EXPLANATIONS

TO ACCOMPANY

SHEET 154 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

ILLUSTRATING PARTS OF THE

COUNTIES OF LIMERICK AND TIPPERARY.

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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, M.A.; J. O'KELLY, M.A.;
A. B. WYNNE, F.G.S.; J. KELLY, ESQ.

COLLECTORS OF FOSSILS, &C.:

MR. C. GALVAN; MR. A. M'HENRY.

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

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

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

Condensed memoirs on particular districts will also eventually appear.

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

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EXPLANATIONS

OF SHEET 154 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

General Description.

The district comprised in this sheet of the maps includes a part of the county of Limerick on the western side, with the villages of Bruff, Hospital, Pallasgrean, and Oola, and a portion of the county of Tipperary on the eastern, with the town of Tipperary and the villages of Emly and Galbally.

1. *Form of the Ground.*

The principal features in the form of the ground included in this district are,—the north-western termination of the Galtee mountains, —the Slievenamuck range—a low ridge which we may call the Emly ridge,—some rugged hills towards the N.W. corner of the map, and a line of low but abrupt isolated hills, extending between the villages of Oola and Holycross. The remainder of the district is a comparatively level plain, remarkable for its fertility, being a part of the tract known as the Golden vein.

Only a portion of the northern slope of the Galtees lies within the limits of this district. A few lofty eminences occur on these slopes, one of which exceeds 2,000 feet above the level of the sea, and several others are between 1,000 and 1,500 feet. These summits gradually decline to the west S. of Galbally, forming a low irregular table-land, with several smaller eminences varying from 500 to 700 feet, and connected with the northern slope of the Slievereagh Hills, which lie out of the district S.W. of Ballingarry House.

The Galtees are separated from the Slievenamuck range by the picturesque vale of Aherlow, which varies from about one mile to a mile and a-half in width.

The Slievenamuck range is a long narrow ridge, commencing about two miles W. of the village of Galbally, and extending E. by N. for twelve miles, terminating at the village of Bansha, which lies in the adjoining sheet (No. 155). The average height of this range is about 1,000 feet, but in one place it attains an altitude of 1,215 feet. Its northern slope is very abrupt, particularly in the part which lies just S. of the town of Tipperary, where the steep slope descends continuously into the plain. To the W. of this part, between Ardloman Court and the Gap of Galbally, the abrupt slope is broken, at about half its height, by a broad swell in the ground, which suddenly flat-

tens for a space, and then descends more gently into the plain on the north. The Gap of Galbally is itself a curious little narrow ravine, cutting quite across the ridge, so as to admit part of the drainage from the plain on the N. to flow through it into the Vale of Aherlow, and this, notwithstanding that the ridge itself sinks gradually down about one mile and a-half W. of the Gap, as if to make there the natural passage from the vale to the plain. The ground, indeed, W of Galbally, becomes low and open between the termination of the Slievenamuck range and some higher land to the S.W., which forms the northern termination of the Slievereagh Hills, which were described in the Explanation of Sheet 165 as the Bench Mountains.

The Emly ridge is formed by an undulating rising ground extending from the village of Emly to the Roman Catholic Chapel N. of the Limerick Junction. It varies from about one mile to two in width, and its greatest altitude is 581 feet above the sea.

The hills at the N.W. corner of the district extend from near the village of Pallasgrean, by Kilteely and Herbertstown, to the neighbourhood of Lough Gur, where they terminate in very picturesque rugged hills, partly surrounding the Lough. The principal eminences in this range are those of Derk, 781 feet above the sea; Rathfooroge, 681; Kilteely, 580; Herbertstown and the Lough Gur hills, the highest of which is 532 feet above the sea. Another group of low hills is separated from those last described by a narrow valley passing through Pallasgrean and extending to the west as far as the Camoge river. This group of hills passes into the adjoining sheet to the north (No. 144). The principal elevation occurring in these hills, within the limits of this district, is to the W. of the village of Pallasgrean, where the hill generally known as Pallas Hill attains an altitude of 749 feet above the sea. This elevated land extends to the W. as far as Ballybrood, diminishing, however, very much in height, forming a kind of rugged undulating table-land, sometimes intersected by low flats.

The hills between the villages of Holycross and Oola form a line of abrupt isolated eminences. They are:—Oola Hill, 443 feet above the sea; Cullen Hill, 622; Knockaunavogher, 500 feet; Cromwell's Hill, 585 feet; the hill N. of Castle Farm, and Knockdirk which is 486 feet above the sea.* There is also a hill called Knockainy, a little out of the line, but having an altitude of 537 feet. The rest of the district may be described as an undulating plane, varying from 250 up to nearly 400 feet.

The main water-shed of Ireland passes through this district, separating the basin of the Suir from that of the Shannon. It enters the map near its north-eastern corner, and first runs S., across the railway, to Shanbally Fort, and passes thence in a S.W. direction to Shronell cross-roads; it then makes a bend to the N. and to the centre of the Emly ridge, whence it strikes about S.S.W. past Mooresfort and Ballywire to the old church of Galbally, and curving to the S. again, passes S.S.E. out of this map.

The drainage of the district N. and W. of this line passes into the Shannon by means of the Morning Star and Camoge rivers, which

* Knockdirk and Derk Hill are two distinct elevations, nearly seven miles apart.

are tributaries of the Maigue, and the Canteen River, which runs into the Dead River, while that to the S. flows into the River Suir, by the Rivers Ara and Aherlow.

The Morning Star enters the map E. of Ballingary House, at a level of 430 feet above the sea, and passes into the sheet to the W., near the village of Bruff, at a level of 209 feet. The Camoge is formed by the union of several streams west of Mooresfort House, springing from ground near Emly, about 380 feet above the sea, and passes out of this sheet at Sixmilebridge, at a level of 218 feet.

The Aherlow enters the map S. of Galbally, at a level of 404 feet, and has a height of 220 feet where it leaves it.

The Ara takes its rise on the E. of Mooresfort House, flowing S. of the town of Tipperary, passing out of this map near the northern base of Slievenamuck, at a level of 246 feet.

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2. *Geological Formations or Groups of Rocks.*

Aqueous Rocks.

	Name.	Colour on Map.
	Alluvium, Peat, Bog, &c.,	*Sepia.*
	Drift,	*Engraved dots.*
Carboniferous.	d^5 Coal Measures,	*Indian ink.*
	d^4 Upper Limestone,	*Prussian blue (dark).*
	d^3 Calp or Middle Limestone,	*Not distinguished in this sheet.*
	d^2 Lower Limestone,	*Prussian blue (pale).*
	d^1 Lower Limestone Shale,	*Prussian blue and Indian ink.*
Old Red Sandstone.	c^3 Upper Old Red (or Yellow) Sandstone,	*Indian red (dark).*
	c^2 Old Red Sandstone,	*Indian red (pale).*
	b Lower Silurian,	*Purple.*

Igneous Rocks.

B.	Basalt,	*Dark crimson.*
D.	Greenstone,	
S.	Syenite,	
Ds.	Greenstone ash,	*Pale crimson with dots.*

b. The Lower Silurian Rocks occurring in this district consist of hard coarse sandstones and fine-grained grits, varying in colour between a gray and greenish gray. These beds are interstratified with dark gray and olive gray slates, sometimes very much cleaved. No fossils have been found in these beds.

c^2. The Old Red Sandstone, as in the adjoining districts, consists of beds of conglomerate below, to which succeed red and purple sandstones and gritstones, interstratified with occasional beds of conglomerate and beds of red shale.

c^3. The Upper Old Red (or Yellow) Sandstone.—This series consists of yellow and red sandstones, interstratified with red and green shales and some thin beds of gray conglomerate. These beds are separated from the beds below by a very arbitrary boundary.

The thickness of the whole of the Old Red Sandstone varies between 1,500 and 2,000 feet in this district.

d^1. Lower Limestone Shale.—No good exposure of these beds is visible in this district, but in the adjoining district to the west (Sheet 153), they consist of dark gray flaggy shales and calcareous sandstone, interstratified with beds of limestone.

d^2. Lower Limestone.—Dark gray regularly bedded limestones, with thin bands of black shale between the beds, occur at the base of this group; to these succeed limestones of various shades of colour, varying from a light gray to dark gray or black. The limestone is sometimes magnesian, and occasionally has an oolitic structure.

d^3. The Calp or Middle Limestone is not distinguishable in this district from the Upper Limestone.

d^4. The upper part of the Carboniferous Limestone consists of light gray and bluish gray, crystalline, sometimes thick bedded, limestone, the uppermost beds containing nodules and layers of white and black chert. The thickness of the Carboniferous Limestone in this district is apparently not far short of 3,000 feet, 800 or 1,000 of which may be assigned to the Upper portion.

d^5. Coal Measures.—Black shales form the base of the Coal Measures in this district, over which come a few grit bands, which are succeeded by a series of dark gray, nodular, rusty, splintery shales. To these succeed a series of flags and grit beds underlying more black shale. The thickness of the Coal Measures within the limits of this map is about 1,000 feet.

Igneous Rocks.—The igneous rocks of this district are very various in apparent lithological character. Perhaps one of the commonest varieties is a dark greenish or dark purple trap, at times very compact, occasionally, however, becoming vesicular, and sometimes amygdaloidal, and frequently containing dispersed crystals of felspar. Where amygdaloidal, the vesicles were, in some cases, found to be filled with calcareous spar. Many varieties of a reddish or brownish trap also occur, which usually has a reddish purple base, and is sometimes very compact, containing small dispersed crystals of felspar, at others changing to a coarse granular rock, with large imbedded crystals of reddish felspar.

