which seem to surround them on the E. and S. to be the base of the Upper.

A mile and a half to the N.W. of this, beyond Brown's Cross, are some quarries in dark gray thin-bedded cherty limestone, dipping N.N.W. at 40°. A mile again to the W. of these, beyond Nutstown House, are other small quarries in similar beds, apparently undulating.

North of these again, there is a quarry half a mile W. of Baldwinstown, in thin-bedded dark and light gray limestone with an anticlinal curve, the axis of which dips to the N.E., the beds dipping N.W. at 30° and S.E. at 40°. Between Baldwinstown and Beshellstown House a few scattered quarries may be seen in dark shaly limestone, dipping in various directions.

A little N. of this we come upon the limits of the map, but it will be desirable to trespass slightly beyond them, in order to mention that there are several considerable quarries about Flemingstown R. C. Chapel, in dark gray limestone, thin (or irregularly) bedded, containing trilobites and other fossils, and dipping gently in almost all directions. Within 200 yards of the furthest of these quarries, on the opposite side of a little depression, may be seen the green ashes and slates of the Lower Silurian series, striking about E.N.E. and W.S.W., or obliquely against the boundary of the two formations.

South-east of Beshellstown House and within the limits of the map, beds of dark gray limestone may be seen dipping steadily to the S.E. towards Westown Hill.

Further east we find several quarries in similar beds S. of the bridge at the Ford of Fine, which undulate sometimes towards the west; but, on the whole, dip S. at rather high angles.

Let us now proceed to the Naul, and again step northwards for a few yards beyond the limits of the map, into the picturesque little glen through which the river Delvin finds its way.

The limestone cliffs on which the old castle stands, and the quarries between it and the road, show beds of gray limestone, dipping W. at 40°, but they soon curve round, so as to dip S. at 45°, under the church, and at 35° under the chapel. Farther down the glen, the limestone becomes pale gray, with some dark flaggy beds below it, and curves so as to dip to the S.E. We then lose it, and at about four hundred yards further down the glen find ourselves in Silurian slate, with cliffs of greenstone just beyond. There is, however, an old quarry on the S. side of the glen, about one hundred and fifty yards below the lowest limestone crag, in which the rock is partly limestone in irregular beds, and partly made up of great and small Silurian blocks and fragments, cemented together by strings and veins of gray Carboniferous limestone. This is evidently a portion of the very beach or margin of the Carboniferous sea in which the fallen blocks and shingle from the wasting Silurian land above were enveloped in the calcareous deposits of the Carboniferous period.

V. *f.—The Westown Upper Limestone Shale District.*—If now we enter Westown* Demesne, and proceed southwards up the brook which runs down the hill to the Naul, or up that which just south of the demesne runs W.N.W. into the Delvin, we shall find in each a good continuous section in rocks of a very different character from any of those hitherto described.

* Mr. J. Kelly had, previously to my examination of the country, arrived at the conclusion that the shales on the hill of Westown belonged to the Coal Measures.—(*See Journal of Geological Society, Dublin, Vol. VII.*)—J. B. J.

? p. 253 . .

These consist of hard black splintery shales, so ferruginous as generally to have a rusty stain on the outside, and with a regularly banded aspect that shows them to have been originally deposited in thin beds. Black micaceous grits and sandstones also occur in them, which Mr. Baily recognised as similar to those at Staleen, S. of the Boyne. These beds dip at first steadily S. or S.E. (or in towards the centre of the high ground); but further up the hill they undulate at low angles in different directions, so that the same beds are often repeated in the section.

They are in many places crowded with fossils, which Mr. Baily found to belong to *Aviculopecten papyraceus* and *A. variabilis*, *Posidonomya membranacea* (M'Coy) *Lunulacardium*, crushed specimens of *Goniatites crenistria* and *Listeri*, and specimens of *Orthoceras* and *Dithyrocaris*.*

This black shale series is more or less exposed in quarries and cuttings over all the high land from Westown to Fanning's Walls, two miles on the S.S.W.; the Nag's Head, two miles on the S.S.E.; and Bog of the Ring and Balrickard, three miles on the E. It stretches also across the Hedgestown valley to the Man-of-War Hill and Malheney.

The junction beds between the upper shales and the limestone may be seen at two or three points. In a quarry just N. of Bulrickard House, beds of black earthy limestone may be seen with dark shale between them; and over these, likewise separated by shales, are three beds of hard gritstone, the uppermost three feet thick, all dipping S.W. at 15°. On the opposite side of the basin, at the cross-roads, half-a-mile E. of the Nag's Head, is a large limestone quarry capped by black shales, but without any grit beds. The dip here is N.E. at from 5° to 10°. In a quarry close at the back of the Nag's Head, black shales, with thin black semicalcareous flags, may be seen dipping N. at 30°; while in the low ground, five hundred yards to the southward, is a quarry in thin-bedded dark gray limestone, separated by black shales, dipping S. at 10°. There are two spots hereabouts where the limestone below the shales is brought up through them in little oval dome-shaped elevations, the shales dipping quâquâversally from the centres of limestone. One of these is near Malahow House, and the other a mile and a quarter E. of the Nag's Head, and half-a-mile S.W. of Walshestown House. Three-quarters of a mile nearly due S. of this is a small quarry, just outside the boundary of the shale series, in dark gray limestone, the beds of which are contorted, but on the whole dip N. at 50°.

