EXPLANATIONS

TO ACCOMPANY

SHEET 145 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

ILLUSTRATING PART OF

THE COUNTY OF TIPPERARY.

DUBLIN:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE:
PUBLISHED BY
ALEXANDER THOM & SONS, 87 & 88, ABBEY-STREET;
HODGES, SMITH, & CO., 104, GRAFTON-STREET.
LONDON:
LONGMAN, GREEN, LONGMANS, AND ROBERTS.
1860.

DUBLIN: PRINTED BY ALEX. THOM & SONS, 87 & 88, ABBEY-STREET,
FOR HER MAJESTY'S STATIONERY OFFICE.

THE

GEOLOGICAL SURVEY OF THE UNITED KINGDOM

IS CONDUCTED UNDER THE POWERS OF THE

8TH & 9TH VICT., CHAP. 63.—31ST JULY, 1845.

DIRECTOR-GENERAL OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM:

SIR RODERICK IMPEY MURCHISON,

D.C.L., F.R.S., G.C.ST.S., &C., &C.

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

IRISH BRANCH.

Office in the Museum of Irish Industry, 51, *Stephen's-green, Dublin.*

LOCAL DIRECTOR:

J. BEETE JUKES, M.A., F.R.S., &C.

SENIOR GEOLOGISTS:

G. V. DU NOYER, M.R.I.A.; W. H. BAILY, F.G.S. (*Acting Palæontologist*).

ASSISTANT GEOLOGISTS:

G. H. KINAHAN, ESQ.; F. J. FOOT, ESQ.; J. O'KELLY, ESQ.;
A. B. WYNNE, ESQ.; J. KELLY, ESQ.

COLLECTORS OF FOSSILS, &C.:

MR. C. GALVAN; MR. ——.

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, or in preparation.

Condensed memoirs on particular districts will also eventually appear.

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

AGENTS FOR THE SALE OF THE MAPS AND PUBLICATIONS:

MESSRS. LONGMAN, GREEN, & CO., London;
MESSRS. HODGES, SMITH, & CO., Grafton-street, Dublin;
MESSRS. ALEX. THOM & SONS, Abbey-street, Dublin.

EXPLANATIONS

TO ACCOMPANY SHEET 145, OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

ILLUSTRATING PART OF THE

COUNTY OF TIPPERARY.

General Description.

The district included in this sheet of the map lies wholly within the County of Tipperary. Thurles is the only town in it; Littleton, Clonoulty, and Holycross the principal villages, to which may be added Upperchurch, Ballagh, and Dundrum.

1. *Form of the Ground.*

The western third of the district is composed of high and rather broken ground, forming some hills that may be called the Kilnamanagh Hills; the remaining two-thirds are part of a large plain that extends between these and the Slievardagh Hills, of which a small portion crosses the S.E. corner of the map.

Many minor undulations rise from the plain; and one considerable hill, called Killough Hill, 773 feet in height, three or four miles S.E. of the centre of the sheet. The hills we have called the Kilnamanagh Hills, ascend with rather gentle slopes to heights of 1,100 and 1,200 feet above the sea, and are traversed by long glens, the sides of which are usually steeper than the outer slopes of the hills.

These hills follow no decided line of direction, but form a number of rounded summits, more or less detached from each other. They are part of a large, nearly circular, group of similar hills, which extend for some miles beyond the limits of the map, both to the west and north. There is no general name for the group.*

Their most open and considerable valley within the limits of this sheet of the map, is that of Upperchurch, near its N.W. corner.

The Slievardagh Hills rise to elevations of about 1,000 feet; but no part of their slope, which traverses the S.E. corner of the map, rises higher than 600 or 700 feet.

The mean elevation of the plain, which occupies the greater portion of the map, may be taken at about 300 feet above the sea. It rises towards the Kilnamanagh Hills so as to form a low ridge of about 400 feet in height, running parallel to their general boundary

* Part of this group in the County of Limerick is called the Slievephelim Mountains. The Keeper Mountain is another part of it. Doctor Boat, in his Natural History of Ireland, written about the year 1600, alludes to them as the Twelve Hills of Phelim ghe M'Donagh; they are not now known by that name, and he may perhaps have confused them with the Twelve Pins of Connemara in Galway.—A. B. W.

for about nine miles, but separated from them by a remarkable longitudinal valley about one mile in width.

This valley, running along the foot of the hills, catches all their drainage, and collects it into considerable brooks before it enters the plain. One of these small rivers is called the Clodiagh, proceeding from the extreme N. of the map, and running S. by Pallas House and Annfield to the S. of Moyaliffe, where having received the drainage of all the hills as far S. as Drum Wood, and that of the valley even to near Ballagh, it breaks with the united waters through the low ridge before mentioned, and after receiving the Farneybridge brook empties itself into the river Suir, about three miles S. of Holycross.

Another large brook is that called the Multeen River, from the valley of Fulleennafinoga, which on issuing from the hills runs down this catch-water valley towards the south, receiving a tributary from Glenough, and proceeds out of the limits of the map to join the Suir at Springmount, near Golden.

The Suir enters the map on the north where its water is at a level of about 335 feet above the sea. It runs past Thurles, a little south of which it receives the Drish, and then turns more to the S.W.; but after its junction with the Clodiagh it runs south again till it issues from the map below Forte Edward, where the surface of its water has a height of about 220 feet.

As the whole district drains into the Suir (except about five and a quarter square miles in the N.W. corner of the map), this point will of course be the lowest in the area included in this map.

---

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

Aqueous Rocks.

	Name.	Colour on Map.
	Bog, Alluvium, and other superficial Deposits,	*Sepia.*
	Drift (Limestone Gravel),	*Engraved dots.*
Carboniferous.	d^5. Coal Measures,	*Indian ink.*
	d^4. Upper Limestone,*	*Prussian blue.*
	d^3. Middle Limestone,	
	d^2. Lower Limestone,	
	d^1. Lower Limestone Shale,	
Old Red Sandstone.	c. Old Red Sandstone,	*Indian red.*
Silurian.	b. Lower Silurian, possibly Llandeilo beds,	*Purple.*

Igneous Rocks.

None.

b. *The Silurian Rocks.*—These rocks are mostly argillaceous, consisting of indurated shales or slates,* but are sometimes arenaceous, when they consist of hard gritty and quartzose sandstones.

They are generally dark in colour, and of some shade of gray. Some of them are sufficiently calcareous to effervesce with acids, and these often weather to a dark rusty brown, like rotten stone—many of them also are ferruginous.

Sandy grits, flagstones, and shales or slates, are promiscuously interstratified with each other, in beds of very variable thickness. The sandstones especially vary in thickness from mere flags to massive grits, which show no lamination or stratification, for sometimes as much as ten feet in thickness. These having often a concretionary structure, and being much jointed, look at first sight like igneous rocks, till they are broken open and their particles examined by the lens. Thick beds of splintery and concretionary shale are often met with, and many of the thinner grits and flagstones are separated by shaly partings.

The flagstones are generally composed of indurated calcareous sand; and some of them contain fossils, in thin layers, which appear like variegated flaky lines on the weathered cross fractures or joint faces; and on being split open parallel to the bedding exhibit surfaces covered with minute and often obscure fragments of organic remains. Crinoidal stems and heads, graptolites, orthoceratites, and other shells, are thus exposed; more particular mention of which will be made by Mr. Baily further on.†

Fine hard red beds are sometimes found associated with the gray or pale blue siliceous sandstones, containing small strings of carbonate of lime, and with them occur hard red shales and slates. They are sometimes softer and micaceous, and often greatly resemble Old Red Sandstone beds, giving like some of them a red or rusty stain to the fingers.

It was at one time thought that these beds were in some way connected with the Old Red Sandstone, but they are found so variously associated with the Silurian rocks that it is impossible that they could be part of the Old Red Sandstone; and the only connexion they could have with it is the bare possibility that they may have received an extra ferruginous infiltration from the water in which the Old Red Sandstone was deposited above them.

The cleavage of the Silurian rocks strikes generally nearly E. and W., not unfrequently a little S. of E., and N. of W., but sometimes N. of E., and S. of W. It cannot be said to be well developed in this district, and in the places where it has been observed it usually is either too superficial or too splintery to show its relation to the bedding distinctly, but it appears to cross it at all angles as usual

---

* It has been found impossible in this district to separate the limestone into these subdivisions with sufficient precision to allow of their being drawn and coloured.

* The country people speak of shale or slate as "slig," or "sliggeen."

† It may be well to state here that the graptolites are by far the most common fossils, their remains sometimes thickly covering the surface of such a fracture as that alluded to above. After them the order in numerical quantity is—first orthoceratites, bivalve shells next, and crinoidal remains last. In some of the thick and hard sandstones which are most affected by the weather, many casts of small joints of crinoids, and some fragments of shells, may be found, but generally they can only be perceived in the weathered part; and the fossils, although rare, do not seem to be restricted to any particular locality in this Silurian country.—A. B. W.

elsewhere. The abundant development of small joints also tends to obscure the general relations of the cleavage.

The thickness of these rocks must be very great, as continuous or nearly continuous sections of hundreds of feet may be observed in many parts of them. They are, however, so variously and irregularly inclined that no definite estimate of their thickness could be arrived at.

c. *Old Red Sandstone.*—This group consists of coarse red sandstones and conglomerates in its lower parts, passing up into pale purple and speckled sandstones and flagstones, the whole having occasionally interstratified beds of red shale, becoming more frequent towards the upper part of the formation.

Whitish sandstones, with ferruginous specks, are sometimes seen in the lower, but become more numerous in the upper part of the group, where they often contain pebbles of white quartz and hornstone, as well as patches of green shale: their beds being sometimes separated by green shale partings. In the northern part of the district the calculations for thickness give about 800 feet, but in the southern the thickness would appear to exceed 1,500 feet.

The Carboniferous Rocks are represented on this map by a large development of its characteristic limestone, and a small portion of the Coal Measure shales and grits, at the S.E. corner of the map.

The Lower Limestone shale has not been actually seen by us anywhere in this sheet, although black shale was described to us as having been met with in the drains in one part where it might be expected. The Old Red Sandstone and Limestone have, moreover, been observed at the surface near each other, without any evidence of the existence of the Lower Limestone shale between them; while from evidence collected in other places it is found to be an inconstant and sometimes absent member of the series. It is therefore only supposed to exist, and the colour on the map is inserted more to suggest the place it would occupy if it does occur, than as an assertion that it will be found there.

d^2. *The Lower Limestone.*—It has been for want of sufficient evidence necessary to omit any definite line of demarcation between this limestone and the upper portion of the same group. Indeed the whole seems to be one thick set of beds, which are frequently very similar to each other; but as these limestones are elsewhere divided, the letters signifying the relative places of the subgroups have been inserted on the map wherever the appearance and place of the rocks would warrant the conclusion that they might possibly represent such subdivisions.