At Kilteely a compact pale reddish or flesh-coloured trap, which appears to be principally made up of felspar, assumes a columnar structure of great regularity. There are also varieties of a very tough, compact, fine-grained greenish-gray trap, containing specks of iron pyrites, and also of a dull whitish finely crystalline trap, vesicular in places. A fine-grained black rock, apparently a true basalt, or what would in Germany be called melaphyr, was observed south of Ballybrood. At one locality it assumed a rudely columnar structure.

Perhaps one of the best marked varieties is a reddish or brownish rock, in which are distinct crystals of a reddish felspar, associated with quartz and specks of dark green hornblende, thus constituting a true syenite. This, however, is confined to Knockdirk.

Trappean Ashes.—Associated with these traps are bedded rocks, varying from a very coarse, thick-bedded, brecciated conglomerate to a very fine-grained, thin, regularly-bedded calcareous ash. The base of these breccias is usually of a greenish colour, sometimes, however, changing to a purple. This base appears to be made up

of trap debris and calcareous matter; crystals were observed in it, but with their edges worn; it also contains large angular pieces of trap and limestone.

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

The Old Red Sandstone forms the highest ground in the district, which is the northern slope of the Galtee Mountains, rising to over 2,000 feet above the sea; it also forms the upper part of the Slievenamuck range. This rock, however, also forms the comparatively low undulating ridge west of the Limerick Junction station, and a small patch south of Bruff, and another at the N.E. corner of the map.

The undulating ground stretching along the southern margin of the map, south of Galbally, from which some eminences, such as Knockanebrack Hill, rise to over 500 feet, is composed of the Lower Silurian rocks. This formation also shows itself at intervals along a line about half way down the northern slope of the Slievenamuck range

The low rugged hills in the N.W. corner of the map and the isolated hills between Holycross and Cullen are composed of igneous rocks, with some few exceptions, where they are found to be of limestone.

The high, but gently sloping ground about Ballybrood, as well as the still higher ground which forms a buttress against the north slope of Slievenamuck, east of Ballywire House, are composed of Coal Measures.

All the low land surrounding these elevations has, for its underlying rock, the Carboniferous Limestone.

Here, as elsewhere in the South of Ireland, the Old Red Sandstone obviously rests unconformably on the Lower Silurian rocks, while the Carboniferous Limestone and Coal Measures were deposited in conformable succession over the Old Red Sandstone. The unconformability of the Old Red Sandstone on the Lower Silurian proves the existence of a period of disturbance and denudation between the deposition of those two formations. It is clear that, at a later period, since the production of the Coal Measures, another action of disturbance and denudation has prevailed over the district. The disturbance has bent and broken the rocks so as to cause them to assume their present positions, while the denudation has worn them down so as to produce the present surface.

The following may be taken as a sketch of the position the rocks now hold below the surface:—

The Coal Measures about Ballybrood are stratigraphically the highest rocks in the district. From underneath them rise, towards the west, south, and east, limestones associated with contemporaneous trap rocks and ashes. There are some trap rocks that are also intrusive into the Coal Measures. This upper mass of trap dies completely away towards the N.W., but is continuous on the S. and E., in which directions a band of limestone, half a mile wide, rises out from underneath it. This limestone spreads on the N.W. also round the

Ballybrood Coal Measures, where the upper trap is absent. From beneath that limestone there rises another band of trap and ash, sometimes more than a mile in width, and perfectly continuous across the N.W. corner of the map. Thick limestones again rise out towards the south from underneath this, and undulate for three or four miles, lower beds generally cropping out as we proceed towards the S. and E.

Fig. 1.

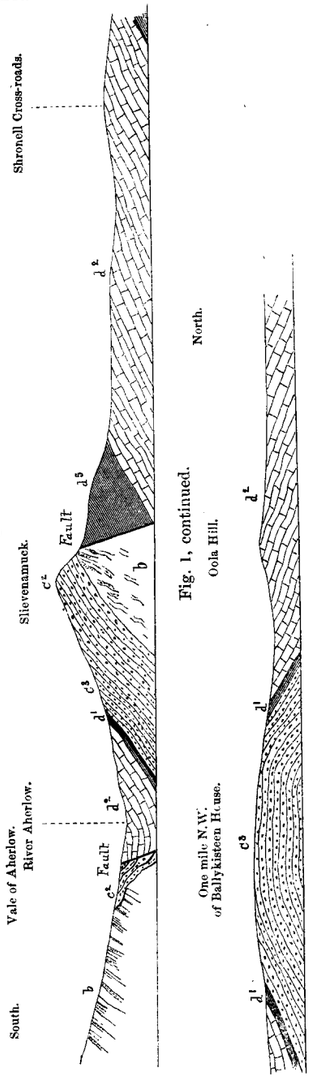

Fig. 1, continued.

Scale—Horizontal, one inch to a mile; Vertical, three inches to one mile.
d^3 Coal Measures. d^2 Carboniferous Limestone. d^1 Lower Limestone Shale. c^4 Upper Old Red Sandstone. c^3 Old Red Sandstone. b Lower Silurian.

The Old Red Sandstone rises out from the limestone at three places, namely—S. of Bruff,—from Emly to near the Limerick Junction,—and at the N.E. corner of the map. Between the lower trap band, however, and the line where the Old Red Sandstone appears, there are five places where igneous rock shows itself in irregular bosses, which are obviously intrusive with respect to the limestone. These may, perhaps, be looked upon as so many foci or orifices through which igneous rock boiled up to the surface and was poured out upon it in sheets, part of which sheets remain in the trappean bands to the northward, while other parts have been removed by denudation from off the area where these foci appear.

The elevations of Old Red Sandstone just spoken of are partial and interrupted, the beds of the Carboniferous Limestone sweeping round them and dipping from them in every direction. South of the line of the Emly ridge a southerly dip is persistent, whenever rock can be seen, to the very foot of the Slievenamuck range, until the top beds of the limestone are brought in and the Coal Measures over them, all dipping steadily

southward over a space of ground four miles in length, south of Mooresfort House and Mount Bruis.

These Coal Measures are suddenly cut off by a great fault, running about E.N.E., and W.S.W. along the northern foot of the Slievenamuck range, where they may be seen in some places in contact with the Old Red sandstone and even with the Lower Silurian rocks (see Fig. 1). The maximum downthrow at such places can hardly be less than 4,500 feet.

The Old Red Sandstone forming the Slievenamuck range likewise dips south, at a mean angle of about 30°, underneath the Carboniferous Limestone of the Vale of Aherlow, where it is apparently brought in contact with the Lower Silurian rocks that lie S. of Galbally, without the appearance of any Old Red Sandstone between them in some places, and with very little in the part traversed by the section.

This has led us to suppose the existence of another great fault running along the south side of the Vale of Aherlow. From this the Old Red Sandstone springs suddenly up to form the northern slopes of the Galtees, on the one hand, and the Slievereagh or Bench Mountains on the other.

J. B. J. and J. O'K.

Detailed Description.

[The principal part of this district was surveyed by Mr. O'Kelly, a small portion of the north-east corner having been examined by Mr. Wynne, and some of the traps by Mr. Kinahan and Mr. O'Kelly conjointly. Mr. O'Kelly has drawn up the following descriptions.—J. B. J.]

4.—*Position and Lie of the Rocks.*

Lower Silurian Rocks.—S. and W. of the village of Galbally the country is covered by a large deposit of drift, which entirely conceals the underlying rocks over a considerable area, and consequently some of the boundaries are obliged to be drawn from very imperfect data. The line of fault, marking the northern boundary of the Silurian, is drawn from data observed E. of the corn-mill south of Riversdale, where the Old Red sandstone disappears, being let down by the fault, and the Silurian and limestone are brought together. south of this line of fault, between Ballingary House and Knockanebrack Hill, the Lower Silurian rocks are very much concealed, and only appear in an occasional quarry. They may be best observed, in this district, east of Knockanebrack Hill, in the stream forming the boundary between the counties of Limerick and Tipperary, where a short continuous section is exposed. Commencing with the lowest rocks observed in this section, west of the corn-mill, we have dark gray fine slate and olive cleaved grits, dipping S. at 40°; over these beds are coarse gray grits, dipping in the same direction, the angle, however, increasing to 60°. Between the bend in the stream and where the road crosses the stream, hard olive-gray micaceous sandstones and dark greenish-gray grit bands, alternating with beds of dark olive and gray slate, are well exposed, the beds being here nearly vertical. The rocks are now concealed for a short distance S. of the road, but shortly appear again, the beds dipping to the S. at from 60° to 80° and striking nearly E. and W., consisting of coarse gray sandstones, alternating with gray and olive slate and

slaty grits and fine-grained grit bands. Some of these rocks are much cleaved, the strike of the cleavage being from E. 10° N. to E. 15° N., and dipping south at 85°. This section is continued beyond the limits of this map, all the rocks included in that portion of the section within the limits of this district being similar to those just described.

Micaceous coarse gray grits occur at the height marked 912, in the stream to the N. of this, and in all the streams near the boundary of the Silurian, slates and sandstones similar to those already described are often exposed, and the strike of the beds appears to be very regular, varying from E. and W. to a little N. of E., and S. of W.