Immediately N. of Balrothery Union Workhouse, several quarries in thin gray earthy limestone may be seen, the beds dipping in different directions; but near the old road, about three-quarters of a mile to the northward, they finally dip to the N. at 30°, and pass under black earthy splintery shales with thin hard flags, which are the basal beds of the upper shales. Black shales with *Posidonomya* may be seen abundantly on the slopes of the hill W. of the Man-of-War; but within a mile S.W. of Dennis Bridge, the limestone appears again in two quarries dipping S. at from 10° to 25°.

On the slope of the ground just N. of Dennis Bridge, we come upon Lower Silurian ground exposing the broken fragments of the slates and the edges of thin beds in many places, both down towards Milverton House on the E. and towards the Bog of the Ring on the W. At the latter place the black shales of the Upper Shale series *in situ* may be seen at several points within five or six hundred yards of Silurian slates and greenstones, the intermediate ground being a bog. At one point, indeed, fragments of slate were thrown out of a ditch much nearer to the Shales, but they were not certainly in place. If, however, there be anything at all here between the Upper Shales and the Silurian slates below, it must, at all events, be very thin; and the

* Mr. Baily has determined a precisely similar assemblage of specimens from the Upper Shale series ("Coal Measures") of Limerick and other parts of the S. of Ireland.

evidence is most in favour of the Upper Shales having overlapped all the limestone, so as to repose directly on the Lower Silurian rocks.

V. *g.*—*The Baldongan District.*—Proceeding now to the eastward of Dennis Bridge we get pale gray limestone in the low land about a mile to the S.E. of it, and dark gray flaggy limestone and shale on the higher ground, three-quarters of a mile still further to the S.E., and also at the junction of the roads, half a mile S. of Milverton House. These latter beds seem to dip steadily to the N. at 10° to 30°. Rather more than a mile E. of this, along the Skerries road, and between Milverton House and Hacketstown House, are the well-known Milverton quarries, large excavations in light-gray crystalline limestone, extensively used for building.* Rather more than half a mile N. by E. of this quarry is an old one now filled up, but from which gray limestone was formerly got.

A mile to the S. of the Milverton quarry is Baldongan Hill, in which fragments of black shale are to be seen on the ground, and are well exposed in places in the Railway cuttings along its eastern side. Under the field road railway bridge, S. of Hacketstown, dark earthy limestones may be seen rising from under the black shales, being the junction beds of the Upper Shales and Limestone.

Scarcely half a mile E. of this is a quarry in pale gray limestone, very irregularly bedded, but dipping apparently to the N. at 40° or thereabouts; and on the other side of Baldongan Hill, in the townland of Ballaghstown, is a quarry in dark gray limestone, with black shale, dipping N.N.W. at 20°.

The outline of the Upper Shales of Baldongan Hill has been drawn in from the shape of the ground.

V. *h.*—*The Shore between Rush and Skerries.*—Having now mentioned all the facts to be observed in the interior of the country, it remains for us to describe the section seen on the coast between Donabate estuary and the Skerries. This section is a very interesting one (see section in fig. 19); but it is very difficult to draw from it any general conclusion as to the grouping of the rocks or to connect it with any thing seen in the interior of the country.

The only beds in it that can be, with any approach to certainty, identified with any elsewhere to be seen, are certain masses of black shale, which from their lithological character, and from their containing *Posidonomya*, are believed to be the shales which overlie the limestone.

A small section of them may be seen in the cliff three-quarters of a mile N. of the village of Rush (see the northern end of the first line, and southern end of the second line of the section given in fig. 19). They are a good deal decomposed and crushed, and rest in the hollow of a narrow trough of thin-bedded dark limestones, with black chert nodules, interstratified with black earthy shales. On the north side of the trough the beds dip S. 10° E. at 40° while on the south side of it they dip N. 25° W. at 80°, but a little farther S. are rolled over in one or two sharp curves. Assuming these beds to be the top of the limestone series, we will now trace the section to the S. It unfortunately happens that the first thing we meet with in that direction is a flat sandy beach, one-third of a mile long, no rock being anywhere to be seen in that intermediate space except a low patch covered at high water, and even at low water completely matted over with seaweeds. The rock is a dark limestone, and it is believed that the beds "roll" or undulate in curves both to the N. and S.

At the south end of the strand a section is met with for about 300 yards N. of the harbour of Rush, exposing beds of dark gray crystalline limestone (used for building), with one or two thin conglomerate layers. Below these

* It has lately been greatly used in the building of the new lighthouse on Rockabill.

