55.

Memoirs of the Geological Survey.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 55 OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND,

COMPRISING PORTIONS OF THE

COUNTIES OF SLIGO AND LEITRIM.

BY

JAMES R. KILROE.

WITH

PALÆONTOLOGICAL NOTES BY W. H. BAILY, F.G.S.

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ARCHIBALD GEIKIE, LL.D., F.R.S.

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

IRISH BRANCH.

Office, 14, *Hume-street, Dublin.*

DIRECTOR:

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

DISTRICT SURVEYOR:

G. H. KINAHAN, M.R.I.A., &C.

SENIOR GEOLOGISTS:

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ASSISTANT GEOLOGISTS:

R. J. CRUISE, M.R.I.A.; F. W. EGAN, B.A.; E. T. HARDMAN, F.C.S.; J. R. KILROE; W. F. MITCHELL; and ALEX. M'HENRY, M.R.I.A.

A. B. WYNNE, F.G.S., Resident Geologist.

FOSSIL COLLECTOR:

R. CLARK.

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

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

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

Condensed memoirs on particular districts will also eventually appear.

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

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PREFACE.

THE district described in this Memoir was geologically surveyed by Mr. Hardman, during the years 1877–78, over by far the larger portion—while the marginal tracts along the south and west were examined by Messrs. Symes, Cruise, and Kilroe. It is remarkable both for its geological structure and physical features; forming a portion of that extensive tract bordering the shores of Donegal Bay, where the Carboniferous limestone rises into a position in a scenic point of view not surpassed by that of any part of the British Isles. But the district is chiefly remarkable for the narrow band of more ancient metamorphic rocks, which traverses it from west to east, and forms a section of the ridge of the Ox Mountains, which, commencing inland from Clew Bay, in county Mayo, ranges in a north-easterly direction by Lough Conn and Lough Gill almost to the banks of Lough Melvin. These uplands are formed of gneiss and granite, hornblendic and micaceous schists, quartzites, serpentines, with thin bands of crystalline limestone; but their exact geological age will, probably, ever remain unknown, since they may belong either to the Laurentian (or Archæan) group, or to the Lower Silurian, or to both. This question I have already discussed in my paper on "The Laurentian Rocks of Donegal and of other parts of Ireland" (Scient. Trans. Roy. Dub. Soc., Vol. I., ser. 2, p. 252), and need not here be reopened.

The Explanatory Memoir to Sheet 55 has been written chiefly by Mr. Kilroe in the absence of Mr. Hardman, who has gone on special duty to Western Australia.

EDWARD HULL, *Director.*

30*th October*, 1884.

EXPLANATORY MEMOIR

TO ACCOMPANY

SHEET 55 (SLIGO) OF THE MAPS

OF THE

GEOLOGICAL SURVEY OF IRELAND.

General Description.

Of the area included in this sheet, about 87 square miles on the east lie in the county of Leitrim, about 124 on the west side in Sligo, and the remainder is occupied by arms of the sea, Ballysadare and Sligo bays, which just enter the sheet on the west.

The principal places, besides the chief town of the county, Sligo, are the towns Collooney and Drumahaire, and the villages Ballysadare, Riverstown, Drumkeeran, Ballintogher, and Toberscanavan.

Physical Geography.

Configuration.—The eastern extension of the Ox Range crosses the sheet E. by N. as a broken ridge of some 650 feet average elevation, and forms a striking feature in the district, viewed from either side. Its rugged outline stands in marked contrast to the gently sloping hills which, on the south-east, bound the flat country stretching away from the southern foot of the ridge; and, scarcely less so, to the scarped profiles characterizing the hills along the north margin of the sheet.

The highest point of this ridge is the summit of Cloonaquin, or Benbo Mountain (1,365) at the north margin, from which the ground falls away towards Drumahaire; and immediately north of this place it is comparatively low and flat. Westward it again rises, and forms a chain of hills, the principal of which are Rock Wood or Slish Mountain (967 feet), Slieve Deane (900), Union Wood (440), and Carrownageeragh (602) west of Collooney. Its western part, besides being crossed by three valleys, is cut transversely by deep clefts or ravines, locally termed "alts," in the same general direction as the valleys, viz., N. by W., so that it assumes a serrate appearance when seen from certain points of view. The northern side of the ridge is in places very precipitous, in contrast to that observable on the southern side, which slopes gradually upward; and the hills forming the ridge are generally rounded in outline, as if by glaciation.

Towards the eastern margin of the map the Drumkeeran valley, opening on the country surrounding Lough Allen, lies between two gently-sloping ridges, which trend south-eastward,

extending into the adjoining sheets. That on the north, the Bord-al-daig, forming a spur of the Lackagh Hills, terminates abruptly north-westwards in the escarpment overhanging Larkfield, and attains an elevation of 1,066 feet. The hill bounding the valley on the south consists of a double ridge, the two limbs of which are separated by a minor valley, formed by the Arigna river in its upper reach. From the apex whence the limbs diverge, the northern limb, known as the Curraghs, rises gradually south-eastward some 350 feet, reaching 1,377 feet above datum, due south of Drumkeeran. The southern limb, or Bralieve Range, attains a height of 1,498 feet above datum in Carrownadagny Mountain, two miles south of the apex above mentioned, and it is flanked by two fairly-developed escarpments looking N.E. and S.W.

Between Lough Gill and the north margin the ground is peculiarly rugged, the surface being studded with numerous rocky hillocks, isolated from each other by a network of glens. The sides of many of these hillocks form petty escarpments. A steep face of rock capped by a thin covering of rich soil, with a slope sweeping outward from its base in a graceful curve, are the usual elements observable in these minor features: so that this area affords a miniature representation of what is to be seen a few miles further north, where a group of picturesque and imposing masses are chiselled out of an undulating tableland, of which Benbulben may be mentioned as a noble and impressive instance. At the head or east end of Lough Gill the ruggedness is excessive. Precipitous cliffs and scaurs, forming the sides of flat-topped hills, overhang the deep glens separating them. O'Rourke's Table is one of these hills, and another "bears a marked resemblance" in its outline to Knock-na-Rea.* Numerous plantings add variety and attractiveness to this naturally picturesque locality.

There can be little doubt that subterraneous waters, charged with carbonic acid, played an important part in hollowing out the ravines just referred to; the rock of the locality being massive limestone full of jointing. A number of underground channels must even now exist, as may be inferred from several hollows (such as those occupied by Loughs Colgah and Anelteen) having no visible outlet for waters collected in them from the surrounding areas.

The geographical conditions of, and environing Lough Gill, combine to render it the focus of highly attractive scenery. The rugged ground near the north margin, just described, reaching to the lough, yields an indented shore-line. The minor features there studding the surface are succeeded by others, increasing in magnitude, which carry the eye backward to the Benbulben group. Well-wooded shores and islands, varied by the undulating parks about Hazelwood and Holywell, form the fore-ground; and the attractiveness of the panorama is enhanced by the strong contrast to all the above sylvan scenery, presented on the south side of the lake by two bold masses, which rise abruptly from its shore to heights of 741 and 947 feet above its smooth surface.

* Paper by A. B. Wynne, F.G.S., Jour. Geo. Soc., Dublin., Vol. X., p. 36.

Drainage.—The lough receives the drainage of about 80 square miles of the present district, and occupies a rock basin of some 3,400 acres. It empties into the sea at Sligo, by the River Garwogue, which flows upon a rock bed where it narrows, a little below the steamer landing-stage at Cleveragh, near Ellenville.*

A hollow extends from the widest part of the river by Bellanode and the Union Workhouse, to the sea, suggesting the probability of this having once been a second channel of outflow for the waters of the lough. The stream now occupying this course, flowing outward towards Sligo bay drains a small peat deposit on the lough brink, which there dams up the water at its present level. The water level given on the maps is 20 feet above datum, but this varies considerably with the rainfall. A lowering of the area to the extent of some 19 feet, therefore, would render the lough a land-locked arm of the sea; and it would require a further lowering of some 50 feet to submerge the neck of land between Aghamore bay, on Lough Gill, and Belladrihid, allowing the sea to enter by Ballysadare bay. The area south of Sligo bay, including the headland of Knock-na-Rea, would under such conditions form an island. (Fig. 2.)

The Bonet river, entering the sheet by the north margin, follows a zig-zag course along a valley formed by Benbo Mountain and the Larkfield escarpment, towards Drumahaire. It there enters alluvial and boggy flats, through which it makes its way towards Lough Gill, forming the principal channel of supply to this volume of water. Its tributaries drain a considerable extent of the high grounds near the east margin, and some of this drainage it receives through Belhavel lough. The principal outlet of this sheet of water is the Diffagher river, which flows south-eastward, so that the lough is situated upon the water-shed of the two drainage basins.

The tributary streams of the Diffagher river abrade the slopes on each side of the Drumkeeran valley, forming ravines, those on the north side manifesting striking uniformity of direction, and enclosing minor ridges ranged generally south-westward with corresponding regularity.