On the bye-road leading S.E. from the town of Galbally, gray and greenish grits, interstratified with dark gray and dark green slates, may be observed in two quarries, the beds striking E. 10° N. and dipping S. 10° E. at 70°; some of these beds are cleaved in the direction of the bedding. Similar rocks, having the same dip and strike as at the last locality, are exposed on the road E. of Lisnagreebe, two miles S.W. of Galbally.

Hard coarse gray and greenish grits, with thin slate bands, may be observed in a quarry south of Ballingarry House, the beds striking W. 10° N. and dipping S. 10° W. at 80°; and similar beds appear in the stream to the W.

The Silurian rocks, which appear on the northern slope of the Slievenamuck range, owing to the great dislocation which traverses the northern base of the range, are well exposed in Garryduff wood. They consist of red and olive brown micaceous sandstones, interstratified with thin bands of dark purple and green slate and fine-grained grits, all dipping in a southerly or south-easterly direction, at from 40° to 60°.

Similar beds may be imperfectly traced for a mile and a-half to the west of Garryduff wood, but it is often difficult to identify them as Silurian owing to the way in which the rocks are fractured along the fault, and the Silurian rocks are here often of a very red colour, and sometimes bear a strong resemblance to the sandstones occurring in the Old Red Sandstone.

A little patch of Silurian is again exposed N. of Galbally. The best exposure of the rocks in this patch of Silurian is on the W. side of the road, where fine dark olive and dark purple grits and slate may be observed dipping S. at 50°.

The Old Red Sandstone.—Resting unconformably on the Silurian rocks, the Old Red sandstone may be well observed along the Slievenamuck range and at the S.E. corner of the district in that portion of the Galtees included in this map. In the Slievenamuck range the beds strike very steadily, the general direction being E. by N., and this strike is constant all along the range, and may be observed from the church W. of Galbally to the hill called "The Steeple" at the eastern end, the dip of the beds being always to the south, varying from 10° to 50°, so that we have the same set of beds frequently shown at various places along the strike, and it will be sufficient to describe a few of the sections where they are best exposed. At Carrigeenina, S. of Ballyglass House, the basal conglomerates are particularly well seen along the top of the range and for some distance down its northern slope, where the ends of the beds crop out, forming small escarpments, which may be followed for two miles to the W., as far as the height marked 1,100. Some of these conglomerates are very coarse and thick bedded, the pebbles being generally quartz, with occasional grit, and rarely jasper; these conglomerates dip S. at angles varying from 20° to 40°, the inclination being greatest due south of Ballyglass. Purple grits, red sandstones alternating with indurated red splintery shales, and thin gray speckled conglomeritic grits, may be well observed in the new road south of Garryduff wood; all these beds dip south at from 45° to 50°. Similar beds may be observed, having the same dip and strike as at the last mentioned locality, at several points S. and E. of "The Steeple." N.W. of Galbally the rocks are seen in

several isolated quarries, but no continuous section is exposed. The beds of red shale, thin red grit bands, and thin conglomerates, forming the Upper Old Red, are well exposed in a ravine N. of the police barrack, at the eastern end of the Slievenamuck range. In this section the first beds we meet are micaceous purple and whitish and gray grits, the latter becoming conglomeritic. To these succeed red and nodular splintery shale and gray and speckled thin grits, dipping south at from 50° to 60°, the beds being at one place vertical and at another appearing to dip north, but this is caused by the tops of the beds being bent over. Some light gray sandstones, thin conglomerates, and red shales are exposed in the new line of road south of Garryduff wood, but may be much better observed in the ravine north of the Roman Catholic Chapel west of Ballynacourty House, where some of the beds of the Upper Old Red sandstone are well seen, consisting of alternations of gray, white, and yellowish grits, with beds of red splintery shale. In the vicinity of Galbally these rocks are seen in several quarries and are similar to those already described.

Owing to the drift which conceals the rocks W. of Galbally the Old Red sandstone is very imperfectly seen, being exposed in very few localities, and the boundaries being consequently very arbitrary. At Doonglara fort the lower conglomerates may be observed appearing at the surface; they appear to be nearly horizontal, with a slight inclination to the W. Conglomeritic gray grits are exposed near the parish boundary, about one mile and a-half W. of the last-mentioned locality. Immediately north of the height marked 661 a quarry is open in which the beds dip north at 65°, and consist of coarse-grained red conglomerates and brecciated-looking beds, with red blotches like fragments of slate. To these beds succeed conglomeritic gray grits and reddish purple speckled thin flaggy grits, with thin bands of red shale. Another quarry may be seen about 300 yards N.E. of Cush cross-roads; in this quarry the beds dip to the west at 20°, consisting of white siliceous sandstones, coarse conglomeritic gray sandstone, alternating with red shales.

On the southern side of the Vale of Aherlow, south of Woodville House, the Upper Old Red is well seen, particularly in the streams N.E. of Knockmoyle. In these streams the beds dip N. at angles varying from 10° to 90°, but the angle of dip is not much to be trusted, as the ends of the beds exposed in these streams are frequently bent and make the inclination of the beds appear much higher than it really is, and occasionally making the beds appear to be reversed. The rocks seen on this side of the Vale of Aherlow are the same as those occurring along the Slievenamuck range, consisting of white sandstones, yellowish mottled grits, thin gray and purple grits, with red shale, and sometimes a thin band of green shale. The lower beds of the Old Red sandstone may be well seen on the height marked 2,109 S. of Knockmoyle, and may be traced thence down the slope of the hill to the N.W. A good continuous section of these is exposed in the brook W. of Knockmoyle, all the beds dipping N. by E. at angles varying from 10° to 40°. They may be again seen about three-quarters of a mile to the W., dipping N. at 20°, and a little to the westward of that were seen in two places in a vertical position. Not a quarter of a mile N. of this the limestone appears in the brook nearly horizontal. The beds of the Old Red sandstone all range down into the flat, and terminate abruptly at a certain line, which is therefore presumed to be a line of fault.

West of the Limerick Junction, the Upper Old Red occupies a considerable area, extending, as seen on the map, from a little W. of the village of Emly to near the Roman Catholic Chapel N. of the Limerick Junction, a distance of seven miles, and varying from a mile in width, at its western extremity, to two miles at its eastern. This tract is thickly covered with limestone drift, which seldom admits of the rocks being seen, but whenever they are exposed they appear to be very nearly horizontal or undulating at low angles, which accounts for this extent of Upper Old Red; it is very

slightly elevated above the limestone plain, forming a long low ridge from which the limestone was denuded, just exposing the uppermost beds of the Old Red. From the very imperfect data occurring round this Upper Old Red its boundary is entirely provisional, and is frequently drawn from the form of the ground or nature of the soil, or other imperfect evidence. The following are the localities where the rocks may be observed in this tract:—In the townland of Ardlaman, W. of Ballykisteen House, a large quarry is open; at the bottom of this quarry we have thick, massive, fine white siliceous grits, over which are micaceous reddish purple flaggy grits, with thin bands of greenish brecciated shale, with pebbles of quartz; some of the grits are very ferruginous.* The beds in this quarry are nearly horizontal, with a slight inclination to the S.E. To the W. of Lady's Well, in the county of Limerick, close to the boundary of the Upper Old Red, white and yellowish sandstones, similar to those occurring at the last mentioned locality, but the quarries are now nearly filled up and have not been worked for some time, so that the rocks are very imperfectly seen. White and dull purplish grits, with thin conglomerates, and occasional purple beds, all nearly horizontal, may be seen in the townland of Ballinilty, half a mile S.W. of the height marked 411. Similar beds may be observed S. of the height marked 581, half-a-mile N.E. of it, and also W. of it, on the S. side of the road a quarter of a mile E. of Ballynacree House. At all these places the bedding is not well defined, but appears to be nearly horizontal. About one mile E. of Emly, on the road leading by Ballynacree House, coarse whitish grits dip S. at 10°. This completes the localities where the Upper Old Red sandstone is exposed in the district.

The two spaces coloured as Upper Old Red on the western side of the map, and at the N.E. corner, are completely covered with drift, and the rocks are not exposed within the limits of this district.

The Lower Limestone.—No good continuous section is exposed in the limestone of this district, and it has been found impossible to divide it except at the N.W. corner, where the limestone occurring above the first bed of contemporaneous trap is considered as Upper Limestone, the boundary being a set of cherty beds lying beneath the trap. These cherty beds are not distinguishable at the southern end of the district, and, consequently, no division is made, and the limestones will be described together.

The North-Eastern part.—Commencing at the N.E. corner of the district, at the height marked 444, E. of Boheratreem cross-roads, hard, thick-bedded, bluish gray limestone, crystalline in texture, is well observed occurring in a small hill, the beds forming a dome on the summit, dipping gently in every direction, but more decidedly to the S.E. In the vicinity of Longford Castle, three miles N.E. of Oola, and at the height marked 256 E. of it, dark gray compact limestone, sometimes thin bedded, and containing shaly bands, is exposed in a few quarries and in the river, the beds dipping at low angles. In the river they dip to the north, and at the height of 256 to the south at 5°.