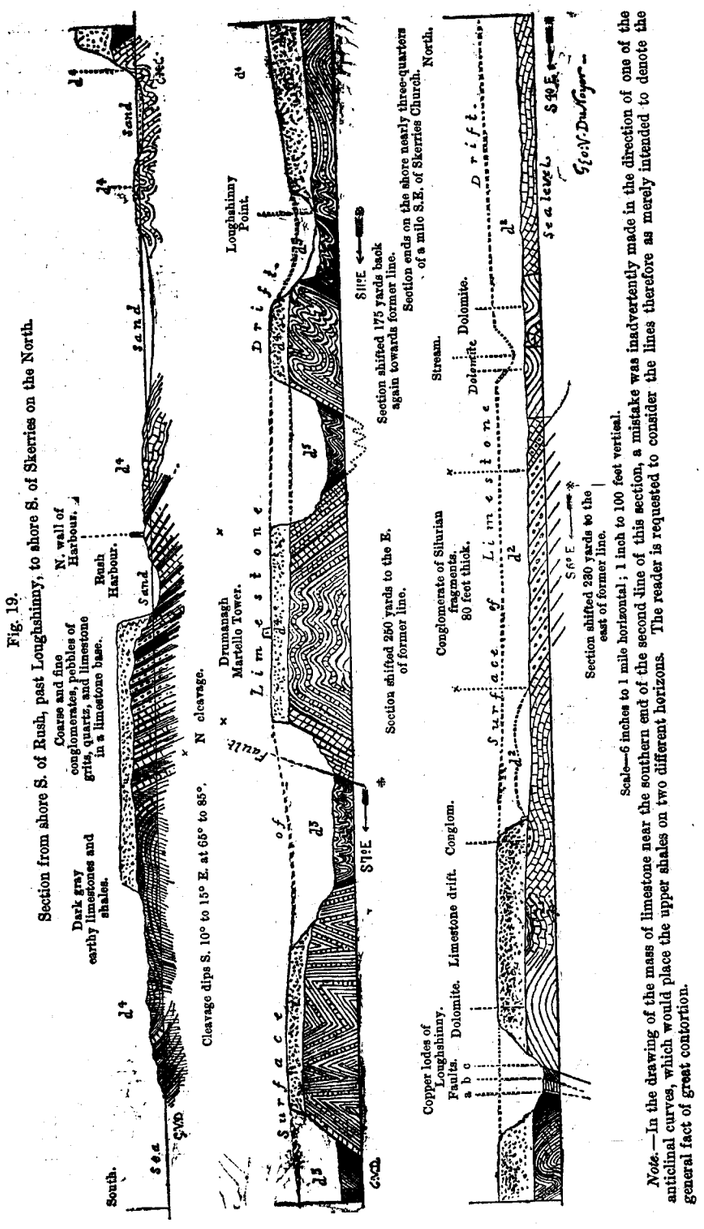


Fig. 19.
Section from shore S. of Rush, past Longhahinny, to shore S. of Skerries on the North.

Note.—In the drawing of the mass of limestone near the southern end of the second line of this section, a mistake was inadvertently made in the direction of one of the anticlinal curves, which would place the upper shales on two different horizons. The reader is requested to consider the lines therefore as merely intended to denote the general fact of great contortion.

are thin dark earthy limestones, and underneath them thicker and more massive beds of the same rock, with dark gray shales below, running along the north wall of the harbour. These beds dip all to the N. at angles varying from 5° up to 25°.

Going round the harbour to the shore on the S. side of its entrance, we meet with thick beds of conglomerate, interstratified with thin dark limestones and shales, all dipping steadily N. at angles of 50° and 60° (see section, line 1, of fig. 19, S. of Rush harbour).

The uppermost conglomerates are sometimes very coarse, containing great rounded blocks of grit or trap, apparently derived from the Lower Silurian rocks, together with numerous quartz pebbles, being embedded in a base of dark gray limestone. Immediately under the eastern wall of the harbour blocks of one or even two feet in diameter may be seen thus embedded.

Close underneath beds made of these coarse materials will be found others of the finest grain, and of most thin and regularly bedded character. Below those again are thicker beds of a finer conglomerate, with regular layers of quartz and other pebbles of the size of walnuts sometimes alternating with equally regular layers of pebbles not larger than peas, and even layers of grains of sand. These beds have regular partings of shale and beds of fine-grained earthy limestone interstratified with them. In the lowest bed of conglomerate many limestone pebbles also occur, apparently Carboniferous limestone. Below that bed, which is nearly at the most prominent point of the shore, we lose the pebbles, and find nothing but compact dark gray earthy limestone interstratified with layers of gray earthy shale. Lower beds rise out to the S. still dipping N. at 60° as far as the point where the coast begins to turn round and trend towards the east. Here they first flatten their dip to an angle of 15°, and then curve round to the W. and S., and continue to undulate in several broad anticlinal and synclinal curves, until we lose them under the sands of the Donabate estuary.

Just at the point where the beds begin to lose their high and steady dip to the N., and roll in gentle curves towards the S., a marked slaty cleavage comes in, the planes of which strike E. 20° N., and dip southerly at angles varying from 65° to 85°. In many places here it requires care to avoid taking the dip of the cleavage for that of the beds.

