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Department of Agriculture and Technical Instruction for Ireland.

MEMOIRS OF THE GEOLOGICAL SURVEY OF IRELAND.

EXPLANATORY MEMOIR TO SHEET 58,

ILLUSTRATING PARTS OF THE

COUNTIES OF ARMAGH, FERMANAGH, AND MONAGHAN.

(SECOND EDITION),

BY

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PREFACE.

THE first edition of this Memoir was issued in 1885, and was prepared by Mr. R. J. Cruise, with palæontological notes by Mr. W. H. Baily. Advantage has been taken of the demand for a new edition to considerably amplify the subject matter, particularly as regards the glacial features, the minerals, and the relation of the soils to agriculture. A considerable mass of gabbro, first brought to the notice of the Survey by Mr. R. Clark, and used for road-metal and building, has been mapped and described. The assistance of Dr. G. W. Lee in naming a number of Carboniferous fossils is gratefully acknowledged.

The country described is typical of the Silurian lands that stretch from near Longford to the coast of Down and into the Southern Uplands of Scotland. Carboniferous beds appear in the north-west. Especial interest is attached to the glacial deposits, as forming thoroughly representative landscapes in the region where the elongated and rounded mounds known as drumlins were first defined.

GRENVILLE A. J. COLE,
Director.

13*th March*, 1914.

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CHAPTER I.

GENERAL FEATURES OF THE AREA.

Area and Scope of the Map (Sheet 58).

The greater part of the ground described in this memoir, which deals with a total area of 216 square miles, lies in the County of Monaghan; small tracts in the N.E. and N.W. of the district lie in the counties of Armagh and Fermanagh respectively.

The towns included are Monaghan, Clones, Ballybay, Rockcorry, and Newbliss, with the village of Smithborough, in Co. Monaghan, and the small town of Rosslea in Fermanagh.

Place-Names.

In Rushe's "Historical Sketches of Monaghan,"* may be found many items of interest to the student of the history and archæology of the Monaghan district, and in this volume the author also gives an interesting account of the origins of the local place-names. Such of these as are of topographical interest are quoted here: the name Monaghan itself is a corruption of an old Irish word Muineachan, meaning "Town of the Monks," or according to some authorities, "a place surrounded by little hills." Annahagh means the kiln of the marsh; Knocknaturley, the hill of the dried-up lough; Killygowan, the smith's wood; Carrickanoran, the rock of the cold spring; Corlat, the round hill of the monument; Cornacassa, the round hill of the bridges; Corness, the round hill of the cataract; Cornamunady, the round hill of the long shrubbery; Drumhirk, the ridge of the boar; Mullaghmat, the withered summit; Tanderagee, the hill of the winds; Tully, a hill; Tullyard, the high hill; Tullyhirm, the dry hill; Uirbalkirk, the hen's tail; Ballybay, the ford of the birch; Clones, Eos's meadow—Eos was a pagan chief; Clontibret, the meadow of the spring, etc. Drum, meaning a back or ridge, enters into the composition of many local place-names, as Drumbarnet, Drumbear, Drumreask, etc., and is the same form as that occurring in the word drumlin (see chapter on the Superficial Deposits, p. 14).

Physical Geography and Geology.

The tract of country south of an undulating line forming the boundary between the Carboniferous and Ordovician (Lower Silurian) rocks, and running from the N.E. corner of the district

* Dublin, Duffy & Co., 1895.

in a W.S.W. direction, passing about a mile south of the town of Monaghan and village of Smithborough, and leaving the western margin of the sheet two miles south of Clones, presents a very irregular surface. Numerous elongated hummocks or low hills, ranging from 400 to 700 feet high, with a general E.N.E. trend, corresponding to the strike of the underlying rocks, are the dominant features of the landscape. The hummocks are largely due to the irregularities of the rock floor, but the rock contours, as in the N.E. of the district, where the ground is covered with a thick accumulation of drift, are often considerably modified by a superficial covering of boulder-clay. The ridges here follow the trend of a former ice-sheet which overspread the area, and which will be referred to further on (see page 16).

To the west and north of the town of Monaghan the ground is comparatively flat or slightly undulating, the heights rising from 200 to 300 feet above datum. In this area the drift ridges trend in a general N.E. and S.W. direction.

The rocks included in the area represented by this sheet belong to the Carboniferous, Gotlandian (Upper Silurian), and Ordovician (Lower Silurian) formations. Of these the Carboniferous beds occupy a triangular tract of some 75 square miles in the N.W. corner of the sheet, and the Gothlandian a similar tract of about 45 square miles in the S.E. corner, while the Ordovician is represented by a belt, about 5 miles wide, stretching across the sheet in a direction nearly N.E. and S.W.

A valley, particularly well marked from Smithborough westwards, runs along the undulating line above mentioned. This valley is in many places covered with bog and alluvial flats.

The junction between the Carboniferous and Ordovician rocks lies to the south of this valley, the latter rocks forming a gentle shelving floor over which the Carboniferous beds were originally deposited.

The highest ground in the district, over 700 feet above datum, is in the N.W. corner of the map, where the limestones are capped by Yoredale sandstones which form the southern termination of the Slieve Beagh plateau. No outcrop of these sandstones was observed, the ground being covered with drift; but the evidence to the west and north, and the continuation of the plateau escarpment indicate beyond doubt the occurrence of these beds as shown on the map.

The drainage of the district is effected by three distinct water-channels. To the south and west of Monaghan the greater part of the rainfall flows into the Erne river; the Blackwater flowing through Scotstown carries the drainage of that district into Lough Neagh; while the waters from a small tract in the south-east flow into Muckno Lake at Castleblayney, and finally into the sea at Dundalk Bay.

The shape of the ground presents the usual character due to the underlying rocks, namely, an irregular, knotty outline where the rock is of Silurian age; and the comparatively low-

lying and undulating plain, with bogs and alluvial flats, where the Carboniferous beds prevail.

The geology of the district has been slightly referred to by Sir Richard Griffith and John Kelly, in their papers on the subdivision of the Carboniferous rocks of Ireland.*

Reference to the lead deposits at the eastern margin of the sheet is to be found in Sir Richard Griffith's "List of Mining Localities," † and an account of the iron-ore deposit of Calliagh appears in a paper by Prof. O'Reilly, published in the Proceedings of the Royal Irish Academy.‡

CHAPTER II.

STRATIFIED ROCKS.

This chapter treats of the geological formations of the district. The sedimentary series are dealt with in ascending order.

List of Systems and Series Entering into the Structure of the District.

SEDIMENTARY ROCKS.

Post-Pliocene and Recent.

Alluvium.
Peat.
Glacial Drift.

Carboniferous.	Sign on Map.
Yoredale Series.	d^3
Upper Limestone.	$d^{2'''}$
Calp or Middle Limestone.	$d^{2''}$
Lower Limestone.	$d^{2'}$
Gotlandian (Upper Silurian).	
Llandovery.	b^4
Ordovician (Lower Silurian).	
Caradoc or Bala.	b^3
Llandilo.	b^2
Igneous Rocks.	
Gabbro.	Gb.
Dolerite, Basalt.	B.