The lowest of the limestone beds which have been seen are dark, earthy, and crinoidal; and the whole of the lower portion of it seems to be of a darker colour than the upper. The bedding is generally very apparent, owing to the frequent occurrence of shale partings. Pale gray limestone is also found, in which, however, sometimes the bedding lines cannot be seen, and crinoidal beds are frequent.

The dark and earthy portion of the limestone seems to reach its greatest thickness in the neighbourhood of Dundrum; but although in one or two quarries some of the black beds are siliceous looking, no band of chert, like that met with by Mr. Kinahan in Co. Limerick, appeared to indicate here an horizon by which to divide this from—

d^4. *The Upper Limestone*, which consists of a quantity of gray beds, of different shades and textures, but without the general darkness of colour which characterizes the lower group. Shale beds, too, are less frequent, and many corals are to be observed, chiefly of the Lithostrotion-like forms. In these limestones also Fenestella, and other of the Bryozoa, seem to be much more common than among the lower beds. Some of the more thick and compact beds of limestone, both in the upper and lower subdivision, have a curious waved concretionary structure, occurring sometimes in concentric bands, with a faintly marked fibrous texture at right angles to the curve. This seems sometimes to be associated with the fans and cups of the Fenestellæ; but also resembles the concretionary concentric bands often seen in travertine. Where the limestones were observed close to the base of the Coal Measures, they were found to contain quantities of the characteristic large Productæ; and as usual to become very cherty.

Of the whole limestone group it may be said, and particularly of the part between that which is certainly the upper and that which is as clearly the lower part of the formation, that pale gray limestone is by far the most abundant variety. From the number of symbols for dip of beds engraved on the map it is obvious that no great tract of this limestone occurs in which the bedding lines cannot be traced; and if the apparently great thickness of the group is due to the local abundance of any particular kind of these rocks, the crinoidal and coralline beds occurring so frequently may possibly account for it. Almost every quarry in the lower part, which appears to stretch from Ballagh to Ballycahill, contains black or dark gray crinoidal beds, associated with an oolitic band; while paler gray crinoidal limestone, also apparently containing in places oolitic beds, occurs about Thurles, and forms a great part of the mass of Killough Hill.

Magnesian limestone or dolomite occurs in many places among the other calcareous rocks, but does not seem to occupy any large or fixed area. It is chiefly seen in the banks of the Suir at Holycross, in the neighbourhood of which place the beds have been greatly disturbed. Where the magnesian element occurs, it has so obscured every trace of bedding, that it is hardly possible to say whether it is interstratified or not.

As the principal evidence of stratigraphical relations is derived from scattered quarries, and not from continuous sections, conclusions with regard to thickness are likely to have much uncertainty. Killough Hill alone, reducing the angles to allow for undulations and local deceptive appearances, shows a nearly continuous section through a thickness of over 500 feet; and making the same allowances for the whole of the rest of the limestone, its probable thickness is estimated at about 2,500 feet.

J. B. J. and A. B. W.

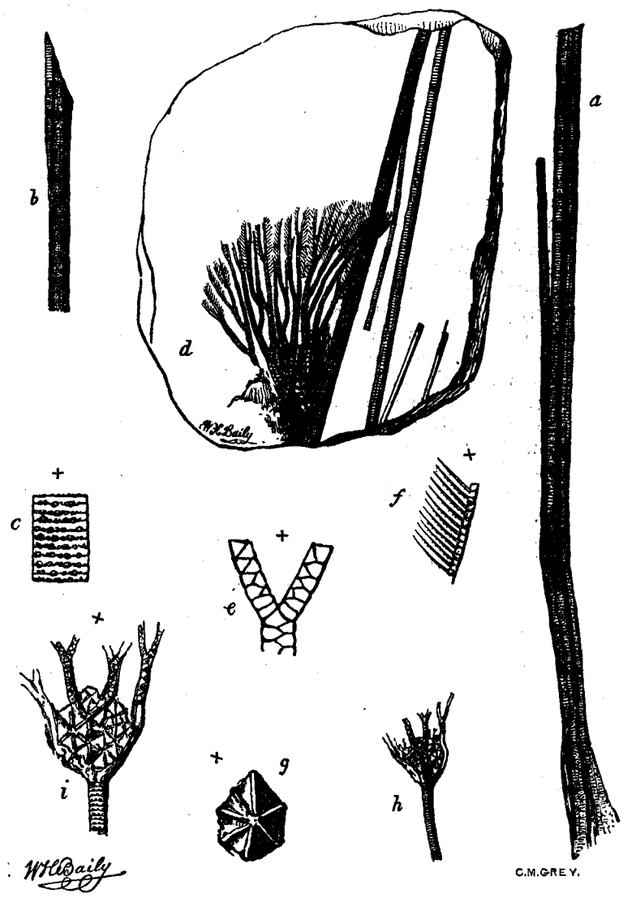
3. *Palæontological Notes.*

The following is a list of the Fossils from Lower Silurian strata, in that part of the County of Tipperary included in Sheet 145:—

Townland of Dooree, $\frac{3}{4}$.*

Rippled surface markings.
Crinoidal joints from grit beds, ×
Graptolithus priodon, *Bronn*, ××
Orthis elegantula, *Dalman*, ×
Orthoceras ibex, *Sowerby*. O. tenuicinctum, and O. pseudo-regulare, *Portlock* ? ×

Fig. 1.



Actinocrinus Wynnei, *Baily*, n. s. Lower Silurian, Reafadda.
The figures marked with a + are enlarged; all the others are of the actual size.

* These numbers refer to the sheets of the six inch map, supposed to be divided into quarters, 1 being the N.W., 2 the N.E., 3 the S.W., and 4 the S.E.

Fig. 3.

Townland of Gortnaskehy, $\frac{4}{4}$.

Fucoid, or other plant remains, ? fragmentary.
Orthis elegantula, ×
Orthoceras tenuicinctum, *Portlock.*
,, lineatum, *Hisinger.**

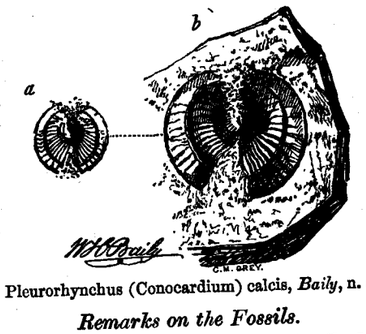
Townland of Roan, $\frac{4}{2}$.

Crinoidal joints, from grit beds, × same as at Dooree, with fragments of Orthis or Atrypa.

Townland of Reafadda, $\frac{4}{3}$.

Actinocrinus Wynnei, *Baily*, n. s. (fig. 1, a—i.)
Graptolithus priodon, ××, G. sagittarius, *Linn*, and G. convolutus, *Hisinger*, sp.
Orthis elegantula, ×
Pleurorhynchus (*Conocardium*) calcis, *Baily*, n. s. (fig. 2, a, b.)
Orthoceras elongato-cinctum ? *Portlock* (fig. 4.)
,, tenuicinctum.
The mark × indicates the abundance of the species.

Fig. 2.



Pleurorhynchus (Conocardium) calcis, *Baily*, n. s.

Remarks on the Fossils.

The discovery of this series of fossils by Mr. Wynne, in a district where they had never been before observed is of great interest, more especially as they present many points of palæontological value.

Ancient tide and current ripples may be seen on some of the fine-grained flags obtained from Dooree, and at Reafadda. Fragments of plants (if so, probably fucoids), although somewhat obscure, occur in a more sandy and micaceous flag at Gortnaskehy.

One of the most perfect and valuable fossils obtained from this district is a new crinoid, which I have named Actinocrinus Wynnei after its discoverer Mr. A. B. Wynne. As it is rare to find Encrinites, especially with the head attached, in Lower Silurian strata, we may consider the obtaining so complete an example a fortunate discovery. The specimens were all collected from finely laminated brownish flags at Reafadda, fig. 1, *a* to *h*, p. 10,

* Figured in Portlock's Geological Report of Londonderry, Pl. xxvii., fig. 2, a, b.

a, is a portion of a long crushed stem, finely and regularly jointed, having rows of small tubercles at the edge of each joint. This specimen has been pressed into an angular form, but another uncompressed stem shows its original cylindrical character, *b*, a portion of which is enlarged at *c*, to show the irregular edge of the joints or articulations and the tubercles studding it. The calyx or head *d*, is composed of a series of irregularly hexagonal plates, each of these being ornamented with about six or seven ridges uniting at each plate, and passing into the corresponding ridges of the neighbouring plates, giving it an appearance as if covered by coarse net work. The rays commencing from these plates bifurcate or branch several times before they terminate, being furnished towards their terminations by the finely jointed pinnules enlarged at *f*. An enlarged outline of the first of these branches is given at *e*, showing the zigzag pattern caused by the dovetailing of the plates composing the arms. A smaller head of the same species, probably a young individual, found with the above, fig. 1, *h*, of which an enlarged outline is given at *i*, has a portion of the stem attached. It shows some of the plates of the calyx and the first branching of the arms.

This species is allied to Actinocrinus pulcher, *Salter*, from the Wenlock division of the Upper Silurian, but differs from it in several particulars. The stem is less in circumference, the articulations closer, and the tubercles not so distinct. The plates of the calyx being also smaller in proportion, the arms are straighter, not so long and flexible, and their bifurcations more numerous than in the Upper Silurian species.

Only one other Encrinite having the head attached is recorded from Lower Silurian strata, viz., the Glyptocrinus basalis, *M'Coy*, from Caradoc or Bala beds, that cannot, however, be confounded with our species, being a very distinct form in which the calyx is nearly globular and the arms undivided.

From the same locality several kinds of Graptolites were obtained, a series of animals which were considered by Professor E. Forbes as belonging to Asteroid Zoophytes, and intermediate in character between Sertularian corallines and Seapens, and since by Professor Huxley, arranged under the Polyzoa or Bryozoa compound forms of Mollusca. These bodies are especially characteristic of the Lower Palæozoic or Silurian period, and form a very important and certain character in determining strata of that age. Three species of the genus Graptolithus, viz.:—priodon, sagittarius, and convolutus, were collected at Reafadda; the two latter species being only found in Lower Silurian strata, and one of them, G. sagittarius, said to be confined to the Llandeilo rocks.* We have here, therefore, an important clue in connexion with the occurrence of other fossils as to the particular geological horizon which the Lower Silurian strata of this district occupy. The typical form of this group of animals is the Graptolithus priodon, here as elsewhere the most abundant species. This at present is the only certain species which lived on into the Upper Silurian period; its range, as given in the Appendix before quoted, being from the Caradoc or Bala to the Wenlock and Ludlow beds.