If we disregard these undulating beds, and calculate the thickness of the beds exposed from the point where the steady northerly dip commences, and carry it on, as well as we can, up to the Upper Shales, first described, we shall have the following section :—

	Feet.
Base of Upper Shales,	
Thin-bedded black limestone, with chert nodules, the part seen about	90
Space of 700 yards, in which nothing is to be seen except some beds, of which	
the dip is not ascertainable,	250
Dark limestones and shales, north of Rush Harbour, say	500
The conglomeritic group, about	500
The beds below the conglomerates, about	
	1,340

From this it appears that there must be a thickness of about 1,300 feet of limestone beds actually seen in this Rush section, without making any allowance for the spaces in which it is hardly possible that additional interstratified beds should not occur.

We now return to the little cliff of black shale north of Rush, and trace the section to the northward. Standing on the Giant's Hill headland, and noting the thin-bedded limestones, which rise at an angle of 40° underneath the Upper Shale series, we shall find, if we walk to the

north side of that little headland, that the limestones are soon traversed by an anticlinal curve, and dip over again to the N. at an angle of 80° underneath the sand and boulders of the little cove called Brook's End. This lies in the hollow of a synclinal curve, since the beds rise out again towards the north, being somewhat contorted, at one point faulted, but dipping generally about S.E. at 35°. The beds continue to have this dip till we reach a lane coming out on the coast, just beyond which there is another anticlinal axis, and the beds beyond it dip N.N.W. at 40°, rising up to 80° as we proceed and pass beneath another small basin of the Upper Shales. These are well seen in the cliff that bounds a small sandy bay, at the northern termination of which they dip S. 15° E. at 50°. We then have the limestones again coming out, but not quite regularly, since the ends of some of its beds seem to abut against the shales. This, and the strike of the limestone beyond seeming as if it would cross the shale, make it probable that there is a small fault here running between the two rocks. N. of this is the headland of Drumanagh, on which the Martello Tower stands. Along the south side of this headland thick massive beds of pale gray limestone dip about S.S.E. at 50°, thinner beds of dark gray coming out from underneath them.

These latter, where the coast turns towards the north, may be observed to undulate in the most regular manner along the shore, and on nearing the northern point of the headland to dip over to the north, and thus bring in again the massive pale gray* crystalline limestone that was seen to overlie them on the S.

Thin-bedded dark gray limestone, with black chert, and shale partings, comes in here over the pale gray, dipping N. at about 40°, and striking along the cliffs which forms the S. shore of Loughshinny bay. A continuous line of low cliff runs northward along the shore of this little bay, and exhibits the most regular and beautiful contortions in the beds. At the southern corner of the bay the dark limestone last mentioned dips with several folds beneath the black shales of the Upper Shale series.

The limestone, however, may be traced along the floor of the bay at low water, undulating beneath the shale, shortly rising out to form a low headland in the middle of it, and then rolling over underneath the black shale again in its north-western corner.

The northern headland of the bay is formed of the same beds of limestone, undulating in the most symmetrical curves round this headland, and along the shore to the north till we reach the little cove, to which a lane comes down from the interior by the Old Copper Mines, when we can just perceive the black shales of the Upper Series coming in again.

In some of the contortions of Loughshinny the beds are seen to be pushed over and inverted for a small space, and the shales which lie between the limestones are in some instances squeezed out from between them on the sides of the curves into hollows that are formed on the top of the folds; not only do the cliffs expose sections of these curves, but the shore in many places shows them in place, from which we learn that the beds are curved in every direction, the anticlinals and synclinals being short and interrupted, forming small oval domes or basins, like large boats either upright or bottom upwards.

Sometimes, too, the symmetry of these oval curves is disturbed by the occurrence of irregular crumples, and squeezes and wrenches, by which the beds have been distorted into quite indescribable forms, one bed disappearing suddenly in the confusion and another taking its place, so that all attempt

* This is one of the instances of the occurrence of pale gray crystalline limestone in the very uppermost part of the series, which warns us against laying too much stress on mere colour and lithological character in the grouping of the beds.

at tracing out the entanglement becomes impossible, although the whole surface of the rock is clear and bare before the eyes.*

Judging from the undulation of the same beds of limestone along the shore, it is to be supposed that the little troughs of the Upper Shales may be connected in the interior, especially as fragments of black shale may occasionally be seen there, and they have accordingly been so connected on the map from the S. shore of Loughshinny Bay up to the Copper Mines. At the little cove where the Copper Mine road comes down to the shore, the shales are much contorted and disturbed, and it is probable that they may here be cut off by faults in the fissures of which the ores might perhaps be deposited that were formerly extracted here.

N. of this cove the limestone differs somewhat in lithological character from that to the south of it.

The first bed seen is indeed a dark gray limestone, but underneath that are thick bedded pale gray limestones, passing down into a mass of yellowish dolomite. The beds dip at first to the S. and S.E. at 25°, but soon come over and dip N. at 20°, under thin dark gray limestone, with black shale.

