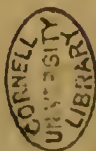


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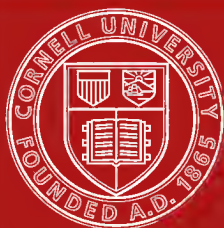
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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY
OF THE NEIGHBOURHOODS OF
FLINT, MOLD, AND RUTHIN.

(EXPLANATION OF QUARTER-SHEET 79 S.E.)

BY

AUBREY STRAHAN, M.A., F.G.S.,

(WITH PARTS BY C. E. DE RANCE, Assoc. Inst. C.E., F.G.S.)

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P R E F A C E .

THE first edition of the Quarter-sheet of the Maps of the Geological Survey (79 S.E.) described in the present Memoir was published in 1850, and was revised up to 1855. The western portion was principally mapped by Mr. W. T. Aveline, the Coal-Measures by Mr. D. H. Williams, and the New Red Sandstone by Professor E. Hull, while the lodes were inserted by Sir W. W. Smyth. The materials for the present Memoir were collected during a re-survey by Messrs. C. E. De Rance and A. Strahan, made on the six-inch scale, when the boundaries of the Glacial and other superficial deposits were traced for the first time. The eastern part of the Quarter-sheet, comprising the New Red Sandstone and the Flintshire Coal-field (exclusive of the Leeswood district), was re-surveyed by Mr. De Rance, the remainder of the map by Mr. Strahan. Quarter-sheet 79 S.E. (Old Series) covers nearly the same area as Sheet 108 (New Series). The limits of the latter lie about half-a-mile further south and further west than those of the earlier map.

The area represented includes portions of the Vale of Clwyd, the Estuary of the Dee, and the intervening high ground composed of Silurian and Lower Carboniferous Rocks.

Considerable changes have been made in the mapping of the Vale of Clwyd. The Trias, formerly believed to overlap the Carboniferous rocks, and to pass on to the Wenlock Shale, is now shown to be affected by a great fault, which throws down both Carboniferous and Triassic strata along the western flanks of the Silurian range. To this dislocation the existence of the outlier of newer rocks in the Silurian area of North Wales is mainly due—a structure that forms a striking analogy to that of the

Vale of Eden. In both these tracts the fault came into existence principally in pre-Triassic times, but was increased after the red sandstone had been deposited. The pre-Triassic movements, of which this fault forms part, led to the second great unconformability observable in this district, viz., that between the Carboniferous and Triassic formations.

The Carboniferous Limestone, Millstone Grit, and Lower Coal-Measures show considerable horizontal changes within the limits of this map. In the northern part they are fine-grained in texture, while southwards the whole series expands, at the same time that clays pass into sands, and sands into pebbly grits. Similarly the black limestone of the north of Flintshire merges southwards into a thick series of alternating sandy limestones and pebbly calcareous sandstones, while the Chert Beds are replaced by massive pebbly grits. Lastly, the Lower Coal-Measures of the south contain thick sandstones, scarcely distinguishable from Millstone Grit, which are almost unrepresented in the north. In the Coal-Measures, too, we do not find the persistence in the seams which is noticeable in other coal-fields further removed from such an old mountain-centre as that of North Wales. The seams vary rapidly in thickness, and the lowest seams of the northern district have remained undiscovered, if they are present, in the southern area. The small coal-field of Leeswood acquired importance from the discovery in it of the Cannel Coal, used for the distillation of paraffin oil. The workings in this coal encountered a river-channel of Carboniferous age, the course of which, so far as proved, has been laid down in Plate I.

Traced towards the west, the changes become still more marked. The strata lying next above the limestone in the Vale of Clwyd show no similarity to the Flintshire Millstone Grit, but so close a resemblance to the Lower Coal-Measures as to indicate that the Millstone Grit thins out along the Flintshire outcrop—a supposition supported by the actual overlap of the grit by Coal-Measures for a short distance near Rhydymwyn.

The New Red Sandstone, for the most part, lies buried under Drift, but the unconformable junction of this rock and the Lower Carboniferous strata can be observed in the Vale of Clwyd, and in the well-known section of Cuckoo Hill, near Hope.

The Glacial Deposits include two drifts of distinct origin, viz., that which travelled from the north over Lancashire and Cheshire, and that which came from Welsh sources in the south-west. The two meet along a line which partly follows the Welsh border, but runs across the gentler hills of the Flintshire Coal-field. Several examples of striated rock-surfaces have been recorded, in all of which the striæ point in the direction in which the Drift associated with them has travelled. Vast numbers of boulders also have been brought from the Snowdon and Arenig ranges and dropped upon the western flanks and the tops of the Silurian and Carboniferous ranges. One of the largest of these erratics is 24 feet long, and its visible portion can scarcely fall short of 300 tons in weight. The fact that the Drift was borne across the outcrops of the various rocks, and nearly at right angles to them, has led to even more variability in the nature of the deposit than is usually observed.

The history of the River Dee is given in some detail, and the valley of this river is shown to coincide with a pre-Glacial estuary (or depression), filled with Glacial Drift. The upper part of the river, however, follows a post-Glacial course through Holt, Eccleston, and Chester, the pre-Glacial valley, now completely choked with Drift, running past Dodleston and Rossett.

Chapter XIII. is devoted to a detailed account of the lead-mines. The veins are separable into two sets of different direction, contents, and age. The principal lead-bearing zones in the Lower Carboniferous Rocks, and the various forms of "vein," "pipe," or "flat," in which the ore occurs, are indicated.

The present Memoir has been edited and mainly written by Mr. Strahan. Mr. De Rance's contributions are as follows:—An account of the Lower Coal-Measures of Northop and Hawarden, on pp. 66, 67, 71; Chapter VII., pp. 72–99, on the Middle Coal-Measures; and notes on the Drift of his area, on pp. 132, 133, 135, 139–144. Several also of the Colliery Sections, given in Appendix I., were collected by him.

The determination of the fossils collected during the re-survey was commenced by Mr. R. Etheridge, but completed by Messrs. Sharman and Newton, who are responsible also for the correction of the synonymy. The lists were submitted to Mr. G. H. Morton also, who kindly noted some additions.

A general geological bibliography for Flintshire and Denbighshire is published in the Memoir descriptive of The Coasts adjoining Rhyl, Abergele, and Colwyn (1885), of which the present Memoir forms in part a continuation.

ARCH. GEIKIE,
Director-General.

Geological Survey Office,
28, Jermyn Street, London,
19th February 1890.

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THE GEOLOGY

OF THE NEIGHBOURHOODS OF

FLINT, MOLD, AND RUTHIN.

CHAPTER I.

INTRODUCTION AND TABLE OF STRATA.

In this Quarter-sheet is found the continuation of the ranges of the Silurian Rocks, Carboniferous Limestone, and Millstone Grit, which run down to the sea near Prestatyn and Rhyl, and which have been described in the Memoir on that neighbourhood (Quarter-sheet 79 N.W.). The principal hills in the present area are as follows:—

			FERT.	
Moel-y-paro	-	-	Upper Silurian Rocks	P
Pen-y-cloddian	-	-	„	1,441
Moel Arthur	-	-	„	1,494
Moel Famman	-	-	„	1,819
Y Foel Fenlli	-	-	„	1,676
Moel Gyw	-	-	„	1,530
Moel Ffagnallt	-	-	Carboniferous Limestone	944
Coed-du	-	-	„	807
Cefn-bychan	-	-	„	885
Cefn-mawr	-	-	„	1,007
Moel Findeg	-	-	„	1,196
Pwll Iwrach or Pant-du	-	-	„	1,324
Hope Mountain	-	-	„	1,080
Halkin Mountain (near Henblas)	-	-	Millstone Grit	951
Moel-y-Gaer	-	-	„	993
Bryn-gwyn	-	-	„	1,113
Nerquis Mountain	-	-	„	1,239

These ranges, which form the first high ground on entering Wales from the plains of Cheshire, run nearly north and south across the western side of the map. On their west the map includes a portion of the Vale of Clwyd, occupied by an outlier of

Carboniferous Rocks and New Red Sandstone; on their east lie the gentler hills of the Coal-Measures of the Flintshire Coal-field; while the eastern side of the map is occupied by a portion of the New Red Sandstone of the Cheshire plains, and by the intervening estuary of the Dee.

The area is drained by the Clwyd, the Dee, and its tributary the Alyn. The Clwyd, rising in the Silurian hills of central Denbighshire, enters the Vale of Clwyd by a steep-sided breach in the Carboniferous Limestone, near Llanfair, and flows thence, in a channel excavated almost wholly in Drift, to the sea near Rhyl. The Alyn, rising in and draining the Vale of Llanarmon, which separates the Silurian from the Carboniferous Limestone hills, flows north as far as Cilcain, but breaks abruptly through the limestone-escarpment near this place, and turns to the south-east across the Coal-Measures by Mold and Hope. On emerging from the deep gorge by which it traverses the limestone, the Alyn falls into an old line of valley, which is prolonged right through the Moel Famman range into the Vale of Clwyd, by way of Nannerch, Caerwys, and Bodfari. This old valley it follows southwards, receiving merely a small tributary from the northern extension named above, which is drained by the River Chwiler (or Wheeler), a tributary of the Clwyd.

The watershed between the Alyn and the Clwyd follows the summit-level of the Silurian hills as far as Moel Arthur. Thence it turns north-eastwards to Moel Plâs Yw, and follows the road by Bryn-y-groes to the south side of Penbedw Park, where it crosses the valley above mentioned. Its height above the sea in this valley is 520 feet, but its exact position is so ill-defined that it seems to be little more than chance whether the stream descending from the south side of Moel Arthur turns to the north into the Chwiler, or to the east into the Alyn. The water enters a subterranean course at Siamber Wen, but reissues at Tardd-y-dwr, at 600 yards distance, and flows thence to the Alyn; but the open-air course, which is still used in heavy floods, runs north of this line and enters the Clwyd system. During the flood of August 1879, both channels were used, so that the water of the stream reached the sea partly by way of the Dee, partly by way of the Clwyd. From this point the watershed runs north-eastwards to Moel Ffagnallt and the chert-hills above Pentre Halkin.

The north-eastern corner of the map is occupied by the Triassic hills of part of the peninsula of Wirral, of which about three square miles, around Great Sutton and Capenhurst, drain into the basin of the Mersey. The small streams flowing over the western part of the peninsula make their way into the estuary of the Dee, which opens out into a trumpet-shaped area of considerable size in the map to the north. The contents and history of this estuary are described in Chapter XII.

The various rocks and Drift-deposits distinguished by colour on the two editions of this map are as follows:—*

Recent and post-	-	{	Alluvium.	
Glacial -			Peat.	
			River Terraces (Gravel).	
			Calcareous Tufa.	
Glacial -	-	{	Boulder Clay.	
			Sand and Gravel.	
Trias, or New	-	{	Upper Mottled Sandstone.	
Red Sandstone			Pebble Beds.	
(Bunter)			Lower Mottled Sandstone.	
			Middle Coal-Measures.	
			Lower	{ Sandstone.
			"	{ Holywell Shales.
Carboniferous	-	{	Millstone Grit.	Chert Beds and sandstones.
			Carboniferous	{ Black Limestone.
	Limestone	{ Calcareous sandstone.		
			Limestone.	
Upper Silurian	-		Wenlock Shale with occasional sandstone.	

* This Quarter-sheet is published in two editions on the one-inch scale, the one for Superficial Geology, showing all the formations named in the table, in the other all the Glacial Deposits being omitted to give a fuller view of the range of the underlying rocks. Manuscript copies of the six-inch maps have been deposited in the Geological Survey Office for reference, or for copying if desired.

CHAPTER II.

UPPER SILURIAN ROCKS.

WENLOCK SHALE.

The whole of the Moel Fammau range is composed of rocks belonging to the Wenlock Shale, and consisting principally of roughly cleaved shales with fine-grained sandstones occasionally interstratified. The direction of the cleavage is almost constant through the whole length of the range; in Moel-y-parc it averages E. 35° S., bending on the south and east sides of Pen-y-cloddiau to about E. 30° S. and E. 25 S. Near Pen-machno it ranges E. 15° — 20° S., and on Moel Fammau E. 10° — 16° S. (except locally on the north side of Moel-y-Gaer, where it points in two or three places E. 10° — 15° N., perhaps owing to faults). South of Foel Fenlli it resumes the direction E. 20° S., or, south of Moel Gyw, of E. 20° — 35° S. The cleavage therefore crosses the range obliquely.

Regarding the district as a whole, we might consider the strike of the rocks to be nearly parallel to the direction of the range, and to be crossed obliquely by the cleavage; but locally the strike and cleavage are generally parallel, for the strata have been bent into a number of small synclinal and anticlinal folds, the axes of which run strictly parallel to the cleavage. This coincidence of direction leads to the supposition that the folds and cleavage were contemporaneously formed, as a result of compression by forces acting from the north-north-east and south-south-west and, as we have elsewhere shown, at a time when the Wenlock Shale was deeply buried under newer Silurian Rocks (Ludlow Beds, &c.)* At the same time, upheaval, due to the same forces, led to the denudation of the newer Silurian strata and to the preparation of the floor of old rocks, over which the Carboniferous group was subsequently spread. At a comparatively late date the district was traversed by faults and gentler folds, by which the Carboniferous rocks, and the Trias also in part, were affected, and by which such striking features in the configuration of the country as the Vale of Clwyd and the Moel Fammau range were produced. The approximate parallelism of the trend of this range to the strike of the strata composing it is therefore accidental.

The description of the Wenlock Shale will be conveniently taken from north to south. On the north side of the Wheeler valley flags are exposed in the deep strike-ravine of Coed-cochion,

* The Geology of the Coasts adjoining Rhyl, &c. (Mem. Geol. Survey. Explanation of Quarter-sheet 79 N.W.), 1885. See also Denudations of North Wales, *Proc. Chester Soc. Nat. Sci.* No. 3, p. 38, 1885.

the dip ranging from 55° to 90° to the south-west; the rock appears again near Maes-mynan, but is concealed by Drift elsewhere on this side of the valley. On the south side, however the Drift-less slopes of Moel-y-parc rise abruptly from the river. A quarry near Caerwys, on the side of the road to Bryn-yreithin, exposes massive and slaty mudstones, which have been used for mixing (after being ground up) with a pure limestone in the manufacture of cement. The greater part of the hill is composed of pale shales, with sandy bands, and occasional thin bands of sandstone or fine grit, one of which on the north-west side of the hill contains some small and obscure fossils. The strata are bent into many small folds, and in more than one instance small cirque-like hollows have been excavated along the anticlines, as, for instance, on the south side of the valley leading up from the Grove. The hill also forms the resting place of a number of erratic boulders of felspathic rock from the Bala Beds, as hereafter mentioned (p. 147).

On crossing the neck that connects Moel-y-parc with Pen-y-cloddiau we find a band of grit and of interstratified shales and thin sandstones, with a steady dip of 30° — 60° to the south-west, the grit containing obscure impressions of minute fossils (chiefly small *Orthis*). These beds, which may be traced through the top of Pen-y-cloddiau and for about 300 yards down its southern slopes, show well the different effects of pressure on sandy and clayey beds; the thin sandstone-bands being crinkled in a number of minute but regular puckers, while the intervening seams of shale are cleaved.

On the south-eastern side of the hill also, in the road to Nannerch, some thin beds of grit, one of which is slightly calcareous, are imbedded in fine well-cleaved shale. But the eastern slopes of the hills as a rule show remarkably few exposures. In the few old quarries that occur the dip generally varies between north-west and south-west, the rock being a more or less sandy shale; in one case a quarry 400 yards north of Plas Yw shows a nodular structure developed in the shale along the cleavage-planes, independently of the bedding.

The south-westerly dip which prevails through Pen-y-cloddiau continues (with local exceptions) through Moel Arthur and Moel Llys-y-coed. From the former hill a hard micaceous sandstone may be traced southwards past a synclinal fold which runs parallel to the cleavage through Moel Llys-y-coed, and thence eastwards as far as the Drift-filled valley at Plas-newydd, its axis running between this farm and Lletty. On the south side of this syncline a corresponding anticline runs a little north of Pen Machno. Three or four hundred yards south-west of Pen Machno some shales, lying immediately above the sandstone which runs through Moel Arthur, have been tried for slates.

From the Bwlch-y-Cilcain southwards some thin-bedded sandstones and shales may be traced for a considerable distance through several of the small folds connected with the cleavage. Nearly in the axis of the anticline, which causes the sharp

westerly bend in the beds north of the fault indicated on the map, there are some trials in a quartz-vein, bearing about E. 37° S., and said to contain specks of copper. There, as elsewhere in these rocks, vein-quartz occurs, whether in a vein or joint, only in or close by beds of sandstone, from which the silica may consequently be presumed to have been derived. Another trial for copper has been made in a crag of shattered sandstone full of strings of quartz about a mile west of the tower on Moel Fammau. There appears to be an ill-defined vein running about north-east, also reported to contain specks of copper.

South of the fault shown, the sandstone dips down the slope at a gentle angle south-westwards, and consequently covers a broad spread. It may be traced thence round the northern and eastern sides of Moel Fammau through some old quarries, being seen in one place to exceed 12 feet in thickness and to contain small encrinites and clay-galls.

The outlying hill of Moel-y-Gaer* consists of contorted shales with lumps of sandstone. On the eastern and north-eastern sides of the hill some slate-quarries have been opened upon an anticline, the cleavage ranging about E. 10° S., or locally E. 10° N.

Four hundred yards south of this hill a quarry in the bottom of the valley exposes flags with *Orthoceras primævum* and *Cardiola interrupta*. Several parallel ridges formed by the outcrop of bands of sandstone are passed on the way up Moel Fammau from Bwlch-pen-barras. The beds dip to the north and north-east so as to sweep round the west side of the hill, but cannot be traced more than two or three hundred yards. On the Bwlch there occur shales with concretions and in places flaggy, dipping south and south-westwards. The same dip prevails on Foel-fenlli in shales with thin sandstones, exposed about the east end of the camp.

Where the Mold and Ruthin road crosses the range (at a height of 944 feet above the sea), a south-westerly or southerly dip prevails in sandy or occasionally flaggy shales; still further south along the watershed the dip becomes locally south-east, in shale with thin sandstone, but further to the west resumes the prevalent westerly to south-westerly direction. In the next Quarter-sheet a southerly and south-easterly dip prevails.

The Silurian rocks occupying the south-western corner of the map belong to the same subdivision, and call for no particular notice. A general description of the Upper Silurian strata of Denbighshire will be found in the Geology of North Wales (Geological Survey Memoirs, vol. iii.), by Sir A. Ramsay, and in Notes on the Geology of the Vale of Clwyd (*Proc. Chester Soc. Nat. Sci.* No. 3, 1885), by Prof. T. McK. Hughes.

* Not to be confounded with Moel-y-Gaer on Halkin Mountain.

CHAPTER III.

CARBONIFEROUS ROCKS.

THE VALE OF CLWYD.

Structure of the Vale.

In general structure the Vale of Clwyd resembles the larger Vale of Eden. In both a great fault, running a little west of north, has thrown down the Carboniferous Rocks westwards far below the general level of the platform of Silurian strata on which they rest, and in both the synclinal trough thus produced has subsequently received great deposits of red sand of Triassic age (Fig. 1.)*. We have elsewhere pointed out that the Silurian strata were contorted, cleaved, and worn down into some sort of a platform (or plane of marine denudation) before the Carboniferous Rocks were deposited upon them;† the break between the two groups being one of the most striking in the British Isles. A scarcely less marked discordance divides the Carboniferous from the Triassic strata, for the red sands of the latter rest upon an eroded surface composed indifferently of any of the Carboniferous subdivisions (except the lowest), or are even banked up against little cliffs cut out of these rocks. From this we infer that the disturbances, of which the Vale of Clwyd Fault forms part, took place, in part at least, before the Trias was deposited; but on the other hand we have evidence of their having been continued in post-Triassic times also.

The following sub-divisions of the Carboniferous group occur in the Vale of Clwyd:—

Carboniferous Basement Beds.

Carboniferous Limestone.

Millstone Grit (a possible representative of).

Lower Coal-Measures.

The Carboniferous Rocks, arranged generally in the form of a trough, rise from beneath the Trias on either side of the Vale. On the west side the limestone forms a conspicuous range, much broken, however, by faults. In the northern part striking south-eastwards, it runs naturally parallel to the Vale, but south of Denbigh ranges nearly east and west so as to tend to run across the Vale. This tendency, however, is counteracted by north and south faults, occurring at somewhat regular intervals, and each throwing the strata down to the east. By these repeated shifts the general southerly trend of the limestone-escarpment is preserved, notwithstanding the east and west strike of the rocks composing it. South of Ruthin the limestone resumes the southerly strike and runs continuously to the end of the Vale. One only of the faults referred to lies within this Quarter-sheet. The limestone on its west side strikes east and a little south of east, that is, towards Ruthin, but is cut off by the north and south fault of

* See also Horizontal Sections, Sheet 43.

† Geology of the Coasts adjoining Rhyl, &c. (Geol. Survey Memoir).

Llanfwrog, and next reappears some distance southwards. A similar but smaller shift lies on the western margin of the map.

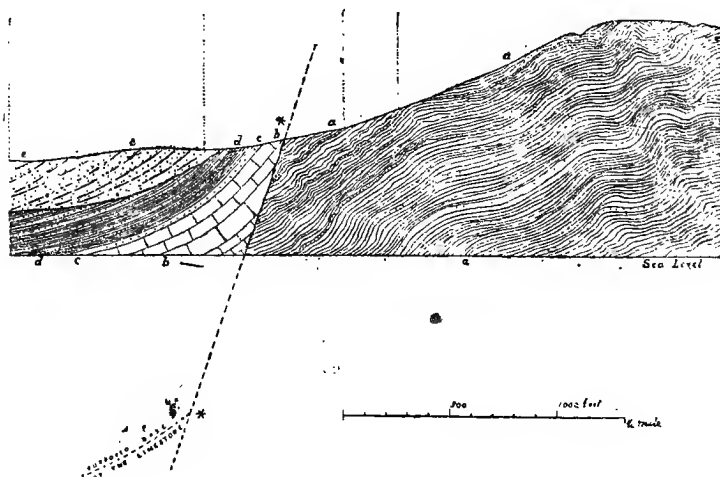
On the east side of the Vale we find a different structure. A continuous line of fault, running all down the Vale, throws the Carboniferous Rocks and, as is believed, the Trias also against the Silurian strata, the limestone appearing at intervals in long strips, but so narrow as to form an insignificant feature.

The original survey of this ground was made on the assumption that these strips of limestone consisted of the lower beds of the subdivision, and that they rested unconformably upon, instead of being faulted against, the Silurian Rocks. At the same time the absence of the greater part of the limestone and of the rest of the Carboniferous group was accounted for by the supposition that they were unconformably overlapped by the New Red Sandstone. The limestone composing the strips, however, has been ascertained to belong to the top of the subdivision, and to be conformably overlain by shales and sandstones of supposed Lower Coal-Measure age. The existence of a fault therefore, which had already been suspected from the shattered condition of the strata, was demonstrated. The fault throws down below the surface nearly the whole of the limestone, the whole of the Basement Beds (if any exist on this side of the Vale), and an unknown thickness of Silurian Rocks. The method of computing that the displacement effected cannot fall short of 1,500 feet is shown in the following section (Fig. 1).

Fig. 1.

Section across the Vale of Clwyd Fault, showing the displacement.

W. 20° S.			E. 20° N.
Angle	Angle	Path	Edge of
in lane.	in lane.	Edge of	Moel-y-Gaer.
		Moorland.	



- a. Wenlock Shale. b. Carboniferous Limestone.
 c. Thin pebbly grit (? Millstone Grit). e. New Red Sandstone.
 d. Purple shales and sandstones (Lower Coal-Measures).
 * to * shows the *minimum* displacement of the fault.

In the description of the northern end of this fault its important influence on the structure and scenery was referred to,* and the name of Vale of Clwyd Fault suggested for it, inasmuch as it was one of the principal causes of the preservation of this outlier of Secondary and late Palæozoic rocks in the Silurian area of North Wales.

We have noticed that the present interpretation of the structure of the Vale of Clwyd differs considerably from that offered in 1850 in the first edition of the map, when it was believed that the New Red Sandstone rested generally on Carboniferous Limestone, or even overlapped all the Carboniferous Rocks and passed on to the Upper Silurian strata. We now know that over a great part of the Vale the red beds repose upon Lower Coal-Measures, and, though they pass on to the Carboniferous Limestone, overlap the upper beds only of that subdivision. This being the case along the margin of the Vale, we may infer that in the more central parts they rest everywhere upon either Lower Coal-Measures, or towards the north end possibly even upon Middle Coal-Measures. We will now proceed with the evidence for the present interpretation of the structure.

(1.) The Basement Beds.

These strata, though continuous along the western side of the Vale, appear in two places only east of it, in the one case near Cwm (as described in the Memoir above alluded to), in the other and more doubtful instance near Penbedw. Northwards they consist chiefly of conglomerates, but to the south pass into red flaggy sandstones and shales. They rest, always with an extreme unconformity, on the Silurian rocks.

The evidence for their existence near Penbedw consists in traces of red shale seen in the streams on the northern and southern sides of the park. The section is exceedingly obscure, and no estimate of the thickness or range of the strata can here be made. Near Ruthin, in numerous exposures in the stream above Llanfwrog, red sandstones and shales dip at about 20° towards the limestone to the north-east. On following up the stream to a point where it divides, we may observe the junction of the red strata with the Wenlock Shale, the lowest of the former, a slightly conglomeratic cornstone, dipping east-north-eastwards at 15° , while the Wenlock Shale beneath dips northwards at 30° . At the foot of the limestone-hill, and at a higher horizon, red and green shales crop out, while intervening sandstones and shales appear by the side of the road, half-way down to the stream.

These red strata are cut off to the south by an east and west fault, and to the east by a cross-fault, which ranges north and south, and throws them into contact with the New Red Sandstone, as can be seen in a quarry 250 yards west of Llanfwrog Church.

* *Geology of the Coasts adjoining Rhyl, &c.* (Geol. Survey Memoir), 1885, pp. 8, 20-22.

The pit has been opened in soft red and white sandstone (New Red Sandstone), but towards the west touches a breccia made of fragments of Basement Beds and New Red Sandstone mixed, and containing specks of copper-pyrites. On digging through this breccia, which is clearly "fault-stuff," we quickly reach the Basement Beds in place. Towards the south this fault throws limestone and Basement Beds in succession against Wenlock Shale; the Basement Beds, however, are not well exposed for nearly half a mile, though they run on as far at least as Efenechtyd (Quarter-sheet 74 N.E.), where a shaft has been sunk into white and yellow sandstone belonging to this subdivision. Another fine exposure of these strata occurs in the valley of the Clywedog, just beyond the margin of this map (see also p. 15).

(2.) The Carboniferous Limestone, Millstone Grit, and Coal-Measures.

Commencing with the eastern side of the Vale, and working southwards, we meet the first exposures of limestone at Pen-llwyn and Fron-yw. A quarry near the former exposes limestone, stained red, shattered, traversed by strong curving and slickensided joints, and dipping towards the south-west and west at 45° . The breadth of outcrop cannot exceed 250 yards, for Silurian rocks occur immediately east of the quarry, while in the wood below a strong spring marks the junction of the limestone and New Red Sandstone. Whether the red sand here rests naturally on the limestone, or is thrown against it by a fault, remains doubtful. No conglomerate or breccia occurs, as might have been expected in the former case, but on the other hand red-staining is a common feature in rocks on which Trias has been deposited. In the limestone to the north of the quarry the red colour has led to some explorations for hæmatite. The next exposure southwards occurs in a small hole, 100 yards west of Fron-yw, where limestone seems to dip westwards at 45° , but the bedding-planes are obscure.

About Plâs-Llangwyfan the rock is concealed by Drift, but comes into view again in the stream at Rhiw-pebyll, where a quarry shows shattered limestone. Some coal, said to have occurred in this quarry, seems to indicate that the beds belong to the lower more probably than to the upper limestone (p. 19), but they are nevertheless faulted against the Wenlock Shale, as may be seen in the brook. The shale is completely smashed up near the line of junction.

The limestone again appears behind the farmhouses, 300 yards further south, where it is intensely shattered, and abundantly infiltrated with sulphate of baryta. It seems to occur as a wedge in a split of the Vale of Clwyd Fault, being thrown on the east against Wenlock Shale, or rather a blue clay formed by the complete trituration of this rock, and on the west against red rocks, proved in an old shaft and borehole by the side of the road, but whether stained Coal-Measures or Trias could not be ascertained.

An old quarry 250 yards east of Groes-fawr, by the stream to Gales, furnishes the next exposure. There again the limestone is

infiltrated with sulphate of baryta, and both it and the Silurian strata, seen in the brook close by, are in a completely shattered condition. Towards the west the limestone, which has a breadth of 25 yards only, is faulted against purple sandstone, probably of Lower Coal-Measure age. The Trias, which appears below the junction of the streams by Felin-uchaf, is believed on the evidence of the next section to be faulted against the purple sandstone within a short distance of the limestone-boundary. The southern extension of the limestone is marked by a swallow-hole by the side of the road, at 200 yards distance.

In the next section of the Carboniferous rocks, at Pentre, we find the purple sandstone faulted directly against the Wenlock Shale, the whole of the limestone having been cut out. Along the fault, as visible in 1880, the Silurian rocks were smashed up into a breccia for a distance of 20 yards, and again at a little distance further east were traversed by a line of smash, probably a branch of the great fault. On its west side the purple sandstone is faulted against Trias, as may be seen in the lane 70 yards west of Pentre-bach, the sharp and clean-cut line of fracture hading at 78° to the west. It is believed that this same fault throws Trias against the purple sandstones near Groes-fawr also. From here to Plâ--Dolben we meet with no section, but in top of the yard of this farm find Wenlock Shale, while water issues in the middle of the yard, probably marking the line of the fault.

At Llangynhafal purple sandstone comes into view in the brook, dipping nearly west at 33° . Though the junctions are not visible, yet here again the purple beds are evidently faulted against the Silurian rocks on the one side, and the Trias on the other. The breadth of outcrop of the purple beds amounts to 90 yards; though no limestone is seen, lumps of sulphate of baryta, which may be picked out of some red clayey fault-stuff, indicate that the limestone is not far below the surface.

At Bryn-bedw the limestone reappears, as before, intensely smashed, and containing much sulphate of baryta. The fault between it and the Wenlock Shale is filled with a blue clay (ground-up Wenlock Shale) and lumps of limestone. The limestone seems from its broken condition, and from the abundance of sulphate of baryta in it, to be faulted also against the purple sandstone. We see the latter and its junction with the Trias in the lane from Dol-y-caean, the actual line of contact being steeply inclined, with the two rocks jumbled together along it, as though it also were a fault.

A wedge of limestone commences at Bryn-bedw and widens out southwards. At Bryn-tirion a level has been driven into it for about 12 yards in search of hæmatite, while 300 yards further south some quarries expose dark limestones with bands of purplish shales, more like the lower than the upper beds of the subdivision. The strata generally dip westward at 45° , but in the northernmost quarry, which lies between the great fault and a branch springing from it, they dip south-south-eastwards at 6° , so as to strike towards

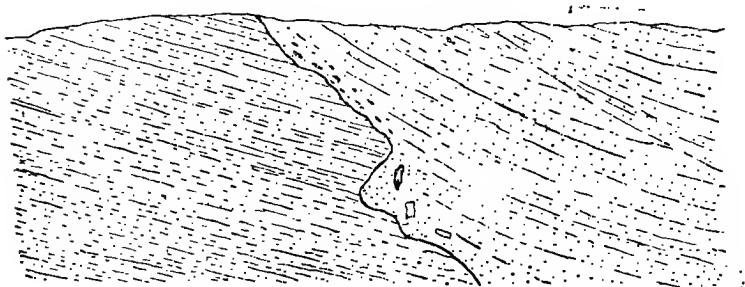
the Wenlock Shale close by. The limestone as before contains much sulphate of baryta.

In a lane near Plâs-drâw we again see the junction of the Trias and the purple beds. The line of junction slopes at an angle of 45° — 50° , the Trias seeming to have been deposited against a steep and partly overhanging bank of the purple sandstone, a few lumps of which have become imbedded in the Triassic sand (Fig. 2). The brook running down to Plâs-drâw also shows the two in close neighbourhood, though the actual junction is obscured.

Fig. 2.

Unconformable Junction of the Trias and Carboniferous Rocks, near Plâs-drâw.

(Height of Section about 8 feet.)



Purple Beds (Lower Coal-Measures).

Red current-bedded sand
(Trias).

In the next dingle, which descends by Bron-y-felin and Llanbedr Farm, we reach one of the best sections of the purple beds in the Vale of Clwyd, and for the first time clearly see their relation to the limestone. The New Red Sandstone is believed to end off, under the Drift, about 100 yards east of Llanbedr Farm. Thirty yards further on purple sandstone with bands of shale dip nearly west at 25° to 45° , and in the wood purple shale with a similar dip is exposed for about 120 yards. These purple beds are underlain by about 20 feet of black shale with thin bands of sandstone, and with a small seam of coal, on which some shallow shafts have been sunk. This again is underlain by about 10 feet of purple sandstone having at its base one foot of coarse conglomerate containing quartz-pebbles an inch in diameter, and other rocks. The conglomerate lies on fine-grained sandy limestone, the junction being visible in the brook, and in an old quarry on the south bank, and having been proved also in two shafts on the north bank. In the brook-section the conglomerate rests on a gently undulating surface of the limestone, so as to appear sometimes to be unconformable to it, or in other cases to be interstratified with it, this appearance, however, being due to the squeezing up of the beds by pressure. Within a few yards

distance, at the end of the wood, a fault with a downthrow west crosses the valley, and shatters all the strata near it. Its position is clearly marked on the north side of the dingle by a crag of white limestone which forms its upcast side. The upper part of the valley shows much shattered white limestone, with a band of red sandstone 8 inches thick interstratified, the strata dipping at first north-east, but nearer to the Wenlock Shale being too much shattered for the bedding to be recognised. The great fault crosses about 100 yards east of the fault mentioned above, but lies hidden under red Boulder Clay. The Silurian rocks first appear under Bron-y-felin, dipping south-west at 40° .

Here then we have clear evidence that purple beds, as might have been inferred from their relations to the New Red Sandstone previously described, are of Carboniferous age. We see moreover that, though they lie next above the limestone, and thus take the place usually occupied by the Millstone Grit, yet they bear no resemblance to the rocks assigned to this subdivision in Flintshire. For the sandstones are coarse-grained, but soft and evenly bedded; and in addition to grains of quartz contain abundance of mica in large flakes, and of white decomposed felspar; those of the Flintshire Millstone Grit on the contrary consist of clean quartz-sand, generally with white quartz-pebbles. The purple beds are made up as much of shale as of sandstone; in the Flintshire Millstone Grit, on the other hand, shales are subordinate.

On the other hand we find a close resemblance to the purple beds in some shales and sandstones which lie next above the Millstone Grit near Mold, as described on p. 69. It will be shown subsequently (p. 53) that the grits, sandstones, and chert which constitute the Millstone Grit on the eastern side of the Moel Famau range are overlapped for a short distance by Lower Coal-Measures, and we may suppose that this is part of a general overlap of the Lower Carboniferous by the Upper Carboniferous Rocks in a westerly direction, corresponding to that which takes place in a southerly direction in the Midlands, the thinning away of the lower rocks in both cases being due to the neighbourhood of a coast-line. We may well suppose therefore that the Millstone Grit may be absent in the Vale of Clwyd, or represented by only a thin band of conglomerate.

The next dingle, by Fron-ganol, gives the section of Trias described on p. 117. The junction with the purple beds, though partly obscured by talus, can be traced across the brook, and up the bank at a high angle, showing that the Trias rests against a slope of purple beds so steep as to be almost a cliff. The latter occupy the brook for about 80 yards, and, as shown in an old hæmatite-trial of 12 yards depth, consist principally of purple shale with some sandstone. The limestone, which rises from under the purple beds at an angle of 60° , and appears in the brook for 30 yards distance, resembles the rock seen in the preceding section. A shaft, sunk in the fault between the limestone and the Wenlock

Shale, penetrated only blue clay, the result of the grinding-up of the latter rock in the fault.

The next section occurs in the stream-bed, 450 yards north of Llanbedr Hall. The New Red Sandstone runs to within about 20 yards of the Silurian rocks, the intervening space being occupied by a purplish clay apparently containing fragments of Wenlock Shale, and perhaps all fault-stuff. The Silurian rocks are much shattered, and have a purplish tinge. The two are seen again in close juxtaposition 120 yards north-north-east of the Hall, where the Wenlock Shale shows no staining, and the Trias possesses its usual character of a soft non-conglomeratic sand.

Immediately to the south of the Hall the limestone suddenly reappears, in the brook and in a quarry at Cae-glâs. The brook enters a subterranean course at the fault between the limestone and the Wenlock Shale, and issues at the foot of a little limestone-cliff, in a mass of red and purple clay containing fragments of limestone and New Red Sandstone jumbled together, and no doubt a fault-stuff. The rest of the stream-bed lies in Trias. The quarry shows in part a thin-bedded sandy limestone, with yellow and greenish shales, dipping to the south-west at 35° . These strata seem to belong to the lower limestones of Flintshire, in which case the fault on the west of the limestone must form the line of greatest displacement. Here, as is generally the case, the limestone occurs merely as a wedge between two parallel lines of fracture, forming parts of one great line of dislocation. It is not seen again south of the quarry.

In the next dingle the line of fault is obscured by Drift, and in the stream running down to Bathafarn the Wenlock Shale only is seen. It appears close to the reservoir, and has been tunnelled into in search of coal. The Carboniferous (if any) and Triassic rocks are concealed by red gravelly Drift. From the absence of any feature to mark the line of fault, it seems likely that the New Red Sandstone is in direct contact with the Silurian rocks along this part of the Vale.

The Carboniferous Rocks reappear in the dingle running down to Ysgubor. The Wenlock Shale is shattered for a distance of 130 yards from the fault; grey limestone with thin bands of shale, dipping nearly west at 87° to 90° , occupies the dingle for a distance of 6 yards, and is succeeded westwards by thin-bedded black limestone, dipping in the same direction at 65° to 70° , the total distance occupied by limestone being 35 yards. Over the limestone lies deep-red or purple shale breaking into rhomboidal fragments, and occupying the dingle for about 15 yards. The Trias, which comes next, seems from its disturbed condition to be introduced by a fault. The black limestone seen in this dingle is probably the same bed that runs through the quarries on Graig-fechan (Quarter-sheet 74 N.E.).

The great Vale of Clwyd Fault may be traced southwards in the adjoining Quarter-sheet by Sined, Pentre-coch, and along the east side of Graig-fechan (Y Graig-wyllt on the one-inch map)

to the Toll-gate on the Ruthin and Wrexham road, where it forms the eastern boundary of the limestone of the south end of the Vale. Beyond this point it has not been traced.

Turning now to the western side of the Vale, we find the limestone in the valley of the Clywedog, 150 yards above Buarthau, dipping a little south of east. Further up the stream the dip becomes southerly, and so continues as far as a limestone-quarry, where it turns to the west at 8° . The quarry displays about 30 feet of white limestone, overlain by a more thinly-bedded rock with a little purple shale, while the river below exposes the top of the Basement Beds. A few yards further west, and just beyond the margin of this map, the strata are thrown down about 35 feet to the east by a north and south fault, on passing which we get a clear view of the somewhat abrupt junction of the limestone and Basement Beds. About 200 yards further up the stream again, an old trial for hæmatite exposes the junction of the Basement Beds and the Wenlock Shale, the bedding of the two being nearly at right angles. The impure limestones, which run through Flintshire at the base of the Carboniferous Limestone, cease to be distinguishable in this and some other parts of the Vale of Clwyd.

The limestone next appears in the quarries of Pen-y-graig, as a white fine-grained rock, dipping at angles of 5° to 16° to the north-north-east. This rock lies comparatively high in the series, for it is succeeded at 800 or 900 yards to the south-west by a second parallel range of quarries in encrinital limestone, dipping north and north-east at angles of 7° to 10° , and resting directly upon the Basement Beds. The lowest zone of limestone contains small quartz-pebbles and rounded fragments of Wenlock Shale.

This range terminates eastwards against a fault running due north and south, and throwing down the New Red Sandstone. The fault appears in the sand-pit at Llanfwrog, described on p. 10, and might probably be exposed by a little digging in a dingle 600 yards north of that spot.

The base of the New Red Sandstone runs a few yards east from the sand-pit mentioned, for a pit 100 yards north-west of Llanfwrog Church shows the purple beds (Lower Coal-Measures) dipping north-north-west. The Trias and purple beds are thrown in succession against the termination of the limestone-escarpment of Coed Marchan by an east and west fault.

The Carboniferous Limestone runs from Llanfwrog southwards for about four miles without interruption. Near the south end of the Vale the whole series, with the overlying purple beds, is exposed (Pen-y-bont, Quarter-sheet 74 N.E.), but northwards the Trias gradually creeps across the edges of the purple beds, and then of the upper limestones, until it conceals about half the series. The highest Carboniferous strata seen here within this map crop out at Coed Marchan, and consist of massive limestone with a reddish tinge, doubtless due to staining. The ground between Coed Marchan and Galchog is occupied by thick and

massive limestones, corresponding to the middle limestones of Flintshire (p. 20), and dipping at 10° to 20° to the east-north-east, while the lowest beds appear in a quarry 500 yards north-north-west of Galchog. The last-named consist of sandy impure limestones with bands of argillaceous limestone of a porcellanous texture, and rest immediately upon the Basement Beds. They resemble the impure lower limestones of Flintshire.

The description of the Trias of the Vale of Clwyd will be found on pp. 116-118.

CHAPTER IV.

CARBONIFEROUS ROCKS.

EAST OF THE MOEL FAMMAU RANGE.

CARBONIFEROUS LIMESTONE.

The Carboniferous Limestone of this tract can be roughly divided up by lithological characters, which, however, change rapidly in a southerly direction. The lower part of the subdivision consists of dark argillaceous limestones with shales, forming a passage up from the Basement Beds to the purer limestone above, and though distinguishable in a general way from the rock above, cannot be separated from it by a hard and fast line upon the map. The upper portion of the subdivision consists in the north of the area of black, thin-bedded limestones, locally known as "Aberdo Limestone," but towards the south, of a series of alternating limestones, and calcareous and pebbly sandstones. Subsequently it will be shown that by a corresponding change the Millstone Grit passes from a chert in the north to a thick mass of coarse and pebbly sandstones in the south, and that as the "Aberdo Limestone" forms a passage from limestone into chert in the north, so the calcareous sandstones link on the limestone to the coarser form assumed by the Millstone Grit in the south.

The name of "Aberdo Limestone" is locally applied to the rock on account of its possessing, in common with the Liassic limestone of Aberdo (or Aberthaw) in South Wales, the property of forming hydraulic cement. The name of "Black Limestone," however, will be used in this Memoir, in order to avoid applying the same name to rocks of Carboniferous and Liassic age.

The central part of the Carboniferous Limestone consists of massive white limestone which forms most of the highest points in the escarpment, and has yielded much of the lead in the neighbourhood of Mold.

The first attempt to divide up the great mass of the Flintshire limestone was made by Mr. Morton, who worked northwards from Denbighshire into that county at the same time that the re-survey was in progress in North Flintshire. In his valuable paper he establishes four principal subdivisions, viz., those given above, and an "upper grey limestone" lying above the middle white limestone.* Though their boundaries are not sufficiently definite to be traced upon the map, yet these subdivisions provide the means of referring fossils or marked rock-bands to their true horizons, and

* The Carboniferous Limestone and Cefn-y-Fedw Sandstone of Flintshire, 8vo., Liverpool, 1832. (Reprinted from *Proc. Liverpool Geol. Soc.*, Sess. 1881-2.)

they are therefore frequently referred to in the text and in the fossil-lists in this Memoir. The following list gives the names employed by Mr. Morton, alongside of those which had come into use by the Geological Survey :—

<i>Geological Survey.</i>	<i>Mr. Morton.</i>
Millstone Grit	Cefn-y-Fedw Sandstone.
{ The Black Limestone (North Flintshire)	The Upper Black Limestone.
{ The calcareous sandstone series (South Flintshire)	
The grey and white limestone	{ The Upper Grey Limestone.
The lower brown limestone	{ The Middle White Limestone.
	The Lower Brown Limestone.

(1) The lower brown limestone.

We may conveniently commence the description of the Carboniferous Limestone by tracing this subdivision from north to south, and noticing the exposures of its junction with the Wenlock Shale below.

North of Caerwys the base lies hid for a long distance under Drift, but in the ravine of Coed Maes-mynan, near that village, comes into full view. The limestone dips a little east of north at 17° , the Wenlock Shale in the opposite direction at 31° , the two lying therefore nearly at right angles. The limestone is thin-bedded and impure, several argillaceous bands possessing a peculiar porcellanous texture and conchoidal fracture. The section follows :—

Old quarry in the lower beds of the limestone, Coed Maes-mynan.

	FEET. INCHES.
Black shaly limestone	- 1 2
Dark porcellanous limestone	- 1 6
Do. do. rubbly	- - 9
Very hard black limestone with a hackley fracture	- - 4
Sandy shale	- - 1
Very hard black limestone with a hackley fracture	- - 9
Do. do. earthy	- - 10
Do. do. decomposed into a soft yellow sand or loam	- - 3
Green and yellow shale with a sandy band	- - 6
Hard black hackley limestone	- 2 0
Porcellanous limestone	- - 9
Hard black hackley limestone	- 1 2
Porcellanous limestone	- 1 3
Yellow sandstone	- - 6
Hard black limestone, weathering to yellow sand	- 2 0
Porcellanous limestone	- - 3
Hard black limestone, shaly below	- 1 0
Porcellanous limestone	- - 1
Hard black limestone, sandstone, and green shale	- 2 0
Porcellanous limestone	- 2 0+
	19 2

These strata run along the hill-side to the next valleys, Afon Trefraith and Afon Ffynnon Fair, near the latter of which a quarry shows eight feet of argillaceous limestone, in beds about one foot thick, with sandy bands, black shales, and black calcareous bitumenous layers, underlain by 15 feet of thicker-bedded limestone with a few nodules of blue chert. Lower down in the hill-side there crop out sandy and shaly beds with obscure plant-remains resembling those of Moel Hiraddug,* while the upper part of the same series appears at intervals in the slopes below Gledlom, and runs down thence towards the Sun Inn. Above Melin-y-wern, the upper of two quarries shows bluish-grey limestone, but the lower exposes brown limestones with nodules of bluish glassy chert and a few thin bands of yellow sandstone, alternating with blue rather flinty-looking limestones.

Here the beds cross the valley and pass under the thick Drift-sand on which Nannerch stands. They are next seen in a quarry near Nannerch Station, which lies partly in crystalline limestone and partly in porcellanous and dark-coloured beds, the latter containing a coal-smut 1 to 1½ inches thick. Brown sandy and porcellanous limestones occur again in the south end of Pen-bedw Park, but the dry ravine running south-west towards Siamber Wen is occupied by white and grey limestone of the kind that usually overlies the impure lower limestones, from which it would seem that the impure limestones are either taking a higher place in the series, or that the strata are displaced by a fault. The former theory appears the more probable, for when the beds next appear at Cefn-Maly and Bwlch, near Cilcain, a band of the Lower Limestone type, running at an average distance of 700 yards east of the actual base, is clearly underlain by the massive grey limestones which appear in the quarries north and south of this village.

The base of the limestone may be traced as far as Craig (now ruined) by the evidence of swallow-holes, situated under the northern slopes of Ffrith Mountain, but at this point is shifted by a fault with a considerable northerly downthrow. South of the fault the only evidence of its position consisted in a newly fallen-in hollow in a field above Pen-lan, clearly the commencement of a swallow-hole; larger holes occur near the high road by Ddaugae. In the ravine by Pwll-y-blawd, and in a disused pit on the west side of the road at Tan-y-bryn, brown and black sandy limestones and porcellanous limestones of the same type as those of the Caerwys neighbourhood occur, evidently near the base, but the junction is not seen. Thence the base can be traced by swallow-holes past Tafarn-y-gelyn† above Bryn-bowlio, but immediately to the south is again shifted by the Maes-y-safn vein, a powerful downthrow to the north. On the south side of the fault, in the bed of the river, a reddish sandy and current-bedded limestone, in

* Geology of the Coasts adjoining Rhyl, &c. (Geol. Survey Memoir), p. 9, 1885.

† Mr. Ashworth's well, situated about 100 yards from the cross-roads up the Mold Road, is said to have been sunk to a depth of 90 feet in limestone.

places slightly conglomeratic, and evidently forming nearly the basement-bed of the subdivision, lies beneath brown limestones with a little calcareous sandstone, exposed on the east side of the old watercourse. The position of the actual base is indicated by an old swallow-hole near Llanferres Church; and by an old shaft on the east side of the road opposite the church, where yellow and red shaly limestone and shale were proved. Here again the base seems to be shifted, apparently by the Pant-du vein, which throws the strata down to the north, but the lower beds pass under Alluvium and Drift-sand for the next mile, and re-appear on the east side of the river at Bryn Alyn, where they are introduced by the Blaen-y-nant vein. Thence they run round the hill above Llwyn-y-frân, where they consist of dark limestone with brown calcareous sandstone. At Cwaen-y-ffynnon they are lost under the Drift again, but are shortly thrown in again by the Westminster lode, a fault parallel to and with a similar downthrow to those of Blaen-y-nant and Maes-y-safn. Both at Bryn Alyn on the north side of the Blaen-y-nant, and near Bryn-y-gloch on the north side of the Westminster lode, a thin conglomeratic band with small quartz-pebbles occurs, separated from the impure lower limestone described above by probably not less than 250 feet of massive grey and white limestone.

Within a short distance the limestone once more crosses the river, the first indication of its presence on the western side being the strong spring of Ffynnon Wenwyl. A quarry in an old limekiln, near Rhiw-yale, exposes dark-coloured sandy limestone, dipping E. 30° S. at 22° .

(2.) The grey and white limestones.

The limestones overlying the impure lower beds described above are massive, pure, of a crystalline texture, and generally light colour, whence the name of Middle White Limestone, applied to them by Mr. Morton. They not only rise into the hills enumerated on p. 1, but form generally a broad plateau of a height of 600 to 1,000 feet above the sea. In the northern part of the map the total breadth of outcrop of limestone, including the narrow belts occupied by the lower impure beds and the upper Black Limestones, amounts to nearly four miles, but this great spread results in part from the repetition of some of the beds by large strike-faults. Towards the south, where no such complication exists, the width of outcrop varies from $1\frac{1}{2}$ to 2 miles, the total thickness amounting to 2,570 feet (see detailed section, p. 37).

The greater part of this mass of limestone presents no such features as to render possible the tracing of beds or horizons, except in a general way, but in its upper part it becomes split up by the wedging in of shales and black argillaceous limestones (North Flintshire) or of calcareous sandstones and grits (South Flintshire). It will be convenient, in describing it, to return

to the northern part of the area, and proceed southwards, as before.

Though the lower impure limestones are concealed by Drift all along the eastern slopes of the Silurian hills north of Caerwys, as before mentioned, the massive grey beds overlying them rise to the surface in a number of quarries near Croes-waen and Caerwys Hall, with a dip ranging from 15° to 20° to the north-east. Further in this direction however the dip becomes irregular, and the limestone assumes a shattered appearance along the valley that runs between Ffrith-y-garregwen and Marrian-tref-Edwyn, doubtless in consequence of a fault of considerable importance, which follows this hollow, running nearly parallel to the road and through the pits in sand and fireclay subsequently alluded to (p. 119); but from the similarity of the beds on either side of it the fault cannot be traced for much more than a mile.

To the north of this line the dip is still variable, though with a general prevalence towards the south-east near Plas-newydd, Llyn-du, and Merllyn. Close by on the east runs the great fault which throws in an outlier of shales and sandstones (Lower Coal-Measures).