* See Appendix to Sir Roderick I. Murchison's Siluria. Third edition, 1859.

Univalve and bivalve shells of Mollusca seem to be very rare in the ancient strata of this district, only one or two species of Brachiopoda being observed. The most abundant is the Orthis elegantula, a species which, in the British Islands, ranges through nearly all the Silurian strata from Llandeilo rocks to the Ludlow beds. It is here found occurring in groups of a few individuals at three of the localities mentioned.

The only other bivalve shell collected is the Pleurorhynchus calcis; a new species, fig. 2, *a*, *b*., p. 11. This specimen was obtained by Mr. Wynne at Reafadda, and is of great interest from its being the oldest example of that remarkable genus at present known. At first sight I considered this very rare fossil to be the Pleurorhynchus pristis, *Salter*; but on a closer examination and comparison with the original specimen of that species in Sir R. Griffith's collection it is evidently distinct—its differences being very well marked. It presents the same surface to view, viz.,—the truncated or posterior end. (In the description of P. pristis this is called by mistake the *anterior* side*). It differs from that species in its form, being nearly orbicular. The cordiform depression, which is well defined by a sharp ridge, is more extended, and the markings on its surface of a less uniformly reticulated character. Our species, of which an enlarged figure is given at 2 *b*, having on each side about fifteen strongly marked and slightly undulating ridges, which radiate from the beak or siphonal tube, passing over the boundary of the cordiform depression to the outer margin, where they become less distinct. Three equally distant well-marked ridges only are observable crossing these close to the base of the beak, whilst in P. pristis the whole surface of the cordiform depression is covered by finely reticulated lines.

There are now four species of this genus known from British Silurian strata; and it is remarkable that each characterizes a separate group of rocks, viz.:—

Pleurorhynchus	calcis,	*Baily*, n. s.	Llandeilo Rocks. ?
,,	dipterus,	*Salter*,	Caradoc or Bala.
,,	pristis,	*Salter*,	Llandovery Rocks.
,,	æquicostatus,	*Phillips*,	Wenlock Rocks.

The three first of these species are found in the Lower Silurian of Ireland, and not yet in that of England. One of these, P. dipterus, has been discovered in Ayrshire, as well as at the Chair of Kildare. The fourth is an Upper Silurian species found at Wenlock and Woolhope in England. The maximum development of this genus was, however, during the Carboniferous epoch.

The most abundant of the fossils collected in regard to the number of species, were Orthoceratites, a genus of external shells belonging to the class Cephalopoda, which had its greatest development in the older rocks. Several kinds were obtained; some of them being identified with those described by General Portlock, from Desertcreat, Tyrone. One of these, finely marked with transverse and regular ridges, O. tenuicinctum, *Portlock*, was collected from three localities. A single, but well marked, specimen of Orthoceras ibex,

* See Sir R. Griffith's Synopsis of the Silurian Fossils of Ireland. Addenda, p. 71. 1846.

Sowerby, showing its coarse rings passing round the shell at equal distances, was obtained from Dooree. This species, in Sir R. Murchison's Appendix to Siluria, before alluded to, is said to range from the Caradoc or Bala to the Ludlow Rocks, being most abundant in the Upper Silurians.

A well preserved fragment of Orthoceras lineatum, *Hisinger*, figured by General Portlock in his Geological Report of Londonderry and Tyrone, Pl. xxvii., fig. 2, a, b, was collected at Gortnaskehy.

Some of the Orthoceratites in this collection are smooth, without any trace of septal divisions; a peculiarity which led Professor Edward Forbes to consider the possibility of such forms being gigantic Theca or Creseis.* One of this character, doubtfully referred to the Orthoceras eleganto-cinctum, *Portlock*, ? is shown of the actual size, fig. 3, p. 11. It is eight inches long, and rather more than half an inch wide, gradually tapering to a very fine point. From its wrinkled and flattened appearance, this shell was evidently very thin, and perhaps membraneous or horny.

W. H. Baily.

September 5, 1859.

---

4. *Relations between the form of the Ground and its Geological Structure.*

The Kilnamanagh Hills on the west are composed of the Silurian and Old Red sandstone rocks. The central plain is underlaid by the Carboniferous Limestone, and the Slievardagh Hills are composed of the Coal Measure shales and sandstones.

As the Silurian is the lowest rock in the district, and the Coal Measures are the highest, it is clear that the general dip of the rocks, or their inclination downwards into the ground, must be from the west or north-west towards the east or south-east. This general conclusion is in accordance with the facts actually observed in many places. The Coal Measures in the S.E. corner of the map may be observed, in both natural and artificial excavations, to dip gently towards the E.S.E.; while the limestones in the quarries immediately below, dip in that direction at an angle of 20° or 30°, and clearly pass under the Coal Measures. When indeed we examine the limestone quarries scattered over the central plain, we find the beds inclining in various directions, showing that the dip is not perfectly steady or regular, but that the beds frequently undulate. The most usual dips, however, are easterly and southerly; and as we approach the Kilnamanagh Hills, and rise on to the low ridge before described as running parallel to their boundary, we find the dip almost invariably E. at low angles, from 5° to 15° or 20°. The beds below these, if this inclination be continued, must rise up to the surface towards the west; and we accordingly find, as we rise on to the slopes of the Kilnamanagh Hills, that the Old Red sandstone, which we know to lie below the Carboniferous limestone, has "cropped" to the surface, and rises gently up on to the flanks of the hills till its lower beds appear capping some of their nearer and lesser summits.

* Forbes on Creseis in "Geological Society of London Journal," i. p. 146.

The following sketch section will illustrate this feature of the beds, (see fig. 4.)

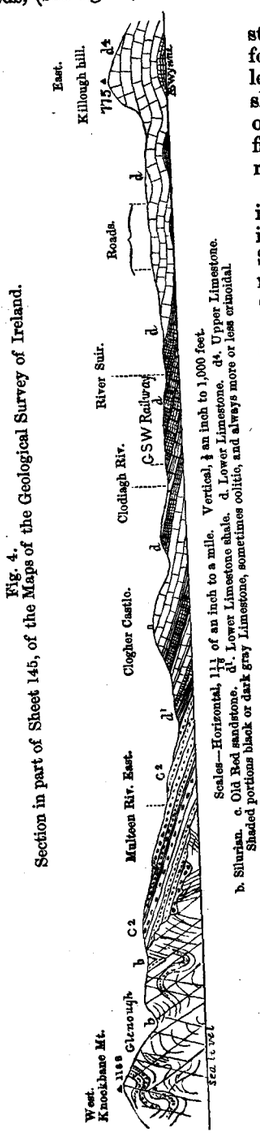


Fig. 4.
Section in part of Sheet 145, of the Maps of the Geological Survey of Ireland.

The outcrop of the Old Red sandstone beds is sometimes very striking, forming small scaurs with projecting ledges of rock, as in the accompanying sketch, fig. 5, page 16, which was taken on the road from Upperchurch to Annfield, and shows some of the lower beds rising to the west.

The distant hill is Knockalougha, and is composed of Old Red sandstone on its left-hand slope, and of the Lower Silurian in its other parts, while the rising ground to the right is formed of Old Red sandstone.

When the basal beds of the Old Red sandstones have risen to the surface, the rocks below them necessarily appear still further west, and consequently, the hills to the west of the Old Red sandstone boundary must consist of the Silurian rocks. These rise to still greater heights than the hills which are covered by Old Red sandstone, and form a country of somewhat different aspect, in which the features are bolder, and the declivities generally more abrupt. In the Silurian district, too, there is a less direct relation between the form of the ground and the inclination of the beds than in the other regions, the inclination of the surface being often directly opposed to that of the rocks below it. The beds here are usually tilted up at very high angles, and dip in many and various directions; while on the outer slope of the hills which are formed of Old Red sandstone, the surface of the ground generally slopes in the same direction, as the dip of the beds, and often nearly at the same angle.

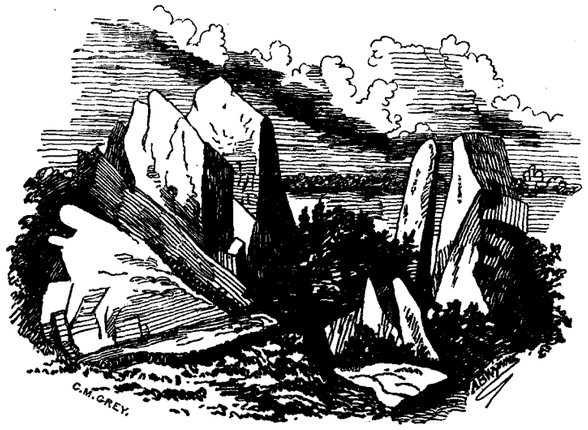
These general statements suggest what is by a little investigation found to be the truth, that the Old Red sandstone rests unconformably on and across the edges of the beds of the Silurian rocks, filling up previously existing hollows in them, and thus forming a level floor which passes down conformably beneath the gently sloping beds of the Carboniferous formation.

Fig. 5.

Outcrop of Old Red sandstone, Drumduff.

On the western side of the section, fig. 4, these facts are also indicated by drawing. It is not only by the general form of the hills, however, that the Silurian ground is contrasted with that formed by the Old Red sandstone, but even in the details, where the rocks appear uncovered by their usual thick clothing of bog, heather, or soil. The sketch, figure 6, taken at Aughnaclogh, near the N.W. corner of the map, will illustrate this when contrasted with figure 5. The weathered blocks of grit rock in figure 6, clean cut and angular, whether standing or fallen, could hardly be taken for blocks of Old Red sandstone such as it is found in this district.

Fig. 6.



Weathered mass of hard Silurian grit and slate. AUGHNACLOGH.