These beds make one or two undulations, and might easily be taken for some of the beds about Loughshinny, or south of it. A little to the northward they dip S.E. at 20°, and strike out to sea; and thick beds of gray limestone crop out from beneath them, striking at first along the shore, and dipping E. at a low angle. These beds are also frequently converted into yellowish or reddish dolomite, especially along the joints. They have some dark gray earthy limestones interstratified with them, and a small layer of pebbles of quartz and grit makes its appearance here and there among them. At a distance of 700 yards from the Copper Mine road there comes in a bed of an earthy character like recomposed Lower Silurian debris, containing rounded pebbles of Carboniferous Limestone. The dip here is N.E. at 5°; and over this bed is a set of conglomerates, containing some rounded and some angular fragments of Lower Silurian grit and slate rock, greenstone, and other traps, as well as pebbles of quartz, embedded in a gray limestone, which is more or less impregnated by earthy matter derived from the Lower Silurian debris, sometimes to such an extent as to deprive it almost altogether of its calcareous character.

The highest bed of these conglomerates is just N. of the most projecting point of land here, and in that the base in which the Silurian pebbles are embedded is a true limestone. This dips N. at 15°, and passes underneath a set of beds of pale gray limestone, in some places largely and suddenly metamorphosed into yellowish brown dolomite, all dipping steadily N. or N.N.E. at 10° or 15° for half a mile along the shore towards Skerries. Beyond this point no rock is to be seen till we reach the Lower Silurian beds N. of Skerries, or those which at a distance of about 700 yards N.E. of the limestone compose Shennick's Island. The thickness of the pale gray limestone, which is to be seen over the conglomerates on the north, may be taken at about 200 feet, and that of the conglomerates themselves at about the same thickness.

There remains the question to be answered,—what place in the Carboniferous Limestone series do these conglomerates occupy? Mr. Du Noyer supposes them to belong to the Lower Limestone, and that a band of Lower Limestone stretches from the shore here past the Milverton quarry to Dennis Bridge, where it is overlapped by the Upper Limestone. This supposition has been followed on the map for the reasons stated in the note at p. 7.

* The study of such a locality is very instructive to the geological surveyor, showing him on the small scale what is of equally possible occurrence on a much larger one.

It involves, however, the supposition of a great decreasei n the thickness of the Upper Limestone between Rush and Skerries. If the Milverton quarry, and that near the road, three-quarters of a mile S.S.E. of Hacketstown, lie in the Lower Limestone, and the shales in the railway cutting 700 yards E. of the latter belong to the Upper Series, the space left for the Upper Limestones will not be more than about 500 or 600 yards wide. But as none of the observed dips hereabouts exceed 25° at the outside, it will follow that the Upper Limestone can only be about 250 feet in thickness; yet not more than two miles to the southward we find the beds assigned to the Upper Limestone certainly to exceed 1,300 feet in thickness. Such a thinning out in so small a distance is a perfectly unexampled phenomenon in beds like limestone and shale, nor is there any recorded instance of it even in conglomerates, which are, of all rocks, the most irregular and capricious in thickness.

But this difficulty is not the only one, for it so happens that of all the observed dips to the eastward and north-eastward of the Baldongan patch of Upper Shales, not one of them is towards these, nor is any rock anywhere to be seen thereabouts that has the supposed peculiar lithological characters of the Upper Limestone.

It appears to me, then, more reasonable to suppose that there is no true Lower Limestone anywhere N. of Rush, but that all the beds belong to the upper part of the series, or the part not very far below the Coal Measures, whatever may be their lithological characters.

Arguing, indeed, from lithological characters alone, the singular fact of a conglomerate of Silurian pebbles occurring in the Carboniferous Limestone would seem to be stronger lithological evidence in favour of the beds wherever those conglomerates occur, being on the same geological horizon, than any mere differences in the colour or texture of the limestone associated with them could be against it.

The fact of the beds along the shore last described, and those S. of Milverton House, dipping towards the Lower Silurian rocks, on which they undoubtedly rest, is easily explicable on the supposition of their being upper beds which have overlapped the lower, and abutting against the Silurian rocks at their termination.

If any change has taken place in the position of the Old Silurian surface by which it has been made to incline back at a lower angle than that at which it stood when the limestones were deposited against it, it may of course readily happen that the limestone beds will now be found dipping on to it and against it.

J. B. J. (chiefly from the field notes of G. V. D.)

VI.—*The Drift.**

The Drift over the whole of this county consists of three deposits when complete. The Lower Boulder clay (Till), a dark or brown stony clay, very stiff, containing a large amount of rolled limestone fragments, of various sizes, as the lowest deposit; and the second, loose sand and gravel, with marine shells, containing principally limestone pebbles, though fragments derived from all sorts of Lower Silurian, and such kinds of rock, form a large per-centage of the whole. Pebbles of granite are not uncommon in this gravel; and chalk flints, and pebbles are also sometimes present; The lowest of these deposits is found over the northern portion of

* Three divisions of the Drift can be recognised in the coast sections both of Howth and Killiney. They consist of (1) the Lower Boulder Clay, or Till; (2) the Middle Sands and Gravels (with marine shells); and (3) the Upper Boulder Clay. This last has been generally denuded away.—E. H.