* Dublin Quarterly Journ. Science, vol. ii. and 13th. Report Brit. Assoc. (1843), p. 42 et seq.

† Journ. Geol. Soc. Dublin, vol. ix. (1860), p. 140.

‡ Series 3., vol. i. (1889-91), pp. 446-53.

LOWER AND UPPER SILURIAN SYSTEMS.

Nearly two-thirds of the entire area of this sheet are occupied by Silurian beds, the remaining third being referable to different sub-divisions of the Carboniferous System. When the original survey of the north-east of Ireland was being made, all the Silurian rocks of that region were mapped as Lower Silurian, certain indefinite areas, that of the Monaghan district among them, being considered as representing the Bala and Caradoc of Wales, while others were regarded as belonging to the same stratigraphical horizon as the Llandilo deposits of the latter country. A subsequent revision of the geology of this portion of the Irish Silurian area, carried out by the officers of the Survey, revealed new fossil localities, and furnished evidence which enabled the officers to trace the boundaries of the principal sub-divisions of the Silurian System that had been already recognised in the corresponding rocks of the Southern Uplands of Scotland. Thus it became possible to continue the boundary line between the Upper and Lower Silurian of the Scottish rocks into the Irish area, and to extend it almost in a straight line from Copeland Island, east of Belfast, by Lisburn, Gilford and Cavan, to near Lough Gowna in Longford. To the south of this line the Silurian rocks are predominantly of Gotlandian age, with, here and there, patches of the underlying Bala beds appearing at the surface. North of the same boundary line a narrow belt of Lower Silurian beds, consisting mainly of Caradoc grits and slates, separates the Upper Silurian from the outcrop of Carboniferous strata that lies beyond. The belt runs from N.E. by E. to S.W. by W. through the centre of the Monaghan area, having an average breadth of about five miles.

Ordovician (Lower Silurian). LLANDILO BEDS.—Protruding through the Caradoc or Bala grits and slates, about a third of a mile north-east of the town of Newbliss, a small, irregular, lens-shaped inlier of Llandilo Beds has been noted. These beds consist of dark shales and mudstones with occasional dark cherty bands, dipping at a high angle (45°-60°) to the W.S.W., and in places to the N. at 20°. A good section of the rocks may be seen in the railway cutting a little to the east of Newbliss Railway Station, where the beds are fossiliferous. Several graptolites, including the zonal species of the Glenkiln shales, *Cœnograptus gracilis*, have been found here, associated with *Climacograptus bicornis* and *Dicellograptus*.

CARADOC OR BALA BEDS—As has been already stated, this formation occupies a belt about five miles broad, running N.E. by E. to S.W. by W. through the centre of the present sheet. No fossils have been found in these beds within the limits of the sheet, but at Lisglynn, two miles beyond the N.E. corner of the area, graptolites have been found in the shales of this formation.

The rocks generally consist of hard greenish, greyish, and bluish grits, with occasional bands of dark grey and purplish flags and shales. The general strike of the beds is E.N.E., and the dip, with few exceptions, south-south-easterly at angles varying from 25° to 80°, the general dip being 60°.

As a rule the rocks are covered with Glacial drift, but good sections were observed in the following localities: E. of Castleshane, on the main road between Monaghan and Castleblayney, dark grey grits and shales were noted, dipping S.S.E. at 55° to 60°; similar beds can be seen along the same road as far as Milltown. At the latter locality delicately laminated bluish flags interstratified with hard greyish grits dip S.S.E. at 80°. In the quarries at Cormeen, 1 mile S.E. of Rossmore Castle, near the main road leading from Monaghan to Rockcorry, dark shales and sandstones dipping S.S.E. at 30° were noted; and in several places, such as Killeevan, 2 miles N.W. of Newbliss, and at Garran, 4 miles N.E. of the same locality, massive green grits are exposed. At Monaghan Road Railway Station, there are quarries in thick-bedded green and blue grits, and at the Presbyterian Meeting House, 1½ miles N.E. of the station, a quartz lode 2 feet wide was noted in massive fine conglomeritic grits. Only one more locality in the Ordovician belt need be referred to here, namely, that at half a mile E. of Smithborough, where blue and purple slates and micaceous shales are brought up along a line of fault against the Lower Limestone.

Gotlandian (Upper Silurian). LLANDOVERY BEDS.—These beds, which are the only representatives of the Gotlandian formation in this district, occupy about 45 square miles in the south-eastern portion of the sheet. They consist of dark fissile slates, massive grey and green grits, flags and shales, dipping to the S.S.E. at high angles. Fossils have been found in this formation only at two localities within the sheet, namely, at Derryarrily, 3½ miles N.N.E. of Ballybay, where the black shales yielded the graptolites *Climacograptus scalaris*, *Diplograptus*, and *Monograptus tenuis*, and at Cordevlis, 1 mile E.N.E. of Rockcorry, where the black shales have furnished specimens of the last-mentioned species.

From south of Milltown to the margin of the sheet, there are numerous sections in grey grits, flags, and shales, all dipping southwards. Most of these exposures occur as low, smooth, ice-planed, and occasionally striated rock masses. South and north of Ballybay, massive grey and green grits, with straggling quartz strings, occur in irregular knolls and bosses, all dipping southwards at angles from 55° to 60°, and at the town of Rockcorry green and blue grits and slates, very much broken by joints, are exposed.

The foregoing description represents fairly the general character of the different sub-divisions of the Silurian formation in the district, with the principal localities where the rocks

can best be studied. A reference to the map will, however, show numerous other places where the beds are exposed, but they are all similar to those already described.

It has been stated above that throughout the area both the Ordovician and Gotlandian beds preserve a prevalent dip towards the S.S.E., and often at high angles. It must not be supposed that this indicates a regular descending series from the highest to the lowest beds in either of the formations. There is, indeed, every probability that, as in Scotland, the strata were intensely plicated in pre-Carboniferous times, so that the beds are folded back upon themselves and repeated in many anticlinal and synclinal folds; such foldings in the Gotlandian beds may be actually observed along the coast sections to the S. of Newcastle, Co. Down. Thus, notwithstanding their high angles of dip, the strata occupy considerable breadths of ground, making their apparent thickness far greater than the reality. The lens-shaped outcrop of Llandilo rocks near Newbliss is an anticlinal arch of the older part of the system showing through the superincumbent younger strata.

CARBONIFEROUS SYSTEM.

Although the rocks of the Carboniferous System occupy about 75 square miles in the N.W. portion of the sheet, comparatively few exposures of the beds are to be seen, owing to the general covering of the ground with drift. Numerous fossils have been found in the calcareous beds, but, unfortunately, these have proved to be of little or no value for the purpose of zoning. The coral *Lithostrotion martini*, from Drumbarnet, two-thirds of a mile N.E. of Bellanode, however, shows that the beds of that locality correspond with the Lower Visean (S_1) or some higher zone of the Avonian Section. The boundaries marked on the map between the different subdivisions of the Carboniferous strata are largely conjectural, and are determined in part from evidence drawn from the Carboniferous areas of the adjoining sheets.