On examining figure 4 with attention, one circumstance is well calculated to arrest our attention, and that is, the abrupt western termination of the different beds of the Carboniferous limestone and Old Red sandstone. Each bed rises regularly out from underneath the superincumbent one, and ends at the surface suddenly, without any gradual thinning out. This is a true representation of the facts as they may be observed in the field; and we may reasonably ask what

is the reason of it? Why when the lower beds of a group stretch further west the upper beds of the same group are not equally extensive, and why they all end thus suddenly? The answer is, that they did all formerly stretch much further to the west, and that large portions of them have been removed by denudation. This striking fact is well illustrated by the occurrence of outlying patches of Old Red sandstone lying beyond the general boundary of the formation on the Silurian rocks, and being evidently portions of the beds of Old Red sandstone, which formerly spread much further to the west—those portions having been just spared by the denuding agency, while all the remainder was removed.

It is also shown by facts, such as those seen in Killough hill, of which a sketch is given, figure 7. This hill is a very characteristic

Fig. 7.

Killough Hill. Slievenaman in the distance.

specimen of a limestone hill, having a terraced escarpment formed by the abrupt termination of its beds, while the other side is a gentle slope conforming more or less perfectly to the inclination of the beds. The cliff, like all other cliffs, has evidently been formed by the wearing action of the sea, when the country stood at a lower level, and the waves beat against its foot, subsequently modified, perhaps, to a greater or less extent by the action of atmospheric agencies. This steep cliff faces the north, while the long gentle slope stretches from it to the south, a fact in accordance with many others, showing that when Ireland was last beneath the sea, the prevailing currents of that sea set from north to south.

We learn then from the facts disclosed to us by the examination of the district, the following points in its geological history:—

1st. There was a deep and open sea at a very early period, known as the Silurian period, at the bottom of which the Silurian rocks were deposited in regular horizontal layers, enclosing the remains of some of the animals that lived in that sea.

2nd. These once horizontal layers were lifted up, tilted, broken through, bent in various directions, and large parts of them washed away and removed by the action of denudation.

An almost inconceivable lapse of time is required to produce this result, and probably these rocks, or part of them, formed dry land during, at least, a portion of that time.

3rd. The Silurian rocks were again below water, and the Old Red sandstone was deposited on their broken and denuded surface at the

bottom of that water. It seems probable that this deposition of Old Red sandstone took place during a gradual depression of the previously existing land, so that as that land sunk and the water spread wider and wider over it, almost every successive bed of Old Red sandstone occupied a larger area than the previous one, and the upper beds, therefore, overlapped and concealed the lower.

4th. The district was now again occupied by an open sea in which the beds of the Carboniferous limestone (chiefly composed of the remains of marine animals), were gradually accumulated to a thickness of between 2,000 and 3,000 feet.

5th. The pure limestones were succeeded by beds of black mud and gray sand, still enclosing the remains of some marine animals, eventually mingled with those of plants, forming the lower beds of the Coal Measures.

We can see no reason to limit the extension of the Limestone and Coal Measures, or to suppose that all the now detached portions of those of Ireland were not originally continuous, forming great connected sheets over the whole, or nearly the whole, country.

6th. These rocks also became subject to the action of the disturbing forces of elevation, and the wasting forces of denudation, so that eventually they assumed their present positions, were limited to their present areas, and the present form of the surface of the country was produced.

7th. The facts relating to the Drift, which will be detailed further on, also teach us that Ireland, with nearly its exact present surface, was depressed beneath the waters of the sea (during the comparatively recent Pleistocene or Glacial period), some slight modifications being produced in the outer surface of the rocks by the action of that sea; and considerable heaps of loose gravel, sand, and clay, as well as boulders and blocks of rock being piled here and there upon its surface, or strewed about over it.

J. B. J. and A. B. W.

The principal part of the district included in sheet No. 145, was surveyed by Mr. A. B. Wynne, the south-east corner only having been examined by Mr. O'Kelly.

Detailed Descriptions.

5.—*Position and Lie of the Rocks.*

Silurian Rocks.—These rocks form the core of the Kilnamanagh Mountains at the west side of the map, where they may be seen frequently at the surface. The drift being thin, except in the valleys, knobs and crags of the harder rocks often protrude from the sides and summits of the hills; while exposures of the softer kinds may be seen in ditches, in road cuttings, under limekilns, and in similar localities. The dips are so various that it has not been found possible to form any thing like a correct estimate of the thickness, either of the whole group, or of any definite subdivision of it.

The axes of the contortions are seldom parallel to each other; and all the rocks bear evidence of having been greatly crushed and crumpled. From the similarity of the beds to each other, few faults have been detected, although it is probable that many exist.

Perhaps the best section in these rocks is to be seen on the Anglesey road from the village of Hollyford, for about two miles northwards; but as it is not sufficiently continuous or complete to serve as a key to the structure of the district, we may commence the detailed description at the north-western corner of the map, proceeding first eastward, and then southward. As the rocks, however, are met with in so many places, and are so much alike in all, no good purpose would be served by pointing out every spot where they may be seen. The dip arrows, as engraved on the map, will indicate many of those places; but there are many others where, though the rock was visible, its dip was not clearly determinable. It will, therefore, be sufficient to notice the principal places in each locality where the rocks have been observed.

In the townlands of Curreeny and Cummer-Mulloghney, at the head waters of the Clodiagh, strong, splintery, and flaggy gray beds occur in the streams which form the northern and southern boundaries of the last-named townland. They strike about 30° N. of E., having various dips; those in the stream to the north inclining at an angle of 30° in that direction; while those in the southern one incline at angles to the south, varying from 30° to the vertical. Following the Clodiagh to a place called Gortnaspinka, dark gray grits and flags may be observed in the river there, both vertical, and dipping south at 70°. Further on, near a ford,* are more gray grits, undulating and dipping to the west at 20° and 30°. Cleavage planes may be observed in them, striking a little south of east. North of the Clodiagh here, is the hill of Glastrigan, on which may be found projecting knobs of gray grit and slate; and on the top of another elevation, between this and the townland of Knocknagarvie, thick gray grits are seen bent into a bold anticlinal, the axis of which strikes west, dipping also in that direction at about 25°. In a cutting where the new Clodiagh line of road and the old one enclose a small triangular space, are some dark gray fine flaggy grits, striking nearly E. and W., and dipping at high angles to the south. They appear again in the bank of the river opposite to this place.

On the northern and western slopes of Knockatoora, an elevation rising near this from the eastern bank of the Clodiagh, gray and olive gray hard grits and sandy shales occur, dipping at high angles in various directions. Eastward of this, the rocks are seen in many places projecting from the surfaces of the hills. An exposure of them occurs in the townland of Rusheenmore, where they are traversed by a large contortion, and dip to the east and north. They consist of strong gray grits and slates; the cleavage of the latter striking 10° N. of E., with a dip of 70° to the north.

* Above this ford there is a large block of dark-coloured fossiliferous limestone in the river, which must have come from a considerable distance.

Near where the Clodiagh crosses the boundary of the Old Red sandstone, a contorted mass of hard fine variegated gray purple and green grit, concretionary in places, and sufficiently calcareous to effervesce with acid, is exposed by the river. The beds seem to have a contorted dip at a low angle, in a westerly direction. South-west of this, where the Old Red boundary makes a sudden bend at a small stream, its lower conglomerate and some Silurian grits may be observed very nearly in junction. The conglomerate, of which a good deal is seen, dips south at 10°; while the thin-bedded Silurian grits, of which a thickness of about 70 feet is exposed in a lane-way, are chiefly purplish red, with some gray flaggy beds below. They dip south at an angle of 70°; but their dip and strike are not continuous for any distance, as other dips occur in their immediate neighbourhood (see map). Red Silurian rocks, very similar to these, may be seen at many places to the southward of this, along the irregular boundary of the Old Red sandstone, and from their occurring so constantly close to, though not in every instance the nearest rocks to the boundary, it is supposed either that, notwithstanding the diversity of dips and angles among them, they are a definite band of red beds occurring in the Silurian formation (like similar bands in the Lower Silurian elsewhere), having a general strike nearly in the same direction as the boundary of the Old Red sandstone, or else, that they are different Silurian beds, all of which are altered in colour, and reddened by the infiltration of iron from the overlying Old Red sandstone, or from having formed the floor of the ferruginous water in which the Old Red sandstone was deposited.

The former of these suppositions seems to be supported by the fact of red beds being found in the glen west of Glenough, and in another south of Hollyford, at a considerable distance from the Old Red, and separated from it by some of the ordinary gray ones; while the latter appears more probable, when it is borne in mind, that similar red beds are very frequently, indeed almost always, found close to the boundary of the Old Red all the way, from the glen mentioned as next westward of Glenough, out of the map northwards to the Devil's Bit, and in other places in the neighbourhood of this district. If the change is the result of infiltration, it must have affected the rocks to a very considerable depth; while the red colour is apparently too prevalent to owe its origin to the mere action of the atmosphere on the ferruginous ingredients of these particular beds.*

In the neighbourhood of Upperchurch are some of the localities where characteristic Silurian fossils were found. The rocks in which they lay consisted also of the same kind of grits and shales as those already described—gray being, however, the prevailing colour. Close to the village are some greenish gray grits, concretionary shales and thin flags, dipping a little west of north at 60°. Graptolites were found in these; and on the road from this place towards Thurles, are some nearly vertical gray flagstones, striking N.E. and S.W. across the road, which also contain fossils. They were found in a small quarry, near a house on the north side of the road, in the townland of Gortnaskehy, and consisted of Graptolites, Orthoceratites, and small bivalve shells. The east side of the quarry appeared to be the most fossiliferous. Further on along this road, and near where it divides, the red silurian rocks again appear, dipping at various angles. It is not here very easy to see which are Silurian and which the lower beds of the Old Red, as they occur so near each other, and are both so much alike in colour. Texture is the chief guide in distinguishing them, the Silurians being harder

* From the frequency of the occurrence of Red Silurian rocks near the Old Red boundary here, and in other adjoining localities since examined, I am inclined to think that the supposition with regard to infiltration is the correct one; or, at least, that the alteration in colour has a direct connexion with the overlying unconformable Old Red sandstone.—A. B. W.

and closer grained, while the angles of inclination at which their beds lie, usually higher than those of the Old Red sandstone, are here generally low, but have some high dips among them. Where the Silurian rocks run in for a short distance across the general strike of the Old Red here, a knob or boss of the hard red beds seems to have formed a projection at the bottom of the Old Red sea. It is composed of beds which are much twisted, the angles of dip being high, both at the sides and over the axes of the contortions. The stone is heavy, and seems to contain a good deal of iron. It effervesces with acid, particularly along certain red crystalline veins. In the Owenbeg river, about half a mile S.E. of this place, the red Silurians again occur; their beds undulate a good deal, but do not, on the whole, deviate much from a horizontal plane. Up the stream, they seem to dip under deeply weathered gray grits, at an angle of 20°; while in an opposite direction they become brecciated, the beds having only gentle undulations. A little way below where they are last seen, the coarse red and white sandstones of the Old Red may be observed, dipping away from them at low angles.