the district under review, but it terminates at elevations, varying from 300 to 400 feet, above the sea. Wherever, therefore, we have land standing at this elevation, we will find that the subsoil pebbles are a breccia, derived almost entirely from the local rock, hence we have a large portion of the high grounds of Malahide, and that which extends northwards to Westown, the high ground to the W. of Walshestown, with the lands of Knockbrack, part of Balrickane and Walshestown, free from this erratic drift clay deposit. So, likewise, is the higher ground of Flemingstown, in the county Meath, W. of the Naul, and the higher elevations of the plateau surrounding the old posting stage called the "Man-of-War." Shennick's Island, opposite Skerries, affords an interesting proof of the extreme age of this drift clay. It measures 575 yards in length from N.W. to S.E. by about 150 in width, and is formed of thin gravelly clay, which the sea has now abruptly escarped on the N.W. of the island, to the depth of forty-six feet. On the opposite shore, S. of Skerries, the same deposit is also escarped by the sea to the depth of forty-one feet, the distance between the two being in one place close on three-quarters of a mile. This channel has, therefore, been cut by the sea long subsequent to the depositions of this clay, which, no doubt, represents the remains of what was once a very large extent of land, stretching into the Irish Sea. The same fact just noticed has been mentioned in connexion with Lambay Island, which is two miles and a half from the nearest point of the main land, the deepest part of the channel being over five fathoms. The *east* face of Howth also affords us another proof of the existence of land having extended here far into the sea. On the top of the cliffs, from Foxhole on the N. to Lough Levin on the S., a distance of 600 yards, we found this brown gravelly clay, containing numerous limestone pebbles, plastered against the rocks, and terminating at an elevation of about 100 feet above the sea, having a main width of only seventy yards. On the N. of this, between Foxhole and Piper's Gut, we have a small detached portion of this drift resting in a hollow of the cliffs, and on the east side of Ballypoint, as well as over the cliffs E. and W. of the "Lion's Head," we have not only this brown gravelly clay with limestone pebbles, but a deposit of recent sea shells, at an elevation of fully 100 feet above the sea. These are well seen on top of the cliffs near the Lighthouse. Limestone gravel is found on Howth, N. of Kitestown, at an elevation of 349 feet, the rocks beneath being rounded, smoothed, and striated, the direction of these scratches being 60° W. of N. and E. of S.; and this deposit is very generally found over the hill at this height as an average maximum elevation.

Enough has been said to prove the great antiquity of this deposit by the amazing amount of denudation which has taken place since its formation. Generally over the northern portion of the district, Sheet 102, we shall find the Drift spread over the entire face of the country till we pass to the southward of Malahide, where the limestone knolls of Feltrum, St. Doulaghs, with the higher elevations of Malahide and Portmarnock hills, are bared of it. As the greatest height which the ground attains is at Malahide, and only 203 feet, the Drift was doubtless at one time spread over these eminences, but its removal is the last result produced by the action of the sea, as the land was being brought to its present elevation above it.

As we enter on the southern portion of the district (Sheet 112), the Lower Boulder Clay becomes covered by the sand and gravel deposit, which on the higher grounds formed of the granite and slate is alone present.* The differences of elevation observable in the Drift as a whole

* The Drift along the district bordering the Dublin Mountains has been described by Mr. John Kelly, who has traced the gravel on Montpelier Hill to a height of about 1,200 feet.

in its extent over the southern portion of Sheet 112 are very remarkable. On the W. flanks of the high ground of Ballybrack, Mr. Wyley fixes the boundary of the "Loam with coarse limestone gravel" at only 100 feet in elevation, while at the distance of only eight miles W. of this the same observer discovers "very coarse gravel, containing abundant pebbles of limestone, arranged in highly inclined coarse and fine layers," resting on the eastern summit of Montpelier Hill, at an elevation of 1,235 feet above the sea. This is not here a mere local deposition, as it defines the western limit of the Drift, which extends easterly for the distance of two miles and a quarter over the undulating ground between this hill and that of Kilmashogue, on the S.W. flanks of which it attains a height of 1,200 feet. On the W. side of Montpelier Hill the Drift does not attain the same altitude as on the E.: 1,000 feet appears there as its maximum; and at the distance of one mile and a quarter from the limestone gravel, at the S.E. summit of the hill, it does not go higher than 700 feet above the sea.

The Three-rock Mountain, which lies to the E. of Kilmashogue, has, on its western side, the Drift gravel, extending to the height of about 1,200 feet, but on its eastern it is almost bared of this deposit, even at an elevation of 100 feet; all trace now left of this former covering being a few pebbles of black chert and dark gray siliceous limestone, scattered here and there over the surface. As we approach the land to the W. of the village of Stepaside, we again find the limestone-bearing Drift, in which Mr. Wyley detected some chalk flints; but its maximum elevation is now only 500 feet.

This deposit can now be traced easterly for the distance of about two miles, when it terminates at a maximum elevation of 450 feet on the flanks of the granite ridges of Carrickmines. Easterly from this the Drift covers the lower grounds, till it reaches the sea to the eastward of Ballybrack, where it forms the coast line, and is escarped to the depth of sixty-three feet.