The Owenbeg enters from the west, and flows eastward. It is joined near Annaghmore by the Owenmore flowing northward, and continues its course to Collooney, where it forms rapids, falling over several successive beds of limestone rock, about 36 feet in the aggregate, from the higher to the lower level. Further on it receives the Unshin river, which flows northward by Riverstown, Cooperhill, and Markree, but turns westward near the junction. After passing this point the united waters make their way to the sea, through a gap in the mountain range, under the name of the Ballysadare river. This enters the sea at Ballysadare by a fall similar to that at Collooney, referred to above.

* The river here is no more than a few inches deep in a dry season, as I am informed by my colleague, Mr. A. B. Wynne, F.G.S., to whom I am indebted for several interesting notes on this area, including the following, viz.: that Hazelwood is connected with the mainland by a peat deposit only, which now stops up what must in recent times have been an open channel—the continuation of Annagh bay. Hazelwood would then have been an island in the lough.

Fig. 2.—KNOCK-NA-REA FROM FINISKLIN NEAR SLIGO.

Showing erosion of Carboniferous Limestone.

Two other valleys have been already mentioned cutting across the range, beside that just referred to near Collooney, and of these one is occupied by a stream, which discharges a portion of the water collected south-east of the ridge into the Lough. This gap may be observed N.W. of Ballintogher, opening northward by a bell-mouth at Bunowen bay, between the north-eastern shoulder of Slieve Deane and Rockwood. The collecting ground of the stream, before entering the gap, omitting that portion of it ascending the south-eastern flanks of the range, is no more than two and a half square miles in extent, which seems small in a consideration of the probable agent to which one may attribute the formation of this, the Slish Wood valley. It does not, however, seem to have been much more extensive at any time during the more recent stages of the physical history of the district. Thus, its water-shed, running generally upon rock, is at least 105 feet higher on the west side than the Unshin river, where this turns westward towards Collooney, and on the east side, 173 feet higher than the Bonet river, below Drumahaire. It is, moreover, some 80 feet higher than the highest point of the Ballydawley gap, so that were there no valley at Collooney, the waters now issuing through the latter would find exit by the former, preferably to the longer course by Slish Wood; and it is probable that, at no very remote period, the Unshin river found by this channel its passage outward to the sea.

It may be just noted that though the outlet of Lough Gill forms a rude continuation to the line of Slish Wood valley, it cannot be asserted that the stream which excavated the valley initiated the direction of the outlet; for, at a period when the stream could have made its influence felt across the Lough, the outlet of the latter may have been towards Ballysadare bay—the natural direction of its water current under the influence of the Bonet river.*

Formations and Groups of Rocks entering into the Structure of the District.

Aqueous Rocks.

Recent or Post-Pliocene.

Name.	Colour of Map.
Raised-beach, ...	*Burnt Sienna.*
Alluvium, Bog, and other Superficial covering,	*Raw Umber.*
Drift or Post-Pliocene, ...	*Engraved dots.*

Carboniferous.

d^4 Millstone Grit, ...	*Light Indian ink.*
d^3 Yoredale Shale, ...	*Light indigo.*
„ Sandstone, ...	*Yellow with red dots.*
$d^{2'''}$ Upper Limestone, ...	*Dark Prussian blue.*
$d^{2''}$ Middle Limestone, ("Calp"), . . .	*Indigo.*
$d^{2'}$ Lower Limestone, ...	*Light Prussian blue.*
d^1 Lower Carboniferous Sandstone, . .	*Prussian blue and Indian ink, with yellow dots.*

* It does not appear to me that the direction of the above named streams has had much to do with the outlet of Lough Gill. The lough is a "rock-basin," as I have already shown ("Phys. Geol. of Ireland," p. 196), and owes its form, and position of outlet, more to ice-abrasion than to that of water.—E. H.

Metamorphic.

Name.	Colour of Map.
ν Gneiss, ...	*Pink.*
μ Mica Schist, ...	*Pink.*
qμ Micaceous Quartzite, ...	*Pink with yellow wash.*
q Quartzite and Quartz Schist, . . .	*Yellow.*
Σ Serpentine, ...	*Pink, lined with green.*

Igneous.

B. Dolerite, ...	*Burnt carmine.*

Metamorphic Rocks.

The broken ridge, already described, forming the eastern continuation of the Ox Range, consists of metamorphic rocks, which traverse the sheet E. by N. in a band of two miles average width. In the eastern and western portions of this band the beds dip conformably to the axis of the ridge, and generally high, particularly in the eastern portion. The prevailing *directions* of dip are, however, contrary—that in the western portion being south by east, whilst that in the eastern is north by west, as indicated on the map and in section 2, where, moreover, the unconformability of Carboniferous strata with these beds is strikingly manifest.

In the middle portion of the band, lying between Drumahaire and Collooney, the dip varies considerably in direction, and the beds are frequently vertical, so that here the unconformability above mentioned is even, if possible, more strikingly observable; for beds almost vertical strike directly *at* the Carboniferous boundary north of Ballintogher.

Mr. Hardman, referring to the metamorphic rocks of this area, states* that they consist of "four classes, viz., granitoid gneiss, gneiss proper, mica schist, and quartzite. But in a few cases only is it possible to determine a boundary between any two of them. Thus, the first may be seen to pass into the second, and so on. A good example of this is to be seen in the section west of Slieve Deane, where, in the space of some 400 yards, there are numerous transitions of gneiss, schist, and quartzite into each other without any apparent rule or order in the process, all apparently changing indifferently, one into the other. On the whole, the gneiss largely predominates; the quartzites come next, and the mica schist last of all."

Gneiss.—In colour this rock is usually gray, weathering lighter gray, and it consists of quartz, felspar, which is generally pink, and white and black mica, frequently accompanied by hornblende. The quartz is often milky, and forms the principal constituent throughout. In parts the gneiss is highly quartzose, as, for example, near the western margin of the map as may be seen in the section along the lower road from Drumahaire to Lough Gill.

The gneiss is usually fine-grained, but is also, as already noticed, coarse or granitoid. This variety occurs east of Ballysadare, where

* In an interesting paper, read June 19th, 1882, before the Royal Dublin Society, from which extracts are frequently adopted in the present memoir.

the mica is abundant, and chiefly dark-coloured; also at Carrigeencor lough and a few other points.

The gneiss is often intensely gnarled, which is most frequently to be observed in the middle portion of the metamorphic band, that lying between Drumahaire and Ballydawley gap. A fine instance of this may be seen in Cashelore, north of Ballintogher, along the road running E. and W.

It has been already noticed that in this portion of the metamorphic area the beds dip variously, the prevailing direction of strike being normal to the axis of the ridge. The geographical connexion thus existing between the displacement of bedding *en masse*, and the crumpling of the rock in detail, may be suggestive of contemporaneity.

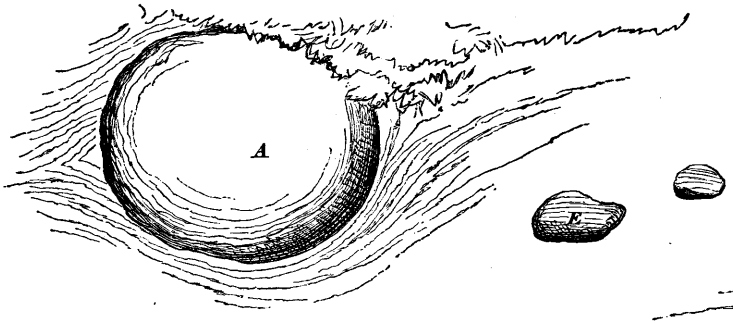
The gneiss is traversed by frequent veins of pegmatite, cutting the foliation transversely, and consisting of large crystals of felspar, quartz, and white mica—though the last is often wanting. Large masses of the same are also frequently observable, apparently filling pockets in the rock. These masses and veins often contain hornblende, and are even schorlaceous occasionally, as was found in one instance E. of Carrigeencor lough. Tourmaline was also noted north of Ballydawley Lough, near the Carboniferous boundary, by Mr. Hardman, who, in reference to the gneiss, remarks*: it "is the most interesting (of all the varieties of rock met with in the area) from a mineralogical point of view, containing, as it does, a great variety of large crystals of quartz, biotite, muscovite, tourmaline, felspar (both red and white orthoclase), hornblende and olivine, (?) and very often garnets, but in minute crystals." (p. 2).

A band of coarse gnarled gneiss, north and south of Ballydawley lough, striking in the direction of its length and about 200 feet in thickness, is peculiar in containing masses of hornblendic rock which might be named diorite, and in some instances show foliation. The foliation in one or two of these instances seems to run transverse to that of the surrounding gneiss. (See sketch, fig. 3.) Several of these masses weather out after the fashion of pebbles more or less water worn, a hollow encircling each, which marks its junction with the mother rock. Their origin, which is probably a common one, does not seem to be that suggested at first sight by this observation, *i.e.* the rock to have originally been a conglomerate; for almost every size and shape may be observed from a spheroid upwards of three feet in its longest axis, around which the foliation of the gneiss laps conformably, down to a slab two feet in length by two and a half inches in thickness, tapering towards its extremities, and embedded in the folia of the gneiss without derangement thereof; and even more attenuated lenticular masses would probably be discovered, were the rock surface more fully exposed than it is. † Thin streaks of hornblendic schist and gneiss also occur in the same place which bifurcate, and thus become lost in the containing rock.