The beds described above possess no characteristic by which their position in the series can be determined, but close by Hafod Dew (at the southern end of the Coal-Measure outlier) the following section occurs:—

	FEET.
White limestone	—
Calcareous sandstone, or sandy limestone, with white quartz-pebbles as large as peas, and encrinites and brachiopoda	8 to 10
Pure white gannister-like sandstone, current-bedded	6 +

Below these, at a distance of about 350 yards to the south-west, lies a bed of shale with ironstone-nodules. The character of these beds shows that they are the equivalents of the calcareous sandstones which form a passage from the limestone up into the Millstone Grit further south. They belong therefore to near the top of the Carboniferous Limestone (though they crop out near the middle of the limestone-area), and seem to have been brought to their present position by the two faults which throw down the Coal-Measures of the outlier mentioned above, and of Nantfigillt respectively. Though no line of fault can be traced across the area about Berthen and Prysau, yet there doubtless exists a connection between the great dislocations referred to, the general effect being to throw down the beds to the west, so as to repeat the outcrops of a large part of the limestone, and thus give the limestone-area its great breadth. As a confirmation of this view we may mention that the veins in the ground between Hafod Dew and Licswm have yielded lead-ore, for on the above supposition the beds which they traverse must be the same as those in which some of the rich deposits of Halkin Mountain have been worked.

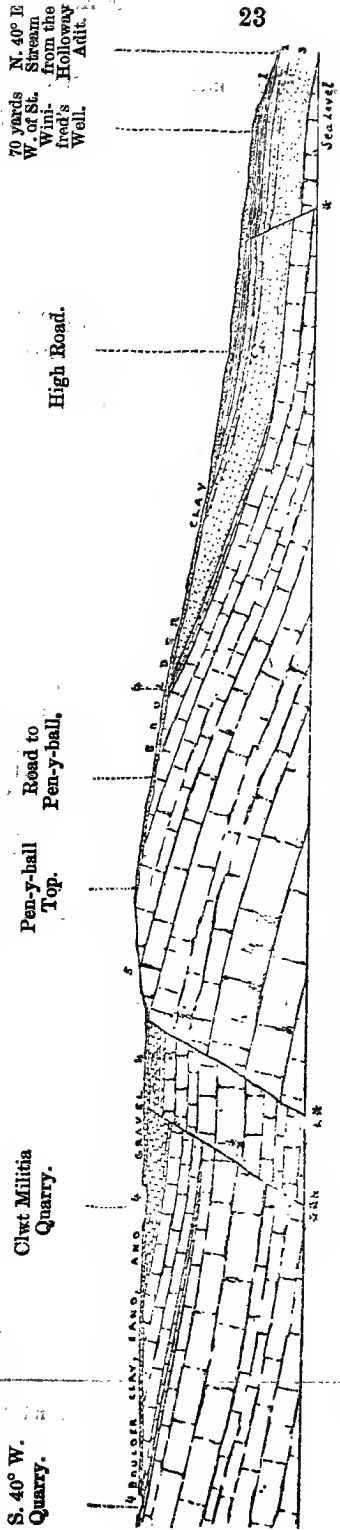
About Garneddwen and Gors a bed of fine white limestone of saccharoid texture occurs; in the former place it runs under the more northerly of two limekilns and is about eight feet thick.

On crossing this presumable line of fault, we find the beds after several minor undulations assuming a northerly and easterly dip so as to pass naturally under the upper Black Limestone of Pen-y-ball, near Holywell, and of Halkin Mountain respectively. South of Calcoed Hall we meet with grey and white massive limestone, with a northerly dip, which, towards the north, is succeeded by grey beds with chert-bands and a white bed with abundant *Productus giganteus*, seen near Calcoed. Near the southern edge of the Common a row of pits displays a black hydraulic limestone closely resembling the Black Limestone ("Aberdo" Limestone) of Holloway. The beds dip to the north-east at 8° to 10° , so as to appear to pass under some grey limestones which rise to the surface at two or three hundred yards distance, but whether they do so, or whether the Black Limestone of the Holloway and Pen-y-ball quarries are thrown down here by a fault, cannot be stated with certainty from the prevalence of Drift. Perhaps they more probably form a lenticular mass of black limestones appearing locally at a lower horizon than the Black Limestone.

The Black Limestone crops out on the north-eastern side of the Common, along the level ground which underlies the ridge known as Pen-y-ball Top (Fig. 3). This ridge consists of a hard thick-bedded white limestone of great purity, dipping, as does the Black Limestone, to the north-east. This apparently anomalous position (by which the Black Limestone appears to dip under the white limestone of Pen-y-ball) is caused by the great Milwr vein, a powerful fault running along the foot of this ridge, and throwing down the Black Limestone on the south-west. The ridge of white limestone runs from Pant Wacco by Pantasa to Pen-y-bryn, forming the "hading" of the Milwr vein all the way. The stone is worked in several places, large quantities being brought down by a tramway from Crecas to Greenfield for exportation and for use in chemical works.

FIG. 3.

Section from Holywell across Pen-y-ball Common.



- 1. Holywell Shales. Lower Coal-Measures.
- 2. Black evenly-bedded chert } Millstone Grit.
- 3. Glassy chert } Holloway Vein (supposed position of, east of the easternmost workings).
- 4. Black Limestones.
- 5. Grey and white limestones } Carboniferous Limestone.
- ** Milwr Vein.
- *** Chert Militia Vein.

(3.) The Black Limestone.

As the Black Limestone ceases to exist as a distinct subdivision a short distance to the south of the neighbourhood last described, we may conveniently complete its description here, so as to keep as far as possible to a geographical order in the references to localities.

This series has elsewhere been described * as forming a distinct upper subdivision of the limestone, running from the sea near Prestatyn by Llanasa, through the "Aberdo" limestone-quarries of Trelogan, Gorsedd, and Holloway. It consists of black argillaceous limestone in thin bands with partings of shale, and acquires importance from its property of forming hydraulic cement when burnt, without being mixed with any other ingredients.

The principal quarries from which the stone is obtained for the above-named purpose occur at Trelogan, Gorsedd, and Holloway (Quarter-sheet 79 N.E.), and on Pen-y-ball Common in the present map. In the Trelogan quarry about twenty-nine bands of limestone are worked, averaging 8 inches in thickness, and separated by thin partings of shale. Towards the top the beds become more shaly and contain some bands of micaceous sandstone. They and the base of the Chert Beds (Millstone Grit) are well seen in the sides of the cutting by which the tramway enters the quarry. A band of common limestone with large *Productus*, *Spirifer*, and *Encrinites*, about 4 feet thick, but rapidly thinning out, lies in the Black Limestone on the east side. Towards the east end of the quarry the junction of the Chert and Black Limestone undulates, so as to give the appearance of a line of erosion, which, however, is probably due to current-bedding, or perhaps in part to a squeeze. Occasionally a band of common limestone with *Productus giganteus* separates the two. The south side of the quarry, according to old miners, consists of white limestone, thrown against the Black Limestone by an east and west vein, but this part is obscured by rubbish. Towards the west end of the quarry some of the bands of limestone die out, or pass into shale with nodules of limestone.

The Gorsedd quarry shows similar thin-bedded black limestone overlain by Boulder Clay. The Waen shaft, sunk 200 yards to the north, is stated to have traversed 15 yards of Drift and 19 yards of Black Limestone before reaching the grey limestone. Further north, again, at 400 yards distance from the shaft, Lower Coal-Measure shale with a thin coal-seam is thrown in by a large strike-fault which runs from near Whitford towards Holywell, cutting out the Chert outcrop.

The same beds appear at intervals along the north or down-throw side of the old Holloway vein, as far as Holloway House,

* Geology of the Coasts adjoining Rhyl, Abergelle, and Colwyn (Geol. Survey Memoir).

where they pass under the Chert Beds of Saith-aelwyd. Near here they cross to the south side of the vein and strike south-eastwards through Coed Saith-aelwyd to the Holloway quarry, whence they may be traced as far as the Holloway House (in Quarter-sheet 79 S.E.) on the road from Holywell to Pen-y-ball (Fig. 3, p. 23). Here they thin out, and the Chert Beds rest directly on grey cherty limestones.

The Holloway quarry shows 35 to 40 feet of black thin-bedded limestone of the same character as that described above, but containing three or more bands of common limestone. The current-bedding of the series here becomes apparent, in some cases a band of common limestone sloping across the edges of the band of black limestone, and joining another above or below; there are also appearances of erosion at the base of some of the beds of common limestone. The "Aberdo" stove is carried down to Greenfield by tramway, and burnt for cement-making, or exported in the raw state (see p. 224).

The effect of the Milwr vein in throwing down the beds to the south-west has already been mentioned (Fig. 3, p. 23). The outlier of Black Limestone thus introduced extends from Pant Wacco (Quarter-sheet 79 N.E.) to Pen-y-bryn, or rather further towards the east than in its normal outcrop at the Halfway House. In two quarries, at Coetia Butler and on the Clwt Militia, the limestone has been worked for cement-stone. The former quarries lie in an angle between the Old Pant-y-nef vein, a north and south fault with a downthrow west, and a branch of the Milwr vein, known as the Smith's Bellows Lode. By each of these the Black Limestone is thrown against the white limestone of Pen-y-ball. The beds undulate with a general dip to the south-west; they resemble those of the Holloway quarry, but are overlain by six feet of greyish-brown crystalline limestone. The Clwt Militia quarry lies close to the mine of that name. The stone dips to the north-east at an angle of 15° , and rests upon grey limestone at a short distance to the south, the boundary, however, being everywhere concealed by Drift, and traceable only by means of the numerous shafts sunk on the Common.

The same strata occupy an angle at Pant Wacco between the Milwr vein and the great fault which forms the western boundary of the outlier of Lower Coal-Measures; they consist of thin-bedded black limestone and shales, dipping south at 21° .

The Black Limestone next appears in the well-known quarries of Halkin Mountain. It probably runs parallel to the Chert boundary about Pwll-clai, though it is not seen on the north side of the Pant-y-pydw vein, an east and west fault with a downthrow south. From this vein, however, it has been followed southwards in a long line of quarries. At first it is separated from the Millstone Grit by a thick bed of brown and white limestone with chert-nodules, and some hard blue limestone without chert, that is worked into window-sills and gate-posts. But at Pen-yr-Henblas

these overlying beds thin out, and the Chert Beds rest directly on the Black Limestone. In a few yards the Black Limestone itself thins out, but reappears on the south side of the Pant vein, west of Halkin Hall, and runs thence for about two thirds of a mile along the base of the Chert. Some of the bands of shale in the Halkin "Aberdo" quarries are noticeable for their richness in *Fenestellidæ*. The specimens here collected enabled Mr. Shrubsole to review the classification of these polyzoa, and to reduce the number of Carboniferous species from twenty-six to five. The following occurred at Halkin:—*Fenestella halkinensis*, Shrubsole; *F. membranacea*, Phill.; *F. nodulosa*, Phill.; *F. plebeia*, McCoy; *F. polyporata*, Phill.*

South of the Long Rake, which runs from Rhes-y-cae to Pentre Halkin, the Black Limestone occurs again, but at a distance of from 100 to 200 yards from the base of the Chert, and separated from it by a grey and white productal limestone. It appears in a number of small quarries near the Old Engine House on the Pant-y-gof vein, and again towards Berth-ddu, where it is cut off by the east and west vein which forms the boundary of the Millstone Grit of Moel-y-Gaer. In this neighbourhood it seems to die away, while sandy limestones and calcareous sandstones with small quartz-pebbles make their appearance at about the same horizon. Further south (in the Mold and Llanarmon districts) similar black limestones make their appearance both in and below the calcareous sandstones, as subsequently described. It will be noticed from the foregoing notes that the Black Limestone before disappearing becomes patchy in its occurrence, and is split up by bands of common limestone, though in North Flintshire it formed a distinct and constant subdivision.

The limestone owes its character and appearance to a small quantity of mud having been present in the water in which it was formed; the deposition of the mud keeping pace with, or sometimes, as indicated by the bands of shale, exceeding the rate of formation of limestone. These conditions suited certain forms of life, such as the *Posidonomya*, *Aviculopecten*, and *Fenestella*, which fossils are accordingly found to recur in such beds, not only in North Wales, but in other parts of the United Kingdom. For these reasons it becomes impossible to make certain that disconnected patches are on the same horizon. The colour that is used on the map to denote the occurrence of the Black Limestone Series has been used also for the similar limestones that appear at other horizons, especially in the southern part of the sheet (pp. 39, 41-44), but without the intention of implying that they lie on the same horizon.

* *Quart. Journ. Geol. Soc.*, vol. xxxv. p. 275 (1879), and vol. xxxvii. p. 178 (1881).

(4.) The grey and white limestones continued, and the calcareous sandstone series.

The description of these limestones will now be resumed, where it was left on p. 22. As a general rule the beds lying next below the Black Limestone (as well as those lenticular patches above it), are heavily charged with silica in the form of nodules or bands of chert and silicified fossils, and especially so in the range extending from Bryn Sannon southwards. There large *Producti* abound, in every case the outer layer of the shell having been converted into the form of chalcedony known as Beekite,* the peculiarity of which mineral in forming a number of rings round scattered nuclei becomes marked on the weathered portions of the shells. At Pwll-clai also, near Holywell, we find a band almost made up of the silicified shells of *Productus*, but, on the other hand, a *Productus*-bed at Ty-coch, near Calcoed, is almost devoid of silica. In the chert-bearing limestones corals are almost invariably, and the encrinites occasionally silicified, while chert-nodules abound.

Below these chert-bearing limestones lies an encrinital limestone capable of a high polish, and known as the Halkin Marble. It is worked on the top of the hill above Halkin Hall, where it occurs in large slabs of convenient thickness for mantel-pieces, &c.† Encrinital limestone occupying about the same horizon occurs again north of this quarry, and ranges towards Bryn Sannon, but much of it is rendered unfit for polishing by the silicification of the organisms.

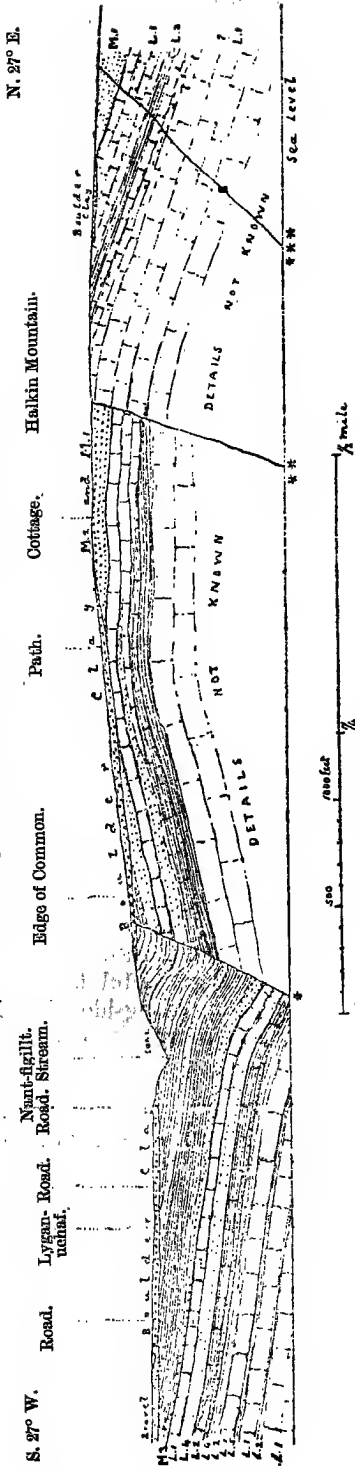
The limestone continues to strike a little east of south from this neighbourhood as far as a valley running from above Halkin to Rhes-y-cae. On crossing this valley, we find the strata dipping nearly south, and finally rising into an anticline, the axis of which runs south-eastwards a little to the east of Moel-y-crio, and through the Rhosesmor Mine. At the same time a well-marked syncline, accompanied by several powerful faults, appears to the west of the anticline, and, running alongside of it, introduces the narrow strip of Lower Coal-Measures, in which the deep Nant-figillt has been eroded (Fig. 4).

* *Geological Magazine*, New Series, Dec II. vol. vi. p. 334. (1879.)

† The beds vary from three inches to a foot in thickness. Their surfaces are dressed with the chisel and rubbed smooth with gritstones and sandstones of varying coarseness. The polishing is commenced with slate and pumice, and completed with putty powder. The marble has been used in Halkin Church.

Fig. 4.

Section across Nant-figillt and the southern end of Halkin Mountain.



- M. 1. Sandstone
- M. 2. Chert
- M. 3. Pebbly Grit
- * Nant-figillt Fault.
- L. 1. Grey and white limestone.
- L. 2. Thin-bedded limestone.
- L. 3. Coral-beds.
- L. 4. Calcareous sandstone.
- L. 5. Coral-beds.
- *** Deep Level Lode, crossed obliquely by the line of section (the position of the level indicated).

The limestone in this end of Halkin Mountain consists of the chert-bearing rock which lies immediately below the Black Limestone. The lowest strata seen are those quarried on the south side of the valley referred to above. The grey and massive limestones there exposed lie below more thinly bedded encrinal rocks with chert. Further to the south a shale-band, with nodular limestone and numerous fossils, appears at a still higher horizon.

On crossing to the western side of the Halkin anticline, we fail to find the Black Limestone in the position it occupies on the eastern side, but can trace, apparently at the same horizon, a brown calcareous sandstone from the Pant-y-ffrith Vein through the southern side of Moel-y-crio to Bryn-hyfyrd, where it is cut off by the Nant figillt fault. Never seeing the Black Limestone and calcareous sandstone together, we are left in doubt as to their relative positions, but we believe the sandstone to be the higher, although it is the forerunner of the great calcareous sandstone-series of the south in the middle of which the Black Limestone lies, if represented at all.

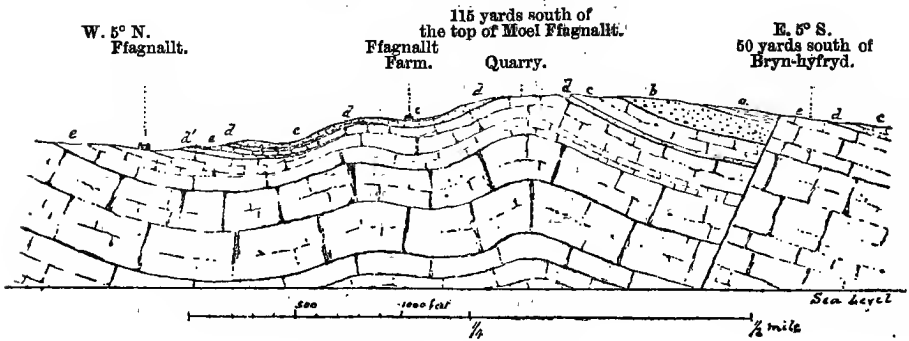
Two inliers of limestone occur in the Millstone Grit area south of Moel-y-Gaer. The one runs from the south side of this hill by Pen-yr-orsedd to Pant-y-terfyn, the limestone, which contains numerous chert-nodules, being exposed in a quarry on the side of the hill. In the Rhosesmor mine the underlying strata form a gentle arch, dipping east-north-east and west-south-west at the two ends of the workings (Fig. 20, p. 181), while the southern extension of the inlier is assumed on the evidence of an old trial-shaft 170 yards east-north-east of the Independent Chapel at Pant-y-terfyn, where limestone is said to lie below the Drift. Two other shafts in a wood 500 yards south-west of the Chapel penetrated calcareous sandstone and limestones, while close by the Millstone Grit appears, with a dip of 40° to the south-east. On the west the inlier, south of the Rhosesmor mine, is bounded by the Nant-figillt fault, which may be traced to Pen-yr-orsedd (Pen-yr-rhos on the one-inch map), and is believed to run on to Gerddi Duon. The second inlier is wholly concealed by Boulder Clay, but was proved to exist by a shaft at Wern-y-Gaer, which is said to have entered limestone immediately under the Drift (Fig. 4).

On crossing to the west of the Nant-figillt fault we enter a region of simpler structure. The principal faults run nearly east and west, and across the outcrops, so that their effects can be more easily recognised, while the strata, except locally, dip in regular sequence to the east. The calcareous sandstone develops rapidly, and in Moel Ffagnallt occupies a considerable space (Fig. 5). Below the Millstone Grit, which forms the eastern slope of the hill, lies a thin limestone (*c*) which crops out near Llyn and runs thence up to the top of the hill, with a dip of 40° to the south-east and east. From below this again rises calcareous sandstone or sandy limestone with quartz-pebbles (*d*). Nearly through the top of the hill runs a sharp anticline, and in

the crown of the arch the calcareous sandstone has been worn through so as to show a small inlier of the underlying limestone, but west of the anticline the sandstone, running down a steep dip-slope to Ffagnallt Farm, near that place carries a small outlier of the overlying limestone (*c*). A second bed of sandstone (*d'*) appears here also, at a lower level. It crops out east of Ffagnallt farm, and dips south-eastwards. The little escarpments formed by the two sandstones are separated by a Drift-filled hollow, in which there are traces of shale.

Fig. 5.

Section across Moel Ffagnallt.



- | | | |
|---|---|-----------------------------------|
| <p><i>a.</i> Holywell Shales (Lower Coal Measures).</p> <p><i>b.</i> Pebbly sandstone and chert (Millstone Grit).</p> | <p><i>c.</i> Top limestone.</p> <p><i>d.</i> Upper Hendre Sandstone.</p> <p><i>d'</i>. Lower Hendre Sandstone.</p> <p><i>e.</i> Limestones and shales. (Details not visible.)</p> | <p>} Carboniferous Limestone.</p> |
|---|---|-----------------------------------|

The same two sandstones appear on the north side of the Bryn-gwiog Vein, and further south near Gwrachen, whence they run to the fine section of Hendre. The ground further west, by Gelli and Garneddwen-bach, is occupied by thick white limestone, but at Hersedd in an intermediate position a thick band of shale with ironstone-nodules crops out and runs thence a little east of Cilcain Hall to the entrance of the North Hendre adit near Felin-newydd. In the limestone over this shale corals abound, a character that becomes conspicuous further south.

We now enter the Hendre Valley, which has been already mentioned as traversing both the limestone and Silurian ranges. Though wide in the Coal-Measures it quickly narrows to a gorge in the upper limestones, but widens out again in the area of the middle and lower limestones, where it contains an abundance of drift-sand. The section in the upper limestones, therefore, of which the sequence has hitherto been somewhat doubtful, is the most complete. The details of the following table were obtained in company with Mr. G. H. Morton, partly by measuring, or where

this was impossible, by estimating the thicknesses of the beds in the north and south sides of the gorge. The section will be found drawn to scale in Fig. 7, p. 38.

Hendre.

		FEET.	INCHES.	
Lower Coal Measures		Soft flaky and micaceous sandstone	2 0	
		Black laminated shale	10 0	
Millstone Grit	South side	Fine quartzose sandstone	1 0	
		White bastard gannister, or stony clay with rootlets	0-6	
		Quartzose sandstone with pebbles as large as walnuts	10 0	
		Thin-bedded dark cherty limestone with shaly partings	6 0	
		Massive white limestone, with many nodules and seams of chert in the upper part	25 0	
	Carboniferous Limestone.	North side	Rubby and thin-bedded limestone with shale	9 0
			Limestone with <i>Syringopora</i> and <i>Encrinites</i>	14 0
			Sandstone with <i>Productus giganteus</i> and <i>Encrinites</i> , and a band of quartz-pebbles near the centre	55 6
			Shale and thin-bedded bastard "Aberdo" limestone	27 0
			Hard blue limestone	5 0
		South side	Shale and limestone	18 0
			Hard blue limestone	5 0
			Sandstone	25 0
			Shale (seen in top of shaft) about	50 0
			Calcareous sandstone full of quartz	3-4
	Very hard massive white limestone with corals		12 0	
	Thin-bedded nodular limestone with corals		55 0	
	Thin-bedded limestone and shale		12 0	
	Shale with fossils		6 0	
	White and bluish massive limestone (upper part of the quarry)		74 0	
Shale (proved in a bore-hole in the quarry) about	20 0			
White limestone (the lower quarry)	40 -+			
		482	4	

At the western end of the quarry the last-named bed is traversed by a fault of uncertain throw, and at a few yards distance by the North Hendre Vein, so that the measurements are interrupted. The shale and limestone with corals, previously alluded to, occur on the western side of these breaks at about 200 yards distance from the quarry, probably between 300 and 400 feet below the second sandstone of the above section. The middle white and massive limestones crop out further west, but are almost entirely hidden in this valley by Drift-sand. Rising rapidly on the south side they run through the Cwt Coed and by the Garreg-boeth above Coed-du to the gorge of the Alyn above Rhydymwyn, where they are finely exposed in a number of bold cliffs on both sides of the river. In crossing these hills, little can be seen but terrace after terrace of massive grey or white limestone, with but a few thin bands of shale proved here and there in the shafts. A powerful cross-course runs from Ffynnon Uleinw by Mwyn-bwll to Hesp

Alyn, where it crosses the river and runs into another north and south fault, on the line of which the Alyn issues after a subterranean course (p. 34). It cuts off the small veins of Coed-du and shifts the Mwyn-bwll Vein, but cannot be traced north of Hendre, though it is popularly reported to have been proved at Pen-y-gelli, and to be the Caleb Bell Cross-course of Holywell. The L'fynnon Lleinw, which rises on the line of the fault, had lost the property of ebbing and flowing attributed to it by Camden, before 1810, when Pennant published his "Tours in Wales."*

Towards the east the limestones referred to pass beneath the series of alternating shales, sandstones, and limestones, which compose the upper part of the series. A shale and thin-bedded dark limestone (perhaps the "coral-bed" described above) appears in the top of a shaft near Mwyn-bwll, and strikes towards the letter *e* of the word Coed-du on the one-inch map. Just behind Coed-du stables, a north and south fault or cross-course throws down sandstone and sandy limestone on the east; the sandstone, which seems to be the lowest of the Hendre section, being visible at the east end of the Mwynbwll mine, near Coed-du, and in the cliffs overlooking the Alyn, above the mill. About 100 yards below the mill the sandstone ends off in the bed of the river against a second cross-course which runs along the road nearly parallel to the first-named, but with a downthrow to the west. The two cross-courses thus form a trough-fault, introducing a narrow belt of the Hendre sandstone to the west of its true position; the repetition of the sandstone-outcrops by this and a third cross-course near Llyn-y-pandy is referred to subsequently. The Coed-du Cross-course cannot be traced northwards across the railway, but the second has been met with in the easternmost explorations on the old Garreg-boeth Vein (see p. 184), its range, as thus determined, indicating that it is probably the same as the North Hendre Vein, referred to on p. 31, as being visible near the west end of the quarry.

Passing to the east of these faults we find the two sandstones of the Hendre section running up the south side of the gorge with a dip to the east of about 16° . The upper bed was formerly worked in a cave on the southern side of the road into grinding-blocks for the Staffordshire potteries, but was found to contain too much lime. On this side of the gorge a white limestone comes in under the upper sandstone, while the shale-bed proved in the bore-hole in the quarry is exposed between the two bridges. To the southward the rocks are lost to sight beneath Drift until they emerge in the sides of the valley of the Alyn, up both sides of which the two sandstones and the shale underlying each of them may be traced, the upper bed, as before, containing a band of quartz-pebbles. Above them lies a limestone with *Productus giganteus*, about 20 feet thick, which is succeeded immediately by a shale of Coal-Measure type. The dip is from 10° — 12° a little north of east.

* Vol. ii., p. 60.

The shaft of the Erw Felin Mine, 250 yards west-south-west of Rhydymwyn Church, is stated to have passed through the following strata :—*

Erw Felin Shaft.

	FEET.
Surface soil - - - - -	24
Limestone and shale - - - - -	18
Shale - - - - -	6
Yellow sandstone - - - - -	15
Limestone and chert mixed - - - - -	45
Limestone and shale - - - - -	51
Sandstone, with a pebble-bed - - - - -	24
Black sandstone and shale - - - - -	60
Light sandstone - - - - -	15
Fine black sandstone and shale - - - - -	60
White limestone - - - - -	15
Black limestone with fossils - - - - -	75
Black shale - - - - -	9
Grey limestone - - - - -	78
Blue shale - - - - -	9
Blue limestone - - - - -	39
Light shale - - - - -	½
Limestone - - - - -	39
Blue shale - - - - -	1½
Limestone - - - - -	39
Black limestone and shale - - - - -	60
	683

We now reach a part of the limestone-range regularly divided up into belts by east and west faults, almost every one of which acquires importance from having contained lead in workable quantity. We may conveniently adopt this natural division of the ground in describing the beds, and commence with the belt included between the Bryn-celyn and the Llyn-y-pandy veins.

In this belt we find five separate outcrops of sandstone, this unusual number being due to the repetition of some of the beds by north and south faults, or cross-courses. The first cross-course runs in the bed of the river at Nant Alyn, cutting off the Bryn-celyn vein, and thence slants up the hill to near the Baptist Chapel at Llyn-y-pandy. On its west or downthrow side a thick sandstone, with a thin band of limestone included, lies below thin-bedded limestone containing a band made up chiefly of corals, the coral-bed previously referred to. This sandstone is without doubt the same bed that runs up the hill on the opposite side of the river above the Mill, and is proved by the occurrence of the coral-bed to be the lowest of the sandstone-series. On crossing to the east side of the north and south fault the same bed crops out again, and runs through the top of the wood that overhangs the Alyn. Here, also, it is separated into two by a band of limestone, though the intervening bed is not clearly seen in this outcrop. Above it lies shaly limestone, which is overlain again by a third sandstone, containing a band of quartz-pebbles, and with

* This section was supplied by Mr. John Lloyd, of Rhyd-y-mwyn.

Productus. This third sandstone runs from Bryn-celyn by Pen-y-fron to the east end of the Llyn-y-pandy vein, and corresponds to the uppermost of the sandstones seen at Hendre. It is therefore at first surprising to find a fifth band with a nearly parallel outcrop still further to the east. The explanation is found in the Bryn-celyn cross-course, a second north and south fault with a downthrow west, which repeats the outcrop of the last-named sandstone. The underlying shaly limestone also recurs, but on the east of the cross-course is overlain by a coarse-grained encrinital band. The cross-course itself has been proved in the mines. It is stated to have shifted the Bryn-celyn vein about 40 yards, and to have cut off the Llyn-y-pandy vein completely, all efforts to discover this lode on its east side having proved abortive. Towards the north, after passing the river, it is lost under the Drift, but probably runs up the valley by Plâs Wilkin towards North Hendre, either joining or keeping near the first-described cross-course of Nant Alyn. To the south all surface-evidence of its existence disappears, though it is said by miners to be the same as the Cat Hole Cross-course. The topmost bed of limestone, a grey encrinital rock, appears in an old quarry at the first letter y of the name Rhyd-y-mwŷn on the one-inch map.

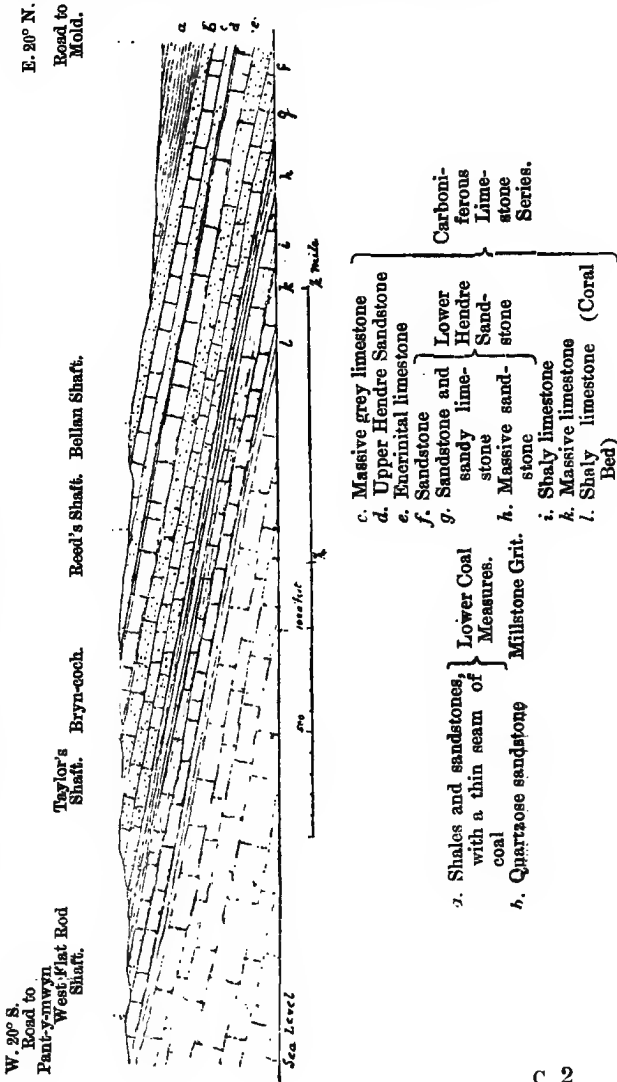
The next belt is included between the Llyn-y-pandy and the Pant-y-mwyn veins. In it there occur three outcrops of sandstone in a true sequence, the lowest bed containing, as before, a thin band of limestone and a considerable thickness of calcareous sandstone; it includes also quartz-pebbles, for the first time. The uppermost sandstone is not well exposed, owing to Drift-gravel, and its boundaries are partly conjectural. About 100 yards west of the lowest sandstone is seen the coral-bed, and between this and the Nant Alyn cross-course there runs a bed of shale, as proved in a shaft in the edge of the wood. The ground to the west is occupied by the massive middle limestones, for the most part bare of Drift. A white saccharoid stone, perhaps the same as that seen near Garneddwen, occurs in a quarry by the side of the road, 150 yards west of the Crown Inn, Pant-y-mwyn. Still further to the west, massive limestones of great thickness (the Middle White Limestone of Mr. Morton) form the cliffs which overhang the Alyn on the east bank; west of the river the limestone becomes darker and less pure.

The Alyn takes a subterranean course in this neighbourhood, the water disappearing in a swallow-hole a little north of Plas-y-egob, and leaving the channel dry as far as the bend near the entrance of the Cilcain stream. Here a spring issues, which runs as far as the Pont Newydd, but is there also swallowed up in fissures near and under the bridge. From thence the channel remains dry as far as a point 200 yards north-east of Hesp Alyn, where the whole river (presumably) issues on the line of a cross-course, which it has probably followed underground for some little distance, but how far is not known. In times of flood the underground channels are inadequate to carry off the water, and the open-air course is also occupied.

The next belt lies between the Pant-y-mwyn and the Pant-y-buarth veins, and is traversed by the less important Bwlch-y-ddaufryn vein. On the southern side of the first-named the upper series is well exposed. The base of the Millstone Grit and the highest bed of limestone, a massive grey rock, appear in a quarry north of the church, while 100 yards to the west the upper sandstone with quartz-pebbles crops out. From beneath this again rises an encrinital and rubbly limestone, seen by the road to Bryn-coch. The two lower sandstones each form a distinct, though small, escarpment, with bands of limestone, sandy limestone with quartz-pebbles, and calcareous sandstone intervening. The coral-bed crops out on the eastern side of the cross-course at its usual distance below the lowest sandstone (Fig. 6).

Fig. 6.

Section along the Vein and Abit-level from Bryn-bellam to Pant-y-mwyn.



The Bwlch-y-ddaufryn vein, with a downthrow north, shifts the outcrops about 100 yards. On its south side the coral-bed and lower sandstone are easily traced, but the beds above them lie in confusion, apparently through the dissolving away of the limestones and the consequent falling in of the sandstones. A quarry on the southern side of the road, and 200 yards west of the church, shows eight feet of limestone in sandstone, but at what horizon could not be detected.

The same difficulty exists in a still greater degree in the next belt of ground, namely, that lying between the Pant-y-buarth and the Gwern-y-mynydd veins, where matters are further complicated by the Cat Hole Cross-course, a north and south fault of unknown throw, and by the east and west fault near Hafod. The upper sandstone crops out close along the boundary of the Millstone Grit, the intervening limestone probably having been weathered away along the outcrop. The sandstone itself is also much broken up, partly in consequence of the almost innumerable explorations for lead made along the outcrop of the Fron Fawnog Flat (see p. 188), and partly also through the dissolving away of the underlying limestone, which led to the accumulation of the lead-ore. A second and lower sandstone occurs in the angle between the above-mentioned faults, but whether it is the lowest or not cannot be determined. On the south side of the Hafod fault the topmost limestone, a grey encrinital rock of a crystalline texture, runs through a line of quarries commencing at a point 200 yards south-west of Hafod. Below it a sandstone may be traced continuously to the Gwern-y-mynydd vein, and is underlain near the Hafod fault by a thin band of black limestone ("Aberdo") and grey limestone. The lower sandstones crop out further to the west, but appear in isolated knolls only, the lowest, which is well seen on the west side of the Cat Hole Cross-course, being a massive, current-bedded rock with quartz-pebbles. The coral-bed runs from the Pant-y-buarth vein at a point just abreast of the lowest sandstone, in a gentle sweep past Cefn-mawr Hall, its outcrop being marked throughout by an abundance of coral débris in the soil: From below it rises the great mass of grey and white limestone which forms the hill of Cefn-mawr (1,007 feet), and beneath these again lie darker, less pure beds, seen in the cliffs on the east bank of the Alyn.

The Gwern-y-mynydd vein throws the strata down to the north about 320 feet, and shifts their outcrops between 500 and 600 yards. The base of the Millstone Grit and the higher sandstones are well exposed on the south side of the vein in a number of quarries, in which the upper part of the following section was obtained.* The thicknesses of the lower beds was estimated from the outcrops in the neighbourhood of Aberdine, and in the valley of the Alyn to the west.

* In making these measurements I had the valuable assistance of Mr. G. H. Mortou.

Gwern-y-Mynydd.

		FEET.
Millstone Grit	{ Coarse quartzose sandstone, with numerous pebbles of white quartz in the upper part	41
	{ Thin-bedded fine-grained sandstone, about	25
Carboniferous Limestone.	{ Calcareous sandstone and limestone	4
	{ (A.) Massive grey encrinital limestone, about	8
	{ Sandstone with limestone in lumps and lenticular masses, with a bed of pale shale 2 feet, and a bed of chert 1 foot thick, 8 feet below the shale	30
	{ Quartzose grit	4
	{ Sandstone, with lenticular masses of limestone and chert	37
	{ (B.) Limestone, massive encrinital, with beds of black "marble"	30
	{ Fine flaggy sandstone, about	3
	{ Black shale	1 to ½
	{ Hard calcareous sandstone, with bands and irregular masses of chert	17
	{ Limestone, with a band of black ("Aberdo") limestone, and fine-grained calcareous sandstone	17
	{ (C.) Massive crystalline limestone, about	8
	{ Sandstone, about	8
	{ (D.) { Limestone, with much chert in interlacing bands, irregular masses, and nodules	8
	{ { Shale	1
	{ { Limestone, rubbly in parts, with "Productus gigantens bed"	16
	{ Beds not seen, about	18
	{ Fine-grained calcareous sandstone and white grit, about	50
	{ Beds not seen, in part massive limestone, about	60
	{ Massive white sandstone, becoming reddish brown in places	180
	{ Beds not seen, limestone in part	180
{ Coarse red brown and white grit, thick	150	
{ Dark and rather impure limestones, about	150	
{ "Coral-bed," shaly and grey limestone, packed with corals, about	20	
{ Massive grey limestones, forming terraces	about 1,500	
{ White limestone	about 1,500	
{ Brown sandy and argillaceous limestones, about	400	
Upper Silurian rocks	—	
		2,636

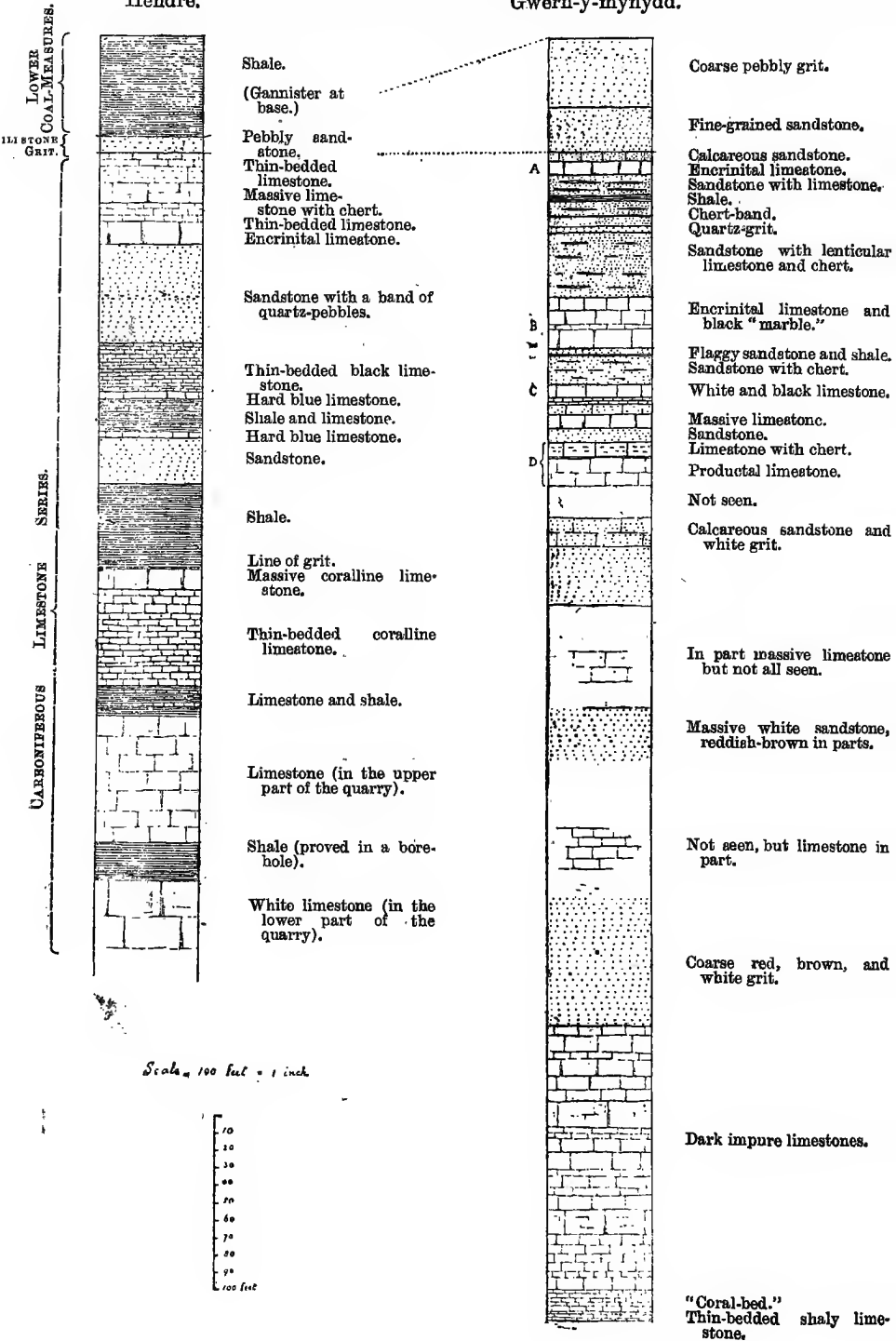
An abstract of the above section gives the following thicknesses for the subdivisions of the Carboniferous Limestone.

		FEET.
Millstone Grit	-	—
Carboniferous Limestone	{ Passage beds, limestone and sandstone	500
	{ Main limestones	1,670
	{ Lower impure limestones	400
Upper Silurian rocks	-	—
		2,570

In Figure 7 that portion of the section which is visible in the quarries is placed alongside of the section of the same strata as seen at Hendre (p. 31), while Figure 8 (p. 40) shows the relation of these sandy limestones to the Millstone Grit above, and to the main mass of limestone below.

FIG. 7.

Comparative Sections of the Calcareous Sandstone Series at Hendre and Gwern-y-mynydd.



The series of alternating sandstones and limestones reaches here a thickness of 500 feet as compared with 189 feet at Hendre. This seems to be due partly to the wedging in of sandstones at a lower horizon southwards, but partly also to a general thickening of all the strata, for the coral-bed, a more reliable guide than any of the sandstones, lies 110 feet further below the base of Millstone Grit in this locality. The details of the Gwern-y-mynydd section show almost no resemblance to those of Hendre, and under such circumstances we can use none but strictly local names for any bed of either sandstone or limestone. Each, however, has been traced as far as possible, and indicated on the map, according to its lithological character.

These strata may be traced continuously round the sides and over the top of Bryn-gwyn, but in the valley which separates this hill from Moel Findeg are broken through by a fault and sharp anticline which range south-eastwards from Colomendy. The topmost limestone is worked in a long quarry on Bryn-gwyn, to a depth of more than fifty feet, this thickness having probably been gained at the expense of the underlying rock, a sandstone with lumps and lenticular masses of limestone. Two sandstones, separated by limestones, rise close by from beneath, while at 200 yards distance from the Millstone Grit occurs a band of bastard "Aberdo" limestone (see section, p. 37) closely resembling the rock seen near Prestatyn.* The lower sandstones form two distinct parallel escarpments running round the western slope of Bryn-gwyn as far as the anticlinal fault referred to. The lower possesses a noticeable reddish-brown colour.

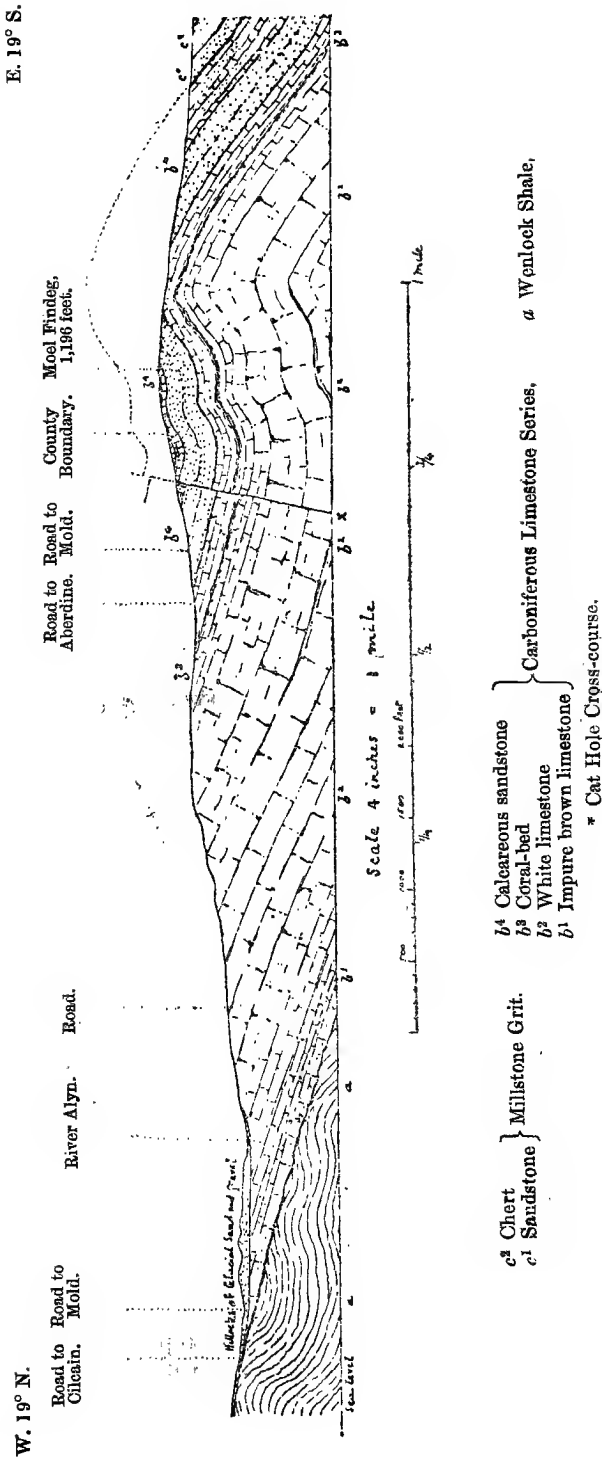
In the neighbourhood just described the strata dip to the east and east-north-east at angles varying from 4° to 16° , but on crossing the valley to the flanks of Moel Findeg sweep round with a dip varying from south-east to south and finally to west. Though the base of the Millstone Grit shows no interruption, yet clearly a fault must start here, with a downthrow north, increasing rapidly towards the west. For the coral-bed on the north-eastern flank of Moel Findeg, occupying its proper position with regard to the sandstones in the upper part of the hill, lies in the line of strike of the sandstone-series of Bryn-gwyn. And again the lowest sandstone of the former hill runs close up to the point where the highest sandstone of Bryn-gwyn appears. Some veins range in this direction from near Colomendy Hall, passing through the fire-clay pit described on p. 124, and probably account for the remarkable disposition of the strata, which is more than can be explained by a simple anticline.

The greater part of the sandstone-series comes into view on Moel Findeg (Fig. 8). The lowest sandstone, a coarse quartzose grit, is overlain by blue and shaly limestone, which however appears only in the débris of a shaft; the next overlying sandstone is reddish, and runs round the top of the hill close to the Trigonometrical Station, a limestone with chert, and containing a

* Geology of the Coasts adjoining Rhyl, &c. (Geol. Survey Memoir), p. 15.

FIG. 8.

Section across the Lower Carboniferous Rocks near Llanferres.



thin band of grit, lying next above it. Above the grit and about 100 yards west of the Trigonometrical Station, a bed of bastard "Aberdo" limestone, associated with a white argillaceous limestone, crops out (the same bed without doubt that is seen on Bryn-gwyn), and this again is succeeded by a sandstone and calcareous sandstone. The highest limestone, a grey encrinital bed, is poorly exposed on the south-west side of the upper part of the hill. Traced eastwards the whole series apparently becomes contracted, the outcrop of one of the lower sandstones running so close to the Millstone Grit, as to leave no room for the upper beds to crop out, even allowing for the high dip of 40° or 50° . The explanation is found in the perishing of the limestones along their outcrop, a fact that has been noticed before. In this case the workings of the Jamaica Mine have proved that the top limestone disappears for some hundreds of yards, and that the sandstones have fallen together in more or less confusion along the line formerly occupied by the perished bed.

The structure of the hill is further complicated by the Cat Hole Cross-course, by which the beds are thrown down to the west, and a third distinct range of the sandstone-series introduced. The cross-course runs through Aberdine by some swallow-holes, and passes through Moel Findeg, 250 yards west of the Trigonometrical Station. The coral-bed occurs in the bend of the road from Aberdine to Maes-y-safn near the lead-vein previously alluded to, and nearly in the line of strike of the same bed as exposed at Aberdine. Thence it runs through the fields to Maes-y-safn, the ground along its course being spread over with coral-débris. The lowest sandstone runs along the east side of the road, and is overlain by a reddish sandstone, as was the case on the other side of the hill. The upper beds and the base of the Millstone Grit are not well exposed.

The Maes-y-safn vein, with a downthrow north, shifts the outcrops between 200 and 300 yards eastwards. On its south side the beds quickly recover their normal north and south strike, the outcrops of the sandstones, all three of which are reddish near Maes-y-safn, being marked by three parallel ridges capped by woods, while the intervening hollows are occupied by limestones. The highest limestone and underlying sandstone appear in a quarry by the side of the road near Tir-y-coed, and in the hollow to the north the former causes an immense swallow-hole. The coral-bed may be found in its usual position.

In the next belt of ground, between the Pant-du and the Belgrave veins, in spite of numerous small exposures, we fail to trace any bed continuously. The coral-bed runs along the road and is succeeded at 100 yards distance to the east by a coarse white grit, which in turn is overlain by a limestone with *Productus*, seen near Gors. Next above comes a black shaly limestone (bastard "Aberdo") with *Fenestella*, possibly the same bed as that seen on Moel Findeg, though it appears to be rather lower in the series. To the east of this we meet only isolated knolls or short ridges of calcareous sandstone or grit, but near the County Boundary once

more find black shaly limestone, calcareous and saccharoid sandstone, while a little to the north some large swallow-holes and an alluvial hollow, partly filled with water, indicate the outcrop of a limestone of considerable thickness. Still further east, and 250 yards north of Llyn Iocyn, an old quarry exposes a dark, shaly, and fossiliferous limestone, weathering yellow, and dipping at 8° a little south of east. This gentle dip accounts for the outcrops being broader than in the belt north of the Pant-du vein, where it ranged from 20° to 38° . A small anticline, after running about 400 yards in a north and south direction, terminates in the deep hollow of Pant-du.