The neighbourhood of Oola.—The limestone is well exposed at Oola Hill, cropping out in many places; it is dark bluish gray, thick bedded, often very crinoidal, sometimes containing dark earthy fœtid beds and bands of black shale; fossils occur abundantly in these beds: the general dip is N., at from 5° to 15°; the beds, however, undulate, at times becoming nearly flat for short spaces. N.W. of Oola, on either side of the road along which the parish boundary runs, the limestone frequently appears at the surface; it dips to the north at from 5° to 10°, and is light bluish gray, thick bedded. Similar limestone is seen south of the grave yard and in a small hill S.W. of the last locality at Rathaleen. The limestone is also well seen at Derk and in several

* Very excellent building stone is to be had in this quarry; blocks can be obtained 35 feet long by 10 feet wide, and the stone is easily worked.

places along the trap boundary, the beds all dipping towards the trap at angles varying from 10° to 20°. The cherty beds are well seen at Derk, in a quarry nearest the trap boundary south of Barna, and also in a quarry close to the trap on the north side of the road north of the railway.

Pale gray massive limestone, without bedding, occurs N.E. and S. of Newtown House, two miles W. of Oola; fossils are very abundant at the latter locality. Dark bluish, gray, highly crystalline limestone, containing dark earthy impure beds, and thin beds of black shale, may be observed south of Ballyfirreen House, where the county boundary forms an angle. A short distance east of the angle the beds dip S.E. at 5°, and west of the angle the dip is W. at 5°; fossils occur very abundantly in these beds. Similar limestones may be seen in the vicinity of Rathard, a mile farther S.W., the dip being N.W. at from 10° to 15°. A small, abrupt, craggy knob of rock occurs at the height marked 520, north of Ballyneety House. The lowest beds seen here consist of hard, compact, blue limestone, resting on which we have massive, coarsely crystalline, crinoidal, pale gray limestone, in which the stratification is not apparent; the lower beds dip N.W. at 35°. Bluish gray, hard, thick-bedded, crystalline limestone, dipping E. at 5°, is exposed in some quarries east and west of Knockaunavoher. Similar limestone is well seen in the hill west of the village of Cullen, the beds dipping to the N.E. at low angles.

North of Ballynacree House the rocks are entirely concealed by drift, and only two quarries appear in the area, extending from the village of Cullen to the Drumcomoge River, and along the county boundary by Ballynaveen bridge, to Knockaunavoher. One of these quarries lies half a mile N.E. of Ballynaveen bridge, at the angle in the county boundary. The bedding in this quarry appears to be nearly horizontal, and the limestone is gray in colour. The other quarry occurs three quarters of a mile S.W. of Knockaunavoher, and is in hard, blue, crystalline limestone, dipping N.E. at 5°.

The neighbourhood of Hospital, Lough Gur, and Bruff.—About Cromwell's Hill, a mile S.W. of Kilteely, particularly on the south side of the trap, the limestone forms low rugged hills occasionally cut up by ravines, in which the rocks may be well examined, the beds dipping N. by W. at from 15° to 25°. The limestone occurring here is blue, or dark bluish gray, crystalline, fetid, and frequently very fossiliferous; it has a weathered appearance, occasionally weathering in lines parallel to the bedding, and also containing thin bands of black shale. The limestone seen at the junction of the trap appears to be very slightly altered, being harder and more compact.

Pale gray, crystalline, massive limestone, dipping N. at 20°, may be seen near Cool House, one mile S.E. of Kilteely. Similar limestone is exposed a mile and a quarter to the E. of the last-mentioned locality, but may be better observed S. of St. James's Well, where the rocks often appear at the surface. Proceeding farther S., towards the trap at Barnanenagh fort, a mile N. of Hospital, the limestone becomes darker in colour and much more regularly bedded, also containing bands of black shale and sometimes nodules of chert. These cherty, shaly beds are well seen where the parish boundary between Ballynamona River and Cromwell's Hill crosses the road; they undulate, with a general dip to the N. of about 10°. Similar beds occur in the vicinity of Quarryfield Cottage, two miles N.W. of Hospital, some of the beds being almost entirely made up of chert. In a quarry 300 yards S.W. of the cottage a bed of red marble, about one foot thick, was observed. Proceeding along the road towards Herbertstown the limestone becomes massive, pale gray in colour, crystalline, and the stratification is no longer visible until we arrive at a quarry immediately beneath the trap S. of Herbertstown, where the dip is N.E. at 10°. In the neighbourhood of Lough Gur and Roundhill Cottage the limestone forms very picturesque low, craggy hills, the limestone frequently cropping out in the slopes of the hills or in ravines. No great

thickness of beds can be examined here, as the beds undulate at low angles, the same beds spreading over a large area. Some of this limestone is massive, pale gray in colour, and crystalline in texture. This limestone appears to lie beneath a set of very cherty beds, which lie immediately beneath the trap. These cherty limestones are well seen at Grange Hill, three miles N. of Bruff, and between Lough Gur Castle and Black Castle. At the latter place the beds roll at low angles, sometimes dipping N. and sometimes S.

On the road between Bruff and Holycross, two miles N. of Bruff, the limestone is exposed in several quarries, and varies from pale gray, massive, in which the bedding is not perceptible, to compact, dark gray, cherty limestone. Owing to the want of sufficient data it is impossible to make any division in these beds, or to say how they lie with regard to each other. Massive gray limestone may be seen in the river at Bruff and at Prospect Hill. At Bruff the beds are nearly horizontal. In the low ground S.W. of Knockdirk, on the south side of the road, a quarry is open in which dark gray limestone, with black shale partings, is seen, the beds being nearly horizontal. This is the nearest limestone to the trap forming Knockdirk Hill. At Kilcullane House the limestone is pale gray and massive. Similar limestone is seen on the road half a mile S. of Kilcullane.

West of the village of Knockainy the limestone forms a low hill, the highest point on which is 537 feet above the sea; this hill extends from the village of Knockainy to the plantation E. of Kilballyowen House. On the southern slope, north of the road leading to Bruff, the rocks are well exposed and extensively quarried; the beds dip S. at angles varying from 10° to 25°, the angle diminishing as we ascend the hill. The limestone is hard, thick-bedded, compactly crystalline, of a blue or bluish-gray colour; some of the highest beds are flaggy, containing thin layers and nodules of chert. At Knockainy the beds are very flat, having a slight inclination to the east, and the same beds may be traced in several quarries round the northern side of the hill, dipping to the north at low angles. Fossils occur very abundantly in these beds.

Limestone, similar in character to that of Knockainy, is seen east of Castle Farm, also where the two roads join north of Hospital and 500 yards east of Ahnageeragh bridge.

Blue and bluish gray limestone is also seen in a large quarry immediately south of the village of Hospital, the beds inclining to the south at a very low angle. Similar beds may be observed at the height marked 331, north of Rathanny House.

The south-western portion.—In the south-western corner of the district the underlying rocks appear in very few localities, being entirely concealed by limestone drift, often over many square miles of country.

The following are the localities where the limestone rock is exposed in this extremity of the district:—At Bulgaden Hall; S.E. of Elton cross-roads; at the old castle S. of Ballynahinch Bridge, which is two miles S.E. of Elton cross-roads; at Knocklong, and Knockareen, two miles S. of Emly, and Gleneefy, two miles N.W. of Galbally. The limestone seen at Bulgaden Hall is blue and light bluish gray, crystalline, some of the beds being flaggy, with shaly bands, the top beds of the quarry being highly fossiliferous, the dip being S.W. at 8°. Gray and pale bluish gray limestone is also exposed in a quarry three-quarters of a mile W.N.W. of Bulgaden Hall and W. of Bulgaden Castle. The limestone is very imperfectly seen south of Elton cross-roads; it is pale gray, magnesian in places, and containing small dikes of dolomite. At the old castle south of Ballynahinch Bridge bluish-gray coarsely crystalline limestone may be observed; the stratification is not very clear, but it appears to be horizontal. Similar limestone, but containing a little chert, is seen near St. Mohna's Well, two miles south of Elton cross-roads. The limestone at Knocklong forms a small hill; it is pale gray or light

bluish gray, very fossiliferous, with strings of carbonate of lime. Compact dark gray limestone, with one bed of shale and thick-bedded crystalline gray limestone, dipping south at from 30° to 35°, may be observed at Clogher Hill, a mile east of Knocklong, and half a mile east of it. At Knockareen we have pale gray and bluish gray flaky limestone, with nodules of chert, dipping beneath flaggy, dark gray, concretionary, shaly, cherty beds. These beds appear to be magnesian in places; they all dip south, at from 10° to 20°. The limestone seen at Gleneefy is massive, gray, with veins of carbonate of lime; the bedding is not apparent in it, nor do fossils appear to be very abundant.

The Tipperary part.—Proceeding towards the town of Tipperary the underlying rocks still continue to be concealed by the drift, and can only be observed in an occasional quarry. In all these quarries, wherever the stratification is observed, the beds dip steadily to the south.

Gray cherty limestone is seen near the Coal Measure boundary, east of Ballywire House, dipping S.E. at 10°. Similar beds, but evidently much lower down in the series, form a craggy little hill close to Mooresfort demesne gate-lodge; the highest point on this hill is 545 feet above the sea, the beds dipping south at from 30° to 35°. Compact, hard, thick-bedded, bluish gray limestone is exposed in a quarry half a mile to the south of the last-mentioned locality. A short continuous section of the lower beds of the limestone is seen in a few quarries at Shronell cross-roads. The lowest beds here are thick-bedded, bluish gray, crystalline, very fossiliferous limestone, to which succeed similar limestones, with thin bands of shale, and higher up again we have hard, dark gray, impure-looking limestone, with bands of black shale between the beds. The beds of limestone vary from about two to three feet thick, and are regularly divided by beds of shale about six inches in thickness. These beds are well seen in a quarry immediately north of the church, and on the south side of the road the highest rocks in the section may be observed, consisting of bluish gray compact limestone; in this section the beds all dip south, at angles varying from 10° to 15°.