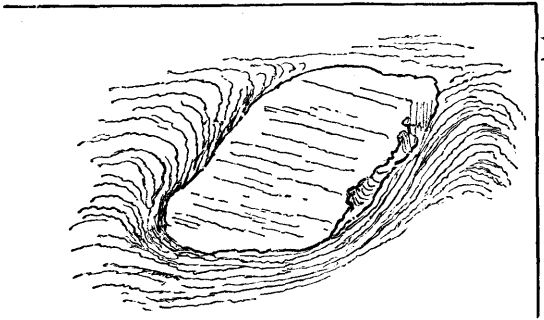
* Supra cit, see p. 12.

† Dr. A. Geikie, who has seen this interesting rock, considers these masses "geodes"—segregations of hornblende rock in the gneiss. They contain specks of a pink mineral which he moreover believes to be sphene.

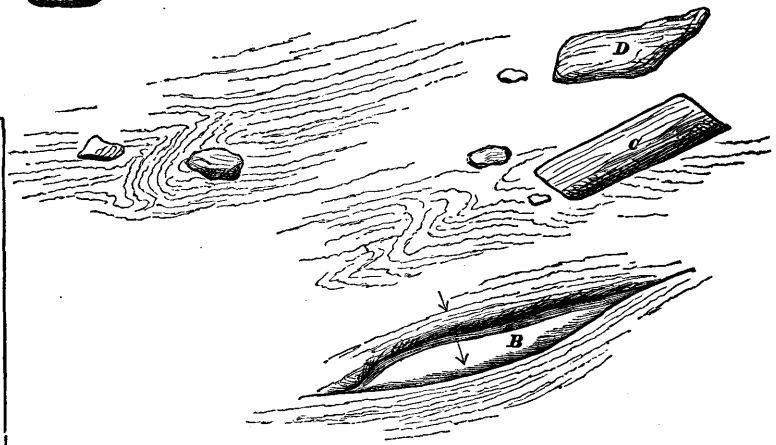
Fig. 3.—Geodes of Hornblendic Rock in Gneiss.



The masses have the following approximate dimensions in descending order as shown in sketch—A, 3′ 6″ × 3′; B, 24″ × 2½″; C, 20″ × 6″; D, 18″ × 6″; E, 9″ × 6″.



Hornblendic mass (15″ × 12″ approx.) included in gneiss from another locality. Lining represents foliation in both.



Sketch-plan (9 yds. by 6 yds.) illustrating occurrence of hornblendic masses in gnarled gneiss; lining shows foliation in each variety of rock.

Quartzite.—The gneiss, which, as has been stated, is in many places highly quartzose, through the disappearance of felspar and mica, passes into quartzite and quartz schist, several bands of which are to be met with. A few of these are indicated on the map, and others of less importance occur at Union Wood, on the north shoulder of Slieve Deane and elsewhere. It is of a light gray colour, weathering white on the outside though beneath the surface the weathered portion is usually brown. It seldom presents the vitreous appearance on a fractured surface of typical quartzite—the metamorphism not having apparently reached that extent; and hand specimens might easily be mistaken for close-grained, hard, Carboniferous grit.

Mica Schist—This variety of rock is meagerly represented, though the gneiss contains numerous insignificant bands from which felspar seems to be absent. In crossing Benbo mountain, by the road running N. W. from Gortgarrigan bridge, a highly micaceous band was noticed in an opening which supplies road metal. But such bands are exceedingly rare.

Serpentine.—Two bands of this rock occur in the district, described in detail by Mr. Hardman, in the paper * already referred to, together with a third which occurs near Manorhamilton. He there writes:—"Of the two bands, the chief one appears at Slish Wood, and occupies the valley running nearly south from Bunowen bay, Lough Gill, for nearly two miles, and has an average width of 500 feet." The second, "near Drumahaire (three miles N. E.) trends nearly east and west. It is probably 300 feet thick at least; but its extension along the line of strike is not ascertainable, owing to thick coverings of drift and bog." It is not, like the former, "perceptibly magnetic, although not generally different in external appearance from it." It also lacks "the numerous bands of tremolite† (?), which distinguish the former."

Mr. Hardman, further writes, in giving its physical characteristics: "The rock is apparently an ordinary serpentine, dark coloured, compact, and somewhat hard. . . . , In all parts of the rock magnetite occurs, but chiefly on the western side of the band. To the eastward the rock is more homogeneous. . . . In the most compact specimen minute grains of black matter will be seen, and on powdering a portion and running a magnet through it, a quantity of magnetite can be extracted. . . . Westwards, this mineral becomes more and more abundant, and close to the western boundary, occurs in very large quantities indeed; and portions of the rock possess all the characters of natural magnets. They attract and repel the magnetic needle, and have distinct polarity."

A structure is distinctly shown on its weathered surface, which suggests planes of lamination in the mass, but in hand specimens this is not observable in detail. Nevertheless, the rock manifests a strong disposition to split up into beds of various thicknesses, the dip of which corresponds with the superficial indications, and generally with the rock bounding it on either side.

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* Supra cit, pp. 2, 4, 6, et seq.

See page 16.

Numerous "well-defined bands may be seen, which, at first sight, appear to be bands of grit, but on closer inspection prove to be bands of a hydrous silicate in all essential points resembling serpentine, but containing a larger quantity of water." They predominate toward the western side of the outcrop; and, like the adjacent rock, contain a large quantity of magnetite.*

The bands consist of light yellow delicately fibrous mineral with silky lustre, answering in every particular to the form of serpentine called *chrysotile.*† It has been referred to as *tremolite*, with a query, on a previous page of this memoir. But Mr. Hardman, while insisting that the mineral contains as much as seventeen per cent. of water, seems also to identify it with "chrysolite," which could easily be a misprint for what is doubtless the real name.

On the roadside, near the northern extremity of the outcrop, transverse joints occur, coated with thin slickensided layers of a light green and bluish translucent mineral‡ which is probably a variety of the same material as the rock itself—"noble serpentine."

The chemical composition of the mass "is nearly that of most rock serpentines, except that it is highly aluminous even when it is perfectly compact, . . . but the chief points worthy of remark are the presence of magnetite and nickel." (p. 8.)

These facts are of interest, in seeking to determine the probable origin of the band. As to this, Mr. Hardman believed that it has been originally "magnesian limestone, intercalated between shales and limestone rocks;" that the silicate of alumina from the shale replaced and gradually eliminated carbonate of lime§; and that this is partially confirmed in the present instance by the serpentine, at its base, merging at the south end of the band "into what has all the appearance of altered Carboniferous shale." It may be noted that the occurrence of bands of limestone, or highly aluminous bands, would be altogether exceptional in this (eastern) portion of the Ox Range; nor does the silica at all preponderate in the serpentine as it does in the adjoining gneiss, &c., and throughout the metamorphic rocks in general in this area.

Among other reasons for questioning the above hypothesis may be mentioned the large proportionate quantity of magnetite contained in the serpentine, to which the author himself alludes in his paper, stating that (as far as he knows) it is "the highest

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* Paper by Mr. Hardman, "Supra cit," pp. 6 and 7.

† See description of these bands, by Professor Hull, LL.D, F.R.S., in the microscopical portion of the paper so frequently referred to. Dr. Hull, there, while adopting the name tremolite, "in deference to Mr. Hardman's determination," questions its applicability. Dr. A. Geikie, named it as above, on his visit to the locality in March, 1884.

‡ Noticed in paper by A. B. Wynne, esq., F.G.S., "On the Geology of Sligo," Jour. Geo. Soc., Dub., Vol. x.

§ Note.—Such a substitution may be open to question. Silicate of alumina could have formed an important constituent of the original band if it were, as supposed, calcareo-magnesian; as in the case of the impure earthy limestones of the Carboniferous series. Magnesia might have taken up silica in lieu of carbonic anhydride, as in the process by which some account for the formation of Connemara serpentine. (Text Book of Geology. A. Geikie, p. 153). But the carbonate of lime remains in these cases, and there is no trace at Slish Wood of this mineral accompanying the serpentine.

on record," (p. 10.)* He there also mentions an alternative hypothesis, saying, that "it is possible the rock should be called eklogite serpentine, if it could be a product of alteration of augitic rocks."* As to this contingency, Dr. A. Geikie refers to the dykes of serpentine occurring in the Old Red Sandstone of Forfarshire and Kincardineshire, in corroboration of his conviction, that "in some cases at least it was originally an eruptive rock." Cotta instances the transmutation of dykes of gabbro at Siebenlehn, near Freiberg, and of granite near Böhrigen and Waldheim, in Saxony, into serpentine.† Bonney also considers the black serpentine of Lizard,‡ metamorphosed lherzolite—an intrusive rock.