The main limestones to the east rise to a height of 1,324 feet, in one of the most prominent points in the limestone-escarpment. Next below the coral-bed is seen a productal limestone, and still further west, about the middle of the wood, a shale with coralline limestone. The upper part of the wood is occupied by massive white limestones, rolling slightly, but dipping generally a little south of east. The highest point is formed by one of these beds, nearly bare of soil, and still dipping east, but a short distance down the west side the hill is traversed by a small anticlinal fold, which may be traced down the crags to Pant-du towards the north and as far as the Belgrave vein to the south, where it runs into a great swallow in the limestone filled with white sand and known as the Pwll Iwrach. This roll is probably connected with the cross-course which runs from Maes-y-safn to Pant-du, and which dies out near the point where the anticline commences. A second similar anticline runs nearly parallel to it, about 100 yards further west. The hollows of Pant-du and Pwll Iwrach seem to owe their origin to the points of weakness caused by the intersection of the Pant-du and Belgrave veins respectively by these folds.

On the top of the hill we meet fine examples of the sculpturing of bare surfaces of limestone by weather. The rocks are traversed by a number of joints and fissures intersecting at all angles, and irregularly widened out by the solvent action of soil-water, while the surfaces and sides of the blocks of limestone have been deeply grooved or fluted by the same agency.

The precipitous north-western side of the hill affords a fine view of the massive limestones which form the middle part of the Carboniferous Limestone series. At its foot lies the deep hollow of Pant-du, a small alluvial flat at the end of a narrow valley which runs up from the Alyn. The valley, though once probably an important line of drainage, is now dry, the water disappearing in shallow-holes at Pant-du, and issuing from an old adit at the west end of the valley.

The Belgrave Vein, a downthrow north, shifts the outcrops about 300 yards, the coral-bed accordingly being moved to the east side of the road. About 100 yards east of Erryrys Rectory a limestone with thin bands of sandstone passes southwards into a grit with quartz-pebbles, overlain by coral-limestone. On the north side of the road, and 300 yards east of the Rectory, there

occurs a sandstone separated into two parts by a band of bastard "Aberdo" limestone and shale, and having shale below it, and coralline limestone above. Traced southwards this sandstone also develops in the upper part into a coarse grit. The next sandstone in upward sequence forms the conspicuous little rock known as Craig Wolf; the lower part of which is formed by a fine-grained calcareous sandstone, the upper by a coarse grit with quartz-pebbles.

The strata described above may be traced as far as the Blaen-y-nant Vein, but at Pant-glas there appears at a higher horizon a series of massive, crystalline, and sandy limestones and calcareous sandstones, which seem to strike southwards under the Millstone Grit, and to be rapidly and unconformably overlapped. Here again it is clear that the outcrops of the calcareous sandstones and lower beds of the Millstone Grit are entirely thrown into confusion by the superficial perishing of the limestones, the supposition of an unconformity between the Millstone Grit and Carboniferous Limestone Series being quite inadmissible.

The shale and bastard "Aberdo" limestone previously referred to as occurring below the coral-bed are not visible in this belt, though they probably run through the small alluvial flats by the side of the road, at Gors and Erryrys. To the west rises terrace above terrace of massive limestone, one of the higher beds, exposed in the side of the wood, being noticeable as showing current-bedding in a massive grey rock with nodules of chert. The western end of this belt is crossed by a north and south fault or cross-course, by which the strata have been shattered and disturbed, but the throw of which, as is the case with most strike-faults, is quite uncertain.

On the south side of the Blaen-y-nant vein, we can see the bastard "Aberdo" limestone in a quarry near Castell, 400 yards south of Erryrys, with massive grey and white coralline limestone above it. The coral-bed, with an abundance of corals, crops out 400 yards further east, and is succeeded by a calcareous sandstone with many quartz-pebbles, seen near the old reservoir of the Bog Mines. Above this again, as before, lies a coralline limestone with *Lithostrotion junceum*, and a reddish sandstone. We now enter ground in which the whole series of calcareous sandstones lies in confusion from the cause mentioned above. A sandstone is seen near the east workings of the Bog Mines, but no sequence can be made out.

The narrow belt between the Pant-y-gwlanod and Westminster lodes gives a more complete sequence, though here also the top beds are clearly missing. The bastard "Aberdo" limestone crops out a little west of the Bog Mines, and in an old quarry specimens of *Aviculopecten*, *Trilobites*, and *Fenestella* together with fragments of *Lepidodendron* and *Calamites* may be obtained. The general aspect of the bed and of the fossils in it resembles that of the Black Limestone of Prestatyn, though the latter probably occurs higher in the series. In this case, as all through the Carboniferous Limestone Series, beds of similar lithological

character are characterised by similar fossils, no matter in what part of the series they occur.

Three hundred yards east of this outcrop there runs a bed of limestone rich in corals, no doubt the same that was noticed near Castell on the north side of the Westminster lode, the true coral-bed occurring 300 yards further east again. The sandstones succeed at the usual distance to the east, the lowest bed being pebbly, and overlain by white limestone. The thick calcareous sandstone and overlying coarse grit which form the Craig Wolf, crop out at Maes-y-droell, where they are overlain by a white limestone, but the highest beds are unrecognisable, the Millstone Grit appearing here also to have fallen in through the dissolving away of the calcareous strata.

(5.) Hope Mountain.

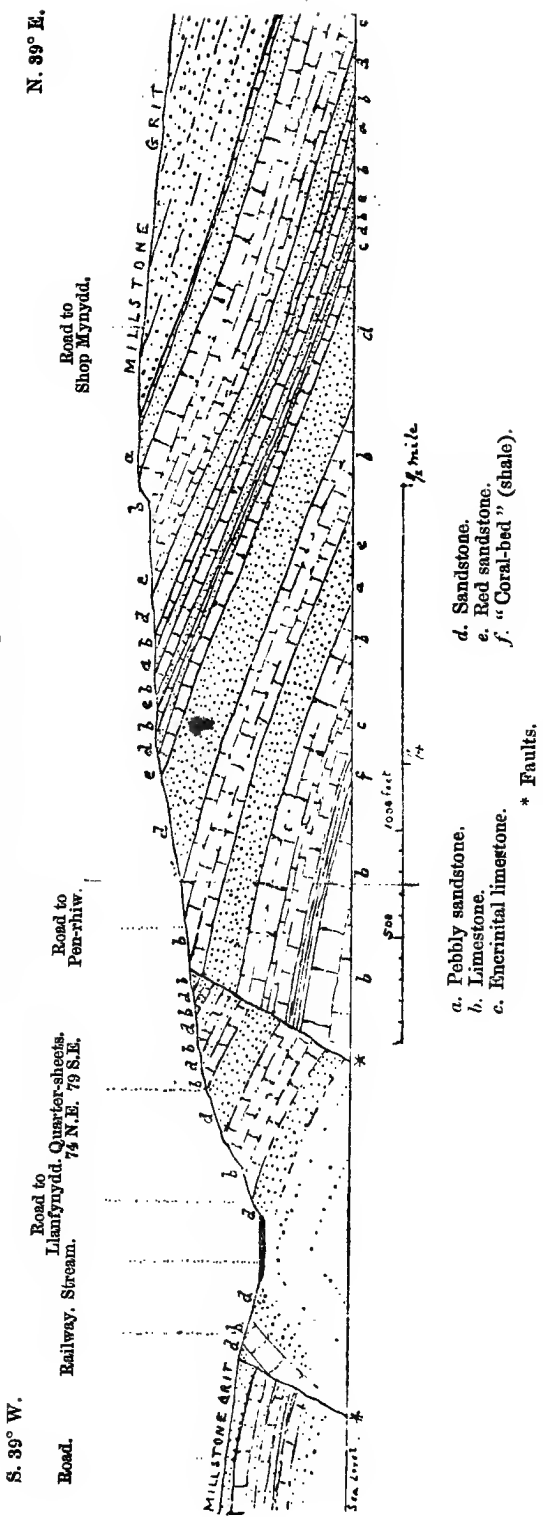
The Carboniferous Limestone of this inlier is brought up by the great Bala fault on the south, and by two almost equally powerful north and south faults on the west, which join at Llanfynydd to form the boundary of the Leeswood Coal-field. The strata present a general similarity to those last described, but are more fully developed.

The lowest seen, thin-bedded and massive grey limestones with a thick band of fine shale, occur at Ffrith (Quarter-sheet 74 N.E.), and are succeeded upwards by grey limestones with thin bands of bastard "Aberdo" limestone, containing abundant corals and encrinites, and probably forming the continuation of the coral-bed. The lowest sandstone, which enters the present Quarter-sheet at Pen-rhiw, possesses a reddish hue and is calcareous; at its base occurs a grey pebbly grit. Above this towards the north there crop out many alternations of sandstone and shaly, sandy, or grey limestones, some of the former being reddish and pebbly, while the limestones are often packed with encrinites. The highest bed of sandstone, which runs through the top of the hill, consists of coarse white grit with quartz-pebbles, some of which are as large as walnuts. Below it lie sandy limestone, yellow impure limestones with concretionary chert in bands, and a bed so full of encrinites, that the soil along its outcrop is principally made up of the broken stems of these fossils. In the sandstone also there occurs a lenticular band of encrinital limestone, seen in some quarries 100 yards north-east of the Trigonometrical Station. This sandstone runs down nearly to the road, skirting the east side of the hill, and there passes under encrinital limestone with quartz-pebbles, and grey flaggy and dark limestones, as seen in numerous places along the Millstone Grit boundary. Near and south of Bryn Yorkin a band of blue chert, probably a silicified limestone, appears locally on the top of the limestone.

In this inlier we find further evidence of the progressive change in the series, through which the sandstones (or sedimentary

Fig. 9.

Section across the northern end of Hope Mountain.



- a. Pebbly sandstone.
- b. Limestone.
- c. Eocrinital limestone.
- d. Sandstone.
- e. Red sandstone.
- f. "Coral-bed" (shale).
- * Faults.

part of the beds) gradually develop in number and thickness towards the south. Entirely absent in the north of Flintshire, they steadily gain in importance southwards along the limestone-escarpment, until they become the most noticeable feature in the upper part of the subdivision. At the same time the grain of the sand increases in coarseness in the same direction; the sandy limestones passing into calcareous sandstones, and finally into grits, while the included pebbles increase from the size of a split pea to that of a filbert, or even of a walnut. The corresponding changes which take place in the Millstone Grit will be described in the next chapter.

CHAPTER V.

CARBONIFEROUS ROCKS—*continued.*

THE MILLSTONE GRIT.

The lithological changes which take place in the upper beds of the Carboniferous Limestone in passing from North to South Flintshire are paralleled by an equally marked variation in the Millstone Grit, the sections at the two extremities of the county being so different, that only by following the outcrops continuously can we establish any correlation. The strata in the north have elsewhere been described as consisting in the upper part of almost solid, dark, well-bedded chert, with thin partings of shale, and in the lower part of brown and blue chert with less distinct partings.* Traced southwards these chert-beds gradually assume the character of sandstones, which become progressively coarser in grain southwards, so as eventually to pass into coarse and pebbly grits in the neighbourhood of Hope. From these facts, and from the nature of some of the beds of chert, it would seem that the deposit as a whole may be regarded as a very fine siliceous sediment, hardened by a siliceous cement.

The origin of Carboniferous chert has been investigated more especially by Professor Hull and Mr. Hardman,† and by Dr. Hinde.‡ By the former it was supposed that the chert results from the replacement of limestone by gelatinous silica; by the latter it was stated that the chert is largely composed of sponge-spicules, accumulated in consequence of the growth of sponges in the same area for a long period, and that it should therefore be regarded as a rock of organic origin. Massive chert, such as that of North Flintshire, according to Dr. Hinde resulted from the existence of sponges exclusively in that area, while nodular aggregations of chert have been formed where the sponges have grown in association with crinoids and polyzoa; he further showed that many of the spicules have undergone partial solution so as to contribute the silica which binds the whole into a rock. Bearing in view, however, the gradual passage of the chert into a conglomeratic sandstone, we should hardly be justified in discarding the theory of the sedimentary origin of the rock in favour of that of a purely organic growth. It not only contains a large proportion of inorganic quartz, but the spicules themselves have probably been sifted out from a mass of coarser material, in consequence of their extreme smallness. Some of the beds of chert, for example the "buhr-stone" of Halkin Mountain, were undoubtedly limestones originally, but have been altered by the

* Geology of the Coasts adjoining Rhyl, &c. (Geol. Survey Memoir), p. 18 (1885).

† *Scientific Trans. Roy. Dublin Soc.*, vol. 1. n.s. p. 71 (1878), and *Proc. Roy. Soc.*, vol. xlii. p. 304, et seq.

‡ *Geol. Mag.*, Dec. III. vol. iv. p. 435 (1888).

replacement of carbonate of lime by silica, as supposed by Prof. Hull.

(1.) Trelogan* and Holywell to Rhydymwyn.

The chert which strikes from Prestatyn through Golden Grove, terminates at Llanasa against a powerful north and south fault with a downthrow east, its last appearance (according to an old miner) being in the foundations of a house 100 yards south of Llanasa Church. On the east side of the fault it is shifted two-thirds of a mile southwards, and about 400 yards further on, is again shifted southwards by the Afon-goch fault. Thence it forms a prominent feature as far as Pentre-ffynnon. Near Afon-goch a quarry yields the following section:—

Chert Quarry, Afon-goch.

	FEET.
Banded chert - - - - -	6 to 8
Chert full of small encrinites - - - - -	3
Chert and limestone; sometimes all crystalline limestone, sometimes containing blocks of chert, with a heart of limestone, or <i>vice versa</i> -	1
Banded chert - - - - -	8+

The encrinital chert is no doubt a silicified limestone, while the bed below it shows several stages in the process of silicification. The banded chert contains no fossils visible to the naked eye, and seems to be a fine-grained sediment, cemented so closely by silica that the original grains have lost their distinct outline. In some gritty bands, however, which appear here and there in the chert, the grains of sand are distinguishable, though so firmly cemented that the rock possesses the fracture of chert.

The chert in the upper and lower parts of the pit is worked into blocks of the requisite size, and despatched to the Staffordshire potteries, for use in the grinding-mills.

The base of the chert and its junction with the Black Limestone runs through the "Aberdo" quarry, as previously mentioned, the former consisting of a siliceous shale, nodular and with lenticular cherty masses, or bullions. The beds undulate, either from current-bedding, or from a squeeze caused by the faults in the neighbourhood.

In the wooded bank above Trelogan the chert dips north at about 45°, and at the foot of the bank passes under laminated shale, so siliceous in the lower part as to ring when struck, but becoming less so upwards and passing up into the next subdivision, the Holywell Shales. The Trelogan Mine was worked almost entirely in this shale and the underlying Chert Beds. The depth to the Chert in the Hannah Shaft at the north end of the mine was 140 yards, and at the Whim Shaft on the north side of the road was 22 yards, giving a dip of about 13° (the two shafts being but a little out of the line of the dip). The former was sunk to a depth of 210 yards without reaching the base of the Chert, and the 190-yard level was driven from it southwards for 510 yards all in Chert. The 160-yard level, running from the

* Quarter-sheet 79 N.E.

Hannah Shaft to the Old Engine Shaft, was also in Chert for its whole length, which is said to be 1,200 yards. The thickness of Chert at the latter must according to this statement exceed 175 yards, when measured vertically. Even allowing for the dip, the thickness of the Chert Beds can hardly be less than 140 yards.

Near Pentre-ffynnon we again find a calcareous band imbedded in the Chert. A curious seam of chert-splinters, imbedded in a hard brown crystalline limestone, occurs in the middle of a limestone of the same character, the whole being over- and underlain by banded chert of the usual appearance. The origin of such a breccia is not at all clear; it would seem as though some of the previously deposited chert had become hardened and broken up before the formation of the brown limestone.

The strata dip here northwards at 16° to 35° , but are cut off on the strike at Pentre-ffynnon by a large north and south fault which runs southwards under Garreg Mountain to Pant Wacco, and thence along the western side of an outlier of Lower Coal-Measures. Though the limestone appears on the east side of this fault above Whitford, the Chert Beds do not come to the surface, for a large strike-fault throws Lower Coal-Measure sandstone and shale against the limestone for a distance of about two miles. The position of the fault was proved at Saith-ffynnon in the adit level to the Waen and Merllyn Mines; where it throws shale with a thin coal-seam directly against the Black Limestone. Further west it seems to bring the Lower Coal-Measure sandstone, exposed half a mile north-west of Whitford, against the Black Limestone which underlies the road south-west of this village, while to the east it cuts off the Saith-aelwyd Chert and Black Limestone on the strike. Nearly all this belt of ground is overspread by Drift, and the absence of any rock-feature constitutes strong evidence against there being any outcrop of Chert between Pentre-ffynnon and Saith-aelwyd.

At the latter place the Chert Beds appear, in natural succession to the Black Limestone, in a low hill 400 yards west of Eyton's Shaft, and pass under a Lower Coal-Measure shale close by. They show here for the first time the commencement of that change by which the chert of the north passes into the pebbly sandstone of the south, for they consist of brecciated and conglomeratic sandstones, containing pebbles of white quartz as large as peas, and small fragments of carbonised plant-remains. A similar (or the same) bed, occurring in the quarry above James's Place, Holloway, reaches a thickness of three feet, and lies between beds of massive chert. In both cases this grit occurs high in the Chert series, this being proved in the former case by the occurrence of the shale as mentioned and by a deep shaft in chert in the wood close by; in the latter by the position of the bed relatively to the base of the Chert as seen in the Holloway "Aberdo" quarry.

From this point to the Pen-y-ball road, the Chert, though concealed by Drift, is easily traced by the assistance of numerous

shafts. South of this road it is well exposed in and above Coed-y-froon as far as Brynford Hall, where it is cut across by the Milwr vein. In its lower part (above the wood) it consists of brown and blue flinty chert, but in its upper beds (seen in the wood) of evenly bedded black flaggy chert, made up of alternating laminæ of black glassy chert and fine cherty sandstone. These flaggy beds are traversed by straight clean-cut joints nearly at right angles to one another, and consequently are easily extracted in a form suitable for building. The upper boundary of the Chert runs along the lower part of the wood, the black flags forming an intermediate stage between the pure chert and the Holywell Shales above. The junction is shown in a quarry 400 yards north-west of the Workhouse, where the lowest beds of the shale are siliceous as at Trelogan, and contain a band of argillaceous limestone (Holywell Cement-stone) with *Posidenomya*. A small outlier of Chert and the overlying shale, on the south side of the Milwr vein near Pantasa Farm, lies hidden below the Drift-sand, but has been proved in shafts; the shale is finely laminated and contains nodules of ironstone.

The Chert-outcrop may be followed southwards from Brynford Hall through Pen-y-pylle and Pen-yr-hwylfa, notwithstanding the prevalence of Drift. The overlying shale appears in the road between Milwr and Pen-y-pylle, and again in that running south-west from Derwen, where a bed of cement-stone, perhaps the same as that mentioned above, lies close above the Chert.

South of Pen-yr-hwylfa, the Chert rises in the hills of Brynmawr and Pen-yr-Henblas, in which it has been largely worked for the Staffordshire potteries. The lower beds are blue and white, but yellow and brown chert has been preferred for quarrying. At the southern end of the quarry, the Chert Beds rest directly on the Black Limestone, and are interstratified with yellow sandstone towards their base. The top beds, seen only in the old mining hillocks, are shaly and flaggy, so as to form a passage up into the shales, as was the case at Holywell. The shales contain here also a band of cement-stone, fragments of which may be picked out of the débris from a shaft 200 yards south of Pentre Halkin Farm, and from a level 300 yards south-west of Hafod.

The lower beds of the chert frequently in this district dip at high angles in abnormal directions, although their boundary preserves its normal strike. A good instance occurs by the side of the road to Halkin Hall, and a quarry on the south side of the road provides the explanation, for the strata dip here from all sides at steep angles towards the centre of the pit, in such a way as to show that the rock beneath has given way, probably owing to the collapsing of a cave in the limestone. If the Chert Beds had been denuded back two or three hundred yards further, the chert filling this hollow would have remained as an outlier, similar to those found in many parts of the limestone-area (p. 119, Fireclay Pits).

The lower beds of Chert at this spot contain broken stems of *Lepidodendron* and other plants, and are no doubt sedimentary, but about a mile further south (300 yards south of Hên Rake),

an old quarry shows hard flinty rock underlain by a crumbling chert, honeycombed with the empty casts of encrinite-stems, and doubtless a silicified limestone. Above is seen massive chert split up by occasional more shaly bands.

Some of this encrinital rock was used together with common chert in grinding flints in the Potteries, and showed such good qualities, and at the same time so close a resemblance to the French buhr-stone, that it was tried with considerable success for grinding wheat. It was worked in the old quarry mentioned above by the same company that excavated the Rhes-y-cae Clay-pit (p. 121). The band of encrinital chert was described as being about four yards thick, and as lying between two layers of a compact siliceous slaty chert, covered with a shivery siliceous shale.*

On tracing these lower beds of the Chert series southwards to the east and west fault at Moel-y-Gaer, we notice a rapid change in their character. While the lowest strata continue as chert, the greater part of the subdivision passes into a quartzose and often coarse sandstone. A bed of shale also, in the middle of the series, runs from the Slip Inn through Halkin by Pant-y-gof to near Croes-y-Stryt. The beds above this shale especially show a marked difference from those on the same horizon at Holywell and Henblas. Here they consist of pebbly quartzose sandstones with carbonised plant-remains; at Holywell they are made up of evenly bedded chert-flags, as already described.

The general south-easterly strike which runs through Halkin Mountain is interrupted by the east and west fault of Moel-y-Gaer. (Fig. 4, p. 28.) Though not actually seen, this fault is easily traced where it separates the limestone from the Millstone Grit, and was proved also in the Halkin Mountain Deep Level, in the position that had already been assigned to it on surface-evidence. The dip in Moel-y-Gaer, on the southern side of the fault, is roughly speaking quâquâ-versal, the lower beds of the Chert series forming an irregularly domed covering, probably of no great thickness, over the limestone that is exposed near Rhosesmor. These lower strata consist of chert as before, but pebbly sandstones come in above, and in an old quarry close by chert and cherty or quartzose sandstone alternate. A quarry 100 yards north of Foel Farm shows a white sandstone with unusually large quartz-pebbles and some obscure casts of brachiopods.

The Moel-y-Gaer fault runs westwards into the Pant-y-ffrith cross-course, but has not been traced beyond it. At the intersection of the two the limestone has perished, and a great mass of Millstone Grit has fallen in confusion into the hollow, to a depth exceeding 80 yards, as proved in a shaft. Again at Moel-y-Crio the Millstone Grit dips so as to apparently pass under the limestone, probably through a similar disturbance. The beds consist of interstratified chert and pebbly sandstone.

* On the Porcelain Clay and Buhr-stone of Halkin Mountain, by W. Bishop & Co. *Phil. Mag.* vol. lix. p. 406 (1822).

The Millstone Grit on the eastern side of the Rhosesmor anticline is much obscured by Drift, and its boundary is more or less hypothetical. Where seen in the quarry on the south-eastern side of Moel-y-Gaer, it consists of chert with a thin band of black limestone interstratified, and in a shaft between Pen-y-rorsedd and Rhosesmor presents the same character. At a higher horizon some cherty and coarse quartzose sandstones, exposed at Caer-fallwch, come on, but we obtain no further evidence till we reach the valley running by Cefn Eurgain and Sifnau-hir (Chimney-hir on the one-inch map). Near the former Lower Coal-Measure shale dips at 30° to 40° , while at the latter Holywell Shales have been proved in the Carth-y-cwd shaft (p. 66). The strata dip to the south-south-east at 40° , and must therefore sweep round as indicated on the map.

On passing the fault which throws in the long strip of Lower Coal-Measures of Nant-figillt, we find the strata again greatly changed. The Chert and quartzose sandstones are confined to a narrow band, rarely exceeding 200 yards in breadth, and finally thin out altogether, while immediately above lies a shale of Coal-Measure type, containing a thin seam of coal. The Chert, alternating with pebbly sandstone, may be traced round the east side of Moel Ffagnallt, dipping east and south-east (Fig. 5, p. 30); while the overlying shale with a thin coal is seen 200 yards east of Llyn, the same coal (presumably) which is stated to be 2 feet thick in a shaft 300 yards north-north-west of Tyddyn-uchaf. South of the Llyn fault we can trace white sandstone sometimes with encrinites, dipping north-east and north, as far as a second nearly parallel fault, on passing which we meet a more distinct range of massive cherty sandstone dipping south-east, and resting in clear sequence on the limestone and calcareous sandstones previously described. The overlying shale is exposed among the old buildings of the Bryn-gwiog Mine, but here the outcrops are all shifted about 550 yards eastwards by the Bryn-gwiog vein, a downthrow to the north. To the south of this vein the chert and white pebbly sandstone sweep round, and strike, under the Drift, towards the valley at Hendre where they next come into sight.

The ravine of Nant-figillt begins where the stream is crossed by the Bryn-gwiog Vein. The description of the beds exposed will be found in the chapter on Lower Coal-Measures, but it may be mentioned here that the lowest bed seen, a black calcareous shale with *Goniatites*, probably occupies the horizon of the Holywell Shales with cement-stones. It appears to be on about the same horizon as the shale in which the coal-seam of Llyn occurs.

When the Millstone Grit emerges from beneath the Drift in the Hendre gorge, it has dwindled down to a thickness of a few feet, and finally disappears altogether a few yards south of the railway. The section on the southern side of the high road shows the following details:--

Hendre.

		FEET. INCHES.	
Lower Coal-Measures	{	Soft flaky and micaceous sandstone - - -	2 0
		Black laminated shale - - -	10 0
Millstone Grit -	{	Fine quartzose sandstone - - -	1 0
		White bastard gannister, or stony clay with rootlets - - -	- 0-6
Carboniferous	{	Quartzose sandstone, with pebbles as large as walnuts - - -	10 0
		Limestone (see p. 31) - - -	- -
		23 6	

On the northern side, though the details are not so clear, we can make out that no sandstone of any thickness underlies the black laminated shale mentioned above. Again in the gorge of the Alyn, above Rhydymwyn, shale of a Coal-Measure type rests directly on the uppermost limestone, a productal bed about 20 feet thick, while the same sequence appears in the adit-levels of the Bryn-celyn, Llyn-y-pandy, and Pant-y-mwyn Mines further south. The first-named level starts from the south of the Foundry, passes through shale with a little sandstone, and intersects a coal-seam about 4 inches thick, with $2\frac{1}{2}$ feet of underclay, which is probably the Llyn coal. The level then passes through a fine-grained yellow sandstone about 10 feet thick, and cherty in the lower part, which probably represents the quartzose sandstone of Hendre, and finally reaches the limestone at about 100 yards from the entrance. Five hundred yards south of the Foundry a level, driven in search of the Llyn-y-pandy Vein, traverses shale and sandstone with *Sigillaria*, *Lepidodendron*, &c., and passes into the limestone at 100 yards from the entrance. A third level close by has proved the Holywell Shales with cementstones to lie just above the top of the limestone, thus affording further proof that the Chert Series has actually thinned out. The Garth Level, which lies 200 yards further south again, enters the limestone in a distance of 20 yards, after passing through shale with about 4 feet of soft sandstone. The evidence therefore of the thinning away of the Millstone Grit, and of the Lower Coal-Measures passing on to the limestone, is conclusive. After a temporary absence of about $1\frac{1}{2}$ miles, however, the Millstone Grit reappears in the form of a pebbly quartzose sandstone, which develops rapidly southwards into a great series of sandstones and cherts, forming the equivalent in the south of the Chert Beds of the north of Flintshire.

The overlap, though rapid, is unaccompanied by any appearance of unconformity. Sandstones, especially when coarse and pebbly, have been generally distributed in banks and shoals by the action of currents, and, whether in Coal-Measures or any other formation, wedge in or disappear in an irregular manner. The overlap of the Millstone Grit here, however, points to the danger of correlating the subdivisions of the Carboniferous Rocks over wide areas, on the assumption that each of the great subdivisions must be represented. As already mentioned, the sections in the Vale of Clwyd are intelligible only on the supposition that the Millstone Grit is absent there also.

(2.) Rhydymwyn to Hope.

The Millstone Grit first reappears on the south side of the Pant-y-mwyn Vein (Fig. 6, p. 35), whence it sweeps round to Waen Church on the top of the limestone, the junction of the two passing through the Waen quarry. The lower part of the sandstone is soft and flaky as seen in the quarry; the upper consists of coarser and more massive grit. Above it (as proved in shafts) lie shale and dark micaceous flaggy sandstone.

Between the Bwlch-y-ddaufryn and the Pant-y-buarth veins the Millstone Grit does not crop out clearly, but seems to have fallen into confusion through the dissolving away of the limestone beneath, as has been frequently noticed elsewhere. The latter of the two veins is said to have been lost towards the east in a mass of disintegrated sandstone. But south of this vein the subdivision develops rapidly into a form in which it continues southwards for some miles, though with an always increasing thickness. Its lower beds, which are rather disturbed from the above-mentioned cause, but are well seen south of Hafod, consist of sandstone, sometimes with numerous quartz-pebbles; the middle part is composed of solid chert, running just above Fron Fawnog and Hafod, and exposed in a quarry 100 yards north of the latter, while the top of the subdivision is made up of flaggy or cherty sandstones with the casts of the stems of plants, and containing a band of shale and of thin evenly-bedded flags. Near the top there occurs a seam of coal, exposed to view near Fronheulog, and stated to be 10 inches thick in a shaft at Gwern-y-mynydd. The Engine Shaft of the Fron Fawnog Mine lies midway between Fron and the road to Gwern-y-mynydd, and therefore traverses the beds described above. The following section, made by Mr. William C. Pagam, has been supplied by Mr. A. Francis:—

Section of Fron Fawnog Engine Shaft.

		FEET.	INCHES.
	Shaft timbered to	-	15 6
	Soil, &c.	-	27 2
	Sandstone	-	77 4
	Shale	-	3 8
[Millstone Grit]	Sandstone	-	41 4
	Shale	-	19 0
	Chert	-	31 6
	Sandstone	-	8 6
[Carboniferous Limestone]	Limestone	-	54 6
	Chert beds	-	40 0
	Sandstone	-	7 2
	Chert beds	-	32 8
	Sandstone	-	7 2
	Limestone	-	44 0
	Sandstone	-	77 0
Limestone	-	5 0+	
			<hr/> 491 6 <hr/>

In this section the shale 19 feet, chert 31 feet 6 inches, and sandstone 8 feet 6 inches thick, correspond to the shale, chert, and sandstone referred to above. The limestone 54 feet 6 inches

appears to be the same bed that forms the top of the Carboniferous limestone at Waen, in the quarries south-west of Hafod, and on Bryn-gwyn. The chert-beds interstratified with the limestone are not recognisable as such at their outcrop, being probably of a character to weather into a granular form, and assume the appearance of sandstones. The base of the Millstone Grit, therefore, in the above section may be taken at the top of the highest limestone, at a depth of 224 feet from the surface. This base is exposed to view in the easternmost of the Gwern-y-mynydd quarries (p. 37), where the details correspond to those seen at Waen, except in the increased thickness. Hence the same strata may be traced over the top of Bryn-gwyn (1,113 feet), the lower or fine-grained sandstone assuming a reddish tinge, while the grit becomes coarser and pebbly. The chert, which crops out repeatedly above this grit, is sometimes white and flaggy. Above it lies a massive sandstone, seen near Bryn-ffynnon, while a depression, 150 yards east of this house, indicates the position of a bed of shale, probably that which runs below Hafod.

The structure of the ground between Gwern-y-mynydd and East Maes-y-safn is complicated by a nearly north and south syncline. Old mine-works, which, though now mostly inaccessible, supply the few opportunities for observing this syncline, show that the strata dip westwards in the shafts above Fron-haul wood, in a shaft 200 yards north-east of Bryn-gwyn Farm, and in the eastern workings of East Maes-y-safn, the result being that the limestone rises to within 80 or 100 yards of the surface along the eastern side of the syncline. To the east of the trough thus formed, the strata quickly resume the normal easterly dip, as may be seen at Pentre-bach and in the Gwern-y-mynydd adit-level.

Some chert-beds, dipping north-west at the northern end of Fron-haul Wood, probably lie higher in the Millstone Grit than those before described; at the southern end of the wood some sandstone, dipping south-west, is overlain by a coal 14 inches thick, as proved in the Fron-haul Mine at 8 yards depth. There appears also in the middle of the Millstone Grit of this neighbourhood a thin impersistent band of limestone, known as the Little Flat. It does not crop out at the surface, but has been proved at 20 yards depth in a trial-shaft by the side of the road, 330 yards south-south-west of Fron-haul. The same bed occurs in the Fron-haul Shaft at a depth of about 50 yards, and with a thickness varying from 1 to 9 feet; and again in the New Shaft, 150 yards north-east of Fron-haul, the section of which was stated by Mr. Mansbridge to be as follows:—

The New Shaft, Fron-haul.

	FEET.
Loose ground, timbered	27
Sandstone	33
Black shale	21
Sandstone	18
Shale, becoming calcareous below, like cement-stone	—
Limestone, white (= the Little Flat)	1½
Chert	—
	100½

It was not seen, however, in the Engine Shaft, the section of which, as given by the same authority, appears below:—

Fron-haul Engine Shaft.

	FEET.
Sandstone, loose - - - - -	126
Small beds of shale - - - - -	12
Sandstone - - - - -	75
Chert - - - - -	33
Shale - - - - -	18
Sandstone - - - - -	16
Shale - - - - -	9
Limestone [the top bed of the Carboniferous Limestone series] - - - - -	3+
	302

From the information we possess we should expect the Little Flat to crop out about 200 yards west of Fron-haul, but it seems to have perished near the surface. Exposures of what seems to be the same bed occur further south (p. 57).

The Millstone Grit on the eastern side of Moel F'indeg rises into a gentle anticline, but shows no faults such as we found in the upper beds of the limestone (p. 39). From East Maes-y-safn the beds strike south-west and finally west, so as to run along the north or downthrow side of the Maes-y-safn vein. The chert-beds, which may be traced without difficulty in the same relative position to the sandstones as before, are white and flaggy, and dip at an angle of 50° to 60° to the south-east and south. The underlying sandstone being much broken up through the perishing of the top bed of limestone along its outcrop, the actual position of the base of the Millstone Grit is ill-defined for several hundred yards.

The section of the Engine Shaft at East Maes-y-safn, according to Mr. Thomas Miners, runs as follows:—

Engine Shaft, East Maes-y-safn.

	FEET.
Chert, sandstone, &c. - - - - -	345
Shale - - - - -	6
Chert - - - - -	9
Sand - - - - -	9
Shale, thinning out to the west - - - - -	6
Grit - - - - -	12 to 15
Shale, clay and sand mixed - - - - -	45
Limestone [the top bed of the Carboniferous Limestone series] - - - - -	—
	435

The same limestone, 150 yards further west, lies at a depth of about 300 feet; 220 yards further west (at Pellow's Shaft) of 270 feet; 400 yards further west of 90 feet; and 500 yards further of 40 feet; this inclination according with an average dip of about 15° to the east. At the Engine Shaft, a westerly dip sets in for a short distance (p. 192).

The Millstone Grit runs as far west as the hill-side overlooking Maes-y-safn, being thrown down here on the western side of the Cat Hole Cross-course. The lowest bed of coarse grit, and the overlying chert, here white and flaky, can be traced in their usual relative positions. On the western side of the cross-course the strata dip to the east, and are cut off on the strike by the Maes-y-safn vein, by which they are thrown against the calcareous sandstones to the south.

On the south side of this vein the lowest grit dips north-east, showing that the valley on the southern side of Moel Findeg occupies a faulted syncline, though the corresponding valley on the northern side lies on a faulted anticline. The Maes-y-safn vein cannot be traced more than 100 or 200 yards after entering the Millstone Grit area, and perhaps dies out, as does the fault connected with the anticline (p. 39).

The base of the Millstone Grit runs thence above the limestone-quarries of Tir-y-coed, through the north-west corner of the wood; the lowest bed being a soft white grit with quartz-pebbles. The chert appears in some old quarries in the wood, on either side of a shallow mere or swamp, partially drained by a swallow-hole, and again in the sides of a swallow-hole near the Pant-du vein, about 400 yards west of the County Boundary. Near the centre of the wood a grey or white crystalline limestone, known as the Little Flat, runs for some distance along the County Boundary. It was proved also in the Truro Shaft, at the north-eastern corner of the wood, of which the following is a section:—

*Truro Shaft, Tir-y-coed.**

	FEET.
Chert - - - - -	35
Black shale - - - - -	35
Grit - - - - -	75
Sandstone and loose ground (the "hanging of the flat")	35
Boulders of limestone in clay and sand - - -	30
	210

At the southern edge of the wood a quarry near the bend in the road shows:—

	FEET. INCHES.
Blue chert, about - - - - -	1 0
Shaly sandstone - - - - -	- 6
Blue chert - - - - -	- 4
Black shale - - - - -	- 1
Sandstone with <i>Productus</i> - - - - -	3 0+

The stones in the walls close by show the serpentine tracks of annelids, the tracks being about half an inch broad with evenly indented margins. From the southern side of the road, about 200 yards further east, a bed of siliceous shale, breaking up into

* This section was supplied by Mr. J. A. Ede.

thin brittle plates, and dipping at 30° to the east, runs down to the Engine Shaft of the East Pant-du Mine. Here the depth to the base of the Millstone Grit is said to be 342 feet, and as this base occurs at the surface close by on the south side of the vein, the downthrow of the vein to the north must amount to just that number of feet.

The Boulder Clay rises up the slopes nearly as far as the road running along the eastern side of Nerquis Mountain, the most easterly exposures of rock showing quartzose and cherty sandstones, and a bed of cherty shale, which crops out in the lane leading down to Pont Terig. The course of the Pant-du vein cannot be traced across the sandstone-area, and the horizon of this shale consequently remains uncertain. It may be the same that has been noticed at the East Pant-du mine.

On the south side of the Pant-du vein, the base of the Millstone Grit lies hid under sandstone-débris, and it would seem from the lie of the rocks that for a distance of at least two miles southwards the outcrops have been disarranged by the superficial perishing of the upper limestones. Between the Pant-du and Belgrave veins the position of the base is indicated only in a small limestone-quarry 250 yards north of Llyn Iocyn,* and by a swallow-hole at the eastern end of this lake. A few yards further south we find on the supposed line of strike of the top limestone a trial-shaft sunk to 35 yards depth, all in sandstone. A little to the east, however, in the hill-side on the north of the road by Pant-glas, there appear sandstone and quartz-pebbles, white shaly chert, pebbly sandstone, siliceous shale, white cherty flags and pebbly sandstone, in regular ascending order as given, and all with a steady dip to the east of about 16° . These strata resemble the chert-series of Tir-y-coed (p. 57), and contain also in the upper part a band of encrinural chert, which is not improbably the Little Limestone (or "Flat") of that wood. On the south side of the road, and further to the east, appears a band of shale, perhaps the same as that exposed near the East Pant-du Mine.

The Belgrave vein effects a displacement of the outcrops of the upper limestones of about 350 yards (corresponding to a vertical shift of about 280 feet), but seems to diminish in throw towards the east, and becomes difficult to trace in the Millstone Grit. The western slopes of Mynydd-du are formed of a coarse grit, occasionally with pebbles and tracks of annelids, doubtless the same bed that constitutes the base of the Millstone Grit in the previous sections. The grit runs from near Pant-terfyn round the hill to near the Moriah Chapel by the Llanarmon Mine, and seems in its course to overlap a large portion of the upper limestones and calcareous sandstones, an appearance which results from the dissolving away of the limestones. One of the few exposures of the coarse grit (near the Trigonometrical Station) shows the beds to be nearly horizontal, an abnormal position probably due to the same cause, for nearer the Chapel they dip at

* So named on the One-inch Map, Old Series.

30° to the east-north-east, an amount that agrees better with the prevailing angle of inclination in the neighbourhood.

This coarse grit passes eastwards under shales and cherty flags, which present a general similarity to the Tir-y-coed beds; they are seen above the Llanarmon Mine, and about 300 yards east of Llyn-y-mynydd-du. A thick shale, perhaps the same bed as that seen at East Pant-du, runs through the middle of the wood, east of Cil-y-waen, and crosses the high road (Quarter-sheet 74 N.E.) below the eastern edge of the wood, to a section in the stream-bed; it contains *Productus semireticulatus* and *Spirifer bisulcatus*, and thus shows that a marine fauna, containing some of the Carboniferous Limestone species, still existed, and was prepared to spread on the recurrence of suitable conditions, during even the later parts of the Millstone Grit period.

The Westminster lode splits eastwards into two branches, the northern passing along the road by the Llanarmon Mine, the southern through Maes-y-droell. In the intervening ground there occur white sandstone, and a loose snow-white current-bedded sand, largely dug near Pen-y-foel for exportation to the Potteries. Over these lie some cherty shale and sandstone, seen in the corner of the wood.

At the southern margin of the map the upper boundary of the Millstone Grit sweeps round towards the east, as far as the fault which throws in the Nerquis coal-field. This boundary, always somewhat indefinite, is here additionally obscure through Drift, but we find some evidence for its position west of Erwau Toll-gate, in the bed of the River Terig, in descending which we note the following sequence of strata in ascending order:—Below Rhyd-y-ceirw shale and sandstone, flags, and shale with thin sandstone and an impersistent seam of coal reaching in places a thickness of 16 inches; above this again (but lower down the river) a massive sandstone with a thin coal-smut, forming a small waterfall near the junction of the stream from Mynydd-du. The river then flows over about 100 feet of shale with a little bastard gannister, which, 450 yards lower down, passes under sandstone with *Streptorhynchus*, *Rhynchonella*, and plant-remains, and shale with bands of black argillaceous limestone containing *Posidonomya*, *Goniatites*, &c. (Holywell Shales). On the hill above on the west side a coarse white sandstone with quartz-pebbles appears to overlies the limestone in the river, though it cannot be actually seen to do so. The limestone so strongly resembles the cement-stones which occur in the Holywell Shales presently to be described, as to render their correlation tolerably safe, especially as beds of the same character have been noticed at about the same horizon here and there over the intervening ground.

The next section occurs in the bed of the River Cegidog, south of Tryddyn. From the margin of the map northwards the river-bed shows sandstone mottled with purple, with a variable dip, generally to a little west of north. About 400 yards west of the fault which throws in the Leeswood Coal-field we find similar shales with bands of black limestone from 4 to 8 inches in thick-

ness, and nearer to the fault black and nodular shale with a little sandstone. The fault is visible and throws in the Middle Coal-Measures to the east as subsequently described.

On the south side of the Cegidog the strata which underlie the mottled sandstone and limestones described above form the high ground of Cae Rhinallt and Pen-llun-y-gwr (Quarter-Sheet 74 N.E.). They dip generally to the north-west, and overlie the Carboniferous Limestone of Nant-y-ffrith in natural order. They consist in the upper part of massive quartz-sandstones, with two beds of shale; one crops out within the limits of this Quarter-sheet, but the other occurs near Greenbank (Quarter-sheet 74 N.E.) and rests upon a sandstone with *Goniatites*, *Orthoceras*, *Streptorhynchus*, and plant-remains,* probably the same bed as that which crops out in the high road to Llanarmon, as previously mentioned. Still further to the south (and lower in the series) is found a white cherty sandstone, associated with a band of sandy and cherty limestone, containing *Productus*, *Encrinites*, and *Fenestella*, and weathering to a friable buff-coloured earth. The lower part of the Millstone Grit consists principally of coarse pebbly grits, with an occasional stem of a *Calamite* or *Lepidodendron* and with a poorly exposed series of cherts, white shale, and fine-grained sandstones interbedded. The general sequence here therefore seems to correspond with what was seen in, and to the west of, the Terig, and the limestones of the Cegidog, like those of the Terig, may be referred to the Holywell Shales (Lower Coal-Measures).

It remains now to describe the Millstone Grit which runs round the north-east sides of the limestone-inlier of Hope Mountain. On the west the grit is faulted against the Coal-Measures of Leeswood by what is believed to be a continuation of the Brymbo fault of the Denbighshire Coal-field. The fault may be traced across the limestone-area, along the margin of the Drift by Pistyll, and about 250 yards above the Hazelwood Colliery; thence about 150 yards east of Pont-y-bodkin to the old Leeswood Colliery workings, where it throws the strata down about 250 yards to the west. Near Tri-thy, however, it joins a fault running about north-north-east, and throwing in the Middle Coal-Measures of Nant Brook and Pont Bleiddyn. The grits, which crop out along the upthrow side of these faults, have a prevalent north-easterly dip, which gives them a false appearance of overlying the Coal-Measures of the valley beneath. The displacement of the fault, which throws down these grits from their position on the hill far below the measures which crop out in the valley, can hardly be less than 1,500 feet (Plate 1. See also Fig. 9, p. 45).

The strata, where they first enter this map, dip to the east, off the limestone, at angles of between 30° to 50° . At the bottom of the hill they sweep round to a north-north-westerly dip of 20° to 37° , as seen in the hill on which Caergwrl Castle stands, and to a

* The occurrence of these fossils was first noticed by Mr. A. O. Walker, F.L.S.

northerly dip, as seen in Bryn-y-gaer wood. Here they dip from the great fault in the same way that the grits of the northern part of Hope Mountain dip from the Brymbo fault; this tendency of faults to act in opposition to, or to neutralise the effect of the dip, being not uncommon, and generally pointing to the two having been produced contemporaneously.

The Millstone Grit here consists of coarse white sand, often crammed with white quartz-pebbles and formerly dug for white sand by the side of the road from Caergwrle to Shop Mynydd. The stems of *Lepidodendron* lie abundantly in the old pits. Just below these pits (but higher in the Millstone Grit) a bed of shale, seen near Celyn, lies below another pebbly sandstone; while still higher beds, seen in the bed of the brook running down to Rhan-berfedd, consist of sandstones and shales, with plant-remains, and are believed to belong to the Lower Coal-Measures.

About Shop Mynydd we see only parallel ridges of coarse pebbly grit, but a little further on, on the road to Pistyll, find rising from beneath them cherty and white laminated flags, which seem to represent the cherts of the Mold district.

From Shop Mynydd the beds strike nearly north until they are cut off by the Pont Bleiddyn fault. Near the Hartsheath Lodge, and again along the top of the hill above Plâs-tég a series of evenly-bedded flags is apparently interstratified in the coarse grits.

CHAPTER VI.

CARBONIFEROUS ROCKS—*continued.*

THE LOWER COAL-MEASURES.

The Lower Coal Measures of Flintshire consist in general of two subdivisions, the lower of which, or the Holywell Shales, is composed principally of shales with bands of black argillaceous limestone (cement-stone), the upper of variable, but often massive sandstones, which were described under the name of Gwespyr Sandstone in the north of Flintshire (Geology of the Coasts adjoining Rhyl, &c., p. 20) but are well developed also near Tryddyn and Hawarden, the whole series, like the Millstone Grit and the sedimentary beds of the Carboniferous Limestone Series, expanding towards the south of the county.

The Holywell Shales, which run throughout the county, and form a convenient base for the Lower Coal-Measures, resemble some black shales with bands or nodules of argillaceous limestone, which occur in the Lower Coal-Measures of Lancashire, and contain a similar fauna, composed chiefly of *Posidonomya*, *Aviculopecten*, *Goniatites*, *Bellerophon*, coprolites of fish, and plant-remains.* The boundary between the Lower and Middle Coal-Measures, though less definite here, yet serves to distinguish those Measures in which no thick coal-seams occur from the productive portion of the formation. In Lancashire the Lower Coal-Measures contain compact hard grits, and fine hard siliceous beds, known as "Gannister," which form the floor of some of the coals. Mr. De Rance remarks that the coarse sandstones and grits with quartz-pebbles occurring at Tryddyn and Hawarden may be referable to the same horizon as the grits in Lancashire, and may be equivalent to such a rock as that of Woodhead Hill, which is as compact as the Millstone Grit.

(1.) The Calceod Outlier.

This outlier is introduced in the middle of the limestone-area by the combined influence of three large faults. On the north it is bounded by a branch of the great Milwr Vein, on the east by the Pant Celyn Fault, and on the west by a large fault, which will be described presently. The outlier is so masked by Drift that its existence was not detected in the original survey of the area.

* This relationship was first pointed out by Mr. A. O. Walker, *Proc. Chester Soc. Nat. Sc.*, No. 2, p. 9 (1878).

The strata rise into view in three small sections only. The most southerly of these exposures occurs in the roadside, 300 yards north-east of Glan-yr-afon, and shows buff-coloured sandstone, dipping, so far as can be seen, to the north-east. The next section lies 300 yards to the north-west, at Calcot-pellaf Farm (Calcoed on the one-inch map), where a small quarry shows massive yellow sandstone, dipping to the north-east, and worked to a depth of 10 feet. The third exposure is found 400 yards north-east of Calcot-pellaf, in a small stream running east and west, where pale-blue shales and pale-yellow sandy flags dip west and north-west at a gentle angle.

Near this point have been sunk the two shafts of the old Kennel Mine, the one as reported on the hanging (downthrow side), the other on the hading (upthrow side) of a powerful vein. The hading (upthrow side) of the vein consisted of white or grey limestone, the hanging of shale; much black limestone also lies in the hillock, but from what position is not clear. A day-level having been driven westwards and intersected sandstone and a seam of coal six inches thick, a boring for coal was made in the side of the stream before mentioned, at a point 250 yards west-south-west of the shaft, and was carried to a depth of 90 yards in shale. There seems to be little doubt therefore that the shafts were sunk on the eastern boundary-fault of this outlier of Lower Coal-Measures. This line of fault is believed to run northwards to Pantasa under the alluvial flat, cutting off on the strike the limestone on its eastern side. On its western side the rocks are thickly overspread by Drift-sand and Gravel to an unknown depth. A spring breaking out near the middle of the flat perhaps marks the actual position of the fault.

We next obtain evidence of its course at Pant, where it cuts through the strong feature made by the massive white limestones on the hading or upthrow side of the Old Holloway Vein, and shifts the vein itself about 150 yards. The accounts of the underground workings in this hollow show that the ground is full of "troubles," but the principal line of disturbance seems to have been met with in driving west-north-west from the Celyn Bog Mine, where the workings encountered a north and south fault, hading westwards at 80° (10° from the vertical), and throwing thick and sulphury shale of Coal-Measure type, on the west, against limestone on the east. The Old Holloway Vein was abruptly cut off, and was next seen, on the western side of the hollow of Pant, 150 yards south of its range as observed on the eastern side of that valley.

Southwards from Kennel the line of fault can be traced without much difficulty, partly by the nature of the soil, the southern point of the Coal-Measure outlier being bare of Drift. Some old trials for lead in a copse 400 yards west-south-west of Calcoed Hall expose flags like those of Kennel, while, 200 yards to the north, massive white limestone dips nearly north at 20° , thus striking directly at the Lower Coal-Measures and proving a point on the line of fault. By similar evidence we can trace it as far

as Dyffryn Calcoed, the several points fixed ranging themselves on a nearly straight line running about south-south-east. This line, if continued, would fall nearly into the line of the great dislocation which introduces the Coal-Measures of Nant-figillt, but it is lost after passing the upper limestones of Hafod Dew, in a mass of nearly homogeneous limestone. As the principal cause of the existence of the outlier of Coal-Measures, and of the repetition of the upper beds of the Carboniferous Limestone, this fault ranks as one of the most important in the district.

On its western side also the outlier is bounded by a fault, the evidence for which is briefly as follows. Both at Bron Calcoed (Fron on the one-inch map) and at Fy-chwarel, near Plâs-newydd, massive grey limestone strikes towards the Coal-Measures, leaving no room for the outcrop of the Black Limestone and Chert Beds, while the actual position of the fault thus indicated is marked by a small valley, filled with Drift-Gravel. A little further south, at Cwtr, near Fy-chwarel, we see a bank of rock, much jointed, traversed by planes of slickenside, and composed principally of a white cherty vein-stuff with small white quartz-pebbles imbedded, either the actual fault, or the altered limestone of its immediate neighbourhood. The presence of the quartz-pebbles shows that the limestone which is thrown against the Lower Coal Measures belongs to the upper sandy-limestones, perhaps being the same bed as that which crops out at Hafod Dew (p. 21), and strikes towards this spot. The fault here disappears under a great spread of Sand and Gravel, but on following the direction indicated by the foregoing evidence we are led to Pant Wacco (Quarter-sheet 79 N.E.), where its position is well marked. The Black Limestone, dipping south at 21° , crops out near the Wacco Mine, while, 100 yards to the west, and directly in the line of strike of the Black Limestone, a bank of white limestone rises, the fault clearly running between the two points. Thence the fault traverses a small hollow to Pant Wacco, where it is known to the miners as the Vein Uchaf. It then runs at the foot of Coed-y-Garreg to Pentre-ffynnon under the name of the Spar Vein, throwing Lower Coal-Measures against the limestone, Black Limestone, and Chert Beds successively.