East of Ballynilard Cottage, two miles S.W. of Tipperary, at the height marked 439, the limestone is extensively quarried. The lowest beds are seen south of the height 439, and consist of thick-bedded, pale, bluish gray, rather compact limestone, strongly oolitic in places. North of the height 439 the limestone is pale gray and dark bluish gray, thick-bedded, with thin bands of black shale. Fossils occur abundantly in the latter beds. The dip is here 15° south by east. Massive bluish gray limestone is seen on the south side of the road, south of Mount Bruis, and at Ardloman Court; at neither of these localities is the stratification visible.

One mile north of Ardloman Court, which is three miles S.W. of Tipperary, dark gray and bluish gray compact limestone, with large nodules of chert, may be observed dipping south at from 10° to 15°. Massive pale gray crystalline limestone is seen in a quarry a quarter of a mile W. of Breansha Castle, two miles S.W. of Tipperary. At Cordangan House, two miles S.E. of Tipperary, gray and bluish gray limestone, with nodules of chert, dips S. at 30°.

The Vale of Aherlow.—In the Vale of Aherlow the limestone occupies a narrow band, resting in the synclinal between the Galtees and the Slievenamuck range. This synclinal is broken through at the south-western end of the vale by the branch fault from the Slievenamuck dislocation, and the limestone is let down against the Silurian rocks. At Galbally several quarries are exposed, and the general character of the limestone is dark gray, crystalline, with occasional impure earthy beds, containing chert, and separated by thin beds of black shale; all these beds are very fossiliferous, and are the lowest beds of the carboniferous limestone, the beds all dipping south towards the fault. At Moore Abbey the angle is 35°, and at the south side of Galbally Bridge not more than 10°, but a little south of the height marked 383 the

dip is S.E. at 40°, and in the river immediately south of the village, in the same direction, at 10°.

Dark bluish gray, coarsely crystalline limestone may be observed dipping south at 35°, west of Galty Lodge, two miles east of Galbally; south of the same locality, bluish gray, massive, crystalline limestone, full of encrinites, fenestella, and other fossils, occurs, the bedding being apparently vertical. Between Janeville and Riversdale dark bluish gray and blue, rather compact limestone, with thin bands of shale, may be observed dipping S.S.W. at 50°. Very cherty, dark gray, impure, earthy limestone, the beds being nearly horizontal, is seen at the bend in the river, south of the height marked 345. Three hundred yards N.E. of the Roman Catholic chapel, W. of Ballinacourty House, massive gray limestone, without bedding, is exposed in a quarry; limestone is also said to have been raised at the Roman Catholic Chapel, and east of Ballynacourty House, but the quarries are now filled up.

Proceeding to the east the limestone is only seen at two more localities on the northern side of the River Aherlow: first, on the bye-road leading to the river south of the Police barrack, where dark bluish gray crystalline limestone, with some impure earthy beds, all very much cut up with joints, may be observed dipping south at 15°. The next place where the limestone is seen, is where the bye-road leading from the E. of the Steeple joins the main road; it is bluish, hard, massive, crystalline limestone, and dips S.E. at 15°. On the south side of the river the limestone is only exposed in a few localities, and may be seen near the Police barrack, which lies S.E. of Woodville House, close to the Lower Limestone shale boundary. The beds seen here are very like the crinoidal beds just above the Lower Limestone shale in the counties of Waterford and Kilkenny; they consist of dark bluish gray crystalline limestone, with thin partings of black shale; the dip is to the north at 75°. Similar beds may be seen about one mile to the east, dipping north at 45°. South of Woodville House, in the brook, some beds of dark gray and black shaly limestone occur, dipping south at 40°.

The Upper Limestone.—The division of the limestones in this district is very imperfect, and the Upper Limestone has only been separated at the N.W. corner of the district, the boundary being, as before-mentioned, a set of cherty beds immediately beneath the first bed of contemporaneous trap, and all the limestone occurring above this band of trap is considered to be Upper Limestone.

Between Sixmilebridge and Friarstown, and north of Caherelly Castle, the rocks are completely concealed by drift. South of Caherelly Cottage dark blue limestone, sometimes slightly oolitic, may be observed, the beds undulating, dipping north at from 5° to 15° south of Caherelly Cottage, and S.E. and N.W. on the hill at the height marked on the map 398. S.E. of Ballingoola Glebe House, between the trap and the alluvial flat, the limestone may be well observed, dipping N.E. at from 15° to 20°; it is thick-bedded, dark blue limestone; west of the church it is light bluish gray, and strongly oolitic; some of the beds immediately resting on the trap are ashy and partly made up of trap debris. Similar limestones are seen north of Herbertstown. At Black Castle, bluish gray limestone is exposed in a quarry, the beds dipping south at 40°, and resting on thin beds of green trappean ash. Owing to the want of exposure of rock, it is impossible to trace out this bed of ash. Light gray magnesian limestone, in which the bedding is not perceptible, may be observed about one mile E. by N. of the last-mentioned locality. West of Ballybrood Rectory, along the Coal Measure boundary, bluish gray limestone is seen in some quarries, the beds dipping towards the Coal Measures at from 10° to 15°.

On the road about half a mile south-west of Crossalaghta, limestone is exposed, and may be observed dipping beneath the ash at a very low angle; it is hard, thick-bedded, dark blue limestone. About a quarter of a mile to the south similar limestone occurs, but containing some thin beds, with chert. Light bluish gray crystalline limestone is seen in the townland of Coologe, near the trap boundary, and about three quarters of a mile west of Pallasmoate; similar limestone is seen at the Glebe-house, north of Pallasgrean, dipping west at 10°.

Coal Measures.—These rocks occur in two localities in this district; but in neither do they occupy any considerable extent of country, or ever attain a sufficient thickness to justify trials in search of coal.

The Ballybrood Coal Measures.—We shall first proceed to describe the rocks of this formation, forming the gently undulating table-land in the neighbourhood of Ballybrood, and which extend into the adjoining sheet to the north (No. 144). An alluvial flat stretching into the Coal Measures occurring within the limits of this district, entirely conceals the rocks over a considerable area.

The lower shales, next the limestone, may be observed in the stream 500 yards west of Ballybrood Rectory; they consist of black and dark gray earthy shales, which dip north at 45°. Similar shales, but nearly horizontal, may be seen on the same side of the road, near where the boundary of the Coal Measures curves round to the east. On the east side of the road, south of Mountminnett House, these rocks may be observed here and there in a few quarries, the beds dipping to the north at from 40° to 50°. A few thin grit beds occasionally occur in the shales. To the east of the alluvial flat the Coal Measures are very imperfectly seen, being covered with drift, with some exceptions, where the edges of the shales appear at the surface; consequently, the eastern boundary of the Coal Measures is, in a great measure, provisional.

The rocks are exposed in one quarry, at the fort on the western side of the road, leading north from Crossalaghta. In this quarry the beds dip south at 30°, and consist of olive gray flags, very much cut up with joints. Dark olive gray splintery shale, very gritty, in which the stratification is obscure, may also be observed about one mile west of the last locality. The debris of dark earthy shales, and occasionally the shales themselves, appear in a few places on the bye-road, extending from the adjoining sheet on the north, and in the stream east of it.

On the hill top, half a mile S. of Ballybrood Rectory, the Coal Measures are traversed by a narrow band of apparently intrusive trap. The shales are well seen on the road, close to the boundary of this band of trap, and are finely laminated dark gray beds, appearing to dip north at a high angle; but, as only a small portion of the tops of the beds are exposed, this dip may be deceptive and only be the top of the beds which are bent over, causing the dip to appear north, whereas, in reality, the beds are vertical, or dipping south.

Dark gray gritty shales may be observed dipping east at 20°, where the road forms an angle turning towards the west. Similar beds are seen near the parish boundary to the west, and along the parish boundary leading to the alluvial flat, in every case the beds dipping from the trap towards the centre of this patch of Coal Measures. The shales observed nearest the trap appear to be but slightly if at all altered by it.

The Slievenamuck Coal Measures.—The Coal Measures occurring south-west of the town of Tipperary form a long narrow band, a little more than half a mile wide, and extend from the south of Gleneefy to about half a mile west of Ardloman Court, where they are cut off by a north and south fault. They form a distinct swell in the ground along this part of the northern foot of the ridge of Slievenamuck.

Much better sections of these rocks are exposed here than at Ballybrood, and they also attain a greater thickness; the strike of the beds is very steady, being generally a little north of east and south of west, and dipping S. at from 10° to 50°. The rocks are exposed in all the streams east and south of the Police station. They consist of dark gray splintery and nodular shales, with

occasional thin olive-gray and gray grits, at the base, and for about 600 feet above the limestone; above these beds we have hard light blue and gray siliceous grits and thin flags; these beds are very well seen in large quarries, about 700 yards south of the Police station, and may be traced east and west in lines of quarries which are worked for the flags, which are sold at from 2½*d.* to 3*d.* per superficial foot.* This flag series is about 200 feet in thickness. The highest beds occurring here may be well observed north of where Slievenamuck is marked on the map, they consist of splintery olive, gray, dark gray, and black carbonaceous shales, with a few grit beds—a very thin bed of culm occurs in the black shale, but too thin to be of any value. Fossils are found in these upper beds, and annelid tracks are common on the flags. The Coal Measures are at least 1,000 feet thick in the section east of the Police station.