Moreover, Dr. Hull's microscopic notes on homogeneous sections of the rock are very suggestive of the meshlike form assumed by the ramifying jointage of olivine crystals in its transmutation into serpentine.§ This materially strengthens the hypothesis, that the band was originally intrusive. And the fact, that it manifests general conformability to the adjacent gneiss, in no way weakens the evidence for this hypothesis; for the trend of the second serpentinous band in the district, which is presumably of similar origin, does not at all stand in the same relation to the neighbouring rock—its strike forming an angle of at least 30 degrees with that of the gneiss, and its hade being southward, while the dip of the gneiss is northerly, over a wide adjoining area.

Dolomite.—One small area of this rock is indicated S. E. of Ballintogher, crossing the county boundary. Mr. Hardman describes it as "highly magnesian dolomite abounding in cavities, containing calcspar, stalagmite, and carbonate of iron. Though derived from Carboniferous limestone no trace of the original bedding remains.

Another small area is to be observed one mile south-east of Drumlahan Bridge, in the triangular space, formed by the intersection of three roads, where dolomite seems passing into serpentine.

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* The next highest proportionate quantity given is that of the serpentine of the Heidelberg, referred to by V. Humboldt, as highly magnetic, and described by Bischof.

† Rocks classified and described, p. 316.

‡ Quar. Jour. Geo. Soc., Vol. xxxiii.—It is interesting to note the several links between this and the Slish Wood serpentine. Mr. Hardman instances the occurrence of nickel in both. At the north end, the rock is quite bastitic, and the schiller spar (bastite) is in all probability an alteration product of eustatite, a characteristic mineral of lherzolite. And if, as is also probable, the mass of the rock is altered olivine, this would form a third link.

§ Sci. Proc. Roy. Dub. Soc. Vol. iii. Micro. Notes on the appearance of the serpentine. E. Hull, LL.D., F.R.S., &c.,

Professor Hull there describes the various specimens, as follows:—

No. 1. The serpentinous mass appears with reticulated or net-like divisions. . . . A few translucent spaces occur amongst the mass of serpentine, &c.

No. 2. The field shows layers of light greenish-yellow serpentine, with net-like structure, similar to that in former specimens.

No. 3. The serpentine has a reticulated structure.

No. 4. Surface showing net-like spaces of light yellow serpentine, mixed with clear, colourless spaces.

Note.—The serpentine has been mentioned by the Ven. Archdeacon Verschoyle, (Proc. Geo. Soc., London, Vol. i.) where he, curiously enough, speaks of it as the continuation of a dolerite dyke, he supposed traceable from the county of Mayo, by Knocknarea, &c., to Drumahaire. To this dyke he attributed the formation of "the Glen," on the south shoulder of the hill.

Magnesian limestone occurs at several other points, as for example, near Castletown, east of Collooney; in Gortnacorkoge and Killarga, four miles east of Drumlahan; and other points to be referred to in the detailed description of the Carboniferous limestone.

Sedimentary Rocks.

Lower Carboniferous Sandstone.—A narrow band of pale yellow and red sandstone, with a little shale, fringes the metamorphic area near Lough Dargan. The prevailing character of these beds is that of coarse-grained sandstone, occasionally pebbly, evidently the debris of the adjoining and underlying gneiss. East of the lough, may be observed light gray chert occurring in the sandstone, in the form of lenticular concretionary masses, or adhering in partial layers to the exposed surfaces of the beds.

Evidences are obtainable for the existence of pebble beds underlying the succeeding division of the formation at various points along its boundary, for example, at Cashelore, north of Ballintogher; Kilcoosy, east of Drumahaire, &c. But at none of these points do the pebble beds assume the degree of importance seen in the locality above referred to, so that they are indicated on the map by yellow dots on the ordinary blue ground of the Lower Limestone, along its northern margin, north-eastwards by Drumahaire.

Lower Limestone.—At Kilcoosy, the stream draining Carrigeencor Lough, lays open an interesting section. A quartz breccia, immediately underlying limestone composed almost wholly of encrinital stems, may be seen very close to siliceous gneiss, which doubtless passes beneath the Carboniferous beds, here as elsewhere forming their floor. The precise junction is however not exposed, nor has it been observed elsewhere in the sheet. It is generally indicated by a hollow, and is there concealed by drift.

The encrinital limestone passes up into highly arenaceous beds, which may be magnesian also, as the limestone composing them weathers deep brown, and contains numerous cavities which are usually drusy. Encrinital limestone, seen at the "Cashel," north of Ballintogher, contains numerous small white quartz fragments, and passes down into quartz pebble beds. Arenaceous limestone likewise forms the lowest visible beds of this division at Moymlough, near the west margin of the sheet.

The above mentioned character, assumed by the lowest beds of the Lower Limestone, supports an assumption suggested by the thinning out of the band, north-eastwards, viz.:—that the formation was laid down against a gradually sinking shore. This being so, it is quite possible the sandstone area east of Lough Dargan, does not represent the true Lower Carboniferous Sandstone division, but is rather an unusual development of basal beds of Lower Limestone age.

North of Ballintogher, in a large quarry, may be observed the typical character of this division. Light and dark gray compact limestone, with metallic ring when struck, beds up to three feet in thickness. The prevailing direction of jointing there is S. 5 E.

A section across the outcrop, near the west of the sheet, presents the following varieties, beginning with the arenaceous limestone, as above described. This is in part bluish gray and thin-bedded, generally massive, and passes up into light gray thick-bedded, compact, and light blue limestone with metallic ring when struck, and clean-jointed. Next follows thinner bedded rock, passing up into dark gray limestone, which becomes flaggy and argillaceous at the boundary with the middle division, as may be seen in the river flowing through Annaghmore demesne.

Near Gortgarrigan, N.E. of Drumahaire, occurs light gray subcrystalline stone, good for burning, and apparently containing little, if any, sand, even in the lowest visible beds. Nevertheless, at the blacksmith's forge, 200 yards N.W. of the bridge, a few beds occur which are remarkably arenaceous, and, like those referred to at Kilcoosy, appear to be magnesian.

Excellent building stone (dark gray and subcrystalline) is obtained from Lower Limestone at Ballysadare, where it is, moreover, wrought into tombstones and other ornamental work. It takes a good polish.

Middle Limestone ("*Calp*").—There are four areas of this division included in the sheet, one of which, occurring east of Riverstown, is known, even as to its existence, chiefly from evidence in the sheet to the south. A band of almost uniform width runs eastward, south of the metamorphic ridge, averaging about the same in amount as the Lower Limestone, viz., a mile and a quarter wide. What thickness of strata this outcrop indicates it is impossible to estimate, as the rock, except at a few points, is covered by boulder clay. Like the Lower Limestone, it appears to become thinner towards the north margin, and to almost entirely disappear N. of Larkfield. Openings occur at Heathfield, Thornhill, and a few other points, by which the character of the rock is ascertainable. At Ardcree bridge, and the two points above mentioned, it is seen to consist of dark gray earthy limestone, weathering into shaley flags, and ultimately into mere calcareous shale, with a few highly fossiliferous beds. These openings afford an approximation to a section across the outcrop, near the west margin; and it may be here stated that not until the Upper Limestone boundary is reached do the beds contain chert.

Hard dark blue and gray fossiliferous limestone, weathering shaley, may be seen in Drumduff, just beyond the counties' boundary. It is here penetrated by a large dolerite dyke, which produces induration at, and near, the junction.

The stream flowing by Ballanagare R. C. Chapel lays open a section on hard dark gray flaggy limestone, weathering quite shaley, by which also the passage upward may be traced into pure gray cherty limestone, doubtless of the Upper division. Similar rock is observable at Gortnacorkoge, S.E. of Gortgarrigan bridge.

The lower, more gently sloping, half of the escarpment at Larkfield, consists of Calp. This is proved by a section of shale or shaley limestone, which may be seen half-a-mile south of Larkfield in a stream draining the escarpment at that point.

Here, as already stated, the present division becomes unusually thin, though, unlike the Lower Limestone, it is traceable, and even seems to increase again in thickness, some distance northward, where it is represented by thin-bedded blue limestone, containing concretionary chert. The latter would indicate the prevailing character of the Calp north of the metamorphic band, at least that area of it lying W. of Lough Gill; for the narrow wedge-shaped strip, cropping out north of Benbo, corresponds more closely in character to the Calp forming the band south-westward from Larkfield to Thornhill. Dark gray flaggy limestone, weathering shaley, containing highly fossiliferous beds—as may be seen on the roadside opposite Rookery, near the fault—is a description of the rock occurring here. The strip just now referred to does not, of course, represent the whole thickness of the division, a large part being, doubtless, hidden by faulting.

In the third area, that stretching from the north margin, southward by Sligo to Ballysadare bay, the Calp is well exposed at several points. In general character it is much less earthy or

Fig. 4.—Massive Jointing in Limestone, Fastowart.

argillaceous than the rock corresponding in age, south of the metamorphic ridge, though the beds cropping out on the N. shore of Ballysadare bay are, perhaps, more earthy than those at Finisklin, near Sligo. But even at Belladrihid the stone seems to have been extensively quarried for building purposes, implying its comparative purity. It there occurs massive, as well as in beds averaging about 8 inches in thickness, and is dark gray in colour. At Finisklin, where the limestone is accompanied by a little shale, it is regularly bedded and clean-jointed, the beds being about a foot in thickness, though also flaggy ; and *zaphrentis* exists in great numbers. At Ballincar, near the north margin, massive limestone beds represent this division.