Lastly the northern boundary also of the outlier is presumed to be a fault, on account of the absence of any indication of the Chert Beds between the Black Limestone of Wacco and the Coal-Measures. The massive chert of this district usually forms an escarpment, but here, on the contrary, we see only a hollow filled with Drift-Gravel. That rock must be supposed, therefore, to be cut out by a fault, running, as denoted by the form of the ground, nearly parallel to the neighbouring Milwr Vein.

(2.) From Holywell to Hope.

The Holywell Shales are faulted against the chert at Holloway Farm by the Old Holloway Vein, which runs east and west with

a downthrow north, but east of that farm they appear on the south side of the vein, resting naturally upon the chert, and ending off in a feather-edge half-way up the hill. As seen near the farm and in several shafts the lower beds of the shale become hard and siliceous so as to pass almost imperceptibly into the black flaggy and clean-jointed chert described on p. 50. Near the mouth of Holloway Boat-level they contain a band of black argillaceous limestone, or cement-stone. In the Coed Pen-y-maes the following section was noted by Mr. De Rance:—

Holywell Shales, Coed Pen-y-maes.

	FEET.	INCHES.
Cement-stone	-	1 6
Black shale	-	14 0
Cement-stone	-	1 10
Black shale	-	16 0
Gnarled sandstone	-	8 0

He notes also that fossiliferous shales and mudstones passing into cement-stones underlie gannister sandstones in the bed of the stream which runs eastwards from Halkin down Coed-y-felin. The same strata are repeated by a fault in a small tributary-brook.

The base of the shales runs through Coed-y-fron, a wood on the south-west side of Holywell, and a quarry by the roadside exposes thin evenly-bedded shales with numerous impressions of *Posidonomya* and occasional hard cherty bands, passing down to a blue or blackish banded chert, which in its turn shades down into a pure chert partly granular, partly glassy, in texture. The overlying shales occupy the deep valley between Wern Sirk and Nant-hill-brwc, and contain bands of cement-stone and numerous fossils, which, as pointed out by Mr. Walker,* correspond to the fauna of the Lower Coal-Measures of Lancashire. Among them occur *Posidonomya Gibsoni* (very abundant), *Aviculopecten papyraceus*, *Goniatites*, and *Bellerophon*, with *Sigillaria* and *Lepidodendron*, and phosphatised coprolites of fish. The cement-stone is obtained by levels driven into the hill-side at Coed Llwybr-y-bi and on the Bagillt road.

The eastern workings on the Milwr and associated veins penetrated the Holywell Shales before reaching the chert, in which alone ore occurred. The shales come into view in the roadside at Milwr and Pen-y-pylle, and in the old hillocks. In the road leading up to Pen-yr-hwylfa a thin band of cement-stone lies a few feet only above the top of the chert. We next find them in the shaft of the Caeau Mine, 200 yards north-east of Caedu (Ty'n Caeau on the one-inch map), which passes through shale with cement-stone, containing *Goniatites* and *Sigillaria*, in gaining access to the chert. The same strata were traversed by the shafts of Sir George's Field (p. 175), and are exposed to view 200 yards east of Halkin Hall. Thence they run along the hillside past Halkin

* *Proc. Chester Soc. Nat. Sci.*, No. 2, p. 11.

Rectory, as proved by the débris from an old adit, 150 yards north-north-west of the house.

The boundary between the Lower Coal-Measures and Millstone Grit now becomes indefinite for two or three miles. The Chert Beds rapidly assume the character of sandstones, scarcely distinguishable from those of the Lower Coal-Measures, while the Holywell Shales are completely hidden. The line has been drawn so as to include the coarse and massive sandstones seen here and there about Halkin and Midlist Farm (Caeau-gleision on the one-inch map) in the Millstone Grit. About a mile south of Halkin it seems to be shifted by the fault which runs along the north side of Moel-y-Gaer, but we have no satisfactory evidence of its position, till we reach the Cârth-y-Cwd shafts, 400 yards north-west of Sifnau-hir (Chimney-hir on the one-inch map). One of these shafts, sunk in search of the Coed-du vein, is reported to have penetrated the following beds:—

*Section of the Cârth-y-Cwd Shaft.**

	FEET.
Gravel, about	10 or 12
Sandstone, about	90
Dark limestone and shale	—
Brown, grey, and white limestone, and calcareous sandstone	—

About 30 yards to the north-west a second shaft, sunk in search of iron-ore, entered, at three or four yards depth, red and black shale with masses of black argillaceous limestone (cement-stone), resting on blue chert. To the south-east of the shafts a white quartzose sandstone with small quartz-pebbles dips south-east at 40°, and lies therefore above the strata proved in them.

Presumably the shale with cement-stone represents the Holywell shales, and the quartzose sandstone belongs to the Lower Coal-Measures, though its appearance, taken alone, would have led to its being included in the Millstone Grit. The sequence shows but little similarity to that of Halkin, but in that respect proves no exception to the general statement already made, that neither the limestone, Millstone Grit, nor Lower Coal-Measures of this neighbourhood can bear a detailed correlation with the same subdivisions as developed at Halkin or Holywell.

The description of the Lower Coal-Measures is here continued by Mr. De Rance as follows:—"An almost dry valley, ranging north and south and leading down to the Alyn at Ty-draw, constitutes a marked feature in the surface-configuration of this neighbourhood. The valley had attained its present depth before the deposition of the Glacial Drift, by which to a great extent its sides are masked and its depth diminished. Above Gwysaney Hall a peaty area of obstructed drainage gives rise to the Black Brook, the level of which at its confluence with the Alyn lies about 350 feet above the sea. From this point the valley rises to

* From a working miner.

421 feet at the lane between Cefn Eurgain and Northop, which is coincident with the watershed separating the waters flowing southwards and northwards respectively. At the point where the road to Quarry Farm crosses the stream, the water drains partly into the peat-moss and partly into a narrow north-east valley, to form the stream known as Northop Brook. The slopes on either side of the latter valley consist of Drift, and it is difficult to account for the curious change in direction of the course of the stream and the formation of a new valley, where the older valley had already been, or was being, re-excavated to the south.

" This depression is joined in its course northwards by the stream from Nant-y-Flint. In ascending either valley from the point of junction we obtain a descending section of the rocks, the strike of which is oblique to the direction of the streams. At the foot of Bryn Moel black shales form the base of a cliff of Glacial Drift, and have been followed in an adit-level in a north-north-easterly direction between Maes-gwyn-bach and Maes-gwyn-mawr. Beneath these lie yellow gnarled sandstones and flags, which rest on grey thin-bedded sandstone and black shales. From beneath these again rises the fine-grained gannister sandstone of Coed-y-Cra, which is well seen around Nant Mill, and above the mill-pond. It is traversed by a bed of black shale on which a shaft has been sunk, but whether for coal or cement-stone could not be ascertained. A good section of the gannister beds occurs in a quarry at Quarry Farm, near Gwysaney, the dip being east-south-east. The following strata were noted :—

	FEET.
Gannister sandstone - - - -	18
Grey shales - - - -	4
Yellow fine-grained sandstone	25

" Further north, at the southern end of Coed Cefn, about 12 feet of gannister sandstone appear, but at Gwern-y-marl are succeeded in their line of strike by flags, which dip east-south-east at 13°, a small fault with a northerly downthrow probably crossing the valley here. The flags rest upon 40 feet of fine-grained sandstone, seen in the little valley below Castell, and this rock, with occasional bands of grey shale, lies upon compact gannister sandstone, exposed where the stream crosses the lane. On the eastern side of the valley at Coed-uchaf, numerous old pits, with some traces of coal, appear to have been sunk through a very black shale to a bed of "gnarled" sandstone, while between these strata and the flags of the western side of the valley there probably intervene some grey compact shales, seen in the bed of the stream at Middle Mill. A quarry east of Middle Mill and on the northern side of the High Road, exposes about 25 feet of yellow sandstone, and lies probably just above the outcrop of the coal referred to above, which, however, is not visible."

We now reach the great fault which introduces the long strip of Lower Coal-Measures of Nant-figillt, and which, as already pointed out, falls nearly in a line with the eastern boundary-fault of the Calcoed outlier. We can conveniently trace its course, while describing the strata exposed in this deep ravine. Its position is first clearly marked on the eastern side of Moel Ffagnallt, where it cuts off the Millstone Grit in its strike towards the north. In the small triangular area included between it and the Grit lies black shale with a seam of coal, said to be sometimes 2 feet thick; the seam comes into sight 180 yards east of Llyn, and was proved in a shaft 350 yards north-west of Plâs Winter. At this farm the chert is exposed, and 250 yards south-east of it, a trial-shaft for the Bryn-gwiog Vein entered limestone at a slight depth, thus fixing another point on the fault. At the Bryn-gwiog Mine the shale rests naturally on the Millstone Grit, but is faulted against the limestone. In the commencement of the ravine of Nant-figillt, at Lletty-yr-eos, we find black shales with *Goniatites*, resembling and doubtless equivalent to the Holywell Shales, lying next above the shale and coal-seam of Llyn. Above the black shales again come pale-blue shale and sandstone of a Coal-Measure type, which dip generally towards the south-east at angles of 5° to 20°, and occupy the remainder of the ravine. On its eastern side the ravine receives two tributaries, in the higher of which the following section occurs:—

Nant-figillt.

	FEET. INCHES.
Gannister sandstone and white clay	4 0
Sandstone	30 0
COAL	— 2 to 6
Fireclay	9 0
Sandstone	6 0
Shale, with nodules of ironstone	8 0 +

In the second tributary stream we find:—

	FEET. INCHES.
White quartzose sandstone (top not seen)	8 0
Black shale	9 0
COAL	— 7
Fireclay	6 0
Shale	25 0
Sandstone	—

The white quartzose sandstone makes a feature in the side of the valley and may be traced for about 300 yards.

In the first-named section the strata dip to the north-east at 30°-40°, that is towards the Millstone Grit, thus fixing a third point on the Nant-figillt fault. In the second section the dip ranges from 50° to 80° towards the south-west, the evidence for the fault here consisting partly in the highness of the dip, especially as compared with the gentle dip of the Millstone Grit, and partly in the character of the beds, which resemble Middle Coal-Measures, rather than the Holywell Shales.

In another ravine coming down from near Rhosesmor and exposing strata of a similar character with a dip of 20° to 30° to the south-west, we find an old level and some shafts, in which an inferior coal, said to have been 15 inches thick, with a dip to the south-east, was worked, but whether one of those mentioned above could not be ascertained. The ravine ends eastwards in a quartzose sandstone, which seems to belong to the Millstone Grit, and thus marks a fourth point on the line of fault. On the same line, but 180 yards further north, we find the hillock of an old shaft made up partly of limestone and partly of Coal-Measure shale, thus confirming the view taken as to the course of the fault. Finally the cutting off of the beds seen at Carth-y-Cwd on the line of their strike gives further evidence of the continuation of the fault southwards. The ground, however, is thickly over-spread by Drift Sand and Gravel. Borings in search of coal have been made near the railway under Pen-y-garth, near Nant, on the Mold and Hendre road near Gerddi Duon, and at Rhyd-y-goleu; but the details were not forthcoming.

In the corner of Nant-figillt wood, 200 yards east of the cliff at Hendre, we see shales resembling those of Llyn and Bryngwiog lying upon a thin representative of the Millstone Grit. The road-cutting on the opposite side of the railway, where the same strata are better exposed, has already been described, and the next sections of the Lower Coal-Measures have been noticed in giving the evidence for the local overlap of the Millstone Grit (p. 53). They show that the Holywell Shales, with cement-stones, rest almost directly on the top of the limestone, while they are overlain by shales and micaceous flaggy sandstones, laid open near Pen-y-garth and between Bellan and Rhual-isaf. At Pant-y-mwyn shale and dark micaceous shaly sandstone lie next above the Millstone Grit, as may be seen in a shaft near Ffordd-hir, and are themselves overlain by some yellow and white sandstones, exposed in the stream south-east of Ffordd-hir, but the succession is much obscured.

Near Fron, where the Millstone Grit has developed considerably in its southward course, the boundary between it and the Lower Coal-Measures becomes obscure, a fall in the ground and an occasional exposure of shale constituting the evidence on which the limit of the grits and cherts has been drawn. The Coal-Measures at Maes-garmon assume a character not seen elsewhere in the neighbourhood, viz., that of soft micaceous sandstone and shales, both of a deep-purple colour. The quarry in which they are exposed lies 500 yards south-east of Maes-garmon. The beds dip to east at 25° and are underlain at 200 yards distance by micaceous sandstone and shale of the usual blue and grey tint, the purple colour being confined to one spot. Whether this hue may be attributed to staining by the New Red Sandstone, under the supposition that this formation once overspread the neighbourhood, or whether the tint is proper to the rock, it is difficult to say; the former is more probable, but in either case it remains

to be explained why the purple tint is confined to the one quarry.

The character of this rock gave the clue to the age of the precisely similar purple shales and sandstones which lie next above the limestone in the Vale of Clwyd; the two rocks being in fact indistinguishable. It follows from their correlation that the Millstone Grit is absent in the Vale of Clwyd, a state of affairs for which we are prepared by the overlap of this subdivision on the east side also of the Moel Famau range.

The next section occurs in a day-level which runs from Gwernymynydd to near the former County Gaol. The level was driven nearly along a line of fault, the strata, which are consequently much disturbed, consisting, so far as they could be observed in such a situation, of shale with dips of 10° to 40° to the east in the lower part, and of sandstone, with a steep dip curving round to the north, in the upper part of the level. The level enters limestone nearly under the Engine Shaft, the dip being about N. 30° E. at 35° – 40° , but for the reasons mentioned above it was not possible to ascertain the sequence of the beds.

At Pentre-bach, 300 yards north-west of Plâs-on some old brick and tile-works in the Lower Coal-Measures expose white shales and fireclays with sandstones containing plant-remains. Near Bryn-goleu a purplish sandstone occurs on about the same horizon as the purple strata of Maes-garmon.

For some distance southwards the rock lies hid beneath a thick deposit of Boulder Clay, but in the Terig, to the west of Erwau Gate, shales with cement-stones, and containing *Posidonomya* and *Goniatites*, come into sight. They are not distinguishable from the Holywell Shales, and presumably mark the same horizon, but seem to be overlain, as was explained on p. 59, by a pebbly sandstone of a Millstone Grit type. In so variable series, however, but little reliance can be placed on the character of a sandstone in determining its age. The same shales appear again in the valley of the Cegidog on the west side of the boundary-fault of the Leeswood Coal-field, as described on p. 59, and at Hafod Abley (Quarter-sheet 74. N.E.), on the east of the same fault, the horizontal shift of the outcrops due to the fault being about 1,100 yards. Of the strata occupying the ground between Rhos-uchaf (Rhos-maen-hir-isaf on the one-inch map) and Penuel, and forming the upper part of the Lower Coal-Measure series, but little is seen, save some massive sandstone, underlain by shale, which crops out south and east of Rhos-isaf, and may be the same bed that forms a wider spread at Tryddyn.

The Lower Coal-Measures which underlie the village of Hope and sweep round the north-eastern flank of Hope Mountain to Pont Bleiddyn are thickly overspread by Drift. Their base-line has been drawn in accordance with the form of the ground, and with the line of strike observed in the Millstone Grit. The only section, which throws any light on the position of this boundary, occurs in the stream running from Shop Mynydd to Rhanberfedd, where shale and sandstones with plant-remains are

exposed. No sections in the Lower Coal-Measures have been noticed on the north-eastern side of this part of the valley of the Alyn.

(3.) Hawarden and Tryddyn.

Carrying on the description of the Lower Coal-Measures into this neighbourhood; Mr. De Rance notes that "at Tryddyn the grits are traversed by an anticlinal axis ranging about N. 30° W., the gannister sandstones dipping S.E. at 30° to 40° at Tryddyn, but N.W. and W. at the Vicarage and at Top Rhôs.

"The gannister sandstones are well seen in Hawarden Park, at the waterfall and at various points below it, and in the bed and banks of Broughton Brook, where they dip to the east-north-east at angles of 24° to 33°. Good sections occur in the quarries in the north-west corner of the Park, near "the Longe," the dip being north-easterly at 35°. Further south, however, at the Keeper's House, and in several sections west of the lane which skirts the Park, the angle of dip falls to 5°. The strata here are much coarser and occasionally consist of a conglomerate made up of pebbles of white vein-quartz. On the southern side of the lane the sandstone dips to the south-south-east at 10°, while still further south, at Dobs Hill and Warren Plantation, gannister sandstones dip south-east at 5° to 8°. West of Bryn Tygg Farm a bank of white siliceous sandstone strikes across the lane, dipping east-north-east at 10°. Immediately south, near St. John the Baptist's Church, hard compact grit dips at 8° in the same direction. At the Brick Works to the east, about 8 feet of Boulder Clay rest upon shale, a small proportion of which is mixed with the clay for bricks. In the quarry at the cross-roads, east of the sixth milestone to Chester, fine-grained sandstone also dips to the east-north-east, which direction is maintained in the sandstones which crop out in Bramley Lane, near Warren Dingle, and along this lane as far as Broad Brook. Close to the railway, about 12 feet of Boulder Clay appear in the brook, and a few yards further down the stream gritty sandstone underlies the clay. A good section occurs in the cutting between the point where the stream passes and the bridge at Babylon, the dip being north-west at 12°. The following thicknesses were noted:—

	FEET.
Sandstone, compact siliceous	14
Black shale	4
Sandstone, fine-grained	12

"No further exposures of rock occur in the railway-cuttings on the southern side of the River Dee, eastward of these sections."

CHAPTER VII.

CARBONIFEROUS ROCKS—*continued*.

THE MIDDLE COAL-MEASURES.

By C. E. DE RANCE.

Introduction.

The boundary between the Lower Coal-Measures with marine mollusca and the Middle Coal-Measures with *Anthracosia*, is generally obscure in the Lancashire Coal-field, and becomes still more so in the Flintshire area. Glacial Drift covers up and conceals the greater part of the Coal-Measure country, and sandstone of the hard gannister type, in Lancashire peculiar to the Lower Coal-Measures, occurs in Flintshire also well up in the Middle Coal-Measures.

In Flintshire numerous beds of sandstone, often of considerable thickness, occur at various horizons, but can seldom be traced for any distance, owing to their thinning out horizontally, or being lost to sight under the Drift, or through the complication caused by the numerous faults that intersect the district.

In Lancashire Professor Hull found some evidence of the Middle Coal-Measures having been deposited on an eroded surface of the Lower Coal-Measures, or Gannister Series. In Flintshire there seems to be an instance of this in the section exposed in the brook called Hen-e-fall, west of Bagillt, where black Middle Coal-Measure shales appear to overlap a gannister sandstone. The latter, however, may also be of Middle Coal-Measure age, and the appearance due to current-bedding in the sandstone.

The five belts, into which the Middle Coal-Measures of Lancashire may be grouped, reach at Worthington, near Wigan, a thickness of 2,200 feet, but at Prescot, in the south-western margin of the Coal-field, of only 1,400 feet, the rate of attenuation amounting on an average for the whole distance of 16 miles to 50 feet per mile. As a fact, however, the decrease amounts to 82 feet per mile for the first 40 miles, and to only 20 feet per mile at Prescot.*

A comparison of the Lancashire, Flintshire, and Denbighshire coal-seams points to another area of subsidence, with increased thickness of deposits, occurring in the Ruabon division of the last-named Coal-field. The Flintshire portion, on the other hand, in which the sedimentary material is least thick, may be regarded as having originally formed a portion of the Prescot Coal-field,

* Vertical Sections of the Geological Survey, Sheet 61.

though now apparently disconnected from it. In both the occurrence of thick coal-seams points to several seams having run together, and, coupled with the comparative thinness of the measures, supports the view of Professor J. B. Jukes that all thick seams consist in reality of a succession of seams, lying immediately one above the other through the failure of sediment in the periods intervening between their formation.

The seams of the Flintshire Coal-field may be naturally grouped into three areas, (1) that extending from Mostyn to Flint, (2) Northop, Hawarden, and Queen's Ferry, (3) Mold, Nerquis, Tryddyn, and Leeswood, forming a northern, eastern, and southern area. The whole lies in the Quarter-sheet now under consideration, except the northern part of the northern area. As regards the eastern and southern areas there is little difficulty in correlating the coals seam by seam, for even where a coal is absent, the character of the measures above and below the missing seam is maintained. But as regards the northern area correlation is more difficult, though certain seams can be identified with a considerable degree of certainty. It is probable that the Three Quarter Coal of Mostyn is the Brassy Coal of the south, that the Five Yard Coal of Mostyn is the Main Coal of Mold and Aston, and that the Durbog, the Dirty Coal, and the Hard Four Quarter Coal of Mostyn correspond to the Premier or Lower Five Feet Mine of the southern area. If this correlation be correct, about 250 feet of the coal-bearing upper beds of the southern section are absent in the northern area between Bagillt and Mostyn, while, on the other hand, no workable coal-seams have yet been discovered in the southern area in the strata corresponding to the lower 380 feet of the Mostyn section.

TABLE showing the thickness and correlation of the four belts of Coal-Seams in the FLINTSHIRE COAL-FIELD.

NORTHERN AREA.			SOUTHERN AREA.		
Thick-ness of Mea-sures.	Name of Coal.	Thick-ness of Coal.	Thick-ness of Mea-sures.	Name of Coal.	Thick-ness of Coal.
Feet.		Ft. in.	Feet.		Ft. in.
48	Cannel and Coal -	8 0	100	Thin Coal - -	1 0
			}	Bind and Cannel Coal -	3 0
				Powell Coal - -	3 0
				Bass Coal - -	4 6
				Hollin Coal -	9 0
79	Three Quarter Coal -	4 0	262	Hollin Bench	2 2
			306	Crank Coal -	2 11
			351	Brassy Coal -	4 6
			406	Rough Coal -	3 0
190	Five Yard Coal -	12 0	419	Thin Coal	0 3
			464	Main Coal - -	12 0

NORTHERN AREA.			SOUTHERN AREA.		
Thick-ness of Mea-sures.	Name of Coal.	Thick-ness of Coal.	Thick-ness of Mea-sures.	Name of Coal.	Thick-ness of Coal.
Feet.		Ft. in.	Feet.		Ft. in.
80	Three Yard Coal - - } Cannel, 1 foot . . . }	9 0	14	Main Bench - -	3 0
116	Blue Cannel - - -	1 6	27	Lower Bench - -	4 0
132	Little Coal - - -	1 8	63	Dirty Coal - -	5 10
			119	Five feet } Stone	{ 5 0
				Double } Coal.	{ 4 6
			155	Double bass Coal -	2 0
			194	Yard Coal - - -	3 6
			260	Cannel Coal - - -	5 0
			270	Cannel Bench - -	2 0
201	Two Yard Coal - -	6 0	339	Wall and Bench (double) - - -	5 9
119	Durbog Coal - - -	6 0	29	Dirty (Upper Four Feet) Coal - - -	5 0
	Little Coal - - -	1 0	45	Jointy Coal (Aston)	11 7
			101	Eight Feet Coal (As- ton) - - -	8 0
180	Stone Coal (double)	6 6	135	Yard Coal (Arley Mine) - - -	3 6
217	Five Quarter Coal -	4 9	215	Premier (Lower Four Feet) Coal -	5 0
74	Badger Coal - - -	1 8			
113	Five Quarter Coal (soft) - - -	5 9			
254	Bychton Coal - - -	6 0			
380	Three Quarter Coal -	2 3			
988	(Total thickness of the four belts.)		1,018	(Total thickness of the belts.)	

(1.) The Northern Area.

In the Bagillt district the coal-seams are more easily correlated with those of Mostyn on the north than with those of Aston and Hawarden, though certain seams appear to be common to all three districts. The Little Coal, 1 foot 8 inches thick, of Bagillt is probably the Three Quarter Coal, the lowest seam of Mostyn. Neither it nor the overlying seams have yet been proved in the southern area, though there appears to be a strong probability that they are present. The thickness of measures at Bagillt between the Five Yard Coal and the Little Coal is 708 feet; that at Mostyn between the Five Yard Coal and the Three Quarter Coal is 798 feet, showing an attenuation to the south-east.

The Bagillt Bottom Coal is 4 feet 7 inches in thickness and corresponds to the Bychton Coal of Mostyn, which is generally

6 feet thick. The Five Feet Coal, 4 feet 9 inches thick at Bagillt, is the Soft Five Quarter Coal of Mostyn, where it is 5 feet 9 inches thick. Above it lies the Badger Coal, which, though absent at Bagillt, reappears further south at Latchcroft, with a thickness of 1 foot 8 inches, and is probably the lowest coal known in the southern portion of the Flintshire Coal-field. The Five Feet Coal lies 204 feet above the Three Quarter Coal at Bagillt but 267 feet above at Mostyn, showing the south-easterly overlap before referred to. The measures and three coal-seams lying below the Hard Five Quarter Coal, here making their first appearance and being unknown in the area to the south, may be appropriately named the "Bagillt Mines." They form a belt below the horizon of the Premier Coal, the lowest seam of the Aston district.

The Latchcroft section is interesting, as forming a link between the sections to the north and south, and having much in common with both. The Hard Five Quarter Coal rests on fireclay, and at the Eleanor Colliery, where the seam is known as the Four Foot Mine, this fireclay contains a six-inch coal. At both localities a dark shale overlies the seam. At Northop Hall and Queen's Ferry the seam receives the name of Lower Four Feet, and at Aston of the Premier Coal.

At Coleshill Colliery the seams are numerous but generally thin and difficult to identify. The lowest worked, the Five Feet, is probably the equivalent of the Bagillt Five Feet Coal. The Lower Dirty Coal, 3 feet 3 inches thick, appears to be absent at Bagillt, and is probably the Badger Coal of more northern localities, occurring between the Hard and Soft Five Quarter Coals.

The Hard Five Quarter Coal is 4 feet 6 inches thick at Bagillt, where it appears to have its maximum development, being thinner to the north at Mostyn, and to the south, where it is generally 3 feet thick, and is known as the Yard Coal. At Queen's Ferry Colliery, however, it reaches 4 feet 6 inches in thickness. The Brassy Coal of Coleshill, 3 feet 6 inches thick, is probably this Yard Coal, and lies of course at a far lower horizon than the Brassy Coal of Flint Marsh, which occurs below the Three Yard Coal. A third Brassy Coal occurs in the southern area between the Main and Hollin Coals at a still higher horizon.

The New Three Yard Coal of Bagillt, with a thickness of 5 feet 9 inches only, should apparently have been called the New Two Yard. At Flint Marsh it increases to 7 feet 3 inches, but contains a nine-inch parting near the base. It may be correlated, somewhat doubtfully, with the Stone Coal of Mostyn, and the Four Feet Mine of Aston.

About 45 feet above the Bagillt New Three Yard Coal lies the Coal and Cannel, 7 feet thick. At Flint Marsh the seam splits up into four beds of 3 feet, 2 feet, 2 feet, and 1 foot 3 inches, separated by partings amounting to 6 feet 9 inches, in all 15 feet.

The relations of the coals between Bagillt and Flint to the adjacent areas and to one another is best seen by comparing the

sections at intermediate points. There can be little doubt that the Bagillt Coal and Cannel may be safely correlated with the Durbog Coal of Mostyn, the Dirty Coal of the Eleanor and Aston Collieries, and the Nine Feet Coal of Queen's Ferry. At Coleshill it becomes the Upper Dirty Coal, and consists of an upper band, 2 feet 4 inches thick, a parting 1 foot 6 inches thick, and a lower band 1 foot 6 inches thick.

Examination of the following table shows that the succeeding Four Feet Coal at Bagillt is probably the Mostyn Two Yard. It decreases in thickness to 2 feet at Flint Marsh and to 1 foot at Coleshill. In the table the various seams are lettered upwards from the Coal and Cannel, which is taken as A.

FLINT MARSH. From the Three Yard Coal.		FLINT MARSH.	FLINT, South.	COLESHILL.	BAGILLT, West.	BAGILLT, East.	MOSTYN.
Ft. in.		Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Ft. in.
10 0	THREE YARD COAL	10 0	10 0	—	7 0	6 0	9 0
50 0	Measures	40 0	35 6	—	—	39 0	36 0
55 0	BRASSY COAL	6 0	7 6	—	99 2	{ 1 6 2 0 1 6 }	{ BLUE CANNEL 1 6 }
87 0	Measures	32 0	28 6	—	—	—	16 0
87 10	COAL (I)	0 10	1 3	2 0	—	—	{ LITTLE COAL 1 8 }
92 9	Measures	4 11	4 7	8 8	DOUBLE COAL 2 10	—	—
98 10	COAL (H)	1 1	1 0	0 4	—	—	—
	Measures	—	7 6	—	—	68 10	—
	COAL (G)	—	1 6	—	—	—	—
	Measures	—	10 6	—	—	—	—
	COAL (F)	70 6	0 4	46 6	—	—	69 0
	Measures	—	12 0	—	—	—	—
	COAL (E)	—	0 2	—	62 9	—	—
	Measures	—	42 0	—	—	—	—
164 4		—	—	—	—	—	—
166 10	COAL (D)	1 6	2 0	1 6	—	{ 1 6 3 0 0 6 }	—
184 10	Measures	19 0	—	17 0	—	15 3	—
186 10	YARD COAL (C)	2 0	—	1 0	3 3	3 6	{ TWO YARD 6 0 }
207 4	Measures	20 6	—	10 8	—	19 3	—
208 10	COAL (B)	1 6	—	1 4	69 0	1 6	119 0
236 0	Measures	77 2	—	52 2	—	30 8	—
293 0	COAL AND CANNEL (A)	7 0	—	{ DIRTY COAL 2 4 1 6 }	{ COAL AND CANNEL 7 0 }	3 6	{ DUR- BOG 6 0 }

The Double, or Lower Double Coal of Bagillt occurs about 100 feet below the Three Yard Coal. It occurs as two seams at Coleshill and Flint also, and is probably represented at Mostyn by the Little Coal. The Upper Double Coal occurs about 40 feet below the Three Yard at Bagillt near the coast, but appears to be absent in the sections further west. It may be correlated with the Blue Cannel of Mostyn, and the Brassy Coal of Flint, which reaches a thickness of 5 feet.

The Three Yard Coal is 7 feet thick on the west of Bagillt, and only 6 feet on the east. At Flint it reaches 10 feet, and at Mostyn, where it is known by the same name, 9 feet. In the southern area it is probably represented by the Bench Coals underlying the Main Coal.

The Main Coal is persistent through the whole of the Flintshire and Denbighshire Coal-fields, extending from Black Park, near Ruabon, to Bagillt, or to Mostyn, if it be correlated with the Mostyn Five Yard Coal, the total distance amounting to 30 miles. At Bagillt the Five Yard Coal is the probable equivalent of the Main Coal of the southern area, and the measures occur above and below it as follows:—

Bagillt.

	FEET.	INCHES.
Hard freestone - - - -	4	0
Blue shale - - - -	12	0
FIVE YARD COAL - - - -	12	0
Clay and warrant - - - -	18	0
Ironstone - - - -	1	0

Flint.

White freestone - - - -	8	6
Blue shales with ironstone bands - - - -	16	5
COAL - - - -	10	6
Warrant - - - -	4	8
White rock - - - -	3	6

It is not certain whether the Flint thick coal is not the equivalent of the Mostyn Three Yard which lies 40 feet below the Mostyn Five Yard Coal; at Bettisfield, immediately north of the map now under consideration, the Five Yard and Three Yard Coals are both present, the latter being 7 feet 3 inches thick, and underlain by fireclay with two six-inch seams of coal.

The Bagillt Two Feet Coal occurs about 130 feet above the Five Yard. It corresponds to the Three Quarter Coal of Mostyn, which lies 100 feet only above the thick seam, thus showing (unlike the distance between the lower seams) an attenuation to the south-east. This is observable also in the measures overlying the Three Quarter Coal. Between the Bagillt Five Yard and the

overlying coal lie a series of ironstones, shales, and a few bands of white sandstone, and over the Three Quarter Coal there occur about 37 feet of measures, of which over 25 feet are freestone, chiefly white.

The Yard Coal above rests on only 1 foot of fireclay and is overlain by 38 feet of light freestone with a band of shale, 5 feet thick. This is the highest bed in the district that can be identified in relation to the coal-seams. In some of the Bagillt sections this coal reaches 4 feet in thickness, and at Mostyn becomes an important seam, known as the Cannel Coal, and consisting of 3 feet of cannel resting on 5 feet of coal. The distance there between it and the underlying seam is about 30 feet.

The coals above the Five Yard are absent in the Coleshill and Flint sections, but reappear under other names in the area still further south, hereafter described. Reference to the general correlation-table on p. 73 shows that these coals occupy the horizon of the Hollin Coal group, and that the sandstones correspond to the Hollin Rock. In the northern area, however, the fireclays are absent.

(2.) The Eastern Area

The Premier Coal, first discovered at Aston Hall on the Hawarden estate, there lies 312 feet below the Wall and Bench, and 75 feet below the Yard Coal, and is 5 feet thick. At Plas Bellin it is 4 feet 3 inches thick, and lies 87 feet below the Yard Coal, and at Queen's Ferry it measures 3 feet 10 inches, and occupies the same relative position. At Northop Hall, Queen's Ferry, and the Eleanor Colliery the Premier Coal is known as the Four Feet, or Lower Four Feet Coal. Further west neither this nor any other seam has been worked below the Wall and Bench, nor is there good evidence to show whether or not they exist. At Ewloe Hall, South Buckley, Nant Mawr, Bron-wylfa, and Mold, the sinkings were stopped in the Main Coal; at Nerquis in the Cannel; and at the Oak Pits (Mold), Leeswood, and Coppa in the Wall and Bench, and in consequence of the exhaustion of these upper seams a large number of collieries have been abandoned without a proper trial having been made to obtain the lower coals. Even in the Aston Hall district, where the Premier Coal has been worked, there appears to be a probability that seams equivalent to the Bychton and Five Quarter Coals of the Mostyn area may be found, if sought for.

The Yard Coal is called the Arley Mine at Aston Hall, but does not correspond to the Arley Mine of Lancashire, which lies at the base of the Middle Coal-Measures of that county. The Premier Coal more probably represents the Arley Mine, if it is present in Flintshire at all. The Arley Mine of Aston Hall is 3 feet 3 inches thick and rests on 10 feet of fireclay, a five-inch coal occurring 13 feet below the mine. About 12 feet of oil-shale lie over the mine, and the shales above, extending up to the Dirty

Coal, contain many coal-partings, beds of bass, and, towards the top, of fireclay. The section at the Eleanor Colliery corresponds in every detail with that between the Arley Mine and the Premier Coal, which, however, are here known as the Yard and Lower Four Feet Coals respectively. The thin seam below the Yard Coal fireclay again appears, with occasional bands of fireclay intervening.

The Four Feet Coal is absent in the Aston Hall section, but its horizon is marked by fireclay and coaly matter. At the Queen's Pit it is 3 feet 8 inches thick, and lies between a dark shale above, and a thick fireclay below. At the Aston Engine Pit it has expanded as in the following section:—

The Four Feet Coal, Aston Engine Pit.

	FEET.	INCHES.
COAL - - - - -	5	6
Black shale with COAL - - - - -	1	3
COAL - - - - -	2	5
COAL, with metal - - - - -	2	0

At the Eleanor Colliery it is 4 feet 6 inches thick, and lies between dark shales, those below it being mixed with coaly matter.

The Dirty Coal is 9 feet thick at Eleanor Colliery, and includes three partings, together making five inches. Below it lies a thin band of fireclay, above it dark shale and dark laminated sandstone. At Aston Hall it is made up of 2 feet 2 inches of good upper coal, a six-inch parting, and 13 inches of inferior coal below. Next above it lies thin shale with a three-inch coal, and then white sandstone. At the Queen's Pit, Aston, this seam is 11 feet 6 inches thick, and is overlain by laminated sandstone.

The Wall and Bench Coals extend, under that name, not only from Hawarden to Mold, but over the greater part of the Denbighshire Coal-field. At the Oak Pits, Mold, a two-inch parting separates 1 foot 9 inches of coal above from the same thickness of coal below. At Bromfield it has no parting, and reaches a thickness of 3 feet 3 inches. The following section of this coal at Aston Hall resembles some of those obtained at Leeswood (pp. 106, 107):—

The Wall and Bench Coal, Aston Hall.

	FEET.	INCHES.
Blue metal - - - - -	—	—
COAL - - - - -	2	0
Fireclay - - - - -	1	0
CANNEL - - - - -	—	4
COAL - - - - -	2	0
Fireclay, good - - - - -	—	—
Metal - - - - -	—	—

Beneath it, at Aston, lies a hard white sandstone, more than 50 feet thick, and separated from a further thickness of 40 feet of

white rock with linstey by a water-bearing band of ironstone. At Mancot Bank the coal expands, as shown below :—

The Wall and Bench Coal, Mancot Bank.

	FEET. INCHES.	
Faiky fireclay - - - -	-	—
COAL - - - -	3	10
Dark faiky fireclay - - - -	7	0
COAL - - - -	8	10
Fireclay - - - -	-	—
Hard sandstone - - - -	-	—

At Sandycroft Colliery, near Buckley, the relation of the Wall and Bench to the Cannel Coal of Leeswood may be noted in the following section :—

Sandycroft Colliery.

	FEET. INCHES.	
COAL and CANNEL Measures - - - -	2	4
WALL AND BENCH COAL { COAL - - - -	22	8
{ Parting - - - -	2	3
{ COAL - - - -	-	3
	4	4

The Cannel Coal of Leeswood runs through the south-eastern portion of the district, but in an attenuated form, and the measures above it, though similar in character, are also much thinner. Its roof at Aston Hall consists of sandstone, and the seam is made up of 8 inches of cannel lying on 18 inches of coal, with fireclay beneath.

The coals lying between the Cannel and Main Coals in the Coed Talwrn and Aston districts cannot be correlated with any certainty. The vertical distance between these horizons at Tryddyn is about 270 feet, at Aston Hall only 140 feet. The Bench Coals and thick fireclays under the Main Coal, though absent at Tryddyn, are present in strong form at Coed Talwrn and Leeswood, and present the same sequence as at Aston Hall. The expansion of the south-western measures takes place between the Wall and Bench Coal below and the Main Coal fireclays above, but principally between the Cannel and Main Coals, the vertical distance between the top of the Cannel and the base of the fireclays at Coed Talwrn being about 250 feet, as compared with 100 feet at Aston Hall.

The King Coal, with a thin cannel, lies about 20 feet above the Cannel Coal at Aston, that is, one-fifth of the distance to the fireclays of the Main Coal. Allowing for the expansion of the measures above alluded to, we should expect to find it about 50 feet above the Cannel Coal at Coed Talwrn, that is at the position occupied by the Yard Coal. The King Coal of Aston and the Yard Coal of Coed Talwrn are therefore probably identical, but the overlying Stone and Dirty Coals of Coed Talwrn are

unrepresented in the Aston section. The following is the section of the King Coal and thin cannel at Aston:—

<i>Aston.</i>					FEET. INCHES.
KING COAL	-	-	-	-	2 4
Warrant	-	-	-	-	3 0
Black bass	-	-	-	-	1 5
Rock	-	-	-	-	- 6
CANNEL	-	-	-	-	- 6
Fireclay	-	-	-	-	4 0

At Mancot the measures again expand, and at Mancot Bank the Cannel, there a coal 1 foot 9 inches thick, and the King Coal, 9 inches thick, are separated by 40 feet of sandstone and shale, this according with the view that the King Coal of the eastern area is identical with the Yard Coal of Coed Talwrn.

The Bench Coals are present in the Aston district, the section below the Main Coal being as follows:—

<i>The Bench Coals, Aston.</i>					FEET. INCHES.
Dark metal	-	-	-	-	—
Dark bass	-	-	-	-	—
UPPER BENCH COAL	-	-	-	-	2 0
Warrant	-	-	-	-	6 3
LOWER BENCH COAL	-	-	-	-	2 0
Light warrant	-	-	-	-	—

The Main Coal at Northop is only 8 feet thick, and is made up as follows:—

The Main Coal, Northop Hall Colliery.

					FEET. INCHES.
COAL	-	-	-	-	3 9
Parting	-	-	-	-	- 2
COAL	-	-	-	-	1 10
Parting	-	-	-	-	- 3
COAL	-	-	-	-	2 0

The depth to the Main Coal of course varies, but averages 120 yards. The dip may be taken generally as 12° to the south-east.

At Dublin Main the Main Coal is 10 feet thick, at Sandycroft 9 feet, at South Buckley 11 feet, at Nant Mawr 9 feet, at Padeswood 10 feet 3 inches, at Coppa 11 feet, at Bron-wylfa 6 feet 8 inches, at Bromfield 8 feet 6 inches (including a 4-inch parting 8 inches from the top), at Mold Argoed 6 feet 6 inches, at the Oak Pits 6 feet 4 inches, at Nerquis 5 feet, at Tryddyn 10 feet 9 inches (with a 1-inch parting 8 inches from the bottom), at Leeswood 9 feet, and at Coed Talwrn 12 feet.

At the Rake Pit, Hawarden, the following section occurs:—

The Main Coal, Hawarden.

	FEET.	INCHES.
COAL - - - - -	3	0
Light and dark metal - - - - -	-	5
MAIN COAL - - - - -	13	6
Warrant - - - - -	9	0

At Mare Hay the roof of the Main Coal consists of an earthy sandstone interstratified with shale, in which the remains of *Neuropteris*, *Pecopteris*, and other plants abound. The coal was divided up by the miners as follows:—

The Main Coal, Mare Hay Engine Pit.

	FEET.	INCHES.
FLAT COAL - - - - -	1	9
BONE COAL - - - - -	1	4
SECOND COAL - - - - -	3	9
BOTTOM COAL - - - - -	4	2

At the Queen's Pit, Aston, the Main Coal is only 4 feet thick, but at Great Mancot 10 feet 6 inches and at Mancot Bank 11 feet 6 inches.

The roof of the Main, or Five Yard Coal, of Bagillt consists of 12 feet of blue shale, overlain by 4 feet of freestone. Over the same coal at Flint occurs blue shale with bands of ironstone; at Mare Hay, argillaceous sandstone; at Coppa, shale, containing a three-inch coal; at Leeswood Green, shale; but at Coed Talwrn Cannel Pit, sandstone, about 45 feet thick. At Tryddyn shale again forms the roof, containing a four-inch and several thinner bands of ironstone. At Aston Hall and Mancot, in the south-eastern area, shale, with bands of ironstone, occupy the whole distance between the Main and Rough Coals. At Mancot Bank these shales contain the Foul Coal, which lies on the same horizon as the three-inch coal of Coppa. At Great Mancot the horizon of this coal is marked by a band of black bass, and at Aston by two inches of ironstone. Below the three-inch coal of Coppa lies about a foot of sandy black ironstone, which at Coed Talwrn and Leeswood Green becomes a four-inch band of ironstone.

The Rough Coal varies in thickness from 2 feet at Dublin Main to 3 feet at Ewloe Hall, 1 foot 2 inches at Nant Mawr, 1 foot 6 inches at Padeswood, 1 foot 4 inches at Coppa, 2 feet 2 inches at Bron-wylfa. At Leeswood, where it is known as the Black Stone Coal, and at Coed Talwrn, it is only 9 inches thick, while at Tryddyn it is called the Black Band Coal, and is made up as follows:—

The Black Band Coal, Tryddyn.

	FEET.	INCHES.
COAL - - - - -	1	0
"Slag" (carbonaceous shale) - - - - -	-	6
COAL - - - - -	-	6

At Mancot Bank the Rough Coal is 2 feet 3 inches thick, at Great Mancot 2 feet, and at Aston Hall and Mare Hay 3 feet thick. Above it lies a band of ironstone, 6 inches thick at Aston and Coppa, which gives it the name of the Black Stone or Black Band in the south-west part of the district. The greater part of the shales separating the Rough and Brassy Coals contains bands of ironstone, sometimes a foot in thickness, in the centre of hard white sandstone. This, the Rough Coal Rock, is not invariably present; at Mare Hay it is about 14 feet thick, and at Coppa about 20 feet thick, but at Coed Talwrn and Tryddyn it thins out, and shales with bands of ironstone fill up the whole of the space between the two coal-seams. The floor of the Rough Coal is generally a fireclay of fair quality from 5 to 10 feet thick, but at Coed Talwrn consists of sandstone, nearly 20 feet thick, and at Coppa a three-inch seam of coal occurs 13 feet below the Rough Coal.

The Brassy Coal at Dublin Main is 3 feet 7 inches thick, at Ewloe Hall 3 feet, at Sandycroft 2 feet 8 inches, at South Buckley 3 feet 6 inches, at Nant Mawr and Padeswood 3 feet, at Coppa 4 feet, at Bron-wylfa 1 foot 11 inches, at Mold Argoed 3 feet, at the Oak Pits 2 feet 8 inches, at Coed Talwrn 4 feet 6 inches, at Aston Hall 3 feet, and at Great Mancot 3 feet 10 inches. At the last-named it is overlain by 6 inches of "bastard cannel," and has beneath it, and separated by a thin warrant, a nine-inch seam of coal. In the Mancot Bank Colliery the Hollin Coal is 4 feet thick, and is underlain, both here and through the Aston Hall and Coed Talwrn districts, by about 10 feet of good fireclay, but from Northop Hall to Coppa the fireclay is only a foot thick and rests on rock. The roof is formed by a band of dark shale, immediately overlain by white quartzose sandstone. At Tryddyn Colliery the Brassy Coal occurs, as at Great Mancot, in two beds.

The Brassy Coal, Tryddyn Colliery.

	FEET. INCHES.
COAL - - - - -	4 6
Fireclay - - - - -	- 6
COAL - - - - -	1 3

At Aston Hall the sandstone above the coal reaches 33 feet in thickness and extends up to the warrant underlying the Crank Coal. It is there known as the "Brassy Coal Rock."

The Crank Coal varies in thickness from 1 foot 3 inches at Aston Hall, to 1 foot 8 inches at Mancot Bank (where it is called the Foul Coal), 1 foot 9 inches at Padeswood, 2 feet 11 inches at Coppa, 1 foot at Bron-wylfa, 1 foot 3 inches in Coed Talwrn Wood Pit, and only 4 inches at Tryddyn. In the Aston Hall and Mancot district it is underlain by about 5 feet of fireclay and overlain by a few feet of shale, over which occurs the "Crank Rock," a sandstone about 15 feet thick. At Coppa a half-inch seam of coal and a well-marked series of ironstone-bands occur

in these shales, within a thickness of 20 feet, while the "Crank Rock" above, with a thickness of nearly 20 feet, extends up to the Bench Coal warrant, which here immediately underlies the Hollin Coal. At Leeswood Green, where the coal is only 3 inches thick, the sandstone immediately overlying it becomes shaly in the upper part, and at Coed Talwrn Wood Pit white sandstone, separated by a band of black shale into two beds, forms the roof, while 10 feet of fireclay forms the floor of the coal. At Tryddyn Colliery the "Crank Rock," recognised under that name, lies immediately above the Crank Coal, and attains a thickness of 15 feet.

The Hollin Coal gives the following measurements in different parts of the area. At Dublin Main 6 feet, Ewloe Hall 3 feet, South Buckley 3 feet 6 inches, Nant Mawr 6 feet 2 inches, Mold Argoed 6 feet, Bromfield 6 feet 10 inches, Oak Pits 6 feet 7 inches, Padeswood 6 feet 6 inches, Coppa 5 feet 10 inches, Bron-wylfa 3 feet, and Nerquis 5 feet. At Tryddyn, where it is known as the Two Yard Coal, it occurs in two beds, the upper 5 feet, and the lower 3 feet thick, with 1 foot 3 inches of fireclay between. At Northop Hall it is 4 feet thick, at Mare Hay 6 feet, at Aston Hall 7 feet 6 inches, and at Mancot Bank 8 feet thick. In the central district the Hollin Coal rests on a thin bed of fireclay overlying a light-coloured sandstone, which may be regarded as an upper "Crank Rock." At Leeswood, Coed Talwrn, and Tryddyn, a dense black shale, bitumenous at the last-named locality, intervenes between the coal and this rock. At Coppa the Hollin Bench Coal occurs below the Hollin Coal, the section being as below:—

Coppa.

	FEET.	INCHES.
"Hollin rock" - - - - -	12	6
Dark shale - - - - -	14	3
"Slag" and CANNEL - - - - -	1	0
BIND COAL - - - - -	1	0
Bass - - - - -	4	8
POWELL COAL - - - - -	3	0
Bass coal - - - - -	4	6
HOLLIN COAL - - - - -	5	10
Shale - - - - -	-	9
BENCH COAL - - - - -	2	2
Light warrant - - - - -	1	0
Upper "Crank rock" - - - - -	18	4

In the Aston district the measures between the Hollin and Crank Coals become thinner, and a thick bed of fireclay overlies shales with ironstone, above the Crank Rock. The same sequence occurs also at Mancot Bank. The shales forming the roof of the Hollin Coal, generally bitumenous, become highly so in the Tryddyn district. In them occur the Powell, Bind (or Bine), and Massey Coals, which constitute one group with the Hollin Coal. Eastward, towards the Mancot area, the shales gradually give way to thin-bedded and compact sandstones, the thickness of which increases so rapidly that the Bind and Hollin Coals are

55 feet apart at Mancot Bank, as compared with 5 feet at Coppa and Tryddyn, at 5 miles distance.

At Leeswood Green this whole group from the Bind to the Bench Coal is represented by one seam of 4 feet 6 inches, and at Coed Talwrn Deep Pit by a coal 2 feet 10 inches thick above and one of 1 foot 6 inches below with no less than 34 feet 10 inches of shale between. At Tryddyn the group occurs as follows:—

Tryddyn.

	F.EET.	I.NCHES.
Black bitumenous shale	-	29 6
POWELL and BENCH COALS	-	3 0
Black bitumenous shale	-	6 0
HOLLIN, or TWO YARD COAL	-	5 0

The Aston Hall section shows a remarkable similarity to that of Tryddyn in all seams from the Main Coal upwards, the distances between the Main and Rough Coal or between the Rough, Brassy, Crank, Hollin, and Bind Coals being almost identical in the two sections. Nor is there much difference in the thickness of the seams, while the increased importance of the Brassy Coal Rock at Aston forms almost the only change in the character of the measures.

The Bind Coal at Aston is 3 feet 6 inches thick, and rests on 6 feet of black shale, as at Tryddyn. There is an increase in the proportion of sandy material in the measures, though the latter gain nothing in thickness, and a comparison with other sections indicates that this increase takes place along local lines of no great horizontal width. In this relation we may compare the sections at Northop Hall and Mancot Bank, about four miles apart:—

<i>Northop Hall.</i>			<i>Mancot Bank.</i>		
	Ft.	In.		Ft.	In.
Linstey	-	14 7	}	Linstey, &c.	- 118 0
MASSEY COAL	-	10		Ironstone	- 4
Warrant	-	1 8		Ironstone-shales	- 1 0
Shale	-	14 3			
BIND COAL	-	1 8		BIND COAL	- 2 9
Warrant	-	2 6		Warrant	- 12 0
Linstey and metal	-	50 2		Sandstone and linstey	- 42 0
HOLLIN COAL	-	4 0		HOLLIN COAL	- 8 0

At Dublin Main the Bind Coal becomes known as the Hard Bone Coal, and the section gives the following details:—

Dublin Main.

	F.EET.	I.NCHES.
COAL	-	3
WARRANT	-	1 6
MASSEY COAL	-	10
WARRANT	-	7
HARD BONE COAL	-	2
WARRANT	-	2 9
Metal, with nodules of ironstone	-	38 3
HOLLIN COAL	-	6

The dark shales over the Bind Coal terminate at Northop Hall with the Massey Coal and its fireclay, and are there about 12 feet thick. At Coppa, where the coal dies out, they increase to 15 feet, and at Leeswood Green and Coed Talwrn to more than 40 feet in thickness, but at Tryddyn, where they are highly bitumenous, they measure only 30 feet. At Mare Hay, where also the Bind Coal is absent, the shales over the Hollin Coal are 12 feet thick; and at Dublin Main 30 feet of shale overlie the Massey Coal. At Mancot Bank the Bind Coal shales are replaced by 40 feet of thin-bedded sandstones with partings of shale.