At the western end of this patch of Coal Measures several quarries may be observed north of the height marked 806. The rocks occurring in these quarries being a continuation of the beds before spoken of, need no further description.

The Lower Trap-band passing by Lough Gur, Herbertstown, Kilteely, and Derk.

Under this heading we shall include a small portion of the adjoining district (Sheet 153), in the vicinity of Skool Hill and the Grange.

If we proceed to Skool Hill, which lies about one mile north by west of Sixmilebridge, we shall observe dark blue and cherty gray limestone, dipping to the S.E., at from 50° to 60°. A thin bed of fine-grained calcareous blue ash, about two feet thick, occurs in this limestone; it is best seen about one hundred yards south of the school-house. Over this bed of ash are about sixty or seventy feet of limestone, when light bluish, fine-grained calcareous ash again appears, dipping conformably with the limestone, and, if we proceed to the east, along the old road, limestone no longer is visible, but a hard, compact, conglomeritic green ash may be observed at the corner of the wood and a little east of it. The fine calcareous blue ash, seen resting on the limestone, may be traced for about one-third of a mile to the N.E., along the strike of the limestone, where it appears to thin out to the north. Gray limestone occurs in the ash and may be seen three hundred yards south of the height marked 425, dipping S.E. at 50°. This limestone appears to form a wedge-shaped mass in the ash, thinning out to the S.W. near the old road, and thickening to the N.E. with the ash thinning out on either side. Dark blue compact trap is exposed in the deep drain, a little south of the gate lodge, at the entrance to the Grange; it is the only place the trap is well seen here, owing to the drift, which completely conceals the rocks for a considerable distance to the east. The ash is also very imperfectly seen, being only exposed in a few places.

* Immediately over the place where the word Slievenamuck is engraved on the map, the Coal Measure shales may in some of the small gullies be seen dipping directly at and abutting against the blue Lower Silurian slate rocks, over which may be seen, a little higher up the hill, the base of the Old Red sandstone resting on the upturned and denuded edges of the Lower Silurian rocks; and crossing over the hill to the S. the rest of the Old Red sandstone may be seen at intervals, always dipping S., and finally plunging under the *bottom* of the Carboniferous limestone in the Vale of Aherlow. If on the other hand, we walk from the line of fault down the hill towards the north, we get a long steady section, showing from 700 to 1,000 feet of Coal Measures, from under which the top of the Carboniferous limestone crops out in the plain of Tipperary. I do not know anywhere in the world so enormous a dislocation so clearly and indubitably shown, or so marked out to the eye by changes in the features of the ground consequent upon it. These features always puzzled me when travelling by railway in the neighbourhood, from the strange and unnatural aspect, before Mr. O'Kelly had examined the ground and discovered the reason of them in this grand dislocation of the rocks, which cannot be less than between 4,000 and 5,000 feet in amount.—J. B. J.

To the south-west of Skool Hill the rocks are concealed by the large bog which occurs here, and do not again appear till we arrive at a small elevation in the bog, about one mile and a-half to the south, where green ash again appears, dipping east at about 15°; the underlying limestone is seen a little west of the ash. We again lose sight of the rocks for a short distance till we arrive in the vicinity of Grange and Lough Gur, where the limestone, ash, and trap are particularly well exposed, and are without doubt a continuation of the ash and trap observed at Skool Hill.

North of Lough Gur the limestone forms picturesque hills, some of which attain an altitude of over 500 feet. It is similar in character to that occurring in Skool Hill, no doubt being the same beds coming to the surface. The direction of the dip is here from north to north-east at from 15° to 20°.

If now we proceed along the old road from Grange towards Sixmilebridge, we first meet with dark gray crystalline and cherty gray limestone well exposed on the east side of the road, the beds dipping north-east at from 15° to 20°. If we continue for a short distance the limestone disappears, and we come on beds of trappean ash, having the same dip and strike as the limestone, but curving round as we proceed to the north, and dipping about E. 15° N. These beds consist of coarse brecciated green ash, the paste being of a greenish colour, and made up of trap, debris, and calcareous matter. In this paste are large angular pieces of limestone and trap. Some of these beds of ash are full of large cavities formed by the decomposition of calcareous matter. The ash next the limestone is thin-bedded, fine-grained, and sometimes very calcareous. Between the old and new road, about half a mile north of Grange, the ash is sometimes traversed by a regular system of joints, striking about north-east and south-west, and nearly vertical. These joints give the ash at this locality a rudely columnar appearance. The thickness of the ash in this section, from where it is first observed above the limestone to the solid trap, appears to be at least 350 feet.

The junction of the ash and trap is seen about half a mile south-west of Sixmilebridge (on Sheet 153). Between the decided solid trap and the ash is a vesicular, brecciated-looking mass of trap, which may possibly have been the base of a flow of lava. A little north of this last-mentioned locality the trap is very well exposed. It is usually of a dark bluish green or dark purple colour, sometimes very compact, at others vesicular and amygdaloidal, and generally containing embedded crystals of felspar. A solid band of trap was observed about one-third of a mile S.W. of Sixmilebridge, between a vesicular bed above and a broken brecciated looking mass below, as if another flow of lava had occurred here. This band of solid trap is about twenty feet thick. Trap is exposed at Sixmilebridge and on the old road leading south; and between this road and the alluvial flat to the east it is exposed in many occasional spots, and is similar in character to that just described.

The ash so well exposed at Grange may be traced along the southern boundary of the trap towards Herbertstown, but evidently thinning out as we go eastward, a section observed N.E. of Lough Gur Castle only giving a thickness of about eighty feet.

The junction of the ash and limestone is exposed in a quarry on the roadside about 550 yards north-east of Lough Gur Castle, where the following section was procured:—

Section of Quarry in the townland of Lough Gur, north-east of Castle.

	Ft.	In.
Cherty limestone, over	20	0
Decomposed green ash,	2	6
Bluish, green, calcareous, laminated ash,	4	0
Limestone, slightly ashy,	1	8

	Ft.	In.
Green ash,	0	2
Fine-grained, decomposed, ash,	0	4
Green ash, obliquely laminated,	1	7
Fine laminated ash,	0	8
Green compact ash,	1	8
Obliquely laminated, shaly ash,	0	10
Concretionary calcareous, ashy, limestone,	1	4
Compact ashy limestone,	2	0
Green shaly ash, very much weathered,	0	5
Ashy limestone,	0	7
Compact green ash, over	4	0
	41	9

On the east side of the road, near the last mentioned locality, thick, coarse, indurated beds of purple ash may be seen dipping at a low angle to the east. Some of these beds have a concretionary spheroidal structure, and often contain nodules of limestone. Where the ash is observed next the trap it appeared to be very much indurated, and immediately under the trap it is a compact fine-grained grit-like rock. Dark purplish trap, frequently amygdaloidal and porphyritic, is seen along the ash boundary as far as the alluvial flat to the west. South-east of Ballingoola Glebe House, a little west of the height marked on the map 399, vesicular ashy-looking brecciated trap is seen, which may possibly have been the top or bottom of a flow of lava. A solid compact dark purple trap appears above it, on which the limestone rests, dipping to the north at 15°, and the limestone continues to be well exposed along the northern boundary of the trap to the church, and is frequently seen in close proximity to the trap, the beds dipping north at from 15° to 20°. The limestone is regularly bedded, of a dark bluish gray or light bluish gray colour, oolitic in places.

North of Roundhill Cottage the trap often appears at the surface, forming knobs and hillocks of rock. It is also well seen in a cutting on the road half a mile west of Cloghansoun Bridge. It is here very porphyritic, containing crystals of dull whitish felspar. It is much cut up by irregular joints, and on the north side of the road there is a good example of slickenside in the trap.

Purple ash is seen 400 yards north-west of Roundhill Cottage, but is not well exposed, being visible only in a few spots; it dips N.W. at 15°. As we proceed to the east from this last locality the ash is not again visible till we arrive on the road south of the village of Herbertstown, where it is again imperfectly seen, so that the stratification could not be determined. To the south of this is an outlying mass of ash. It is well seen at the surface on the east side of the road; but as no quarry or cutting has been opened in it, the stratification could not be determined. It is traceable on the eastern side as far as the bog. It is a brecciated mass, containing large rounded pieces of limestone and trap. Limestone is well seen north of this outlying ash; it dips north-east at 10°. In this limestone is a small intrusive trap dike about two feet wide; it strikes E. 15° N., and dips S. 15° E. at 60°.

The trap is exposed in many places in the vicinity of Herbertstown, and is well seen at the village. It is very similar in character to that occurring to the west, being sometimes vesicular and amygdaloidal, and at others porphyritic. The overlying limestone is also well exposed north of the village, almost in contact with the trap, and is similar to that seen resting on the trap to the west, and before described, only it here inclines to the north at a higher angle.

East of Herbertstown the trap does not make much feature in the form of the ground, nor are the rocks so well exposed, being very much covered with drift; they may, however, be observed at the old church and in the stream east of it. West of St. Bridget's Well it again appears, and is well seen,

forming several knolls and hummocks of rock. It is here a very tough bluish gray or purple trap, containing crystals of felspar.

