EXPLANATIONS

TO ACCOMPANY

SHEETS 147 AND 157 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

ILLUSTRATING PARTS OF THE

COUNTIES OF KILKENNY, CARLOW, AND WEXFORD.

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

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

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

Condensed memoirs on particular districts will also eventually appear.

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

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EXPLANATIONS

TO

ACCOMPANY SHEETS 147 AND 157

OF THE

GEOLOGICAL SURVEY OF IRELAND.

As the ground included in these two sheets of the map forms a district of which the explanation of one part would be incomplete without that of the other, it has been thought best to describe them together. The area included in the two sheets belongs chiefly to the county of Kilkenny, but part of its north-eastern side is in the county of Carlow, and the south-eastern corner is in Wexford.

The principal places in Sheet 147 are the city of Kilkenny, and the villages of Gowran, Goresbridge, Bennettsbridge, and Dungarvan, in Kilkenny county; and the towns of Bagenalstown and Borris, in county Carlow.

In Sheet 157 lie the towns of Thomastown and Graiguenamanagh, with the villages of Inistioge, Stoneyford, Knocktopher, and Ballyhale, belonging to Kilkenny; and the town of New Ross, in county Wexford.

General Description.

1. *Form of the Ground.*

The form of the ground included within these two sheets is very various. It may, perhaps, be best described by first marking the course of the two principal rivers, the Barrow and the Nore. The River Barrow enters the district a little north of Bagenalstown, with a level of about 132 feet above the sea, and runs in the main due S. to below New Ross. The neap tides run up it as far as St. Mullins.* The Nore comes into the district a little to the N.W. of Kilkenny, with a level of about 160 feet, runs through that city, and continues with a general course of about S.E. and by S. till it falls into the Barrow, about two miles above New Ross. The tide flows up it to Inistioge.

Between the valleys of the Nore and the Barrow, along the northern margin of the district, there is a ridge of high land, which forms the southern margin of the Castlecomer table-land. It has one elevation of 1,100, and some others of about 1,000 feet above the sea. This ground slopes gently southwards towards the plain of Kilkenny, and more steeply eastwards towards the valley of the Barrow, and has almost everywhere a well-marked escarpment towards the south and east.

South of this high ground is an undulating plain, sometimes varied by small hills or eminences, few of which rise more than 250 feet above the sea. This low undulating ground extends from Kilkenny to Ballyhale towards the S., and to Goresbridge and Bagenalstown

* In pronouncing this name the accent should be laid on the *last* syllable.

towards the E. Its mean height certainly cannot much exceed 200 feet above the sea.

To the eastward of that part of the Barrow which runs from Bagenalstown to Goresbridge, there is a district which is more rocky, and often more abruptly undulating than the plain just spoken of, and has also a greater mean altitude, since several of its eminences rise to 500 and 600 feet above the sea. As we proceed towards the south and south-west, this ground becomes much more hilly, till we find altitudes of 1,200 feet and upwards, with deep valleys and dells between them. These hills lie about half-way between the Barrow and the Nore, the two highest points being Croghan and Coppanagh Hills, each a little over 1,200 feet.

Still further south we find still loftier hills rising on each side of the Barrow, as it flows from Graiguenamanagh past St. Mullins. There is one point of 1,608 feet, to the eastward of St. Mullins, which is sometimes called the White Mountain, while on the other side of the river is Brandon Hill, 1,694 feet high, with a large tract of ground about it, exceeding 1,000 feet in height. This, the highest land in the district, lies between the Barrow and the Nore, while to the west of the latter river Mount Alto* is 919 feet, with other points about it of more than 800 feet. A hill in the parish of Jerpoint West is 882 feet, and there are many hills in the country lying south of Thomastown and Inistioge, of 600 and 700 feet in height. As we approach New Ross the eminences diminish to about 300 feet, and the general level of the ground sinks in like proportion.

There appears to be a tendency to form a ridge of high land across the district in Sheet 157, from N.E. to S.W., along which line are ranged all the loftiest points in the district, Brandon Hill being the principal. If this line be continued to the westwards into Sheet 156, we find the Nine-Mile-House table-land and Slievenaman nearly on its continuation, supposing it to be bent a little so as to run more directly west.

The high ground, however, from which these hills rise, is not only furrowed by valleys running in opposite directions down its slopes, but is cut completely through by four valleys, nearly at right angles to its general direction. Two of these valleys are the gorges of the Barrow and the Nore, and so deeply are these cut down that the tide flows up them nearly to points midway between the loftiest heights of the adjacent hills, and even in the country above the points to which the tide reaches, the rivers have not any more rapid fall while flowing between the hills than they have on the plain to the N.W. of them.

The two other valleys which cut through these hills, are those of the Arrigle River, or Glenpipe, and that traversed by the Kilkenny and Waterford Railway.

The little Arrigle River runs through the hills from S. to N. The level of its water is a little over 300 feet, near Glenpipe, falling to 150 below Firgrove, and the River Nore receives it between Thomastown and Inistioge, at a level below 30 feet. The other valley is not traversed by any river, a small watershed crossing it from E. to W.

* There is an excellent panoramic sketch of the beautiful view from Mount Alto in Mr. Weaver's Paper on the Geology of the S.E. of Ireland, in Transactions of the Geological Society of London, Vol. V., First Series.

about Catstown and Castlegannon, the lowest point of which seems to be about 320 feet. This separates the brooks running N. to the Nore from others which flow S. to the Suir.

It is a curious fact, in the physical geography of Ireland, that the channels of the Barrow and the Nore should leave the central limestone plain by thus traversing with deep cuts hilly and rocky ground, the general or mean level of which is far greater than that of the inland country which the rivers flow across. The valley of the River Nore, indeed, before it reaches the hilly country in this district, has already cut through another group of hills which intervene between the plain of Borris-in-Ossory, and that of Kilkenny.

It is clear that, in these instances, it has been the previous excavation of the valleys which has caused the rivers to flow down them, and not the flow of the rivers which has excavated the valleys. For if these valleys were filled up to half the height of the adjacent grounds, the rivers would find much lower points of escape, either northwards towards the Liffey or the Shannon, or southwards to the Suir and the Blackwater, and would certainly never have run through the heart of the mountains if the valleys had not been already prepared for them.

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

Aqueous Rocks.

		Colour on Map.
	Alluvium, Bog, or other superficial covering,	*Pale sepia.*
	Drift (limestone gravel),	*Engraved dots.*
Upper Palæozoic. — *Carboniferous.*	d^5. Coal Measures,	*Indian ink.*
	d^4. Upper Limestone,	*Prussian blue (dark).*
	d^3. Calp, or Middle Limestone,	*Prussian blue and indigo.*
	d^2. Lower Limestone,	*Prussian blue (light).*
	d^1. Lower Limestone Shale,	*Prussian blue and Indian ink.*
	md. When any of the above limestones are magnesian from original deposition,	*Olive green.*
	$\mu\delta$. When magnesian from subsequent dolomitization,	*Olive green with blue dots.*
Upper Palæozoic. — *Old Red Sandstone.*	c^3. Upper Old Red or Yellow Sandstone,	*Indian red (dark).*
	c^2. Old Red Sandstone,	*Indian red (pale).*
Lower Palæozoic. — *Lower Silurian.*	b^2. Bala beds,	*Pale purple.*
	β. Do. when metamorphosed into mica schist, and gneiss,	*Pale pink.*

Igneous Rocks.

Greenstone, or Diorite,	*Dark crimson.*
Greenstone Ash,	*Light crimson, dotted.*
Elvan,	*Dark carmine.*
Granite,	*Carmine.*

The Lower Palæozoic Rocks.

b². *Lower Silurian Rocks.*—No fossils have been found in these rocks within the area included in these two sheets of the map. When, however, they are followed into adjacent districts on the east and south, they are found occasionally to contain fossils of the same species as those found in the Bala beds of North Wales, and hence the whole group is assumed to belong to that formation. It is, however, quite possible that some or all of the rocks in this area are either lower or higher than the actual group of the Bala beds; but as there is no reason for drawing any broad line of separation between the fossiliferous and the unfossiliferous parts, we may feel sure, at all events, that they all belong to the Lower Silurian period, and are on or about the horizon of the Bala beds.

The rocks consist of earthy clay slates and thin, fine-grained, siliceous grits. Their most usual colours are dark gray, often with a greenish tinge; but they sometimes are more nearly black, and occasionally become red, or variegated red and green.

Nothing definite can be said as regards their thickness, or as regards the order of succession of their different parts, since no large continuous sections are to be seen in them. There are, however, frequent small exposures of them, in which they commonly appear to dip at very high angles, often in different directions, but sometimes in the same direction for considerable distances. Their thickness must, then, certainly be several thousand feet, since neither the base nor the summit of the group is anywhere discernible, and the different portions visible are often several hundred feet thick.

β. Lower Silurian Rocks Metamorphosed into Mica Schist, and Gneiss.—It invariably happens as we proceed from the parts of the country remote from the Granite, towards the spots where that rock appears at the surface, that a most marked change is perceptible in the lithological character of the Silurian rocks. The change is most striking and most universal in the clay slates, but is often more or less apparent in the gritstones.

At a distance from the granite the clay slates are generally dull and earthy, having little or no lustre even on their smoothest surfaces. If mica occurs, either in the grits or slates, it has the form of minute spangles, each little flake being separated and distinct from the rest, and generally of a rounded form. When, however, we arrive within a certain distance of the granite, that is within one or two miles (as the case may be) of the appearance of the granite at the surface, the clay slate begins to assume a lustre, its surfaces having, as it were, a glaze on them, which is visible throughout the mass, however it may be broken up, and is even perceptible in the dried mud, derived from these rocks, as it lies on the road side. There are no more distinct mica spangles visible here than elsewhere; but the substance of the rock itself glistens with a silvery lustre.

Still nearer to the granite we find no longer any rock that would be called clay slate, but different varieties of schistose, foliated rocks, such as would be called talcose schist, chloritic schist, or mica schist and gneiss. The rocks have also that wrinkled or minutely corrugated

structure so common in mica schist. Where the argillaceous rocks had grit bands of one or two inches thick interstratified with them the corrugations are wider, and the grits are often but little altered except that they appear lighter in colour, and more purely siliceous, and rather more resembling quartz rock in texture. The foliation, or splitting of the micaceous layers in these instances, is strictly parallel to the curves in the grit beds, showing that the foliation coincides with the bedding.

Immediately on the margin of the granite, the grit bands are often still more highly metamorphosed, and become fine-grained gneiss, and, in some instances, coarse-grained gneiss, with large crystals of feldspar developed in it.

In the detached patches included within the general granite area, the metamorphism is still more highly marked, the specimens of gneiss and mica schist being quite undistinguishable from those of the Highlands of Scotland, or any other so-called "primitive or crystalline" country.—(See postea, pp. 28 to 36).

It must be understood that the pink colour, which is drawn in the one-inch map everywhere round the margin of the granite, is only meant as a visible representation of the general fact of metamorphism. It is not at all intended that the outward boundary of that pink colour should be a strict representation of the line where that metamorphism ceases. Some of the slates outside of that line may be more metamorphosed than others that lie within it In the majority of instances, however, the nearer to the granite, the more complete is the metamorphic action. To endeavour to represent, except in a vague and general way, an equal amount of metamorphism by equal tints, would have been a hopeless and a useless task; neither would it have been advisable to have left the colourer without some guide. It was, then, necessary to draw a boundary for the metamorphic colour, within which that influence is always certainly apparent, but beyond which it is also occasionally perceptible to an indefinite amount, and an equally indefinite extent.

The Upper Palæozoic Rocks.

c. *The Old Red Sandstone.*—The Old Red sandstone rests quite unconformably on different parts of the Lower Silurian rocks, and stretches across them on to the Granite.

Its base sometimes contains fragments of the slate or granite on which it rests. It is a coarse, brownish red sandstone below, often becoming conglomeritic from the presence of quartz pebbles. Higher up, the sandstones are finer grained, and sometimes become shaly and argillaceous. The colours are sometimes green or gray, but red predominates throughout.

In the upper part, which is separated from the rest under the name of the Yellow or Upper Old Red sandstone, there occur many beds of yellow sandstone, and of green, or greenish yellow, fine-grained argillaceous rock, interstratified with bright red sandstones or red shales. Some of these very fine-grained, greenish coloured, beds seem to be nothing but indurated clay, without any fissile structure entitling

them to be called either shale or slate, and might be conveniently called "clay-rock."*

No fossils have yet been found in any of the lower parts of the Old Red sandstone, but in the upper part the remains of plants are abundant, and some shells and fish-remains occur. These are described by Mr. Baily in his Palæontological Notes.

The total thickness of the Old Red sandstone may be taken at about 700 or 800 feet at a maximum in the southern part of the district, but it thins out as we proceed northwards until the last traces of it are perceptible a little east of Goresbridge, beyond which it completely dies away and disappears.

The Carboniferous Limestone.—This formation has been subdivided in this district into four subordinate groups.

d¹. *The Lower Limestone Shale* is the lowest of these. The top beds of the Upper Old Red or Yellow sandstone are seen in some places to consist of calcareous sandstones, interstratified with dark shales; over these are other beds of dark shale, often calcareous, or with thin, flaggy, and nodular beds of dark limestone. The limestones become more frequent as we ascend, and shortly assume the preponderance, so that we have beds of dark limestone above, and of calcareous sandstone below, each interstratified with shales, and separated from each other by a few feet of more or less pure shales.

The whole of this little group, of which the entire thickness never exceeds 150 feet in this district, is highly fossiliferous. Small bivalves (? modiolæ) sometimes appear in the sandstones below, and abundance of Encrinites, Fenestellæ, Spiriferæ, &c., in the shales and limestones above.

The appearance of marine shells always marks the basal boundary of the Carboniferous group, no marine shells having hitherto been found anywhere in the Old Red sandstone.

d². *The Lower Limestone* is generally a dark gray, often nearly black crystalline limestone. The lower beds, immediately above the Lower Limestone shale, are generally thick, and excessively crinoidal, seeming to be made up of fragments of encrinites. Higher up it is often more flaggy, while its uppermost part is very magnesian, with the bedding greatly obscured and often nearly or quite obliterated. In this magnesian part the fossils are often equally obliterated. This dark, sometimes black, magnesian limestone, seldom contains sufficient magnesia to become a true dolomite, though often enough to enable the observer to distinguish it by its sugary texture and appearance, and sandy feel, from the gray, non-magnesian limestone with which it is associated. It occurs in such a regular band across the country, running so parallel to the strike of the other rocks, and is sometimes so completely interstratified with them, that we have preferred to look upon it as an original deposition of more or less magnesian limestone, and distinguish it from other true dolomites to be mentioned presently.

This subdivision has a probable thickness of about 1,200 feet.

* "Clay-stone" is a name that has been already applied to a variety of igneous rock; and though it is now going out of use, yet, to avoid any ambiguity, the word "rock" has been adopted instead of "stone."

d³. *The Calp or Middle Limestone.*—This sub-group consists of black limestone, generally compact or very close-grained, sometimes earthy, with frequent partings of black shale between the beds, and sometimes beds of black shale about four or five feet thick, the whole being regularly and generally thinly bedded. Some of the beds afford black marble.

Fossils occur occasionally and sparingly throughout, but not in such abundance as in the other sub-groups. Except the rarity of fossils, however, there cannot be said to be any palæontological distinction between this and the other carboniferous groups.

The thickness of this sub-group may be taken at about 600 or 800 feet.

d⁴. *The Upper Limestone.*—These beds are generally massive, gray, crystalline limestone, the colours being dark gray below, but much lighter as we ascend towards the higher beds, which are almost invariably pale gray limestone up to the base of the Coal Measures.

It often abounds in fossils; large Productæ and fine corals being much more abundant in it than in the lower beds.

The thickness of the sub-group may be taken at about 1,500 feet.

In some parts of the Upper Limestone, extending apparently within the general limits of the Calp, there occur large masses of highly crystalline dolomite, generally of a pale yellow colour. These are very irregular in form and mode of occurrence, coming in suddenly across the general strike of the beds, and often enclosing pieces of non-magnesian limestone. In one instance, at least, the dolomite assumes a dyke-like form, running for some miles across the country and across the strike of the beds, with a width of about a quarter or half a mile, and terminating quite suddenly on each side along well-defined boundaries.

d⁵. *The Coal Measures* here, as elsewhere in the centre of Ireland, consist of black and olive coloured shales below, interstratified with gray or greenish grits and flagstones above, over which come other alternations of clay, shales, and sandstones, containing a few thin beds of coal. Of these beds of coal only the two lowest appear to occur within this area, and that only in one locality, about two miles N. of Castle Warren. These may probably be looked upon as coals Nos. 1 and 2 of the Castlecomer field (see Explanation 137), and the probable total thickness of Coal Measures within this area may, therefore, be taken as not exceeding 1,500 feet.

Igneous Rocks.

D. *Greenstone or Diorite.*—Some masses of highly hornblendic greenstone occur in the district included in Sheet 157, with crystals of dark hornblende and pale green feldspar, sometimes as much as a quarter of an inch across.

Another variety is finer in grain, but still with very distinct crystals of dark hornblende, pale feldspar, and flesh-coloured feldspar, making a very handsome rock. A few spangles of bronze-coloured mica are sometimes scattered about it, and little crystalline granules which may possibly be quartz, in which case it would pass into a syenite.

These two varieties of Greenstone have possibly been metamorphosed by the subsequent intrusion of Granite (see p. 34).

In another district the greenstone is still finer and more nearly compact, forming a more common variety of the rock.

There is yet another variety of igneous rock which is coloured as a greenstone though its characters are more obscure. It is very hard and tough, of a pale green colour, with large and distinct, but not well developed crystals of pale earthy looking feldspar scattered through a rather mottled dark and light green base, which may be hornblendic or contain the constituents of hornblende, although no distinct crystals of that mineral are apparent. Spangles of bronze-coloured mica, however, are said to have been observed in it here and there.

This is the rock which occurs near Ballyneale, associated with greenstone ash.

Greenstone Ash.—The rock coloured and lettered as greenstone ash, is a fine grained, laminated, and rudely stratified rock, of a green colour, and a flaky texture, made up of minute feldspathic particles, among which are some, that from their dark green colour, may possibly be of a hornblendic nature. It is not certain whether its splitting into thin parallel layers be due to the original lamination of deposition, or to a subsequent cleavage; but the stratification, although sometimes rude and indistinct, is clearly true stratification, and not mere jointing, since it is quite distinguishable from the numerous joints by which the rock is traversed.

Granite and Elvan.—The granite is apparently of the same composition throughout, as that of the Dublin and Wicklow mountains generally. It consists of feldspar, two varieties of mica, the black and the white, and a considerable proportion of quartz. (See Explanation of Sheets 102 and 112, and a paper by Professor Haughton and myself, in Trans. R. I. A., vol. xxiii.) It is, for granite, a very perishable stone, often decomposing on the ground to considerable depths. All the large blocks on the hill side are weathered, even to the centre, of a dirty rusty brown colour, and easily broken down into sand. When used as a building stone, it soon acquires rusty blotches, which eventually spread over the whole surface, and finally crumble away.

The granite veins, or elvans, which occur only in the immediate neighbourhood of the granite, differ from the mass partly in the rareness or absence of mica, and partly in the fineness of their grain, the crystals of feldspar and quartz being often exceedingly minute, so that in a hand specimen the rock might be mistaken, at first sight, for one of the fine grained gritstones which occur in the Lower Silurian beds. Other elvans, however, are coarser, showing imperfectly crystalline granules of feldspar and quartz, with now and then a small plate of mica.