At almost every point the Calp may be observed to contain chert, which increases in quantity upward. But even west of Belladrihid, at a low horizon in the division, chert occurs in decided quantity ; so that the existence of this substance in the limestone may be said to distinguish the Calp north of the metamorphic ridge, at least west of Lough Gill, from that south of the ridge ; and form a second point of contrast. The difference may be accounted for by conceiving that the latter set of strata were deposited in a shallower sea than the former, and that the then representative of the Ox Range formed a barrier between the areas. This supposition is, perhaps, corroborated by the thinning out of the Lower Limestone and the thinning of the Calp north-eastward.

Upper Limestone, occurring in four isolated areas, occupies a larger aggregate extent of the sheet than any other division of the Carboniferous formation. The largest of those areas stretches in a wide band north-eastward, sending a spur towards the south-east. It thus, equally with the Lower Limestone and Calp, retains parallelism to the metamorphic ridge. Lough Gill lies within the limits of a second area of Upper Limestone, being almost entirely surrounded by this rock, and, besides, there are two outlying areas, one S.W. of the town of Sligo, and another forming the cap of Knocknarea.

The limestone is usually pure, light gray, often bluish, and massive, though occasionally thin-bedded, and even flaggy. Chert is of common occurrence, both as concretionary and bedded, and at many points the rock is fossiliferous, often highly so, containing corals, encrinites, &c.

In the north-east and south-west of the band, first mentioned above, the ground is rugged, massive beds of limestone jutting out in crags at a low dip ; and at Larkfield, near the north margin, such beds form a fine cliff, crowning the escarpment.

In the intermediate space, the ground between Belhavel lough and Drumfin is generally low-lying, and undulates. Here the rock is, in great part, concealed by drift, but wherever exposed it is observed to be of the above-described general character. Thus, at Coola Cross, N.E. of Riverstown, occurs gray rubbly limestone, with chert, corals, and other fossils ; and at Carrowkeel, near Sooey R. C. Chapel, a straight quarry face reveals several beds of massive, gray, highly fossiliferous limestone, containing wavy bands of chert.

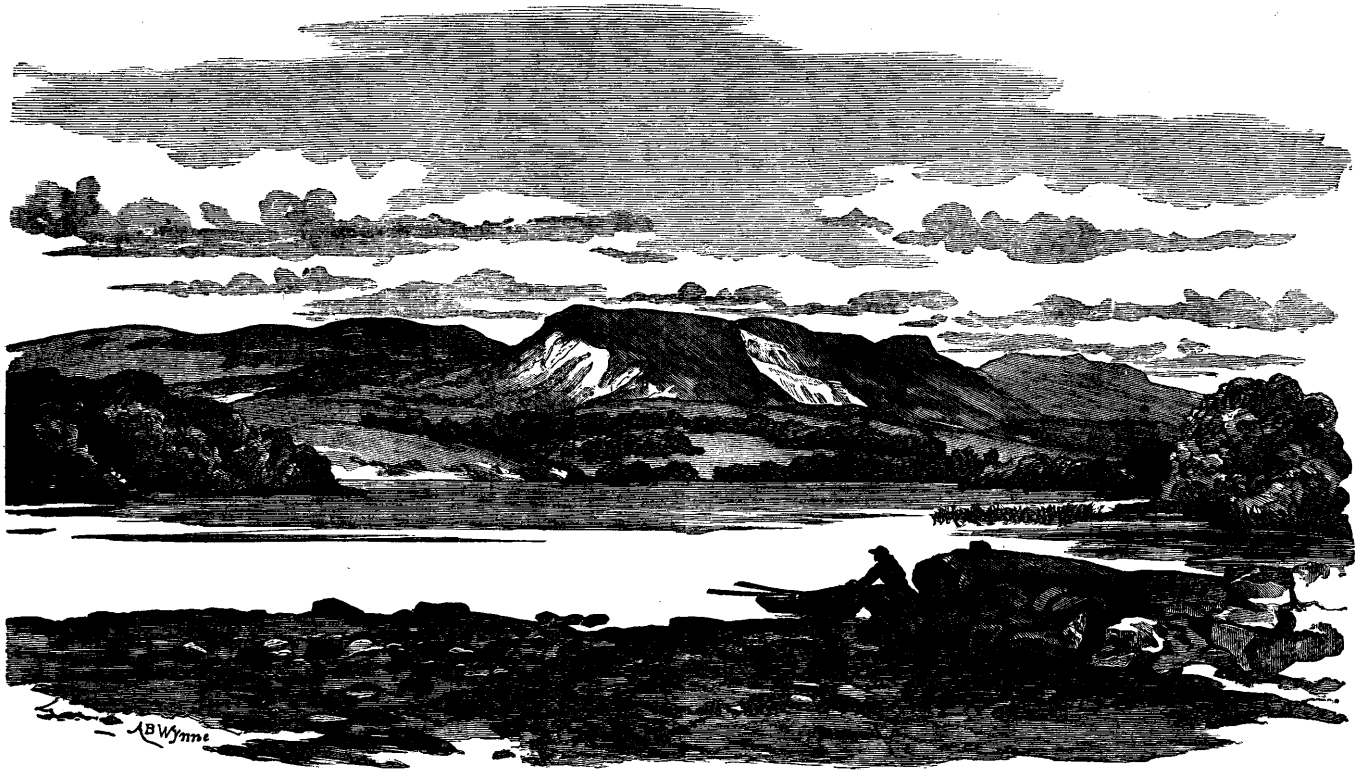

Fig. 5.—Limestone Hills North of Lough Gill, Sligo, from Doonee Pier.

In Killarga, and at other points north of Belhavel lough, the limestone is distinctly magnesian, and at Lugnaskeehan, the rock, besides being magnesian, manifests an exceptional structure resembling conglomerate, the pebbles forming it being cemented by calc-spar.

The south-eastern spur running along the flank of Carrownadagney mountain, consists of massive-bedded gray limestone, containing an abundance of chert and corals, and showing much vertical jointing. Caves are of frequent occurrence, and very impressive natural cuts or ravines may here be seen; the chief one is about 20 yards in width between vertical walls, which rise to a height of 80 feet above the bottom. This slopes eastward, and meets another running W. 15 N., which slopes westward, forms an angle of about 30 degrees at thair junction in Carrowmore. They were, doubtless, once underground channels, though now dry, formed by water draining the slopes of the receding Yoredale escarpment.

The succession of beds is so clearly traceable from the shore of Ballysadare bay, north-eastward towards Oakfield, that little difficulty is experienced in determining an exact boundary between the Calp and the Upper Limestone there indicated on the map—the latter being pure, and of a light gray, whereas the former is earthy, and darker in colour. Both alike, however, contain a large quantity of chert, in the locality referred to. The Upper Limestone is particularly well exposed, but in following the succession of beds north-eastward to and along the Railway line, the ground becomes obscured by drift, and Calp is again met with dipping towards the Upper Limestone area, but at a low angle; so that the latter seems to be thrown down against the Calp, along a fault which, near the small Lough Naminbrack, breaks the continuity of the strike of both Upper Limestone and Calp beds near the great fault. Without such a fault the common strike just referred to would seem to indicate that the divisions blend here.

Returning to the Cloverhill area, the Upper Limestone seems to strike south-eastward across the Belladrihid alluvial flat into Calp ground, which implies a second fault north-eastward along the flat. Confirmatory evidence for the existence of this break is to be found at Belladrihid, where Calp beds are tilted at 80° on the west side of the Railway line. The Upper Limestone at Cloverhill, therefore, occupies an angular space formed by the meeting of the two faults above described.

The rugged character of the ground north and east of Lough Gill has been previously noticed. Crags, scaurs, and small escarpments of limestone occur here in immense variety (see sketch). The rock itself is of the usual character, bluish gray, chiefly massive, though occasionally thin-bedded and flaggy, and very much jointed, which doubtless initiated the numerous gullies and

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NOTE.—The so-called "Diamond Rock" in Cashel, east of Drumahaire, occurs on the roadside, and contains Irish diamonds in cavities. They were obtained chiefly from the soil of the fields beyond the quarry some ten or twelve years since by the country-people.

ravines now existing in the locality. Chert is of almost universal occurrence throughout the beds, and in places occurs in marked proportionate quantity. The rock also contains corals, encrinites, and other fossils*.

The prevailing dip is southerly, but very slight, and the beds are horizontal over a considerable area N.E. of Lough Gill. They dip exceptionally high near the metamorphic ground, which is evidently to be accounted for by proximity to the great fault which brings these Carboniferous beds to so comparatively low a level.

Fig. 6.—Configuration of ground N. of Lough Doon (Lough-a-Doon) about Fawnlion.