Lower Limestone.—With an outcrop varying from about 2 to 4 miles in breadth, these beds extend across the district in a belt running in a direction almost N.E. and S.W. The rocks consist generally of light or dark grey and blue crystalline limestones, with a few shaly beds. In some cases, as at Kildoagh, near the 11th lock of the Ulster Canal, the limestone deposits are highly arenaceous.

Sections of the rocks may be conveniently studied at the following localities. Half a mile W. of Monaghan, in Cornacassa demesne, there are quarries in thick-bedded grey crystalline limestone dipping W. 10° N. At the fault-boundary E. of Smithborough, dark blue thick-bedded limestones with shale partings dip N.W. at 25°. The limestone is

much used for building and for road-metal. At the bend in the river south of Smithborough, there is an exposure of dark grey shaly limestones dipping N. at 5°. In the river, two miles S.W. of the latter locality, similar beds were observed quite close to a basaltic dyke. Midway between Smithborough and Clones, at Stonebridge, there are numerous quarries in blue thin evenly bedded limestone, with shale partings; the beds dip here at the comparatively high angle of 30°. A quarter of a mile N.E. of these quarries there is a well marked synclinal curve in greyish blue limestone. The only remaining locality which calls for notice is along the railway at Clones, where dark blue thick-bedded limestones dip N. at 25° to 30°.

CALP OR MIDDLE LIMESTONE.—Although occupying a far wider tract of country than the Lower Limestone, fewer exposures of these beds were noted, the rocks being hidden beneath a more uniform covering of drift.

A good section may be seen at Drumbarnet, two-thirds of a mile N.E. of Bellanode, where fossiliferous limestones and shales dip N. 20° W. an an angle of 30°. At the cross-roads near Clonamully House, south of Scotstown, thin flaggy and shaly limestones were noted, and in the river section, half a mile S.E. of the village, dark grey shaly limestones occur. Half a mile west of the same village, also in the river section, black shaly fossiliferous limestones dip N. at 10°. At Drumloo Bridge, 2½ miles W.S.W. of Scotstown, similar beds were observed.

UPPER LIMESTONE.—This deposit consists of a narrow band one mile in breadth, breaking off in a steep scarp or ridge facing the south. No rock-exposures were noted, and the boundaries of the formation indicated on the map had to be drawn from the shape of the ground. Where the rocks are seen in the districts to the west and north, they consist of light grey evenly-bedded limestone.

YOREDALE SANDSTONE.—As already stated (page 2), these beds are entirely concealed by drift. They are, however, well shown in the escarpment surrounding the Slieve Beagh plateau, to the north and west, beyond the margin of the sheet, where they vary from pale yellow grits to siliceous sandstone, similar in character to the overlying Millstone Grit.*

CHAPTER III.

IGNEOUS ROCKS.

GABBRO.—About 2½ miles south of Monaghan town a mass of igneous rock extends from the townland of Beagh to that of Carrickanoran, along the general strike of the Silurian beds.

* See Memoir of Geol. Survey, Explanation to Sheets 45, 46, 55.

The mass, which is about 2 miles long by about ¼ to ⅓ mile wide, is difficult to map, its boundaries being mostly obscured by a thick covering of drift. Good sections of the rock may be seen on the old road at Mullyknock and again to the east of the road at Tanderageebrack, where it has been quarried for building purposes and for road metal. The rock is a handsome dark green gabbro, coarsely crystalline at its core, but fine-grained and aphanitic at the edges of its outcrop, where it has been chilled by the Silurian deposits into which it was intruded. The latter circumstance indicates that the rock is subsequent in age to the Silurian rocks of the district, and as it follows the direction of the axis of folding, and as far as could be observed shows no cleavage structure, the presumption is in favour of the mass having been intruded during the folding of the Silurian rocks which took place in early Devonian times.

Microscopic characters :—The coarser variety from Tanderageebrack is an altered gabbro, in which the rod-like felspars crystallised before the augite, which thus occupies the interspaces, often without regular form. Ophitic structure is, however, absent. Some of the finer material of the former groundmass has decomposed to chlorite, and the species of the felspar is no longer determinable. The outermost zone of the felspar prisms remains commonly clear and transparent, and appears to result from re-crystallisation, since it presents a ragged and irregular surface, spreading out into areas which were no doubt once occupied by fine-grained matter, and which are now filled by chlorite. Magnetite appears in skeletal forms, some of which suggest its derivation from the iron set free during the decay of olivine.

The marginal zone of the above rock, as seen at Carrickanoran, is aphanitic in grain and is very compact. It consists of minute rods of felspar with interstices occupied by pyroxenic granules. The alteration of the felspar conceals any twining that it may have possessed. The rods occasionally show the tufted grouping that connects these compact rocks with the variolites. Calcite occupies a number of small crevices in the altered mass. Were the grain coarser, the rock would no doubt appear as an ordinary augitic dolerite, in which the felspar crystallised first, leaving the residual magma to form granular pyroxene in the interstices. Small green pseudomorphs lie scattered in the ground, which suggest the former presence of olivine. The specific gravity of the rock is 2·80.

G.A.J.C.

Dolerite.—South of Corcaghan Lough, and about 2½ miles north of Monaghan Road Railway Station, a great dolerite dyke, from 60 to 65 yards in width, runs at first S.E. to N.W.

and then bends round to the west, extending in a nearly E. and W. direction. This dyke is probably of Tertiary age.

Microscopic characters :—This rock is an ophitic olivine-dolerite of somewhat fine grain, in a well-preserved state. Globules of residual brown glass occur, resembling those in the Tynemouth dyke* described by J. J. H. Teall. There is little doubt that this rock, like that of Stonebridge, belongs to the Cainozoic series.

G.A.J.C.

A little farther west, at the southern corner of Greagh Lough, may be seen a dyke of altered dolerite.

Microscopic characters :—This rock has a general resemblance to the gabbro of Tanderageebrack, but is on a finer scale than the specimen described from that locality. The rods of repeatedly twinned felspar are decomposed and dusky, and the pyroxene, once present in the interstices, has passed into chlorite, in which some residual granules lie. Chlorite lines cavities in the rock, the centres of which have been filled by calcite. In places, pyrite has developed in groups of cubes, which sometimes exhibit parallel growth. Fibrous chalcedony seems the latest product of decay or infiltration, and fills up interspaces between the pyrite crystals.

G.A.J.C.

Two and a half miles S.W. of Smithborough an evenly crystalline dark blue dolerite dyke, 150 yards wide, was noted both in the railway cutting and on the river bank, to the S.E.