The Hollin Rock, a white quartzose sandstone, obtains its maximum development in the Mare Hay district, where it is more than 140 feet thick without any intercalated shale; at Northop Hall it reaches 200 feet, but contains many bands of shale throughout. The shales increase in importance towards Coppa, but are traversed by bands of light and grey sandstone, the whole forming a series of nearly 130 feet thickness. At Leeswood Green rather less than 30 feet of freestone occurs between thick shales, and at Coed Talwrn only 25 feet, but the section does not include the whole of the rock. At Tryddyn the Hollin Rock reaches a thickness of 100 feet with occasional shale-partings. At Mancot Bank, where it is 45 feet thick, the upper 17 feet are red, and the remainder white.

A coal, 1 foot in thickness, rests on six feet of fireclay at Coppa, 140 feet above the Bind Coal. At Tryddyn it increases to 1 foot 6 inches, and becomes known as the Half Yard Coal, the section being as follows:—

<i>Tryddyn.</i>					FEET. INCHES.
Ironstone shales	-	-	-	-	13 8
COAL	-	-	-	-	- 4
Blue shale	-	-	-	-	8 8
HALF YARD COAL	-	-	-	-	1 6
Brown fireclay	-	-	-	-	6 0

(3.) The Fireclay Series.

The well-known Buckley Fire-brick Works occur along a belt of country ranging north-north-west to south-south-east, and bounded on either side by faults. The composition of a Buckley Fire-brick has been ascertained to be as follows:*

<i>Buckley Fire-brick.</i>						p.c.
Silica	-	-	-	-	-	88.1
Alumina	-	-	-	-	-	4.5
Lime	-	-	-	-	-	1.2
Protoxide of iron	-	-	-	-	-	6.1
						99.9

* J. Napier, *Phil. Mag.*, Ser. 4, vol. iv., p. 348; 1852.

Napier describes these bricks as being used in the construction of furnaces and chimneys in copper-works in Wales in parts exposed to great heat and to currents of air, but not where melted matter can come in contact with them, and as being also used in the Flintshire lead-smelting furnaces. The flat tiles manufactured at Buckley are largely employed by the railway-companies for paving the station-platforms, and the fire-bricks in the construction of waterworks, where a dense and durable brick of uniform quality is requisite.

The series is well developed at Northop Hall, where the following section has been proved:—

The Fireclay Series, Northop Hall.

	FEET.	INCHES.
Fireclay - - - - -	15	8
Very hard white rock - - - - -	6	2
Fireclay - - - - -	14	1
Yellow shale - - - - -	9	1
Fireclay - - - - -	1	8
Yellow shale - - - - -	18	2
Fireclay - - - - -	6	1
White rock - - - - -	33	9
Red fireclay - - - - -	5	0
White rock - - - - -	5	2
Fireclay - - - - -	-	10
White shale - - - - -	8	11"
White rock - - - - -	7	1
White shale - - - - -	3	9
White rock - - - - -	2	5

At Coppa the fireclay series is represented by light-coloured rock and blue shale; at Leeswood Green by soft shale; and at Coed Talwrn by blue shale with occasional bands of white rock. But it should be noted that at Tryddyn the fireclays rest upon shales, and that it is possible that their horizon lies above the point at which the Coed Talwrn and Coppa sections commence.

The Fireclay Series, Tryddyn.

	FEET.	INCHES.
Blue fireclay - - - - -	12	0
Brown fireclay - - - - -	6	4
Dark shale - - - - -	5	6
Shale, with ironstone - - - - -	2	3
Dark shale - - - - -	5	7
COAL - - - - -	-	4

In the Mancot Bank section the fireclays, with a thickness of 51 feet, lie next below the Glacial Drift, and immediately above the Hollin Rock. Like the upper part of this rock, the fireclay has here a red colour.

At Buckley the following section was measured:--

The Castle Brickworks, Buckley.

		FEET.
Hard fireclay	- - - - -	9
Dark "	- - - - -	3½
Yellow "	- - - - -	10
Red "	- - - - -	3
Sandstone	- - - - -	10
Fireclay	- - - - -	16

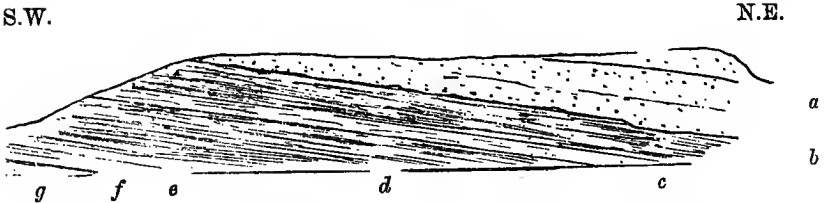
On the west side of the pit 4 feet of Boulder Clay rest upon 30 feet of fireclay.

Proceeding southwards we find the next section in Parry and Sons' pit at Ewloe Barn, north of the high road between Mold and Queen's Ferry. On the east side of the pit the fireclay is capped by yellow sandstone, and on the west by Boulder Clay. In a colliery by the side of the road the Hollin Coal is worked beneath the site of the clay-pit, but by a different company. On the south side of the road the Ewloe Barn Brickworks show 12 feet of yellow sandstone on 20 feet of red fireclay, or on the west side 30 feet of fireclay, the dip being E.N.E. at 10°.

At Brookhill the series occurs as shown in the following section and figure:—

Fig. 10.

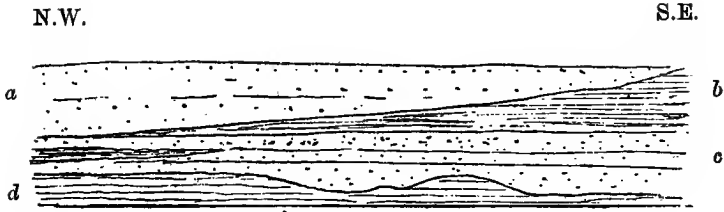
Brookhill Brickworks.



	FEET.		FEET.
a. Rock	- - - - - 17	e. Light shaly fireclay	- 3
b. Purple fireclay	- 17	f. Coal-seam	- 0½
c. Light "	- 3	g. Grey fireclay	- 17
d. Dark "	- 16		

South of the lane to Buckley Mountain, the Trap Brickworks show the base of the yellow sandstone resting on the fireclay, with a dip to the north-east. A small fault ranges W.N.W. through the northern part of this clay-pit, and to the west of the point where the above note was made.

Fig. 11.

Trap Brickworks.

	FEET.		FEET.
a. Yellow rock	- 16	c. Sandy fireclay	- 12 to 16
b. Hard fireclay	- 12	d. Fireclay	- 8 to 14

The following sections were noted in the same neighbourhood :—

The Etna Brickworks.

	FEET.
Purple clay	8
Yellow rock	11
Soft rock	9
Grey fireclay	4½
Light sandy clay	3½
Dark fireclay	4
Very dark fireclay	5
*Flaggy sandstone	3
Flaggy shale	6
Dark shale	6
COAL	1

Old Ewloe Brickworks, south-east corner.

	FEET.
Yellow rock	12
Purple fireclay	14
Grey rock	2
Grey clay	2
Grey rock	2
Purple fireclay	16+

At the north-eastern corner of this pit 25 feet of yellow sandstone rest on 24 feet of purple fireclay. The sandstone appears also in the cutting by the side of the railway, near the lane leading from Burntwood Pentre to St. Matthew's Church.

Three large excavations form the Mount Pleasant and the Knowl Lane Brickworks. In the north-eastern pit, worked from the former, the following section was noted, the dip being E.N.E. at 5°:—

* This and the beds below it crop out in the north-west corner of the pit.

CARBONIFEROUS ROCKS.

Mount Pleasant Brickworks.

	FEET.	INCHES.
• Yellow rock - - - - -	25	0
Grey fireclay - - - - -	30	0
COAL - - - - -	-	8
Purple fireclay - - - - -	3	0+

In the pit immediately to the west, belonging to the Knowl Lane Brickworks, the dip is E.S.E., and the section on the western side of the pit shows:—

	FEET.	INCHES.
Yellow rock - - - - -	40	0
Fireclay - - - - -	10	0+

Southwards these strata are thrown down to the south by a small east and west fault, but 60 yards further on are brought back to their former position by a second parallel fault, the two thus forming a trough. A third fault, with a small downthrow to the north, ranges E.N.E. from the northern corner of the Knowl Lane Brickworks, and merges into the first-named. In the trough between the faults coal and black shale come into view at the base of the fireclays. The southernmost of the three excavations named above shows the fireclays in force in the south-western corner:—

	FEET.	INCHES.
Red fireclay - - - - -	4	0
Yellow rock - - - - -	25	0
Grey fireclay - - - - -	20	0

At the north-western corner of the same pit and near the branch-railway there appear:—

	FEET.	INCHES.
Boulder Clay - - - - -	4	0
Grey fireclay - - - - -	19	0
Shale and ironstone - - - - -	-	10
COAL - - - - -	-	6
Grey fireclay - - - - -	2	3
Coal with a three-inch parting - - - - -	3	0
Greyish fireclay - - - - -	4	6

The Knowl Hill Brickworks are placed upon Boulder Clay lying between two mounds of Glacial Sand and Gravel, one of which forms a prominent ridge known as Knowl Hill, rising to 562 feet above the sea-level. A pit at the back of the works (which are now abandoned) discloses:—

	FEET.	INCHES.
Boulder clay - - - - -	6	0
Fireclay - - - - -	40	0

(4.) Details of Faults and abandoned Colliery-workings in the above areas.

The whole of the Flintshire Coal-field is intersected by parallel faults, repeating the beds again and again. Instead, however, of being nearly a mile apart as in Lancashire, these faults

often occur at intervals of only 300 yards. Owing to the thick covering of Drift their position can rarely be determined at the surface, nor, even when proved in the older workings, can their underground course be always fixed with sufficient accuracy to be placed on the six-inch maps. In many cases no plans appear to have been made, or when made either were defective or have been lost. The following notes give all the information at present obtainable as to the old workings, and the faults proved in them. Those in the Bagillt district and to the north are described first, then the Mold and Padeswood area, finally the Hawarden and neighbouring old collieries.

A section across the Bagillt collieries, made in 1849 and preserved at the Home Office, shows that three main faults had then been proved to separate the district into four belts. Proceeding from east to west, or from the Dee towards the high ground, we first cross Belt A, which was worked from the Smithy Pit and a bye-pit on the property of Sir John Hanmer, the former reaching the Five Yard Coal at 80 yards depth and the latter the Three Yard Coal and still lower seams on the adjacent property. The lower seams were also cut into by the Engine Pit, which reached a depth of 167 yards 2 feet, and was sunk in the boundary-fault from 50 to 66 yards depth. The fault separating belts A and B is a downthrow west of 18 yards. It hades at 55° from the vertical, an unusually low angle, and is 14 yards wide.

Belt B, which includes coals from the Two Yard down to the Main, is bounded to the west by a fault with a downthrow east of 13 yards, a width of 11 yards, and hading at 22° from the vertical. This fault cuts off and neutralises the previously mentioned boundary-fault, and forms with it a wedge, in which the coals occur in gradually decreasing area downwards. The Two Yard Coal alone crops out at the surface, the lower seams terminating underground against the fault. The coal was worked from the bye-pit, which was carried down to the boundary-fault, a depth of 150 yards, and from which a level was driven to the Engine Shaft.

In Belt C, on the other hand, the area of the coals increases downwards from a breadth of 60 yards in the Five Yard Coal to nearly 300 yards in the Three Yard Coal, before they are in succession cut off by the boundary-faults, the faults in this case throwing the strata down on either side of, and consequently hading away from, the belt between them. The seams, of which the Five Yard alone crops out at the surface, were worked from No. 2 Pit in Belt B, and from No. 5 Pit in Belt D, the latter shaft entering Belt C at the point where the western fault cuts through the Yard Coal. No. 2 Pit was carried to a depth of 120 yards, and a metal-drift was driven westwards to intercept the Five Feet and Stone Coals, and possibly the Three Feet Coal, the lowest seams worked in this district. In Belt C the Main Coal was

called the "New Coal," and was the lowest seam proved. The fault intersected by No. 5 Pit throws the strata down westwards 55 yards, and hades at 35° from the vertical, its width being 9 yards. The seams are neither turned up nor dragged down where intersected by this fault, but are cleanly cut through.

The strata dip eastwards in all the belts, in Belt A at 12° , in Belt B at 16° , in Belt C at 24° , in Belt D at 30° , the increase taking place, not gradually, but at the faults.

At the Padeswood United Collieries the Main Coal Upcast and Downcast Shafts lie 550 feet apart, the Brassy Coal Engine Shaft being 250 feet further to the east, and the Brassy Coal Upcast Shaft further on again. Between the two Brassy Coal Shafts runs a north-north-westerly fault, throwing the strata down 30 feet to the west, while a parallel fault runs east of the Engine House, with a downthrow of 10 feet to the east. These faults were proved in the Brassy and Main Coals.

Some shafts in a field south-east of Padeswood Hall, on the Mold and Chester road, are stated to have been sunk to the Hollin Coal at a depth of 90 yards, and the Four Feet Coal is said to have been worked out. According to another account this was the Lower Bench Coal, which was worked from a square shaft south of the Hall; the Four Feet Coal crops out a little further south, and ranges east-south-east. A pit on the south side of the L. & N.W. Railway, 400 yards west of the Buckley Railway, is reported to have reached the Four Feet Coal at a depth of 24 yards, which, if correct, implies that there must be either an anticlinal axis or a strike-fault between the two pits. Owing to the thick covering of Glacial Drift there is no evidence of the structure visible at the surface.

To the north lie several old pits, information concerning which has been supplied by Mr. Cottingham of Chester. The shaft in the wood, 400 yards north of the old Bannal Pit, was 75 yards deep, and from it a downbrow was carried north-eastwards in the Main Coal to under Dirty Mile. Westward at Spon Green, near the Prince of Wales Inn, the Main Coal lies at 70 yards depth, but is thrown down to a depth of 120 yards at the No. 1 Pit, on the west side of a fault ranging north-north-east through Spon Green. Still further west the Lexham Green Fault throws the Main Coal down to 145 yards.

The Pen-y-ffordd Fault ranges parallel to the Hope and Hawarden road, as far as Tinkler's Dale, where it turns to the north-east, and runs by Hawarden Castle. It throws the Middle Coal-Measures down on the west against the Hawarden grits and gannister sandstones. The old Bannal Pits, situated at the foot of the embankment and bridge which carries the lane from Whitehall House to Spon Green over the railway, lie on the west side of this fault, and reached the Main Coal at a depth of 20 yards. In Bannal Lane, a boring, though carried for 90 yards in Middle Coal-Measures, failed to intersect any workable coal.

A section drawn through the Rhyd-y-galed Colliery in a north-easterly direction (magnetic), and commencing towards the south-west, gives the following details:—

Belt A contains the outcrops of the Cannel and the Four Feet Coals. The measures dip to the north-east at 9° , as far as a fault which throws them down 25 yards eastwards, and changes the dip. The position of the coals was proved in borings, of which No. 5, commencing immediately below the outcrop of the Four Feet Coal, passed through 138 feet of alternating measures and 162 feet of sandstone, but no coal-seam.

Belt B is separated from Belt A by what may be termed the synclinal fault. It lades at 31° from the vertical, and is 15 feet in width. The No. 1, or Engine Shaft, 94 yards deep, was sunk in the fault, which necessitated a short tunnel being driven to intersect the Main Coal. The coal dips to the south-west at 13° . No. 2 or the Bye Pit, 30 yards distant from the Engine Shaft, is 79 yards deep. The belt is about 270 yards wide, and is terminated by a fault, also with a downthrow east of 15 yards; it is traversed also by a parallel fault with a downthrow east of 6 yards.

Belt C is bounded by a fourth fault which has a downthrow east of only 2 yards, but produces a remarkable effect on the dip, the strata being tilted up at an angle of 41° in this belt. The Cannel and Main Coals only seem to have been worked, from No. 3 Shaft 71 yards in depth, and from No. 4 Shaft 51 yards in depth.

In Belt D the angle of dip falls to 12° westwards. The Main Coal was worked from the No. 5 or Air Shaft, which was 34 yards deep. No. 4 boring, commencing on the actual outcrop, proved a coal, 3 feet thick, at 46 yards, and another, 3 feet 6 inches thick, at 71 yards from the surface.

In Nant Mawr and Old Nant Mawr Collieries the Main Coal dips to the south-south-west, and the sandstone above it appears in the stream above Bryn-faigas. The same dip is maintained in the Padeswood New Colliery, but in the workings from the Coppa Colliery towards the Mold Valley Oil-works is exchanged for a north-north-easterly inclination. The axis of the syncline thus formed roughly coincides with the line of the railway.

The fault, passing 500 yards west of Pont Bleiddyn, is believed to cross the Alyn, and to range north-north-west by Plâs Major and White-house Farm. On its east side, and south of the Alyn, the Wall and Bench Coal was worked at Marston's Colliery, near Tyddyn-y-glo, at a depth of 56 yards, while on its west side the Main Coal lay at a depth of 30 yards, the throw of the fault being thus proved to be 200 yards down to the west.

The seams worked at Stryt-cae-rhedyn lie in a belt bounded by two faults, both downthrows to the east of 25 yards. The most northern pit, near the southern margin of Lees Wood, reached the

Main Coal at 60 yards, and one of the shafts was sunk on the eastern boundary-fault of the belt. A shaft 150 yards further south entered the Brassy Coal at 28 yards depth, while 250 yards south of the first-named shaft the Main Coal lay at 75 yards depth in a pit east of the Farm House, and at 85 yards in a pit south-west of the same building.

At the Cheapside Colliery, Ewloe Green, abandoned in 1876, the Brassy Coal was of good quality, but was traversed by one of those vertical crushes, which are a common feature of this Coal-field. Such crushes can be best studied in the Eleanor and Mancot Collieries, where an area of each seam has been crushed and rendered worthless along a certain vertical plane, which traverses the midst of a belt, and is not connected with the faults limiting the belt. The area affected is irregular in shape, and often includes a number of narrow tracts running together like the rays of a star-fish. The Cheapside measures are traversed also by small faults ranging N. 15° W., and all with downthrows to the east of a few feet. The Main Coal dips E.N.E. at 12°.

Great Ewloe Colliery* is terminated eastwards by a north and south fault, which was proved by Messrs. Rigby and Hancock, for a distance of two miles from the north side of the Chester and Holyhead Road to the road from Mold to Chester, called the Dirty Mile. The strata dip eastwards towards the fault, and are thrown down westwards by it. A driving east from the No. 1 Engine Pit, which lies nearest the Dirty Mile and was sunk on the fault to a depth of 120 yards, proved a narrow belt of Main Coal, cut off to the east by another parallel fault with a downthrow west. No. 2 Engine Pit, also sunk on the fault by Messrs. Leach and Co. to a depth of 110 yards, reached a second narrow belt of Main Coal, known as the "Botany Bay run," cut off to the east by another parallel fault. A third Engine Pit, sunk to 86 yards depth on the fault, near the Level Houses, proved another narrow belt of the same coal, known as the "Yorkshire run," and terminated like the others by a fault with a downthrow west; the dip in all the runs was eastward. An adit, or water-level, towards Hawarden Hayes, which is still traceable, was in a ruinous condition at the time of Mr. Beckett's visit, but was believed by him to have met no coal, but he states that the Hollin Coal was proved in the shaft nearest the Level Houses, and that a two-foot seam was found in borings made in the level, at a point 400 yards east of the old Hall. The fourth and final trial to prove the coal east of the Ewloe Fault was by an engine-pit about 90 yards south of the Holyhead road. At a depth of 140 yards this shaft met with another narrow belt of the coal, known as the "Bantry run."

* Much of the information concerning this neighbourhood has been derived from a Report on the Hawarden Estate to the late Sir Stephen Glynne, by the late Mr. H. Beckett.

Towards the north the Great Ewloe Colliery is bounded by an east and west fault with a downthrow north, which meets the "deep fault," and intersects a third fault 90 yards west of the Boar's Head, where the Main Coal was not more than 30 yards from the surface. A level driven under the Mold and Queen's Ferry road, passing through the first-named fault, met with the Main Coal, thus proving the throw to amount to 80 yards. The third fault runs from the Boar's Head to the Great Fireclay Fault at Buckley in a north-north-easterly direction, and with an easterly downthrow. The Great Fireclay Fault, as proved principally by "the old men," passes under Mount Pleasant Knowle and crosses Dirty Mile near Lane End, throwing the measures down to the south-west. The amount of Main Coal abstracted from 450 acres of land in the Great Ewloe Colliery, which was not intersected by cross-faults, probably amounted to five million tons.

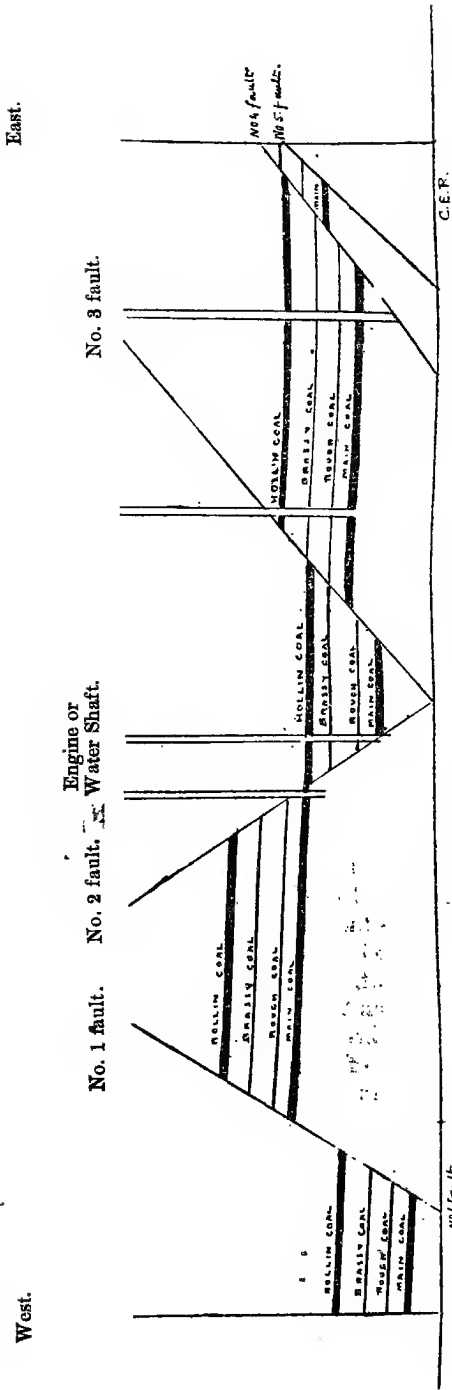
Little Mountain Colliery was bounded by a prolongation of the "deep fault" of Great Ewloe on the east, and of the "Great Fireclay Fault" on the south-west, and by a branch from it, which joins the "deep fault" near the junction of the old Banwell and Lane End road with the cross-road to Dirty Mile. The Engine and Bye Pits, in the plantation, reached the Main Coal at 80 yards depth, the seam dipping eastwards at 14° . An east and west fault traverses the colliery and throws the strata down to the north, so that the Brassy Coal lies at a depth of 80 yards in a shaft further north.

The southern and deepest Main Coal workings terminated against the Mare Hay south fault, which ranges east and west, and south of which the seam lies at a higher level. Westwards the "old men" worked up to the "west or No. 1 fault" (Fig. 12), which, with a downthrow west of 45 yards, ranges northwards and terminates against the "Mare Hay north fault," which ranges east and west. No. 2 Fault, parallel to No. 1, and with a width of 30 yards, throws the Main Coal 35 yards down to the east; it has been traced 436 yards and terminates against the "north fault." No. 3 Fault, parallel to Nos. 1 and 2, is a downthrow west of 10 yards, and No. 4 of 12 yards. No. 5, or the "east fault," also a downthrow west, commences under Shotton Lane, and proved the limit of the coal, for a level driven for 30 yards and a boring made in the end of it penetrated measures only, as given below:—

	FEET.
Slate-clay [shale] - - - - -	12
Quartzose sandstone - - - - -	1
Slate-clay - - - - -	4
Rock [sandstone] - - - - -	—

A rush of water, issuing from the rock, caused the work to be discontinued.

Fig. 12.
Section across *Hawarden Old Colliery, Mare Hay.*



Scale 88 yards to 1 inch.

The Main Coal between the 3rd and 4th faults dipped at 11° (or about 1 in $5\frac{1}{2}$) on the average towards the southwards; in the Engine or South Shaft its base lay at a depth of 133 yards 2 feet 6 inches, but 218 yards further north at a depth of 93 yards. A level driven from the old workings through the South Fault in a south-easterly direction having proved the extension of the Coal-field, the New Mare Hay Colliery was sunk and the coal obtained, but the dip proved to be at an angle of 18° to the east and south-east, and the ground to be much cut up by small faults, while the South Fault widened considerably westwards, towards Ewloe Green. The new shaft was sunk on a north and south fault, in measures which dipped to the south-east at 23° , and a level was driven from it to a field of Sir Stephen Glynne's, opposite the Boar's Head. In this field Mr. Beckett observed a pair of pits full of water, from which the Hollin Coal had been formerly worked, and which had been sunk on what was called the "Hollin Coal Fault."

The Ewloe Hall Colliery Engine Shaft had reached a depth of 111 yards at the time of Mr. Beckett's visit. The Hollin Coal Faults do not appear to affect the coals lying at a lower level. At Ewloe Cross the Hollin Coal was worked for 260 yards on the face of a north and south fault, analogous to the Mare Hay fault, and when the pumping engine at the south side of the colliery was stopped, an outbreak of water in a field to the north, on the property of Admiral Dundas, proved the prolongation of the fault in this direction. The coal was bounded to the east by an irregular level passing under the Turnpike Road, and connecting the shafts at the two extremities. The Hollin Coal dipped eastwards, and showed an average thickness of 5 feet 10 inches.

The Mount Pleasant or Wood Pit Colliery proved the base of the Main Coal at 23 yards, and of the Mount Pleasant Coal at 93 yards from surface, the latter coal being divided as follows:—

	FEET. INCHES.	
TOP COAL	-	1 8
Parting	-	0 $\frac{1}{2}$
COAL	-	7 0
Shale	-	1 10
BOTTOM COAL	-	1 10

Borings, commenced at the base of the Main Coal (at a point 9 yards nearer the surface than in the shaft) and carried to a depth of 146 yards, proved only a seam of coal 1 foot 6 inches thick. The coal in the colliery dipped to the east, and was worked on the crop-side from a level driven north-north-eastwards from the shaft. At 100 yards westwards from the Engine Shaft, the workings cut the "great fireclay fault," which throws down the measures to the west and ranges a little west of north.

The section of the Latchcroft (or Lodgecroft) Colliery will be found in Vertical Sections, Sheet 77. (See also p. 215.) Mr. Beckett states that the slack of the coal-seams at Latchcroft possessed the property of "caking" in the coal-oven, a property not possessed by the slack of the coals of Mare Hay and other collieries, which was con-

sequently worthless. The measures dip to the east at 12° , and the colliery was traversed by east and west faults. North of the colliery lie some still older workings, which may be traced northwards for 400 yards, on the west side of the lane from Shotton to Killins and Wepre. A boring carried from the Five Quarter Coal to a depth of 150 yards passed through alternations of shale and sandstone, and proved a two-inch coal at 102 yards, a three-inch coal at 108 yards, and an eighteen-inch coal at 131 yards depth.

The Mancot Colliery also was not in work at the time of Mr. Beckett's visit, but he learnt from miners who had been employed in it that the dip of the Main Coal varied from 8° to 11° to the east, and that the seam was of good quality, but that a large quantity of water had to be contended with. Two important faults were proved, the more southerly of which ranged W. 34° N. under the Rector's meadow and under the yard behind Daniel Ash, with a downthrow to the south of 40 yards. The Engine Shaft, close to Frog Hall, was 147 yards deep, and the Bye Pit reached the base of the Main Coal at 140 yards depth. The seam had a strong floor and roof of shale, but the upper foot of coal was left to support the latter, as well as pillars, at first $4\frac{1}{2}$ yards; afterwards $2\frac{1}{2}$ yards square. The Main Coal was 12 feet, the Brassy Coal 4 feet, and the Hollin Coal 7 feet thick. The Colliery was worked for about 11 years and yielded about 25 workman's tons (42 cwt.) a day. The Main Coal gave off much gas.

The Eleanor Colliery was worked in a belt of coal 500 yards in width in a trough between two faults ranging about N. 25° W., and probably continuous with those proved at the Clay Hill Colliery and the pits under Great Mancot. At the old colliery west of Blackbrook Cottage the Four Feet Coal lay at a depth of 104 yards, but in the Clay Pit of 180 yards, the dip being to the south-west. The fault worked up to between these points throws the measures down as much as 100 yards, and is probably identical with the Eleanor western fault. The Eleanor eastern fault is a downthrow west of 65 yards at Pentre, but of doubtful amount at Eleanor, the coal not having been proved on the Queen's Ferry (eastern) side of the fault. Further south, in the old colliery west of Pentre, the Four Feet Coal lies at 175 yards depth. The measures dip eastwards at the Eleanor Colliery.

(5.) The Neston Coal-field.

The Middle Coal-Measures underlie the southern area of the estuary of the Dee from Bagillt to Broughton, but at the latter place are unconformably overlapped by the New Red Sandstone. On the northern side of the estuary they reappear at Denhall, near Neston, whence they have been followed about a mile under the estuarine deposits. The borings quoted in the Appendix, pp. 215-220, seem to show that the whole of the alluvial flat, as far

east as Queen's Ferry, rests upon this subdivision of the Coal-Measures.

At the Old Neston Colliery, Denhall, coal was formerly worked within the area embraced by the map now under description. The lowest seam worked was the Five Feet Coal, which rests on a thin band of fireclay and is overlain by dark shales, and fire-clays, with thin seams of coal, one of which occasionally reaches 2 feet in thickness, the whole forming the Six Feet Bench Coal. The next seam in ascending order, the Six Feet Mine, rests on a hard dark sandstone, while above it lies a remarkable bed of black bass with an underlying fireclay, in which *Anthracosia* occurs abundantly. The seam in this respect closely resembles the Rushy Park Mine of the Wigan Coal-field, and may probably be correlated with it. The Arley Coal of Aston Hall, which is overlain by an oil-shale, is probably also the same coal. The measures at Neston dip to the north-west, that is, towards Mostyn. They lie below a covering of 45 feet of clay, chiefly Boulder Clay, and yield a distinctly brackish water.

On the outcrop-side of the Old Neston Colliery lies that of Ness, at which the following coals were worked:—

Ness Colliery.

	FEET. INCHES.
FIVE FEET COAL - - - - -	5 0
MEASURES - - - - -	75 0
SEVEN FEET COAL - - - - -	7 2
MEASURES - - - - -	90 0
TWO FEET COAL - - - - -	2 3

These coals were worked for a considerable distance under the estuary, a tunnel 2,000 yards long having been driven in the Two Feet Coal, and another, 1,000 yards long, in the Six Feet Coal, which lies 90 feet above the Five Feet Coal.

Still higher seams have been proved in the later workings at the Neston Collieries in the adjacent Quarter-sheet, and a seam of cannel has been proved at about the same horizon as the Cannel Coal of Aston Hall in Flintshire.

CHAPTER VIII.

CARBONIFEROUS ROCKS, MIDDLE COAL MEASURES—*continued.*

THE LEESWOOD COAL-FIELD.

Structure and Faults (see Plate 1).

This coal-field occupies a deep trough between the Lower Coal-Measures of Tryddyn on the west, and the Lower Carboniferous rocks of Hope Mountain on the east. It is thrown in by two great faults ranging a little west of north, but is traversed also by many others with a general north and south trend. The Main Coal is the thickest seam, but the coal-field came more especially into notice after the year 1858 from the workings in the Cannel Coal, which was in requisition for the distillation of paraffin-oil. The Hollin Coal was formerly worked on the west of the Coal-field, but is said to become thin and of little value on the east side of the Coed Talwrn brook. The relative positions of these and the other coal-seams is shown in Vertical Sections, Sheet 78. (See also pp. 213, 214.)

The western boundary-fault of the coal-field is exposed to view in the Cegidog, where the cement-stones, described on p. 59, are thrown against measures with a six-inch seam of coal, dipping at 60° near the fault, but at the normal inclination of 15° — 25° at a small distance from it. At the Tan-llan Colliery, 900 yards west of Ffrith-bellaf, the Cannel Coal, with a dip of 1 in 3 (19°) was proved at 50 yards depth, while a little further north a line of old shallow workings mark the outcrop of the Main Coal striking towards Ffrith-bellaf. The three faults shown in this coal, taken in order from west to east, throw the strata down westwards 26 yards, 18 yards, and 8 yards respectively.

The boundary-fault reappears in the stream one-third of a mile east of Tryddyn, where it throws shale and sandstone (Middle Coal-Measures) against laminated flags of Lower Coal-Measure age. Thence it runs nearly under Lodge Farm (Tryddyn Lodge on the one-inch map), its precise position in the Main Coal being 100 yards east of the farm-buildings. At the Frank Farm also the Main Coal has been worked up to the fault, which runs 30 or 40 yards east of the buildings with an estimated throw of 100 or 150 yards. There, however, it ceases to be the boundary-fault, and merely throws one part of the Middle Coal-Measures against another (Plate 1).

Near the Frank Farm the Main Coal was missing over an area about 100 yards square. Both on the north and south sides of

the barren area, the coal was doubled in thickness, not through a thickening in the seam, but by one portion of the seam having been thrust over another, a fact which was proved by the repetition of the recognised partings and characters of the coal, and by the double occurrence of an associated seam, called the Finger Coal; both the Main Coal and the Finger Coal were found twice in their proper relative positions in the same vertical sinkings.* A similar effect has been produced in the Somersetshire Coal-field by the well-known Radstock "slide-fault."†

North of Frank Farm the fault we have been tracing enters the valley of the Terig, where the Yard Coal, with a thickness of 2 feet 8 inches, crops out on its western side nearly on a level with the old workings along the outcrop of the Main Coal on its eastern side. The eastward downthrow of the fault, therefore, at this point equals the thickness of strata between the two coals, which, according to the sections of the Coed Talwrn Colliery, amounts to about 70 yards.

From the Lodge Farm northwards the Middle Coal-Measures are bounded by two faults branching off to the north-west. In the angle of measures between the faults the Cannel Coal was proved at a depth of 25 yards in a bore-hole 400 yards north-west of Frank Farm, but was not found in other borings nearer to the Frank Farm fault, whether from the faulty nature of the ground, or from the existence of a "wash" (see p. 109) did not appear. It is said to have been proved in the valley of the Terig, below the outcrop of the Yard Coal referred to above. These measures are thrown by the faults alluded to against the Lower Coal-Measure sandstones of Tryddyn.

We will now follow the faults which form the eastern limit of the Coal-field, and throws the measures against the limestone and Millstone Grit of Hope Mountain. The effects of a great fault seldom appear more clearly than here. Standing on the top of the hill, we see the Millstone Grit rise steeply towards the west; yet in the valley, 500 feet below, where the limestone might be expected to emerge, lies the Coal-field. On realising that to build up the complete sequence of strata on Hope Mountain would perhaps double the height of the hill, we gain some idea of the magnitude of the dislocation which has thrown the Middle Coal-Measures from that elevation to the bottom of the valley.

Towards the south-east the Coal-Measures are faulted against the Carboniferous Limestone. The fault follows the valley of the Cegidog from Ffrith (Quarter-sheet 74 N.E.) to Llanfynydd, and in the railway-cutting 600 yards south of the latter, throws Millstone Grit against the upper sandy beds of the limestone. It passes thence about 100 yards east of Llanfynydd Rectory, and so into the great boundary-fault.

* This information was supplied by Mr. W. Lea.

† On the Faults and Contortions of the Somersetshire Coal-field, by J. McMurtrie. *Proc. Bath Nat. Hist. and Antiq. Field Club*, vol. i. (No. 3), p. 127, 1869. See also Report of the Coal Commission for 1871, vol. i. p. 40.

The great boundary-fault comes through from the Denbighshire Coal-field (Quarter-sheet 74 N.E.), where it is known as the Brymbo Fault, crosses the Cegidog at Cymmau Hall, and, traversing the limestone and calcareous sandstones of Hope Mountain, enters the present map at Pen-rhiw. Though of no great throw here, after being joined at Mynydd-bychan by the fault last described, it has the effect of bringing the Cannel Coal against the lower beds of the Millstone Grit, thus cutting out the greater part of the Millstone Grit, the whole of the Lower, and a part of the Middle Coal-Measures.

The base of the Millstone Grit, as we have already seen, runs a little south of Mynydd-bychan with a westerly strike. A short distance down the slope, however, and in this line of strike, lies the Hazelwood Colliery, in which the Cannel and Wall and Bench Coals are worked, thus indicating the position of the fault. On the south side of the colliery the coals dip eastwards towards the fault, but sweep round with a north-westerly dip, which perhaps may be considered the normal direction on the south side of the Leeswood Coal-field. To the north of the colliery the strata dip locally westwards, that is from the great fault. The No. 2 Pit, which occupies about the centre of a trough thus formed, reached the Cannel at 52 yards depth, and a bore-hole, 200 yards south of Mynydd-bychan, reached it at 30 yards depth. The Wall and Bench Coal, the outcrop of which is marked at a point 300 yards south of the Colliery by a line of old shallow workings, lies $17\frac{1}{2}$ yards below the Cannel Coal.

Proceeding northwards along the boundary-fault we find an old level 250 yards south of Pen-y-coed, said to have been driven into the outcrop of the Cannel Coal, which must therefore rise about 60 yards between the level and the No. 2 Pit of the Hazelwood Colliery. The coal, however, whatever it is, is cut off close to this point by a fault, which runs on the east side of Pen-y-coed. This fault, a downthrow to the west of 60 yards, has been proved for a distance of about 700 yards southwards from the point where it springs from the boundary-fault. On its western side, 150 yards north-west of Pen-y-coed, in some pits now abandoned, the Brassy Coal was proved at 20 yards and the Main Coal at 60 yards depth. Abreast of the point where this and the boundary-fault join, a fresh fault comes into existence, which, starting 300 yards south-west of Tri-thy with little or no shift, acquires a downthrow to the west of 40 yards, 300 yards further north (Plate 1).

The great fault we have been tracing now ceases to be the boundary-fault of the Coal-Measures, but continues its course through the middle of the Flintshire Coal-field. It passes 150 yards west of Tri-thy and 150 yards east of Pont-y-bodkin (Rhyd-osper on the one-inch map) to the old workings in the Main Coal in Leeswood. Near the new school it throws the strata down 250 yards to the west, the depth to the Two Yard Coal on its western side being 80 yards and to the Half Yard Coal on its eastern side 30 yards.

The Coal-field is limited in this direction by a south-easterly branch from the great fault last described, some Coal-Measures exposed in Nant Brook occupying the angle between the two. These measures, which lie in the line of strike and dip towards the Millstone Grit, thus proving the existence of a fault, seem to be low in the middle division, for the Half Yard Coal has been largely worked in the north-west side of the ravine, and the Cannel Coal is said to crop out near Fferm. At a point 400 yards north of Tri-thy a boring proved Coal-Measures to a depth of 40 yards close to the line of fault.

Having traced the faults on either side of the Coal-field, we will notice those which traverse the intervening ground. They run, generally, a little west of north, and have a curious tendency to act in opposition to the great boundary-faults. Thus many of those near the western side throw the strata down to the west, that is, the opposite way to the neighbouring boundary-fault, and the same may be observed of some of the faults on the eastern side of the Coal-field. As an example of the first the three faults previously alluded to as having been proved in the Main Coal may be quoted, while the faults running through Pont-y-bodkin (Rhyd-osper on the one-inch map) furnish instances of the second. All these small faults "throw" in the opposite direction to the great boundary-faults near which they run.

In the south of the Coal-field a north and south fault, running through Coed Talwrn to Tan-llan, was proved in working the Main Coal to be a downthrow westwards of 40 yards near the former place. It shifts the outcrop of the Main Coal from near Tan-llan to near the Wood Pit Colliery, near which, on the eastern side of the railway, the coal used to be visible.

This exposure occurs on the west side of, and close to, a fault running on the west side of Pen-y-coed. The throw of this fault has been proved to be 25 yards down to the east south of Pont-y-bodkin, but 6 yards down to the west at a point 400 yards north of this place. One hundred yards further north again the throw diminishes to nothing, but increases again to 28 yards and 26 yards at and north of Leeswood, with a downthrow east, as at first. Towards the south the downthrow east must be greater than towards the north, for at the Pen-y-coed Pits, about 150 yards south of the exposure of the Main Coal, the depth to this coal was 60 yards. This and the fault east of Pen-y-coed, previously referred to, constitute a trough, throwing the strata between them down about 60 yards.

Returning to Leeswood we find a second fault, with a downthrow of 25 yards to the east, running parallel to and about 120 yards west of the one just described. Between the two several smaller faults, all more or less parallel, and with downthrows to the east, have been proved, principally in the Main Coal, which lay at a depth of 140 yards at the Flue Pit. The Two Yard Coal was also proved at 80 yards depth at a neighbouring pit, from which we learn that the strata on the western side of the great boundary-fault are high in the Middle Coal-

Measures. The Main Coal, however, rises to the surface in the side of the valley near Cae-bleiddyn Colliery, partly in consequence of the rise of the strata, and partly through the influence of a fault running north and south through Cae-bleiddyn, with a downthrow east of 99 yards.

This fault comes into existence east of the Frank Farm. On reaching the south side of the valley named above, it has acquired a throw of 95 yards, increasing on the north side to 99 yards, as proved by its throwing the Main Coal face to face with the Cannel Coal.* Further north again, after crossing the patch of Alluvium known as the "Gravel Fault," we find the Wall and Bench Coal at 35 yards depth, and the Cannel Coal at 90 yards depth, on the western and eastern sides respectively of the line of fault. The Cannel Coal lies 21 yards above the Wall and Bench, and from these data the displacement may be calculated as being 76 yards. The fault has been proved along the course described in working the Cannel Coal.

East of the Frank Farm this fault is intersected by another, also proved in the Cannel Coal, with a downthrow west of 13 yards, diminishing to 3 yards north of that farm. North of this again, and nearly in a line with it, a fault with a downthrow east of 25 yards has been proved in the Main Coal; while 150 yards east of the farm a fault with a downthrow east of 7 yards has been proved in the Cannel Coal. It will be seen that the faults here are not only numerous, but variable in the amount and even direction of their throw. It will be remembered also that the Main Coal was found to be doubled near Frank Farm, by what seemed to be a slide-fault.

While tracing the faults of this complicated little Coal-field, we have noticed the outcrops of, or depths to some of the coal-seams. We will now take such information as is available for the purpose of tracing their range in greater detail.

The Main Coal.

This, which as regards thickness and quality is the principal seam, is described as a good hard steam-coal. It is constituted as follows in the collieries named.

Coed-Talwrn Ironworks.

	FEET.	INCHES.
Shale with nodules of ironstone	-	8 0
TOP COAL - - - 3 ft. 0 in. }	-	-
FURNACE COAL (soft) 3 ft. 6 in. }	-	10 6
BOTTOM COAL - - - 4 ft. 0 in. }	-	-
Black carbonaceous shale and coal	-	2 3
LITTLE COAL - - - - -	-	2 3
Grey underclay with ironstone -	-	4 5

* The throw is here given, as marked on the Colliery Plan. But sections of the No. 3 Cannel Pit and the Deep Pit give 85 and 95 yards respectively as the distance between the Main and Cannel Coals at Coed Talwrn.

Coed Talwrn Colliery.

					FEEET.	INCHES.
Black shale	-	-	-	-	8	11
MAIN COAL	-	-	-	-	12	0
WARRANT	-	-	-	-	11	6
Blue metal	-	-	-	-	3	0
COAL	-	-	-	-	2	6

The southern outcrop of the Main Coal has been already traced by the old workings near Tan-llan to near the Wood Pit in Coed Talwrn, and thence back to the south of Pen-y-coed, by the fact of its having been found at 60 yards depth in the pit close by. Continuing northwards we find it at 140 yards depth in the Deep Pit, Coed Talwrn, at 61 yards depth in No. 3 Cannel Pits (Cae-bleiddyn Colliery on the six-inch map), and at 140 yards in the Flue Pit at Leeswood, 370 yards west of Leeswood New Hall. From these data we learn that the measures dip northwards from Tan-llan to near the Deep Pit, but that at Leeswood they are inclined eastwards towards the great fault.

On crossing the 95-yard fault we easily trace the outcrop of the Main Coal in the old workings along the brow of the hill up to the Tryddyn Lodge fault. The appearance of the seam at the surface here proves that the measures must rise towards the north, so as to form the northern side of a syncline, which we know to exist from the northerly dip observable in the stream running past Coed Talwrn Foundry, and the southerly dip of the Main Coal at Frank Farm and Tryddyn Lodge. It is worthy of mention that as the strata begin to turn up towards the north, the 95-yard fault comes into existence, and as the rise continues, so the fault increases. Had the fracture not taken place, the measures underlying Leeswood would have shared in the upward tilt.

The next point to be fixed on the outcrop of the Main Coal lies at the eastern end of a patch of Alluvium between Celyn and Leeswood. This deposit occupies a hollow, which marks the course of a pre-Glacial valley filled with gravel, and known among the miners as a "gravel-fault." This and other old lines of drainage, which are of course distinct from true faults on the one hand and from the "washes" in the Cannel Coal on the other, will be described in the Chapter dealing with the Glacial Deposits. The Cannel Coal, as before remarked, lies at 90 yards depth on the northern side of the hollow (east of the 95-yard fault), while the Main Coal, occurring at its usual distance above the Cannel, crops out in the side of the gravel-filled hollow.

The Cannel Coal.

This coal seems to have been discovered and first worked in 1858. Mr. H. Beckett,* writing in 1864, remarks that "until

* On the Recent Discovery of Cannel Coal in North Wales, by H. Beckett. *Trans. Dudley and Midland Geol. and Sci. Soc.*, No. 3, p. 87, 1864.

within a late period the Main Coal was the lowest seam generally wrought in Flintshire. In fact the Hollin and the Main Coals furnished the chief supplies, for both home consumption and steam or shipping purposes. Two intermediate beds, locally known as the Brassy and Rough Coals, had in a few localities been worked to a limited extent, to supply the . . . brickworks of the Buckley Mountain." Thin bands of Cannel, he continues, had long been known in Denbighshire and Flintshire, as for instance a band, sometimes attaining a thickness of six inches, near the centre of the Main Coal. The Leeswood Cannel Coal was found at Leeswood Green. The Main Coal having been unexpectedly found to have been previously worked by the "old men," explorations were carried on below it with the view of finding a seam of cannel reported to exist at Nerquis. "The first borings below the Main Coal at Leeswood Green passed through several workable seams of ordinary coal; and at a depth of about 93 yards from the Main, the Cannel Coal was reached, and eventually proved to be four feet thick." In following the Cannel towards the west, the "90 yards fault" (or 95-yard fault) was proved, which has been already described.

The Cannel is stated by Mr. E. Nixon* to have attained its greatest thickness in a pit on the east side of the 95-yard fault, where he measured the following section:—

	FEET.	INCHES.
Shale - - - - -	1	0
SMOOTH CANNEL - - - - -	2	0
CURLY CANNEL - - - - -	1	6
Shale - - - - -	1	0
	<u>5</u>	<u>9</u>

The following sections of the Cannel are given by Mr. N. R. Griffith†:—

Coppa Colliery, at points about 170 yards distant from one another.

	Ft. In.	Ft. In.
SMOOTH CANNEL - - - - -	-	2 2
CURLY CANNEL - - - - -	1 4	to 1 4
Shale - - - - -	-	4½ to - 10
Bad CANNEL - - - - -	-	4 to - 5
Ironstone - - - - -	-	2½ to - 2
COAL - - - - -	-	½ to - 3
	<u>2 3½</u>	<u>to 5 2</u>

* The Coal-fields of Denbighshire and Flintshire. *Proc. Liverpool Geol. Soc.*, Sess. 7, p. 46, 1866.

† On the Flintshire Cannel Seam. *Trans. N. of England Inst. Eng.*, vol. xix., Plate xix., 1870.

Bromfield Colliery.

	FEET. INCHES.
SMOOTH CANNEL - - - - -	- 10
COAL - - - - -	1 8
	<hr style="width: 50%; margin-left: auto; margin-right: 0;"/> 2 6

Coed Talwrn Colliery, The Wood Pit.

	FEET. INCHES.
SMOOTH CANNEL - - - - -	2 0
CURLY CANNEL - - - - -	- 8
COAL - - - - -	1 4
	<hr style="width: 50%; margin-left: auto; margin-right: 0;"/> 4 0

The sections of the No. 3 Cannel Pits, and of the Deep Pit, Coed Talwrn, give the following:—

No. 3 Cannel Pits.

	FEET. INCHES.
Black shale - - - - -	1 0
SMOOTH CANNEL - - - - -	2 4
CURLY CANNEL - - - - -	1 2
	<hr style="width: 50%; margin-left: auto; margin-right: 0;"/> 4 6

The Deep Pit.

	FEET. INCHES.
Conglomerate - - - - -	- 7
SMOOTH CANNEL - - - - -	- 7
CURLY CANNEL - - - - -	1 1
Shale - - - - -	- 10
COAL - - - - -	- 5
Ironstone - - - - -	- 9
	<hr style="width: 50%; margin-left: auto; margin-right: 0;"/> 4 3

Mr. Beckett (*op. cit*) states that a rich oleaginous shale, four to 10 inches thick, forms the roof of the Cannel Coal, where the seam occurs in its perfect form. The smooth cancell, curly cancell, and shale are the most valuable parts of the seam. The bad cancell and ironstone are usually neglected. According to Mr. Griffith, "there is no perceptible 'parting' between the 'smooth cancell' and 'curly cancell' or between the 'curly cancell' and 'shale,' although the change from one to the other is in each case well marked, and the three differ very much in appearance, chemical composition, specific gravity, and value.

'Smooth cancell' breaks, with a large conchoidal fracture, 'curly cancell' with a small conchoidal, and 'shale' with a semi-earthly fracture. 'Curly cancell' and 'shale' are both harder than 'smooth cancell,' and 'curly cancell' and 'shale' both give a brown streak when scratched, while 'smooth cancell' gives a black streak."

The specific gravities and chemical composition of "smooth cannel," "curly cannel," and "shale" are given as follows by Mr. Griffith:—

	Smooth Cannel.	Curly Cannel.	Shale.
Carbon - - -	79·87	77·81	68·32
Hydrogen - -	5·78	8·47	5·28
Oxygen and Nitrogen	8·09	6·32	5·88
Sulphur - - -	0·57	0·71	0·65
Phosphorus - - -	—	—	0·07
Water - - -	2·84	0·68	2·30
Ash - - -	2·85	6·01	23·00
	100·00	100·00	100·00
Specific gravity - - -	1·282	1·219	2·15

Composition, exclusive of sulphur, phosphorus, water, and ash:—

Carbon - - -	85·20	84·03	85·59
Hydrogen - -	6·17	9·15	7·14
Oxygen and Nitrogen	8·63	6·82	7·27
	100·00	100·00	100·00

The Cannel Coal has been examined and reported on by Dr. Andrew Fyfe also, and compared with other well known seams with the following results, as given by Mr. Beckett*:—

	Cubic feet of Gas per Ton.	Illuminating Power one Foot Candles.	Grains of Sperm per foot.	Value of Coals in lbs. of Sperm.	Comparative Value of Coals.	Coke per Cent. of Coals.	Comparative Value.	Carbon per Cent. in Coal.
Wigan Cannel - -	12·01	5·	·86	617·	1·18	68·5	2·19	85·
Torbane Hill - -	15·482	10·3	1·243	2736·	5·13	31·2	1·	38·4
Leeswood Smooth Cannel -	9·972	8·2	·981	1401·7	2·64	68·3	2·14	94·68
Leeswood Curly Cannel -	14·28	10·9	1·308	2668·3	5·025	50·5	1·61	91·5

Dr. Fyfe draws attention to the excellent gas-producing qualities of the curly cannel, and to the smooth cannel as a coke-giving coal, taking the per-centage of carbon as an indication of value. But Mr. Griffith, writing at a later date, states that " 'curly cannel' and 'shale' are used chiefly for the manufacture

* *Trans. Dudley and Midland Geol. and Sci. Soc. No. 3, p. 93, 1864.*

of paraffin-oil, by distillation at a low red heat. 'Smooth cannel' is also used for making oil, but the greater part of what is now raised is sold for gas-making. 'Curly cannel' produces about 80 gallons of crude oil to the ton, 'smooth cannel' about 35 gallons, and 'shale' about 33 gallons. The oil produced from 'curly' and 'shale' is superior in quality to that produced from 'smooth cannel.' The price, according to Mr. Nixon, writing in 1866,* was 28s. a ton for curly cannel, 9s. a ton for smooth cannel, and 8s. 6d. a ton for shale at Leeswood. Over one thousand retorts were erected or in course of erection in the districts of Leeswood, Coed Talwrn, and Coppa Collieries for the manufacture of oil from the cannel.