Magnesian limestone occurs on the south shore of Lough Doon, where the beds are set up at about 60 degrees, dip northward. Eastward in Leckaun, N.W. of Benbo, and near the main road to Manorhamilton, the beds of limestone seem to be magnesian, and what is even more exceptional in this division—arenaceous. (Fig. 6). The limestone is also magnesian near the great fault, a quarter of a mile S.W. of Sriff Cottage, on the east shore of Lough Gill.

It may be added that the rock at a few points, where free from chert, is well adapted to burning; that at Holywell may be especially mentioned. Carns' quarry, a mile and a half south of Sligo, has also yielded stone for burning.

For a variety of reasons it is impossible to estimate the thickness this division assumes in the district, either north or south of the metamorphic ridge.

Yoredale Series—is represented by shale and sandstone, the former of which largely preponderates. Evidence for the existence and mode of occurrence of the sandstone towards the north-east corner of the sheet is very meagre, and chiefly obtainable in adjoining ground to the east, surveyed and described by Mr.

* Mr. Hardman notes a "trilobite (Griffithides)" at Dhunee Rock, on the south shore of Lough Gill.

Wilkinson. When the sandstone and shale both occur, the former underlies the latter.

The shale spreads out southward, and occupies a wide extent of country, west and north of Drumkeeran. There is here no representative of the sandstone above referred to, though thin beds of grit have been met with occasionally, contained in the shale. They are quite exceptional.

The shale, which seems to be of considerable thickness, is well exposed in the ravines formed by streams draining the slopes on each side of the Drumkeeran valley. The prevailing aspects presented by the shale are very dark gray, or nearly black, flaggy and slatey, or fissile and laminated when weathered. It is usually calcareous, and contains beds of dark gray earthy limestone, which weathers shaley. It is, moreover, frequently stained with iron oxide, and contains ironstone in bands and nodules, which occasionally occur in such quantity as to form a deposit of decided importance commercially. The beds are not usually fossiliferous, though both plant and animal remains have been noticed about two miles west by north of Drumkeeran.

Ironstone deposits are of infrequent occurrence in the shale south of the Drumkeeran valley, and of little commercial value. But on the north side they assume a rare degree of development, and chiefly in the townlands of Gowlaun and Tullynamoyle, about three miles and a half due north of Drumkeeran. Here the ore was regularly excavated and systematically smelted at intervals for some time, until about twenty-five years since, when the works were closed. Detailed notes on the ironstone mines and works generally, will be found in the section of this memoir devoted to minerals, &c.

A bed of good fire-clay also occurs in Gowlaun, near the iron-works, one foot in thickness.

Millstone Grit.—Following the Gowlaun and Tullynamoyle streams upward towards their sources, thick-bedded hard quartzose gray grits are met with, about the 1,050 feet or 1,100 feet contour line, which represent the Millstone Grit of this district. The boundary is concealed by bog and drift, except in the former stream bed. The beds appear to be horizontal, or to dip slightly towards the mountain top, and it is quite possible, as, indeed, it is reported, that the first coal of the series crops out within this sheet. Stronger evidence for its occurrence obtains a mile beyond the sheet margin eastward in the range, as indicated in the adjoining sheet.

J. R. K.

A small tract of these rocks with coal seams is to be found in the extreme S.E. of the sheet.

They consist of massive quartzose fine-grained grit, with two coal seams, forming the north-western termination of the Connaught Coal Field, described in our Memoir, and by other authors.*

The strata are disturbed by a series of (nearly) N. and S. faults, all having a downthrow to the E., as shown on the map.

* See Ex. Mem. Geo. Survey, Sheets 66, 67, giving Analysis, list of Authors, &c.

Few exposures of the beds occur, the ground being covered in the most part with peat, but the sections noted were similar to those to the S. and E.; namely, the "middle coal" being separated from the underlying "crow coal" by about 70 feet of grit. The seat of both seams is an even-grained sandstone, with rootlets of stigmaria; the "crow coal" having a sandstone roof, while the "middle coal" has invariably a roof of shale about ten feet thick. All the beds dip slightly, from 5° to 7°, to the centre of the mountain.

The middle seam has been worked in the townlands of Lugmore and Selteenasaggart, or "Corry Mountain." In Lugmore the coal runs from 21 to 24 inches in depth; while in Corry Mountain it was said to be 30 inches thick. The latter thickness I was unable to verify, as the adit by which it was worked was closed at the time of the examination of the district. The middle coal is of fair quality, fit for domestic use, but in no case was the crow coal worked, it being mixed with bands of shale, rendering it commercially useless where tried.

R. J. C.

Igneous Rock.—A dyke of dolerite, about 300 feet wide, occurs east of Ballintogher, at the counties' mearing, and is traceable nearly a mile in a waved course south-easterly. At both extremities the rock is concealed by drift, and though its extension north-westward and south-eastward is highly probable, evidence for this is wanting. The dyke consists of dark bluish-gray dolerite, containing olivine and hornblende; is evidently intrusive, the calcareous shale through which it penetrates being apparently indurated at the junction; and manifests a rudely columnar structure in the mass.

Drift.—Several areas in this district are devoid of boulder clay, chiefly the metamorphic ridge, or a great part of it, the more rugged portions of the surface represented on the map by the upper limestone colour, and the hill-tops on either side of the Drumkeeran valley. The slopes of these hills are, however, covered by this deposit, which in some places reaches 30 feet in thickness, and the streams furrowing the slopes lay open sections of the boulder clay as well as of the underlying shale. Along the mountain foot also—the lowest ground in the sheet—there are small areas at which the rock is visible, or covered only by very thin drift or soil.

In the lower ground of the large area lying S.E. of the metamorphic ridge, over the outcrops of the Lower Limestone, Calp, Upper Limestone, and Yoredale Series, the drift occurs in oblong hillocks, whose longer axes trend westward, in the Drumkeeran valley, and by Riverstown, towards the Ox Range; south-westward in the Larkfield valley, towards Drumahaire; and north-westward, about Thornhill and Annaghmore, near the west margin of the sheet.

In this area the drift is brown and slate-coloured, and contains numerous blocks of limestone, yellow and pale brown grits, greenish gray flaggy sandstone, &c.—many of which are smoothed

and striated. As it approaches and ascends the slopes of the Lackagh hills, and the Curraghs, bounding the Drumkeeran valley, the matrix becomes much darker in colour; and thus, as well as by containing, in its lowest portions especially, fragments of black shale, attests the origin of a large proportion of its bulk.

Near the mountain foot, the drift is gravelly, a very small proportion of clay being admixed. It contains rounded blocks of limestone as well as rounded pebbles of the varieties of rock above mentioned as occurring in the boulder clay. Such gravelly drift also occurs on the north side of the Range, in and near the valley running along the mountain foot, between Aghamore bay and Ballysadare bay; on the north side of the latter bay also, near Seafield, and elsewhere on the S.E. flank of Knocknarea, about Cloverhill, &c.

Near Seafield may be observed an elongated gravel mound, running W. by S., which resembles a true esker. Patches of gravelly drift occupy the small valleys and ravines which cut up the surface north of Lough Gill; and tongues of boulder clay which do not appear to be thick, pass up the valleys by Rookery on the north side, and beyond Gortgarrigan towards Larkfield, on the southern side of the metamorphic ridge.

South of Sligo, the boulder clay contains numerous large blocks of limestone, smoothed and striated; and spreads over the surface in an undulating sheet, not generally thick; indeed the rock at several points is devoid of covering. North-east of the town, similar drift occurs in oblong hillocks, the prevailing trend of which is westward.

An observer is at once struck with a marked point of contrast between the drift on the north, and that on the south side of the metamorphic ridge, viz.:—the large number of metamorphic blocks—chiefly gneiss, which are embedded in, and scattered over the surface of the drift, north of the range, and evidently derived from it. Several of these erratics are of large dimensions, and are found resting on the limestone in areas devoid of, or covered only by, a thin coating of clay.

We have here, therefore, marked corroborative evidence of the direction in which the ice moved, as independently shown by groovings on *roches moutonnées*, crag-and-tails, &c., observable along the ridge at various points, and indicated on the map in the usual manner.

A terrace of sand and gravel occupies a well defined area of about half a square mile, west of Aghamore bay on Lough Gill. From the entire absence of such gneiss blocks as are above referred to, both from its surface and interiorly, while they bestrew the ground adjoining it, its formation is judged to be evidently of later date than the boulder clay and gravel mounds occurring a little to the west. It is banked up against ordinary drift of the locality on the south, and is bounded on the west by the small stream which drains Lough Naminbrack. This stream seems to cut through the terrace before entering Aghamore bay, and there forms a steep bank, upon which a recent opening has

been made for sand or gravel; so that some fifteen feet in depth is well exposed. Alternating layers of fine and coarse sand, with gravel also at intervals, dip away from the lough; and though diligent search was made, no organic remains* were discovered by which to discriminate as to whether the formation is of fresh or sea water origin. One point may be mentioned, possibly bearing on the question, namely, that its average height above datum corresponds exactly with the depth to which the land should be lowered, so as to admit the sea by way of Ballysadare bay, each is approximately seventy feet.