Microscopic characters :—This rock is a well-preserved ophitic olivine-dolerite, verging towards basalt. The order of crystallisation of the minerals is felspar (basic labradorite), olivine, magnetite, augite. The fact that the two latter minerals are here rarely associated suggests that the magnetite developed as a final product of a tachylytic ground-work, very rich in iron, which remained interstitially in the felspar mesh in places from which the pyroxenic ingredients had been drained to form augite elsewhere. The rock agrees in general characters and condition with the basalts of the Cainozoic dykes of northern Ireland.

G.A.J.C.

Basalt.—Several basalt dykes were noted along the eastern margin of the sheet. At Clonaneor, a quarter of a mile north of the Dundalk and Enniskillen Railway, and close to the eastern margin of the map, a dark blue finely crystalline basalt dyke, seven yards wide, occurs, and farther north, at Cremartin

* " British Petrography " (1886), p. 203, and " Amygdaloids of Tynemouth Dyke," Geol. Mag., 1889, p. 481.

Lough, a similar dyke was observed. In the latter case the basalt was rudely columnar. Another dark fine grained basalt with zeolites occurs as a dyke at Crossaghy and Coolartragh. All these dykes have a N.W. and S.E. trend and are presumably of Tertiary age.

CHAPTER IV.

PALÆONTOLOGICAL NOTES.

LOCALITIES FROM WHICH FOSSILS HAVE BEEN COLLECTED.

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Geological Formation, Situation, and Lithological character of the Fossiliferous Rocks.
		Co. MONAGHAN	ORDOVICIAN (LOWER SILURIAN) Llandilo.
1	17/2	Newbliss.	Railway cutting a little to the east of Newbliss Railway Station; mudstones and dark shales with occasional cherty bands.
			GOTHLANDIAN (UPPER SILURIAN) Llandovery.
2	14/3	Derryarrilly.	Rock exposure 3½ miles N.N.E. of Ballybay; black fissile slates with yellow bands.
3	18/4	Cordevlis.	Quarry 1 mile E.N.E. of Rockcorry; black shale.
			CARBONIFEROUS.
4	7/3	Hillhall.	Quarry a little N.E. of Faulkland Bridge; dark bluish limestone and black shale.
5	8/2	Foremass.	Rocks in River Blackwater, south of Carrachor House, close to the road, a little west of Scotstown; dark grey limestone and shale.
6	9/1	Edenbrone.	Two-thirds of a mile S.E. of Scotstown; dark shaly limestone.
7	9/1	Drumbarnet.	Two-thirds of a mile N.E. of Bellanode; grey flaggy limestones and shales.
8	9/2	Telaydan.	Quarry, in a field near Lamb's Lough, one mile and a half N. of Monaghan; earthy light grey limestone.
9	9/2	Crumlin.	Rocks on the banks of the River Blackwater at Faulkland Bridge Upper; sandy limestone and dark grey shale.

The memoir of the Geological Survey of Ireland on Sheet 58 of the one-inch map, which includes the country round the town of Monaghan, is now reissued in a revised form. The opportunity has been taken to add a chapter on the relation of the soils to agriculture in the district, and to describe the mound-like hills (drumlins), formed of glacial boulder-clay, which give such diversity to the surface. A small coloured geological map is inserted in the memoir.

This publication, price $3\frac{1}{2}d$, may be obtained through any bookseller from Mr. T. Fisher Unwin, 1 Adelphi Terrace, London, W.C., who is the sole Wholesale Agent to the Trade in the British Isles outside the County of London; or from the Director-General, Ordnance Survey Office, Southampton.

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LOCALITIES FROM WHICH FOSSILS HAVE BEEN COLLECTED—*con.*

No. of Locality.	Quarter Sheet of 6-inch Map.	County and Townland.	Geological Formation, Situation, and Lithological character of the Fossiliferous Rocks.
10	9/2	Straghan or Carnasore.	Rocks on the banks of the River Blackwater at Faulkland Bridge; dark grey limestone and shale.
11	9/4	Roosky.	Old quarry near Infirmary, at the east end of the town of Monaghan; dark grey limestone and shale.
12	9/4	Annahagh.	Old quarry between preceding locality and the Fever Hospital; light grey calcareous beds.
13	9/4	Killygowan.	Quarry a little south of the town of Monaghan; grey limestone and shale.
14	10/1	Kildoagh.	Quarry near the 11th Lock of the Ulster Canal; arenaceous limestone.
15	12/1	Latgallan.	A little N.E. of Stonebridge, three miles N.E. of Clones; dark blue compact limestone.
16	12/2	Skervan.	Rock-cuttings and quarry on the banks of the Ulster Canal, about half a mile S.E. of Smithborough; dark grey limestone and shale.
		Co. FERMANAGH	
17	35/2	Errasallagh.	Rock-exposures, and quarry 4 miles W.N.W. of Rosslea, a little west of margin of sheet 58; grey crystalline limestone and dark and grey shales.

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 mark **x**, where placed before them, is intended to denote their comparative abundance. The Carboniferous fossils determined by the late Mr. W. H. Baily are indicated on the list by an asterisk placed after their names.

All the other Carboniferous fossils have been kindly named by Dr. G. W. Lee of the Geological Survey of Great Britain.

ORDOVICIAN (LOWER SILURIAN).

LLANDILO.

HYDROZOA; Graptolitoidea.	Localities.
Climacograptus bicornis	1
Coenograptus gracilis	1
Dicellograptus sp. indet.	1

GOTLANDIAN (UPPER SILURIAN).

LLANDOVERY.

HYDROZOA; Graptolitoidea.	Localities.
Climacograptus scalaris	2
Diplograptus sp. indet.	2
Monograptus tenuis	2, 3

CARBONIFEROUS.

PLANTÆ.

Plants, branching or dichotomous. ? Algæ	12

PORIFERA; Hexactinellida.

? Hyalostelia parallela (M'Coy)	17

ACTINOZOA; Zoantharia.

Campophyllum or Caninia	x 7
? Caninia	7
Chætetes tumidus *	5, 8
Lithostrotion martini, M. Edw.	7
Michelinia grandis, M'Coy	7
Zaphrentis sp. indet.*	7

ACTINOZOA; Alcyonaria.

Stenopora sp. indet.	7
Syringopora sp. indet.	x 15

ECHINODERMATA; Crinoidea.

Crinoid fragments,	5, xxx 8, xx 10, 11, 16, 17
Poteriocrinus crassus *	10

ANNELIDA; Chætopoda.

Spirorbis caperatus (M'Coy)	6

BRACHIOPODA.