J. B. J.

3. *Palæontological Notes.*

The most remarkable fossil locality within the boundary of Sheet 157 is that on the top of Kiltorcan Hill, near the Ballyhale Railway Station. It derives its great interest, not only from the perfect state of preservation and abundance of the organic remains found there, but also from the more important fact of the probable relation of this and similar deposits in Ireland, to certain beds belonging to the Old

Red sandstone of the North of Scotland and the Orkneys, described by Sir R. I. Murchison.*

The rock in which these beautiful fossils occur is a greenish yellow sandstone, fine, and coarser grained; the fine-grained compact variety readily separating into large slabs of a uniform thickness. The beds dip at a very low angle, probably not more than four or five degrees to the S.W. On a casual inspection, about two years ago, I found the section exposed was the following, in descending order:—

No. 1. A superficial deposit from eighteen inches to two feet in thickness, composed of broken fragments containing the same plants as the beds beneath.

No. 2. Fine-grained greenish sandstone separating into layers, with Adiantites Hibernicus and other plants; one foot.

No. 3. Coarser sandstone, *not* readily splitting into layers, with Coccosteus and other fish remains, and a few fragments of plants.

No. 4. Fine-grained sandstone, readily splitting into layers, containing Adiantites Hibernicus, and other plants; the lower layers being coarser, with large but not well preserved specimens of the same fern.

A more extensive working of these beds would be very desirable,† trifling excavations only having been hitherto carried on in them; and that principally for scientific investigation, the stone not being a durable one for building purposes.

As it is intended to publish a separate memoir on this district, with detailed descriptions of the organic remains, it will be unnecessary to give here more than a sketch, illustrated by a few figures of some of them, as an aid in directing attention to this particularly interesting and important fossil locality.

The majority of the fossils found in this locality are those of plants. The most abundant amongst them are the detached fronds of one of the most ancient tree ferns, Adiantites Hibernicus, Fig. 1, p. 14, which was first made known by Professor Edward Forbes, at the meeting of the British Association, at Belfast, in 1852, and referred by him provisionally to the genus Cyclopteris. M. Adolphe Brongniart has since removed it from that genus in consequence of its possessing an intermediate pair of leaflets between the pinnules; for this and other reasons he considered it to possess generic characters more allied to Sphenopteris, and therefore referred it to Adiantites, a section of that genus to which in his opinion it bore the greatest resemblance.‡ It has since received additional interest from the discovery of several specimens exhibiting various stages of fructification, and illustrating other parts of its structure. Fig. 1, p. 14, *a* is a representation in outline, somewhat restored, of a large portion of one of the fronds reduced to one-sixth of the natural size;§ *b* is a sketch of one of the leaflets, natural

* Quart. Journ. Geol. Soc. of London, 1859, vol. xv., p. 354, &c.

† This has since been done, about twelve square yards of the fish-bed having been bared by our two Fossil Collectors, under Mr. Baily's directions: a great number of fine scales and fragments of fish were procured; but no entire fish, or any thing which appears, on a cursory inspection, very different from what has been got before.—J. B. J.

‡ See Sir R. Griffith and M. Adolphe Brongniart, on the Fossil Plants of the Yellow Sandstone; Journal of the Royal Dublin Society, 1857, p. 313, and Journ. Geol. Soc. of Dublin, vol. 7, p. 287.

§ The largest fragment of a single frond of this magnificent fossil fern collected by the Geological Survey, and placed with the other specimens from this locality in the Palæontological Gallery of the Museum of Irish Industry, measures two feet long by one foot ten inches broad.

size, showing the venation by longitudinal striæ, which are occasionally forked; *c* is a single branch in fructification, taken from another specimen; it shows the spore cases which were originally aggregated into clusters and granulated.*

Fig. 1.

Adiantites Hibernicus has been found at other localities in the neighbourhood, viz., at about a mile and a half on the road side near the Corn mill, on the road to Ballyhale; at Jerpoint, south of the abbey, and in the cutting of the Waterford and Kilkenny Railway, at Ballyhale;* also near Cork, at Tivoli Villa, accompanied by Anodonta Jukesii, and at other localities further west.† In Scotland it is said to occur in the Upper Old Red sandstone, associated with Holoptychius and other genera of fish, not hitherto met with at Kiltorcan.‡

* Mr. H. T. Humphreys, of Woodview, Merrion-avenue, Blackrock, to whom we are indebted for the loan of several interesting specimens, from the fine collection made by him at this locality, was the first to discover this fossil fern in fructification.

Fig. 2.

The only other remains of fossil ferns hitherto observed from this locality are two well preserved specimens of a very distinct species, described by me in a paper read before the British Association, at Aberdeen,§ under the name of Sphenopteris Hookeri. A figure in outline of this specimen is given, Fig. 2 *a*, reduced to a little more than half natural size; it has a slender rachis or stalk from which proceeded branches of bipinnate leaves, dividing into several obtusely terminated segments; *b* is an enlarged portion of one of the branchlets of leaves, showing the diverging and forked character of the veins.

The other associated plants, consist of a large group with fluted and punctated stems and branches of a peculiar character, and an arrange-

* Vide a paper on Cyclostigma, &c., by the Rev. Prof. Haughton, read before the Royal Dublin Society, May 27, 1859, in the Nat. Hist. Review, vol. 7, p. 209.

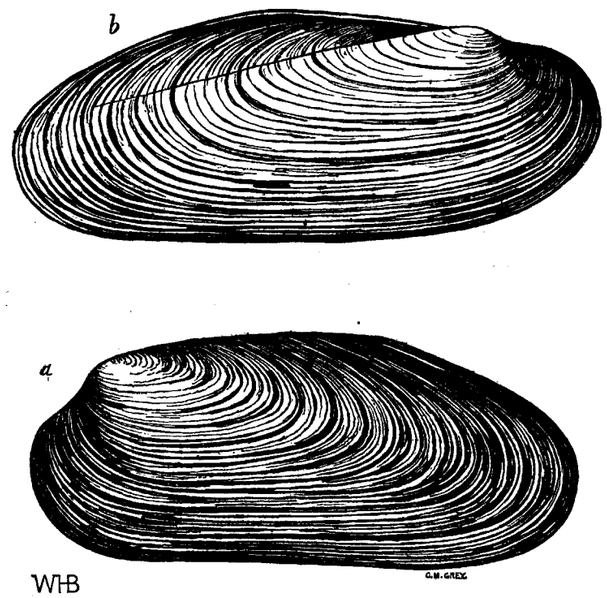
† Notes on the Classification of the Devonian and Carboniferous Rock of the South of Ireland, by J. B. Jukes and J. W. Salter, in the Journ. Geol. Soc. of Dublin, vol. 7, p. 63.

‡ See the Table of Characteristic Fossils from the Old Red Sandstone, by Sir R. I. Murchison, in the Quart. Journ. Geol. Soc. Lond., vol. 15, p. 437.

§ Vide Report of the Twenty-ninth Meeting of the British Association, at Aberdeen, in September, 1859—Transactions of the Sections, p. 98.

ment of leaf scars and leaves in alternate whorls. They have been formed into a new genus, Cyclostigma, by the Rev. Professor Haughton, several species having been described by him in the paper before quoted. There are also fragments of cone-like bodies, which bear a close analogy to the fruit of Lepidostrobus, described and figured by Dr. J. D. Hooker.*

Fig. 3.



WHB

The large bivalve shell, Anodonta Jukesii, *Forbes*, of which figures are given above (reduced to half natural size), is rather abundant at Kiltorcan Hill, occurring with the plants before mentioned; no other mollusc having hitherto been found in those beds. It is closely allied to the fresh-water mussels of the present day, being referred to an existing genus which is remarkable for the thinness of its shell, and the absence of hinge teeth. Fig. 3, *a*, exhibits the exterior of this elongated shell, with its well marked lines of growth, characters common to existing fresh-water unios and river mussels; *b* is from a cast of the interior of the left valve of a very large specimen; it shows the impression or cicatrice of the adductor muscle, and the straight toothless hinge line.

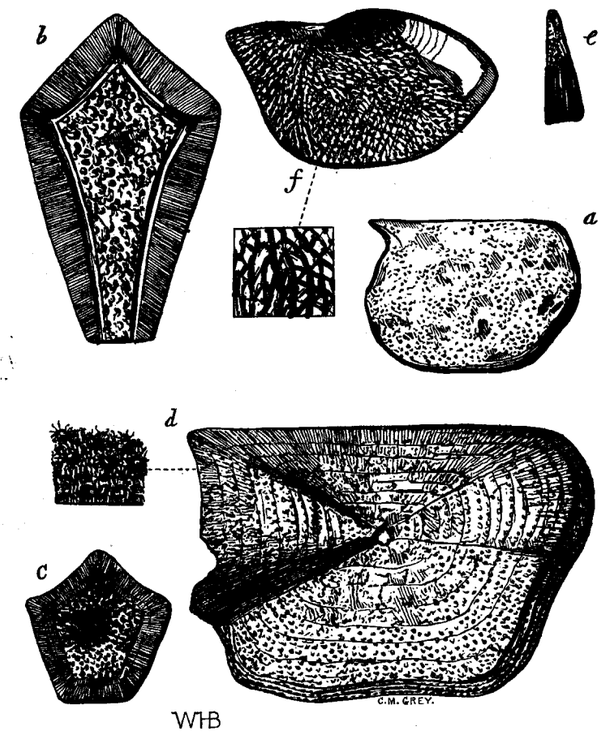
Fragments of a Crustacean, doubtfully referred to Eurypterus Scouleri(?) *Hibbert*,† by Mr. Salter, have been also found with the plants and other fossils at Kiltorcan.

* Memoirs of the Geological Survey of Great Britain, vol. 2, part 2, p. 440, &c.

† Vide a paper by J. W. Salter, in the Quart. Journ. Geol. Soc. London, 1859, vol. 15, p. 232.

The most interesting and important of all the organic remains from this locality are, however, the Ichthyolites. These consist principally of bony scutes, or the separated osseous plates of ganoid fishes, peculiar to the Old Red sandstone. The majority of these fish remains (a group of which is shown, Fig. 4), unquestionably belonged to Coccosteus; there are others again which may be referred to the genera Asterolepis, and probably to Bothriolepis and Pterichthys. Two detached teeth are the only remains of a dental character yet found. They are both conical and ridged, resembling very closely M. Agassiz's figures of the larger teeth of Bothriolepis, to which genus one of the scutes, Fig. 4, *f*, may also be referred. On a more detailed examination of the large collection we already possess, other genera may possibly be added to those above mentioned.

Fig. 4.



WHB

At Fig. 4 are represented some of the forms of teeth and scutes, before mentioned, of the natural size—*a* being one of the plates of

the buckler of Coccosteus, having a finely granulated surface,* almost identical with a specimen from Altyre, in Scotland; *b* and *c* are probably intermediate plates of Coccosteus(?) *d* is a large plate of the Asterolepis, the magnified portion showing the beautiful star-like character of its slightly granulated surface. On comparison I found this almost exactly similar in character to a specimen from the Orkneys, and had little hesitation therefore in referring it to that genus; *e* represents one of the teeth before mentioned, as agreeing more with Agassiz's figure of Bothriolepis, than with that of Dendrodus to which it had formerly been referred. The peculiar character of the scute *f*, as shown by its magnified surface, would also favour the supposition of its belonging to the former genus.

The identification of these fish remains clearly indicates their belonging to genera, the majority of which are said to be confined to that division of the Old Red sandstone of Scotland called "Caithness Flags," according to the table of characteristic fossils from that formation appended to the paper by Sir R. I. Murchison, before quoted.†

The assemblage of organic remains from this locality all favour the supposition of a fresh-water origin for the deposits in which they are imbedded. The large fern being so abundantly distributed throughout the beds, and in such a comparatively undisturbed condition leads to the conclusion that it grew and flourished close to the spot where its remains are now entombed, which may have been the margin of a fresh-water lake.

The molluscan shell is certainly a fresh-water species, and there is no conclusive evidence here, at least, against the peculiar crustacean and fish having also been inhabitants of fresh water; Sir R. I. Murchison informs us that in Russia "fish belonging to genera characteristic of the Old Red sandstone, are associated in the very same beds with sea shells, corals, and crinoids," a fact which he considers sufficient to upset the theory of the fresh-water origin of the Old Red Ichthyolites. With all due deference I would, however, suggest that the beds he alludes to in Russia may have been deposited under estuary conditions, thus causing a mixture of fresh water and marine species, an occurrence which is not unusual in bays at the present day.‡ April 4, 1861. W. H. B.

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4. *Relations between the Form of the Ground and its Internal Constitution, and general sketch of the latter.*

The high ground spoken of in page 5 as occupying part of the northern margin of the district, is composed of the Coal Measures, being, in fact, the southern edge of the elevated, basin-shaped, plateau of the Castlecomer Coal field (see Explanation of Sheet 137, and engraved longitudinal sections, Sheets 1, 2, and 3, New Series).

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* Taking advantage of the opportunity offered by the meeting of the British Association, at Aberdeen, to consult the fine collection of Old Red sandstone fishes in the Museum of Marischal College, brought together on that occasion, I found the fish remains of Kiltorcan bore the nearest comparison to those from Altyre in Morayshire, and to others from the Orkneys. W. H. B.

† Quart. Journal, Geol. Soc. of London, vol. 15, p. 437.

‡ A good example of such a case is described by Mr. Jukes in Excursions in Newfoundland, vol. 2, pp. 23, 29. W. H. B.

The plain of Kilkenny, that spreads round this high land towards the south and east, is formed by the Carboniferous Limestone.

The Carboniferous Limestone rises out directly from underneath the base of the Coal Measures. Towards the east this rise seems to be regular and continuous, so that, within the space of about three miles, the whole of the beds of the formation rise up successively to the surface, and allow of the appearance of the rock that lies below the Limestone, which is here Granite.

Towards the south, however, the rise of the limestone beds is not so regular and continuous, since, after rising to the surface, they often arch over and dip in various directions, and then rise up again, so that they spread in undulations over a greater area than they do towards the east.

Still, notwithstanding these local irregularities, they strike, on the whole, pretty regularly N.E. and S.W., and rise towards the S.E., so that in the latter direction we come successively on lower and lower beds, passing from the Upper Limestone across the Calp, to the Lower Limestone and Lower Limestone shale, until we come eventually on the formation that lies below the Carboniferous Limestone, which, in this direction, is found to be Old Red sandstone.

As we pass from the Carboniferous Limestone plain between Bagenalstown and Goresbridge into the Granite country that lies east of it, we should not be aware of any very striking change in the form of the ground. It was said before, page 6, that the country towards the east was rather more hilly and rocky, and had a slightly greater general altitude than the plain of Kilkenny, and we should see that, in travelling eastward, we were approaching actual mountains, which rise in that direction beyond our present district. Notwithstanding the absence of any marked change in the form of the ground, we, nevertheless, pass at once from the Carboniferous Limestone on to a widely spread region of Granite, which is here the rock that lies directly below the limestone. The change takes place along a slightly curved line, running nearly N. and S., and attentive observation will show a small bank running along the known or supposed boundary of the two formations.

There would, doubtless, be a more marked alteration in the aspect of the country, as we pass from the limestone on to the granite, if it were not for the thick covering of limestone gravel which is spread over both rocks, or rather which spreads from the limestone district more or less over the lower grounds of the granite area. As we proceed eastwards, the difference between the two districts becomes more apparent, and still more as we go southwards; the granite region in both directions becoming loftier, and showing more distinctly hills of the peculiar rounded, mound-like forms, always assumed by granite.

In travelling southwards from Bagenalstown, along the boundary of the two rocks, we should first meet with evidence of some other rock interposed between them in a quarry of Old Red sandstone, about a mile E. of Goresbridge. South of that, by Thomastown and Ballyhale, a regular ridge makes its appearance, rising gently up from beneath the limestone plain to heights of 400 or 500 feet above the sea, and increasing in importance as we go southwards. This ridge is made of Old Red sandstone, and, except at Thomastown, where it

is cut through by the valley of the Nore, it is continuous down to the southern margin of the district and beyond it. It rises, in some places, to altitudes of more than 800 feet, and forms high, barren, heathery moorlands, in the parishes of Derrynahinch and Jerpoint West.

The beds of Old Red sandstone comprising it, dip very gently to the N.W. and W. and are often nearly horizontal at the top of the ridge. As far as Ballyhale they pass to the N.W. under the Carboniferous Limestone, but S. of that village they are not covered by any higher formation, the beds flattening in the valley of the Kilkenny and Waterford Railway, and then rising gently up towards the eastern margin of the Nine-Mile-House table-land (in Sheet 156).

There are four outlying patches of Old Red sandstone capping hills outside (to the eastward of) its general boundary. One of these is on the N.W. slope of the hill called Freagh Hill (in Sheet 147), and attains an altitude of 1,045 feet. Two smaller ones occur a mile or two S. of that (in Sheet 157) one forming Bishop's Hill, and the other the summit of Coppanagh Hill, 1,202 feet high. The fourth is marked near the southern margin of Sheet 157, just N. of Ballintlea.

The two largest of these outliers lie on the line of watershed between the rivers Nore and Barrow, showing distinctly that they were left there by the denuding forces having spared them while they cut more deeply down into the country on each side of them.

The line drawn along the boundary between the Carboniferous limestone and the Granite in the northern part of the district, and continued along the lower boundary of the Old Red sandstone in the southern part of the district, is the line of separation between the ground formed of the Upper Palæozoic formations, and that composed of the much more ancient Lower Palæozoic rocks.

The Upper Palæozoic rocks are the Old Red and Carboniferous formations, while the Lower Palæozoic comprise here the Lower Silurian beds and the Granite, which has been intruded into them, and converted part of them into mica schist and gneiss.

The hills which lie between Dungarvan and Graiguenamanagh, called Croghan and Coppanagh Hills, and the ground about them, are composed of the Lower Silurian rocks, which in some places are corrugated and "micacised" (if we may be allowed to coin such a term); but in others remain as blue clay slate.

The point of 1,608, called the White Mountain, about three miles and a half E.N.E. of St. Mullins, and forming part of the ridge stretching from Mount Blackstairs, is on the Granite, though the mica schist comes nearly up to it on the S.E. Brandon Hill is similarly granite about the summit, with mica schist, soon passing into unaltered clay slate, on its western slopes. Although these, the two highest pieces of ground in our district, are formed of heavy looking, gently swelling mounds of granite, it by no means follows that that rock always makes higher ground than the adjacent metamorphic rocks. In the high land that stretches S.W. from Brandon Hill to the Nore, detached patches of granite make their appearance at the surface, scarcely rising higher than the mica schist immediately about them, while there is higher ground between them and the summit of Brandon made entirely of mica schist. In the two detached masses of granite to the west of the Nore, the exhibition of that rock at the surface is in each case

chiefly due to the excavation of a valley down through the covering of metamorphic rock into the granite which lies below; without which excavation very little of the granite would have been visible.

Wherever, indeed, within the granite area or immediately on its borders the ground is higher than usual, we there have the surface boundary between the mica schist and the granite most irregular, and small outlying patches of metamorphic rock are most frequent upon it, and, on the contrary, when the granite ground is low, there its surface boundary is most regular and even, and the granite area is most free from isolated patches of mica schist when once that boundary is passed.