The following is a list of the shells found by the Rev. M. Close, at Ballyedmonduff, at an elevation of 1,000 feet above the sea, in gravel, and determined by Mr. W. H. Baily and Dr. Carte:—*Trophon muricatus, Fusus?, Turritella communis, Ostrea edulis, Pecten* (two species) *Cardium edule, C. echinatum, Astarte compressa, A. elleptica, A. sulcata, Cyprina Islandica, Artemis lincta Venus striatula, V. Casina, Lutraria elliptica, Mactra stultorum, Tellina? Mya truncata, Pholas, crispata,* and *Balanus balanoides.*

Near Coldbeck House, in gravel 1,200 feet above the sea, the following were also observed:—*Fusus?, Cardium echinatum, Cyprina Islandica, Venus striatula, V. Casina, Mactra stultorum.*

The following were identified by Dr. Scouler, from the shelly gravels of Howth, belonging to the Middle Drift Series:—*Turritella terebra, Turbo littoreus, Nerita littoralis, Buccinum undatum, Cardium edule, Cyprina Islandica,* and *Pecten varius.* (Journ. Geol. Soc., Dub. vol. i., 270).

And Dr. Oldham adds the following from the same deposits at Killiney and Bray:—*Ostrea edulis, Tellina solida, Pecten operculatus, Pullastra decussata, Nucula oblonga, Astarte Gairensis, Corbula nucleus?, Saxicava rugosa* (*Ibid.*, vol. iii., p. 69).

When Dr. Oldham read his paper (in 1844), he contented himself with expressing the opinion regarding the age of these shells, that they belonged to the most recent of the Tertiary period. More recent observations have shown that the gravels of Killiney Bay are the representatives of the

He also recognised marine shells in Glenismaule, at an elevation of 600 feet (Journ. Geol. Soc., Dub., vol. vi.) The Rev. M. Close, F.G.S., has since discovered them at 1,200 feet (Geol. Mag., Dec. 2, vol. i.)

Middle Drift-period, when the land was deeply submerged, and the shell-bearing gravels were lifted up along the flanks of the mountains to elevations exceeding 1,200 feet, as shown by Mr. Close.

E. H.

On the western side of Sheet 112, between the Grand Canal and the River Dodder, there is a very well defined Esker ridge, formed chiefly of limestone gravel and sand, which commences at the distance of nearly half a mile N. of the elevation marked 194 on the map (and westward of Drimnagh Castle), and extends southwards in a bold winding course for the distance of nearly two miles and three quarters to the River Dodder, at the cross-roads of Balrothery, where it terminates. A single isolated mound of similar gravel is, however, to be seen at Fir House, south of the Dodder, opposite the end of the Esker. About its northern end the Esker is about thirty-five feet above the level of the surrounding plain, and forms several branches. In the townland of Green Hills, three-quarters of a mile S.E. of the elevation first alluded to, the height of the ridge is about sixty-five feet above the plain, or 254 feet above the sea; its outline now becomes much more definite, like a narrow ridge, a character which it retains for the remainder of its extent. At Airmount, the highest elevation of the mound is 290 feet above the sea, and about sixty feet above the adjoining land; and at its southern termination it is 290 feet, or forty feet above the undulating plain at either side. From this point northwards, for the distance of two miles and a quarter, this Esker forms the route selected for an ancient road, which is still in use.*

Raised Beach.—At intervals along the coast, from Co. Antrim southwards to Dublin Bay, are to be found gravelly terraces, fringing the shore, and rising a few feet above high water. On the N.E. coast of Antrim the elevation of this terrace is about twenty feet above this datum, but when observed southwards, it is found gradually to lessen, so that between the mouth of the Boyne and the north shores of Dublin Bay, it varies from eight to three or four feet, and along the south shores the terrace cannot be identified, as it merges into the present strand. The gravel usually contains bleached shells of existing species.†

The terrace is well seen along the shore near Gormanston, also opposite Lowther Lodge, near Malahide, and along the western shore of Ireland's Eye; it also forms the narrow neck of land which connects the Hill of Howth with the mainland. This neck being formed of shelly gravel, resting on Boulder Clay.‡

* The Esker ridges look indeed like artificial embankments thrown up across the country in order to carry a road across a swamp, or for some similar purpose, and they have often been taken advantage of in this way. That now described seems formerly to have been continued to the south across the Dodder, since there are mounds similar to it at Fir House right in the line of it. Large gravel pits have been opened in it at the Green Hills, and the arrangements of the beds of sand and gravel, and their assortment into layers of coarse and fine material, is very curious. These layers generally slope from the centre towards each side, mounds of large blocks often forming a central ridge or nucleus for the deposit.

These Eskers were in all probability formed in the shallowing waters of the sea, as the land last slowly rose through it, the materials being heaped up by the piling action of opposing currents.

They are analogous in mode of formation to the bars of harbours, and to the sand banks that frequently run along shallow shores, with channels between them and the beach in which the set of the tide is often different to what it is outside them.—J. B. J.