Athyris planosculata *	5, 16
Athyris sp. indet.	5, 7, 14
Chonetes hardrensis *	10
Chonetes sp. indet.	13
? Davisiella sp. indet.	14
Orthothetes sp. indet.	7, 14, 15, 16, 17
Productus cf. concinnus (Sow.)	9, 16
Productus giganteus *	16
Productus cf. punctatus (Mart.)	16
Productus semireticulatus *	11, 12, 15
Productus cf. undatus (Defrance)	14
Productus sp. indet.	17
Rhynchonella sp. indet.	4
Spirifer bisulcatus *	16

	Localities.
Brachiopoda—*con.*	
Spirifer cf. convolutus (Phill.)	17
Spirifer striatus *	10, 12, 16
Spirifer sp. indet.	17
Spiriferina cristata *	12
Streptorhynchus crenistria *	5, xxx 12, xxx 16
Syringothyris sp. indet.	14
Polyzoa.	
Fenestella antiqua *	5
Fenestella sp. indet.	x 16, 17
Mollusca; Heteropoda.	
Bellerophon apertus *	16
? Grammatodon cingulatus (M'Coy)	6, 17
Crustacea; Ostracoda,	
Leperditia okeni *	xxx 9
Pisces.	
Palatal teeth	4, 9

Remarks on the Fossils.

The fossils from the Carboniferous strata are of ordinary types, and are not very abundant except at a few localities; the small bivalve crustacean, Leperditia okeni, at locality 9, the brachiopod, Streptorhynchus crenistria, at localities 12 and 16, and crinoid fragments at localities 8 and 10 are comparatively numerous. Many of the specimens from both the Silurian and Carboniferous strata are very imperfectly preserved, which renders the naming of them a matter of considerable difficulty.

CHAPTER V.

SUPERFICIAL DEPOSITS.

These deposits, consisting of glacial drift, bog, and alluvium, cover most of the area dealt with in this memoir. It is only on the eastern and south-eastern portions of the sheet that any extensive exposures of solid rock were noted. The remainder of the area is for the most part covered with boulder-clay, and here and there in the hollows and river valleys with peat and alluvium.

BOULDER-CLAY.

Nearly all the material of which the boulder-clay is composed corresponds with that of the underlying rocks. Thus, overlying the Carboniferous Limestone, the bulk of the drift consists of a

brown or bluish compact clayey matrix, embedding limestone or calcareous sandstone boulders, while over the Silurian rocks a looser till, with a coarser matrix of a lighter colour, prevails. Some " erratics " or foreign boulders are sometimes to be met with in these drifts, but, except near the boundary between the Carboniferous and Silurian formations, they form quite an insignificant proportion of the deposits. The material for the vast accumulations of boulder-clay, which in some parts of this district attain a thickness of over 70 feet, must have been originally derived, prior to the Glacial Epoch, mostly from an old soil which had been formed *in situ* by the process of weathering. In glacial times, when Ireland was completely covered with ice, this district was overwhelmed by one or more immense ice-sheets, which pushed forward at the base of the ice all the débris then lying loose on the surface of the ground, and to this material were added rock-fragments, plucked off by the ice from the rock-floor, or borne on the surface, or carried in the interior of the glaciers.

The peculiar hummocky topography of the Monaghan district is due in part to the uneven character of the rock-floor, and partly also to the irregular manner in which the drift has been distributed by the ice that passed over this region. In the bare ground round Clontibret, at the eastern side of the district, the lumpy and uneven character of the rock-surface of the Silurian area may be conveniently studied. Here, as a result of the folding and differential weathering of the beds, the features of the ground present a type of landscape not different from that of the remainder of the Silurian area of the sheet, except that the hummocks lack the smoothness of outline characteristic of the knolls and ridges of the drift-covered country.

In the central and southern parts of the district the ridges run mainly in an E.N.E. direction, which is also the direction of the strike and axis of folding of the Silurian beds. In this part of the area the topography is mainly attributable to the irregular outline of the rock-floor, over the projections of which accumulations of drift of variable thickness have been moulded by the ice as it moved over them. On the other hand, most of the ridges and hummocks of the northern part of the area consist entirely of drift, and are oriented quite independently of the character or condition of the underlying rock-surface. They represent, in fact, those curious mounds of boulder-clay to which the Rev. Maxwell Close, in 1866, applied the name *drumlin*—a term which is now generally adopted by geologists all over the world.*

A drumlin is a low lenticular ridge of drift, symmetrical about its longer axis, but typically having one of its ends steep and blunt, while the other end narrows and slopes more gently to

* "General Glaciation of Ireland," Journ. Geol. Soc. Ireland. Vol. 3 (1886), p. 212.

the general level of the ground from which the hummock projects. In addition, the highest point of the crest of the ridge is commonly nearer to the blunter and steeper end.*

Drumlins vary in length from a couple of miles downwards, being on an average rather more than half a mile long. Dr. Früh of Zürich gives the average length, based on 500 measurements, as 1 kilometre (five-eighths of a mile), and the ratio between the long and the short axes of the drumlins as about 2·5 : 1.† Their heights above the surface upon which they rest are as variable as their lengths, but, according to the same authority they seldom rise more than 30 metres (100 feet) above the general level of the drift.‡ Frequently the hollows between the mounds are occupied by alluvial flats, bogs or lakes, which have arisen as a consequence of the obstruction of the pre-glacial drainage by the drift. It is only where drumlins occur as isolated mounds that they are likely to assume their typical form. When grouped together, as they usually are in the Monaghan area, they coalesce, overlap, or mutually interfere with one another, so that the fundamental plan on which they have been moulded by the ice is obscured.

Another, and perhaps the most important feature of these ridges is the fact that they are found to be oriented in the direction of the ice-movement, as indicated by the glacial striæ seen in adjacent rock exposures, and further, the steep blunt ends of the hummocks are pointed up-stream, although frequently the form is reversed, in which case the steep ends occur on the lee side.

Various theories have been advanced from time to time to account for the formation and distribution of drumlins. None of these hypotheses appears to be wholly satisfactory, and it is unnecessary to discuss their relative merits here. It may, however, be regarded as certain that the material of which the mounds are composed is subglacial drift or ground-moraine, which has been transported at or near the base of the ice, and that their peculiar form has been impressed upon them by the ice during the passage of the last glacier over the district in which they occur.

As has been already stated, the ridges in the southern portion of the area are not true drumlins but consist of rock-cores covered with more or less thick deposits of boulder-clay. They have no relation to the direction of ice-movement, their position and shape being determined almost entirely by the pre-glacial topography. In the northern part of the area, where true drumlins prevail, two sets of ridges, running in two different

* See "The Drumlins of Wisconsin" William C. Alden, Bulletin No. 273, U.S.A. Geol. Survey, 1905.

† "Die Drumlins-Landschaft mit specieller Berücksichtigung des alpinen Vorlandes," p. 67.