Limestone is seen in close proximity to the trap on its southern boundary, about half a mile west of St. Bridget's Well; it dips north at 35°. No ash is visible between this limestone and the trap, so that it probably thins out altogether, and the trap rests directly on the limestone; or a very thin band of ash may possibly exist, but as none has been observed along this portion of the trap, we have arrived at the former conclusion, and omitted the ash on the map. Limestone is seen in a quarry half a mile north of the last-mentioned locality, near the northern boundary of the trap, dipping north at 15°.

At Kilteely, particularly on the south side of the hill, the trap is very well exposed. It here forms columns of great regularity,* which gradually disappear on the north side of the hill. The trap is here of a pale reddish colour, very compact, containing crystals of red felspar. North of Kilteely it becomes coarsely granular.†

In the vicinity of Rathfooroge good exposures of the trap occur. It is generally of a purplish gray colour, sometimes changing to a speckled flesh-coloured striated-looking trap; the latter variety is also seen in the bye-road north-west of Rathfooroge. Some of the trap is very much weathered, which often gives it the appearance of an ash.

Beds of ash occur in the trap east of Rathfooroge; but, owing to the want of sufficient exposures, the boundaries of these beds of ash, as marked on the map, are entirely provisional; they may possibly extend farther, or perhaps not even so far as represented. The long lenticular bed of ash nearest Rathfooroge is best seen 600 yards N.E. of the height 681. It is of a greenish colour, sometimes rather compact, at others, brecciated, containing angular fragments of trap. There are also some beds of compact purple ash associated with the green ash. These beds dip south at 15°.

The two lenticular beds of ash marked on the map west of Derk, consist of coarse purple ash. In one place it is regularly bedded, inclining to the west at 15°.

The trap is very well exposed on Derk Hill; sometimes it is a compact reddish felspathic-looking rock, at others, a greenish gray porphyritic rock, the embedded crystals being felspar. Trap is well exposed north of Derk Hill, appearing in many places up to the limestone boundary, where the trap and limestone are seen in the townland of Coologe within 100 yards of each other, near some farm buildings. This is the last locality where the trap and limestone are visible near each other along the northern boundary of the trap. The trap does not make much feature in the form of the ground north-east of Derk Hill; and, owing to the drift which here occurs, it is not so well exposed as to the west. However, it may be seen in several places on the road leading north from Barna, and in occasional places east and west of it.

The ash marked on the map north-east of Pallasgrean is not anywhere exposed within the limits of this district; but it is well seen in the adjoining Sheet (144).

It probably thins out, as no beds of ash have been met with overlying the trap as we proceed along its boundary towards Sixmilebridge.

Green ash is seen dipping beneath the trap at Derk and Barna; but it is evidently only a thin band. It is also visible in the railway cutting north of the height marked 298, and cherty limestone is well seen at Derk, below its horizon.

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* See Dr. Apjohn's Observations on a Trap District in the County of Limerick, Vol. I., Part 1, *Journal of the Geological Society of Dublin*, page 33.

† The actual thickness of the Lower Trap-band at Kilteely, between the limestones above and below it, seems to be not less than 1,000 feet. (See engraved sheets of sections, sheets 7 and 8.)

The Upper Trap-band about Rathjordan, Crossalaghta, and Pallas.

The igneous rocks occurring in this district are of a much newer date than those to the south, a considerable lapse of time having intervened between their eruptions, during which the thousand feet of limestone separating the two bands of contemporaneous trap was deposited. This upper band of contemporaneous trap was erupted near the close of the period in which the Carboniferous limestone was deposited, as the Coal Measures are principally deposited directly on the trap. (See engraved sections, sheets 7 & 8.)

Fig. 2.
Diagrammatic Section from Knockdirk Hill to Ballybrood.

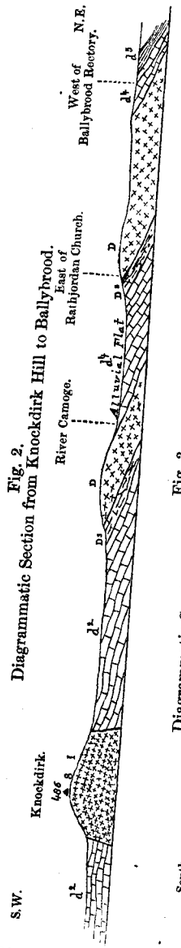
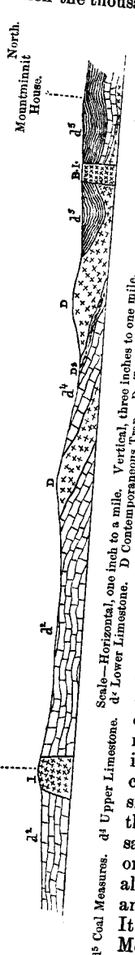


Fig. 3.
Diagrammatic Section from near Castlefarm to Mountminnet House.



Dark blue and bluish gray limestone, slightly oolitic and magnesian in places may be well observed half a mile south-east of Rathjordan old church; it dips north-east at from 20° to 30°. Above this limestone, dipping north at about 30°, flaggy and shaly thin-bedded purple ash may be seen 200 yards south of the same old church. This ash dips beneath dark green and purple trap, well exposed in the vicinity of the old church. The trap is sometimes a very fine amygdaloid, again changing to a very compact dark purple trap, sometimes having a concretionary spheroidal structure. There is also another variety which is local, only occurring in a few places. It is a very compact, fine-grained blackish trap, and appears to be a true basalt.* The narrow band of trap in the Coal Measures south of Ballybrood, belongs to this variety; it appears to be intrusive into the Coal Measures and the contemporaneous trap, being possibly the newest igneous rock in the district (see Fig. 2). This basalt is well exposed in a cutting on the road south of Ballybrood, also at the height marked 378, and east of it, near the alluvial flat. It is seen in contact with the Coal Measure shales, on the south side of the road, west of the height 378.

If we proceed to the west from this, trap is seen in several places near the Coal Measure boundary, and the Coal Measure shales are seen a little to the

* It is what the Germans call "melaphyr," a term which Seuft applies to the basalt or Rowley Rag of the S. Staffordshire coal field. Distinguishing it from basalt is making a distinction without a difference.—J. B. J.

south, near the parish boundary, dipping south at 25°. Trap is also visible along the southern boundary of the Coal Measures, and the shales are seen in several places, dipping north at low angles, evidently having been deposited on the contemporaneous trap, which probably had a very irregular surface, some of it not being covered by the highest beds of limestone, while other parts were so covered, for south-west of Mountminnett House limestone is seen resting on the trap and dipping away from it, at angles ranging from 5° to 10°, under the Coal Measures (see Fig. 3). This limestone thins out to the east and cannot be traced beyond where the basalt appears in the cutting on the road. Basalt again occurs on the road, one-third of a mile east of Rathjordan Church; it is here rudely columnar.

Dark purple trap is seen in several places to the east, as far as the alluvial flat; but its contact with the underlying limestone is not anywhere exposed till we arrive on the road, half a mile S.W. of Crossalaghta, where limestone and ash may be observed in contact in a cutting on the road. The limestone is here hard, massive, and of a light bluish colour; there is not much of it seen, the overlying ash being cut through, exposing a few beds of limestone. The first bed of ash seen in contact with the limestone is finely laminated, hard, compact, thin bedded, of a light bluish colour, and very calcareous; over this is coarse green and purple ash. These beds dip N.E. at a very low angle. The trap marked on the map, south of this, is probably a portion of the upper bed of trap, extending farther south, owing to the flatness of the beds, and the trap forming a very thin irregular bed on the limestone, which here escaped denudation. The narrow band of limestone separating this isolated patch of trap from the upper bed, is drawn from the limestone observed S.W. of Crossalaghta, and, from the form of the ground, the rocks being much concealed by drift, and, consequently, the boundaries in a great measure provisional. Limestone is well seen south of this isolated patch of trap, dipping north at 5°.

Trap is exposed in many places in the vicinity of Crossalaghta, and west of it, as far as the alluvial flat. It is similar to that occurring to the west, being sometimes compact, dark, purple trap, often becoming vesicular and amygdaloidal. A good example of glacial wearing is seen 300 yards west of the height 477, where the rocks are much rounded and the glacial striæ have a nearly north and south direction.

If we proceed to the north-east from Crossalaghta, the rocks are very much concealed by drift, only appearing in two or three places; nor does the trap make much feature till we arrive north of the road, a mile and a-half west of Pallasgrean, where the rocks begin to be very well seen, the trap cropping out in many places in Pallas Hill, and attaining an altitude of 749 feet above the sea. The trap is not seen in contact with the overlying Coal Measures within the limits of this district, and the boundary of the Coal Measures is drawn from the form of the ground.

The underlying ash is seen 200 yards north-west of Pallasgrean. It here consists of a few thin beds of calcareous brecciated ash, and ashy limestone. These beds are cut off to the east by a small fault, "a downthrow to the east," and the beds of ash may be seen abutting against the solid trap. They are not again visible on the eastern side of the fault till we meet them about 600 yards north-east of the fault, where the underlying limestone is also visible. A lenticular bed of gray glistening trap occurs in the limestone north of the Glebe House, and extends into the adjoining Sheet (144).

Oola Hill.—The small patch of ash marked on the map two miles south-east of Oola, is very imperfectly seen, and its boundary is entirely speculative. It forms no feature in the form of the ground, and was only observed on the eastern side of the railway, where the ash was exposed in two places at the surface. It is a very coarse brecciated purple ash, containing fragments of trap and limestone. I was unable to determine the stratification in it.