These facts are quite intelligible on the supposition that the original surface of the granite on its first consolidation was an irregularly undulating one, with ridges and hollows on which the slates rested, and *against*, and, as it were, *down into*, which they often apparently dipped; when the ground is comparatively high, that is, where the denudation of the ground has been comparatively least, there we have the original irregularly undulating surface of the granite most nearly preserved, and, consequently, its surface boundaries are most irregular and its apparent alternation with pieces of mica schist most frequent. Where, on the other hand, the granite has been most deeply cut down into, there we have these original irregularities of the surface of the granite most completely removed, and get most deeply towards the heart of the original mass of rock, into which it was impossible for the superincumbent masses of mica schist to penetrate, however great might have been the pressure upon them, or however fluid the consistence of the granite.*

The facts now summarized, of which the detailed description will be given in the following pages, will be found to lead to the following conclusions:

First—The Lower Silurian slates and grits, after being horizontally deposited in the waters of some sea, and acquiring a thickness of several thousand feet, were invaded from below by the intrusion of a vast molten mass of matter, which, on cooling, formed granite, and were violently crumpled and contorted, so as to have their once horizontal beds tilted and bent into highly inclined positions in many directions.

Whether the intrusion of the granite and the disturbance of the beds was a simultaneous action, is not certain. I am myself, from consideration of the facts on the ground, inclined to the belief that the beds were greatly disturbed before the intrusion of the granite, perhaps in consequence of its disturbing effects upon them while it was working its way upwards through still lower rocks, and that the beds were already highly inclined in different directions when the granite came in contact with those parts which now touch it.

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* Should any geologist have any doubt on his mind as regards the deep-seated, igneous origin and upward intrusion of granite, or as regards the purely metamorphic formation of mica schist out of argillaceous, and gneiss out of arenaceous, rocks, he could hardly find a better district for the removal of those doubts than the one now treated of. If he walk from New Ross to Pollmounty, and examine the abundant evidence in that district, and then examine the country S. and E. of Inistioge, and the immediate neighbourhood of Graiguenamanagh, he will, with myself, find every lingering doubt remaining from the old traditions of the ancient geology disappear from his mind.—J. B. J.

Second—The heat (or other influence) derived from the granite converted the clay slates and grits into mica schist and gneiss, for a distance of some hundred feet from the surface of the granite, that effect gradually disappearing and becoming evanescent beyond that distance.

Third—The rocks were subsequently acted upon by a denuding agency, which gradually removed and swept away a thickness of many thousand feet of the Lower Silurian formation, and exposed at the surface beds once at a great depth below it.

If we allow that the molten rock could only form granite when cooled and consolidated at a great depth below the surface, and that if poured out on the surface, or even brought near it, it would have produced, on consolidation, another variety of igneous rock, the appearance of granite at the surface may be taken at once as proof of the subsequent denudation.

We have, however, in the district, no lack of evidence of vast denudation, independently of that appearance of the granite. Great series of beds, sometimes several hundred feet thick in single detached sections, rise up at a high angle, and terminate abruptly at the present surface of the ground. It is clear that when those beds were horizontal, they did not terminate thus abruptly, but were continued for an indefinite distance. There must then, in this contorted district, be now many detached portions of the same set of beds that were at one time continuous all over it. The connecting portions, and the continuations of all the beds which thus terminate abruptly at the present surface of the ground, have been removed subsequently to the tilting and bending of the beds, or were, perhaps, partly removed during the disturbing process, and partly since that process ceased to act.

Fourth—This denudation took place at a period prior to the deposition of the Old Red sandstone.

This is shown by the fact that the base of the Old Red sandstone, now rests on the upturned denuded edges of the Lower Silurian beds, stretching from them on to the granite, and from that again to different parts of the Silurian rocks; and also that the Old Red sandstone is not altered or affected by the granite, but, on the contrary, contains fragments of it, and is partly made out of the debris of that rock and of the slates.

In like manner, where the Old Red sandstone gradually dies out and disappears, the base of the Carboniferous limestone rests upon the granite and is unaltered by it.

It is clear that along the lower boundary of the Upper Palæozoic rocks, we have the original surface on which those rocks were deposited, and that the bottom of the water in which that deposition took place, was formed of the bare Granite and denuded edges of the Lower Silurian rocks, just as much as would the bottom of the sea now be so formed if the whole Granite and Lower Silurian area were depressed beneath the sea.

Fifth—The deposition of the Old Red sandstone thus unconformably on the Lower Palæozoic rocks was followed by the regularly successive and conformable deposition of the Carboniferous limestone and Coal Measures.

Sixth—That deposition was succeeded, during some subsequent* unknown period or periods, by movements of disturbance acting from below, and the agency of denudation acting from above, so that the Upper Palæozoic rocks were, in their turn, tilted, bent, and broken, and large parts of them removed by denudation.

Arguing from the abrupt termination of the Upper Palæozoic beds at the present surface of the ground, in the same way that we did with respect to the Lower Palæozoic beds, we arrive at the conclusion that these also spread at one time over a much wider area than they do now, and from their position we at once see that this former spread must have been towards the south-east of their present termination. Much, then, if, indeed, we may not say all, of the Lower Palæozoic country on the south-eastern side of the district, was formerly covered by horizontal, or nearly horizontal, beds of Old Red sandstone, and that by beds of Carboniferous limestone, and those again by the continuation of the Coal Measures.

By drawing sections through the outliers of Old Red sandstone already spoken of, we can restore, to a slight extent, the original floor of the water, or the surface of Lower Palæozoic rock, on which that Old Red sandstone was deposited (see figs. 7 and 8, page 37, and forthcoming engraved Longitudinal Sections.)

This gives us some idea of the amount of denudation that has acted on the Upper Palæozoic rocks, and also of that which has again been brought to bear upon the Lower Palæozoic rocks, after they had been again uncovered and brought to the surface by the stripping off of the beds of the Upper Palæozoic rocks.

Great as has been this subsequent destruction of the Lower Palæozoic rocks, however, it is easy to see that their denudation before the deposition of the Old Red was far greater.

Seventh—No deposition of any more recent formation than the Coal Measures is known within the area, until that of the gravel and other superficial "drift" which was scattered over the country during the glacial or pleistocene period.—J. B. J.

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* It is most probable, if we judge from analogy with what is known in other parts of the British Islands, that the chief part of the denudation of the Upper Palæozoic rocks took place before the deposition of the New Red sandstone, just as that of the Lower Palæozoic rocks chiefly took place before the deposition of the Old Red sandstone.

Detailed Descriptions.

[The country included within the limits of these two sheets of the map was surveyed by Mr. W. L. Willson, now of the Geological Survey of India, and Mr. A. Wyley, formerly of the Geological Survey of Ireland, and since Superintendent of that of the Cape of Good Hope.

The following detailed descriptions have been drawn up, chiefly from their notes, by myself.]

J. B. J.

5.—*Position and lie of the rocks.*

From the way in which the rocks are disposed in this district it will be best to commence with the details of the Lower Palæozoic rocks, and we will take first the neighbourhood of New Ross.

Lower Palæozoic Rocks.

Neighbourhood of New Ross.—Immediately S. of New Ross, on the road side, may be seen greenish, brownish, and purplish slate, sometimes slightly micaceous, in thick massive beds, much contorted, but, on the whole, dipping S.E. at 30°. Similar beds may be seen further S., about Belle Vue Cottage and Oatlands Demesne, the purple colour becoming more frequent. At the bend of the road, across the gully S. of Oatlands, these beds undulate so as to dip N.W. in some parts and S.E. in others.

The same beds, with some black slate, may be seen on the roads about Talbot Hall and Arnestown Mill, where the prevailing dip seems to be to the north-west at high angles.

A little E. of Arnestown Mill some dark sea-green and dull purple slates were formerly quarried for roofing slates, for which, however, they were not well adapted from their thickness and weight.

Hard green and purple grits and slates may be seen about Dunanore Bridge, dipping to the N.W. at angles varying from 10° to 65°.

About a mile and a half N.E. of Arnestown Mill, in the townland of Lackeen, is a hill capped by a square wood. The slaty rocks may be seen at many places over this ground, with colours varying from black to gray and green, and they include several dykes or beds of a kind of greenstone, which is described as "compact and somewhat flaky, with iron pyrites sometimes forming a constituent mineral of the rock; this, weathering out, leaves it very vesicular. It has in parts a cleaved or bedded appearance." A small dyke or bed, tapering out both ways and much decomposed, crosses the road S. of this hill, and a large one, quarried for road stone, may be seen near the cross roads N. of the hill, and another in the fields just S. of Berkley Forest demesne.

They all run N.E. and S.W. with the strike of the beds, and might either be contemporaneous beds or intrusive dykes.*

To the north of New Ross good exposures of the slate rocks may be seen in the cuttings of the new road over the river bank, and also down the valley of the brook running out to MacMorough Castle. They consist generally of

* In the country immediately to the southward of that now described, more considerable masses of greenstone occur, some of which are undoubtedly intrusive. There is one mass on the river bank, a little S.W. of Dunganstown, consisting of a coarsely crystalline compound of green, white, and pinkish feldspar and brown hornblende. The slates in contact with it are altered, being harder than usual, more like grit in texture, of a brown rusty burnt appearance, and splitting into small angular fragments in consequence of a number of concealed joints which run everywhere through the mass of the rock. It is interesting to observe the very different kind of alteration produced by this mass of greenstone, and that to be seen as we approach the granite. There is not the slightest appearance of foliation or of micaceous lustre here; on the contrary, any tendency to split into flakes or slates seems to have been counteracted, and the rock is more dull and earthy than ordinary. (From my own notes.—J. B. J.)

a dark gray, sometimes greenish or purplish, slate rock, the darker layers often alternating with lighter seams, each being not more than the tenth of an inch in thickness, so as to give the rock a striped or ribboned appearance. The rocks are often greatly contorted, but appear, on the whole, to have a southerly or south-easterly dip at angles varying from 40° to 90°.

Just a mile due E. of MacMorough's Castle, between Ballyanne old bridge and Mount Hanover, there is a good exposure of these rocks on each bank of a little valley. They consist here of blue and dull gray clay slate, greatly corrugated on a small scale, and dipping, on the whole, S. or S.S.W. at angles of 35° or 40°, and traversed by a well defined cleavage that dips S. 10° E. at 30°.

Purple slates are seen near the gate-lodge of Berkley Forest demesne, dipping S.E.; and near Whitemoor hard green and gray gritty slates dip E. at 50°, with much crumpling.

Country between New Ross and Lukeswell.—The rocks just described to the east of the Barrow, N. and S. of New Ross, strike generally across the river into the county Waterford. They may be seen in the northern part of Annagh House demesne; just S. of Rosbercon, and also north of that place; in a gully by Bawnjames House, and at the bend of the river north of that, in all which places their dip is southerly at angles of 30° or 40°.

Further westward various small exposures of those rocks may be observed along the roads and in little quarries or ditches, or natural gullies about Slievecarragh and Ballycurrin, and up northwards to Ballyknock and Tinneranny. The beds often dip apparently in many different directions, but the exposures are generally too slight and superficial to make the observations of much value.

Still further west, about Ballalog and Smithstown, and Glenpipe, in the valleys of the head waters of the Arrigle brook, gray and blue smooth clay slate is seen abundantly, the beds dipping to the north or north-west at angles varying from 10° to 75°. These valleys are succeeded to the west by some high, barren ground, covered by local drift and blocks of granite and sandstone, beyond which clay slate may be seen at intervals up to the boundary of the Old Red sandstone.

Four small greenstone dikes were observed in the townland of Ballynooney East, striking N.N.W. and S.S.E. through the point marked 687. South-west of these is a patch of Old Red sandstone just N. of Ballintlea, consisting of nearly horizontal beds of coarse conglomerate with slate detritus round it.

About a mile N.N.W. of Ballintlea, near a place called Ballynooney North, hard gray compact silty clay slate was observed, dipping in one place N.E., in another N.W. at 35°, and a little north of that, at Ballyvatheen, again N.E. at 35°.

Immediately to the west of these places the Old Red sandstone comes in, showing beds of coarse conglomerate, striking nearly due N. and S., with a slight, almost imperceptible dip to the westward. It is remarkable that in all the country to the westward of Slievecarragh, there seems to be no repetition of the green and purple slates which show themselves about New Ross and Rosbercon. These beds, however contorted they may be, seem, nevertheless, to have a definite N.W. and S.E. strike, and not to appear in the country to the N.W.

Judging from the great prevalence of south-easterly dips in all the country between new Ross and Inistioge, I am inclined to suppose the purple and green slates south of New Ross to be some of the uppermost beds of the Lower Silurian formation that enter into the structure of the district.

The Ballyneale Ash Beds.—Another evidence in favour of the general N.E. and S.W. strike is to be found in the occurrence of a peculiar band of rocks running in that direction for three or four miles, through the parish of Listerlin, by Ballyneale and across the Nore towards the Rower.

These are first seen in the steep northerly slope of some high land, the summit of which is 809 feet high, and has Rath Aniska about a third of a mile to the E.N.E. of it.

Near the summit of the hill, the hard bluish gray slates dip to S.E. at angles varying from 30° to 60°, from beneath which hard grayish feldspathic flags make their appearance with long irregular beds of "finely crystalline greenstone," which, however, may be "crystalline ash." These beds may be traced for more than half a mile towards the N.E., through the townland of Brownstown.

Blue clay slate appears again from underneath them, still dipping to the S.E., and may be seen in the fields near the upper corner of Brownstown Wood. A much thicker band of ash runs through the wood, having a surface width of more than 300 yards, gradually thinning out and ending about 600 yards to the S.W. of the wood, but running to the N.E. uninterruptedly for two miles. This is described as "green hornblendic slate, with mica in some places," and more definitely as "green hornblendic flaky rock, with patches (imperfect crystals) of feldspar scattered throughout the mass." Bands in it are described as "solid greenstone," or as "apparently true greenstone."

I did not, when I visited it, observe any mica, neither could I satisfy myself of the presence of hornblende. Some parts of the rock were minutely crystalline, with small dark shining facets of crystals, which appeared to me to be most like feldspar, but these parts might have been either a crystalline ash, or a trap affected by cleavage. Except for its occasional dark green colour I should have been, perhaps, more inclined to consider it a felstone ash rather than greenstone ash.

There is, however, a considerable band of crystalline igneous rock near the centre of the ash, about three quarters of a mile S.W. of Ballyneale. This trap-rock is intensely hard and tough; it exhibits pale green imperfectly crystalline patches of what may possibly be feldspar, scattered through a very confusedly crystalline darker coloured base of mottled dark and light green, with portions showing a fibrous structure and glistening lustre, but all so imperfectly formed, that it is impossible to determine any of the constituents by simple inspection only.

It may pass under the name of a greenstone, inasmuch as it is certainly a *green stone* of igneous origin, but it is by no means certain that it is composed of the simple minerals feldspar and hornblende. I did not remark any quartz in it.

This hard band of trap disappears as we proceed towards the N.E., but the ash or green flaky rock goes on, is quarried for road stone and wall building near Abbeyneale, and strikes across the Nore, and is clearly seen at two or three places in the townland of Ballilogue, still striking N.E. till it disappears under an accumulation of local clayey drift. Its surface width here is about 200 yards.

It preserves throughout its course an apparently steady dip to the S.E. of 30° or 40°, with the same gray or bluish slates above and below. These latter may be seen near the Nore for about 500 yards above the ash, while below it, or up the course of the river, there is a continuous section to be seen in the woods on its eastern bank, for a distance of nearly a mile. These beds are described as lead gray in colour, very slightly micaceous with occasional gritty beds, and about the centre of the section there occurs a group of hard strong grits, interstratified with dark blue slates. The dip of these latter beds is very steady to the S.E. at about 30°, while the softer slates above and below are more corrugated, and more irregular in dip, curving so as to dip to the S.W. or N.E. occasionally, but on the whole dipping to the S.E.

In endeavouring to trace the Ballyneale ash beds farther to the N.E., we are met for the space of about two miles with a country greatly covered by local drift consisting of clay and shingly gravel, so that no rocks at all are

seen in or near the strike of these ash beds, till we pass the village called "The Rower."

We then find a band of "green hornblende flags," which are precisely similar to the Ballyneale ash, and apparently the same beds. The band is narrower here than it is further to the S.W., but it still strikes N.E., and is seen at three or four places for the distance of about a mile, up to the woods that clothe the high precipitous cliffs, overhanging the river Barrow, just north-west of Coolhill Castle. In this cliff it may be traced along the dip for a little way to the S.E., when it disappears beneath the water. The same blue and dark gray slates too appear above and below it in the parish of "The Rower," as about Ballyneale, except that as they approach the granite they become in some places "strongly micaceous," while in others, especially in the blacker parts, they are spoken of as "unaltered."

Strike of the beds against the Granite boundary.—The Ballyneale ash, taken by itself, where it may be seen striking uninterruptedly N.E. and S.W. for a distance of over three miles, with a steady south-easterly dip, is a strong evidence in favour of the generally steady strike of the Lower Silurian rocks of the district. This is supported by the equally steady dip and strike of the strong grits in the middle of the wood on the eastern bank of the Nore, to the northward of Ballilogue. The non-appearance of either of these groups of rock in the country, either to the N.W. or S.E. of these places is *pro tanto* an argument against the repetition of the beds in anticlinal or synclinal curves of small radius at all events, and in favour therefore of the steadiness of the south-easterly dip, and consequently of the great thickness of the rocks. If we may look on the ash N.E. of the Rower, as a continuation of that of Ballyneale, and there is every evidence for and nothing against the supposition, these arguments are still further strengthened, for we should then have good proof of the steady strike for a distance of seven or eight miles at least, of the whole mass of the slate rocks against the broad termination of the granite about St. Mullins.

This N.E. and S.W. strike of the Lower Silurian rocks, either parallel to the surface boundary of the granite, directly up to and against it, is confirmed by all the facts to be seen in the district.

Whatever allowance we may make for the original stratification of these beds being obscured by a N.E. and S.W. cleavage or foliation, and the one being sometimes mistaken for the other, there are abundant instances when this mistake could not possibly be made, to support the statement that the "lie and position" of the Lower Silurian beds has no relation to that of the granite. The intrusion of the granite has not given any tilt or communicated any elevation to the beds it comes in contact with, it has not brought up any lower beds, or caused any great mass of beds whatever to dip away from the granite. The beds are no more contorted (I am not now speaking of the minute corrugation of the laminæ, but of the folding of groups of beds) in the immediate neighbourhood of the granite than they are at a distance from it, neither do they incline at a higher angle. The relations of the granite to the Lower Silurian rocks, would be most truly described by supposing the granite to have burrowed slowly upwards into a mass of superincumbent rocks, eating them gradually away and absorbing their substance into itself, rather than endeavouring to burst through them, until finally the impelling force urging it upwards ceased, and the destructive process was arrested, leaving however, the traces of its gradual progress in the immediately adjacent rocks, which traces gradually disappear as we recede from the granite.

With these facts and this hypothesis in our minds, let us return to the neighbourhood of New Ross and examine the rocks round the extreme southern termination of the granite area.

New Ross to Pollmounty, &c.—We have previously (p. 25) described the rocks as far as Mac Morough Castle and Ballyanne old bridge. Proceeding

along the road by the river to Kyleroe, we should immediately after passing Anne's bridge, be struck by the more micaceous or silvery lustre of the rocks. They are also minutely folded and corrugated, so that the layers seem all crumpled into forms like the letters v and w. This corrugation may be perceived even south of the bridge, dying away south of Woodville, but it becomes still more marked as we proceed towards the north or approach the granite. The notes on the six-inch maps of county Wexford, are as follows:—"Folded over like the letter W in small sharp contortions"* "bluish gray shining and micaceous slate, beautifully wrinkled," "more shining and micaceous, folded and twisted," &c. When we come within a hundred yards or so of the granite, we can find nothing but the most perfect mica schist mingled occasionally with quartzose layers.