On the northern slopes of Knockalougha, the streams afford sections in the Silurian, which here consists chiefly of gray and olive gray grits, concretionary shales, and some flags, dipping at high angles in various directions. In a large quarry on the Anglesey road, near Upperchurch, are some thin gray concretionary grits and shales; in the coarser or more sandy beds of which, fossils, chiefly casts of small Encrinital joints, have been found. To the west of Upperchurch, and distant about a mile and a-half from it, is Gleninchinaveigh, where a bed or vein of anthracitic coal was discovered in these Silurian rocks, and was partially worked during the year 1857. A more particular description of this coal will be found further on. The rocks in the neighbourhood are the usual dark gray grits and fine muddy beds, many of which are here cleaved into slate. In the valleys to the westward and north of this, hard gray, slightly calcareous sandstones, like those before described, are frequently seen.

Directly south of Gleninchinaveigh, and its neighbouring hills, is a low rounded rising ground, between the head-waters of the Multeen and the Owenbeg streams; it is called Dooree, after the townland of that name situated upon it. Here, in a quarry at its southern side, the first fossils of this Silurian district were discovered in a coarser bed than is usually met with, lying between dark gray flagstones, which dip to the north at 65°. The fossils consisted of very minute casts of Encrinital joints generally, and some varieties of Orthoceras in the flagstones. Shells, and fragments of shells, occur both in the grit and flagstone. West of this, along the Anglesey lines to Newport and Hollyford, the gray grits and flags may be frequently seen, but there are no large exposures of them.

We come now to the country N.E. of Hollyford, in which the Copper mines are situated. The Anglesey road here exposes, at intervals, a great quantity of Silurian rocks, all very similar in character to those we have been describing, and all more or less contorted. By this road runs a small stream, and on its western bank opposite to where a rivulet falls into it from a deep ravine, and at a distance of a mile and a half from Hollyford, is the Reafadda fossil locality, by far the best hitherto found in this district. The fossils occur in the same sort of dark blue (?) calcareous flags, in which they are most frequently found. They include some good Encrinite stems and heads—one having branching arms; some slender varieties of Orthoceras,* more than seven inches long; Graptolites of different kinds, and small shells, &c. The rocks are exposed also in the stream which passes by Hollyford mines, and its tributaries. They present no

* See Pal., notes, pp. 10 to 13.

unusual varieties, and are as much contorted as usual. To the south of the village they are seen along the Anglesey road to Tipperary, in the Hollyford river, and in a stream which runs nearly parallel to it from its source underneath Knockbane, but ultimately falls into it. Along the course of this stream some of the red beds, similar to those previously noticed, may be met with; and they occur also in a deep ravine, the stream from which passes close by Hollyford Police-barracks, and falls into the river there.

In the smaller streams tributary to the upper part of the Eastern Multeen, the Silurians are sometimes seen; but that river itself gives very few sections. The rocks are, however, exposed where it passes through a defile just as it leaves the Silurian district. They are there thin, red, hard, and heavy grits, dipping under gray, very hard, and quartzose grit and olive shales; the whole inclining to the west at 60° and 70°. At the upper part of Glenough, the Silurians appear, but only in the smaller streams, and on the steeper declivities. The stream itself affords no section until it reaches the place where another from Knockbane falls into it over the picturesque cascade of Poulanass. There may be observed a great variety of rocks, all very much contorted, and quite vertical in some places, striking generally north and south. They consist of gray thin flags, hard grits, red flaggy beds, variegated grits, gray, streaked with red, and olive rusty-looking shales.

Having now gone over the principal places where the Lower Silurian rocks may be seen, we will proceed to notice the Old Red sandstone, beginning at the south and passing northwards along its strike.

c^3. *Old Red Sandstone.*—This formation occupies a considerable space at the S.W. corner of the map, from which it strikes northward in a wide, but very irregular band, between the Silurian and the Limestone. It rises everywhere from beneath the latter rock, and rests upon the former; running up the long external slopes of the hills, sometimes to their most elevated points, while in the valleys, owing to the amount of denudation having been greater, the band is always more narrow. Two small patches seem to occur as outliers on the summits of elevations, but the evidence is only tolerably good for one of them. This is the one farthest south, in the townland of Glenpaudeen, a mile and a-half S. of Hollyford. The road crossing the hill here, exposes some coarse red rubbly conglomerate, lying apparently nearly horizontally; while in the valley southward of this, and below it, olive gray and purplish Silurian beds may be seen in the stream, which, there crossing the Silurian boundary, lays bare the red sandy and conglomeritic beds of the Old Red sandstone, dipping southward at low angles, not exceeding 15°. Half a mile south-west of Knockbane, and at the most southern point of Glencarbry townland, the red sandstones of this formation are found at an elevation of 1,091 feet—they appear to lie nearly flat. In the country south of this, the ground is gently undulating as far as Bishop's Wood, where the mountain slope becomes a little more abrupt. The rock is rarely seen, and where it is, dips southward at angles, the greatest of which is only 10°. The beds are either very similar to those already described, or consist of coarse white-speckled and ferruginous sandstones; good examples of which may be seen at Barraderry, a little more than a mile southward of the outlier last alluded to, on the old road from Hollyford to Taylor's cross-roads.

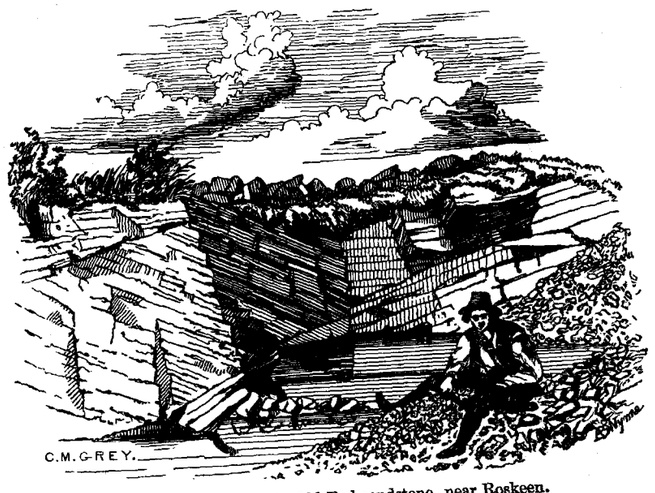
In the stream to the N.E. of Bishop's Wood, red flaggy, and obliquely laminated beds were observed dipping down the hill at low angles; and in the stream from Glenough, red sandstones and shales occur near the boundary of the Silurian. North-east of this, near the road from Glenough to Clonoulty, and in the Glashaninshagh river, red speckled, ferruginous, and whitish flaggy sandstones dip a little south of west, at angles varying

from nearly horizontal to 15°. Northward still, similar beds having a similar dip and direction, were observed in many places on the townland of Turraheen, at the highest part of which an outlier of these rocks is believed to exist.

On the exterior slopes of the elevation called Knockalougha, coarse, pale, purple, red, whitish, and speckled sandstones, sometimes conglomeritic, with some red shales, may be seen; and on the high ground, about a mile south of this elevation, there is a peculiar soft conglomerate, consisting of a red shaly base, containing pebbles of dark purple hard grit. This is remarkable as being very similar to that occurring in the most southerly of the outliers alluded to just now. In a direction somewhat south of east, and about two and a-half miles distant from the place where the conglomerate appears, a large quarry has been excavated beside a stream near the village of Drumbane, the beds exposed are pale purple and grayish sandstone, with thick beds of red shale in the upper part of the quarry; while below are found certain white beds, enclosing small scattered pebbles of quartz, all the beds being more or less characteristic of the upper portion of the formation, but here affording beautiful freestones, much used in the ornamental parts of the modern buildings in the country, for which, however, the white sandstones are preferred. Below these, purple and red sandstones are again found.

North of Drumbane very much the same kinds of rock are observed undulating over the country and forming elevations which decline towards the limestone; the principal dips being at low angles in an easterly direction. The sandstones are frequently obliquely laminated, as at a quarry in Knockane, near Roskeen Police-barracks, of which a sketch is given in figure 8.

Fig 8.

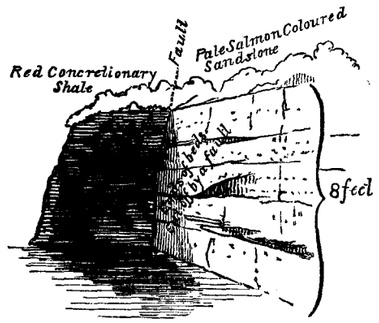


Oblique lamination in Old Red sandstone, near Roskeen.

The Glashaglorah river, above where it passes by "Cottage," exposes a good deal of Old Red sandstone rock of the usual kinds. A fault may be here well seen, which brings a thick bed of red nodular shale against

pale salmon-coloured and yellowish gritty sandstones, apparently nearly horizontal, but probably having a slight dip to the south. The subjoined sketch of it was taken at a short distance above a new mill (see fig. 9).

Fig. 9.



The Old Red sandstone shows itself frequently all along the boundary of the Silurian, from Knockalougha to where it leaves the map. It consists of coarse red and whitish sandstones, speckled and sometimes conglomeritic; but only forming a decided conglomerate in one place where it has been before alluded to, as occurring nearly in junction with the Silurian. The Clodiagh river gives a good section through some almost horizontal and gently undulating beds of this formation, where they are of the usual kinds. In this section, the lowest as well as the highest beds seen are associated with thick red shales; and if we judge from the surface exposure of the rocks, the thickness would appear to be less here than in any other part of the district included in this map.

The last beds visible along the boundary, north of the Clodiagh, contain some cupriferous sandstones—the copper occurring as small disseminated grains. The bed containing most copper could not be found, but its angular fragments are scattered over the fields in the neighbourhood.

d. *Carboniferous Limestone.*—This formation occupies about two-thirds of the map. The rock is seen best upon Killough hill, and the range of low hills which runs parallel to the base of the Kilnamanagh mountains. It is also visible in small cliffs along the course of the River Suir, and in a number of quarries scattered over the face of the country.

To describe these places we shall commence at the west part of the northern limit of the Limestone formation on this sheet; and as the quarries will be found numerous, their general characteristics only, in each locality, will be mentioned.