Intrusive Traps.—The traps forming the low abrupt isolated hills, between the villages of Cullen and Holycross, are all believed to be intrusive. They occur at five localities, namely, Knockdirk, Castle Farm, Cromwell's Hill, Templebredon, and a hill one mile south-west of Cullen. At Knockdirk the trap forms a rugged hill, of a circular form, more than half a mile in diameter, rising very abruptly on its western side to a height of 486 feet above the sea, the surrounding low ground being about 250 feet.

Near the summit of Knockdirk, and on its western and southern slopes, the trap is well exposed, often appearing at the surface, and frequently forming knolls and bosses of rock. It is generally of a reddish or brownish colour, often very deeply weathered to a dull reddish purple; but, in some cases, when the rock was broken, the fracture was of a greenish gray tint, and the rock there resembled a felstone porphyry. The best marked variety on this hill is about 150 yards south-east of the height 486, where distinct crystals of quartz may be observed in the rock, with reddish felspar and small specks of dark green hornblende, thus constituting a true Syenite. No immediate contact of this trap with the limestone is anywhere exposed.

The next intrusive trap occurs about two miles and a-half east of Knockdirk, a little north of Castle Farm House, where it forms a small rugged hill. The rocks are not here so well seen as at Knockdirk, being much concealed by drift; but may be observed at two places: first, on the old road west of Barnanenagh Fort; and, secondly, near the farm houses on the road north of Castle Farm. It is a pale greenish, or sometimes bluish gray, rock, compact, or slightly granular, containing crystals of dull whitish felspar, and full of small specks of iron pyrites. It is slightly vesicular and calcareous, and sometimes contains minute specks of mica.

Cromwell's Hill trap is very similar to that occurring at Castle Farm, being a compactly granular, pale greenish rock, with dull whitish crystals of felspar. It is well exposed near the height 585, and west of it, where its immediate contact with the limestone may be seen on the southern boundary. The limestone dips towards the trap at from 15° to 30°, and the beds may be observed abutting against a nearly vertical dyke of trap. Notwithstanding their close proximity to so large a mass of obviously intrusive trap, they seem scarcely at all altered.

The Templebredon trap commences about half a mile east of the termination of the Cromwell's Hill trap, and extends one mile and a-quarter to the east, and is about one quarter of a mile wide. It is a coarsely granular reddish trap, with large embedded crystals of red felspar; where exposed to the atmosphere it is deeply weathered. The junction of this trap with the limestone is not anywhere exposed, but the trap itself may be well seen.

The trap in the hill west of the village of Cullen is a dull reddish rock, containing crystals of red felspar; it also sometimes contains greenish crystals, which appear to be silicate of magnesia.

Trap dykes.—A small intrusive trap dyke, about four feet wide, occurs in the limestone one mile and a-half N.W. of Emly. It strikes E. 5° S., and is vertical. It is only visible in one quarry. It is a compact bluish trap, with specks of iron pyrites.

A similar dyke was observed in a limestone quarry 200 yards N.W. of Shronell cross roads. The limestone here dips south at a low angle, and the trap dyke strikes E. 10° N., dipping north at 85°.

Another small intrusive dyke, about three feet wide, striking east and west, and dipping north at 85°, is seen in a limestone quarry on the Waterford and Limerick Railway, three quarters of a mile S.E. of Oola.

A small vertical dyke, striking E. 10° S., may be seen in a quarry one mile and a-half south of the Graveyard, about a mile N.E. of Castle Lloyd; it is about three feet wide. Two small dykes, varying from six inches to

two feet in width, may be observed in a quarry on the county boundary, about one mile east of Oola Hills Cottage.

5. *Drift.*—All the low ground in this district is, with very few exceptions, covered with drift. It is sometimes very irregularly deposited, large accumulations of it occurring in some localities, where it is heaped up in hillocks and esker-like ridges, the latter, however, not being sufficiently well defined to be traced with accuracy for any distance. It is difficult to estimate what the thickness of the drift may be in some of these places where it occurs in such quantity, concealing the underlying rocks for many square miles; but in all probability it often exceeds 100 feet, while in other localities there is only a very thin covering, sometimes being only a few feet in thickness.

Although the drift is generally confined to the low ground, it is occasionally found at a considerable height on the hills, but never to any great extent, occurring only in small patches.

The general character of the drift is the same as that occurring in the adjacent districts, being either coarse gravel, principally made up of limestone pebbles, or clayey gravel and yellowish clay, containing boulders of limestone and other rocks. Fine sand is also found in some localities. It is often associated with the coarse limestone gravel, either in patches or lenticular masses.

Large masses of drift occur north and east of the town of Tipperary. In one place north of the town the drift forms an esker, which may be traced for some distance north of the town, where it makes a ridge of considerable height above the surrounding low ground. It commences west of the church in the town, extending along by the fever hospital, west of Springville Cottage, where it curves round to the east as far as the height marked on the map 429. Here the esker curves round to the N.W., and is soon lost in the undulations which here occur in the drift, and continue on by Pegsborough House towards Boheratreem cross roads.

The esker varies from twenty to fifty feet above the adjacent low ground. It is rather irregular in form, sometimes being narrow and again spreading out to a considerable width. Some good sections of the drift are exposed in it, and they are found to consist of coarse gravel and sand. The gravel is principally made up of limestone debris, but pebbles of sandstone, trap, and other rocks also occur in it. Some limestone boulders, from three to four feet in diameter, were observed in the gravel near the top of the esker.

East of the town of Tipperary great mounds and hillocks of drift occur, forming very sharp undulations in the form of the ground. The Waterford and Limerick Railway cuts through this drift in many places, and good exposures of it may be observed. It is very similar to that occurring in the esker at Tipperary, only, perhaps, a little more clayey. But the limestone pebbles also preponderate here, and they are generally very much water-worn. Patches of fine sand also occur here.

At the village of Galbally the limestone drift contains many sandstone and grit pebbles. To the west of Galbally the drift is a kind of yellowish clayey gravel. It often contains large angular blocks of limestone, but does not contain so many limestone pebbles as the drift in the centre of the district. The drift over the remainder of the district included in this map is very similar to that already described. It varies slightly in some localities; but, on the whole, may be considered as limestone gravel.

The drift occurring on the southern slope of the Slievenamuck range, as also on the opposite side of the Glen of Aherlow, and on the northern slopes of the Galtees, may be considered as derived from the subjacent rock. It is very local and of a very red colour, and does not often contain rounded pebbles. Limestone pebbles are seldom met with in it.

6. *Minerals.*—Lead, copper, iron, barytes, and a trace of zinc are found in

this district. The principal ores in which they occur are the sulphurets—namely, galena, copper pyrites, mundic or iron pyrites, heavy spar, and blende. Carbonate of lead and carbonate of copper are also found, but in small quantities.

All these minerals are found in the vicinity of Oola, about half a mile north-east of the railway station.

The principal lode has a nearly east and west bearing, underlying to the north at from 85° to 90°. This lode is visible at the surface in a quarry on the side of the hill, about 500 yards north-east of the R. C. Chapel. It is here from fifteen to twenty feet wide, and is a very hard whitish blue trap-pean-looking rock, full of minute specks of iron pyrites. Through this run nearly vertical veins of sulphate of baryta, which is usually the gangue of the ores. This lode may be traced for three-quarters of a mile to the east, where several shafts have been opened on it, but never to any great depth. They are now abandoned, and the workings were only carried on at the western end of the lode, when this mine was visited in June, 1859; copper pyrites, galena, baryta, and iron pyrites were then being raised. A cross lode, which runs N. 39° E., had just been discovered at sixteen fathoms, which contained lead and sulphur ore. It hades to the north-west at 85°. About one-third of a mile to the east of the engine-house two trial shafts had been sunk, in one of which copper, sulphur, and a trace of lead and zinc ores were found; in the other, only lead. Further east there are the remains of old workings on two nearly east and west lodes, both of which hade to the northward. The most southern of these is supposed to be a continuation of the main lode, and in it workings were carried on, an old shaft and adit level being still open. This lode contains lead, copper, and a trace of zinc. In the lode to the north of this there is an open working which does not appear to have ever been sunk deep. It is said only to contain lead ore.

Another lode, bearing E. 10° N., lies south of the main lode. Its direction passes through Oola Hills Cottage, underlying to the south at 80°. This lode has not been worked, but trials have been made on it, and the lode is exposed in a shallow open work 300 yards east by north of Oola Hills Cottage. At this place traces of carbonate of copper and gray copper, and specks of lead were observed. The lode was here about two feet in width.

In some of the black shales associated with the main lode are small veins of sulphate of baryta, which sometimes contain a little mundic and galena.

A dyke-like fissure, full of yellow tenacious clay, occurs in the limestone a little south of the village of Oola. It is called the Oola Lode, and may be observed in a quarry on the north side of the old road leading to Tipperary, immediately south of the village. This is about six feet wide. It bears east and west, underlying to the south at 80°, the beds of limestone dipping north at from 10° to 15°. This clay contains boulders of limestone and occasional boulders of lead; one of the latter was found weighing 168 lbs. Along the north wall of the dyke there is a small vein of carbonate of lead from one to three inches wide. This, when followed east a short distance, was found to cross the dyke, and is said to be continued along its south wall.

The per-centage of silver in the galena found at Oola is about twenty-nine ounces to the ton.

Argentiferous galena is found in the Glen of Aherlow a little west of Riversdale, where it was observed in a thin vein of carbonate of lime.

J. O'K.

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