On the six-inch maps of Kilkenny, on the opposite side of the Barrow, about Tintine, we have the following notes, taken in order from south to north:—"Gray slates with thin gritty laminæ, contorted." "Blue slates, very slightly micaceous." "Dark bluish argillaceous slate, often with a gritty texture." "Shrivelled lead blue slate, slightly micaceous." "Gray, crumpled, very strongly micaceous slate, traversed by an elvan dike;" and lastly, "Very bright contorted slates, in parts one mass of mica." These notes occur within a space of less than a mile, approaching the granite obliquely, the latter observation being made at the point nearest to the granite, on the other side of the river.†

In the wood just S. of the point 104 on the east bank of the Barrow, there is a band of dark green, very micaceous and hornblendic-looking schist, which is said to be like those of the Ballyneale ash beds, altered by contact with granite. The band strikes N.E. up to the granite, and has below it "light gray, silvery-looking, gneissose slates, with indistinct crystals of andalusite," the whole dipping S.E. at low angles. If this really be a piece of the Ballyneale ash beds, it must be brought in by contortions; but it is just as likely to be part of a similar bed on a different horizon.

There is a kind of bay of slate runs in N.E. for nearly half a mile into the granite here, in which layers of mica schist and gneiss may be seen alternating with each other, while another similar bay appears to come in from the other side of the granite, so that the two nearly meet. They are, however, separated by a slight ridge of granite, which is continuous at the surface, from Cantwell's Bridge to the northward, throughout our district, and, indeed, from that even as far as the S. side of Dublin Bay.

It will be seen on reference to the one-inch map, how very sinuous the boundary of the granite is all along this its southern termination. There are

* I have preferred to speak of these as corrugations, and to keep the word "contortion" to describe the larger curves.

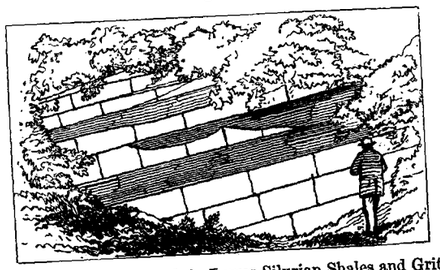
† It cannot be always taken for granted that the distance of the surface boundary of the granite is the measure of the absolute distance of the granite surface itself from any particular spot. We must allow for undulations and irregularities in the surface of the ground, and also for those in the subterranean surface of the granite. The granite may in many places rise nearly up to the surface of the ground without appearing at it, or the ground may have in many places been nearly worn down to the granite without actually reaching it. We may then expect sometimes to come upon places where the rocks are greatly altered, and then find them less so as we travel towards the granite boundary; because we were in fact nearer to the irregular subterranean granite surface at the one point, than in some intermediate points between it and the granite boundary.

There is also another reason why we must be prepared to meet with irregularities and apparent exceptions in the alteration of the rocks, and that is because of the original differences in the mineral constitutions of the different beds. Some beds may be easily acted upon by an amount of influence which may be unable to produce any sensible alteration on other intermediate beds. Some beds may be more purely siliceous, for instance; others may have been more carbonaceous, while others may have contained more iron or more alkalies, and the effects must of course vary with these circumstances.

also several outlying patches of mica schist included within the general granite area. These, however, are much more numerous in reality than they are represented on the one-inch map, the scale of which is too small to admit of the whole of them being inserted without exaggeration. The surface of the granite, north of the two slate bays just mentioned, is, in fact, dotted over with little patches of mica schist and gneiss, and these little patches are themselves seamed with granite veins. In some of the mica schist here, garnets are said to be common.

These may be very well studied in the road side that runs along the Pollmounty brook, from Ballywilliam to Pollmounty Bridge.* In many cases the appearances in the little cuttings by the road side are exactly as if thick beds of granite were interstratified with beds of mica schist and gneiss, all dipping to the S. at angles of 30° or 40°. As, however, these beds of altered rocks cannot be traced for any distance laterally, in either direction along the surface of the ground, we may reasonably conclude that their extension downwards into the earth is as slight as their lateral extension along its surface. They are, in fact, mere tongues of mica schist and gneiss let into the granite while that was yet fluid, portions of that molten matter being at the same time squeezed and injected up between the beds of the aqueous rocks for some distance, all taking place, of course, while the two rocks were buried deeply under many thousand feet of superincumbent rock.

Fig. 5.



Quarry by side of Pollmounty Brook in Lower Silurian Shales and Grits, altered into Gneiss and Mica Schist.

Fig. 5 is taken from a rough sketch made in Pollmounty Glen, in the year 1856, showing some beds of gneiss and mica schist, which no one, at a distance of a few yards, would have taken for any thing but ordinary shale and sandstone. When broken the shales were found to have become perfect mica schist, and the sandstone a fine-grained granular gneiss, hardly to be distinguished from a fine-grained granite till closely examined.†

* In a hasty walk down this road, in September, 1860, I found the sections much obscured by fallen earth and bushes, but enough was still visible to show the apparent interstratification of bands of granite, gneiss, and mica schist. The new railway on the other side of the brook is, unfortunately, at too high a level to make any cuttings necessary, except through mere superficial sand and gravel.

† I have, in the annexed diagram (fig. 6), drawn a supposed vertical section through the junction of some granite and aqueous rock, such as is not uncommonly to be seen in granite districts, in which the shaded part represents some highly inclined slate rock, and the white part the granite, with its irregular boundary and intrusive veins. Now, if we suppose this to be a representation of what takes place on a larger scale, and to give us a true idea of the nature of the upper surface of a great mass of granite at any conceivable depth, it will enable us to understand the appearances shown in this district,

Proceeding from the district now described towards the N.E., we find that the general boundary of the granite becomes much more regular, running off towards the N.N.E. with a slightly sinuous outline. As, however, the granite just within the boundary rises into a lofty ridge, it continues so far to be thickly strewn with patches of embedded metamorphic rock. Sometimes these patches are more like mica schist, sometimes more like gneiss; they are almost always narrow in proportion to their length, and strike to the N.E. with an apparent dip of not more than 30° to the S.E.

The granite is said to be "coarse and very feldspathic," and in two or three places near the summit of the ridge it is said to occur in "large flat tabular masses, and to have a lamellar structure apparent in it for the distance of a few feet downwards, the lamellæ conforming to the slope of the hill, and also to the surfaces of the little beds or banks of slate or schist which seem to be caught in it. The laminar structure disappears gradually, and is lost at a distance of a very few feet in the regular crystalline aggregation of the mass."

Directly we leave the summit of the ridge along which the county boundary runs, and descend towards the interior of the granite, we lose all trace of any metamorphic bands or patches, and meet with nothing but solid crystalline granite.

We have here the strongest indication that the part in which the schist occurs is at or near the original surface of the granite.

There is not much rock exposed on the outer or eastern slope of this ridge, but "blue silty micaceous slate" is seen to dip S.E., at from 10° to 30°, in the

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and, I believe, in all other districts where large masses of intrusive granite can be seen in contact with slaty or schistose rocks.

It is clear that if the denudation be arrested at the line *a b*, we should have a surface of slaty rock only, dipping at a high angle, without any evidence of the existence of granite so close below, unless the metamorphosed condition of the slates might be

Fig. 6.

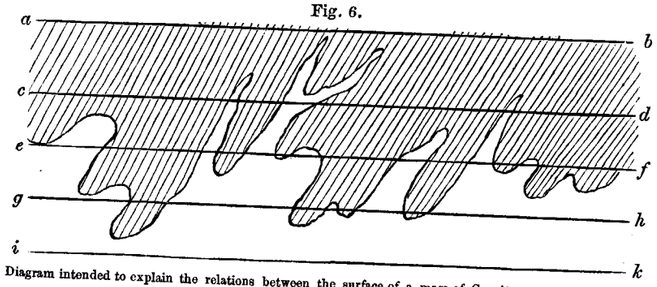


Diagram intended to explain the relations between the surface of a mass of Granite and the Slate Rocks above it.

taken as such. If the denudation had proceeded down so far as to produce a surface at the line *c d*, granite veins would appear here and there in the slates, in some cases as if interstratified with, in others cutting across the beds.

If, again, the surface be formed along the line *e f*, we should have masses of granite appearing to alternate, with thick beds of slate that would seem as if dipping under the granite masses.

If the rocks be denuded down to the line *g h*, we should have a general granite area, with little lenticular or irregularly shaped patches of slaty rock, resting here and there upon the granite, and still seeming to dip into it.

But if the level *i k* be reached, then the whole area shows nothing but granite, and the deeper the excavation (or denudation) proceeds the wider becomes the granite area.

If the lines, instead of being straight and horizontal, were inclined and variously undulating, it is obvious the same general effects would be produced, modified, of course, by the shape of the granite mass below and the form of the surface above.

bed of the brook, a little N. of Ballywilliam, and in the brook by Cummer, at the margin of the map similar rocks are seen with a similar dip, the two being probably part of the same set of beds.

The Rower District.—We will return now to the parish of The Rower, in county Kilkenny.

About Ringwood House, at the junction of the Nore with the Barrow, we have dull greenish clay slate dipping S.E. at 50°, and on the bank of the river, S. of Tinnislatty, similar rocks contorted, but dipping, on the whole, south-easterly at from 30° to 60°. The section higher up the Nore, above Ballilogue, has already been described.

Going up the brook between Ballinabarney and Coolnamuck Houses, dull gray and green slates may be seen, and from Clodiagh Bridge, where the road crosses that brook to the church of the Rower, there may be seen in the little road cuttings and ditches the ends of beds of gray, green, bluish, or black slates. Where sufficient of the rock is exposed to let the dip be determined, it was always found to be to the S.E. at 40° or thereabouts. In some places the slates are spoken of as crumpled (corrugated), and in some as slightly micaceous, or shining. There is, however, very little of the rock well seen, except here and there in the western banks of the River Barrow.

The granite crosses this river from the county Wexford, on the south, close to where the capital "R" of the parish name "The Rower" is engraved on the one-inch map.

At the bend of the river, a little below that, is a section in the slate rocks similar to that already described as to be seen a little further S., near Tintine. The first rocks met with after leaving the granite, are described as "blue silty slates, with very thin lamination, much altered, almost one mass of mica in parts, twisted and undulating." This is about 300 yards from the granite. A hundred yards farther on we have "black shrivelled slates, with numerous thin grit beds, not so micaceous as the slates farther down the river;" and below that, "blackish slates, not remarkably micaceous, with thin grit beds." Now, this place where the beds are "not remarkably micaceous," lies just opposite the centre of the little bay of slate which was described before as stretching into the granite from the west. In other words, it is farther removed from the outcrop of the granite than any other part of the section along the river here.

S. of this we again approach rather more near to the granite boundary, and we find "very bright micaceous slate, much contorted (corrugated), and quite the same as the slates in the wood of Tintine, farther down the river."

Going back again to the place where the granite first crosses the Barrow from the southward, we find it occurring in rocky lumps, up to the picturesque bend where we reach the ruins of Coolhill Castle.

In the fields and lanes outside the granite boundary are many small exposures of "blue silty slate" and "black slate," in some places said to be "micaceous," in others described as "altered," and in others again as "unaltered." They are said to be either nearly horizontal or to dip slightly W. or S.W.

We then come upon the green flaggy feldspathic and hornblendic beds, which are believed to be the extension of the Ballyneale ash beds. These are well seen at one or two points; and in one quarry not more than 500 yards, in a direct line from the granite boundary, I was surprised to find them not a bit altered, but precisely the same as those at Ballyneale, although the slates immediately below them were here a bright silvery mica schist.

A small vein or bed of gneiss was observed in the granite, a little E. of the tower of Coolhill castle, which is said to be in some places slightly hornblendic, but it is impossible to say whether this has or has not any connexion with these ashy beds. Mr. Wyley, when surveying the country, seems to

have been so struck with the resemblance between the Coolhill ash beds, resting on silvery mica schist, and those found a mile and a-half lower down on the other side of the river, each group seeming to terminate abruptly at opposite banks of the river—as to have speculated on the possibility of their being the same beds shifted by a great fault running about N. by W., and S. by E. If such a fault exist it must have a huge downthrow to the W.; and as its line would run by Graiguenamanagh, and nearly coincide with that along which the granite is brought to such a sudden apparent western termination, for much of the distance between New Ross and Graiguenamanagh and for three or four miles N. of the latter, the idea is not without a certain amount of plausibility. It is, however, not supported by any direct evidence in its favour, and the general facts seem to be against it.

In the little valley north of this band of ash, are "blue, strongly micaceous, slates," all dipping steadily S., at angles of 30° or 40°. Half a mile still further north are other blue shining micaceous slates, seen in the side of a lane that leads to Ballinvarry Bridge. These dip S.S.E. at 10°, close to the granite boundary, and thus appear to dip at or into the granite. An isolated patch of mica schist "much twisted," is included in the granite a little east of this. Small exposures of blue slate "much altered," are seen near the granite about Ballinvarry, and an isolated patch dipping to the S., is included in the granite a little to the northward. Beyond that nothing but granite is to be seen up to the summit of Brandon Hill.

West of Ballinvarry the granite boundary is suddenly deflected to the S., and then curves round towards the W. by Cullaun and Ballygub New; and many detached patches of mica schist are included in the granite area.

In the bed of the little brook, 500 yards W.S.W. of the group of houses called Cullaun, by the side of a little wood, the water falls a few feet over a ledge of granite, which is obviously *in situ*, and from which some very gneissose mica schist dips S. at 35°. The granite itself has here, also, a gneissose appearance, from the fact of the mica plates being arranged parallel to each other for the distance of a few feet. These parallel plates of mica seemed to be quite horizontal.

We have here on a small scale an instance of a gneissose granite, and a metamorphic gneiss in juxtaposition; the one derived from a parallel arrangement of one of the crystalline constituents as they formed in the rock during the process of consolidation, the other from a semi-crystalline structure being communicated to materials that had already a parallel arrangement when deposited under water. The granite itself seems to be part of a small isolated appearance of that rock at the surface, which is apparently quite surrounded by metamorphic rocks.

Brandon Hill District.—The gently swelling summit of Brandon Hill appears to be altogether composed of granite, the ground being covered with weathered blocks of that rock, which on the south side lie so thickly as at a distance to look like snow. The northern, eastern, and southern slopes of the hill appear also to contain nothing but granite. On the west side, however, mica schist makes its appearance in the ground at a distance of 500 yards from the top; and over all the gently sloping ground thence to the Nore, opposite Woodstock, the ground is composed partly of granite and partly of mica schist. There are no good exposures of the rocks, nor are there any marked features in the form of the ground to enable us to distinguish between the area occupied by one rock and that of the other. The closest attention to little ditches and cuttings, small jutting crags, little sections in brooks or rills, and the appearance of the rock in the roads and cart tracks, is necessary to determine which is which.

It appears that the original surface of the granite had a gentle, slightly undulating, slope to the W.S.W., and a steeper inclination to the N. and S.; or else that its undulating surface was subsequently elevated towards the

E.N.E. so as to give it that slope. It rests now, at all events, in that position, and is slightly skinned over here and there with patches of mica schist, the inclination of whose beds (even where that point can be determined) gives no indication of the thickness of the patch of which they form part, since they are all cut off below by the nearly horizontal surface of the granite.

The mica schist that stretches over the hill a little west of the summit of Brandon Hill, is nearly continuous across it from north to south, but not quite so, as two little hollows cut through it down to the granite on the southern slope.

From Ballygub New, however, the metamorphic coating completely covers the granite over the crest of the hill, and thus terminates the continuous surface appearance of the granite in this direction.

Three other patches of granite, however, appear at the surface a little further west, making little elevations that barely rise above the surpounding mica schist.

The two northern of these show rock that seems to differ somewhat from the rest of the granite in the absence of the white mica and the superabundance of black, the rock resembling some of the detached bosses of granite that rise to the surface between Enniscorthy and Wexford.

The slaty rocks by which the granite is everywhere surrounded is often described as "rolling," sometimes as "nearly horizontal," but much trust must not be placed in these observations of the lie of the rocks. Near the granite they are spoken of as "very gneissose slate," "earthy gneiss," "bluish gray slate very much altered," and the presence of andalusite is occasionally noted. While as we recede from the granite they are described as "blue micaceous slate," and shortly as argillaceous slate only, with or without grit bands.

Granite and Mica Schist west of the Nore.—The granite seems to descend rather more deeply beneath the surface in the valley of the Nore, and then to rise again into two gentle mound-like bosses, one of which may be called the Curraghmore granite, and the other that of the Arrigle Glen.

The Curraghmore granite rises in Killeen plantation to a height of 919 feet, making the highest point of the immediate neighbourhood; but on all sides except the S.E., is very shortly covered by slaty rocks, which in some places are described as "feldspathic," and in others as "very gneissose with large granite veins cutting through them." Had the ground remained towards the S.E. of equal height with that on the other sides, the granite would have formed a small circular boss only in the plantation; but it falls towards the S.E. into a shallow oval valley, traversed by a little brook running out by Brownsford Bridge.

The rim of this valley is everywhere formed of mica schist, except in Killeen plantation and at the S.E. corner near Tullagher, the granite only appearing a little way down the inside slope of the boundary ridge, and only in consequence therefore of the excavation of the valley. This is remarkably apparent in the brook near Brownsford Bridge, where a little neck of granite follows the brook a little way in consequence of the deeper cut there down through the mica schist.

Passing over the ridge which bounds the Curraghmore valley on the west, and descending towards Glenpipe, in the valley of the Arrigle river, small exposures of slaty rocks more or less altered, may be seen here and there in the roads and ditches.

About Glenpipe itself, the blue argillaceous slate does not seem at all affected, but in the little brook that comes down the hill a quarter of a mile to the north of it, "silty slates" and "hard grits," are described as "very micaceous" and "much altered."

Near the National school-house the Arrigle brook cuts into the granite; nothing but crags and blocks of granite, some of them *in situ*, others slightly

rolled over, being seen on either side of the brook for a distance of more than a mile.

The granite boundary runs steadily N. up to a little N. of Tullaun Bridge, with "altered slates" perceptible here and there outside of it. It then turns with a very sinuous outline towards the N.N.W., and ascends the side of the valley till it is covered by the Old Red sandstone.

Where the Arrigle leaves the granite, it passes by some little cliffs of blue slates, and beds described as "coarse ashy grits, all apparently much altered, and hornblendic in parts." These are said all to dip to the S.E. at 60°, or thereabouts, or towards the granite; and similar beds, with the same inclination, are mentioned as to be seen in the roads and ditches about Fir Grove, and between that and Killeen plantation.

Returning towards Glenpipe the granite may be seen here and there up the slope of the hill, W. and S.W. of the National School, about Coolnahan and St. Mullin's Well, and underneath the little woods S. of that just below the summit of the ridge. In some of the brooks the granite may be seen to a depth of eight or ten feet, greatly decomposed, a mass of disintegrated rotten crystals below passing by insensible gradations up into a regularly stratified granitic sand, the evidence of the atmospheric action of rain, &c., on the undisturbed granite.

Just as we reach the crest of the brow we everywhere come upon nearly horizontal beds of Old Red sandstone, spreading along the surface of the ground, and forming the flat, barren, heathery moorland which borders the valley on the west.

Greenstone in the Granite.—On the slope of the ground N.W. of Coolnahan, there are several spaces covered with large blocks and crags, some of which appear to be *in situ*, composed of a rock, which is not granite, and some of which is certainly greenstone. The blocks are almost absolutely confined to certain spaces which, together with the fact that some of them appear to be unmoved, has induced the belief of the rock existing there in place. There are two varieties of it, one of which might be called a greenstone porphyry, and the other a syenitic greenstone.

The first has large distinct crystals, of a dark fibrous looking hornblende, scattered through others of an apple-green feldspar. This rock had a certain resemblance to the trap associated with the Ballyneale ash, and appeared to me to be just such a rock as that was likely to form, if a portion of it were to be caught in and re-baked by the granite. Flakes of bronze-coloured mica also appeared in it.