In the direction indicated, the Limestone is seen close to the Old Red sandstone, in the townland of Annfield. It dips towards the S.E. at about 10°; being composed of fine dark gray compact and subcrystalline varieties of calcareous rock—some beds apparently having a thickness of 10 feet. North-west of this place, where a small drift hill protrudes from the alluvial flats, W. of Inch House, black and gray crinoidal and crystalline limestone appears to dip in an easterly direction at a low angle. In the space between Inch House and Dovea House, several quarries occur. The dips observed here are in various directions, and the limestone is not constant in colour or texture; being in some dark and earthy, with beds of shale; and in others, more in the vicinity of the last-named place, pale violet, and very compact.

From this place eastward to the Suir, the country is covered with drift; and when the limestone is seen again in the country beyond, it is found to consist of nearly similar varieties to those just described. It appears in a number of quarries about Athnid. It is sometimes fossiliferous; and the dips, from the diversity of their directions, show that it is contorted, the angles being usually low.

At the N.E. corner of the map, in the townlands of Shanballyduff, Moyneard, Boolabeha, and their neighbourhood, the limestone is frequently seen. It is generally either dark bluish and subcrystalline, containing few fossils, except crinoidal joints and stems; or else, pale lavender gray compact and splintery, associated with some darker coloured highly fossiliferous beds, containing a quantity of the remains of Fenestellæ, or other Bryozoa, as seen near a by-road east of a bog which lies close to the northern boundary of the map; or of broken fragments of crinoids packed together, their stems internally crystallized, and consisting of white carbonate of lime, as may be observed where a number of roads approach each other near some plantations south of the above-mentioned bog. Where the road from Moyne to Two-mile-Borris meets that from Thurles, dark and pale bluish gray limestone, containing fossils, and being in places slightly magnesian, dips towards the S.E. at about 15°. From this place southwards, along the road to Two-mile-Borris, dark bluish limestone occurs in two places—one to the north of Eyremount Cottage, and the other close to Boolabeha. It seems to lie nearly horizontally, dipping at a low angle southwards, and at the latter place looks slightly oolitic. Along the margin of a bog, part of which comes into the map S.E. of this place, darker gray and black limestone occurs either horizontal or dipping southward at low angles. West of this bog, on the high ground some six hundred yards from the Drish River, and close to a road in the townland of Piercetown, are two exposures of black compact limestone, which weathers blue, and has a conchoidal fracture. Its dip is also south at about 5°. Where this road crosses the same river by a ford further down its course, the stream gives a short section in some dark gray, nearly horizontal, beds, which are in places shaly. North-west of this place, near where a parish boundary runs for some distance along the road from Thurles to Johnstown, and at a bend in the road, is an old quarry, in which some gray siliceous looking limestone was observed, with one sandy looking magnesian bed; all lying probably horizontal. At the distance of about a mile northwards from here, where there are two cross roads, and near the most easterly one, are gray variegated limestones, full of Fenestella-like fossils—in some places being yellowish and magnesian. About 200 yards south of the other cross roads, near Rossestown, is a knob of bluish and variegated gray limestone, with magnesian blotches.

The rock is seen in a good many places south and west of Brittas Castle, and in its neighbourhood. In the demesne there are two quarries in which were observed pale gray compact limestone, with sandy-looking magnesian layers, dipping to the S.E. at 15°; and at a short distance west of the south gate-lodge, is some compact dolomitic limestone, which is, when weathered, sandy-looking and rough to the touch. Similar rocks to these, and a pale blue variety, were observed still further south, in the townland of Grange. In those quarries west of Brittas demesne, where the dips are all southwards, at angles varying from nearly horizontal to 20°, the upper beds apparently are pale gray, while those underneath are black and dark gray, rough, compact and cherty, with thin crinoidal beds in their lowest part. Westward of this, in the neighbourhood of Kilrush House, are black and dark gray compact earthy and crinoidal beds, containing some fossils, and dipping southwards at angles varying from 5° to 10°. On the opposite

side of the bog which lies between the places where these beds are seen and the hamlet called The Rag, by the road from Thurles to Borrisoleigh, is some dark gray compact limestone in two quarries.

At the Rag may be said to commence the limestone ridge, which runs, with but one interruption, parallel to the base of the mountains, and at a distance of about a mile from them all the way from here to Ballagh. There are many exposures of the rock along it, as the symbols upon the map will show; the general dip being in a direction somewhat south of east at an average angle of 10°. Towards its northern end, and north of Castle Fogarty, the beds are dark gray compact and crinoidal; some of the latter kind being almost entirely composed of fragments of Actinocrinus, but containing other fossils as well, amongst which the Rhynchonella pleurodon seems to be numerous. Some high ground extends from this ridge at Ballycahill eastwards, and on it, as well as in many places near the road from this place to Thurles, dark gray and black earthy limestones were observed. The dips here are various, being generally, unlike those on the ridge, in a southerly or westerly direction, at angles from 10° downwards.* South-east of Castle Fogarty, and at about the highest part of the ridge, an apparent extension of the dark beds, previously noticed as existing to the north of that place, occurs. They are sometimes magnesian, and in the neighbourhood of Ballycahill National school, contain black and dark gray oolitic and crinoidal beds. Along the road from Farney Castle to Mealiffe House, similar beds were observed, containing paler oolitic limestones, magnesian in places; and close to the river, near Ballyoughter bridge, N.W. of Mealiffe House, crinoidal and shaly beds may be seen.

At the other side of the Clodiagh River, where the further extension of this ridge strikes southward, more of the dark shaly and black limestones occur. They are exposed in several places, and appear to be somewhat contorted just where the hill rises south of the Clodiagh. From this place southwards, however, and in the neighbourhood of Clonoulty, the dips are all pretty regular, at low angles, varying from 5° to 15°, in a direction about 20° S. of E. Between Clonoulty and the base of the mountains, at a place called Coolanga, are some of the lowest beds of this formation. They consist of dark gray and black limestone, undulating at low angles, and sometimes containing a number of fossils.

At the village of Ballagh, there are some large quarries in bluish and dark gray oolitic and fossiliferous limestone, having in some places an olive tinge, and appearing to be slightly magnesian. Some of the beds here are earthy looking, and some very crystalline. Southward of this village, near a place called Borheenacunna, dark gray limestone appears in a few quarries; and near the Railway Station at Gooldscross, black and calpy looking beds, sometimes containing small crystals of iron pyrites, occur.

Dark gray compact and cherty limestones, very similar to those already described, are seen underneath the ruins of Clonyharp and Clogher Castles, northward of Gooldscross; and in the space lying between the limestone ridge, the Great Southern and Western Railway, Gooldscross, and the village of Hough. Similar rocks are also seen N.E. of this village, near the railway; and in a cutting thereon, close to the railway bridge between Hough and Holycross, some gray, sparkling, slightly oolitic-looking, dolomite occurs.

* At Ballycahill, in quarries near the road, Strophomena crenistria, a characteristic Brachiopod shell of the lower part of the Carboniferous limestone, was observed to be in great abundance, with small corals, Zaphrentis Griffithii, and numerous joints of crinoids, weathered out of the beds.—W. H. B.

Due north of this bridge, within two miles, are a number of quarries in dark-coloured and cherty limestones, having generally a more or less southerly dip, at angles of 25° and less, some beds being almost horizontal.

South-west of Raheen Park, near this, and on the road from that place to Thurles, a good many quarries also occur, containing dark and pale gray limestones, dipping in various directions; and such limestone is seen also in some places where no dip could be observed, as near the Holycross Glebe-house, and on the margin of an alluvial flat near the Hill Houses. These beds are in some places fossiliferous, and some of them contain a quantity of the Fenestella-like fossils so frequently met with in the limestone of this map.

In the neighbourhood of Holycross,* the rock frequently appears. It may be seen near the roads leading from the village to Hough, Thurles, Littleton, Killough Hill, and Cashel, and also in the River Suir. It consists of the usual varieties of gray, dark gray, and blackish limestone; having, on the whole, a southerly or south-easterly dip at various angles, but none exceeding 20°. Some of these limestones are shaly, and some very pale and compact, with a number of joints, having a north and south direction. At an old castle, some little distance from the east bank of the Suir, about a quarter of a mile above the village, is a quarry in gray granular-looking limestone, exhibiting oblique lamination in some of the beds. Whitish gray and brown dolomite, associated with gray compact limestone was observed along the Suir at Abbeyview, and just below the bridge at Holycross.

Proceeding up the course of the River Suir from this place towards Thurles, south of Ballycarrane House, and on that side of the river, are some dark bluish and gray limestones, containing fossils. They dip apparently to the south, and are very similar to some beds seen along the road leading to Thurles from this place. On the opposite side of the river, near the house above-named, black and gray limestones are again seen, dipping in the same direction; and on the Great Southern and Western Railway, which makes a considerable bend here, some magnesian and dark gray compact limestone occurs. The latter rock is again seen between two bridges which cross the railway south of the 87th mile-post.

Several quarries occur in the vicinity of Thurles, in dark and pale gray compact limestone, often magnesian, as at the quarry near the north side of the Race-course, in two directly south of it, in some quarries near its western end, and in the directions of the Bowling-green and the Pike; near which latter place, and northwards of the Glebe-house, is some gray sparkling dolomite.

Within and near a somewhat triangular space enclosed by the road from Thurles to Littleton—the one which passes from the same place by Two-mile-Borris, and the old Dublin road, running in a north-easterly direction from Littleton—gray limestone, in some places dark, and in others very pale, may be observed: some of it is magnesian. It is quarried sometimes through a thin covering of drift, and sometimes occurs in bare projecting bosses of rock. The bedding is not always distinguishable, it seems to be frequently nearly horizontal; but some dips, as high as 15°, have been taken inclining in various directions.

At the western corner of the space above indicated, the limestone is dark gray and compact, in places containing shaly beds; and at the west side of a marsh near this, exceedingly fossiliferous beds were observed, some of them consisting entirely of masses of corals (Lithostrotion, &c.).