Raised Beaches.—Between Finisklin and Gibraltar, near Sligo, is a strip of silty deposit which rests on boulder-clay, and is from one to three feet in thickness. It is full of cockles and other shells, and, being appreciably above high water mark, seems to be a raised beach. A shell bed, five feet above the strand, a little south-west of Gibraltar, may also have once been continuous with the above deposit.

A larger area than either of the above, on the north shore of Ballysadare bay, connecting Inishmore and Inishbeg with the mainland, now seldom if ever overflowed by the sea, seems to be evidence of a slight elevation of the land.

Peat, Alluvium, &c.—Besides the large tracts of peat covering the mountain tops W. and N. of Drumkeeran, and the high ground at the north margin, several smaller areas sprinkled over the lower ground may be observed. The largest are those N.W. of Drumfin, W. of Belhavel lough, at Annaghmore, &c. Several of these areas enclose loughlets, which suggests the gradual encroachment of the decaying vegetable accumulation upon formerly larger sheets of water. And such may indicate the origin of most of these deposits. The depth to which the peat accumulates is occasionally great; thus, at the south end of Ballydawley lough, a short distance in from the brink, Mr. Herne proved it, by boring, to be thirty-seven feet in thickness. In many instances the peat is in immediate connexion with alluvial deposits, spread out to considerable distances from banks of the river forming these deposits, similarly to enlargements of the river.

Liberty may be taken before closing this section of the memoir, to draw attention to a number of *sepulchral stone circles*, about fifty in number, noted on the six-inch map of the townland of Carrowmore, about two miles south-west from Sligo. They generally lie around, chiefly on the east and south of the carn marked as *Listoghil*, on the one-inch sheet. Stone caves also exists in the locality, as well as a "Caltragh"—a pagan cemetery; and a "Cashel."

Faults.

The complex dislocation of the strata about Ballysadare and Belladrihid forms a link between the great break entering the sheet from the west, and that which forms the northern boundary

* The shells discovered by Mr. Wynne, and referred to in his paper (Jour. Geo. Soc. Dub., Vol. x. p. 39) did not occur in this deposit, but in the gravelly drift.

of the metamorphic band eastward. Thus a wedge of gneiss is brought up between the last mentioned break, and one running south-eastward through Ballydawley lough, against strata of the Carboniferous age; and thick-bedded dark gray limestone is to be seen half a mile east of Ballysadare, belonging, doubtless, to the Lower Limestone division. The continuation of this break along the valley stretching eastward from Belladrihid is attested by the highly cherty Calp and Upper Limestone beds dipping away from the line of fault. This remark applies similarly towards the east margin where a narrow band of Calp is indicated on the map. Strong confirmatory evidence for the existence of this fault is to be found at Dhunee Rock, by the side of the Sligo and Ballintogher road, on the shore of Lough Gill, where massive limestone beds strike at the gneiss, here rising precipitously upward some hundreds of feet, on the south.

The two faults represented as running N.E. and S.E., between Lough Gill and Ballysadare bay have been already alluded to (p. 24). And a few minor faults indicated along the southern flank of the range, and transverse to the Carboniferous boundary, seem established by displacements of that line.

The break which enters the sheet from the south, E. of Riverstown, though of obvious importance, depends for proof of its existence and direction upon evidence obtainable in the adjoining sheet.

Minerals and Mines.

Several minerals of commercial interest have been discovered in the area under description; and some exist in such quantity as to have led to various attempts to utilize them. None of these attempts however have proved fairly successful.

The important deposits of ironstone, north of Drumkeeran, have been already referred to. Here the ore was regularly excavated and systematically smelted, at intervals, for some years until 1858 or 1859, when the works were closed.*

These ironworks, commonly known as those of Creevalea, are situate in the townland of Gowlaun, and the mining was carried on chiefly in Tullynamoyle, two adjoining townlands, lying on the south-western flank of the Bord-al-daig range. All along this slope streams have excavated gullies and ravines, in which deep sections of the Yoredale shale are exposed to view. N.W.

* Note.—The Manager, who has since been retained as caretaker, has given me the following account of the works: They were commenced in 1852 by Mr. Donald Currie, who at great expense erected two large blast furnaces, and a small one, a steam-engine and engine-house, roasting and coaking kilns, tramway to the mine, and cottages for workmen. The proprietor becoming bankrupt in 1854, Mr. Ridges, of London, the mortgagee, purchased the works and rented them to Mr. Potts of Dublin, who carried on the mining and smelting on a small scale. For the latter process he utilized the mountain peat, compressing it according to Buckland's patent, coaking it afterwards with culm obtained some four miles S.E. from Drumkeeren; but, this coke working badly with the blast, the project was abandoned; and since then, the works have not been reopened. The ore was on the spot at less than four shillings per ton. The pig iron was excellent in quality, could be drawn out by hammering; and a *cannon* manufactured from it did service in the Crimean campaign. The only way apparently in which the process could be carried out remuneratively is in having English or Scotch coal transferred by rail to a much nearer point to the works than any at present available.

and S.E. of the townlands above mentioned, ironstone deposits occur; but in no neighbouring ravine are they so rich, as in the two which traverse the small area now under particular notice. Here the deposits resemble those in Slieve-an-ieron, with which they compare favourably in value.

There are several layers of ironstone, both continuous and nodular, but the principal one is a continuous band reaching to ten inches in thickness; it varies, however, and at some points is no more than six or seven inches—nine would be about the average thickness. Over this occurs a seam of shale from four to six feet in thickness, which yields the most productive supply of ore, in the form of nodules, which vary in size up to masses of two tons weight.* Two or three layers of these spheroidal masses occur in the band of shale, and are disposed so as to almost touch each other usually. Internally they are rudely columnar or honeycombed, and they split up along joints coated with red oxide of iron. In colour they are dark metallic gray, and are very dense, being as much as 3·49 sp. gr. Bands of such nodules are interspersed throughout the shales, as has been said, both above and below this horizon, but here they assume their greatest development, and are richest; and by means of a day level run on the seam 1,000 feet eastwards, with cross cuts 36 feet long, a large quantity of rich ore has been extracted. The yield of metallic iron, according to Buchan, is 39 per cent. for the balls, and for the chief bed 38 per cent.†

The limestone in Ballynakill, two miles north-east of Riverstown, contains a small quantity of hematite; heaps of rubbish close by, from an old furnace, may indicate that this source of ore was appreciated years ago. The rubbish contains charcoal and magnetic oxide of iron.

On the south flank of Knocknarea, in Seafield, a well sunk by W. Phibbs, esq. yielded galena, zinc blende, and copper pyrites, from hard flinty Calp limestone.

These minerals occur in larger quantity in Abbeytown, west of Ballysadare, and were followed up to some extent in the mine still open there, which has been worked at intervals for some eighty years, though all work has ceased in it for the past three or four.

The galena contains a considerable percentage of silver; and the principal yield was from a bed of rich lead and zinc ore four

* See an exhaustive paper by Buchan, published by the Roy. Dub. Soc., Vol. ii. p. 8. Free use has been made of this excellent paper in the preparation of a portion of this Memoir.

† The following analyses are taken from Mr. Buchan's paper, who also gives analyses of ferruginous shales of this locality.

—	Carbonate of Iron.	Carbonate of Lime.	Carbonate of Magnesia.	Alumina.	Clay & Silica (from decomp. Silicates).	Organic Matter.
Balls, . . .	82·07	4·13	traces.	1·4	11·6	·8
Chief bed, . .	78·92	–	5·88	1·4	11·75	2·05
Second bed, . .	73·53	–	11·92	1·4	11·30	1·85

to six inches in thickness. This was worked by means of a day level run southwards, a short distance into the bank which slopes upward from the shore of Ballysadare bay. Some hundreds of tons of ore have been put out by Mr. Middleton, the late partner of the firm Middleton and Pollexfen, of Sligo, &c.

A pit was also sunk at the same place, fifty-two feet deep, showing the following section :—

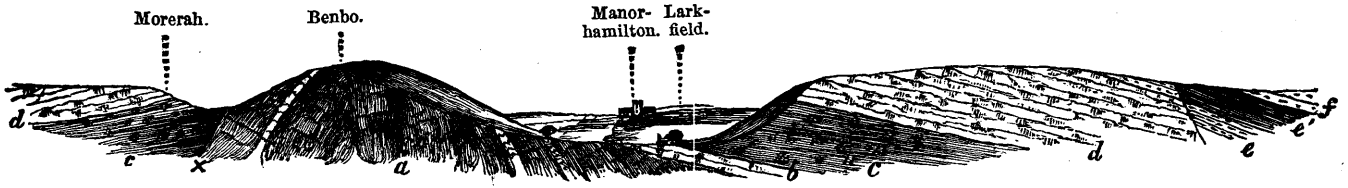
SHAFT SECTION, 25 FEET, AT SILVER-LEAD MINE, BALLYSADARE.