‡ Ibid.

directions, occur, one set bearing a little to the east of south, and the other about 40° to the west of south (Fig. 1). The striæ observed in this district all follow the former direction, so that it becomes a problem of some difficulty to account for the orientation of those drumlins which point north-east and south-west. It has been suggested to the writer by Mr. Kilroe, as a probable explanation of this phenomenon, that the north-east and south-west ridges were formed by the Scottish glacier which is known to have invaded the north of Ireland in this direction, prior to the development of the Irish ice. As a matter

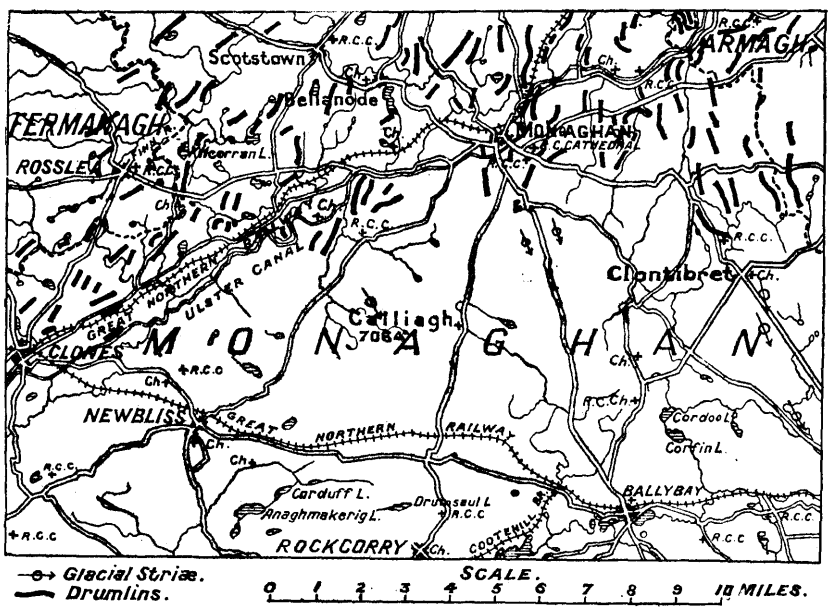

FIG. 1.—Map showing the orientation of two series of Drumlins in the Monaghan district, and the parallelism of the eastern series with the direction of glacial striæ.

of fact the striæ found in the areas represented by the adjoining sheets to the north and north-west of the Monaghan district nearly all run N.E. and S.W. parallel to these ridges. As the latter set of drumlins are situated on part of the axis of precipitation from which the Irish ice-sheet was fed, the mounds might easily have been protected from subsequent disturbance by an overlying stratum of snow or ice which remained in a condition of static equilibrium. It is easy to imagine how this basal layer of the central ice did not take part in the general radial ice-movement, while that overlying it flowed outwards, impelled by the shearing stresses set up by gravitation.

A peculiarity of the drift ridges of this area that run N.E. and S.W. is that, contrary to the general rule, their steep ends, with some exceptions, are pointed down-stream. This,

however, is not a unique phenomenon. Kinahan and Close have drawn attention to similar occurrences in the west of Ireland, where, west of the town of Galway, the drumlins of the locality have their narrow, gently sloping, northern ends pointing up-stream, with their blunt and steep southern ends on the lee side.* The drumlins of the Monaghan district are best developed in the Carboniferous area, but are by no means confined to that formation. Their distribution is indicated approximately on the map, fig. 1, and their influence on the landscape is shown in Plate II. Some of the best drumlin sections of the district may be seen on the railway between Clones and Monaghan.

SANDS AND GRAVELS.

These deposits were noted in a few localities.

On the road leading from Scotstown to Terdavnet, just at the northern margin of the sheet, there occurs a deposit of sand intercalated in the boulder-clay. The sand has been much used for building purposes, for which it is well adapted. Gravel ridges were also noted at Smithborough, and at Killyvilly Lough and Black Lough, N.E. of Rosslea. Another gravel ridge, in which have been found pebbles of jasper and Silurian sandstone, occurs at Drumgoole, about ½ mile E. of Faulkland Bridge Upper, and at Silverstream some well bedded gravels may be seen near the road, just north of the 15th Lock of the Ulster Canal.

River gravels were noted beside the Blackwater river at Leam Mac Cullagh Mill, Killymarran, and at Rafeenan, south of the road which runs N.E. from Cappog Bridge.

BOG AND ALLUVIUM.

These deposits are more extensive in the north-west of the district than in any other part. They occur also in the S. and E. and are nearly absent in the centre of the sheet. Their position and extent will be seen on reference to the one-inch map, and require no further remarks.

GLACIAL STRIÆ.

Owing to the general covering of the rocks with drift, and to their rapid weathering when exposed, glacial striæ were but seldom noticed. However, in the eastern and south-eastern sides of the area, where the rocks are frequently bare, and on the exposed patches of the gabbro mass, three miles south of the

* "The General Glaciation of Iar-Connaught and its Neighbourhood in the Counties of Galway and Mayo" (1872), p. 7.

town of Monaghan, ice-moulding and well-marked glacial striæ, with a general bearing to a little west of magnetic north, have been observed. The following are the localities where striæ have been noted:—

No. of ¼-sheet of 6″ Map.

13/2 Striæ bearing N. 30° W. occur in gabbro south of Tanderagee Lough, and bearing N. 15° W. on a similar rock in the townland of Ramanny.

13/3 Striæ bearing N.N.W. occur west of the road in the townland of Blackraw.

14/2 Striæ bearing N. 35° W. were noted in the townland of Lemgare.

14/4 Striæ bearing N. 25° W. may be seen beside the road just north of Lough Nahinch. Near the road N.W. of Rockfield House, delicate well-preserved striæ, bearing N. 10° W. and N.W., were noted on the smoothly rounded surface of shales below a thin covering of drift. About ½ mile south of the latter locality striæ running N. 30° W. occur in massive fine-grained grit, and similar ice-markings, with a north-west trend, may be seen on the surface of grits ½ mile still farther south.

19/2 Striations bearing N. 25°-35° W. have been found on the rounded bosses of massive grits, just south of Cremartin Lough; and about ½ mile to the west of the latter locality, in the townland of Dunfelimy, well-preserved striæ and ice-furrows may be seen on the surface of fine-grained grits.

19/4 Ice-furrows bearing N.W. were noted on the surface of hard siliceous grits S.E. of Oghill Lough.

CHAPTER VI.

MINES AND MINERALS.

In the townland of Calliagh, about 5 miles S.S.W. of the town of Monaghan, there occurs a shale rich in iron and manganese. This deposit has been described by the late Professor O'Reilly, in a paper read at the Royal Irish Academy "On the Occurrence of Idocrase in the Co. Monaghan."* The ore may be seen in a quarry at the top of the hill locally known as Logwood Hill, and can be traced to the E.N.E. along the general strike of the Silurian beds. Red ferruginous shales may be seen also about 1 mile to the N.E. of this locality, on

* Proceedings of the R. I. Academy, Series 3, Vol. I. (1889-91), pp. 446-53.

the road near Ballagh Lough, and again to the north of Drumbear Wood, 1 mile south of Monaghan town. Both these last-mentioned deposits are probably repetitions of the Calliagh beds as a result of the folding of the strata which has taken place extensively in the Silurian rocks of this area.

The iron and manganese minerals which occur in the Calliagh shales are contemporaneous with them, having been washed in from an old land surface as these Silurian muds were being deposited.