† This terrace was described by me at the meeting of the British Association at Brighton in 1872, and identified with the twenty-five feet raised beach of Scotland. E. H.

‡ This gravel is carefully to be distinguished from the shelly gravel of Balscadden Bay, which belongs to the Middle Drift series.

At Lowther Lodge, near Balbriggan, the shells are abundant, often fragmentary and generally bleached, and the following species were identified by Mr. Baily on the occasion of a visit we paid the district together in 1870:—*Litorina litoreus, Purpura lapillus, Rostellaria pes-pelicani, Trochus, Dentalium, Turritella communis, Turbo cinereus* (colored), *Mya arenarea, Cardium edule, C. echinatum,* and *Pecten maximus.*

The gravel terrace of Sandymount and Merrion is probably the most southerly remnant of the raised beach. Along the valley of the Liffey it merges into the alluvium of that river, forming the level ground occupied by the buildings of the University of Dublin, of Dame-street, Sackville-street, and the north-eastern suburbs of the city. These terraces are now inserted in the new edition of the map of the survey, Sheet 112.

E. H.

VII.—*Mines.*

Lead.—A bunch of very pure galena was worked in the mica schist, which rests on the granite on the S. side of Killiney Hill, and nearly due south of its summit, the adit to the lode being driven in from the shore, where it is yet to be seen. The present railway cutting exposed a thin vein from this bunch high up on the flanks of the hill. The work was abandoned after a considerable quantity of lead had been extracted, as sufficient indications of its continuing to be productive were wanting. Indeed, it was not likely that it would be found much farther, as the mica schist, in which alone the ore was found, is itself but of very small bulk, being merely a mass wedged into the granite.—(See p. 34.)

Copper.—Some years since copper was raised at Loughshinny (Sheet 102). It was found in three distinct and nearly parallel lodes, coinciding perhaps with a fault that may dislocate the limestones, with a downthrow to the S. The strike of the lodes, as near as can be determined from the superficial evidence on the adjoining shore, is 30° N. of E. and S. of W. They are fifty feet apart; and from the information I received on the spot, I learned that at the distance of 900 feet from the shore the two northern lodes joined, and then struck southwards to the S. lode, where after a short distance they were cut off by an E. and W. fault, and lost, thus rendering the workings unproductive.

The southern was found to be the only permanent lode, the two others being termed "variable."

When I made the survey of this district in the year 1849, the Loughshinny mines had long ceased to be worked, and I had no means of gathering more information regarding them than that which I have here stated.

A layer of carbonate of copper occurs in the limestones of Malahide hill, S. of its summit.

Ironstone.—Bands of an impure variety of this mineral are to be found in the railway cutting through the Coal Measures on the E. side of Baldongan Hill, and thin layers of the same, or a rock very closely resembling it, occurs in the Lower Limestone shales, exposed in the railway cutting, S. of Donabate.

Manganese.—This mineral was at one time found abundantly in the dolomite of Sutton, on the E. of Howth, but the supply appears to have been worked out.

G. V. D.

Sir R. Griffith, in his "Catalogue of the several localities in Ireland where mines and metalliferous indications have hitherto been discovered," gives the following list of places which are mostly within the limits of these two sheets. The mines that have been worked are printed in Italics:—

		No. of Ordnance Sheet.
Dublin,	Ashtown, Lead,	14 & 18
	Castleknock, Lead,	17
	Cloghran, Lead,	14
Clontarf Mines,	*Clontarf*, Lead with Zinc,—first shaft sunk 1809, Griffith, MSS., Mines of Ireland,	19
	Killester, Lead,	19
	Crumlin, Lead,	22
	Dolphinsbarn, Lead with Zinc,—abandoned from influx of water, Griffith, MSS.,	18
	Kellystown, Lead,	13 & 17
	Kilmainham, Lead,	18
	Phœnix Park, Lead,	18
Golden Ball,	**Ballycorus*, (*Mount Peru*), Argentiferous Lead with Zinc and Native Silver,	26
Ballycorus Mines,	**Rathmichael*, Lead,	26
	**Shankill*, Lead,	26
Howth,	**Howth*, Lead,	16
Howth Mines,	*Sutton*, Manganese,	15
Kingstown,	**Dalkey*, Lead with Zinc, and Tin,—Griffith, MSS.,	23
	**Mount Mapas* (*Killiney Hill*), Lead,	23
	*Seapoint, Copper,	23
Rush,	*Lambay Island, Copper,	9
	Loughshinny, Copper,—Griffith's Mining Report of Province of Leinster,	5

In his "Report on the Metallic Mines of the Province of Leinster," made to the Royal Dublin Society, and dated November 1st, 1827, he gives detailed descriptions of some of these mines, especially those of Clontarf.

In the same Report he also gives details of the working of a lead mine, called the Church Mine, at Wheatfield, near Celbridge, in Sheet 111; and in the Catalogue, speaks of indications of lead at Freagh, near Edenderry, in Sheet 110, and of copper, at Punchersgrange, near Newbridge, in Sheet 120.

J. B. J.

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