In 1862 28,816 tons, and in 1864 120,000 tons of cannel were raised in Flintshire by the following collieries; Leeswood Green, Leeswood Hill, Coed Talwrn, Coppa, and Nerquis. In 1865 150,000 tons were raised.†

The Leeswood Cannel Coal is identified by Mr. Beckett with the Lower Yard Coal of Ruabon, a seam widely known as a first-class house-coal. As pointed out by Mr. Griffith, "the change from cannel to bituminous coal appears to be gradual. On both the northern and southern outskirts of the area in which the cannel seam is found its lower portion is replaced by coal." This area may be defined as the south-western corner of the Flintshire Coal-field, but the Lower Yard Coal has been met with as a true cannel, nearly four feet thick, at Cefn-bychan and Plas Kynaston, south of Ruabon; the coal changes to cannel gradually, and, as at Leeswood, the cannel appears at the top of, and thickens at the expense of, the coal. At Cefn Mawr also this seam occurs as a cannel, 3 feet 6 inches thick.

The Cannel Coal is subject to a peculiar form of "trouble" known among the miners as "washes." These washes have been carefully observed by Mr. N. R. Griffith, from whose paper the following quotations are taken.‡ The largest wash yet known runs under Coed Talwrn in a form that will be described presently. On approaching the wash, and generally about 80 yards distance from it, the seam becomes thin, while in the wash "the place of the seam, and of some of the measures above and below it, is filled by a soft black metal, which disintegrates rapidly on exposure to the atmosphere . . . occasionally waterworn boulders of cannel and masses of conglomerate containing cannel are met with in this 'wash' . . . and occasionally small isolated pieces of cannel are found, which were evidently islands in the ancient river." The Main and other coals, above and below the Cannel, were found in their regular position, and of their regular thickness.

* The Coal-fields of Denbighshire and Flintshire. *Proc. Liverpool Geol. Soc.* Sess. 7, p. 46, 1866.

† The Coal and Iron Industries of the United Kingdom, by R. Meade, 1882, p. 181.

‡ *Trans. N. of England Inst. Eng.*, vol. xix, p. 75, 1870.

A smaller wash at the Coppa Colliery "is filled with rock and conglomerate, with occasional small water-worn pieces of cannel. One remarkable boulder, weighing about four tons, was found in this 'wash'; it consisted of 'smooth' cannel, 'curly' cannel, and 'shale;' but their ordinary position was reversed, *i.e.*, the 'smooth' cannel was underneath the 'curly,' and the 'shale' on top . . . In approaching this 'wash' the roof of the seam, at a distance of about 60 yards from the edge of the 'wash,' changes from black metal to rock, similar to that with which the 'wash' is filled. The seam also grows thinner, and it is evident that the upper portion of it has been removed by denudation." In another instance at the same colliery a wash was 18 yards broad, and the cannel in it only 2 feet to 2 feet 6 inches thick, while it was 4 feet 6 inches thick on either side. The part of the seam missing was nearly the whole of the 'smooth' cannel.

The course and form of the great wash has now been determined over a large area in the workings of the various collieries. It will be best understood by reference to the accompanying map (Plate 1). The form is rather that of a lagoon than of a portion of a river-bed, and the material with which it is filled is such as would be deposited in tranquil, not in running, water. On the other hand some branches of it are suggestive of the estuaries of streams running into a lagoon, while the smaller washes may well mark the positions of tributary lines of drainage. It will be remembered also that the material filling the smaller washes was a conglomerate, or presumably a consolidated river-gravel. Only a portion, however, of the great wash is left in existence, for it is cut off on the east side by the great fault, which brings measures older than the Cannel Coal up to the surface. But whatever may have been its complete form, we see enough to recognise in it a remarkable instance of contemporaneous denudation, in the course of which the coal, muds, and sands were torn up and re-distributed as a gravel almost immediately after their deposition, though after a sufficient lapse of time apparently to allow of a certain degree of consolidation.

Another form of "trouble" in the Cannel Coal has been described by Mr. Griffith in the same paper. For a distance of about 70 yards in the workings of the No. 6 Pit, Coppa Colliery, the Cannel was thrown out of the normal dip, and pinched into a "leader" of soft black shale, streaked with coal, though the roof and floor kept their usual characters throughout the whole distance. This form of trouble is attributable to compression.

The Cannel Coal, as already mentioned, was reached at 50 yards depth at the Tan-llan Colliery. It crops out presumably near the Cegidog valley, but is not anywhere visible. From the Wood Pit (see Plate 1) that part of the Cannel which lay south of the wash was worked, the position of the outcrop, as shown on the one-inch map, being calculated by reference to that of the Main Coal. A coal-crop south of Pen-y-coed, said to be that of the cannel, has been already mentioned.

The Tryddyn Lodge and Tryddyn Farm Collieries lie in the wash (see Plate 1), but the Deep Pit, Coed Talwrn (Vertical Sections, Sheet 78, No. 4), has been sunk on the edge of a small area of cannel, bounded by the wash on the west, and the great fault on the east. A level was driven from this pit north-westwards across the wash to reach the Cannel on its western side, and the breadth of the wash was proved to range from 400 to 600 yards at this point.

At the No. 3 Pit, near Cae-bleiddyn (Sheet 78, No. 2), the Cannel was reached at 148 yards depth, but on crossing the 95-yards fault to the Brick Works we find the Yard Coal cropping out, while the Cannel occurs at 20 yards depth, and crops out in the valley close by, underneath the Alluvium and Drift (Plate 1, see also p. 134). Further west the dip becomes westerly, and the Cannel runs down to 40 yards depth at the Cae-bleiddyn and North Leeswood Collieries. But on the western side of the Tryddyn Lodge Fault it is brought up to the surface again, as shown. The boreholes on the north-west of the Frank Farm were put down for the purpose of proving this range of the Cannel; one of them entered the Cannel at 25 yards depth at a point 450 yards north-west of the farm.

On the eastern side of the 250-yard fault strata older than the Cannel are brought up to the surface, as already shown, and the workings have been chiefly in the Half Yard Coal. But the Cannel comes in near Fferm, cropping out about 150 yards south of the house, where it is said to have been formerly visible.

Other Coal Seams.

The outcrop of the Yard Coal at the Brick Works near Cae-bleiddyn has been already referred to. The section shows the following details:—

Cae-bleiddyn Brick Pit.

	FEET.	INCHES.
Clay	-	-
COAL	2	0
Dirt	-	2
COAL	1	0
Dirt	-	2
COAL	1	0
Fireclay and shale	8	0+
	12	4

The section in the valley south of Celyn shows a coal 2 feet 8 inches thick, said to be the Yard Coal. The Hollin Coal is said to crop a little south of the No. 3 Pit, Cae-bleiddyn (see Plate I.), and 300 yards south-west of the Brick-pit, mentioned above. A thin coal, perhaps the Half Yard, appears in a clay-pit on the north side of the railway near Pont-y-bodkin.

One of the coals at Coppa is known as the Nant Seam from a resemblance to the seam of that name at Ruabon. This identification however is considered by Mr. De Rance to be founded on an error. The so-called Nant Coal of Coppa corresponds to the Yard Coal of Leeswood, while a number of thin seams with fireclay, about 17 yards above the Yard Coal at Leeswood, more probably represent the Nant Coal of Ruabon. According to this view the following sections show the character of the Nant Coal of Ruabon at Leeswood.

Coed Talwrn, No. 3 Cannel Pits.

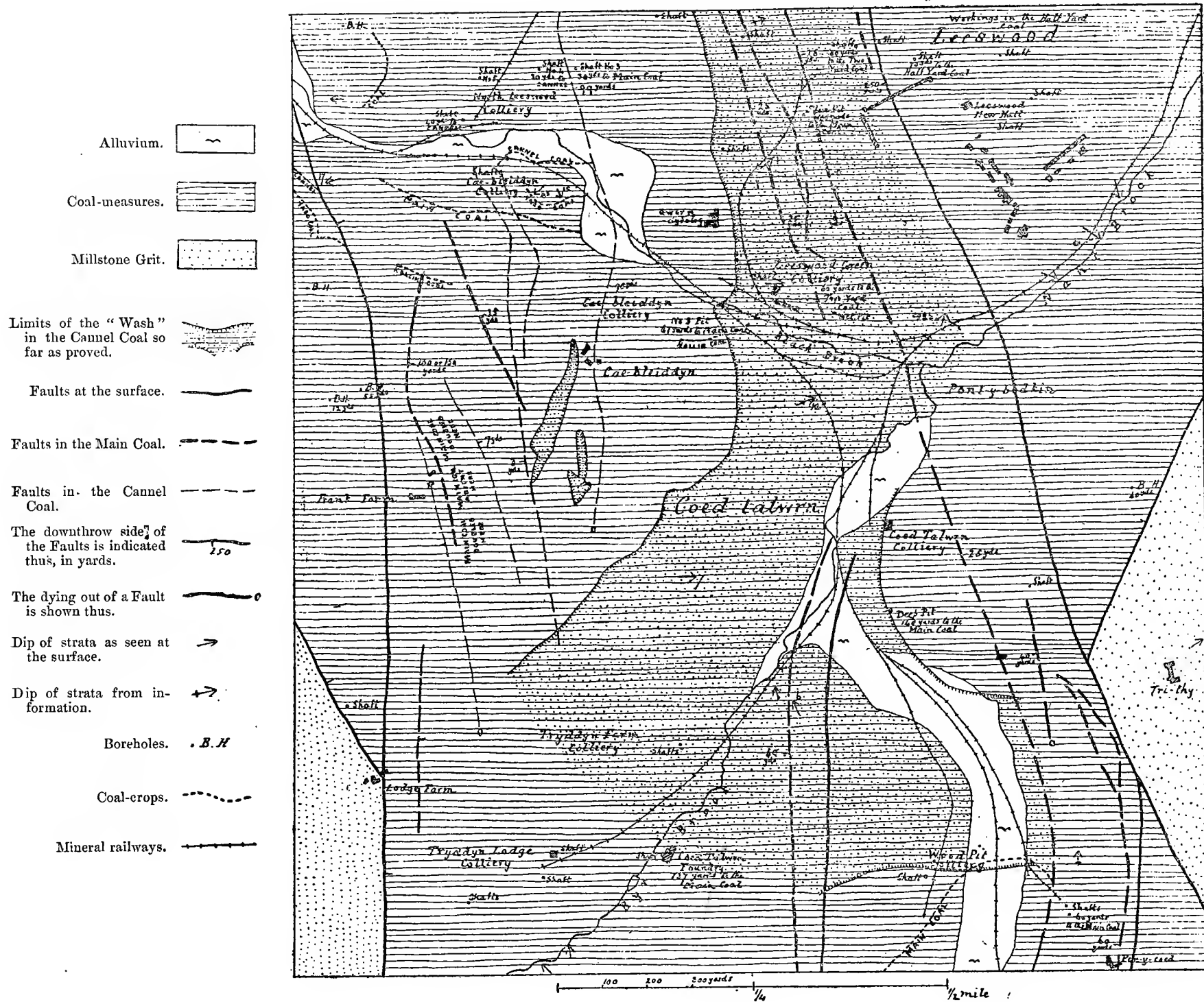
	FEET.	INCHES.
Four bands of ironstone, separated by shale	-	6 2½
COAL (supposed NANT COAL of Ruabon)	-	2 1
Measures	-	62 6
YARD COAL	-	3 6

Coed Talwrn, Deep Pit.

	FEET.	INCHES.		
NANT COAL of Ruabon (supposed)	{	COAL	-	5
		Black bass	-	2 6
		Fireclay	-	6
		COAL	-	6
		Dark clunch [fireclay]	-	7 3
		COAL	-	10
		Grey clunch	-	8 1
Measures	-	-	40	11
YARD COAL	-	-	3	9

Further details concerning the less important seams are given in the Colliery Sections in the Appendix, pp. 213-215, and in Vertical Sections, Sheets 77 and 78.

Map of the Leeswood Coal-field by A. Strahan.



Alluvium.

Coal-measures.

Millstone Grit.

Limits of the "Wash" in the Cannel Coal so far as proved.

Faults at the surface.

Faults in the Main Coal.

Faults in the Cannel Coal.

The downthrow side of the Faults is indicated thus, in yards.

The dying out of a Fault is shown thus.

Dip of strata as seen at the surface.

Dip of strata from information.

Boreholes. *B.H.*

Coal-crops.

Mineral railways.

100 200 300 yards 1/4 1/2 mile

CHAPTER IX.

THE NEW RED SANDSTONE OR TRIAS
(BUNTER).

(1.) Cheshire and Flintshire.

The three subdivisions of the Bunter, viz., the Lower Mottled Sandstone, the Pebble Beds, and the Upper Mottled Sandstone, are all found within the limits of this Quarter-sheet. The low Drift-covered plain of Broughton, Dodleston, Pulford, and Rossett separates the escarpment of Pebble Beds on which Chester and Eccleston* stand from the Carboniferous area of Flintshire and Denbighshire, and is believed to be underlain by Lower Mottled Sandstone, our knowledge of which, however, is derived from one section only, and some borings. The section alluded to occurs about one and a half miles north-west of Hope in a brook flowing from Cuckoo Hill to Moor-side; it was described in 1869 by Prof. Hull as follows :—†

Here we have a continuous view of the rock from the basement upwards for a distance of a third of a mile. The New Red Sandstone, which is seen resting unconformably on shales and thin-bedded sandstones of the Millstone Grit Series, consists of rather coarse soft sandstone, passing from a deep purple (the colour of the rock beneath) upwards through all the shades of red, yellow, and white. The change from white to red is often instantaneous, and does not always take place along horizontal, but sometimes inclined, and even vertical lines, having in fact no apparent connection with the stratification. It is evidently a change subsequent to the deposition of the beds, and arising from the partial withdrawal or deoxidisation of the sesquioxide of iron. Occasionally, as at Bridgenorth, the laminæ of oblique bedding preserve an exact parallelism for several yards. The beds at the base of the subdivision require special notice. The lowest consist of a dark purple arenaceous breccia 10 feet in thickness, full of fragments of the underlying grits, and small rounded pebbles of white quartz. The latter diminish in size as they recede from the base till they become the minute particles of sand which constitute the great mass of this subdivision. It is therefore probable that the white quartz-pebbles, the largest of which scarcely exceeds the tenth of an inch in size, have the same origin as the sand of which this subdivision is composed. Besides these the basement-

* Geology of the Neighbourhood of Chester (Geol. Survey Memoir), 1882, pp. 2, 3.

† The Triassic Rocks of the Midland Counties (Geol. Survey Memoir), 1869, pp. 37, 38. The strata referred to as Millstone Grit in this description are now identified as Lower Coal-Measures.

bed contains bands and nodules of conglomeratic and concretionary ironstone. The conglomeratic ironstone has a metallic lustre, and consists of masses of small quartz-pebbles cemented by, and thickly coated with, peroxide of iron. The concretionary variety has a rusty appearance and more compact structure. In the beds higher up all traces of iron-ore and fragments of rock are lost. The subdivision then assumes its characteristic features.

FIG. 13.

Brook-Section at Cuckoo Hill, showing the unconformable Junction of the New Red Sandstone and Lower Coal-Measures.

(From a sketch by Prof. E. Hull.)



The section thus described provides the only exposure that exists of the base of the New Red Sandstone in Flintshire, and our knowledge of its position further north is derived only from wells and boreholes. In a well at Broughton Hall red sandstone was found under the Drift at 180 feet depth, and at Dodleston village at 145 feet depth (p. 222). The position of the boundary north of Broughton has been determined approximately by the boreholes quoted on pp. 216-222.

In the considerable area of Lower Mottled Sandstone between Burton and Blacon Point but few sections occur. Those at Burton and Burton Point, which are the best in the district, and display the junction with the Pebble Beds, were described by Professor Hull as follows:—*

“Commencing at the Point and walking northwards we cross over higher beds of the Lower Mottled Sandstone, till we arrive at the base of the Conglomerate subdivision. The former consists of interstratified hard and soft beds of various shades of red, yellow, or white, without pebbles; but upon arriving at the line of junction great quantities of quartzose pebbles suddenly make their appearance, and continue more or less abundant all along the section. These extend nearly across the strike for a distance of 350 yards, giving (with the dip of 22° to 25°) a thickness of 400 feet, which is less than the total amount, as the highest beds are concealed from view. Further north the beds are thrown down by a fault against the Coal Measures. It

* The Triassic Rocks of the Midland Counties (Geol. Survey Memoir), 1869, pp. 39, 40, Fig. 18.

is scarcely necessary to remark that, wherever the rock is composed of Lower Mottled Sandstone in the peninsula between the Dee and Mersey, that position is the most favourable for sinking in search of coal. Moreover the general north-easterly dip of the Flintshire Coal-field, together with the existence of the Coal-field near Neston, point to the probability of the continuance of coal under the entire peninsula. As the Coal-Measures of Neston are brought to the surface by a fault, we are deprived of information as to the presence or absence of Permian strata. At any rate, the unconformity of the New Red Sandstone to the Coal-Measures and Permian prevents the possibility of speculating with certainty upon the depth of coal below the surface, further than by remarking that, wherever the Lower Mottled Sandstone reaches the surface, the thickness of the New Red Sandstone is not greater than 500 feet, and generally less."

FIG. 14.

Coast Section at Burton Point, showing the Junction of the Pebble Beds and Lower Mottled Sandstone.

(From a sketch by Prof. E. Hull.)



Of the Pebble Beds at Burton Point Mr. De Rance remarks that they are extremely current-bedded, and contain many quartzite-pebbles, generally of an oval shape, and occasionally six or seven inches long. Some pebbles of a pale-purple colour are distinguished on the outside by eye-like markings, the outer ring of which is dark-purple, but the central portion of a lighter tint than the surrounding mass. The beds are hard and compact, and, weathering more slowly, project over the soft Lower Mottled Sandstone beneath. This is particularly well seen in the hamlet of Burton.

(2.) The Vale of Clwyd.

The New Red Sandstone consists, all through the Vale of Clwyd, of highly current-bedded bright-red sand, generally scarcely coherent, but in a few places sufficiently hard to form an inferior building-stone. Occasionally it contains a few small fragments of older rocks, but for the greater part is as entirely devoid of pebbles, as it is of fossils. The planes of current-bedding, which form one of its most striking features, occur in great sweeping curves, one set of which is sooner or later cut off by another, as though the sand, after deposition, had been partly swept away again by variable currents. The bedding being always of this description we fail to ascertain the true dip, but from the constancy with which the planes dip westwards at high angles (ranging from 20° to 55°) at the foot of the Moel Famman Range, may infer that the deposit has been tilted up towards the east, along the line of the Vale of Clwyd Fault. For the same reason and from the absence of any marked horizons in the sand we are unable to estimate its thickness. A well sunk at Ruthin to a depth of 400 feet is stated to have been in the same sort of rock from top to bottom,* but it should be remembered that the New Red Sandstone is underlain by purple Carboniferous Sandstones, which are scarcely likely to be distinguished by a well-sinker. The depth to its base no doubt varies considerably, for, as has been shown, this rock is affected by both the Vale of Clwyd Fault and the numerous north and south faults on the western side of the Vale.

Owing to the unconformability between the two formations, we cannot say positively on what member of the Carboniferous Series the New Red Sandstone rests at any given point. The overlap by the latter is not so great as was formerly supposed, for in every case where it comes in contact with the Silurian rocks its position is due to a fault, and throughout a great part of the Vale it rests upon Coal-Measures or the top beds of the limestone. Yet at the southern end of the Vale the New Red Sandstone, resting on Coal-Measures near Pen-y-bont, creeps across the edges of the underlying strata, until near Ruthin it has overlapped more

* This information was obtained by Mr. W. T. Aveline from a well-sinker.

than half the Carboniferous Limestone. The Carboniferous Rocks therefore must have been tilted, and subjected to considerable denudation, before the red sandstone was deposited, and we are thus led to the inference that the great faults alluded to above are in part pre-Triassic. As a result of this overlap the New Red Sandstone rests generally on older rocks along its margin than towards the central parts of the Vale, and it may even conceal here and there patches of Middle Coal-Measures, dropped in by the combined influence of some of the faults; but that such patches, if they exist, could be profitably worked for coal is highly improbable, the expense of reaching them, the smallness of the field, and the probably inferior quality of the coal being all taken into account.

The northernmost exposure of New Red Sandstone in this Quarter-sheet occurs in the cross-roads 500 yards north-west of Plâs Ashpool, and shows soft bright-red current-bedded sandstone, faulted, as is believed, directly against the Wenlock Shale. But at Pen-llwyn a wedge of limestone intervenes, giving off a powerful spring at its junction with the red sandstone (p. 10). The shaft and boring, 500 yards east of Llangwyfan Rectory, described on p. 10, furnishes the next evidence of the position of the Trias.

A good section in the stream running by Felin-uchaf exposes rock of a bright-red in the eastern, and of a pale-red in the western part of the dingle, traversed by current-planes which dip westwards at 30° to 40° . Similar sections occur at Waen-wen, near Llandyrnog, and in the cross-roads half a mile further east, the current-bedding, as before, dipping at a high angle westwards. At Pentre-bach the fault between the New Red Sandstone and Lower Coal-Measures becomes visible, as noticed on p. 11.

About Ty-coch the red sandstone appears again, and at Llangynhafal is laid bare to within a few yards of the Lower Coal-Measures, though not to the actual junction. The current-bedding dips at 50° to 55° westwards. Three hundred yards south of the Church, and again near Plâs-drâw the junction is exposed, which forms the subject of Fig. 2 (p. 12).

Drift here overspreads the central part of the Vale, but a little further south, between Llanbedr and Llanbedr Farn, thins away, leaving nearly bare a large area of red sandstone of a rather harder character than usual. The stone has been quarried for building at Fron-ganol, and has been used in the construction of Ruthin Castle, but is too soft to be considered a good material. It varies in colour from deep-red to brown, and the current-bedding planes are remarkably parallel and constant in a dip of 35° to 40° to the west-north-west. It seems to rest naturally upon Lower Coal-Measures. The Trias comes repeatedly into sight about Hirwaen also, with a current-bedding dip of 45° to 50° to the west. It is traversed by some small faults, parallel to the great Vale of Clwyd fault. The exposures at and north of Llanbedr Hall and in the Ysgubor Dingle have already been noticed (p. 14).

The road-cuttings on the east and south-east sides of Ruthin give us a good view of bright-red soft current-bedded sandstones, in which, however, the steep westerly dip, so constant in the current-bedding along the eastern side of the Vale, gives place to a variable inclination at an angle of 15° to 25° only. This deposit doubtless underlies the broad alluvial deposits of the Clwyd, as far west as the limestone-cliff of Craig-y-ddywart, and the sand-pit at Llanfwrog, described on p. 10, which mark two points on the line of the Llanfwrog fault.

CHAPTER X.

SANDS AND FIRECLAYS IN THE CARBONIFEROUS LIMESTONE.

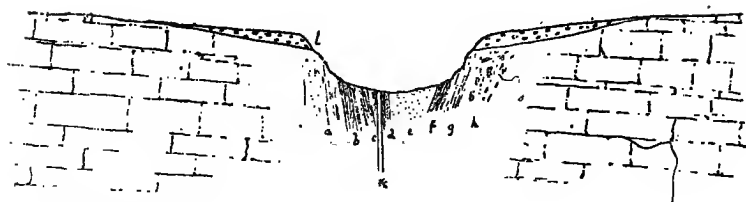
These deposits form the subject of a separate chapter, more on account of the difficulty of assigning to them a definite age than from their importance. Older than the Glacial Period, they may be of any age subsequent to the Carboniferous. They acquire some interest from their containing traces of pre-Glacial land-surfaces, the plants of which, however, are too far perished for recognition.

Several irregular pipes or pockets in the limestone on the line of fault, which runs about W. 30° N., half a mile north of Caerwys Hall, are filled with clay, sand, and decomposed chert, and overspread by Boulder Clay. A pit in one of these pockets, 500 yards west of the Toll-Gate, lies within the area of the yellow Boulder Clay full of Wenlock Shale débris, described on p. 137, and is now filled with this material; another, 500 yards east of the Toll-Gate, shows white, red, yellow, and blue clay resting on, or filling deep chasms in, the surface of the limestone. The white clay was used in manufacturing tobacco-pipes, but was abandoned some years previously to 1867, when it was described by Mr. Maw. Dark laminated clay, dipping steeply towards the centre, was then visible near the margin of the pocket.* In two small holes further east white sand, formed by the decomposition of a siliceous vein-stuff, has been dug for fireclay.

We have already referred to a pipe in the limestone near Rhes-y-cae, in which traces of a pre-glacial land-surface have been preserved under Boulder Clay. The contents of this pipe consist of masses of cherty sandstones and shales imbedded in sand and clay, sometimes presenting a variety of red and yellow tints, but often of a snowy whiteness. The accompanying figure illustrates the general arrangement of these materials.

* G. Maw, *Geol. Mag.*, vol. iv. p. 241.

FIG. 15.

Old Fireclay Pit at Foel-ddu, near Rhos-y-cae.

- | | |
|--|---|
| <ul style="list-style-type: none"> a. Sand, shale, and yellow clay. b. Yellow clay. c. Yellow shale and sandstone. d. White shale, with a layer of chert on top. e. White sand. | <ul style="list-style-type: none"> f. Black bed. g. Slate-coloured clay. h. Mixed sand and clay with broken masses of sandstone. l. Boulder Clay. |
|--|---|

* Shaft sunk to a depth of about 30 yards from the original surface and then stopped by water.

On the top of the white shale *d* of this section lies a white porous stone, a decomposed chert, with numerous casts of small encrinites, which, with the associated shales and sandstones, so closely matches the lower beds of the Millstone Grit in the neighbouring escarpment, as to leave no doubt as to its origin. In the process of settling down the mass of strata has assumed a steep inclination towards the centre of the pipe, and the space around it has been filled with a structureless sand and clay such as would result from the disintegration of a similar rock. The Millstone Grit must clearly have extended over the site of the pipe when the mass alluded to began its descent, though the escarpment now lies 450 yards east of the spot. We may calculate also that, the dip being about 8° , the base of the Millstone Grit would be about 200 feet above the present position of the fallen mass. What length of time would be required for the eating back of the Millstone Grit escarpment 450 yards, and the lowering of the surface of the limestone 200 feet, we have no means of making even an approximate estimate.

The vegetable matter occurs in a bed of black carbonaceous clay (Fig. 15, *f*), which rests on a slate-coloured clay, the two together having the appearance of an old vegetable-soil (p. 139). From their inclined position, however, we infer that the sliding of the contents of the pipe has been renewed since the black bed formed the surface of the ground. The Boulder Clay on the contrary remains as it was deposited during the Glacial Epoch, except that it has been dug through in gaining access to the fireclay. It runs all round the pit, with a thickness of 2 to 6 feet, but thins away gradually against the surrounding slopes of limestone. It formerly hid the pipe entirely from view. Mr. Maw, who described this pit in 1867, stated that the thickness

of the Drift at that time (probably nearer the centre of the hollow) ranged from 20 to 30 feet, and added that in places the contents of the pipe "are very unconformable, perfectly horizontal sand beds terminating abruptly against almost vertical strata of tough plastic clay, and in another place a little pouch of level layers of sand lies in the midst of similar beds very much inclined."*

The contents of this pipe consist in part of blocks of Millstone Grit, as stated above, but include also a quantity of white sand, some of which is so fine-grained as to be impalpable. This sand seems to have resulted from the decomposition of chert, cherty sandstones, and calcareous sandstone, while the clay probably forms the insoluble residue of the upper argillaceous beds of the limestone, mixed with disintegrated shales of the Millstone Grit. The calcareous sandstone series occurs both to the north at Hafod Dew (p. 21) and to the south at Moel Ffagnallt, though it is not well developed in the immediate neighbourhood of the pit. The limestone which forms the walls of the pipe is not such a rock as would furnish more than a small proportion of the sands and clays.

The sand and clay of this pocket seem to have been first worked shortly after the year 1816, when Mr. Hooson obtained a lease of all clays, rocks, and stones (except limestone) within the liberties of the Earl Grosvenor, and formed a company under the title of the "Welsh Company at Nant-y-Moch, near Holywell." The sand after separation from the clay was used for glass-making, while the white cherty sandstone was ground down and employed, under the name of "Rock Cambria," in the composition of china and earthenware, instead of, or mixed with, ground flint.† The pit was described in 1821 by Dr. Traill as follows‡:—

"Just below the soil lies a coarse clay, coloured by iron, and in some places by carbonaceous matter. It is friable from being much mixed with sand. The colouring matters are unequally distributed giving a variety of red and yellow tints. The carbonaceous portions are blackish-grey, but they burn white in the fire. They have been used as an oil-paint. Under this lies a thick bed of white quartz sand, slightly cohering when wet, from containing a little white clay. This sand, when washed, seems well adapted for the glass-house, or might be used instead of flint-powder in porcelain manufactories. In some places, this sand is richly variegated with bright red and yellow hues, from nests of coloured clay, the yellow portion of which have most of the qualities of *variegated clay*. The bed of sand becomes more fine as it descends, and, at the depth of two or three yards, passes into a pure white clay, which we shall now describe.

* *Geol. Mag.*, vol. iv., p. 241, and Fig. 1.

† On the Porcelain Clay and Buhl stone of Hukin Mountain, by W. Bishop & Co. *Phil. Mag.*, vol. lix. p. 404, 1822.

‡ Observations on the Mineralogy of Hukin Mountain, &c. *Edin. Phil. Journ.*, vol. iv. pp. 258-261.

The great mass of this clay, when dried, has the following characters. It is either snow-white, or has the faintest tinge of greyish white. Its particles are dull and dusty, soiling strongly. When rubbed between the fingers, the fineness of its particles prevents harshness, and it is rather soft, though not greasy to the touch. This is the general character; but some masses disseminated through the bed, and especially in the lowest point yet reached, have rather a greasy feel, and, when rubbed, become shining on the surface

When either the dull or the greasy-looking clay is thrown into cold water, it rapidly gives out air, with a hissing sound, and falls into powder; the greasy sort rather less rapidly than the other specimens of the clay [which had been diffused through water, and again dried] yielded more than 80 *per cent.* of silica; the rest was alumina, and a most minute trace of iron. The clay is known in commerce by the name of *Cambria*.

It forms a thick bed, the extent and exact depth of which has not been ascertained. It is found in several adjacent mines. In a shaft one mile west of the present clay-pit, it occurs twenty yards below the surface; as also in another mine a quarter of a mile south of the pit. Mr. Bishop having sunk a shaft about 26 yards E.S.E. of the deepest part of the pit, found different layers of coloured clay and also thin pure white clay, almost to the depth of 60 yards from the surface. At this depth, the workmen came to limestone. Among the white sand, and also in the clay, is found a greyish white crumbling stone, with a slaty structure now in great request with the potters, under the name of *Rock Cambria*. It is shipped for 12*s.* 6*d.* *per* ton, and is now employed in the potteries as an excellent substitute for Gravesend flints.

The clay is dug out of an open pit; and, after being diffused through water, to free it from any admixture of gritty sand, is dried and sold at Flint for 3*l.* 12*s.* *per* ton. It is now greatly prized by our potters, for the beautiful quality of the ware produced, by mixing with plastic clays, containing more alumina. By itself, it evidently has too much silica to form a perfect *biscuit*. When the attempt is made, it produces one of dazzling whiteness; but this may be scraped with a knife, and *flies* when glazing is attempted. If, however, *cambria* be mixed in due proportion with common potter's clay, it forms a *stone-ware* of superior colour even to our finest Worcestershire china. The fine Halkin clay has also been used in the manufacture of the finer sorts of porcelain."

A second pipe filled with sand and clay, 300 yards further south, and on the south side of the Long Rake, has been sunk into to a depth of 8 yards without the limestone being reached. These two pits were still worked in 1879 for fire-clay, the water being removed from the first-mentioned by means of a siphon. The sand was loaded in vessels at Greenfield at 10*s.* a ton, or in trucks at Nannerch at 7*s.* a ton.

A deposit of a similar nature occurs in the west end of the China Rake, near its intersection with the Caleb Bell Cross Course at Pwll Melyn, and also at Craig-fadog between Pwll-melyn and Nannerch. A pit west of Trinity Church (2 miles west of Mold), according to Mr. Maw penetrated 45 feet of white clay under 93 feet of drift and loose boulders of limestone, and another at Fron Hall proved a layer of white clay under limestone-débris at a depth of 140 feet: the former pit seems to have been in the calcareous sandstone series, the latter is probably one of the shafts mentioned on p. 191 (Fron-haul).

Close to Bwlch Farm, half a mile west of Rhes-y-cae, lie the ruins of a brick-kiln, and a pit full of water. Here a similar pocket in the limestone was worked, but the materials were used for bricks after being ground up together. This pit was open at the time of Mr. Maw's visit, and was thus described by him. The sand and clay were sunk into to a depth of 40 feet, limestone closing them in all round. They lay in thin bands of white, grey, yellow, and black sands, separated by layers of tough white clay, very regular and continuous, but not more than two or three inches thick. The darker beds of sand and clay contained a great deal of carbonaceous matter, and here and there, in contact with the clay-beds, were layers of black carbonaceous earth. The whole of the strata were full of slight dislocations and slips, as though they had moved downwards in the limestone-cavity after their deposition.* This pit occurs just on the margin of a small patch of Drift-gravel.

South-east of Rhes-y-cae, and about 400 yards east-south-east of Moel-y-Crio a similar deposit has been dug. The old pits are full of water, but white, yellow, and brown sand, and fireclay occurs, and are said to extend to a depth of more than 80 yards. This pipe lies on the Pant-y-ffrith Cross Course, just at the point where this vein passes from the limestone into the Millstone Grit area.

At the Glan Alyn Mine, 500 yards north-west of the Loggerheads Inn on the Mold and Ruthin road, an irregular mass of sand and fireclay fills a huge hollow in the limestone. The clay is red, yellow, and white the sand chiefly white, but iron-stained in parts. The cavern extends principally to the east along one of the Cat Hole Veins, but northwards also along the Nant Alyn Cross Course, which intersects the Cat Hole Veins at this point. No lead-ore occurs, but fragments of snow-white fine-grained sandstone and chert are scattered through the sand, and in one place a dark sludgy layer resembles the black bed of the Rhes-y-cae pit, described on p. 120. The limestone forming the walls of the cavern is white or grey, of a porcellanous texture, and dips eastwards at 50° to 60°. According to the manager of the mine the cavern forms the entrance to a great pipe running down with the beds eastwards; the pipe was reached at 50 yards depth in a whim-shaft on the hill above, 40 yards to the east.

* *Geol. Mag.*, vol. iv. p. 241, Fig. 2, 1867.

A somewhat similar pipe to that of Rhes-y-cae occurs in the limestone half a mile south-east of Colomendy Hall, near Mold. The section, which is now obscured, has been described by Mr. Mackintosh as follows:—

“Section of Deposits near Colomendy Hall.

(Order descending.)

1. Brown clay, with a few nearly angular stones, some of them scratched; 7 feet in thickness.
2. Sandy and clayey gravel, with numerous stones (both small and rather large), most of them rounded, and some of them scratched; from 2 to 3 feet.
3. Brown clay, with many stones, and at its base large boulders, most of them much scratched and striated; about 6 feet.
4. Bluish or dark-coloured clay, with many stones, the latter much polished, and intensely and often uniformly scratched and striated; greatest thickness about 6 feet.
5. The stony blue clay graduating downwards into laminated stoneless blue clay, with black carbonaceous matter; about 3 feet.
6. The above passing downwards into more or less laminated white clay graduating into white sand; about 18 feet.
7. Broken and decomposing chert.
8. Carboniferous Limestone rock.”*

The pit is situated on the Coed Cynric Vein, which ranges south-eastwards towards the valley on the northern side of Moel Findeg (p. 39); close to the pit some small veins start in a nearly westerly direction from the south side of the main vein. The workings at 66 yards depth were carried through sand and clay, but those at 112 yards depth encountered only occasional masses of these materials in swallow-holes. Lead-ore occurred in the form of carbonate of lead, as lumps resting on the limestone, or scattered through the sand.†

A swallow-hole in the Maes-y-safn Mine, 100 yards west of the Grosvenor Shaft, and at a depth of 150 yards, was filled with white sand, derived no doubt from the calcareous sandstones which crop out at the shaft and in the hill-side to the east of it.

Two pockets occur in the bare limestone-crags south of Pant-du, near Llanferres. One forms an enlargement of the Belgrave Vein, at its intersection with a small anticline (described on p. 42); the other lies at Pwll-heli, 500 yards to the south-west, near but not actually on the Blaen-y-nant Vein. One of these two pockets, probably the latter, was described by Mr. Maw as follows:—The clay, which had been lodged in an angle of a sort of amphitheatre in the limestone, had been worked for pottery from a shaft 75 feet deep. The shaft penetrated limestone-débris and drift for 5 feet, then entered tough white clay which was not bottomed. “A head driven from the bottom of the shaft towards the Mountain Limestone escarpment, intersected horizontally 21 feet of white

* *Geol. Mag.*, Dec. ii., vol. 1, p. 67, 1874.

† The lumps of carbonate of lead in such cases have been formed by the breaking up and weathering of a vein of galena. Many similar deposits, both of fireclay and carbonate of lead, occur in Derbyshire. See *Geology of North Derbyshire* (Geol. Survey Memoir), 2nd ed., pp. 125, 126, 163, &c., 1887.

clay, 84 feet of soft chert breccia, and 27 feet of black laminated clay, the limit of which was not reached."* The pockets lie a mile and a mile and a half west of the Millstone Grit outcrop respectively, but about half as far only from the base of the calcareous sandstone series, which is well developed in this part of the county (pp. 42, 43).

The general character of the contents of these pockets indicate that they have been derived from the upper beds of the limestone and from the Millstone Grit. In the Rhes-y-cae pit the mass of Millstone Grit can only have reached its present position by falling, but in most of the others the material is fine and seems to have been brought by underground streams. It has generally travelled along veins from east to west, the pockets forming enlargements of such veins, often at their intersection with a north and south cross-course. These veins usually contain chert-breccia and a siliceous vein-stuff for some distance westwards from the chert-outcrop; the north and south cross-courses on the other hand are generally filled with clay and spar close up to, and even under the chert. The calcareous sandstones and limestones which form the passage from the Carboniferous Limestone into the Millstone Grit include sediments of every degree of coarseness and chemically formed rocks, such as limestones, of every degree of purity, and would yield on disintegration such a mixture of sands and clays as occur in the pockets, the clays, it will be remembered, being distinguished by the large proportion of finely divided silica in their composition. The pure whiteness so often noticed has probably resulted from the pockets having formed the site of marshy spots, the power of water charged with vegetable acids to remove the colouring iron-salts from such sands being well known.

* *Geol. Mag.*, vol. iv. p. 244, 1867. The pits had been abandoned in 1879.

CHAPTER XI.

SUPERFICIAL DEPOSITS.

INTRODUCTION.

The Superficial Deposits, which overspread so large a part of this area, consist of the following sub-divisions:—

Alluvium and Tidal Alluvium	-	-	-	} Recent.
Peat	-	-	-	
Calcareous Tufa	-	-	-	} Post-glacial.
River-terraces	-	-	-	
Boulder Clay	} partly contemporaneous			- Glacial.
Sand and Gravel				

These sub-divisions are all distinguished by colour on the edition of the Map for Superficial Geology; on the edition for Solid Geology the Glacial Deposits are omitted.

The principal sheets of Alluvium lie in the estuary of the Dee, on the low plain of Rosset and Pulford, up the valley of the Alyn, and in the Vale of Clwyd. Peat is almost limited to small mere-basins, occupying hollows in the Drift. Calcareous Tufa occurs in unusual mass near Caerwys. River-terraces are found at Rosset and in the Vale of Clwyd, in both cases at points where the rivers leave the hills to wander over low-lying plains. The Glacial Drift spreads over the whole of the low ground and over a large part of even the higher ground, excepting the prominent points in the successive hill-ranges formed by the Silurian Rocks, the Carboniferous Limestone, and the Millstone Grit.

BOULDER CLAY, AND SAND AND GRAVEL (GLACIAL).

INTRODUCTION.

Though the Glacial Deposits are here separated into these two lithological divisions only, yet they include a considerable number of varieties. The Boulder Clay in particular changes so much from one locality to another, according to the nature of the rock from which it has been derived, as to present an absolute contrast in colour, texture, and contents in two adjacent areas. Yet the varieties of Boulder Clay have these characters in common: that they are composed of an unstratified material derived from various sources, not sorted by water, and more or less ice-scratched, gravelly if derived from a sandstone, clayey if from shale or slate, red if from New Red Sandstone, yellow if from Coal-Measures or Wenlock Shale. The sands and gravels, on the other hand, are well-stratified and well-sorted pebbly deposits, occurring in or

under the Boulder Clay. It will be seen, then, that the origin of the deposits has been taken in preference to their composition or sequence as the basis of classification.

Before entering on the detailed description of the sections, we will make a few general observations on the area as a whole. The Drift in this part of Wales has travelled, generally speaking, from the west-south-west, though in the neighbouring parts of England it has come down from the north-north-west. Our present district, therefore, includes a portion of the boundary along which the Drift from the west meets and in part mingles with the Drift from the north.* To the former belong all the Glacial Deposits of the southern half of the Vale of Clwyd and of the Valley of the Alyn, as well as those which lie on the high limestone-plateau west and south of Holywell. The latter includes the Drift of the northern part of the Vale of Clwyd, of the sea-border of Flintshire, and of the Triassic area of Cheshire.

In the case of the Drift of western origin, the direction of transport has been nearly at right angles to the strike of the strata, and across four great belts of rock of different lithological constitution, namely, the Trias of the Vale of Clwyd, the Wenlock Shale of the Moel Famau range, and the Carboniferous Limestone and Millstone Grit of Flintshire. From each of these the material has moved north-eastwards, so that a red Triassic Drift lies on the slopes and runs up the valleys of the Silurian Range, a Wenlock Shale Drift overspreads large areas of the limestone, while the limestone and Millstone Grit have provided the bulk of the materials which conceal the western margin of the Flintshire Coal-field. To this variety in its source also are due the rapid changes in the nature of the Welsh Boulder Clay, previously alluded to. The Boulder Clay of the Cheshire plain, on the other hand, derived from a great area of Trias, shows uniformity in colour and texture.

The glacial striæ of the English and Welsh areas respectively agree in direction with that of the Drift-transport. Though at present unknown in the part of Cheshire included in this Quarter-Sheet, they abound about Liverpool, and in other parts of South Lancashire, their mean direction being about north-north-west to south-south-east. Within the boundaries of the Welsh Drift, on the other hand, the striæ point about west-south-west to east-north-east. The map forming Fig. 16 is reproduced by kind permission of the Council from the Quarterly Journal of the Geological Society (vol. xlii, p. 370). It shows by a dotted line the approximate position of the boundary between the Welsh and the northern Drift, and at the same time indicates the position and direction of the glacial striæ (see also p. 144).

* See also "On the Glaciation of South Lancashire, Cheshire, and the Welsh Border." *Quart. Journ. Geol. Soc.*, vol. xlii, p. 369, 1886. And Notes on the Geology of the Vale of Clwyd, by Prof. T. Mc.K. Hughes. *Proc. Chester Soc. Nat. Sci.* No. 3, p. 1, 1885.

(1.) The Vale of Clwyd.

The clays, sands, and gravels in the Vale of Clwyd are difficult to separate, for the clay frequently becomes so gravelly as to pass horizontally into the deposit mapped as gravel. For the same reason we cannot always say whether the one form of Drift lies above or below the other. Such evidence as we possess, points to the sand and gravel rising from below the Boulder Clay, or being in part contemporaneous with it. The Drift is generally red, but buff-coloured sand and yellow clay are not uncommon.

Commencing at the north, we find a gravel full of Wenlock Shale at the Grove, and in the valley eastwards large banks of sand and coarse gravel with great boulders of felstone. South of the Grove yellow Boulder Clay runs up to the foot of the hills, becoming red further west.

Southwards again a great spread of sand and gravel is overlain here and there by 3 to 4 feet of red clay. The sand is in part red or deep-red, and in part buff-coloured and interstratified with pebble-gravel containing much Wenlock Shale. The gravel runs far up among the hills eastwards. The Boulder Clay south of this gravel-patch is red and tough towards the central parts of the Vale, but rocky and mixed with gravel towards its eastern boundary. Southwards it shades gradually into the broad sand and gravel-area of Llan-gwyfen and Llandyrnog.

Here we experience a difficulty in separating the sand-Drift from the clay-Drift. For though this area is characterised as a whole by a sand and gravel-soil, yet we frequently meet with red and grey rocky clay and loam. The gravel consists largely of Wenlock Shale, and the sand is generally red. Both are seen in a pit by the roadside north of Pentre-felin.

Southwards also this sand and gravel-area shades into one occupied chiefly by clay, generally of a red colour even in its extension up the valleys on the north and south sides of Moel-y-Gaer. Similarly the valleys east of Llanrhydd contain narrow tongues of tough red clay, though a yellow tint and a gravelly texture prevail in the Boulder Clay area round the village. The patches of sand and gravel about Llanbedr consist in part of red sand and in part of Wenlock Shale gravel.

On the western side of the Vale the Glacial Deposits have been greatly denuded by the Clywedog and other streams, and redistributed as river-gravels. At Coed-oerllwyn and Plâs-Ynys we see a pebbly gravel, replaced, or perhaps overlain, to the south by a tough yellow and red Boulder Clay. The red colour extends to the eastern side of the limestone-escarpment; but west of this feature the Boulder Clay becomes yellow, and is made up of the waste of Wenlock Shale.

(2.) The Valley of the Chwiler (or Wheeler).

Red sand has travelled up this valley from the Vale of Clwyd in such bulk as to have been originally mistaken for New Red

Sandstone in place. The tint becomes less intense in the upper reaches of the valley, but can be distinguished here and there as far as Mold. The hillocky form generally assumed by this member of the Drift is characteristically displayed, the rounded outlines of the sand-hills, or ridges, forming conspicuous features for several miles along the bottom of the valley. The hillocks lie with their longer axes generally parallel to the side of the valley, and are believed to have been deposited as sand-banks in the Glacial Sea. Such hills are commonly known as Eskers, but in North Wales the titles *Bryn* (hillock) or rarely *Moel* are applied.

On the north side of the valley, above Waen-yr-odyn, this deposit consists of red sand and gravel, full of pebbles of Wenlock Shale, and rises into a multitude of ridges and hillocks. At Macs-mynan also it is made up of red sand, but two prominent ridges of gravel occur on either side of Coed Maes-mynan, that on the east containing much limestone, as well as Wenlock Shale and Lower Silurian boulders (see also p. 138). Close by a little red Boulder Clay rests on the red sand. Near Groesffordd the red sand forms a conspicuous little esker, and on the south of the river, where it runs up the slopes of the Wenlock Shale hills, contains interstratified bands full of Wenlock Shale pebbles.

The sand and gravel run up among these hills, but are replaced in the upper part of each valley by stiff yellow clay, packed with fragments of Wenlock Shale to the exclusion of all other rocks. The yellow clay extends up to, or a little above, the 1,000 feet contour, and contains scratched stones. Whether it passes under or into the sand and gravel could not be ascertained.

At Sarn Mill two small hollows, one filled with water, lie between eskers. Such hollows occur generally where Drift-sand is developed,* and abound near Nannerch. In this neighbourhood the fine red sand, which was so plentiful in the lower reaches of the valley, becomes less common, while on the other hand gravel, into the composition of which Wenlock Shale enters largely, occurs in profusion. Eskers and hollows occur also near Pen-rhiw, the former having an artificial appearance.†

North of Ty-isaf a railway-cutting exposes gravel, composed at the two ends of the cutting chiefly of Wenlock Shale, but towards the middle of limestone, the one changing into the other gradually. Maes-y-groes stands on a remarkably sinuous gravel-ridge.

At Maes-y-cyffion we cross a low watershed, and enter the drainage of the Alyn, the description of the Drift of which will be continued under another heading. It should be noticed, however that the deposit runs continuously through from the system of the Wheeler into that of the Alyn.

* As for instance at Delamere (Geology of Chester,—Geol. Survey Memoir—p. 17) and Ellesmere.

† Some eskers near Glust were pointed out as Roman lead-works. They have elsewhere in this district had an artificial origin wrongly attributed to them.

(3.) The Upper Valley of the Alyn.

The valley of the Alyn includes two separate reaches, the upper, or Vale of Llanarmon, trending northwards between the Limestone and Silurian ranges, the lower stretching south-eastwards across the Coal-field. The upper reach of the Alyn Valley in one sense forms a continuation of the upper part of the Chwiler Valley, both owing their direction and existence to the outcrop of the two rocks named above. Though in the one case, the Chwiler, after following the strike of the beds for some miles, breaks away across the Silurian hills, and in the other the Alyn turns sharp across the limestone-escarpment, the valley notwithstanding runs continuously through from Caerwys as far south as the Bala Fault (where the strike of the rocks is uninterrupted), and for the whole distance forms the resting ground of a strip of Drift. Having already described the northern part of this strip, we will now follow its continuation past Cilcain and Llanferres up the Vale of Llanarmon.

The gravelly deposit of the neighbourhood of Ty-isaf, Glust, and Tardd-y-dwr is replaced southwards by a yellow clay packed with fragmentary Wenlock Shale, which spreads not only over the base of the limestone, but runs up the limestone-slopes eastwards and far up the valleys in the Silurian hills westwards. This clayey deposit generally occupies the low ground, and tends to level up the inequalities of the rock-surface; the sand and gravel on the other hand, though more prevalent in the valleys, yet frequently mount the slopes in a most capricious manner, or occur in isolated and conspicuous mounds on the hill-tops. This habit of the sand to form ridges and hummocks, distinguishes it from the clay-Drifts, which form a surface nearly level, or gently inclined in conformity with the general slope of the rock-surface beneath. These characters are well shown in the valley now under description.

Though the valley of the Alyn is occupied by sand and gravel, the tributary valleys on its western side contain long gently inclined tongues of Boulder Clay, a tough grey and yellow clay, packed with fragments of Wenlock Shale, but with few foreign boulders. Here and there a ravine shows the great thickness of the deposit, while the presence of a few scratched stones prove it to be a true Glacial Drift, and not a rain-wash from the surrounding slopes. In the heads of some of the long valleys it runs up to a height of about 1,100 feet, but in all cases is limited by the form of the ground, rather than by the height above the sea.

The valley of the Alyn itself on the other hand, and its eastern slopes, are occupied by a sand and gravel-Drift, with the features characteristic of this deposit. In Bryn-y-castell, 200 yards north of Maes-y-groes, there occurs a good example of an esker, while an equally characteristic hollow lies near Pwll-y-blawd. The line engraved on the Map separates the sand and clay-Drifts approximately only, the one seeming to shade horizontally into the other.

The composition of the Drifts points to their having been derived chiefly from the Wenlock Shale of the Moel Fammau range; fragments of this rock form the principal ingredient in the clay, and have probably supplied the matrix also, while limestone scarcely appears among the boulders, until we pass some little distance to the east of the limestone-boundary.

(4.) The Lower Valley of the Alyn.