According to the analyses carried out by Dr. W. Adeney, and quoted in Professor O'Reilly's paper, the ore from the quarry at Logwood Hill contains from 33·4 to 42·2 per cent. of ferric oxide, and from 5·9 to 7·55 per cent. of manganese peroxide. The red shales near Ballagh Lough and Drumbear Wood are undoubtedly much poorer in these ingredients.

The following, quoted also from Professor O'Reilly's paper, is a complete analysis of the richest sample of iron ore obtained from the Logwood Hill quarry :—

SOLUBLE PORTION.

Ferric oxide,	42·20	per cent.
Alumina,	7·55	,,
Manganese peroxide,	6·24	,,
Cobaltous oxide, Nickelous oxide,	0·03	,,
Lime,	0·35	,,
Magnesia,	0·21	,,
Phosphoric acid,	0·03	,,
Water expelled at 120° C.,	3·21	,,
Loss on gentle ignition,	3·21	,,

INSOLUBLE PORTION (ignited).

Silica and titanic acid (trace),	29·51	,,
Ferric oxide and Alumina,	4·74	,,
Lime,	0·79	,,
Manganous oxide and Magnesia,	0·87	,,
Soda and potash,	1·09	,,
	100·03	

In the same quarry, as observed by Professor O'Reilly, a vein of quartz 3 inches thick, and containing the mineral idocrase, is found between slickensided surfaces in the ferruginous shales, at a point in which these shales bear evidence of much crushing and movement.

In the eastern and south-eastern portions of the area represented by this sheet, several lodes, chiefly of galena, are known to exist, many of which were worked about the middle of the

last century. Of these the most important, perhaps, is the Tassan lode, the course of which may be traced along a line marked by the sites of numerous disused shafts, first in a north-north-westerly direction, just beyond the margin of the sheet, from Tassan Lough, and then curving round towards the north, running for two miles almost directly north and south through the townlands of Tassan, Tonagh, and Coolartragh. According to the late Mr. Egan of the Geological Survey, the vein contains galena (lead sulphide) and zinc blende (zinc sulphide) in a matrix chiefly of quartz with some carbonate of calcium.* The workings at the southern part of the main Tassan lode are said to have extended under Tassan Lough and to have reached a depth of 80 fathoms.† In the sinking of a pit at Coolartragh near the boundary of the latter locality with the townland of Toonagh, a band of galena was reached, underlying to the east, with a basalt dyke 3 feet thick forming its western wall, and half a mile farther north in the same townland an engine-shaft boring cut the lode at a depth of 30 fathoms. These mines have long since been abandoned, but a large and valuable amount of ore is supposed to remain yet unextracted. In his list of Mining Localities, Sir Richard Griffith states that the Coolartragh mines have yielded argentiferous lead with zinc and barytes.‡ A specimen of galena from the Tassan mine examined in the Survey laboratory, contained ·019 per cent of silver.

To the S.W. of Tassan Lough, about 150 yards from the main lode, and running parallel to it, another mineral vein containing lead ore has been proved, and in the course of excavations at the east and south-east of the lough, rich veins of galena are said to have been encountered.

In the neighbourhood of Clontibret, just north of Carrickaderry House, lead ore is reported to have been found among the dark shales, grey grits and flags of that locality, and at Crossmore, S.S.W. of Glebe House, lodes of galena were discovered in the excavation of two shallow pits which were sunk in the year 1856. The sites of three disused shafts may be seen at Carrickanure, lying almost in a straight line running north and south: lead ore was encountered in the sinking of all three. The most southerly shaft, which was sunk about the year 1843, tapped a rich vein of galena which was worked at the time; this shaft was 7 fathoms deep.

Antimony and lead ores have been mined in a deep glen at the boundary of the townlands of Lisglassan and Tullybuck. Galena is said to occur here in a lode 6 ins. to 2 ft. thick, striking north and south, and with it is associated the antimony ore stibnite (sulphide of antimony). The sites of the three disused

* Geol. Survey Memoir to accompany Sheet 59, p. 27.

† Ibid., p. 27.

‡ Journ. Geol. Soc. Dub., Vol. IX., p. 150.

shafts of this mine are indicated in the map, fig. 2 ; the deepest of these is said to have been sunk to a depth of 20 fathoms.

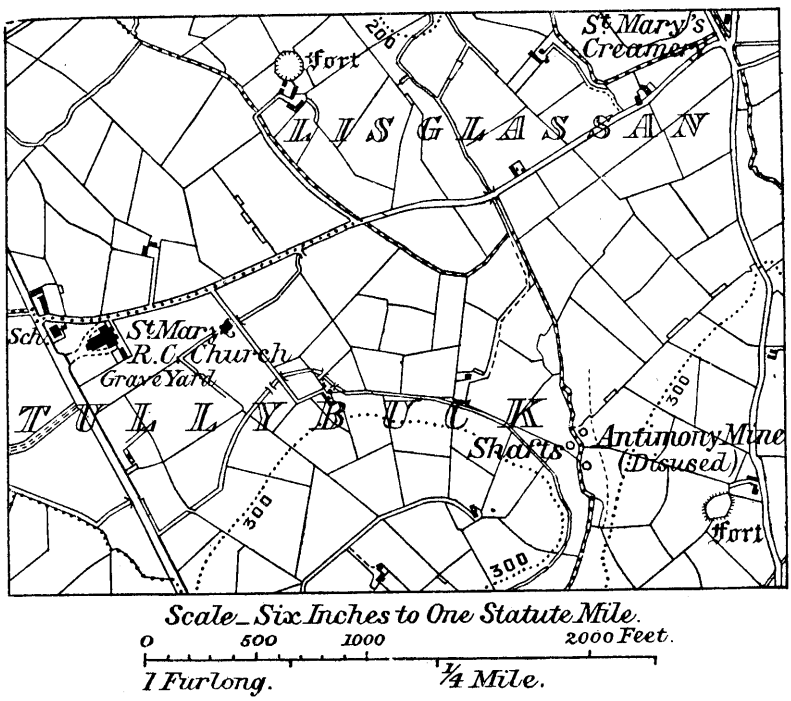

FIG. 2.—Map showing the site of the old Antimony Mine north of Milltown.

In the south-eastern part of the district, represented by this sheet, lead ore has been found in a few places, though not in such abundance as in the localities already mentioned. Thus it was mined at one time north of Ghost Lough, in the townland of Derryhallagh, and at Clare Oghill, where shafts or pits sunk to a depth of 8 fathoms are said to have tapped a very rich lode.

CHAPTER VII.

SOILS AND AGRICULTURE.

Nowhere does the influence of geological structure reflect on the agriculture of a district more strikingly than in the Monaghan area. The peculiar rolling and hummocky surface-features of the ground, resulting, as we have seen, partly from the folding and differential weathering of the rocks, and partly from the accumulations of drift left by the ice at the end of the Glacial epoch, are, perhaps, the principal factors, not only in defining the system of farming followed in the district, but

even in determining the size of the agricultural holdings. Farming on a large scale with labour-saving machinery is impossible on ground like that of the present area, consisting mainly of steep-sided hummocks, separated from one another by peaty or alluvial patches, which are frequently of a swampy character. Tillage operations under such conditions have necessarily to be conducted on a small scale, as spade-labour is often the only practical method of cultivation.