In the neighbourhood of Two-mile-Borris, and near the eastern corner

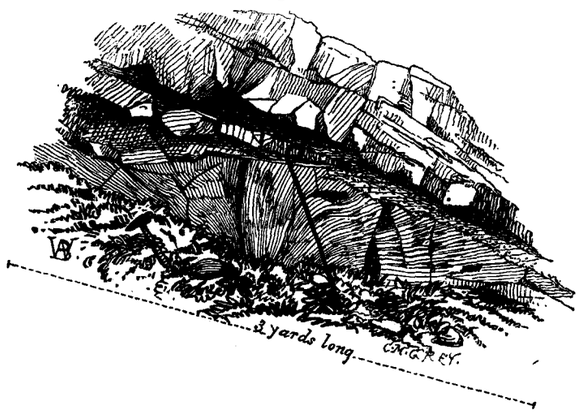
* Famous for its magnificent ruins.

of the triangular space, the rock is sometimes dark bluish and sometimes pale gray, in places slightly magnesian; the beds undulating at low angles, with a general inclination to the west. At the southern corner of the space north of Littleton, the limestone is either dull dark gray and compact, or pale whitish and bluish, and also contains magnesian portions. The dips are low, and in various directions, their angles not exceeding 15°. At one place in this neighbourhood, between Cooleroo old castle and the cross roads S.E. of it, some obliquely laminated gray limestone occurs; some of the layers consisting of ordinary limestone alternating with others formed of crinoidal fragments.

South-west of Littleton, and between that place and the village called the Horse and Jockey, are a group of quarries in dark, bluish, and pale gray limestone, dipping in various directions. Some of these show oblique lamination, and the limestone in some is oolitic, and in others crinoidal.

In the neighbourhood of the village last named, the limestone may be seen in several quarries. It is generally compact, and of a gray tint, sometimes so dark as to be almost black. It contains some beds which are highly fossiliferous. One quarry in the townland of Curraheen, by the side of the road to Grallaghmore, and about 300 yards S. of the village, exhibited one very remarkable bed, consisting almost entirely of large corals of several kinds, quite uninjured, and in the position of growth. One large mass of Lithostrotion irregulare, *Milne Edwards*, (according to Mr. Baily who examined a block of it), was no less than nine feet in length, and upwards of two feet in height, in its central portion. The following sketch of it will serve to show its mode of occurrence, and its appearance in the quarry.*

Fig. 10.



Lithostrotion in a quarry near the Horse and Jockey village, County Tipperary.

The dips in this neighbourhood, as elsewhere, are irregular, both in their direction and amount, the angles being usually low.

* This was the largest fossil coral I ever saw, and the only one that could be at all compared to the large stools of Mæandrina and great blocks of Porites, that are to be seen in existing coral reefs. The whole bed, however, in which these corals occurred, did not exceed three or four feet in thickness, so that the assemblage of fossil corals here had no resemblance to that of existing corals in reefs, scarcely even to a diminutive fringing reef.—J. Beete Jukes.

Between this locality and Holycross are many scattered quarries in pale and dark gray limestone, sometimes fossiliferous; the apparent general dip of which being southward, argues that the beds pass under Killough Hill—a very conspicuous object in the vicinity. Upon the northern face and top of the hill, the rocks are well exposed; their surfaces are often rugged and rain-worn. In many places they are deeply fissured; and all bear evidence to the degrading action of the weather. The beds dip southward at an average angle of 15°. Those forming its summit and southern slopes consist of gray limestone, either earthy or crystalline, in some places oolitic, in others crinoidal; while in some instances it appears to be magnesian.

A well sunk within the bend of a road, between the hill and Gaile House, passed through a quantity of white crystallized carbonate of lime, occurring, probably, in the form of a large vein.

South and west of Killough Hill, between the River Suir and Ballytarsna bog, a number of quarries occur, at intervals, exhibiting many varieties of pale and dark gray limestone, sometimes blue, and frequently crinoidal. Black and dark gray beds may be seen on the Thurles and Cashel road, almost due west of Gaile House, where the magnificent spring, called Toberadora, bursts up through cracks and fissures in them. All the limestone in this neighbourhood undulates at low angles, and many of the beds are fossiliferous, as in the townlands of Ballinree, Peake, &c., &c.

A. B. W.

Immediately south of the Glebe House, one mile and a-half east of the village of Dundrum, a quarry in dark gray earthy limestone may be observed, dipping east at 5°. Limestone of a similar character may be seen in the vicinity of Ballymore House, and for a mile south of it; also at Goldscross, and in the townland of Baunmore. At all these last noticed localities, the limestone is of a dark gray colour, sometimes almost black, very often having a shaly appearance, and sometimes containing thin beds of black shale. The general dip is to the east at from 5° to 10°. Thick-bedded bluish gray crystalline limestone may be seen in a quarry which has been opened in the townland of Ballycamusk, three-quarters of a mile north-west of Nodstown House, dipping S.E. at 10°. A quarter of a mile north of the last-named locality, as also in Longfield demesne, and south of it, on the road leading along the west side of the River Suir, and on the east side at Ardmayle, similar limestones may be observed in many quarries, sometimes varying slightly in texture and colour, and becoming occasionally magnesian. The dip of the beds varies from E. to E. by S., at from 5° to 10°; but at Ardmayle the dip is E. by N. at 10°. Oolitic limestone may be seen one mile from Ardmayle church, on the road leading from Ardmayle to Nodstown House. It is of a light bluish gray colour, and very massive, the stratification being obscure. One mile south of Boherlahan, massive, thick-bedded, bluish gray limestone dips north at 10°; and at Ballykelly church,* similar limestone may be observed dipping south at from 10° to 15°. In the neighbourhood of Ballinure, and in the townlands of Manserghshill, Ballintogher, and Greystown, the upper beds of the limestone may be very well observed cropping out in many places near the Coal Measure boundary, and exposed in many quarries. It is of a light bluish gray colour, crystalline in texture, thick-bedded (with the exception of the beds immediately below the Coal Measures, which are thin-bedded), containing large irregular lumps and nodules of black and white chert, and chert layers sometimes from four to six inches thick. All these beds dip to the south, under the Coal Measures, at from 10° to 15°.

* At Ballykelly church, a boulder of granite, two feet in diameter, was observed.

Coal Measures.—A small portion only of the Coal Measures enter within the limits of this map, just crossing its S.E. corner. They consist entirely of the lower shales of the formation. In the immediate vicinity of Noan House, the black and dark gray shales which form the base of the Coal Measures may be seen, and in several places, for a mile to the east of Noan, the best sections being in the stream along which the parish boundary runs, and in the by-road leading from the parish boundary to Helen Park. In both mentioned places the sections are in the beds immediately above the limestone only. In that along the parish boundary the beds dip south at from 10° to 15°, and consist of dark gray and black shales, and dark gray gritty bands. In the by-road the beds dip S.W. at 25°, and are the same as those last-mentioned, curving round with the boundary of the limestone. In the road cutting immediately west of Graystown church, a short continuous section may be well observed, in which the beds dip east by south at 15°, with the stratification very well defined, as the rocks consist of alternations of black and dark gray shale, interstratified with thin dark olive gray grits. In the same road, and about 400 yards to the S.E., another short section is exposed, in which the beds consist of gray, dark gray, and black shale, some of the beds being sharp and splintery, others nodular, all having the same dips as those at the last-named locality. 'This dip, however, does not appear to be continuous from one section to another, as in the stream midway between them the bedding appears to be horizontal.'—J. O'K.

6. *The Drift.*

The drift of sheet 145 does not seem to differ essentially from the mass of that spread over the centre of Ireland. It is composed of fragments of the local rocks, generally rounded, but sometimes subangular, among which there may be found pieces of rock not known to exist within a considerable distance.

This deposit is widely spread over the surface of all the lower ground in this district, covering and filling up hollows in the underlying rocks, but not necessarily limited to any fixed elevation. Its chief constituent in the low ground is limestone, pebbles and fragments of which, either well-rounded or subangular, are embedded in fine or coarse sand, or in stiff yellowish calcareous clay. It is very unevenly distributed, being at one place thin, and at another of considerable thickness, and sometimes altogether absent; however, there are no large spaces left uncovered by limestone *detritus*, of one kind or another, which, generally speaking, extends from the east side of the map, westwards round the base of Killough Hill, and up on to the low ridge spoken of as occurring near the foot of the Kilnamanagh Mountain. But it will be observed that the deposit concealing the rocks and their boundaries in the space between these hills, and the mountains themselves, is chiefly sand and clay, and not limestone gravel. It has, therefore, been coloured upon the map the same as several other accumulations of alluvial detritus, which will be noticed just now. Beyond this interruption the drift no longer presents itself as a mass of limestone *débris;* but more frequently when sections of it appear as well as on its surface, it takes the character of a local deposit chiefly formed of mixed fragments of the underlying and neighbouring rocks. Limestone boulders are still found in it in many places, as in Glenough, where a sufficient quantity of them may be collected from the stream to be worth burning for lime.

Numerous boulders of syenite and other rocks, transported from a distance, may be met with in varying quantities anywhere within the map where "drift" is found; but were more frequently noticed among the hills. A very large boulder of syenite was observed beside the stream which flows from the ravine, opposite to the Reafadda fossil locality, near Hollyford.

At a short distance east of the Anglesey line of road, another of limestone has been noticed as occurring in the Clodiagh river, near its head waters, and many smaller ones were frequently met with scattered over the country.

The height at which "drift" proper may be found is not at all well defined, as indeed none of its boundaries are. Masses of local debris occupy the bottoms of many of the mountain glens, and, like snow-drifts, fill up hollows at very considerable elevations, and contain lumps or boulders of limestone at heights of 600 feet; but above that elevation the limestone fragments become scarce, and higher up still would be considered entirely absent, if a close search did not now and then enable one to find little pieces of chert so small, weathered, and changed, that they could not be recognised as part of the Carboniferous limestone formation, except for their containing now and then minute casts of the joints of crinoids.*

The alluvium of the "flats" marked on this map, usually lies upon drift of some kind, and in some cases is overlaid by bogs, while the surface underneath the large bogs is found to consist as usual of a fine bluish muddy clay, or of a wide spreading, generally level, expanse of "drift." Sometimes, however, low rising grounds composed of gravel, &c., project through the surface of the bog, as in the neighbourhood of Littleton (see map.)†

Along the course of the Suir and its tributaries also, many of these flats occur, as well as crossing the road from Thurles to Borrisoleigh. The bogs on this map, except two isolated ones on the north, one near the centre, and one at the S.W. near Dundrum, lie chiefly at its eastern side and S.E. corner, where they form part of an extensive chain stretching away to the north and north-east, by Maryborough and Kildare, to the Bog of Allan. Like others of the Irish bogs, they contain frequently the roots, stumps, and fallen trunks of forest trees.

7. *Mines and Minerals.*

The minerals found in veins traversing the rocks in the district included in this map, are chiefly quartz and barytes, in the Silurian and Old Red sandstone, and carbonate of lime in the Carboniferous limestone.