The other variety was a fine-grained and more equably crystalline compound of green and flesh-coloured feldspar, with black hornblende, the whole of the crystals bright and glistening with some very minute glassy-looking facets among them, which might possibly be quartz. If this were the case, the rock would become a syenite; but having been myself previously deceived, and seen better judges than myself deceived, in taking minute brilliant facets of feldspar for those of quartz, I hesitate to assert the fact.

Near the northern margin of this piece of granite, on the road to Plebertstown, there appear to be other masses of this greenstone or syenite, partly in the granite and partly outside it.

The occurrence of greenstone in granite or intruded through it, though not altogether unexampled, is yet rare; and I am on the whole inclined rather to look upon these masses as most likely to have been pieces of greenstone dykes or beds in the Lower Silurian rocks, and to have been included in the granite at the time of the intrusion of the latter. The occurrence of a little patch of "perfectly altered" slaty rock, not far from one of them, at the top of the hill, just outside the Old Red sandstone, in the townland of Castlecosher, makes it likely that the denudation has not eaten very deeply into the granite there, and the occurrence of similar rocks, and of ashy and hornblendic

looking beds in the Silurian, outside the Granite, tends to confirm the suspicion.

Neighbourhood of Inistioge.—Very little rock is to be seen in the valley of the Arrigle, for nearly two miles N. of Firgrove, but beyond that there are two or three exposures of blue silty slates, quite unaltered, sometimes with "hard ashy grits," all dipping S.E. at 60°, or thereabouts. Proceeding over the ridge, down towards Inistioge, similar rocks are to be seen, no appearance of alteration being mentioned in any rock to the N.W. of a line drawn from Firgrove to Inistioge. As we recede from the granite masses, indeed, either towards the N.W. or towards the S.E. the metamorphic effect disappears much more rapidly than it does in the spaces lying between them, evidently in consequence of the granite sinking more slowly in the general direction of its range than it does upon either flank of it.

There is a cutting by the side of the lower road, N. of Inistioge Bridge, exposing a good section in some gray slates, slightly micaceous, and in places corrugated. They are here and there traversed by many large quartz veins crossing each other in different directions. These quartz veins, which have all the appearance of regular "lodes," do not exhibit any metallic ores; but they are often coated with layers of green mica, a quarter of an inch thick, the flakes of mica splitting at right-angles to the layer: irregular seams of similar mica traverse the masses of quartz in different directions.

In the different little cliffs and ravines on either side of the Nore, especially those in the beautiful demesne of Woodstock, similar slates, more or less altered, and with or without quartz veins, are to be seen.

Country between Inistioge and Graiguenamanagh.—In the country between Inistioge and Graiguenamanagh, the slates and grits may be seen in the brooks, in road side cuttings, and in small quarries, having an almost invariable strike to the N.E. and dip to the S.E., at high angles.

As we approach the granite on the S. we meet occasionally with small elvan dikes likewise running N.E. and S.W., but only to be traced by the appearance of the rock here and there, at the surface between the edges of the slate rocks. There is little appearance of "micacisation," till we come within half a mile or so of the granite.

Country round Coppanagh Gap.—About two and a-half miles north of Inistioge, there is a sharp ridge of a hill, known as Saddle Hill, rising to 854 feet; it runs N.E. and S.W., and along its crest may be traced some hard feldspathic looking beds that may be a band of ash. They are nearly vertical in some places, in others dipping at high angles to the S.E.

Similar rocks make the crags known as Carrickaphreeghann, S. of Coppanagh Gap; and it is remarkable that in these hills the slates are more micaceous, that is, more like mica schist, than they are in much of the country between them and the granite of Brandon Hill. The appearance of an elvan dyke, coursing N.E. on the S.E. slope of these hills, and their micaceous appearance, leads to the belief of a granite ridge existing, perhaps, at no great depth below them.

Crags of slaty rock can be seen all round the slopes of Coppanagh Hill, a little below the summit, which is nearly flat-topped; but on walking across that flat summit, a level floor of coarse brown sandstone may often be seen beneath the grass and heather, and near the brow of the hill, the edges of some almost horizontal beds of that rock appear, showing that the hill is capped by a thin coating of Old Red sandstone. (See section, fig. 7.)

Similar facts are apparent on the top of another lower and smaller hill, called Bishop's Hill, half a mile N.W. of Coppanagh, while still further west another heathery bank, with a little escarpment facing towards the east, marks the regular continuous boundary of the Old Red sandstone resting on the upturned edges of the slate rocks, and dipping gently towards the west, beneath the limestone plain.

Rather more than a mile N.E. of Carrickaphreeghann is the crag marking the point of Croaghan (1,194 feet above the sea). This is composed of blue silty slate, dipping N.W. at 50°, with strong quartz veins cutting through the rocks.

A little to the N.W. of this similar rocks dip S.E. at 50°, and in all the Lower Silurian country, which is included in the southern part of Sheet 147, between the Old Red sandstone on one side and the Granite on the other, wherever the slates and grits were observed, their beds dipped at high angles, almost invariably either N.W. or S.E., usually the latter. In either case the strike was steady from S.W. to N.E., or directly at the boundary of the granite, as it runs N.W. from Graiguenamanagh.

The slope of the hill from Croaghan towards the N.W. is very gentle and regular, at an angle of about 8°; a very slight rise occurs on it at the part called Freagh Hill, and this is formed by an outlying patch of Old Red sandstone, which is scarcely separated by a little hollow, where the slates are bared again, from a small projecting promontory of it, that stretches up the lower part of the slope beyond the general boundary of the formation. It is clear indeed from the section (fig. 8), that this slope of Croaghan and Freagh has only just escaped being entirely covered by the Old Red sandstone; and that in those parts of it where the Lower Silurian appears at the surface, the denudation has only just stripped it of the Old Red sandstone, and thus re-exposed the old floor on which that rock was deposited. It may be doubtful whether that floor was then horizontal or slightly inclined.

The Neighbourhood of Graiguenamanagh.—We will now go back to the granite forming the northern slope of Brandon Hill, and briefly describe the interesting facts of metamorphism to be seen as we trace its boundary towards the north.

On the northern slope of Brandon Hill, the boundary of the granite is a sinuous line, owing partly to the undulations in the original surface of the granite, and partly to those in the present surface of the ground. It strikes down the slope across the River Barrow, about a mile S. of Graiguenamanagh, and a little inside the boundary on the right bank of the river just opposite Knockeen Rock, a band or vein of slate may be seen in the granite, and dipping S. towards its main mass. This is described as "very gneissose" in one part, while in another it is said to be "much altered, being very compact and hornblendic."

North of the main boundary of the granite, and west of the high road, there is a wood through which may be seen a partially exposed section of the rocks, now much obscured by vegetation and fallen soil. My notes on it, made in walking from Graiguenamanagh, in May, 1856, are the following:—

At the north end of the wood are gray grits, rather thick-bedded, greatly undulated, but silicified, not micacised: they appear to undulate along the road, but on the whole to dip northerly.

When directly opposite the north end of the island made by the canal, the dip was decidedly N. at 50°, and here were thin slates very micaceous. In going S. from this the slates become more and more like mica schist, and some of the grits become fibrous and gneiss-like; but some seemed merely more siliceous than usual, till near the granite boundary, when all the rocks were most micaceous and schistose.

On entering the granite itself, it appears at first also gneiss-like, either from an arrangement in the flakes of mica near its borders, or because some of the grit-beds have been more or less absorbed into the granite.

Near the junction the schistose rocks were so penetrated by granite veins, that the whole looked like a regular alternation of beds of granite, mica schist, and siliceous gneiss.

It is evident that we have here a repetition on the northern side of the granite of the facts observed at Pollmounty on its southern side; and that

Fig. 7.

Section from Kilfane Limestone Quarries, two miles north of Thomastown, through the outliers of Bishop's Hill and Coppanagh.

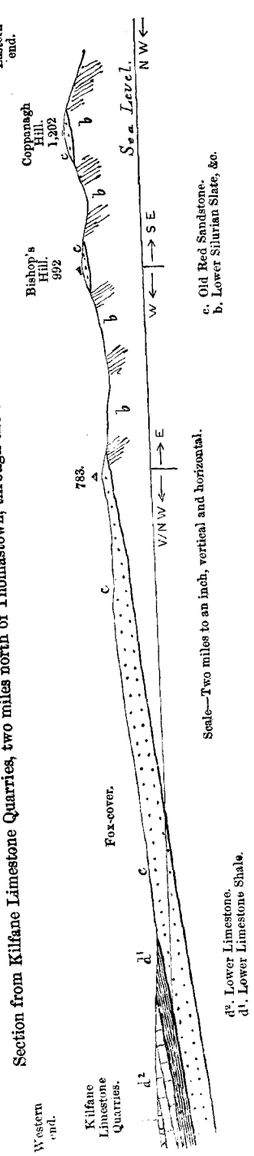
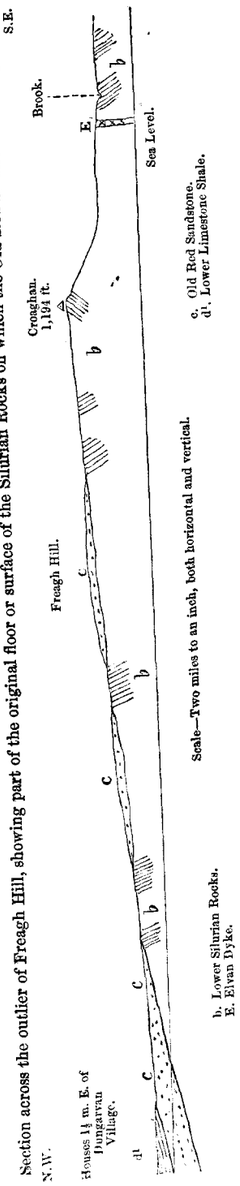


Fig. 8.

Section across the outlier of Freagh Hill, showing part of the original floor or surface of the Silurian Rocks on which the Old Red Sandstone was deposited.



similar facts would be obserable whenever a section was exposed on the margin of the granite.

The general boundary of the granite here, after crossing the river towards the N.E., turns round and strikes off towards the N.N.W., just by Graiguenamanagh. The river also winds in such a way as to be again crossed at right angles by the granite boundary on the N.E. margin of the town.

There are, unfortunately, no good continuous sections anywhere, but the following facts may be observed:—In the wood just under the new road N.E. of the town many parallel bands of different varieties of micaceous and gneissose rock may be observed, with granite veins running parallel between them. Near the north end of the wood is a mass of gneiss, with layers of black mica and long finger-like crystals of white feldspar an inch long, giving the rock a porphyritic appearance. Another bed of this, if indeed it be not the same, may be seen in the centre of the wood, and again on the other side of the river a little lower down, forming the crags just N. of Tinnahinch, on which the small wood stands.

This rock is here regularly laminated in beds two or three feet thick, with planes of stratification parallel to the lamination, and two sets of joints at right angles to it. Some of the beds are finer grained than others, and without the crystals of feldspar, while others have them as well shown as in the granite of Waterloo bridge. The lamination and bedding are both nearly horizontal, with a gentle curve in one place, exactly as in a slightly disturbed aqueous rock; yet so intensely crystalline is the whole mass, that when the country was originally surveyed, these rocks were included in the granite, though remarks were written as to its "bedded appearance" and the probability of its being metamorphic.

Some detached narrow bands of a similar rock, only without the large crystals of feldspar, may be seen in a lane half a mile E. of Tinnahinch, and as far within the general granite boundary. Higher up the Barrow, beyond the first bend towards the east, a tongue of metamorphic slaty rocks may be followed for a mile in that direction, being the continuation apparently of those seen in the little wood on its west side. These are described as "slate, very gneissose and highly micaceous," "very gneissose micaceous earthy slate," and in one place the granite is said to "pierce the slate with large veins."*

In the country along the margin of the granite north of Graiguenamanagh the exposures of the rocks are few and far between, and there was no special point of interest observed. The slates, as they approach the granite, become micaceous as usual; and in a distance of four miles, or one mile S. by E. of Powerstown, slates and granite are alike concealed by beds of Old Red sandstone and Carboniferous Limestone, which sweep unconformably across them.

The Borris District.—All the low country about Borris, and thence northwards up to the N.E. corner of Sheet 147, is composed of granite, more or less covered by limestone gravel or by the local debris derived from the granite itself.

About three miles E. of Borris, however, about Killedmond, near the margin of Sheet 147, there is some higher ground, in which we probably get more near to the original upper surface of the granite; and we accordingly find it full of large and small patches and veins and strings of metamorphic

* I have myself not the least doubt, after twice visiting this neighbourhood, that the porphyritic gneiss above described, which is perfectly crystalline and with as large feldspar crystals as any specimen of porphyritic gneiss I ever saw, is nothing more than a Lower Silurian slate or grit rock altered by coming in contact with the granite. More frequent examples of the rock would, I think, be seen in this country where there are larger and better sections, as in a visit to the Rower in 1860 I observed several large blocks of it scattered about near the margin of the granite there, which were at least as likely to have been derived from some adjacent source as to have been transported thither from Graiguenamanagh.

rock, which were wedged into and embedded in it from the under surface of the originally superincumbent Silurian rocks.

It would be a tedious and useless task to enter into a detailed description of these almost innumerable detached pieces of mica schist thus entangled in the granite. They are generally described as "gneissose micaceous slate." They strike generally to the E. of N., and to the W. of S., dipping now one way and now another, at angles of 60° or 70°, but not probably penetrating to any great depth down into the granite.

A few scattered pieces of these rocks, with the same general characters, may be seen farther S., about Ballymurphy, and in the ground between that place and Graiguenamanagh, thus keeping up a connexion between the tongues of metamorphic rock which stretch from the Lower Silurian ground west of Graiguenamanagh, and these isolated patches thus far removed from it in the general granite area.

It is worthy of remark that the general N.E. and S.W. strike which was observable in all the Lower Silurian ground outside the granite in Kilkenny and Wexford, is still to all appearance steadily preserved in these beds, which thus rest upon and dip down into the granite itself, even when these are separated by some miles from the silurian country by large areas of continuous granite. This of itself proves how little share the intrusion of the granite had in producing disturbance or dislocation in the beds, under and into which it gradually eat its way.

Upper Palæozoic Rocks.

The Old Red Sandstone, near the S.W. corner of Sheet 157.—The little outlying patch of Old Red sandstone at the southern end of the district, just N. of Ballintlea, is composed of beds of coarse conglomerate in a nearly horizontal position. It caps an elevation on one side of a small shallow valley, on the opposite side of which, near Ballynooney South, are similar beds of coarse red sandstone and conglomerate, with red cleaved shales, all lying also as nearly horizontal as possible.

These beds may be traced towards the north, showing themselves here and there along the surface of the ground, where they are noticed as "coarse sandstone and conglomerate, containing fragments of quartz, feldspar, and mica," "conglomerates and sandstones with red shales interstratified," "red and gray sandstones and conglomerate," and so on. They are all marked as dipping very slightly to the W., generally at 3° or 4°., and never more than 5°. Proceeding in the direction of the dip, we meet with other rather higher beds of red and white sandstone, with some red shales and an occasional band of conglomerate. These and "red silty sandstones" are the rocks mentioned as occurring all about Lukeswell.

Following the boundary of the Old Red sandstone towards the point where it passes from the slates on to the granite of Arrigle glen, the following notes by Mr. Wyley are met with on the six-inch map:—"The sandstones very granitic in structure, evidently derived from the granite exclusively or nearly so;" "pebbles of granite of the size of hen's eggs in the Old Red conglomerate;" "Old Red conglomerate, very coarse, composed of pebbles of quartz, granite, altered grit, and altered slate, arranged in thick massive beds, four to six feet in thickness, ranging north and south, and dipping W. at 3°."

I can answer for the correctness of these descriptions, and for the glittering and crystalline appearance of some parts of the Old Red sandstone when freshly broken open, in consequence of the slightly worn state of the crystalline granules of which it is composed. These granules are, however, chiefly quartz, the feldspathic constituent of the granite having been probably ground down into clay, and many of the mica spangles washed away, although a good deal of them still remain.

There are, nevertheless, some beds of conglomerate in which the pebbles

are wholly white, opaque, vein quartz, perfectly rounded, and the rock not more granitic than any other conglomeritic sandstone. Mr. Wyley notices some of these close above the granite, and says they are "exactly like the rocks at Tory Hill and Cat's Rock, places ten or twelve miles distant."

Walking towards the west, we again come, in the country about Castlegannon and north of it, upon red, gray, and whitish gray sandstones, with some red shales and an occasional band of conglomerate—every rock seen appearing to have the same almost insensible inclination to the west. Many of these beds are described as "red silty sandstones."

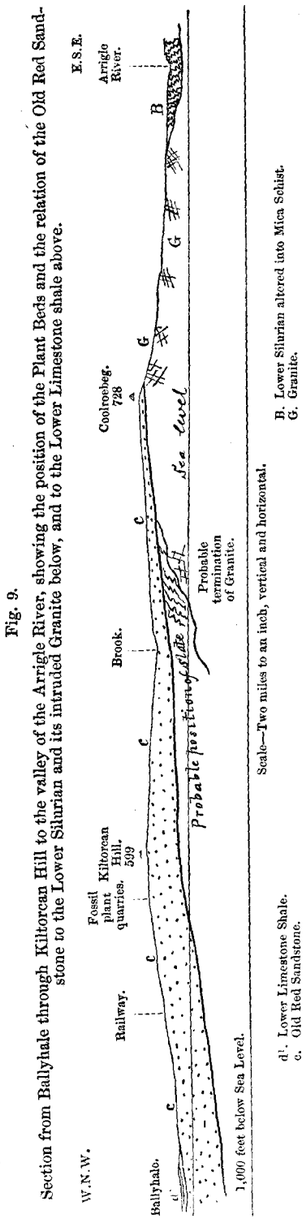
A similar description may be given of the Old Red, as far as the termination of the Arrigle glen granite; but as we go north the inclination of the beds towards the west seems to increase, so that some of the lower beds dip as much as 10° in that direction in some places. The consequence is, that the higher beds of the formation of which we have not yet spoken are more quickly reached in proceeding to the west than they are where a low angle of dip and a gentle fall of ground cause them to recede farther in that direction.

The Kiltorcan District.—A little S.E. of the village of Ballyhale is the townland of Kiltorcan, the highest point of which is 600 feet above the sea. A mile and a half due E. of this, we reach the lower boundary of the Old Red sandstone resting on the granite; and the following is the section across the Old Red sandstone at this part:—

Immediately above the granite, and close to the boundary of the Old Red sandstone, a block was observed with one large and several small pieces of granite in it. For a thousand yards to the westward, beds of red, gray, and reddish gray sandstone, containing all the constituents of granite, were observed, often sloping at the same angle as the ground, so as to form rough sandstone floors, partially covered with coarse sand, heather, and rough herbage. These continue as far as a small hollow, in the bottom of which is a little brook, the water of which is at a level of about 500 feet above the sea. To the west of this the ground rises gently to the west

Fig. 9.

Section from Ballyhale through Kiltorcan Hill to the valley of the Arrigle River, showing the position of the Plant Beds and the relation of the Old Red Sandstone to the Lower Silurian and its intruded Granite below, and to the Lower Limestone shale above.



up to a height of 600 feet in about two-thirds of a mile; and the beds dipping at 5° or 6° in the same direction, are made of red muddy or silty sandstone and red shaly sandstone, until we come to whitish and greenish gray compact fine grained sandstones, and then to greenish compact hardened silt and red and yellow silty sandstones. (See section, fig. 9.)