Besides the influence of geological structure, there is also a historical reason for the small and nearly uniform size of the agricultural holdings of this district.* Prior to the early part of the last century, the county of Monaghan was the home of numerous small industries, the principal of which was the manufacture of linen. Practically the entire population was industrially engaged, and, as but a small amount of labour was available for agricultural pursuits, each family was content with possessing land sufficient for the production of the raw material used in its particular industry and for its own food-requirements. As a result of the operation of both these causes, the holdings at the present day of the great majority of the farmers of the county of Monaghan are under 30 statute acres in extent. On an average about one-third of each farm is under cultivation, the remaining two-thirds representing permanent pasture or waste. The system of farming that obtains in this district is what is known as mixed farming, that is, a system in which tillage is combined with the production of milk and the raising of live stock. Potatoes, turnips, swedes, mangolds, oats, flax, and grass for pasture and hay, are the main farm-crops produced, and these are grown in rotations, which vary slightly in different localities, the most usual succession being the following :—

Oats on lea,
Potatoes and roots manured,
Flax or oats,
Oats with grass seeds,
Grass for several years.

Occasionally the position of flax in the rotation varies from that given above, and, instead of being sown alone, it is sometimes laid down with grass seeds. The period that the land is allowed to remain under grass is determined largely by the size of the farm and the circumstances of the farmer. On the best managed farms the land is renewed whenever the pasture begins to show signs of deterioration. Formerly it was the common practice to manure the land but once in a rotation; but now the more progressive farmers, taking advantage of the improved methods brought under their notice by the Department of Agriculture and Technical Instruction, not only supple-

* For a detailed account of the agricultural and industrial conditions of the Co. Monaghan at the end of the eighteenth century, see Coote's "Statistical Survey of the Co. Monaghan." Dublin, 1801.

ment the farmyard manure applied to potatoes and roots by the addition of suitable artificials, but apply to the lea oats and grass lands, as well, liberal dressings of artificial manures.

In the district north of Rosslea, on the poor peaty stretches, towards the Slieve Beagh plateau, the following rather primitive rotation is sometimes practised :—

Potatoes manured,
Oats,
Potatoes manured,
Oats with " seeds,"
Grass for several years.

On the Lower Limestone formation, especially round Clones and Smithborough, is to be found the most fertile land within the area of the map; but even in these localities the soil cannot be considered of the highest grade. Much of the Lower and Middle Limestone areas are allowed to remain under grass, and in places the lands are admirably suited for permanent pasture. Where the overlying drift is largely composed of limestone débris, the soil is rich in phosphates, and the covering pasture is excellent for the raising of store cattle. The cultivation, moreover, of the steep drumlins is an expensive and difficult operation, and no doubt the pasture system in such cases is the most economical one to adopt. The soils of the Carboniferous System in this area, are very variable in texture. Sometimes, as in the district north-west of the town of Monaghan, the local limestone drift is modified by the Yoredale sandstone from Slieve Beagh, and the resulting soil is an open loam, easy to till, and suitable for most crops. Frequently, however, the soils are stiff and impervious, and artificial drainage becomes necessary.

In the Carboniferous area, to the north of Rosslea, towards the Slieve Beagh plateau, the hummocks are sandy and stony, with stiff boggy land in the hollows, the soils becoming more barren as the mountains are approached.

The soils of the Silurian district are equally variable, and are heavy or light, according as the predominant originating rock is shale or sandstone. Immediately south of the town of Monaghan, the soils are usually light and stony, and are suited for tillage whenever the form of the ground allows. Farther south, along the course of the Dundalk and Enniskillen Railway, the soil is of a heavier character, and here it is that flax is more generally grown. The pastures on the Silurian lands are mainly of an inferior type, with a vegetation suggestive of a deficiency of phosphoric acid and lime in the soils, though the sowing of bad grass seeds and the practice of seeding the first crop hay may be responsible, to a large extent, for their inferiority. On the heavier grass lands of this formation, manuring with basic slag should well repay the farmer for the outlay.

The hummocks of the southern portion of the sheet exhibit

many of the peculiarities of the drumlins of the Silurian tracts of Co. Cavan.* As in some of the mounds of the latter area, the slopes of the hillocks of this region are not uniformly convex in outline, but exhibit upper and lower convex slopes, separated by a sharp concave flexure. Corresponding with the slopes, two varieties of soil are recognisable and can easily be separated in the field by the differences in the vegetation which they support and by the character of the drainage. Derived from one and the same type of boulder-clay, these varieties have been produced by a re-assortment of the original drift material. From the steep-sided crests of the hills, above the concavities already referred to, the finer material is being continually washed out by the rain and deposited on the gentler lower slopes. As a result of this continual "soil-creep," the residual soils of the higher ground are coarse in texture and are, in consequence, characteristically well-drained, while the soils of the lower slopes possess a much higher proportion of the finer soil-grades, and normally require artificial drainage. In many cases the latter slopes are ridged to run off the superfluous surface water.

* Mem. Geol. Survey of Ireland, "The Geological Features and Soils of the Agricultural Station, Ballyhaise, Co. Cavan" (1910), p. 8.

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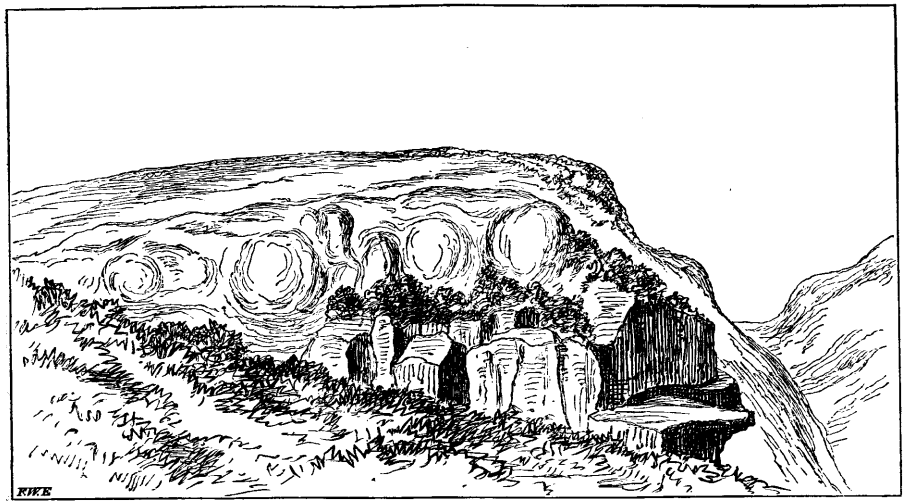

Globular structure in Micaceous Dolerite, Slieve Gullion, 650 yards N. of Calliagh Berras Lough.