Sulphate of barytes occurs in thick dyke-like masses, and in small veins in many of the Silurian grits; and wherever it has been observed it re-appears pretty frequently within a limited area. Some of these hard Silurian grits present the appearance of a tangled mass of such small veins or strings cutting each other at all angles.

This mineral has also been found at the following localities. At Glenough, in a ravine situated on the east side of the stream, and somewhat less than a mile and a quarter due north of Poulanass waterfall, where it occurs as a vertical vein bearing E. and W., and having a thickness of two feet three inches near the source of the Glashanashagh river, a tributary to the Multeen.

In strings in some slaty shales by the south side of the last-named river, where it runs through a narrow defile in the townland of Turraheen Lower.

In a coomb about a mile south of the mining village at Hollyford, and in other places in small quantities.

Quartz occurs in ordinary forms of the opaque and semi-transparent varieties of that mineral, and is too common to require a particular notice of its precise localities.

Carbonates of lime and iron are also met with in small quantities in the

* In recently examined localities out of this map, but connected with the district, these fragments occur at elevations of over 1,000 feet.—A. B. W.

† Mr. Miller, C.E., informs me that alternations of alluvium and peat were formerly observed in an excavation at the mouth of the Farneybridge river, near Moyaliffe.—A.B.W.

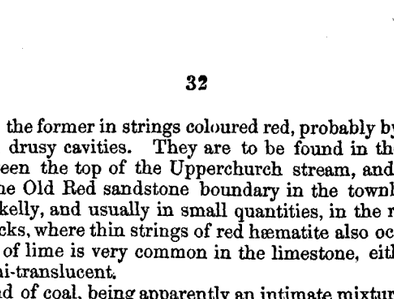
Silurian rocks; the former in strings coloured red, probably by iron, and the latter in small drusy cavities. They are to be found in the townland of Moyland, between the top of the Upperchurch stream, and the Clodiagh valley, along the Old Red sandstone boundary in the townland of Ballyboy, near Gortkelly, and usually in small quantities, in the red portions of the Silurian rocks, where thin strings of red hæmatite also occur. Crystalline carbonate of lime is very common in the limestone, either white and opaque, or semi-translucent.

Coal.—A kind of coal, being apparently an intimate mixture of anthracite and graphite, occurs in the lower Silurian rocks at Gleninchinaveigh, near Upperchurch. It appears rather in the form of a vein than a bed, occupying a space of about four feet in width, between the vertical walls of what seemed to be certainly a fissure, and was perhaps a fault, which strikes N. 10° W.

A shaft was sunk in the year 1857 upon it, to the depth of ten fathoms, but was discontinued in consequence of the walls of the vein approaching, and reducing the width of the mineral so much, that it became unprofitable to work it. From this shaft a driving was made at the depth of six fathoms from the surface, and was carried along the strike of the vein, for a distance of thirty feet.

A small portion only of this shaft, probably not more than a fathom, below the timbering and sheathing, (which extended to a depth of about twenty-four feet), could be examined when the country was surveyed in October, 1858. The rock, consisting of a hard dark gray or blackish siliceous grit at its western side, and at about thirty feet below the surface of the ground, was observed to have a smooth slickenside surface, nearly vertical, and forming the wall of the carbonaceous deposit on that side of the shaft. On the opposite side of the deposit the wall seemed more uneven, and the beds, consisting of alternating gray hard grits, and thin shaly bands, appeared to dip N.E. at 60°. Some of the harder beds seemed to crop out from this side of the shaft supporting those above them whose ends were cut off by the fissure, while underneath them, the softer ones were worn away to a distance of some ten inches or a foot from the general plane of the surface of the wall, and each lower bed projected a little further than the one above it, until another hard one was reached, when an indentation of the same kind could be again observed. The projecting ends of these beds were worn smooth and rounded, as if the friction which produced the slickenside on the opposite wall had also acted upon them (see fig. 11.)

Fig. 11.



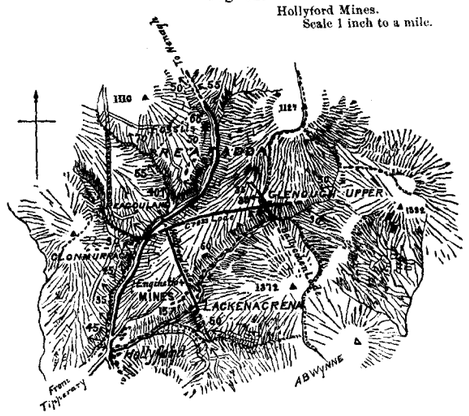
The deposit where the vein could be seen, in junction with both walls of the fissure, appeared to be more crystalline and lighter at the east side

of the shaft, than at the west, where it appeared to be much crushed, dull, and powdery. It was likewise apparently compressed and forced into the irregularities on the east side of the shaft, where the masses of rock above described projected into it.*

Copper ore occurs in the Silurian rocks, near Hollyford, at the west side of this map, in irregular fissures of considerable length, intersecting each other nearly at right angles; their position will be best understood by referring to the annexed sketch, fig. 12, taken from the one-inch map, to which the names of the townlands have been added.

Fig. 12.

Hollyford Mines.
Scale 1 inch to a mile.



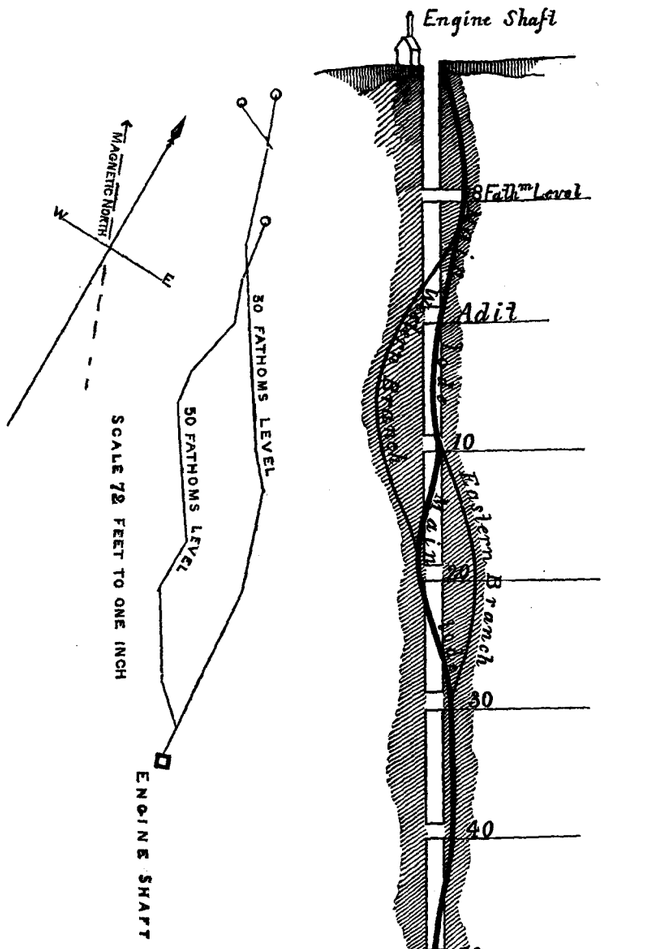
These mines have been worked at different periods. When visited by me in the summer of 1858, operations were being carried on at the Hollyford lode, under the direction of Mr. John Pascoe, who kindly furnished me with most of the following particulars, but the works have since been discontinued, and the mines closed. It will be seen that the Ballycohen and Hollyford lodes strike about 20° west of true north, the former, perhaps, a little more W., and the cross lode has an average bearing of nearly 15° N. of E. They are all more or less nearly vertical; the Ballycohen one being said to dip towards the west at 80°. As far as could be ascertained, works had been carried on in former times along the cross lode from Glenough, to where it crosses the Anglesey road at Clonmurragh, and where this joins the Ballycohen lode, the miners found what they termed "old men's workings" and tools.† The last-named lode was also worked formerly, and was said to be productive, but was abandoned on account of drainage difficulties. The fissure which the Hollyford lode occupies is very irregular along its sides, although it preserves a generally vertical position. This lode measures, at some places, only six inches in width, while in others it has had a thickness of as many feet. It is brecciated and generally contains yellow pyrites; but gray and peacock ores are also found, as well as a dark coloured variety, called by the miners, black ore. Some of the adjacent grits are so cut up by small quartz fibres, as to take the appearance of a breccia; but no large masses of quartz appear with the ore, though it is often present in small veins. Sulphate of barytes was

* Close to this place, in a stream that nearly coincides with the strike of the Ballycohen lode, graptolites were found.—A. B. W.

† Mr. Richard Millett, C.E., kindly afforded much information about this deposit, and the excavations were made under his direction, by desire of the proprietor, Mr. George Armstrong, of Moyaliffe House.—A. B. W.

observed at several places underground; where the rocks were found to consist entirely of hard grits, and hard splintery shales, and to incline in various directions. Several shafts have been sunk on this lode, some so deep as ninety fathoms, but at that depth the lode was poor. Numerous levels have also been excavated, the dialling of parts of two of which, the thirty and fifty fathom levels, are given in figure 13; they, as well as the transverse section, are taken from sketches kindly given to me by Mr. Pascoe.

Fig. 13.



That the supposed fault in which this lode occurs, like many others, encloses portions of the adjacent rock in consequence of smaller fractures having separated from it, and then returned to the original break will become evident on reference to the annexed vertical section (transverse to the lode), representing fifty fathoms of the engine shaft, where two smaller ones will be seen to branch from the main lode, one to the west, the other to the east, continuing for some distance, and again rejoining it. It would be almost impossible to say what the throw of this fault or fissure is, if indeed it has any, for the curves of both sides of the lode seem to correspond rudely to each other. However, as it is in a probably faulty neighbourhood, this appearance may be deceptive.

Copper has already been stated to occur in small quantities in the Old Red sandstone rocks, as disseminated particles in the beds, between the northern boundary of the map, and the river Clodiagh. It is unimportant in a mining point of view, but accords with the circumstance of cupriferous beds being found elsewhere on about the same horizon in these rocks.

Iron mines are stated to have been worked at a remote period on the townland of Gortnahalla, not far from Mr. Chadwick's mill, but at a little distance south of the Clodiagh. Here sulphur is also reported to have been found; and close to where the old mines are said to have been, heaps of the "debris" are still pointed out, now overgrown with grass, &c. Upon trying to find out of what these heaps were composed, pieces of hard, and very heavy red and gray grit were obtained, some veins in which effervesced with acid.

A. B. W.

DUBLIN: Printed by ALEX. THOM & SONS, 87 & 88, Abbey-street,
For Her Majesty's Stationery Office