These beds appear on the top of the ridge to be absolutely horizontal. It is in one of these "greenish yellow or greenish brown compact silty beds," as Mr. Wyley describes them, that the plants, shells, and fish scales were found, which have been already mentioned. The stone splits readily into large flags, is very fine and even in texture, in some parts more gritty, in others more purely argillaceous, for some of which the name of "clay rock" is proposed to be used. On the western slope of the hill red beds appear at different levels both N. and S. of these green beds, in such a way as to make it difficult to say whether they are under or over the green and yellow stones; for it is sometimes difficult to determine whether they appear in consequence of the fall of the ground being greater than the slope of the beds or not.

Red sandstones certainly come in in the lower ground between the foot of Kiltorcan Hill and the Carboniferous Limestone, and these seem to be again covered by whitish and yellowish brown sandstones, in which some imperfect casts of small bivalve shells were found, and which seem to be immediately beneath the base of the Lower Limestone shales.

The whole thickness of the Old Red sandstone here, from its base resting on the granite, to the top covered by the Lower Limestone shale, does not probably exceed 700 feet. The upper beds of the Old Red, which contain yellow and greenish sandstones, flags, and shales, interstratified with the red beds, have been separated from the rest under the name of the Upper Old Red or Yellow sandstone, and a separate figure, "c^3," and a darker colour, has been assigned to them on the map. It would, however, be quite impossible to point out on the ground to any definite boundary as that which separates this Upper Old Red from the remainder of the formation. It is a purely arbitrary and conventional subdivision, and is determined merely by the general lithological character, by the occasional occurrence of plant remains, and by stratigraphical position, none of which are alone sufficient to prove the beds to belong to this upper group, and all three of which combined may possibly be sometimes fallacious.

Valley of the Kilkenny and Waterford Railway.—Beds having more or less of the yellowish green or white colours interstratified with the red sandstones and shales, stretch from Ballyhale through the valley by Dogstown and Carrickshock to Newmarket, and may be seen in many small crags, dipping gently to the N.W., N., and N.E., as they range across the valley. They may be seen also farther S., about Kilkeasy, in various places, and are believed to stretch as far S. as Knockmoylan, where the lower beds are supposed to crop out from underneath them.

Some beds of yellow and yellowish gray sandstone, about Ballyhimmin, were supposed to render probable the occurrence of an outlier of the upper beds about that place.

A fault will be seen running N. and S. across the map, along the eastern side of this valley, and just at the foot of the ridge, of which Kiltorcan Hill forms part. Mr. Wyley believed that a line of fracture occurred here, partly on account of the beds in the valley about Ballyhale seeming to be as high as, or higher than, those on Kiltorcan Hill itself, and partly from evidence seen in the sheets both N. and S. of 157. I think it probable that some crack does run along the line marked as a fault in the map, although I feel sure that the dislocation is nowhere large, and is sometimes perhaps evanescent.

The ground rises towards the west up to the slope of the Nine-Mile-House

table-land, and the beds of the Old Red sandstone rise with the ground, and a little faster than it, so that on attaining the level of the table-land, we find the basal conglomerates of the Old Red sandstone cropping out in small crags, and overlooking a district composed of the Lower Silurian slate rocks. These conglomerates as they dip towards the west become covered with beds of red and white sandstone and shales, just in the same way as do those before described that dip eastward from the granite and silurian slates of the ridges bordering the Arrigle Glen.

A little north of the hamlet of Catstown Mr. Wyley notices the occurrence of Red sandstones and slates, over which are "hard, greenish, ringing, thin flags, composed of clear micaceous and quartzose sand, with a siliceous cement. In this was a layer quite full of land plants, with fluted stems, and broad sedgy leaves, the cellular structure being often preserved."

Ballyhale to Goresbridge.—We will now trace the Old Red sandstone from the neighbourhood of Ballyhale to its termination near Goresbride.

About Baunskeha and Ballymadigue "fine red silty sandstones" occur, with in one place "twelve feet of coarse white sandstone of granite origin;" and about a mile to the west of these places "yellow sandstones" are frequently mentioned together with the red. At one place, just a mile W.N.W. of Ballyconway Bridge, near the end of a little lane between the cross-roads and the trigonometrical point 359, in the southern part of the townland of Ballylowra, some very old quarries are mentioned by Mr. Wyley as "appearing to be those from which the ornamental stone of Jerpoint Abbey was obtained. The stone is very soft, composed of grains of quartz and earthy feldspar, with mica to a small amount. Hammer-dressed stones have been found about there, and the tradition is that when the particular beds of stone were reached, they were wrought underground in the form of a tunnel."

The beds still strike steadily northwards, with a very gentle dip to the west, but as we approach Jerpoint Abbey the dip becomes more north-west, and the strike consequently N.E. The dip is still, however, very gentle, so that the little brook coming down from Baunskeha to Jerpoint cuts through some of the upper beds, and leaves them as an isolated patch, capping a little eminence on its eastern side.

The rock is shown hereabouts abundantly in many picturesque little cliffs, covered with wood, from Jerpoint to Thomastown. Plant impressions may be seen occasionally in the sandstones.

Mr. Wyley says, "all the cut stone used in Jerpoint Abbey (with the exception of the pieces supporting the tower, and some other trifling exceptions, which are of limestone) has been obtained from the upper beds of the Old Red sandstone. Considering its extreme softness, it has stood better than one would have expected. For an outside work it is unfit."

Quarries of the upper beds may be seen in Thomastown itself, showing in one place a small fault where red beds abut against yellow. A good section in the lower, harder, red, green, and white sandstones, dipping N.N.W. at 3°, may be seen in a road-cutting S. of Grenan Lodge; and almost the very bottom beds may be seen here and there in small quarries, on each side of the river, where the lower boundary of the formation crosses the river.

After crossing the river these beds strike nearly east for a time, and run up along the hills, rising to a height of 500 feet in some places, with a distinct escarpment of fifty feet above the top of the Lower Silurian slates, on which they rest. The lower beds may be very well traced thence for two or three miles to the N.E., consisting of red sandstones and conglomerates, dipping N.W. at 3°, or thereabouts, and passing in that direction under whitish and brownish sandstones. The lower part of the Old Red here makes a rough heathery ridge of barren land, contrasted with the more fertile and woody, and pleasanter undulating tract that sinks slowly towards the limestone on the

N.W., or the steeper but greener slope on the S.E., which belongs to the Lower Silurian rocks. The boundary between the Silurian and Old Red is very well marked hereabouts, the slates appearing in the roads and ditches, and the soil in the ploughed fields being full of their fragments, although many blocks of Old Red lie about them, till we reach the boundary, when the slaty fragments suddenly disappear, and small crags of Old Red sandstone are often visible.

This description applies as far N. as Cloghscregg Castle, east of which rise Bishop's Hill and Coppanagh, which have already been spoken of as capped by level, almost horizontal, floors of Old Red sandstone, of no great thickness or importance, but interesting, as leading us to observe the former extension of the formation over the country to the eastward.

We then reach a shallow valley, stretching across the Old Red sandstone in which it is almost entirely concealed by local drift of clay and sand beyond which the formation again rises into higher ground, some of the lower beds spreading up towards the east to a height of 720 feet.

This is about two miles S.E. of Dungarvan, and a little beyond the strike again changes more towards the east, and the beds dip more nearly due N. At one part the ground rises towards the S. with such a regular gentle slope, nearly parallel to the inclination of the beds of the Old Red, as to carry those beds far up the slope of the hill. Red sandstones stretch up to the trigonometrical point 697, and after being just removed from off the ground so as to expose the Silurian slates for a space, they set in again, and stretch up Freagh Hill to the height of 1,045 feet, near the margin of Glencoum wood, forming the outlier already spoken of.

To the eastward of this the ground falls rapidly, and the Old Red sandstone has been cut back to much narrower limits. It is obvious, moreover, that its thickness begins here sensibly to diminish. About Ballyhale its total thickness may probably be about 700 feet. This is the result at least given by a carefully protracted section across it, on the scale of six inches to the mile. About Thomastown the surface width of the formation measured from the town to where it crosses the Nore, is about 7,000 feet, if we suppose it to have an average dip of 5°, it will still have a thickness of 600 feet. About two miles east of Dungarvan, however, there is some flat ground in which the surface width of the Old Red certainly does not exceed 2,500 feet. This, with a dip of 5°, would give only 217 feet, and even with a dip of 10° would only make it 435 feet thick. It has this inclination at two places just to the east of this part, one showing "beds of gray and reddish sandstone derived from the waste of granite, with large unbroken plates of mica," and the other higher beds of "greenish, white, and yellow sandstone, with beds of red silty slate." For two miles further to the E.N.E. beds of red sandstone below, and yellow, interstratified with red above, may be seen occasionally in roads, brooks, and small quarries, and we then come to the part where the Old Red passes from Lower Silurian slates on to Granite again, since it here meets the boundary of the main mass of Granite, as it ranges N. from Graiguenamanagh.

This is about a mile S. of Mount Loftus, and though there is no good exposure or section of the rocks, yet the cutting of a road shows the Old Red here and there stretching from the part where the Lower Silurian slates are unaltered across the part which is micacised, and resting directly on the Granite.

From this point the Old Red sandstone runs almost due north. Red and yellow sandstone is seen N.W. of Mount Loftus in some roads and small quarries, and near Brookhill House, and up to Barronmount House. It dips W.N.W at 5°, and does not occupy a greater width between the granite ground and the Limestone than a few hundred feet, and is probably not thicker than fifty feet. Only one other quarry of it is to be seen further north. This is at the bend of the road, about 1,000 yards E. of Goresbridge,

where some rather thick beds of red quartzose sandstone make their appearance, dipping E. at 5°. Beyond this point it is not again seen anywhere.*

The Carboniferous Limestone, near Ballyhale.—In order to begin the description of this formation in detail, we will return to the neighbourhood of Ballyhale. Half a mile N.E. of that place is Derrynahinch House, to the east and south-east of which, and within a 100 yards of it, yellow and white sandstones are partially exposed in one or two places, dipping east at a low angle, while about 250 yards to the S.W. of it is the old ruined church, near which black shales may be seen nearly horizontal, and crowded with fossils of common Carboniferous species. A little way to the N.W. of the old church black shales, mingled with concretionary lumps of limestone, apparently magnesian, may be seen 600 yards N. of Derrynahinch House, blackish shaly limestone, interstratified with black shales, are to be seen in a lane, with several exposures of yellow sandstone 100 yards to the east, the whole dipping eastward at so low an angle as to appear horizontal. Mr. Wyley mentions the occurrence of an abundance of shells and corals, with a few trilobites, in the black shales.

The uppermost beds of the yellow sandstones may be followed from near Derrynahinch S.W. to Ballyhale, and may then be traced at intervals for half a-mile to the N.W., curving round so as to dip gently N.E., but immediately rolling over and dipping N.W. They thus make a small anticlinal promontory, projecting to the north towards Knocktopher. On the east side of this promontory Mr. Wyley describes thick bedded, very massive, magnesian limestone, with black shales between the beds, and resting on dark gray shales. The magnesian limestone, when fresh, is very solid, but speedily decomposes into a brown powder. Copper pyrites and specks of green and blue carbonate are disseminated through it. The beds are nearly horizontal.

Some of the sandstones below are gray, and thinly laminated, but others that appear a little further north quite as close to the limestone, are said to be greenish gray and red.

On the west side of this little sandstone anticlinal are quarries in gray and dark gray magnesian limestone, with pearl spar, and crystals of carbonate of lime, and sometimes with beautifully formed crystals of transparent quartz, some of which are double pointed, lying in the decomposed magnesian limestone. Green talc is said sometimes to line the joints of the limestone.

A little to the S.W. blackish shales, with beds of impure magnesian limestone, are again noted with smooth whitish sandstone a little to the southward of them.

Hereabouts the sandstone recedes to the S., making a little synclinal bay or trough corresponding to the anticlinal promontory before mentioned. In this bay, especially in the townland of Ballybroodan, are several exposures of the black shales, with brown sandy-looking beds lying nearly horizontal, and crowded with fossils of the genera Spirifera, Terebratula (or Rhynchonella), Orthis, &c., together with Fenestellæ, and several corals and Encrinites.

The beds now described seem to stretch horizontally through Knocktopher, where they are again visible, and over a considerable space about it. They are not again visible further west within the limits of this map, except about half a mile due N. of Newmarket, where there are some large quarries.

The lower beds in these quarries are thin, black, earthy limestones, interstratified with black shales, passing up into thicker and more massive and crystalline limestone, with less black shale. The whole is still highly fossiliferous, especially in the lower parts.

* The Old Red sandstone not only disappears north of this point through the remainder of the district now described, but it never appears again at all on the eastern side of Ireland, except in the form of a few local patches, of slight thickness and extent, such as those near the Chair of Kildare, or near Portrane, in county Dublin.

These beds dip at 10° or 12° to the N.N.E., and the highest, or most northeasterly quarry shows dark gray crystalline and crinoidal limestone, in which fossils, except the crinoidal stems of which it is almost entirely made up, become rare.

The total thickness of the beds exposed in this line of quarries cannot be less than 250 feet; the lower fifty feet of which may be assigned to the Lower Limestone shale, and the rest to the Lower Limestone. Mr. Wyley remarks that the series reminded him greatly of the Hook Limestones.

These appear to be cut off towards the west by a dyke-like mass of dolomite, beyond which all the rock seems to be "a gray, glistening, magnesian limestone, full of strings and veins of the magnesian carbonates," from under which, however, the black shales, with fossils, again appear to the S.W. as we approach the slope of Old Red sandstone that rises up towards Castle Morris, in Sheet 156. (See Explanation 156).

Just about 800 yards due N.W. of Knocktopher Church,* there is a large quarry in precisely similar beds to the highest of these just described, with a dip to the W. of about 3°; and similar beds are seen in various other quarries in a N.E. direction as we follow the general line of strike of the beds into the country between Flood Hall and Newtown. There are several quarries about the latter place, one of which is capped by eight feet of blackish magnesian limestone, crossed by straight veins full of spar "containing crystals of both carbonates." Rather more than a mile due S. of Newtown, near the road from Knocktopher to Thomastown, are some small quarries in the Lower Limestone shale, consisting of black shales, interstratified with thin flaggy limestones above, and thin pyritic grits below, dipping apparently to the W. at 6°, or thereabouts.

Thomastown District.—About half a mile nearer to Thomastown, where the road crosses the brook towards the east, the uppermost beds of the sandstone may be seen in a farm-yard just S. of the bridge. They consist of grayish or greenish sandstones below, passing up through gray thin-bedded sandstones, into gray shales, becoming dark bluish gray as we ascend, the whole forming the transition from the Old Red into the Lower Limestone shales.

In a field scarcely a 100 yards N. of the bridge, however, there is an old quarry in dark gray crystalline limestone, with coarse yellowish sandstone ranging by it to the north, and so close to it as to make it probable that a small fault runs between the two. This is one of the observations that render probable the existence of the long north and south crack, which is indicated on the map.

Jerpoint Church House is about two-thirds of a mile N.E. of this point. Just S. of the house coarse whitish and yellowish sandstone may be seen, a little to the north-west of which in the straight road leading towards Stonyford, blackish gray shales, with brown sandy patches, make their appearance; and 850 yards further along that road we find dull gray crystalline limestone dipping N.N.W. at 3°. Few or no fossils are to be seen at either of these places.

Still proceeding towards the N.E. we come to Thomastown itself, where

* Half-way between this quarry and those north of Newmarket are the ruins of a very old church, respecting which Mr. Wyley has the following note. "The stone used in the doorway and windows of this very old church is a yellow or rather brownish white sandstone, belonging to the upper beds of the Old Red. Where there are hard kernels or layers, as it is often the case, it weathers very unevenly. It is the same stone as that used in Jerpoint Abbey, and has evidently been selected for its softness and facility of being worked, being far inferior to limestone in strength or durability. That the architects of the abbey had serious doubts as to its fitness for bearing great compression, is evidenced by their having rejected it and used limestone in the piers supporting the towers. Some very slender piers in Jerpoint Church are also of limestone."

both the banks of the Nore show the upper beds of the Old Red or yellow sandstone, while on the slope north of the river, here and there in the fields and in the roads, beds of black shale, with thin limestone bands, make their appearance, in a nearly horizontal position. They are here full of fossils.

These beds may be seen also in the first cutting on the railway, N. of the station, dipping gently to the north under some other beds, a little farther on, of "blackish, dense, ringing limestone, massive in some parts, in others having partings of shale, which become thicker in the lower beds, with but few fossils except small Spiriferæ."

About half a mile on the old Kilkenny road, due N. of Thomastown, are large quarries in dark gray crystalline and crinoidal limestone, dipping N.N.W. at about 4°; and a quarter of a mile farther on are other quarries in thin bedded, blackish crystalline limestone, dipping N.W. at 10°, and full of fossils, of which Spiriferæ were the most abundant, but Orthis, Leptænæ and small Productæ, were also common.

Similar limestone is seen in scattered quarries in the country between this point and Newtown.

We have now examined a broad strip of ground for six miles, from S.W. to N.E., and seen that the rocks, with some local variation, preserve everywhere the same general order of succession, black shaly beds below, resting on the upper part of the sandstones, and covered, as we ascend, by thicker and more massive beds of dark crystalline limestone.

Thomastown to Dungarvan.—Between Thomastown and Dungarvan, four miles further to the N.N.E., the few exposures of rock which are to be seen in the limestone, are entirely in accordance with these statements.

There are two large quarries just N. of Kilfane, in which the beds dip nearly due W. at about 10°. The upper beds are blackish crystalline limestone; the lower consisting of the same rock, with partings of shale; fossils not very abundant.

At a group of houses in the townland of Kilmanaheen, a mile S. of Dungarvan, yellow sandstones are to be seen in a lane to the east, and thin black gray shales, with rusty arenaceous layers, in a lane to the west, the dip being about W. at 5°.

Not half a mile beyond Dungarvan, to the E.N.E., is a large quarry in strong bedded, black crystalline limestone, dipping N.W. at 10°, while on the road running S.E. of Dungarvan, as also in the lane leading S.E. from this quarry, the top of the yellow sandstone is to be seen in contact with the bottom of the black shales, both dipping N.W. at a very low angle.

Stonyford to Dungarvan.—Having thus laid down a base line of about eleven miles in length, from S.W. to N.E., we will now proceed to traverse the limestone plain towards the N.W., and examine the beds that lie above those already described.

Rather more than a mile N.W. of Knocktopher is a little place called Danganbeg, near which there is a good quarry of black, irregularly crystalline limestone, dipping about W.N.W. at 5°, and exposing a vertical thickness of fifty feet, or thereabouts.

About 1,000 yards further to the N.W. is another large quarry in thin bedded, black limestone, dipping W. at 7°, or thereabouts—(this is near the Hermit's Cave); and similar beds may be seen, to the westward, near Tinvaun, where they dip N. at angles varying from 10° to 12°, and thus show the strike of the beds to be curving towards the W.; as also N. of the Hermit's Cave, where they dip N.W. at 10°. All these limestones are full of fossils.

As we proceed to the N.E., however, from Danganbeg, we shortly come upon a rising ground exposing masses and crags of dull gray, glistening magnesian limestone, heavy, scarcely effervescing with acids until ground down, almost devoid of fossils, and readily decomposing, especially along the joints, into a coarse, rough, very heavy sand.

This is the first appearance, as we proceed from the south, of a regular band of black or dark gray magnesian limestone, which stretches thence for some miles to the N.E., with an average width of about 1,000 yards. It surrounds and encloses one little patch, and another large one, of black, rather shaly limestone, devoid of magnesia, and full of fossils, between the Hermit's Cave and Flood Hall, beyond which it seems to be unbroken for some distance.