We now resume the description of the Drifts of the valley down which the Mold and Denbigh Railway runs, at the point where we left it on p. 130. The red Drift-sand which runs up from the Vale of Clwyd, becomes less intense in colour near Hendre, and seems to give place to a pebble-gravel composed of Wenlock Shale and limestone. The deposit is well developed about Bryn Alyn, and Pant-y-terfyn, and on the opposite side of the river from Rhual near Mold to Nerquis. A pit near Gerddi Duon shows stratified loam and sand with coal-dust, derived presumably from the Coal-Measures of Rhydymwyn and Nant-figillt, while the absence of coal-dust in the Drift of the Hendre and Chwiler valley confirms the conclusion previously stated as to the eastward direction of the currents along that hollow. Detritus of the purple beds of Maes-garmon (p. 69) has also travelled, generally speaking, eastwards. At Rhual coarse pebble-gravel rises into many ridges and terraces, one of the former running nearly east from Maes-garmon for about 600 or 700 yards; while terraces occur on the south side of the road near Rhual, one of them forming the site of the Victoria Alleluatica Obelisk. But the most conspicuous Drift-feature of the neighbourhood is known as the Bailey Hill at Mold, a fine example of a sand and gravel-esker, though its original form has been modified artificially. The red tint in the sand which has been traced up from the Vale of Clwyd dies away in this neighbourhood.

The Boulder Clay on the north bank of the Alyn between Rhyd-y-mwyn and Mold consists of red and yellow clay, sometimes gravelly. Though forming lower ground than the sand and gravel, and generally ending off against a rising slope of this deposit, it probably overlies it; but their relative positions are nowhere clearly shown. The clay contains much limestone in places.

The description of the Drift of this neighbourhood is here continued by Mr. De Rance as follows:—“The Drift-sand occupies a considerable area on the slopes of the deep valley drained by Black Brook, between Gwysaney Hall and Soughton. About 12 feet of gravel rest upon sandstone in a quarry at Black Brook, below Tyddyn-uchaf. Here the sand passes under Boulder Clay, and further east thins away, so that in the rock-exposures south of Soughton Boulder Clay rests directly on Coal-Measure sandstones. The level of the sand and gravel, where it rests on the rock on the valley-slope, is about 400 feet, and that of the Boulder Clay, where resting on

the gravel, about 450 feet above the sea. At Llwynegrin the beds are lower, and at Rhyd-galed the sand and gravel appear to lie upon a lower Boulder Clay, but eastward of Bryn-yr-haul pass under Boulder Clay at about 450 feet above the sea. Further east again they thin out against slopes, which rise to over 500 feet at Llwyn Offa. The sands show current-bedding in a pit between the stream and the lane near Pen-y-waen, the section being—

	ft.
Boulder Clay - - - - -	6
Gravel - - - - -	2
Sand with planes of current-bedding dipping south-east - - - - -	14

“ From Mold the sand and gravel extend southwards to beyond Nerquis. Sand was formerly worked in a pit at Bromfield Hall, and is exposed at the Oak Pits, Broncoed, and the Tower. In the bottom of the deep cutting of the Mold and Tryddyn Branch of the L. & N.W. Railway it rests on Boulder Clay, a position probably occupied also by the Boulder Clay south of Waen Farn, Rhyd-y-cleifion, and at Tan-y-bryn, where 8 feet of rather fine gravel is exposed. Eastward in the valley of the Terig, between el are and Bryn-y-ffynnon, Boulder Clay rests directly on Coal-Measure sandstone. Near Nerquis Church, about 35 feet of coarse sand and fine laminated gravel are seen in a pit at a height of 600 feet above the sea. No shell-fragments were observed, and the character of the deposit points to an origin in the waste of adjacent rocks. Near Pont Iago this sand seems to rest upon Boulder Clay, but at Pont Terig, on the opposite side of the stream, clay alone is seen, resting upon the rock.”

South of Nerquis we enter a district deeply laden with Boulder Clay, and almost devoid of the stratified sands and pebble-gravels which are so well developed around Mold and along the Alyn. The district is drained by the Terig, the Black Brook, which runs past Leeswood to Pont Bleiddyn, and the Cegidog, these lines of drainage being in part at least of post-Glacial origin, and taking the place held in pre-Glacial times by a large valley now choked with Drift.

The valley alluded to runs from the Terig near Plas-newydd eastwards to Pont-y-bodkin (Rhyd-osper on the one-inch map), thence turning southwards, and joining the Cegidog valley near Llanfynydd (Penuel on the one-inch map). For the first part of its course it is occupied by a small stream which rises near Plas-ym-Mowys, and flows westwards into the Terig. The next section of the valley carries part of the drainage of the same neighbourhood eastwards to Pont-y-bodkin by the stream known as Black Brook (Plate 1), the watershed between the two sections being so indefinite as to suggest that it was a mere accident whether the water on entering the hollow of the old valley turned along it westwards to the Terig or eastwards to Pont-y-bodkin.

At Pont-y-bodkin the Black Brook leaves the line of the old valley, and makes a short cut to the Alyn near Pont Bleiddyn, by the narrow ravine of Nant Brook, which it has cut in Boulder Clay and Middle Coal-Measures. The old valley thus left dry continues its course southwards, serving merely to carry off the rain that falls on its slopes, but a slight bank would suffice to turn the stream from the new ravine of Nant Brook back to the old line of drainage.

The difference in the ages of the ravine of Nant Brook and the old valley is clearly indicated by the distribution of the Drift. The former is cut through a nearly level sheet of Boulder Clay into Coal-Measures, but in the latter the Boulder Clay runs down the slopes, and lies below the alluvial deposits at the bottom. We may conclude, therefore, that in pre-Glacial times, when the old valley formed the outlet for the drainage of the neighbourhood, the ravine had no existence, but that at the close of the Glacial Period the water was here and there diverted from its old course by the accumulations of Drift, and forced to cut new channels.

On its northern side, half a mile north-west of Gwern-dyfolog, the old valley was joined by a tributary, which, now filled up with gravel, constitutes a "gravel-fault" of the miners. The North Leeswood Colliery Company in working the Cannel Coal encountered this trough of gravel at 27 yards depth. A slight depression in the Boulder Clay, and a strip of Alluvium about 600 yards long and from 30 to 70 yards broad, indicate the position of the trough. It runs about east-north-east as far as it has been traced, and is dry both above and below ground. The bottom of the old valley was proved in the same way by the Caebleiddyn Company at a point 500 yards west-north-west of Gwern-dyfolog, where the Cannel Coal ended off against gravel at a depth of 15 to 20 yards below the Alluvium. At the Hazelwood Colliery also, on the north-east side of Hope Mountain, the Cannel Coal cropped out in the side of the gravel-filled valley, at a depth of 30 yards below the Alluvium. The gravel in this case was wet, and contained great boulders of limestone. Such "gravel-faults" are, of course, quite distinct from the "washes" in the Cannel Coal.

The Boulder Clay of the neighbourhood is well seen in the valleys of the Cegidog and Terig and their tributaries, as a tough, yellow and red till, packed with great boulders of limestone, calcareous sandstone, Millstone Grit, and a few of Upper Silurian Rocks. The boulders, which are well glaciated and range up to a cubic yard in size, seem to have been derived from the outcrops of the various rocks named above, which form the succession of hill-ranges to the west and south of Nerquis. Though in this case we cannot fix the exact direction of Drift-transport, we infer that it was probably rather to the north of east from the occurrence in the Coed Talwrn valley of boulders of the so-called Permian sandstones, which occur near Wrexham. A similar rock appears in the Drift near Padeswcod also. The clay described above rests

generally on the bare rock around Tryddyn and along the Terig, but occasionally a bed of sand intervenes, as at the Frank Farm and at Nerquis Junction.

Returning now to the valley of the Alyn we find it clearly indicated on the Drift Edition of the map by the sand and gravel which follow its lower as well as its upper reaches. The description of the Drift is continued by Mr. De Rance as follows:—

“The sand crops out along the northern side of the valley from Bron-wylfa, and along both sides from Llong downwards. Between this place and Leeswood Hall it is capped by Boulder Clay, and slopes down below the alluvial deposits of a plain more than a third of a mile in width. The clay is manufactured into bricks and tiles near Tyddyn Farm; it is of a dull-reddish colour, and contains the usual assemblage of Lake District erratics, with a few fragments of marine shells.

“Southwards at Pont Bleiddyn, where the alluvial flat scarcely exceeds 50 yards in breadth, a curious change in the direction of the river takes place, though the nearly east and west trend of the valley is continued in a depression ranging from Padeswood to Rhyd-y-defaid. The artificially drained flat in this depression contains some peat, especially in its western part, and is drained by another Black Brook, which becomes a fairly important stream, before it joins the Alyn above Hope. On its west and south sides the depression is enclosed by series of mounds of sand and gravel, to the irregular deposition of which it owes its origin.”

Below Hartsheath, particularly where the valley widens out after passing the spur of Millstone Grit, a variable mass of fine sand and gravel rises into ridges, such as Bryn Alyn, or encloses hollows, from one to another of which the river has cut a sinuous course. Wide alluvial flats generally mark the position of such hollows, while the narrowing of these flats indicates the reaches where the work of the river has been to excavate rather than to fill up in establishing a uniform gradient for its channel. Just below Hartsheath two eskers protrude as islands through Alluvium which has been deposited around them. At Caergwrle the whole valley narrows almost to a ravine in passing a bold Millstone Grit ridge, but opens out again southwards in Quarter-sheet 74 N.E. The sand in the neighbourhood just described contains much coal-dust in the finer beds, but few shells, and those only in small fragments. The gravel is made up of Carboniferous and Silurian débris in varying proportions, with a small per-centage also of rocks foreign to the counties of Flint and Denbigh. The following per-centages of the boulders in two adjoining pits illustrate these points.

Gravel-Pit at Pont-y-delyn (Y Fagl on the one-inch Map.)

Limestone, sandstone, and chert	.	-	-	60
Wenlock Shale and Bala Beds	.	-	-	35
Pink granite, black porphyry, &c.	.	-	-	5

Gravel-Pit by the side of the Railway, 400 yards east of the above.

Limestone, sandstone, and chert	-	-	-	25
Wenlock Shale and Bala Beds	-	-	-	70
Granite, porphyry, &c.	-	-	-	5
				<hr/>
				100
				<hr/>

The long hill which extends from near Hope to Hawarden is entirely overspread by Drift, a Boulder Clay with sand and gravel apparently rising through it in irregular patches. Along the crest of the hill the Boulder Clay is yellowish and stony, and consists principally of ground-up Carboniferous Rocks, but eastwards gradually becomes chocolate-coloured and less stony so as to pass horizontally into the Cheshire type of Boulder Clay, which overspreads the low ground of Dodleston and Pulford. Near Burton Hall this red clay has been manufactured into bricks and drain-pipes. At Marford, near Gresford (Quarter-sheet 74 N.E.), these two types of Boulder Clay are separated by a bold brow of sand and gravel, against the foot of which the red nearly stoneless clay of the Cheshire plains thins away. The feature enters the map now under description and runs for some two miles past Rackery, where sand, with planes of current-bedding dipping E. 35° N., is exposed. It dies away under the Boulder Clay of Lower Mountain, but probably reappears in the remarkable strip of sand which runs from Cuckoo Hill to Hawarden, and thence extends in bold ridges as far as Ewloe. At Roff Mount, near Gresford, a conspicuous point on this brow of gravel, the boulders, nearly all of which are of Welsh origin, occur in the following proportions:—

Per-centages of Boulders at Roff Mount.

Silurian, small pebbles	-	-	-	45
Carboniferous Limestone, rather large	-	-	-	35
Carboniferous chert and sandstone	-	-	-	10
Bala Volcanic Series	-	-	-	5
Coarse-grained pink granite	-	-	-	5
				<hr/>
				100
				<hr/>

(5.) Halkin Mountain.

This elevated plateau is physically bounded on the south and south-west by the valleys of the Wheeler and Alyn, and on the east by the fall in the ground where the Millstone Grit is succeeded by the softer Coal-Measures. Northwards it is continued in the elevated limestone-escarpment which runs towards Prestatyn, while to the north-east it is dominated by a still more lofty tract of Upper Silurian Rocks. The higher points of this plateau reach a height of but little short of 1,000 feet, and a large part of it ranges from 600 to 700 feet above the sea; yet a great portion of it is overspread by Drift, presenting no marked difference to

that of the lower ground. The development of Drift-sand at this height, and especially of eskers, such as Moel-y-Crio, in the most prominent positions, forms a noticeable feature. Fragments of marine shells have been observed in the sand up to a height of 965 feet above the sea.

From Caerwys northwards for some miles the boundary between the Limestone and the Wenlock Shale lies beneath a thick mass of Boulder Clay, which slopes down gently eastwards, as it passes off the hills of Wenlock Shale on to the Carboniferous Limestone. This Boulder Clay is yellowish and crammed so full of the débris of Wenlock Shale, as to be scarcely distinguishable from the soil produced by the weathering of that rock. It extends, however, far over the limestone-plateau keeping much the same character, and only at a distance of some two or three miles east of the Carboniferous boundary begins to include a sensible proportion of Carboniferous débris. The Drift, therefore, travelled from west to east here, as was the case in the valley of Wheeler close by (p. 129).

Towards Pantasa, Brynford, and Pen-y-ball this Boulder Clay occurs in patches only, and its place is taken by a gravelly drift, passing into stratified pebble-gravel and fine well-bedded sea-sand, with fragments of marine shells of recent species. But whether the clay or the sand and gravel is the older we have no evidence to show.

The sand and gravel, as elsewhere, is piled up into ridges and hillocks which at Pantasa trend about west-north west, but generally speaking the Drift-hillocks show no prevalent definite direction in this neighbourhood.

In the gravel at Ffynnon-graeanau, near Pantasa, a rudely stratified and very stony deposit, about 90 per cent. of the boulders are foreign to the neighbourhood, and almost all are well rounded and not scratched. The following were noted:—

Ffynnon-graeanau Gravel-Pit.

Bedded ash (Bala Beds).
 White granular quartzite.
 Silurian slate, 1 specimen.
 Subangular Carboniferous Limestone, 1 specimen.
 Quartzite (Vein-quartz from Silurian Rocks), 3 specimens.
 Granite, 3 specimens.
 Encrinital chert, 1 specimen.

But generally speaking Carboniferous rocks are the most abundant among the boulders at this distance from the Silurian range, as in the following list of per-centages:—

Bron Calcot Gravel-Pit.

Limestone	-	-	-	-	40
Chert	-	-	-	-	10
White quartzite	-	-	-	-	10
Bala Volcanic series, &c.	-	-	-	-	40
					<hr/>
					100
					<hr/>

At Brynford a pit shows coarse limestone-gravel, resting on fine sand with shell-fragments and with drifted coal, which last has probably been derived from the Coal-field further east. This would indicate a southerly or westerly direction for the Drift-transport, and that we have here reached the zone along which Drift of Welsh origin from the west mingles with Drift of northern origin. A further confirmation of this appears in the nature of the Drift which borders the Dee (p. 140).

The Wheeler in its course along the south-western side of the plateau now under description receives four tributaries on its right bank, viz., the stream of Coed-cochion, of Maes-mynan west of Caerwys, of Afon-y-trefraith east of Caerwys, and a stream near Ysceifiog, which rises at Pantasa, and traverses nearly the whole of the limestone-plateau. Up each of these the red sand-Drift of the Wheeler valley runs a greater or less distance, so as to touch here and there the entirely distinct Wenlock Shale Drift of the plateau, notwithstanding which we find difficulty in deciding if either can be said to be older than the other.

In the first-named tributary a gravelly clay, crammed with Wenlock Shale, passes, as it enters the Wheeler valley, into a sand-Drift with beds of gravel composed of Wenlock Shale. The ravine of Maes-mynan seems to have been once almost filled up with Drift. Hanging on the eastern bank of limestone we observe red sand, capped by Boulder Clay, evidently a part of the red Drift of the Wheeler valley. On the top of either bank lies a ridge of gravel made up of blocks of limestone and Wenlock Shale, with a few boulders from the Bala Beds. A patch of Boulder Clay, in part reddish, but made up chiefly of Wenlock Shale, extends thence nearly to Afon-y-trefraith. A great deposit of tufa forms the most striking feature in Afon-y-trefraith (p. 150), but about a quarter of a mile up the valley a patch of pebble-gravel occurs, the pebbles of which have travelled up from the main valley.

The Pantasa stream, rising in the great deposit of gravel on which the old race-course is situated, crosses an inlier of Lower Coal-Measures, wanders through the Alluvium of an old mere-basin at Ffynnon-graeanau, and then enters a well-defined valley leading past Ysceifiog. South of the mere-basin near Ffynnon-graeanau this depression is bordered on both sides by steep gravel-banks, rising to a level with the adjoining plain, while in its sides and bottom the uneven surface of the limestone has been laid bare here and there. Near Waen-isaf a portion of the stream runs down into some old lead-workings, but in the Coed Tyddyn-halen and thence to Ffynnon fair there are several springs (possibly the same water) issuing from joints in the limestone and bringing up air with them. The Ffynnon fair is not considered good drinking water.

In the south end of Coed Tyddyn-halen a little tough chocolate-coloured Boulder Clay beneath the sand rests on the rock; higher up the lane leading to Mynydd-llan there occurs coarse limestone-gravel with sand again above, while the surface of the

plateau, still higher up, is overspread by the usual yellow and red Boulder Clay with many fragments of Wenlock Shale.

At the mill a boulder of felstone lies on the bank of the stream, measuring 15 feet \times 12 feet \times 6 feet. Another in the lane running from Fron measures 6 feet \times 5 feet \times 4 feet. At Mynydd-llan there is a boulder of Silurian grit, about 3 feet long. Another large boulder of felstone lies in fragments near Bron-fadog,* and one of spherulitic felstone at Gledlom measures upwards of 7 feet in length.

South of the Drift-covered area of Brynford there is a considerable tract of limestone bare of Drift except for small isolated patches here and there. But at Rhes-y-cae both sand and gravel and Boulder Clay reappear in force, each containing a large proportion of boulders of western derivation, as in the following instance :—

An Esker near Waen-trochwaed, Rhes-y-cae.

Wenlock Shale	-	-	-	-	75
Bala Volcanic Series, quartzite, &c.	-	-	-	-	15
Carboniferous Limestone and chert	-	-	-	-	10
					100

The most conspicuous esker, perhaps, in all this part of Wales, is known by the name of Moel-y-Crio. It is formed by a small patch of sand with fine gravel, which towards its southern end rises into so abrupt a mound as to appear artificial. The apex of the mound is 982 feet above the sea, and there occur in the sand fragments of several shells, among which *Tellina* and *Cardium* can be identified.

A patch of Boulder Clay near Rhes-y-cae, which formerly overspread a hollow in the limestone, acquires unusual interest from the fact that beneath it there occur traces of vegetable soil. Presumably this soil is a relic of the pre-Glacial land-surface, preserved from destruction during the Glacial Period by the accident of its having slipped down with other materials into a pipe in the limestone. The identification of plants in this soil would be of the greatest interest, but the microscope has revealed only the fibres of roots and some small fragments of wood, which were submitted for examination to Dr. Stolterfoth. He found that the wood-structure was easily seen under the microscope, and resembled that of oak. For the full details concerning this pit the reader is referred to p. 120.

(6.) The Coal-field and the Triassic Area.

The description of the Drift deposits of the above-named areas is furnished by Mr. De Rance :—"Holywell lies at the head

* An idea that treasure was concealed under such large boulders in times of invasion has led to many attempts, not always successful, to blow them up with dynamite.

of two valleys, the northern of which is occupied by the Nant-hil-brwc, the southern by the Holywell stream. In both valleys sand and gravel underlie Boulder Clay, but thin away in the tongue-shaped area between them at an elevation of 300 feet above the sea. The larger portion of the Nant-hil-brwc water descends by the remarkable valley which runs about N. 30° W. parallel to the strike of the strata, and which was taken advantage of in the construction of the earthwork known as Wat's Dike. Along this valley Boulder Clay rests upon the Lower Coal-Measures, without the intervention of any sands, which, however, come on east of a line ranging from Panton Hall towards Gadlys. In the dingle east of Tyn-y-pistyll (Kiln on the one-inch map) the sand is seen under 24 feet of Boulder Clay, in which fragments of *Turritella* and *Tellina balthica* (?) occur; further down the stream the base of the Boulder Clay is not reached at 30 feet, but still lower the sand re-appears at the surface.

"In the neighbourhood of Greenfield sands and gravel are well exposed, both in the slope between Coed Mawr (Quarter-sheet 79 N.E.) and the Holywell valley, and to the south of that valley towards Chip Wood, where they rest upon bare rock. Eastwards the sand dips under Boulder Clay but reappears at the bottom of the bank which bounds the tidal alluvial plain between Greenfield and Bagillt. At the Dee Bank Works, Boot, and a few other points, the sand is seen to be underlain by a Boulder Clay.

"Good sections of the sand and gravel occur along the railway in the Holywell valley above the Victoria Mills, and the Meadows Works. Halfway between these two points the section consists of:—

	FEET.
Boulder Clay - - - - -	3
Sand - - - - -	25
Gravel (down to the level of the rails) - - - - -	55

"In the coarser portions of the gravels fragments of marine shells occur, amongst which the following are identified:—*Psammobia ferroensis*, *Tellina balthica*, *Turritella terebra*, and *Buccinum undatum*. Further south, in two streams flowing down to Ty-coch, these deposits rest directly on Coal-Measure sandstone.

"Around Cornist Hall and Bryn-goleu sand rises again from beneath Boulder Clay between the 100- and 300-foot contour-lines. Narrow outcrops of soft yellow sand are seen also at Coed Ffrith at about 200 feet above the sea, and at Tyn-y-pistyll at 300 feet, the junction with the upper clay being well-marked. At the junction of the Bryn-y-garreg stream with that of Nant Flint sand intervenes between two Boulder Clays, but thins out west of Coed-y-cra. In the small valley between Pen-y-lan and Nant Mill, it again rests on a lower Boulder Clay.

"Sand emerges from beneath Boulder Clay on both sides of the valley of Flint brook, and has been dug at Tyddyn, where it is current-bedded to the E.N.E. On the opposite side of the valley, north of Bryn-y-cwn, lies a distinctly scratched boulder of Coal-

Measure sandstone, measuring $4 \times 3 \times 2$ feet. An erratic of Lake District Volcanic Ash, measuring $3 \times 2 \times 2$ feet, occurs at the end of the footpath S.S.E. of Little Leadbrook Farm; and another measuring $2 \times 2 \times 2$ feet lies a little lower down.

"The surface of the rock rises at Flint from beneath high-water mark, and in the railway-cutting south of Flint Station is over-spread by 9 feet of purple Boulder Clay, increasing to 14 feet near the Rifle Range. The clay contains numerous Lake District erratics, some of a bulk of 18 or 20 cubic feet occurring in the brickyard between the Ancient Ditch and Mount Place. At Pen Gôch Hill 6 feet of dull-red Boulder Clay rest on purple fireclay, and Boulder Clay rests directly on Coal-Measures also at Coed-on, Wern, between Northop and Ewloe, and near Soughton Hall, though in several of these instances the sand crops out at only a few yards distance, its boundary probably marking the limit of the original sand-bank. The Boulder Clay around Northop and Bryn-Edwin is exceedingly compact and stiff, the few erratics it contains being generally referable to the Lake District.

"Between Leadbrook and Flint Mountain a ridge of sand rises to about 250 feet above the sea. The sand passes under Boulder Clay, both on the rising ground to the south, and in the descending slope to the north, but in the latter direction thins out, so as to allow Boulder Clay to rest directly on the rock at Coed-on Farm and Croes-ati Mill. At Kelsterton also Boulder Clay 16 feet thick rests on sandstone, but at Rockcliff Hall and further west about Oakenholt Hall and Leadbrook the rock is bare, and in the quarries near the old limekiln, some beds, dipping at a low angle to the N.N.W., show slight traces of having been dragged over from north to south. Another Driftless area between Top-y-fron and Bryn-saer is limited southwards by the Boulder Clay under which the sand of Broad Oak and Pentre-môch is wedged in. Whether the absence of this sand about Top-y-fron and Leadbrook is due to denudation or limited deposition, there is no evidence to show.

"At Connah's Quay the wide tract of Alluvium which forms the left bank of the Dee from Saltney terminates, and the tide washes a cliff of which the following gives the section:—

	FEET.		
Boulder Clay	-	-	7
Sandstone	-	-	4
Black shale	-	-	4
Sandstone	-	-	24

"At Shotton also, and in the lower portion of the Wepre valley the Boulder Clay rests on the rock, but sand occasionally intervenes, rising to the surface in a small area west of Wepre Mill.

"In the valley between Pentre-môch and Vinegar Hill the sand intervenes between two well-marked Boulder Clays, though it is absent on the west side of the railway. In the deep valley at

Ewloe Castle it rests directly on the rock, and at Castle Hill underlies a Boulder Clay with numerous erratics of Lake District origin. In a pit south-west of Wepre Hall, gravel with traces of shells of *Tellina balthica* and *Turritella* is exposed, but, followed to the railway-cuttings near Broad Oak Farm, is seen to wedge out and to be replaced by soft yellow sand. Further west, where a considerable amount has been removed in the railway-banks, the sand is overlain by dark-purple Boulder Clay, the line of junction being very sharp.

“The ridge ranging from Ewloe to Hawarden consists of coarse shingle with occasional bands of soft current-bedded sand, as may be well seen in the gravel-pit immediately above Aston Villa, on the Mold and Queen’s Ferry road, where the following section was noted :—

	FEET.
Reddish Boulder Clay with northern erratics	4
Shingle, apparently derived from an older Boulder Clay; contains fragments of shell	22
Current-bedded soft sand (base not seen)	10

“At Mare Hay Colliery the section of the Drift, according to the late Mr. Beckett, was as follows :—

	FEET.
Sand	24
Clay [Boulder Clay]	27
Sand	54

“A considerable exposure of Glacial sand and gravel occurs at Hawarden. The tract occupied by them is traversed by Grooms Dale, the stream of which, uniting with that of Tinkler Dale, flows through Hawarden Park and forms Broughton Brook. The beds of all these streams lie in the Coal-Measures, on which the sand and gravel rest, with here and there patches of Boulder Clay intervening. East and south-east of Hawarden Castle the sands plunge beneath an upper Boulder Clay at about 135 feet above the sea, but they extend southwards in an interesting exposure, varying in width from 30 to 250 yards, and following all the sinuosities in the contour-lines caused by the valleys of the small streams which flow down to the low ground eastwards. This sinuous outcrop nearly follows the 200-foot contour-line, but rises slightly northwards, so as to reach 270 feet at Hawarden Old Castle. Gravel was formerly dug in Gravel Hole Wood. To the east and west this deposit passes under Boulder Clay, but both the clay and the sand thin away against the sandstone-ridge of Bilberry Wood, which rises to a height of more than 400 feet above the sea. The Boulder Clay, however, overlaps the sand, so as to rest directly on the sandstone, an exposure of which showed it to be glacially striated in a direction N. 30° W.

“In the Buckley District sand and gravel underlie the Boulder Clay, but not, however, continuously. At Knowl Hill there occur ridges or mounds of gravel, seen to a depth of about 26 feet,

and containing numerous Lake District boulders, associated with local sandstones and rolled pieces of coal, with fragments also of *Tellina balthica*, *Turritella terebra*, and *Buccinum undatum*. The gravel rises to 561 feet above the sea, and appears to pass under Boulder Clay at 500 feet. In the lane north of Field's Farm Boulder Clay to a thickness of 3 feet rests on fine sand at a height of about 370 feet above the sea. Further north we reach the tract of sand which extends towards Hawarden, as already described. In the district known as Ewloe Town, between Buckley and Ewloe, the Boulder Clay contains but few erratics, local sandstone forming most of the boulders. The clay rests occasionally on sand, as at Field's Farm. Its base is well seen in the valley of Altamy Brook, where the deposit consists of purple clay with many scratched erratic boulders. At Stonybeach Wood a boulder of Coal-Measure sandstone, measuring 6 x 5 x 3 feet, lies at about 330 feet above the sea. The underlying beds are soft, and show no traces of glaciation, but at Bryn-y-bâl, the rock was much crushed and decomposed, and cracks between the opened bedding-planes appeared to have been filled up with Boulder Clay. The Boulder Clay is manufactured into earthenware pots and drain-tiles at Ewloe Pottery.

"From Buckley southwards to Hope Junction there extends a thick deposit of Boulder Clay, an interesting section of which has been opened in the cutting immediately north of Hope Junction Station. The clay, about 7 feet in thickness, rest on a mound of sand, which rises to a height of 4 feet above the rails. Further north the cutting, which is 16 feet in depth, shows that the Boulder Clay contains a mass of sand 14 feet in length and 2 feet in thickness, and tapering away at the ends. Further north the clay thins away to 4 feet, but thickens again at Bannal to 8 feet without any sand being seen, while further on again beds of gravel come on at a higher elevation. Boulder Clay in the cuttings through Bannal contains many rounded boulders of Lake District rocks, but here and there patches of grey clay in which well rounded local rocks only were noticed. Southwards from Hope Junction the sheet of Boulder Clay is continued over Lower Mountain, described on p. 136.

"The Cheshire Boulder Clay varies in colour from a deep-chocolate red or purple to yellow, the latter tint being seen only near the surface, and being probably due to the action of surface-water on the contained iron. The clay is traversed by two sets of vertical joints, ranging almost at right angles to each other; which have been followed by roots for four yards or more, and along which a deep-blue or olive-green colour has been produced by the passage of water. It contains numerous boulders of the Lake District Volcanic Rocks, none exceeding a cubic yard in size, and when washed is found to contain much sand. On the coast between Burton and Shotwick flints occur which much resemble those from the coast of Ulster.*

* See also Geology of the Country around Prescot (Geol. Survey Memoir), p. 28.

"The clay is seen resting on sand in the railway-cutting north of Capenhurst, and at the foot of the sea-cliff south of Shotwick, the latter spot having been chosen for the site of a castle, doubtless from the facility for obtaining water from the sand. The choice of the position of the hamlet of Capenhurst, which marks an inlier of sand, may have had a like origin."

GLACIAL STRIÆ.

The following instances of Glacial striæ have been noted within the limits of this Quarter-sheet.

Locality.	Direction.	Height above Ordnance Datum.	Discoverers.	Where first described.
Pen-y-ball (near Holywell) -	{ N. 85° E. } { N. 40° E. }	815	G. W. Shrub. - { sole - - -	<i>Proc. Liverpool Geol. Soc.</i> , 1875-76 and 1878-79.
Pen-y-gelli (near Holywell) -	{ E. } { E. 15° N. }	700	A. Strahan -	<i>ib.</i> 1878-79.
Gwern-to (near Minera) -	E. 18° N. -	1,100	Do. -	<i>Quart. Journ. Geol. Soc.</i> , vol. xlii., p. 374, 1886.
Hope Mountain -	N. 15° W.	530	Do. -	<i>ib.</i>
Do.	N. 45° W.	—	D. Mackintosh	<i>ib.</i> vol. xxx., 1879.
Bilberry Wood, Hawarden -	N. 20° W.	—	C. E. De Rance	<i>ib.</i> vol. xlii., p. 388, 1886.
Coed-nant-y-wrach (near Caeerwys).	N. 20° W.*	450	A. Strahan -	<i>ib.</i>

A complete list of all the striæ that have been observed along the coast and border of North Wales is given in *Quart. Journ. Geol. Soc.*, vol. xlii., p. 388, from which the following quotation and diagrams† are taken. "It will be seen that along the east border of Wales there is a very marked parallelism among the striæ in a general east-north-east direction. Out of the whole number observed in this part of the district, five only occur in that quarter of the compass in which the Liverpool striæ are so thickly grouped, . . . and all these occur on the outskirts of the Welsh drift-area. The remainder . . . agree in direction with the drift-transportal of the area in which they are situated." The majority of the striæ of South Lancashire and Cheshire on the other hand point a little more south than south-east, or nearly at right angles to the Welsh striæ. The Drift of South Lancashire and Cheshire also travelled in general towards the south-south-east, so as to abut against or in part mingle with the Welsh Drift which travelled towards the north-east (Fig. 16, p. 128).

* Direction affected by the local configuration of the ground.

† By kind permission of the Council of the Geological Society.

FIG. 17.
Diagram showing directions of Striæ in South Lancashire and Cheshire.

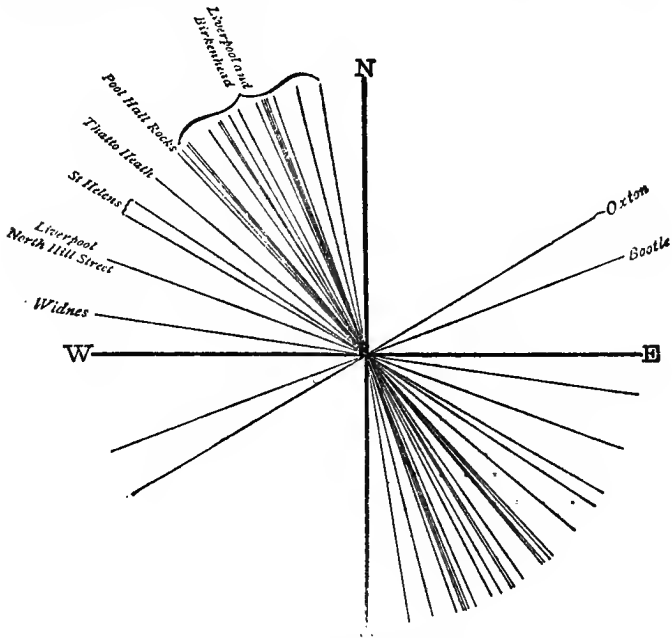
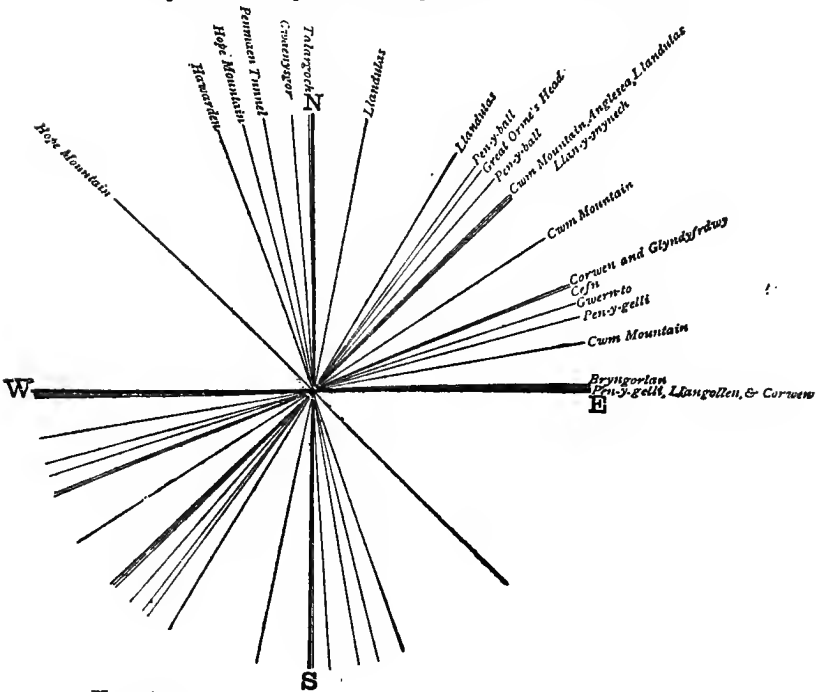


FIG. 18.
Diagram showing directions of Striæ on the Welsh Border.



BOULDERS.

The distribution of boulders in North Wales and the adjoining counties of England had been most carefully investigated by Mr. Mackintosh before the commencement of the re-survey of Flintshire. His conclusions have received full confirmation, and the accuracy of his observations, as well as his priority on the ground, must form the excuse for quoting in full from some of his papers. He first noted the position of the boundary between the Welsh and northern Drifts in the following passage. "Pebbles and small boulders of Eskdale and Criffel granite are thinly strewed along the north Welsh coast from Anglesey to the Point of Air; but nowhere have they penetrated into the Welsh valleys, excepting to a trifling extent into the Vale of Clwyd. From the Point of Air in a S.S.E. direction, they increase in number and size along the coast, but with the exception of a few granite and other pebbles, scarcely any northern Drift has reached the summit of Halkin mountain The western boundary of northern boulders may be roughly drawn along the eastern border of Halkin mountain, and thence by Caergwrle and Ruabon to Church Stretton."*

To the east of this line northern erratics abound, and on the coast from Dawpool to some distance south-east of Parkgate, Mr. Mackintosh measured two of felstone (one, he believed, from Wastwater Screes), the diameters of which were $8 \times 6 \times 6$ and $5 \times 4 \times 2$ feet; two of greenstone, $7 \times 5 \times 4$ and $6 \times 4 \times 4$ feet; and two of Criffel Granite, $5 \times 3 \times 3$ and $3 \times 2 \times 2$ feet.† To the west of the line great boulders of the Lower Silurian felspathic igneous series of the Snowdon and Arenig ranges lie in extraordinary profusion.

The range of Upper Silurian Rocks which forms the east side of the Vale of Clwyd has in particular intercepted a great number of blocks in their journey towards the north-east. The boulders lie most thickly clustered on the west slopes of Moel-y-parc, Pen-y-cloddiau, and Moel Arthur, but many have found a passage across the range by way of the Wheeler Valley and have lodged themselves on the limestone-escarpment about Ysceifiog and Nannerch, while others, which lie upon the high Carboniferous ground in the southern part of the map, seem to have crossed by the less accessible passes of Bwlch-pen-barras and Bwlch-y-parc. The highest yet observed in this Quarter-sheet lies within the camp on Pen-y-cloddiau at 1,441 feet above Ordnance Datum, and measures $2 \times 1\frac{1}{2} \times 1\frac{1}{4}$ feet. Two others, rather larger, but at 1,431 feet and 1,320 feet elevation respectively, occur also inside the earthwork. The largest known boulder lies 200 yards west of Plâs Wilkin, near Rhydymwyn, at 620 feet elevation, and measures $24 \times 18 \times 9$ feet; it is known as *Y Garreg boeth* (the hot stone), and gives its name to the lead-vein close by. Another

* *Quart. Journ. Geol. Soc.*, vol. xxx. p. 712, 1874.

† *Ibid.*, vol. xxix., p. 355, 1873.

well-known boulder marked on the map at Erryrys,* and termed *Maen-digychwyn*, ("the stone that cannot be stirred") lies at 1,120 feet and measures $12 \times 12 \times 10$ feet.

The great number of the boulders whose positions have been recorded on the six-inch map renders their separate enumeration impossible. We will therefore note generally their relative abundance in different parts of the Moel Famau range, and the extent to which they have spread over the ground east of that range. The boulders, except where otherwise stated, belong to the Lower Silurian Igneous Series, which extends from Conway through the Snowdon and Arenig groups to Barmouth. Only those boulders exceeding a length of 2 feet have been taken into account.

They abound on the slopes of Moel-y-parc; a well-marked cluster of twelve being noted on the map on the shoulder south of Castell, between 500 and 600 feet, with one of limestone close by at 300 feet. Many more occur in the valley of Castell, the largest measuring $10 \times 6 \times 5$ feet, and four on the western slope of the hill at 950 feet, the largest being $11 \times 6 \times 5$ feet.

On the northern slope also we find a cluster at 500 to 800 feet, the largest of which, lying in Coed-bedw, measures $12 \times 10 \times 7$ feet, while one of white quartzite measures $4 \times 4 \times 3$ feet. Many more are scattered over the top of the hill. The boulders round Ysceifiog were alluded to on p. 139. The largest, which is marked on the map about $1\frac{1}{2}$ mile north of the village, at 642 feet elevation, measures $12 \times 8 \times 6+$ feet, and another measuring $4 \times 5 \times 8+$ feet lies at the north end of the Ffrith-y-garreg-wen Training Ground at 623 feet; they occur also, but not abundantly, on the old Race Course and Pen-y-ball. Several, ranging up to 7 feet in length, lie near Gledlom.

Along the west slope of Pen-y-cloddiau boulders abound, one of the largest occurring at 520 feet elevation, and measuring $12 \times 10 \times ?$ feet; three lie on the top of the hill as noted above. A few may be found on the east side also, and several are dotted about the slope of Pen-y-ffrith, above Bryn-ffynnon, between the 800 and 1,100-foot contours, as shown on the map. At Garnedd-wen, 1 mile north-east of Nannerch, two lie on the limestone between 600 and 700 feet, measuring $10 \times 5 \times ?$ feet, and $2\frac{1}{2} \times 2 \times 2$ feet respectively. To the west of Moel Arthur and along the watershed in which the Moel stands, they occur in numbers; at the head of the valley east of Rhiw-pebyll they lie between 700 and 900 feet, and in a distance of half a mile along the watershed north from the Moel over a dozen may be counted, one of the largest ($14 \times 7 \times 9+$ feet) marking a sharp angle in the County Boundary at 1,181 feet. South of Moel Arthur but few occur on the high ground and two or three only have crossed to the east side; one, south of Cilcain, at 650 feet, measures $9 \times 7 \times 3$ feet, and another on the east bank of the Alyn, east of Bryncelyn, $4 \times 2\frac{1}{2} \times 4+$ feet. A few boulders of grit (? Upper Silurian)

* So named on the six-inch map. The boulder lies a quarter of a mile north of Castell, as shown on the one-inch map.

occur in the valleys about Cilcain and Rhydymwyn. The Garreg-boeth has been previously mentioned.

Several lie between 800 and 1,000 feet on the west slope of Moel Dywyll, the largest, at 930 feet, measuring $18 \times 10 \times 6$ feet. The one boulder of limestone which has been noted at a high elevation occurs on the hill at about 1,460 feet and measures $5 \times 5 \times 3$ feet. Its position is indicated on the map three quarters of a mile north-west of Moel Fammau. A boulder marked on the map half a mile north-west of Tafarn-y-gelyn, at 980 feet, measures $16 \times 9 \times 8+$ feet, and three others lie together at Ty'n-yr-ynn, east of Tafarn-y-gelyn. Two occur at Maes-y-safn between the 800 and 900-foot contour-lines, and one, resting on the Millstone Grit at Bryn-gwyn at 890 feet, measures $9 \times 5 \times 3$ feet.

A few boulders lie scattered over the limestone of Coed Marchan, south of Ruthin, and two or three on the low ground south of Llanrhydd, but they are scarce on the slopes of the hills above Llanbedr and Llanrhydd. One lies 160 yards east of the top of Bwlch-pen-barras at about 1,140 feet and measures $14 \times 8 \times 9$ feet, and another on Moel Gyw at about 1,100 feet measures $7 \times 5 \times 4+$ feet. Two together on the watershed 600 yards south of Moel Gyw at 1,200 or 1,300 feet, measure $4 \times 3 \times 3$ feet and $7 \times 4 \times 4$ feet respectively, the more northern of the two being known as *Y Garreg-llwyd* (the grey stone). Half a mile to the west lies a boulder measuring $9 \times 6 \times 3+$ feet at 1,050 feet, and two thirds of a mile south, on Moel Llech, one of $8 \times 4 \times 4+$ feet, at 1,158 feet.

The Maen-digychwyn has been already noted; within half a mile to the north-west of it lie three more boulders. Near Pant-y-gwlanod, one third of a mile south-south-west of Castell, a boulder at 970 feet measures $5 \times 4 \times 3$ feet; another south of Gelli-gynan at 780 feet measures $6 \times 5 \times 4+$ feet; a third marked on the map near the Bog Mines (south of Llyn-y-mynydd-du), measures $8 \times 6 \times 4$ feet, with one close by at Maes-y-droell of $4 \times 3 \times 2$ feet, the elevation being about 1,100 feet. One boulder measuring $2 \times 1\frac{1}{2} \times 1+$ lies at 1,250 feet on the south side of Llyn Cyfynwy (Quarter-sheet 74 N.E.). Very few, if any, have found their way to Hope Mountain and Lower Mountain. The abundance of felspathic boulders in the neighbourhood of Llanarmon was first noticed by Mr. Mackintosh, who gives particulars concerning several not mentioned above.*

* *Quart. Journ. Geol. Soc.*, vol. xxx., pp. 717, 718. 1874.

CHAPTER XII.

SUPERFICIAL DEPOSITS—*continued.*

RIVER TERRACES.

This Quarter-sheet includes portions of two extensive deposits of river-gravel, namely, that of the Alyn, near Rossett, and that of the Clwyd, near Ruthin. The conditions which led to the distribution of the gravel are similar in the two cases; in both the gravel was brought down by streams from the upper part of their courses where the gradient was steep, and spread out in an irregularly shaped delta over the low ground, where the streams lost their transporting power.

The valley of the Alyn at Gresford has been excavated in a terrace of Glacial Sand and Gravel, by the washing away of both sand and a vast number of pebbles. But it will be readily seen that before the excavation of the valley the gradient of the river must have been far steeper than at present, and that the stream, now rapid, must then have amply sufficed for the task. But at Rossett the river flows out over a low plain of Boulder Clay, where it must from the first have been slow, and here accordingly we find that excavation has been exchanged for deposition, and that the material removed from the valley at Gresford was spread out irregularly over the surface of the Boulder Clay. The great width of the gravel-flat thus produced is intelligible on the supposition that the river repeatedly blocked itself with the material it was bringing down, and kept changing its channel, as happens in the case of a delta. The width of the deposit at Rossett falls but little short of two miles, and it extends down the river for nearly three miles. A pit about a quarter of a mile east of Rossett Station, shows the gravel to be coarse and roughly stratified.

In the case of the Clwyd valley the gravel was brought down by the Clywedog from that part of its course where the river is torrential and was spread out over the low ground in the vale of Clwyd, for about a mile northwards from the point where the Clywedog leaves the hills. It occurs in the banks of the Clywedog, near Rhewl, as a coarse torrential deposit; but further out in the plain the stones are smaller, and a little loam lies here and there above the gravel. At Rhewl Station a cutting does not reach the bottom of the gravel at 10 feet depth, and shows the deposit to be packed full of half-rolled fragments of Wenlock Shale, which rock forms the bulk of the material at Pen-ffordd-dwr also. A small terrace near Ruthin seems to have been formed in part of materials brought down by the Llanfwrog stream.

CALCAREOUS TUFAS.

Two unusually large deposits of this material lie in the valleys of two tributaries of the Wheeler at Caerwys and Ysceifiog, and a third smaller patch occurs one mile north-east of Caerwys. The tufa takes the form of alluvial flats, lying, in the two first-named instances, at a level of 6 to 20 feet above the streams by which it was deposited, the Wheeler and its tributaries having deepened their channels, and cut out ravines, since the tufa was formed.

The best sections are found in the ravines alluded to, by the road-side at Pwll-gwyn, and in the railway-cutting near the Smell Turnpike. The ravines expose a thickness of 18-20 feet of tufa without touching the base of the deposit, and in one case, near Felin-gonglog, show that it contains bands of peat interstratified. The railway-cutting is now grassed over, but according to Mr. Maw* was dug to a depth of 12 feet in tufa, while the excavations made for a bridge close by exposed a further depth of 6 feet of the same material, and a bed of peat below it, one or two feet thick and containing fragments of decayed wood.

The tufa is generally soft enough to be dug, but like the deposit at Prestatyn † is partly hardened into a rock. The harder masses are full of tubular perforations, in which Mr. Maw noticed the impressions of *Equiseta*, *Carices*, and other marsh-plants. The remains of land-shells are most abundant, the following having been collected by Mr. Maw, and identified by Mr. Gwyn Jeffreys, by whom they are all stated to inhabit Wales at the present day.

<i>Limnæa peregra</i> , Müll.	<i>Helix concinna</i> , Jeffreys.
<i>Succinea putris</i> , Linn.	„ <i>caperata</i> , var. <i>Gigatii</i> ,
<i>Zonites nitidulus</i> , Drap.	<i>Charp.</i>
„ <i>crystallinus</i> , Müll.	„ <i>rotundata</i> , Müll.
„ <i>radiatus</i> , Ald.	„ <i>pygmæa</i> , Drap.
<i>Helix aculeata</i> , Müll.	„ <i>pulchella</i> , Müll.
„ <i>aspera</i> , Müll.	<i>Vertigo antivertigo</i> , Drap.
„ <i>nemoralis</i> , var. <i>hortensis</i> ,	<i>Zua</i> (<i>Conchlicopa</i>) <i>lubrica</i> ,
<i>Penn.</i>	<i>Müll.</i> sp.
„ <i>arbustorum</i> , var. <i>alpestris</i> ,	<i>Carychium minimum</i> , Müll.
<i>Zugler.</i>	<i>Cyclostoma elegans</i> , Müll.

The third deposit of tufa mentioned above occurs as an alluvial flat bordering the stream which flows to Pwll-gwyn.

The tufa in every case rests upon Drift-sand and gravel. It seems to have been formed by the wandering of the streams over the surface of the sand in shallow runlets, under conditions which would lead to rapid evaporation of the water. Its formation has now ceased in consequence of the streams being confined in the ravines alluded to above; the deposit, nevertheless, may be regarded as one of late date, of the same age in fact as the alluvial flats into which it merges from a quarter to half a mile up the valleys.

* On the occurrence of extensive Deposits of Tufa in Flintshire, *Geol. Mag.*, vol. iii., p. 253. 1866.

† *Geology of the Coasts adjoining Rhyll, &c.* (Geol. Survey Memoir), p. 40. 1885.

Tufa occurs also "on the eastern side of Wepre Brook . . . about half a mile below Euloë Castle, where it occupies a considerable breadth of steepish bank, and is remarkably full of calcified ferns and other local plants."*

PEAT AND ALLUVIUM.

A few small patches of peat lie in the sites of some shallow meres on the Millstone Grit and Carboniferous Limestone west of Tryddyn. Some of these depressions still contain lakes, as for example Llyn Iocyn (so named on the one-inch map), another small lake 500 yards further north, and Llyn Cyfynwy in Quarter-sheet 74 N.E. In others the water has been displaced by successive deposits of mud and silt, or has escaped through a swallow-hole leading into the limestone below. But in several the conditions have been favourable for the growth of weeds, which in the course of years have converted them into peat-swamps. Among these may be mentioned Llyn-y-mynydd-du, four hollows near Erryrys and Pant-glâs, and one of larger extent south-east of Mynydd-du. Mr. De Rance notes that the narrow alluvial flat occupying the bottom of the valley near Gwysaney Hall, described on p. 66, is chiefly made up of peat, especially near Big Wood, and that a tract of peat at Dunston Hall, near Burton, on the Cheshire side of the Dee, marks the position of a former tarn.

The Alluvium of the Alyn consists of loam or marsh-clay, which frequently rests on a peaty seam with occasional trunks of trees. Beneath lies a coarse gravel, derived chiefly from the Boulder Clay, and sometimes cemented by oxide of iron.

THE ESTUARY OF THE DEE.† (Plate 11.)

(1.) Its pre-Glacial History.

This estuary presents the structure sometimes known as "valley within valley," for the recent deposits of sand and mud occupy a trough cut out in Glacial Drift which itself lies in a wider and deeper valley excavated in the rock. A number of borings made through these deposits in search of coal, which are quoted in full on pp. 215-221, enable us to determine the relative depths of this older pre-Glacial valley, and the post-Glacial estuary. The deepest point yet known in the modern estuary lies on the northern bank of the Dee, one third of a mile south-south-east of Gorst's Farm, where the sea-sand extends to a depth of 60 feet below Ordnance Datum. The deepest point in the pre-Glacial valley yet met with occurs half a mile east of this farm, where the rock-surface has not been reached at 285 feet below Ordnance Datum. But over a large part also of the low Boulder Clay district of Pulford, Dodleston, Kinnerton, Bretton, and Hawarden the rock-surface lies below the Ordnance Datum, and in the absence of Glacial deposits would

* G. Maw. *Geol. Mag.*, vol. iv., p. 305.

† The physical history of the upper part of the Dee has been treated by Sir A. Ramsay in *Quart. Journ. Geol. Soc.*, vol. xxxii., p. 219 (1876), and in the *Geology of North Wales* (Memoirs of the Geol. Survey, vol. iii.), 2nd Ed., p. 314, 1881.

be overflowed by the sea. This depression in the rock-surface extends generally over the area occupied by the soft Lower Mottled Sandstone.

We have elsewhere pointed out that a natural barrier of rock lies in the bed of the river at Chester,* the rock-surface there rising to within a few feet of the Ordnance Datum. The distance from this barrier to the bore-hole alluded to above being about five miles, the surface of the rock must fall at the rate of nearly 60 feet per mile, or probably much more rapidly in parts. This rate being far in excess of the gradient of the Dee, or any other river, in such a rock as the Cheshire Trias, we may conclude that the gorge at Chester did not form the channel by which the Dee entered its estuary in pre-Glacial time.