	Feet.	Inches.
Surface clay and soil,	7	0
1. Dark gray limestone, very compact, calcite veins, and galtena in specks,		
2. Same as above, with zinc blende and galena,		
3. Same as 2, but less ore,	7	0
4. Same, with a good deal of calcite and galena,		
5. Very metaliferous specimen, same as above,		
6. Limestone with calcite, metaliferous, not so good,		
7. Same as 6,	2	0
8. Heavy black limestone, much black jack and galena,	1	7
9. Same as 8,	1	8
10. Black limestone, with blende and galena, not so rich,	2	0
11. Same, but richer in ore,	1	8
12. Same,	2	0
13. Same,	1	6
14. Black limestone, very little ore,	1	6
15. Dark gray limestone, with galena and blende,	1	6
16. Same,	1	8
17. Same, but poorer,	2	0
18. Same, but richer,	2	0
19. Same, poor,	1	6
20. Same, richer and heavy,	1	4
21. Limestone, with blende and calcite,	1	8
22. Same, with good deal of galena,	2	0
23. Same, with much zinc, poor,	1	6
24. Same, with iron pyrites,	1	7
25. Same, richer,	1	7
26. Same, poorer,	1	11
27. Stuff with much blende, and some galena,	1	6
28. Limestone, with much zinc blende,	2	0
	52	0

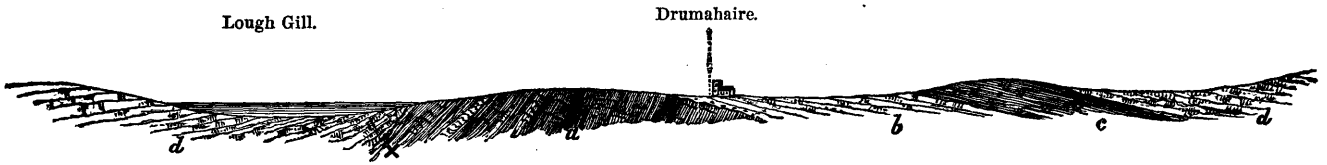
Note: The above section has been copied from pencil note on the back of Mr. Hardman's six-inch map.

Copper pyrites occurs in this mine, in a vein of blackish quartzose grit; and traces of the same mineral were discovered in Shancarrick, two miles north of Belhavel lough.

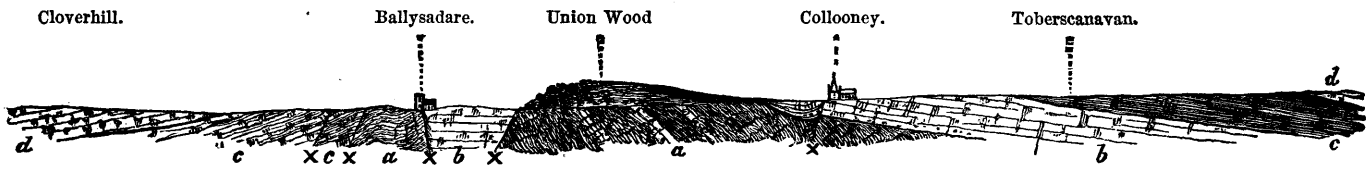
J. R. K.



SECTION 1.—Across Larkfield valley showing (*a*) Gneiss, with beds of quartzite; (*b*) Lower Limestone; (*c*.) Calp; (*d*) Upper Limestone; (*e*) Yoredale Sandstone; (*e'*) Yoredale Shale; (*f*) Millstone Grit; (*x*, *x*, *x*) faults, &c.



SECTION 2.—N. Westward through Drumahaire, showing (*a*) Metamorphic series; (*b*) Lower Limestone; (*c*) Calp; (*d*) Upper Limestone and fault (*x*).



SECTION 3.—Nearly N.S. through Collooney, showing (*a*) Gneiss with beds of quartzite; (*b*) Lower Limestone; (*c*) Calp; (*d*) Upper Limestone, and (*x*, *x*, *x*, *x*, *x*) faults.

Palæontological Notes.

Localities from which Fossils were collected.

No of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Situation, Geological Formation, and Sheet of 1-inch Map.
		County of Sligo.	Carboniferous Limestone.
1	14/2	Bellanode and Rath-quarter.	Half a mile north-east of Sligo; dark gray flaggy limestone. (Lower Limestone on Map.)
2	14/2	Ballytivnan, . .	Quarry on road to Bundoran, one mile north of Sligo; dark gray limestone. (Lower Limestone on Map.)
3	14/2	Ballincar, . .	Old quarry on road to Rosses, one and a half miles north-west of Sligo; light bluish gray limestone. (Lower Limestone on Map.)
4	14/2	Finisklin, . .	Rocks on shore at Gibraltar, Sligo Bay, one and a half miles west of Sligo; dark gray limestone. (Calp or Middle Limestone on Map.)
5	14/4	Magheraboy, . .	Rocks in cutting of Longford and Sligo Railway, half a mile south-west of Sligo; dark gray shales and decomposing cherty limestone. (Lower Limestone on Map.)
6	14/4	Carns, . . .	On old road, one mile south-east of Sligo; gray limestone. (Upper Limestone on Map.)
7	15/1	Colgagh, . .	On road three miles east of Sligo, one mile north-east of Colgagh Lough; dark gray shaley limestone. (Lower Limestone on Map.)
8	15/3	—	Church Island, Lough Gill, rocks on shore, east of Old Church; cherty dark gray limestone. (Lower Limestone on Map.)
9	20/1	Abbeytown and Streamstown.	Rocks on shore at several places in Ballysadare Bay, one and a half to two miles west of Ballysadare; light gray limestone. (Lower Limestone on Map.)
10	20/2	Drumaskirbole, .	Quarry on road to Sligo, one mile north of Ballysadare; dark gray limestone. (Calp or Middle Limestone on Map.)
11	20/2	Carrowgobbadagh, .	On old road from Ballysadare to Sligo, one and a half miles north of Ballysadare; dark gray cherty limestone. (Calp or Middle Limestone on Map.)
12	20/3	Abbeytown, . .	Quarry one mile west of Ballysadare; light gray limestone. (Lower Limestone on Map.)
13	20/4	Cloonmacduff, .	A little north-east of Collooney. (Lower Limestone on Map.)
14	21/3	Kilross, . . .	South end of Lough Dargan, four miles east of Ballysadare; dark gray limestone. (Lower Limestone on Map.)
15	21/3	Tiratick, . .	Quarry near Ballintogher Railway Station and Railway Cutting near ditto; gray compact limestone. (Lower Limestone on Map.)

List of the Fossils collected from the Localities mentioned in the preceding Table.

The numbers opposite each species refer to the places at which they were collected, and the × placed before some of them is intended to denote their comparative abundance.

CARBONIFEROUS LIMESTONE.

Actinozoa.

	Localities.
Chætetes tumidus,	1.
Cyathophyllum ceratites,	4, 8, 11.
„ or Zaphrentis,	1, 9, 14, 15.
Lithodendron affinis,	×× 4, ×× 6, ××× 7, ××× 8, ××× 10, ×× 11, 12.
„ junceum,	7, 11.
Lithostrotion Portlocki,	×× 8.
Syringopora geniculata,	9, 10, 15.
„ reticulata,	× 10.
Zaphrentis cylindrica,	×××× 4, 8, 10, 11, 15.

Echinodermata.

Actinocrinus lævis,	1, 2, 5.
„ sp.	5, 7, 11.
Poteriocrinus crassus,	2, 4.
Crinoid fragments,	1, ×× 2, ××× 3, 4, 5, ××× 6, 7, 13, ×××× 14, ××× 15.

Polyzoa.

Ceriopora rhombifera,	7.
Fenestella antiqua,	1, 2, ××× 5, ×× 6, 7.
„ tenuifila,	2, 5, 7.
„ verrucosa,	2.

Brachiopoda.

Athyris planosulcata,	1, 7, 9, 10, 12, 13, 14.
„ Royssii,	13.
Chonetes Hardrensis,	7.
„ papilionacea,	14, 15.
Orthis resupinata,	13, 14, 15.
Productus fimbriatus,	7.
„ giganteus,	3, 4, 6, 8, 10, 11, 13, 14.
„ punctatus,	3, × 6.
„ scabriculus,	7.
„ semireticulatus,	1, 3, 5, ××× 6, 7, 8, 9, 10, 12.
Rhynchonella pleurodon,	2.
Spirifera bisulcata,	4, 7, 15.
„ glabra,	4, 9, 14.
„ laminosa,	4, 12.
„ striata,	3, 7, 14.
Spiriferina cristata,	1, 6, 7, 9.
Streptorhynchus crenistria,	5.
Terebratula hastata,	15.

Lamellibranchiata.

Aviculopecten ellipticus ?	13.
„ granosus,	1, 12.
„ interstilialis,	6.

GASTEROPODA.

	Localities.
Euomphalus Dionysii,	12.
,, pentangulatus,	6, 11, 15
,, pileopsideus,	12.

HETEROPODA.

Bellerophon apertus,	3, 12, 15.

CEPHALOPODA.

Nautilus sub-sulcatus,	12.

TRILOBITA.

Phillipsia pustulata,	1, 5.

WILLIAM HELLIER BAILY.

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INDEX.

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