It may be seen here and there in crags running by Cherrymount, Knocknabooly, N. of Mount Juliet, and thence to the road and railroad to Kilkenny. It is bordered on either hand by frequent quarries in dark limestone, without magnesia and with fossils, all the beds having a general dip to N.W. at low angles, so that those on the S.E. appear to be beneath, and those on the N.W. to be above the magnesian beds.

Just N. of the point where the railroad is crossed by the ordinary road from Thomastown to Kilkenny, the beds above the magnesian limestone are well exposed, and they are found to be regularly interstratified with thin magnesian beds, forming, as it were, a transition from the mass which is entirely magnesian to that which is quite devoid of it. Half a mile to the eastward of this point beds of ordinary limestone of bluish and blackish gray make their appearance in the middle of the magnesian band, and extend N. past Summer Hill House, and thus appear to divide it into two. The north-western and lesser portion seems to die away about half a mile to the N.W. of Summer Hill, where a narrow band of gray earthy magnesian limestone may be traced between two sets of quarries in blackish gray limestone, with fossils, which is the only rock to be seen about Kibline Castle, and thence to the north-eastward, through the western part of Castlefield House Demesne.

The lower and broader part of the magnesian band, however, runs on to the S.E. of Summer Hill, and thence northwards, through the eastern part of Castlefield Demesne, where it turns to the eastward, and, running a quarter of a mile N. of Dungarvan, unites with a much larger mass of magnesian limestone, which has hitherto run nearly parallel with it from the S.W. Between these two the band of black fossiliferous limestone lying over the magnesian band which we have now traced, is brought to a termination, two quarries of it being seen about three-quarters of a mile N. and N. by E. of Dungarvan with black magnesian limestone surrounding them on all sides except the west.

We will now return again to the S.W., and examine this larger mass of magnesian limestone.

About 300 yards N.N.W. of Tinvaun there is a quarry by the road side, in thick, unevenly bedded, whitish, silvery-looking magnesian limestone, often having a saccharoid texture. This spreads far to the N.W., about Chapelizod House, which is within the limits of the next sheet, to the west, (see Explanation of Sheet 146), and also runs N. to Kells, and N.E. by Kellsborough House, and a little to the north of Stonyford. It is well exposed about those places in little cliffs on the banks of the King's river, which falls into the Nore, a mile and a half E. by N. of Stonyford.

It is generally described by Mr. Wyley as a light gray stone, closely granular or saccharoid in texture, and full of cavities or cracks, which are lined with crystals of the magnesian carbonates (brown spar, bitter spar, or pearl spar). It is here full of nodules and irregular lumps of chert, generally black or dark gray, and some of the cavities and cracks near those have crystals of quartz instead of the carbonate spar. Fossils, especially encrinite stems, are to be seen here and there, both in the chert and the magnesian limestone. The stratification is often obscure and appears irregular, or else the beds seem to have been much rolled and twisted. Near Stonyford this band is a mile and a quarter in width, from N.N.W. to S.S.E., the dip of the non-magnesian beds above and below it being about N.N.W. at 5° or 6°. If

we could imagine the inclination to be steady at 5° for that distance, it would give a thickness of 570 feet for the magnesian band here; but if there be much undulation, that thickness will be much reduced. The beds above it are that black compact limestone which is taken here to represent the calp or middle part of the limestone series. They may be seen in quarries a little to the N.E. of Garrynamann House, and in the brook that comes down to Ennisnag Bridge.

The magnesian limestone may be seen in low craggy cliffs on the left (or east) bank of the Nore, half a mile to the northward of Annamult House, and at several spots further to the N.E.; but though it retains its silvery lustre, and in some places its whitish colour, it generally gets of a darker gray, and becomes, as we we proceed towards the N.E., almost black. It loses the cherty nodules also, and generally becomes more like the lower band of magnesian limestone with which it seems to coalesce, as already described, a mile or so to the S.W. of the demesne of Gowran Castle.

Dungarvan to Goresbridge.—We have now traced all the beds belonging to the lower part of the Carboniferous limestone group, up to the country about Dungarvan. It will be recollected that to the N.E. of this point the Old Red sandstone commences sensibly to dwindle and die out. It will be interesting to examine whether any thing of the same kind takes place in the bottom part of the limestone itself, as we trace it towards Goresbridge and Bagenalstown.

About a mile S.S.W. of Powerstown, in the old road from Graiguenamanagh, the top of the Old Red sandstone may be seen passing up into black sandy shales belonging to the Lower Limestone shale. Going N. along this road, a large quarry, in black limestone, lies about 200 yards to the west of it, the uppermost beds of which are magnesian. Two or three hundred yards further north there is a quarry by the roadside, in gray earthy fine-grained magnesian limestone, and 100 yards beyond that we come to blackish crystalline limestone, with fossils, and one magnesian bed running through the middle of it. All these beds seem to dip N.W. at 10°, or thereabouts. The magnesian limestone is well seen in and about Powerstown itself, and in some small scattered quarries a mile to the N.E. of it, while a quarter of a mile N.W. of Powerstown is a large quarry in the gray non-magnesian limestone over it. This magnesian limestone of Powerstown is believed, therefore, to be an independent lenticular mass of that rock, distinct from the large mass of magnesian limestone which ranges through the country still further to the N.W.

About 700 yards E.S.E. of Johnville Bridge is a large quarry in black muddy limestone, parts of which are crystalline, dipping N.W. at 5°; in the south-western part of this quarry is a dike-like mass of magnesian limestone between two strong joints.

Three-quarters of a mile east of this, and a little west of Barrowmount and Brookhill, the earthy shales, indicating the presence of the Lower Limestone shale, may be seen above the little skirt of Old Red there.

Half a mile further N., in the wood north of the Druid's Altar, there are beds of dark gray shale, alternating with sandy flags below, and with flaggy limestones above, dipping W. at 10°. These are said to be exactly like the beds near Ballyhale. A little west of these on the S. bank of the Barrow, below Goresbridge, beds of black muddy limestone, with shale partings, are seen; they dip W. by S. at 10°, and are full of fossils.

Three-quarters of a mile S.W. of these are gray crystalline limestones, largely quarried and burnt for lime, dipping W. at 10°, or thereabouts; and a quarter of a mile still further west, are quarries in black magnesian limestone, decomposing into sand.

In the north-west outskirts of the village of Goresbridge, dark gray limestone may be seen dipping N.W. at 5°, while a little further west, near Yellow Lough, black magnesian limestone may be seen dipping N.W. under beds of light gray crystalline non-magnesian limestone, and those covered by light gray magnesian limestone. All the darker limestones, both here and elsewhere, and some of the lighter magnesian limestones are very fetid.

It is obvious that we have near Goresbridge a repetition of the same general section that we have traced all the way from the neighbourhood of Ballyhale and Knocktopher.

It will be recollected that the last known exhibition of the Old Red sandstone, as we traverse this district towards the N., is the one a mile or so E.N.E. of Goresbridge. In like manner, the last exhibition of the Lower Limestone shale, is the one just mentioned in the wood N. of the Druid's Altar. How far it extends beyond this is doubtful, since there is no exposure of any rock about the lower margin of the limestone, for several miles to the north. It either dies out shortly, however, or is eventually overlapped by the upper beds of the limestone series, since no rocks answering to the Lower Limestone shale are ever again seen along this boundary of the Carboniferous limestone from Goresbridge into Dublin Bay.*

Goresbridge to Bagenalstown.—The band of magnesian limestone sometimes, as we have seen, containing beds which are not magnesian, ranges from the neighbourhood of Goresbridge nearly due N., still maintaining a surface width of more than a mile. It shows itself here and there in knobs, or has been worked in small quarries, appearing as a dark gray crystalline limestone with cavities; but from its ready decomposition into a mere sand of small crystalline granules, it is of little value even for the roughest purposes.

Less than a mile nearly due N. of Goresbridge on the left (or eastern) bank of the Barrow, there are large quarries in bluish black very fossiliferous non-magnesian limestone in thick beds, nearly horizontal, or dipping W. at 2°. This is about 1,000 yards W.N.W. of the last quarry of Old Red sandstone, and it is itself the last quarry of non-magnesian limestone on this side of the Barrow till we get north of Bagenalstown. This, however, does not appear to be the result of any dying out or disappearance of the Lower Limestone beds, but rather because all the beds to the northwards become magnesian. It will be recollected, or will be seen by reference to the map, that the magnesian band is separated into two beyond Dungarvan, and that these coalesce as we come north, so that as we proceed in this direction, the magnesian element seems to become more abundant and universal in the lower part of the limestone, and eventually to become universal throughout its lower portion.

About a mile N. of Kilgraney House there is a group of quarries showing dark gray very fetid magnesian limestone, some of which is cavernous or cellular, and having that arenaceous look which is so characteristic of magnesian limestone. The beds seem to dip W. at 10°, and some of the quarries are within two hundred yards of the little ridge which is the boundary of the granite.

The edge of the granite, although it is nowhere distinctly exposed, is yet traceable by the occurrence of numerous blocks and crags of the rock, some actually in place perhaps, others just fallen or slightly moved, all the way from Graiguenamanagh to near Goresbridge and Bagenalstown, being bordered first of all by the mica schist or altered Lower Silurian rock, then by the unaltered Old Red sandstone and Carboniferous limestone.

The magnesian limestone is seen again at three places on the banks of the Barrow, and also in Bagenalstown, where there are quarries in both dark and

* It is quite possible that the overlap of the upper beds of the Carboniferous limestone, which is so probable in the Dublin district, commences as far south as Goresbridge or Bagenalstown. In that case, the Old Red sandstone and Lower Limestone shale, may be continuous under Kilkenny and Maryborough, and re-appear at the surface about Slieve Bloom, although they die out altogether, or only occur in discontinuous patches, towards the N. and N.E. through Carlow, Kildare, and Dublin.

light gray cellular or cavernous magnesian limestone dipping N.W. at 8°. Similar rock, with the same dip, may also be seen N. of Bagenalstown, above Wykeham House, near the banks of the river.

It is unfortunate that from the depth of the drift, consisting chiefly of limestone gravel, no quarries have been opened close to the granite, so as to expose the junction of the two rocks. It is probable that if there were we should find pieces of the granite and patches of granite sand enclosed in the limestone, as they have been found at several places in the county Dublin, even at some distance from the granite boundary, and as the sand at all events, if not the fragments, is to be found in the Old Red sandstone to the southward.

Calp, or Middle Division of the Limestone.—Immediately over or to the north-west of the magnesian band which has just been described, we meet with a set of beds that have been grouped together under the above designation. We have already mentioned the occurrence of compact black limestone at Garrynamann, a little N.E. of Kells, in the S.W. corner of Sheet 147. Similar black compact ringing limestone, with or without partings of black shale, are to be seen in scattered quarries over the country to the N.E. of this, up to Ballyda and Danesfort House, and from that to Annamult and the Glebe House of Skeaghaturkish. These beds dip at various low angles to the W. or N.W. or N., in which direction they are succeeded by more massive crystalline gray beds, full of large corals, that will be described presently under the head of the Upper Limestone.

On tracing these beds to the banks of the Nore, we meet with a narrow belt running N. and S. along the river, in which nothing but the local debris of yellow crystalline dolomite is to be met with, evidently derived from the rock just beneath the surface ;* but immediately after crossing the river we again find a line of quarries in thin-bedded black compact limestone, with shaly partings. These beds are seen in many quarries over all the country N.E. of Bennett's Bridge up to Blanchville House. Fossils are rare in these beds, though an occasional coral or producta occurs, and encrinite stems more frequently.

At a little place called Dunbell, between Prospect and Blanchville House, there are three quarries in which the blackish close-grained limestone seems to be strongly magnesian. It is presumed therefore that there is an isolated magnesian boss here, as drawn on the map.

A little N. of Clifden, which is a mile N. of Dunbell, are three or four quarries scattered about, in which black compact, rarely fossiliferous limestone, dips at 5° to the eastward. One of these quarries is three quarters of a-mile N.W. of Clifden. Similar limestones dip S.E. at 5°, a little S. of St. Martin's Well; while half a-mile north of that well, and also still further N. at two points about three miles N.E. of Kilkenny, the same beds dip still N.E. at 5°.

There are still two other quarries in beds apparently the same as those now described. One of these is in the townland of Cellarstown West, just N. of a road leading to Kilkenny, where black compact regularly bedded limestone, with few fossils, dips W. at 8°; and the other is near Sion House, a mile S.E. of Kilkenny, where the dip is S.E. at 10°.

At all these places the black, compact, shaly, and calpy looking beds, dip towards others that have more of the lithological character assigned to the Upper Limestone, and they are therefore believed to warrant the supposition of an anticlinal ridge in the middle beds, the axis of which runs off N.N.W. for four miles from Dunbell, and is then crossed by another smaller anticlinal elevation running about W.S.W. to the outskirts of Kilkenny.

* This dolomite will be mentioned again presently.

That the beds have this lie is rendered probable, by the boundary of the Upper Limestone drawn by it, being parallel to that of the Coal Measures to the north of it, which is one determined upon much more certain evidence.

Returning now to Dunbell and Blanchesville, we may follow the black compact limestone, towards the E., by means of small detached quarries, till we come to a large quarry of it 400 yards S. by E. of Gowran Castle.

Before reaching that, however, we should have passed about Fox Lodge and the Glebe House, by several quarries of yellow highly crystalline dolomite which is seen also a little N. of the town of Gowran. This yellow dolomite appeared to Mr. Wyley to be a part of the calp beds, that had been converted into dolomite subsequent to their deposition by some metamorphic action.

About a mile N.E. of Gowran there are several large quarries of thin bedded, compact, muddy looking black limestone, with shale partings and independent beds of shale, all dipping steadily to the N.W. at from 5° to 10°.

These are the beds that lie above the Lower Limestone magnesian band, described before as ranging to the west of Goresbridge, and form part of the section that may be seen in a westerly traverse from that place.

A still more complete and almost continuous section across this calp band, and into the Upper Limestone, may be studied just S. of Monefelim, where there is a regular chain of quarries opened in a line, about W.N.W. and E.S.E., or directly across the strike. The limestone is sometimes light, but generally dark gray, compact, thin, and regularly bedded with shale partings, with few fossils except an occasional Euomphalus or Goniatite. The lowest beds, or those in the most easterly quarry, are said to be slightly magnesian, and the uppermost, or those in the largest and most westerly calp quarry, are described as "black marble much used for tombstones." It is traversed by two sets of joints, one coursing W. 20° N., and the other N. 30° W., so as to cross each other at angles of 40° and 140°.

The dip is W.N.W., or thereabouts, at angles varying from 5° to 10°, and the width of the band assigned to the calp here is about 4,000 feet, which, with a mean inclination of 5°, would give a thickness of 348 feet.

The quarries near the Glebe House to the west, which are assigned to the Upper Limestone, show more massive crystalline and rougher beds, full of Productæ and large Corals.

Other calp quarries are to be seen further north, near View Mount, and beyond it, towards the N.N.E., an occasional band of dolomite making its appearance in them.

A good section was exposed too in the cutting of the railway, showing many beds of dark shale to be there interstratified with the limestone.

Near the Royal Oak, a mile and a quarter W. of Bagenalstown, there is a large black marble quarry near the middle of the group, and another in the same strike further north, one-third of a mile S.W. of Killinane House, the beds in both dipping W. to W.N.W. at from 8° to 12°.

The Upper Limestone.—In order to trace the order and the range of the lower part of the carboniferous limestone, and describe the position and the lie of these beds in the different parts of our district, it was advisable to commence on the south, where we had their undoubted base in the Old Red sandstone. In order to do the same thing for the upper part of the formation, it will be better to commence on the north, where we have their undoubted top in the shales of the Coal Measures.

Bagenalstown to Gowran.—About three miles N.W. of Bagenalstown, at the extreme northern edge of Sheet 147, or a little way inside of 137, the very bottom shales of the Coal Measure group and the top beds of the Carboniferous Limestone may be seen in junction. The limestone is dark gray, crystalline, with much chert, and the shales are hard, black, or dark gray; the dip of both is W. 10° N. at 5° or 6°.

The Coal Measure shales may be seen for a mile or two S. of this, at many

places on the slope of the hill, but the Limestone is only visible once for the space of a mile, where it is seen to dip N. 30° W. at 5°, and to contain many large Productæ.

The next quarries to the southward are those about a mile to the westward of Shankill Castle, where light gray crystalline limestone is shown in some large excavations. The beds are often five feet thick, and the stone is often full of large Productæ. Nodular layers of white chert occur near their top. They dip at 5° to the W.N.W., and the Coal Measure boundary is not more than 100 yards from them, as shown by some black shales and flags to be seen a little to the northward of them. About a mile to the southward of Shankill Castle, and a little west of Mountrath House, are quarries in the lower beds of this subdivision, consisting of dark gray limestone nd black marble, and coarse massive blackish gray limestone, very fossiliferous, with Productæ, Lithodendron, &c.

Three quarters of a mile S.S.W. of these are the Monefelim quarries mentioned before, as above the calp section there (p. 51), likewise full of fossils, and in thick beds; said to be much "shattered," but not faulted.

Over these occur quarries in thick irregular beds of light brown and yellowish white dolomite, with white chert nodules. The dip is from W. to N.W. at angles varying from 5° to 10°.

The surface width of the band assigned to the Upper Limestone here is rather more than a mile and a half. If we take it as 8,000 feet, and allow as before an average dip of 5°, the thickness of the subdivision will be 696 (say 700) feet;* if the average dip be 10°, the thickness will be 1,392 feet.

If we follow the margin of the Coal Measures to the S.W. from near Paulstown or Shankill, we find abundant evidence of their existence in frequent little exposures of black shale, and large quarries occasionally on the hill slopes, but the appearance of the limestone in the low ground is less frequent.

There are, however, a group of limestone quarries close to the Coal Measure boundary in the townland of Flagmount North, about three miles N. by W. of Gowran. A small anticlinal curve may be seen in these, producing a slight flexure in the boundary of the Coal Measures. Several quarries are scattered over the ground S. of this, showing gray massive limestone, generally full of Productæ and Corals, and rarely containing any Crinoidea. They dip generally at low angles to the N.

South of these, and nearer Gowran, we come upon a tract about three miles long from E. to W., and a mile broad from N. to S., in which the rock seems almost entirely composed of a yellow or dun coloured crystalline dolomite, including here and there smaller spaces of ordinary non-magnesian limestone.

The dolomitic band near Monefelim, mentioned just now, is supposed to be the north-eastern end of this tract, and it seems to terminate more suddenly and abruptly towards the west; its boundaries, however, from its capricious occurrence and sudden appearance and disappearance are very difficult to trace, and those given in the one-inch map must be taken with the requisite allowance.

This dolomitic tract seems to be separated from the other in Gowran, which was described with the Calp by a narrow band, in which there are two or three quarries of dark regularly bedded, partially crystalline, fossiliferous limestone, that does not seem to be at all magnesian.

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* I believe that 700 feet is considerably less than the true thickness of the Upper Limestone of Kilkenny and Queen's County generally; as near Johnstown, in the latter county, there are hills of at least that height above the adjacent plain wholly within the formation, the beds lying at a very gentle angle, and not including either the uppermost or the lowest beds of the group. In county Clare a thickness of at least 1,500 feet of solid limestone, without a break or change, may be measured, bed by bed, below the Coal Measure shales.

Gowran to Kilkenny.—In the townland of Moonhall, about two miles N. by E. of Blanchville House, is the extreme southern point of the Coal Measures of the Castlecomer coalfield. Immediately to the west of this point is a little glen, showing beds in the Upper Limestone for a third of a mile to the southward across their general strike. On the east side of the glen the beds are light gray, massive, rather unevenly bedded, and in parts very fossiliferous. They dip N. at a slight angle under the black gray shales of the Moonhall Coal Measures. On the west side of the little glen, however, towards which these beds strike, nothing is to be seen but light yellow crystalline cellular dolomite without any appearance of fossils, unless the cavities denote the places from which shells have been removed. This dolomite forms a well marked N. and S. band, about 250 yards wide, spreading out to the south so as to be 600 or 700 yards in width, and visible here and there over a space of a mile and three quarters from N. to S.

No limestone is visible close to its southern portion, though there are lines of quarries between it and the other large dolomitic space before spoken of, showing strong thick beds of dark limestone, full of Productæ and other large fossils, dipping steadily N. at from 8° to 13°, and striking directly towards both dolomitic tracts.

Near the northern and narrower part, however, of the dolomite, west of Moonhall, it is terminated by a definite N. and S. line, with light gray massive fossiliferous limestones striking up against it, and dipping N. at 5°. These appear precisely the same beds as those seen in the little glen on the east of the dolomite, which cuts through them like a broad dike, as if it were an intrusive mass of igneous rock.

A little further west, just S. of Clarabricken Castle, are quarries in light gray crystalline limestone full of Productæ, but patches of dolomite occur again half a mile W. and N.W. of that.

A small E. and W. fault seems to run through Clara Castle, as coarse gray limestone, with a band of yellow dolomite strikes N., with a dip of 15° to the E., and a little east of the Castle abuts against black shales belonging to the Coal Measures.

North of the fault these black shales seem to be a good deal disturbed, but the yellow crystalline dolomite comes out from underneath them on the west, and ranges alongside them by Kilmagan House, up to Feathallagh House, where it dips E.N.E. at 5°.

In the country W. and N.W. of Feathallagh House, lines of gray crystalline limestone with Productæ may be traced in many quarries for a distance of more than two miles, all dipping north-easterly at angles varying from 5° to 10°, through the parish of Kilkeeran, into the townland of Fermoyle, in the parish of Kilmadum, where the limestone beds curve regularly round towards the west, and dip N. at 10° or thereabouts. The Coal Measures of course follow this curve, and there are many exposures of the rocks of both formations, which render it easy to trace their boundary with great approximate accuracy.

Even here the limestone is full of dolomite, alternate bands of blue limestone and brown dolomite being seen close up to the base of the Coal Measure shales.

From this neighbourhood the boundary of the Coal Measures sweeps round to the westward and southward, its exact position being greatly obscured by limestone gravel; a quarry of limestone dipping N.N.W. at 5°, may be seen in the townland of Knocknew, with black shales having the same dip 200 yards to the N.W. of it, and another in the townland of Radestown North, shows beds dipping W.S.W., at 5°, in which direction dark gray Coal Measure shales are seen on the hill in Radestown South, which lies about two miles N.N.E. from Kilkenny.

Immediately to the south of these Coal Measures is a line of quarries showing bluish, gray, crystalline, thick bedded limestone, with a few nodular

chert layers. The fossils were chiefly Productæ and Encrinites. The joints were open and filled with brown earth; the dip is N.N.W. at 5°.

A small quarry about half a mile to the east of this shows similar beds, as well as another about a mile to the W.S.W., between the river Nore, and the road from Kilkenny to Freshford.

No other quarries are opened on the northern side of the city of Kilkenny.

The quarry S. of the Lunatic Asylum, and near Sion House, has been already spoken of as belonging probably to the calp division of the limestone. There is, however, another large quarry on the other side of the river before reaching Archersgrove House, which from its containing the large Productæ and other fossils, has been classed as Upper Limestone. It is blackish or bluish gray, thick bedded, the lowest beds affording a beautiful black marble.* The beds dip S. at 10°. Mr. Wyley says that the chief of the Kilkenny marble has been obtained from this quarry and the one near Sion House.

A band of yellow crystalline dolomite shows itself here and there just S. of these two quarries, running E.N.E. and W.S.W. for more than a mile.

Another patch of it also appears a little back from the right bank of the river, half a mile below, while on the opposite side of the river two quarries are seen near the lower road, in massive gray limestone, with fossils such as Goniatites, Productæ, and Corals, the beds dipping S.W. at 10°.

District S. of Kilkenny.—At the bend of the river near River View, we come on a very complicated district, which runs thence for some miles to the southward. Rudely parallel bands of gray limestone, full of Productæ and yellow crystalline dolomite devoid of fossils, run side by side for a mile or two. The dolomite shows no certain stratification, while the beds of limestone, though dipping and striking in different directions, generally abut against the dolomite more or less directly. The dolomite bands either end abruptly towards the N. along an E. and W. line, or are cut off by a fault running in that direction; towards the south they seem to die out more gradually, the western one in about a mile, the next in about two miles, while the most eastern and largest, which is in some places 700 or 800 yards across, continues on down the river to Bennettsbridge, and probably for two or three miles further S.

This band of dolomite has the Calp on the east of it, and the Upper Limestone on the west, so that it is doubtful to which division it properly belongs. At the point where the little brook coming from near Blancheville falls into the Nore, it may be seen in direct contact with the gray massive limestone, containing Productæ and Lithodendron, and the limestone there seems to dip towards the dolomite. Two-thirds of a mile nearly due E. of this, are quarries in calp, not a hundred yards from its boundary, in which the beds dip S.W. and strike, therefore, obliquely against it. The dolomite itself is largely crystalline, hard, massive, much jointed, the joints being sometimes cuboidal, and at others more prismatic, the stratification undistinguishable, and the rock looking, as Mr. Wyley says, like granite at a little distance. It is often very cellular, with cavities as large as walnuts, but sometimes much larger, and it disintegrates in some places quite irregularly.

* Dr. Boate, in his "Ireland's Natural History," which has lately been reprinted by Mr. Thom, together with some other curious tracts, says—"Besides the freestone, which is almost in every part of the land, there is marble found in many places, but most about Kilkenny, where not only many houses are built of the same, but whole streets are paved with it. The quarry out of which they have their marble at Kilkenny is not above a quarter of a mile distant from the town, and belongeth to no body in particular, lying in common, for all the townsmen, who at any time may fetch as much out of it, as seemeth good unto them, without paying any thing for it; it is in fashion like unto quarries of freestone, to wit, a wide open pit, whereout stones and pillars of great thickness and heighth may be digg'd. This marble, whilst it is rude, and as it cometh out of the ground, looketh grayish, but being polished it getteth a fine blewish colour, drawing somewhat towards the black."

Some of the appearances induced Mr. Wyley to suppose that the N. and S. crack already spoken of as possibly running by Ballyhale, was continued here along the bed of the Nore, producing disturbance, although with no great amount of dislocation.

In the piece of country S. of Kilkenny and west of the Nore, as far S. as Bennettsbridge and Danesfort House, there are numerous quarries in the Upper Limestone, which forms here a shallow basin dipping everywhere towards its central portion, about Outrath or near Prospect House. The beds are usually dark gray, thick, and massive, and commonly fossiliferous, the fossils being various species to which Mr. Wyley gives the following names:—Lithodendron and Lithostrotion striatum, Astræa aranea and another, Aulopora gigas, Cyathophyllum basaltiforme, Syringopora ramulosa, Turbinolia fungites, Encrinite stems, Spine of echinus, Echinocrinus(?), Leptæna analoga, Producta large, Orthis large, Lima alternata(?), Cirrhus, Euomphalus, Natica, Loxonema, Goniatites, &c.*

If we were to extend our examination to the westward, into the district belonging to Sheet 146, we should see that the little basin of Upper Limestone was almost isolated by a bay of calp running in towards Kilkenny on the west, as if to meet that already described as running towards it from the east.

The Dunmore Ridge of Limestone.—The Coal Measures which strike down into the valley of the Nore, north of Kilkenny, in Sheet 147, rise out of that valley with the same strike towards the W.S.W., in Sheet 146. They are nowhere actually seen in the bed of the river, but they probably run across it, dipping first to the N.N.W., and then rising again and dipping S.S.E., so as to allow the reappearance of the limestone from underneath them, which takes place north of the Mount Eagle Distillery and Dunmore House, in Sheet 146. This limestone runs also across the N.W. corner of Sheet 147, showing itself as bluish gray crystalline fossiliferous limestone, bent into an anticlinal ridge, the axis of which runs N.N.E. and S.S.W., so that the beds dip S.E. and N.W., passing in each direction under the Coal Measures. It is dolomitic in two places here also, just as it is S. of Ballyfoyle Castle, the dolomite being interstratified in alternate beds with the fossiliferous limestone.

This little ridge of limestone is that which runs up to the cave of Dunmore.

Coal Measures forming the southern portion of the Castlecomer Coalfield.—The black Coal Measure shales, flags, and grits, can be seen abundantly just inside the boundary drawn on the map, and also here and there over the whole space, coloured black on the map, so that there is no occasion to enter into minute details for the mere purpose of proving their existence. The beds are much more contorted than those of the limestone, as usually happens with the softer and more yielding rocks in all disturbed countries, the contortions being both sharper and more irregular in form than in the more massive rocks below.

On the east side of the district, about a mile S.W. of Cranroe, in the parish of Shankill, and the townlands of Kellymount, Coorleagh, and Shankill, there are some extensive quarries which have been long opened in the lower beds of the Coal Measure series, for the purpose of extracting flags. Hard dark gray flags, with annelid or molluscan tracks on them, occur here, apparently at a much lower level than that at which they are worked in the county Carlow and in other places.

There is a good thickness of black carbonaceous shale a little way above them, in which trials (of course unsuccessful), have been made for coal.

* These names were mentioned by Mr. Wyley in his notes written ten years ago. It will of course be understood that Palæontologists have now altered them. They are mentioned here as indications only. They seem in this district to be almost confined to the Upper Limestone, while the Lower Limestone has chiefly Spiriferæ and Encrinites. In Limerick all the above fossils occur most abundantly in the Lower Limestone.—J. B. J.

Other quarries, in beds apparently at a higher level in the series, as well as at a greater height above the sea, occur about a mile N.W. of Cranroe, immediately north of the trigonometrical point 993, in the townland of Lacken, and parish of Oldleighlin. These quarries afford a hard gray flaggy grit, very extensively used. In all these quarries the beds have a general inclination to the westward, rarely exceeding 5°.

Baurnafea Colliery.—About three miles to the west of the flag quarries, and two miles north of Castlewarren two thin beds of coal are worked in the northern parts of the parishes of Shankill and Tiscoffin, in the townlands of Baurnafea and Keevanagh.

The crop of the uppermost of these beds was traced by Mr. Warrington Smyth, in the year 1845, for a distance of more than a mile, from N.N.W. to S.S.E. It was a bed about one foot six inches thick, of culm or impure coal, and dipped to the E.N.E. at about 5°, or from 1 in 12 to 1 in 9. A number of pits were sunk a little way inside the outcrop, the deepest of which was forty-three yards when Mr. Du Noyer visited the colliery in the year 1857. A water level, according to Mr. Smyth, had been driven a distance of 288 yards from a small wood near the southern end of the colliery, in a N.E. direction, cutting the coal at a point where it was only twenty-two yards below the surface.

At the most southern pits the coal flattened, and the crop turned round the hill towards the E., and seemed inclined to strike off N.E., as if the coal formed a shallow trough or basin, but it was never traced farther.

Near the centre of the outcrop another small seam of good coal, about six inches thick, was pointed out to Mr. Du Noyer in the bed of a small stream that forms the boundary between Baurnafea and Keevanagh, 200 yards above the point where it joins two other little streams, one of which forms the boundary of Coolgreany.

This was at a distance of about 350 yards west of the outcrop of the upper coal; and supposing the surface were level, and the dip were 5° on an average, would lie at a depth of thirty yards below it.

In the Castlecomer district, the first or lowest coal (that of Gale Hill), is 6 inches thick; and the second coal is 1 foot 6 inches thick; and 100 yards above it.

This would be a sufficiently close approximation to make it not improbable that these are the two lowest coals of the district, lying at a height of between 1,300 and 1,400 feet above the limestone.

As, however, the Baurnafea colliery is more than three miles distant from the Coolcullen colliery, which is the nearest where any of the Castlecomer coal fields have been identified, any conclusion on that point must of necessity be rather vague.

All the evidence we possess, however, is in favour of the supposition that the coals at Baurnafea are the lowest beds of coal that enter into the structure of the district comprised in Sheet 147; and that, consequently, all the beds in the area coloured black, except the part immediately to the eastward of these coal crops, lie below the coal, and, therefore, that any search in them for coal will be entirely fruitless.

Whatever coal may formerly have existed over this area has long ago been removed and swept away by the action of the denuding forces, which have cut down the rocks in order to produce the present surface of the ground.

6. *The Drift.*

In this district, as in all others in the British Islands, bare rock is only to be seen occasionally. Even if we strip off the mere vegetable covering, and the mould or soil to which vegetation has contributed, we still seldom meet with the solid rock. There is usually a thickness varying from one foot to ten, twenty, or even in some cases 100 and more, of loose and incoherent earthy matters between the actual rock and the soil. This superficial accumulation, as might be supposed, is almost always derived wholly or in great part from the rock which is most prevalent below. Pebbles of granite and granitic sand abound over the granite country, the debris of Coal Measure shales and grits over the Coal Measure ground, fragments of Lower Silurian slates and grits over the Silurian area, Old Red sandstone blocks and sand on the Old Red sandstone districts, and pebbles, large and small, of Limestone, over all the Limestone plains.

It might also be easily accepted as but natural that where high, steeply sloping ground is formed of one kind of rock, and the low plains along its foot of another kind, that more or less of the debris of the higher should be swept down over the lower country. When then we examine the gravel and superficial accumulations that cover the Limestone at the foot of the Coal Measure hills, it need not surprise us to find along with the Limestone pebbles a great quantity of Coal Measure fragments, or that sometimes those are even in the majority; or, lastly, that the Limestone is covered first by a layer of Limestone gravel, and that again by a layer of Coal Measure drift.

Neither should we be much surprised to find blocks of Old Red sandstone lying on the slopes of hills capped by that rock, or the flanks of hills whose summits were Granite, strewed with blocks of Granite, even where the slopes were formed of Silurian slate.

When, however, blocks or pebbles, or fragments of any sort, composed of one kind of rock, are found strewed over the ground at greater heights above the sea than that rock can itself now be found at in the neighbourhood, or when considerable blocks of rock have been transported far from their parent sites, over hills and across valleys, and left in large quantities in situations where no possible natural agency now at work in the district could carry them, our interest naturally becomes excited in the endeavour to solve the problem of their mode of transport.

Limestone Gravel.—Gravel and brown clay, containing a greater or less number of pebbles of Limestone, and some Limestone blocks, are found scattered over some of the lower parts of the Coal Measure country, and running up the valleys that traverse it to a height of sometimes 200 or 300 feet above the Limestone plain. Little isolated patches of it sometimes occur in hollows, as if it had once been much more extensive, and large parts of it removed again.

In the Granite country, too, there is a wide dissemination of Limestone gravel, sometimes mingled with granitic debris, and sometimes side by side with patches of granitic sand in which no limestone is present. The Limestone gravel often mantles round the granitic hills, and mounds up to heights of 600 feet, or thereabouts, or 400 above the general average of the Limestone plain.

It is, however, always confined to the lower grounds and valleys, never covering the tops of the loftiest eminences; and as we proceed to the S. towards Borris and Killedmond, where the general level of the country begins to rise, we lose the Limestone gravel altogether; neither does it run down the valley of the Dinin or Black river beyond Ballymartin.

The limestone gravel, however, runs down the valley of the Barrow almost continuously as far as Graiguenamanagh.

A little above Ballyteigue loch, two miles N.W. of Borris, Mr. Willson describes a section in it sixty feet in height, in which, he says, the limestone pebbles lying in fine gray sand are well rounded and averaging the size of a man's head. There, also, boulders of granite, of about one cwt. each, mixed with those of limestone, but occurring most numerously at a depth of about forty feet from the surface.

The limestone gravel rarely extends more than a quarter of a mile from the river, except where there is a wider tract of low land, as about Graigue-

namanagh. Below Graiguenamanagh the limestone gravel is not apparent till we come to St. Mullins, where there is a small patch of it, the last that is noted on our maps.

In like manner, a narrow interrupted belt of limestone gravel comes down the valley of the Nore, as far as the neighbourhood of Inistioge, beyond which it has not been seen.

No limestone gravel is known to occur over the Silurian and granite country beyond the limits already described.

In the valley, however, of the Waterford Railway, it spreads up for some distance on to the Old Red sandstone hills, as well as in the bottom of the valley.

In the valley the sand is full of limestone pebbles, and these are also found in the clayey flats lying on the summit of the Old Red sandstone moors about Castlegannon, up to heights of 700 feet above the sea; and in one instance near Ballyvatheen and Ballintlea, this drift sweeps across the Old Red on to the Lower Silurian ground, pebbles of limestone two or three inches in diameter being found in the clayey drift there. Sometimes there are much larger blocks, usually well rounded, polished, and scratched.

Esker Ridge.—About a mile to the east of Bagenalstown is a most singular example of those steep ridges of gravel and drift, to which the Irish name of esker* is given. This esker commences just at the edge of the limestone plain, at the S.E. corner of the grounds of Dunleckny House, in a steep conical mound about forty or fifty feet high, having quite an artificial appearance. The ground about its base is about 190 feet above the sea. From this there runs to the S.E. a very well marked ridge of forty or fifty feet in height, like a great railway embankment. The ground rises generally and pretty steeply towards the S.E. up to a height of 300 feet, but the esker runs over this rise of ground, still keeping a height of forty feet above its base, and with steep well defined slopes. It then traverses a little boggy flat near Ballymoon, where it is cut through in two places to allow of the passage of a little sluggish stream. Beyond this the ground rises to a general level of 380 feet, with the esker ridge still continuing across it with well defined sides, and a height of twenty or thirty feet, but beginning to spread to a great width, and gradually dying away about two miles S. of Ballymoon. Its total length is about three miles.

It contains in the sand a good many blocks of granite, as might be expected, since that is the rock on which it rests; but the mass of the smaller pebbles, and some even of the larger boulders, consist of limestone. There are many good sized lumps of a coarse grained white crystalline limestone of a kind not known in the neighbourhood.

There is an obvious tendency in the rude layers or beds of finer and coarser material in this esker to conform to the external outline of the ridge, as if they had been heaped up from opposite sides by opposing currents, or formed in the eddy at the margin of two different currents. This is a common feature in these eskers.

Glens in Granite.—There are many curious little glens worn in the granite in this neighbourhood resembling on a small scale that of the Scalp, near Dublin; and some of the little granite cliffs show obvious water lines running round them at different levels, marks of the last action of the sea as the country rose for the last time through its surface. At one spot, near the south-western angle of a road forming the boundary of the townland of Coolnapish, just a mile S.E. of Ballymoon, there is a little marsh, the drainage of which runs through a small glen in the granite, the cliffs of which exhibit these water lines very plainly, and just where the drainage issues there is the mark of a small waterfall in the smoothing and wearing of the rock. The

* Mr. Robert Chambers informs me that similar ridges are called kaimes in Scotland.

little marsh above could never have supplied water enough to produce a cataract, and if the gorge were filled up its drainage would run off to the north by Ballymoon Castle; but it occurred to me that when this was just at the sea level, the little marsh might be made into a lake twice a day at high water, and that as the tide fell a small cataract would be formed that might produce the effect. The esker lies immediately to the east of the little gorge and does not extend into it. It is probable, therefore, that that esker was formed when the whole country was still lower and quite under water, and that any loose sand or gravel that might have filled up the little hollow or remained in the gorge was subsequently washed out of it. The water lines may be traced for some distance in the sides of the glen below, as it opens out towards the lower land on the south.

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