The depressed area of Dodleston, Kinnerton, and Pulford, on the other hand, forms part of a strip of low ground, which leads directly to the neighbourhood of Erbistock, where the Dee enters the Triassic plain. Throughout this low ground the rock lies buried under Drift at an unknown depth, but probably, as at Dodleston, below the sea-level, while along the eastern side of the low area it rises quickly up to, and nearly 100 feet above, the sea-level. The River Dee through a part of its course over the Triassic plain follows this strip of low ground, but at Holt, and again at Aldford, has been deflected from it by the Drift, and forced to make a new channel, partly in solid rock. The channel so formed at Chester, Eccleston, and Holt takes the form of a notch cut into the nearly level surface of the rock, generally through a thin coating of Boulder Clay, and thus bears in itself evidence of its post-Glacial origin.

The following table shows the depth in various parts of the estuary, at which (1) the base of the recent Alluvial Deposits, (2), the base of the Glacial Deposits, lie below the sea-level.

* Geology of the neighbourhood of Chester (Geol. Survey Memoir), pp. 8, 31.

Table to show the Depth in Feet, relative to the Ordnance Datum, of the post-Glacial and pre-Glacial Valleys of the Dee below Chester.

The sign + indicates that the boring did not reach the base of the Glacial Drift.

			Saltney.
Bottom of the post-Glacial valley.	10 below		Saltney.
		22 below	Pulford.
		—	Dodleston.
		—	Kinnerton.
		—	Bretton.
		10 above	Broughton.
		—	Hawarden (The Rake).
		—	Aston.
		25½ below	Sandycroft.
		—	Latchcroft.
		60 below	Gorst's Farm (on the river-bank).
		—	Gorst's Farm (¼ mile E. of).
Bottom of the pre-Glacial valley.	134½ below		Queen's Ferry Cross Roads.
	103 below		
	20 + below		
	90 below		
	25 + below		
	31 + below		
	62 + below		
	80 below		
	14 above		
	184½ below		
	37 below		
	132 below		
	285 + below		
	177 below		

(2.) Its post-Glacial History.

At the close of the Glacial Epoch the broad depression in the Boulder Clay, which marks the position of the buried valley, was overflowed by the sea, and began to be silted up, a certain amount of erosion, however, taking place along its sides, where the original slopes were cut back into little cliffs. The alluvial flat ranges from 14 or 15 feet above Ordnance Datum on the north side of the estuary to 18 or 19 feet on the southern side, the lower level of the former marking the course pursued by the river before the artificial channel hereafter described was made.

The deposit filling the estuary consists in the lower part principally of running sand, but in the upper of dark mud ("slutch") or sand according to local circumstances. Mr. A. O. Walker observes that in walking across from Bagillt to Parkgate we should pass first in order "a greasy, slippery mud, so riddled by the burrows of a small Crustacean (*Corophium longicorne*), and a Nereid worm, that of the former especially, every square foot of mud contains many hundreds. When this mud is dug into it is blackish in colour, and has an offensive smell; and at a lower depth than the animals above named, are found many specimens of a large shell-fish, *Mya truncata* We should reach, about a mile from the shore, large banks of wet sand, which are the chosen home of Cockles, Lug-worms, and two or three other species of Bivalve-shells, which do not occur nearer the shore. Further out still are beds of pure sand, which the natives call 'chaffy banks,' from their dry and chaff-like character. I believe these to be almost, if not quite, devoid of animal life. On the other side of the river, in Dawpool, where the water is deeper, you get mud again, but now inhabited by great quantities of mussels, which do not occur at all on the Welsh side."*

The nature of the deeper-seated portions of the Alluvium is known only by the bore-holes given in the Appendix, the sinking of a colliery-shaft at Bettisfield, and of the piers of the railway-bridge at Connah's Quay. Though consisting of running sand the Alluvium must clearly contain boulders, more or less roughly arranged in layers, as shown by the following observation, communicated by Mr. A. Dick: "During severe frosts much floating ice descends from the upper reaches of the river and from various parts of the estuary, and is stranded on the sand-banks. These ice-rafts bear stones ranging up to a foot in length, which they drop, on melting, in such quantities that the marsh is dotted all over with boulders. In the course of a few tides the boulders are buried by sand and mud, and disappear from view. The 'deep' or navigable channel of the river, however, constantly changes its position from one part of the estuary to another, and, in so doing, frees the stones, which then roll down to the bottom of the channel, and there lie until by subsequent silting up and shifting of the channel they become

* Observations on Phenomena connected with the Deposition of Sediment at the present day in the Estuary of the Dee, and their bearing upon older Deposits. *Proc. Chester Soc. Nat. Sci.*, No. 2, p. 6. 1878. See also The Silting up of the Dee: its cause, by W. Shone, *Ib.* No. 3, p. 52. 1885.

buried under 20-40 feet of sand. A continuation of this process must clearly result in the formation of a 'boulder-bed' in the running sand at the greatest depth attained by the shifting channel."

Some gravel and lumps of Boulder Clay, which were met with during the construction of the swing-bridge at Connah's Quay, may have been deposited in the manner described above. The circumstances under which they occurred are described in the following note by Mr. Shrubsole: "The new bridge over the River Dee rests on five piers, which are sunk to the depth of 50 feet below the bed of the river. The strata passed through consist of river-silt (a dirty kind of sea-sand) with four courses of 'beachings,' or fine gravel, 2 or 3 inches in thickness. Boulder Clay in fragments occurred in all the sinkings, one of the fragments measuring 9 feet by 7 feet. The base of the sea-sand was not thought to have been reached. Mr. Shone examined the silt from the lowest depth, and found it to contain the usual foraminifera."*

In sinking the shaft of the Bettisfield Colliery (Quarter-sheet 79 N.E.) through the estuarine sand pumping was found to be useless, because of the great quantity of water, and because the sand ran in. The shaft was eventually sunk to a depth of 100 feet below the water-level by means of cast-iron cylinders, into which air was pumped so as to force out the water. An outer cylinder, 13 feet in diameter, and an inner one, 6 feet in diameter, were used, the smaller one being an air-lock through which the men entered, and being connected with the larger one at the bottom by a conical piece or bell. The cost of sinking was about 170*l.* per yard.†

The estuarine sand rests on an eroded surface of Boulder Clay, as shown in the following description by Mr. A. O. Walker: "Mr. Johnson, who superintended the sinking of the shaft of the Bettisfield Colliery at Bagillt, informs me that they sank through 50 to 60 feet of river-sand before reaching the clay. On the surface of this clay they found large boulders partially embedded in it. The under-side of the boulders was more or less angular, while the upper surface was rounded as if by the action of the waves, or perhaps of fine gravel and sand continually driven over it by the current. Attached to the stones were oyster-shells showing that the stones had not been shifted from the position they occupied when the oysters upon them were living. At that time, if there had been no subsidence since, the water immediately under the high bank which runs all along the river must have been 50 to 60 feet deep; but as I believe this is a greater depth than oysters usually inhabit . . . we are justified in concluding that, though the actual bed of the river has been raised by silting up, yet there has been a general subsidence of the whole coast."‡

The estuary of the Dee was formerly overflowed as far as Chester by every high tide, and in Magna Britannia (1720) is shown as an open arm of the sea, "at New Key, near Chester, two

* For a list of the Foraminifera of the River Dee, see J. D. Siddall, *Proc. Chester Soc. Nat. Sci.*, No. 2, p. 42. 1878.

† *Proc. Inst. Civ. Eng.*, vol. lxxi., p. 199. 1883. (Remarks by Mr. A. Lupton during the Discussion on the Sinking of two Shafts at Marsden, by J. Daglish.)

‡ *Proc. Chester Soc. Nat. Sci.*, No. 2, p. 8. 1878.

“ miles broad, and at Hilbree Island four.”* A winding and constantly shifting channel served to drain off the retreating water, or to carry small vessels as far up as Parkgate. The deepest part of the estuary seems to have lain along the Cheshire shore by Burton Point, Shotwick, to Blacon Point, and along what is now known as Finchett's Gutter.

“ The navigation of the Dee, by which, in ancient time, vessels were brought up to the walls of Chester, had been so much impeded by sands, from the frequent changing of the channel, that it occasioned the total ruin of the haven of Chester before the year 1449, as appears by a Commission of Inquiry of that date † : to obviate this great inconvenience, a new quay or haven was made [at or near Shotwick] about six miles from Chester In 1560, a collection for the new haven at Chester was made in all churches throughout the kingdom ; in 1567 there was an assessment for the same purpose on the city. The new haven was at length completed, and for many years all goods and merchandizes coming to, and going from the port of Chester, were there loaded, and unloaded.

“ The improvement of the navigation of the Dee by cutting a new channel, appears to have been first projected by Andrew Yarranton, who published a work entitled ‘ England's Improvement by Sea and Land,’ (in the year 1677) : he tells that vessels of 20 tons burthen could not then come higher than Neston ; and proposes that an Act of Parliament should be procured, for improving the navigation of the Dee by a new channel to be cut from the river, nearly opposite Neston, to pass by Flint to Chester in 1700 an act passed to enable the mayor and citizens of the city of Chester to recover and preserve the navigation upon the river Dee.

“ The undertakers of this work were incorporated by the name of the River-Dee Company ; a subsequent act passed in 1732, which empowered them to inclose a large tract on the banks of the Dee, called the White Sands ; on condition that they made a navigable river from the sea to Chester : this new cut was begun the next year [20th April 1733], and completed in 1754 In consequence of the great expence of cutting and embanking the new channel of the river Dee, and inclosing the adjacent lands, the proprietors did not receive any profits from the undertaking till the year 1775, when they divided two *per cent.* on their principal stock ; the annual proceeds have since gradually increased, and the proprietors now receive five *per cent.*, with the prospect of an improving revenue. The new channel was at first intended only for ships of 200 tons burthen ; but it is now navigable for ships of 600 tons burthen.” § A depth of 13 to 15 feet is said to have been

* *Magna Britannia et Hibernia Antiqua et Nova* (an enlargement of Camden's *Britannia*), 1720. Vol. 1, p. 273, and map of Cheshire.

† Harl. MSS., No. 2003-63.

‡ This quay was in ruins in 1778 (Pennant's *Tours in Wales*, vol. 1, p. 258), and vessels could get no farther than Parkgate. This place took its origin from a haven constructed during the reign of Elizabeth, and remained the principal port for the Irish Packets for many years.

§ *Magna Britannia*, by the Rev. Daniel Lysons and Samuel Lysons. 1810, vol. ii., part ii., p. 417.

maintained by the River Dee Company since the completion of the New Cut.*

The enclosing of the marsh-land was proceeded with as shown in the following table, the position of the banks or "cops" being indicated on Plate 11.

Area of Embanked Land on the Cheshire Shore, taken from a Map of the Dee Company.

	ACRES.
In 1754 - - - - -	1,411
„ 1763 - - - - -	664
„ 1769 - - - - -	348
„ 1790 - - - - -	964
„ 1826 - - - - -	400
„ 1833 - - - - -	158
„ the Parish of Shotwick - - - - -	32
„ Brewer's Hall Marsh - - - - -	61
Total - - - - -	<u>4,038</u>

Area of Embanked Land on the Flintshire Shore.

	ACRES.
In Leach Eye - - - - -	382
Sir John Glynn's Cops - - - - -	72
Saltney Marsh - - - - -	1,836
South bank and land down to Connah's Quay - - - - -	439
Total - - - - -	<u>3,389†</u>

About the year 1870, a bank was constructed from Burton Point to Connah's Quay, but was broken through by the tide before its completion, and the marsh behind it, nearly two miles in extent, remains still unenclosed.

High spring-tides overflow the weir at Chester, and run for 12 or 14 miles up the river. The rise and fall of the tide below the weir is given in the following table:—‡

August 6, 1849.	Greenfield.	Flint.	Pentre Rock.	Connah's Quay.	Sandy-croft.	Saltney.	Chester
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
High water, ordinary spring-tide -	27 6	27 7	27 8	28 6	29 4	29 7	29 8
Low water, „ „ „ -	0 0	9 1	10 6	14 2	15 5	17 9	18 1
Tidal range - - - - -	27 6	18 6	17 2	14 6	13 11	11 10	11 7

The zero of the heights is the low water of spring-tides opposite Greenfield, which is 22·75 feet below the zero of the Chester

* *Proc. Inst. Civ. Eng.*, vol. xxiv. p. 95. 1865.

† The total obtained by adding up the numbers given amounts to only 2,729 acres, but the area of Sir John Glynn's Cops shown upon the large scale map, from which Map 2 on Plate II. has been reduced, amounts to about 732 acres, instead of 72 acres, which would make the total 3,389 acres correct.

‡ This table and the information on the tidal phenomena which follows it have been abstracted by Mr. De Rance from the *Manual of Hydrology* by N. Beardmore (1862), p. 258. It was taken by Mr. Beardmore from the *Minutes of an Admiralty Inquiry* held at Chester in 1849.

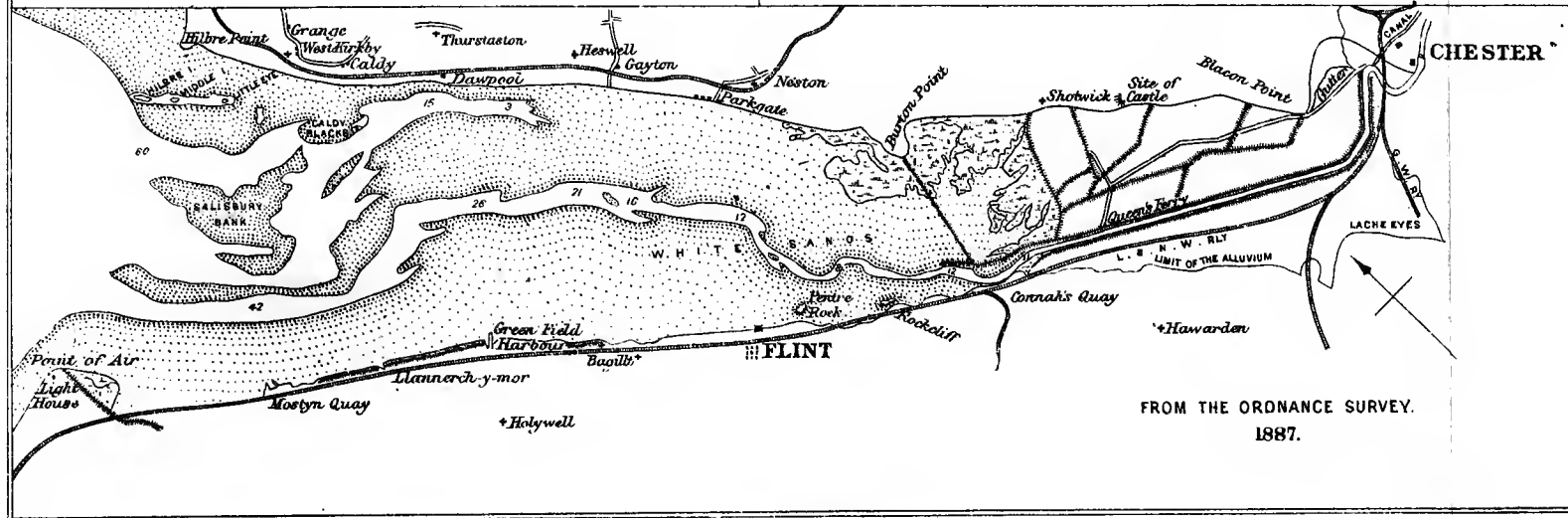
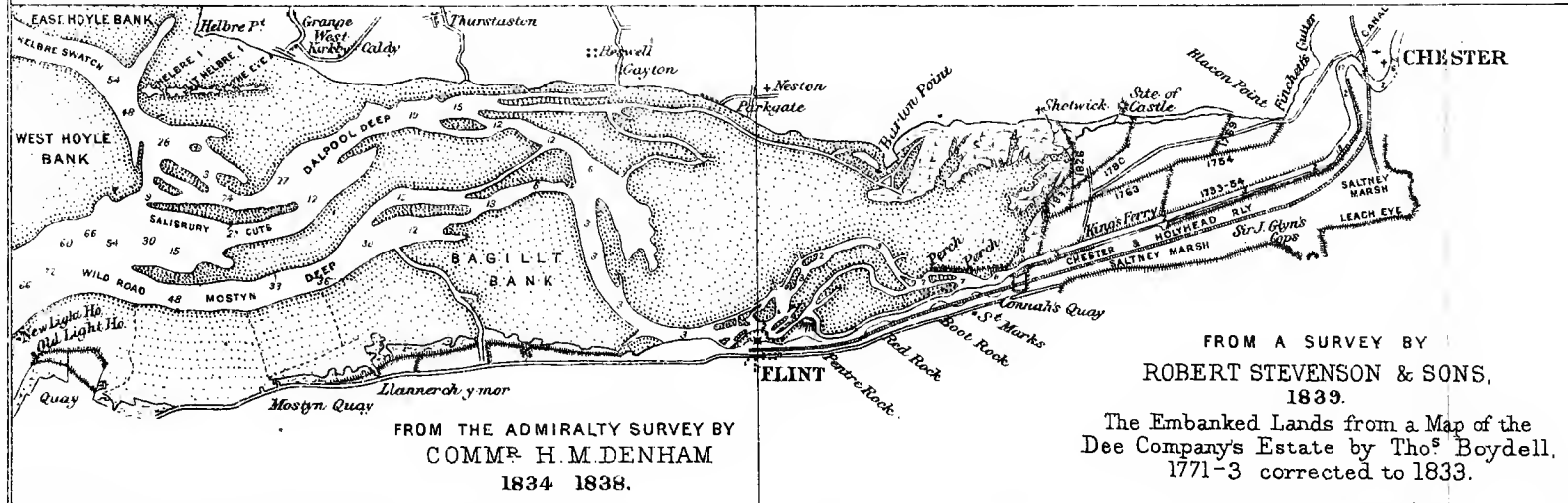
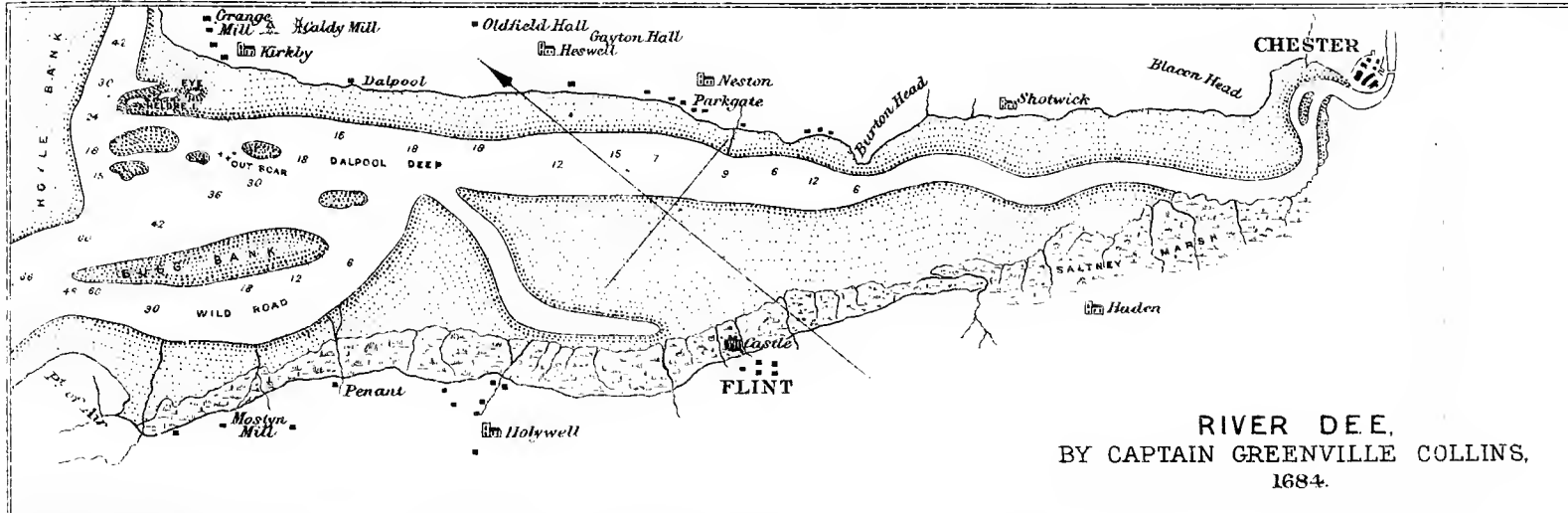
gauge, and 13·50 feet below the mean half-tide level at Liverpool, the relative heights being as follows :—

	FEET.
Greenfield high water, ordinary spring-tides, <i>above</i> mean sea-level	14
Chester zero-level, <i>above</i> mean sea-level	9·25
Half-tide level (mean), at Liverpool	0·0
Greenfield low water, ordinary spring-tides, <i>below</i> mean sea-level	13·50

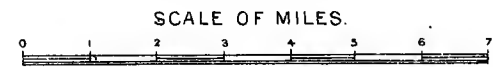
The Old Dock Sill level, at Liverpool, is 4·75 feet below the mean sea-level, which was taken by the Ordnance Survey as their datum. The Greenfield tide therefore rises 18·75 feet above the Old Dock Sill.

The narrowing of the estuary of the Dee causes the tidal wave to form a bore between Flint and Chester. The following table gives the velocity of the head and foot of the tidal wave at the various points named :—

Stations.	Length.	Tidal Range.	Interval of Passage.		Rate per Minute.	
			Foot of Wave.	Head of Wave.	Foot.	Head.
Between:—	feet.	ft. in.	mins.	mins.	feet.	feet.
Flint and Pentre Rock -	4,925	20 2	20	5	246·2	985·0
Pentre and Connah's Quay -	15,575	18 10	45	10	346·0	1,557·5
Connah's Quay and Sandycroft	17,160	16 6	30	9	572·0	1,906·6
Sandycroft and Saltney -	17,250	15 3	20	8	862·5	2,156·2
Saltney and Chester -	7,040	13 8	10	4	704·0	1,760·0
Flint and Chester -	61,950	13 8	125	36	495·6	1,720·8



MAPS
SHEWING ALTERATIONS AND RECLAMATIONS
IN THE
ESTUARY OF THE DEE
BY
A. STRAHAN.
Soundings in feet at low water



FROM A SURVEY BY
ROBERT STEVENSON & SONS,
1839.
The Embanked Lands from a Map of the
Dee Company's Estate by Tho^s Boydell,
1771-3 corrected to 1833.

CHAPTER XIII.

METALLIFEROUS MINES.

INTRODUCTION.

The metalliferous mines are confined in this part of Flintshire to the Carboniferous Limestone and Millstone Grit. The following ores are, or have been, raised :—

Galena, in part argentiferous (sulphide of lead with silver).

“ White lead ” (carbonate of lead).

Blende, or Black Jack (sulphide of zinc).

Calamine, locally known as “ caulk ” or “ coke ” (carbonate of zinc).

Hæmatite (oxide of iron); not abundant.

Copper-pyrites; in small quantities only.

Wad (oxide of manganese); rare.

The ores of lead and zinc have been worked, as it is believed, from the time of the Roman occupation continuously up to the present day. For though in the multitude of shallow shafts and open trenches along the veins we cannot distinguish any as being certainly of Roman origin, yet the discovery of several pigs of lead bearing the stamp of Roman Emperors near the borders of North Wales indicates that ore was both raised and smelted in the neighbourhood.*

Pennant gives reasons for supposing that the ore was smelted at a place called Croes-ati, near Flint. “ There is a tradition that in very old times stood a large town at this place; and it is said that the foundations of buildings have been frequently turned up by the plough. But more remarkable are the great quantities of scoria of lead, bits of lead ore, and fragments of melted lead, which have been discovered in several spots here, and along the country, just above the shore, in the adjoining parish of *Northop*. These have of late been found to contain such quantities of lead as to encourage the washers of ore to farm the spots. In this tract, numbers of tons have been gotten within a small time, especially at *Pentre Ffwrndan*, or the *place of the fiery furnace*; a name it was always known by, and which evinces the antiquity of smelting in these parts.”† He adds that the multitudes of Roman coins, fibulæ, and variety of antique instruments, lately discovered by the workmen in the old washes of this and the next parish, prove that the Romans made Flint their port for exporting the metal. It should be remembered that, in early days of mining (up to the year 1730 in Derbyshire ‡) the ore was smelted in trenches cut in the brows

* A list of these pigs is given in *The Geology of the Coasts adjoining Rhyl, &c.* (Geol. Survey Memoir), 1885, p. 46.

† *Tours in Wales* (1810), vol. 1, pp. 71, 72.

‡ *Geology of North Derbyshire* (Geol. Survey Memoir), 2nd Ed. 1887, p. 121.

of hills exposed to the prevalent wind. The object in bringing it to such a neighbourhood as that of Flint may have been to gain access to streams for the purpose of washing it.

*The Veins.**

The ores of lead and zinc occur in the Chert Beds (Millstone Grit), and the upper and middle beds of the Carboniferous Limestone; while hæmatite has been found only in the lower beds of the limestone. The veins divide themselves into two distinct sets, namely, those running east and west (varying to south-east and north-west), which are usually termed "veins," and those running north and south or nearly so, which are known as "cross-courses." The veins differ from the cross-courses in their contents, as well as in direction. They contain blende and galena, the latter with a proportion of silver ranging up to 14 oz. or very rarely up to 18 oz. per ton. The cross-courses, on the other hand, contain no blende, and are poorer in silver, but frequently show copper-pyrites in small specks or needles. The "spars" also in the two sets can be distinguished by the miners; those of the east and west veins being often largely made up of silica associated with crystalline carbonate of lime in a form known as "tuft,"† while the cross-courses generally contain yellow clay, in which large masses of calc-spar and galena lie imbedded. The cross-courses, which are often empty or in communication with large empty caverns, seem to form the principal underground water-channels; they are usually considered to be of later date than the east and west veins, and, as will be seen in the following pages, sometimes shift them, or even entirely cut them off. A glance at the map will show that the cross-courses run nearly along the strike of the beds, while the east and west veins traverse the outcrops nearly at right angles, displacing them and giving rise to a small transverse hollow (or *pant*) in the successive escarpments. This contrast in the relations of the veins and cross-courses to the rocks they traverse may have caused the difference in their contents.

A large quantity of galena has been raised from a third form of cavity called by the miners "flats." Many of the flats seem to correspond rather with pipe-veins than with the flats, as known in Derbyshire. In those which were accessible at the time of the re-survey, the ore lay as a "bed" (in contradistinction to a vertical rib) in a mass of calc-spar which filled caverns in the limestone widened out along the line of a north and south joint or crack.

In another form of "flat" the pipe or "run" containing the ore follows the junction of a band of limestone and sandstone, from which circumstance the calcareous sandstone series of the neighbourhood of Mold have acquired the name of the "flat-measures" among the miners. Sometimes, as in the Jamaica Mine, the lime-

* The veins are indicated on the published one-inch map, but from want of space neither their names nor the shafts upon them are marked. Upon the manuscript copies of the six-inch maps, which are deposited in the Geological Survey Office for reference, and for copying, if desired, this information is all given.

† More especially in the neighbourhood of the Chert Beds, where the North Flintshire veins are usually richest.

stone has perished altogether to a depth of many yards, and its place has been taken by sand, clay, and disintegrated sandstone, containing masses or "beds" of galena. Flats, whether in limestone or in the calcareous sandstones, owe their existence more commonly to the action of underground water in hollowing out channels than to veins; they follow no known fault, but run down the dip-slope of the strata, probably keeping to the most soluble limestone. While yielding a considerably larger quantity of ore from a given space, they prove to be of less lasting value than the east and west veins.

Gravel-ore is a name applied by the miners to the loose lumps of galena which occur in the soil or in the Glacial Deposits along the "back" of a vein. In the Talargoch Mine a great quantity of ore occurred in this form,* and in the present Quarter-sheet the course of several of the veins, and especially the outcrops of the flats, are marked by clusters of small mine-hillocks.

The most productive zone in the north of Flintshire lies immediately below the thick impervious shales of the Lower Coal-Measures, to which we have given the name of Holywell Shales. In such plastic rocks as shales the veins either vanish or appear only as thin lines of calc-spar, but in the hard rocks beneath, whether chert or limestone, widen out so as to afford space for an abundance of vein-deposits. Generally speaking the line of a fault or vein is marked in the chert by a number of irregular cracks, forming a belt of fissured rock, rather than by a single clean-cut fissure. In limestone, on the other hand, the principal line of fault, though accompanied by more or less parallel strings or fliers, is usually well-defined. The deposition of the ore seems to have been governed not only by the Holywell Shales, but even by the thin bands of shale which occur in the upper part of the limestone; for though in the northern part of the county the ores have generally clustered most thickly under the Holywell Shales, yet in several instances veins, not rich in other parts, have yielded ore immediately below thin bands of shale in the limestone, a notable example being that of the Waen Mine, described on pp. 167, 168.

We have already seen that the Chert Beds keep their character as such only as far as Halkin Mountain, and that south of that region they pass gradually into sandstones, in which chert occurs as a subordinate band. The veins cease to be so prolific in this form of the Millstone Grit, but at the same time the massive limestones, which form the central part of the Carboniferous Limestone, acquire additional richness. Thus the principal body of ore in the Cat Hole and neighbouring veins followed the massive limestones whose outcrop forms the hill of Cefn Mawr, while comparatively small deposits only occurred in the Millstone Grit (Plate III.).

These remarks apply chiefly to the east and west veins, all of which cut across the outcrops of the various rocks, passing in some cases from the area of the Upper Silurian Rocks into that of the Coal-Measures. Acting as channels for the passage of underground drainage, such veins must have carried water derived

* Geology of the Coasts adjoining Rhyl, &c. (Geol. Survey Memoir), p. 47. 1885.

from a variety of rocks, and during a succession of geological epochs, if we may assume that they are, like the great Bala Fault, of pre-Triassic age. During this length of time the limestone, amongst the other rocks, has undergone vast denudation, and, owing to its solubility, has contributed the larger share of the mineral contents of the underground water. Hence our failure to detect lead in a small fragment of limestone does not prove that there may not have been sufficient in the great mass that has vanished to have supplied the ores of the veins.

The influence of the shales on the distribution of the ores seems to have been partly due to their having acted as water-tight blankets, checking the flow of underground water, which must have been eastwards ever since the rocks acquired their present easterly dip. But the precipitation also of the ores of lead and zinc was probably directly due to the giving off of sulphuretted hydrogen during the decomposition of pyrites in the shales. The smallest trace of any salt of lead or zinc in solution would be arrested on coming into the presence of this gas.

Table showing the Direction and Character of the Lead Ore of some of the Flintshire Veins.

	General Direction.	Per-centage of Metallic Lead.*	Silver to the Ton.*
Bodidris - - - -	E. 30° S.	78	oz. dwt. 5 12
Bryn-celyn - - - -	E. 18° N.	77-80	5 12
Bryn-gwiog - - - -	E. 5° S.	77	6 12
Cat Hole - - - -	E. 15° S.	77	5 12
Ciwt Militia - - - -	E.	80	8 0 to 12
Denbigh Consolidated - - - -	E. 37° S.	80	5 4
Fron Fawnog - - - -	E. 25° N.	77-80	5 4
Fron-hauog - - - -	—	81	Nil.
Garreg-boeth - - - -	E. 17° N.	80	5 12
Gladstone - - - -	E. 25° S.	77-79	6 0 to 8
Gorsedd and Merllyn - - - -	E.	81	11 0 to 12
Gwern-y-mynydd - - - -	E.	77-79	5 4
Hendre, Old - - - -	E. 10° N.	77-79	8 0 to 10
Hendre, North - - - -	N.	77	5 12
Holloway - - - -	E. & E. 10° S.	82	16 0 to 18
Jamaica - - - -	?	77-79	5 4
Maes-y-safn - - - -	E. 13° S.	80	4 12
Maes-y-safn, East - - - -	E. (?)	79	5 4
Merllyn - - - -	E.	77-79	6 0 to 8
Mwyn-bwlh - - - -	E. 12° N.	77	5 4
Pant-du - - - -	E. 30° S.	80	5 4
Pant-y-buarth - - - -	E. 8° N.	77-80	5 4
Pant-y-gôf - - - -	E. 25° N.	77-80	5 4
Pant-y-gwlanod - - - -	E. 35° S.	78	5 12
Pant-y-mwyn - - - -	E. 20° N.	81	5 12
Parry's - - - -	N.	80-82	4 8
Pen-yr-Henblas - - - -	E.	80	4 4
Rhosesmor - - - -	E. 30° N.	75-80	10 0 to 13
Rhyd Alyn - - - -	E.	81	7 12
South Prince Patrick - - - -	N.	80	5 12

* These figures were supplied by Mr. D. C. Davies.

LEAD AND ZINC MINES.

(1.) Holywell.

The Old Holloway and adjoining Veins.

The principal vein worked in this mine lies a few yards north of the boundary of this Quarter-sheet, but as it forms the northernmost of the long series of lead-veins of Halkin Mountain will be described here in that connection more suitably than in a separate volume. It runs nearly due east and west, curving slightly southwards towards its east end at Holywell. It has been worked from near Holywell continuously to Pant, where it is broken across and shifted by the Pantasa Fault (described on p. 63); and from Pant to Pant Wacco, where it again is temporarily lost in faulted ground. It seems to reappear west of Pant Wacco in a vein known as the Boutflour, and is believed to run on through Coed Pen-y-gelli past Ffyddion; the total distance proved (including the Boutflour Vein) being nearly $2\frac{3}{4}$ miles. The vein throws the strata down to the north (Fig. 3, p. 23), and forms a conspicuous feature, especially towards Holloway, where it brings Lower Coal-Measure Shales in its north or "hanging" side against the limestone and Chert Beds of Coed Saith-aelwyd, which form its south side, or "foot-wall."

The vein is drained by a level which opens into the Holywell valley about 100 yards north-west of St. Winifred's Well, at a height of about 230 feet above the sea. The level was used for many years as a canal for the conveyance of ore from the mine in barges, and is still known as the boat-level. Pennant describes it as follows:—

"The Holywell level was begun in 1774 . . . I and my two sons made the voyage of this important venture on September the 21st, 1795, and took boat, or rather punt, at the entrance into the work in Coed Cae Dentir. . . . We entered the mouth lighted by candles, stuck in each side of our vessel. The first 40 yards of our way was arched with stone, and so low as to oblige us to stoop. When the arch ceased, the roof was the natural rock, of that species called *shale*. The height begins now to be six feet; the breadth four; the depth of the water, included in the height, is two and a half. After passing in the shaley stratum about 226 yards, we find it is succeeded by that of *chert*, at which spot the level enters my ground, in the field called Coed Cae porfa. There the height to the surface is 18 yards. Several shafts have been sunk for air between this place and the mouth of the level. In a field of mine, called Cadlas hir, was early discovered, at the depth of 31 yards, a strong string of ore, which raised the hopes of the adventurers in the highest degree; and the mineral stock rose in proportion. But alas! in a little time, both spirits and stock fell; for the promising prospect suddenly vanished, an accident too frequent with miners to occasion surprise. The Chert continues to a little beyond the turn-pike road, when we again enter the land of Sir Pyers Mostyn, in a field called Brocknallt, where it stops. Hitherto the level has preserved a strait course: but in this field (where the limestone

stratum begins and is continued to the end of the present workings, above 500 yards) it takes a bend parallel to the road, and so continues so far as Brocnaillt-pella, and then makes another curvature, and near a small but pretty cave crosses obliquely the turn-pike road. . . . Out of this cave is a passage, or sump, or short shaft, sunk for the purpose of both searching for ore, and also for conveying of air, which began to be wanted, into the level. This sump communicates with several others, till it reaches a shaft. . . . In proceeding further we were alarmed with the awful sound of a cataract. On arriving at the spot from whence it issued, the noise seemed to have derived its greatest force from the confined arch of the level; for we discovered it to proceed from a small but elegant cascade, which, in our sight, tumbled down a small hollow, and served to augment the water of the level, which was also increased by several strong springs rising from the sides and bottom with strong ebullitions. Similar noises are said to have been heard in Caetiau' r Odyn. It is possible that this subterraneous water may be one of the feeds of St. Winefride's well, as the field is nearly in a descending line with it. I have also heard, on good authority, of another large stream of water running through a great subterraneous cavern, in working Port-away mine, in Pantasa, in the parish of Whiteford, but its discharge has never been discovered. But to return. After passing this fall, we reached the end of our voyage, at the length of 1,167 yards from the mouth, and at the place where two miners were pursuing the working of the level, and had got within ten yards of the shaft in which the miners are working in the rich vein, beneath the field called Coed Cæ Plwm, or the wood or field of lead. The height from the sole of the level to the surface at this place is ninety-three yards and a half."*

The shaft alluded to is the Old Whimsey Shaft, 260 yards east of Holloway House. In 1879 the level ended at a point in the vein 500 yards west of this shaft, or at a total distance of 1,667 yards from the mouth. The Holloway Vein bifurcates at Bron Holloway, the northern branch or Brammock's Vein running due east, towards the mouth of the boat-level, while the southern branch, or the Old Holloway Vein, ranges rather south of east, towards the row of houses called Brocnaillt. The easternmost shaft on the Old Holloway Vein is the Garden Shaft, which lies on the north side of the high road 220 yards west of Brocnaillt. The level was driven to intersect the Old Vein, and reaches it a few yards west of the Garden Shaft, a branch being driven northwards to Brammock's Shaft to drain Brammock's Vein. From near the same point a branch-adit was driven south-eastwards towards the Halfway House to unwater some north and south cross-courses. From the Garden Shaft the level runs in the vein to the point named above west of Holloway House, sending off a branch to the north from the Old Whimsey Shaft to Eyton's Shaft.

The western workings on the Old Holloway Vein are drained by the Gorsedd level, which starts at Tre-Eden-Owen, at a height of about 400 feet above the sea, runs under the road at the Merllyn

* The History of the Parishes of Whiteford and Holywell, 1796, p. 249.

and Gorsedd Mine, near Waen, to the Coetia Eithin shaft 160 yards north-east of the Druid Inn. Thence it runs in the Old Holloway Vein eastwards to near Pant, and westwards for an unknown distance.

The Old Holloway Vein and Brammock's Vein in their course eastwards pass obliquely from the outcrop of the Chert under that of the Lower Coal-Measures, and the working in them has been stopped only by the increasing depth to the chert and limestone below in that direction. Brammock's Vein is reported to have proved very rich; it is a double vein, the two parts being 17 yards apart, but getting closer together downwards. Roskell's Shaft, which was sunk with the anticipation of catching the two as one vein at a depth of 150 yards, penetrated bastard-chert and shale to a depth of 80 yards, but was then abandoned in favour of the Partridge Shaft on the newly discovered Partridge Vein.*

Near the Old Whimsey Shaft a double vein branches out from the Old Holloway Vein towards the north-east, known in its two parts as the Old Whimsey Vein and the Miller's Vein. At Holloway House a branch having nearly the same direction leaves the main road and runs under Holloway Farm under the name of the Partridge Vein, but splits up into strings after passing the Pant-y-nef Cross-course.

This cross-course forms the strongest of several which run down from Pen-y-ball northwards, and the old shaft-hillocks on which form conspicuous objects as seen from Holywell or Greenfield. Taken in order from east to west, they are named as follows. The Coetia'r Odyn ranges from Yr Odyn to the Halfway House, south of which it joins the Maes Whitford, and runs on to near Brynford, under the name of Sir Edward's lode; it points for the mouth of the boat-level, the Maes Whitford ranging towards Roskell's Shaft. The True Blue Cross-course ranges from near Pen-y-ball Farm to the Garden Shaft. The Coetia Ball, Picton, or Gyrr Fawr Cross-course runs from near Brou Holloway due south to join the Coetia'r Odyn, near Brynford. The Flingallt and Speedwell range through Brou Holloway, and the Old Pant-y-nef, which has been worked for some miles southwards, crosses the Old Holloway Vein about 50 yards east of the Old Whimsey Shaft, and runs on northwards to Eyton's Shaft; while lastly the New Pant-y-nef Cross-course, lying on the east side of the Grange, and about 50 yards west of the Old Pant-y-nef, passes through the Black Limestone quarry to the Clwt Militia. The Old and New Pant-y-nef Cross-courses each throw the strata down to the west, the former bringing Black Limestone against white in a quarry near Coetia Butler, while both are seen in quarries in the Black Limestone near the Grange. Besides the cross-courses mentioned above several smaller strings have been all more or less superficially explored along the north and west slopes of Pen-y-ball Common.

Continuing westwards we find the Portaway Lode close to the western side of the Grange Quarry, the West Holloway or Golch Hill running nearly through Creclas and under Saith-aelwyd Cottage, the Hopewell on the eastern side and the Lord Hill joint on

* This information was supplied by the late Mr. Roskell of Stockyn.

the western side of Mwdwl Eithin, the last-named running about 200 yards west of Naid-y-march.

The cross-courses enumerated above would, if prolonged, join towards the south near Pen-y-ffordd. As a fact, however, most of them die away, the Old Pant-y-nef alone keeping its course. The New Pant-y-nef has been traced to near Ffrith, 600 yards east-north-east of Calcoed Hall. The deposit of ore would probably have been rich had these lodes converged towards the north, where the chert passes beneath the shales.

A few of them were recognised in the working of the Old Holloway Vein. Pennant saw the Maes Whitford, True Blue, and Brocknallt (? Coetia Ball) Cross-courses in the day-level, and a cross-course hading east, 20 yards east of the Little Engine Shaft, is said to shift Brammock's Vein 6 feet southwards on its east side.

The True Blue Lode, according to the late Mr. Roskell, appeared in both walls of the Holloway vein, and brought in water from both the northern and southern sides, that from the northern or Coal-Measure area being a "Harrogafe water," that from the southern or limestone-area being ochry and depositing oxide of iron.* The Gyrn fawr, which seems to be the Coetia Ball lode (and perhaps the Brocnallt cross-course of Pennant), was also described as a strong joint. The Old Pant-y-nef Cross-course was struck in Eyton's Shaft at a depth 68 yards, the total depth of the shaft being 120 yards. The cross-course runs nearly due north to the shaft, but then bends a little to the east, and ranges towards Stockyn Hall. The branch of the day-level to this shaft was driven through shale, but near the shaft entered the top beds of the chert, the beds rising slightly northwards, as is shown by the exposure of chert a few yards west of the shaft. The Partridge Shaft was sunk nearly on the intersection of the Old Pant-y-nef and the Partridge Vein, which however splits up into strings on the eastern side of the cross-course.

In 1879 strings connected with the Old Holloway Vein were being worked from a shaft by the north side of the road at Saith-aelwyd. The vein itself had been cleaned out by the "Old Men," the size of the caverns so made testifying to the amount of ore that had been raised. The rock was hard white limestone, dipping at 10°-14° to the N.N.E., and partly silicified in the wall of the vein, so as to strike fire, while the vein-stuff, down to a depth of 40 yards, was principally made up of silica, but below that depth of white calc-spar. The strings which were then yielding ore, ran nearly vertically downwards, so as to intersect the hanging wall of the Old Holloway Vein. This part of the Old Vein had been rich in calamine, and haded at an unusually low angle.

The West Holloway Mining Company sank a whim-shaft to a depth of 120 yards on the Golch Hill Cross-course at a point 180 yards south-south-east of Saith-aelwyd Cottage (under which the cross-course runs), and worked at this depth along the lode northwards into the Old Holloway Vein, along which they explored

* The spring flowing into the Old Holloway Vein from the New Pant-y-nef Cross-course was known as the "Big Duke," that from the Old Pant-y-nef as the "Little Duke." These and other springs flowing from north and south joints into the day-level were drained by Eyton's Shaft.

both to the east and west. At a few yards westwards they found a joint with a little copper and lead striking out of the vein northwards. Towards the south the Golch Hill Lode, near Crecas, splits up into strings, one of which, about 70 yards to the east of the lode, is known as Allsopp's. About 260 yards to the west of the Golch Hill lies the Hopewell Lode, nearly parallel, but getting nearer to it, where it passes through the limestone-quarry on the northern side of the Milwr Vein.

The Lord Hill joint intersects the Old Holloway Vein in an old Black Limestone quarry 150 yards south-west of Celyn Farm. It runs through a limestone-quarry 230 yards east of Pant, and thence, as is supposed, across the Milwr Vein to near Naid-y-march.

Near this point the Old Holloway Vein encounters the Pantasa Fault, which was described on p. 63. The structure of the hollow, which marks the position of the fault, is imperfectly known, but the information supplied by the late underground manager of the Bog Celyn Mine (given on that page), shows how completely both the vein and the rocks are disordered. West of the hollow, the vein is shifted about 150 yards to the south of the point where it was lost in the Bog Celyn Mine, and runs under Penffordd-bedw and the Druid Inn, and along the northern side of the high road to Pant Wacco. The Coetia Eithin Shaft (150 yards north-east of the Druid Inn) was sunk to a depth of 80 yards, and was drained into the day-level which terminates at Tre-Eden-Owen. The Old Holloway Vein here is shifted about 7 yards northwards on the western side of a small cross-course. The vein has attracted less attention of late years in this part than one running nearly parallel to it, but from 200-300 yards further north, and known as the Gorsedd or Merllyn Vein.

The Merllyn Vein has been worked as far west as the Lloc Baptist Chapel, but the shaft was flooded about 1854. Eastwards it was followed across the Pant Wacco Fault, and some other cross-courses under the buildings of Merllyn to the Lady Fielding Shaft of the Lloc Mining Company, 100 yards east of that farm. The vein was worked to a depth of 60 or 70 yards, but a quantity of ore, reputed to be of the value of 150,000*l.*, was raised from a depth of about 20 yards only in 1850. In 1857, though some ore had been found in the Merllyn Shaft further west, the mine was almost at a standstill.

Near Merllyn Farm the vein seems to divide, one branch, the Gorsedd Lode, having been worked on the southern side of the high road, while the other, or the Merllyn Lode, ranges towards Waen, but was lost a few yards east of Merllyn. This latter branch had been crossed in the Gorsedd day-level, which, happening at that point to traverse a bed of shale 2 feet thick, showed the vein as well defined, but containing only a thin leader of spar. The level was re-opened about 1878; at 300 yards from its mouth at Tre-Eden-Owen the roof had fallen in, and a new adit was driven round the broken ground for a distance of 60 yards. In this part the level traversed shale with a thin seam of coal, but southwards passed directly into Black Limestone, the Chert Beds having been cut out, as it is supposed, by a fault. At Waen the Merllyn Lode

crossed the level in a bed of shale, as above mentioned, but when followed down below the shale into the limestone, developed into a good vein, the ore of which contained from 11 to 12 oz. of silver per ton. The Waen Shaft, 100 yards south of Waen, was sunk to a depth of 90 yards, and intersected the Merilyn Vein at 70 yards. The vein fades to the north, and a few yards west of the shaft is crossed by a joint bearing north-north-west, by which it is thrown down a few feet to the west (the apparent effect being a shift of the vein 7 yards southwards on the western side of the joint in each level). A second joint, 25 yards further west, shifts the vein still further, so far as could be seen in 1879. These joints run a few yards west of the Gorsedd Black Limestone Quarry. East of the shaft the Merilyn Vein seems to be more regular than towards the west. The Gorsedd Vein, in the workings on the south side of the high road, was also shifted by a fault ranging north-north-west, but with a downthrow east. The shift of the vein was therefore southwards on the *eastern* side of the fault. The Waen Shaft was sunk through the following strata :—

Clay, gravel, and sand (Glacial deposits)	FEET.
Black limestone (used for hydraulic cement)	- 45
Greyish-brown and hard grey limestone	- 57
	- 168
	<hr style="width: 100%; border: 0.5px solid black;"/>
	270

The Milwr and adjoining Veins.

This great vein ranges about E. 20° S. from Pant Wacco, where it meets the Old Holloway Vein and the Pant Wacco Fault, to Milwr, about one mile south of Holywell, a total distance of about 3½ miles. The vein throws the strata down many yards on its south side, so as to bring in the Black Limestone, and a small patch of Chert Beds, on the southern side of the White Limestone of Pen-y-ball (Fig. 3, p. 23). All along this part of its course the white limestone forms a pronounced feature on the upthrow side of the fault, dominating the lower ground formed by the comparatively soft Black Limestone; but where the vein passes eastwards into the area occupied by shales, the higher ground lies on its southern or downthrow side.

The richest deposit of ore occurred in the eastern end of the Milwr Vein and in a number of associated strings and joints in the Chert Beds, under the Lower Coal-Measure Shales, but the earliest workings in the vein lay further west in the limestone. They extend nearly continuously as far as Pantasa, and thence at intervals to Pant Wacco.

The Milwr Mine was situated on the eastern end of the Milwr Vein and the associated strings, and was worked as far eastwards as the increasing thickness of shale over the chert would allow. The mine was drained into a day-level, which opens in the southern bank of the Nant-hil-brwc, 600 yards south-east of the Workhouse, and runs thence by Milwr Farm, under Derwen-bach and Derwen-fawr, to Hwylfa-fer. The level was commenced, according to Pennant, in 1754, with the object of draining the "hard shaft" vein

(Herward Vein).* Another day-level runs 70 yards east of Brynford Hall, under the high-road 250 yards south-east of the Workhouse, and opens into Nant-hil-brwc.

The veins worked in this and the adjoining mines will be taken in order from north to south. The Milwr Vein (the Old, or Pant Ithel Vein of Pennant), runs 80 yards south of Pen-y-bryn, 50 yards north of Brynford Hall, and across the high-road at a point 100 yards north-east of Milwr Farm; where last seen (100 yards east of the road) it underlay to the south at 2 in 3, and ranged towards a point about 100 yards south of Cefn Farm. From 50 to 80 yards south of the Milwr runs a joint known as Woodlands (or Ellis') Vein. The Meadow Shaft between the two passed through 40 yards of shale before reaching the chert. The next vein to the south (sometimes called the Beili-gwyn) runs 120 yards south of Brynford Hall, and nearly under Milwr Farm, ranging thence, parallel with the Milwr Vein, towards Pwll-melyn Cottage. It is nearly vertical at the Milwr Farm Engine Shaft, from which it was reached by a cross-cut of 4 yards; a level driven thence eastwards along it at 140 yards depth enters Lower Coal-Measure Shale in about 500 yards, the shale, which contains a thin seam of coal, dipping at a steep angle to the north-east. The Clawddffordd or Cornel-pylle joint runs from Milwr Farm towards the south-south-west, and therefore at an angle with those described above. A shaft upon it by the side of the upper road reached a depth of 120 yards, and Simmond's Shaft, 300 yards further west, of 116 yards. Davies' Vein runs nearly parallel to the Milwr along the northern margin of Pen-y-pylle Common, and falls nearly into a line with the Old Hwylfa Vein; the last-named was worked from a shaft 140 yards deep and situated 150 yards north-east of Pen-y-pylle. The America Vein (the Rost-y-Cegin Vein of Pennant) is nearly parallel to the Old Hwylfa, and runs under Pen-y-pylle House. The Old Herward Vein crosses the upper road 70 yards south of the America Vein, and runs parallel to the Milwr Vein. It is joined at the Herward Mine by the Herward Vein, which runs nearly east and west, with an underlie to the south. The Herward Shaft, near the point of intersection, was sunk to 224 yards depth, and a cross-cut 40 yards in length driven from it to the Herward Vein at 112 yards depth, and another of 48 yards in length at 140 yards depth. The Hard Shaft on the western side of the upper road is 15 yards distant from the 47-yard level in the Herward Vein.

The Old Milwr Engine-shaft, according to an old miner, passed through the following strata:—

	FEET.
Shale [Lower Coal-Measures] about	45
Chert	120
Bastard limestone [Black Limestone]	100
White limestone	-

All the veins enumerated above underlie to the south, except the Beili-gwyn and the cross-vein known as the Cornel-pylle.

* History of Holywell Parish, 1796, pp. 254, 255.

They seem to have been worked out in the Chert, as far under the Lower Coal-Measures as they could be followed, but two only have been detected in the limestone west of the chert-outcrop, namely, the Milwr Vein, and the Beili-gwyn which was worked as far as Brynford Hall.

The Milwr Vein in its course westwards passes a number of north and south cross-courses, besides those which have been enumerated in describing the Old Holloway Vein. Commencing at the eastern end of the vein, we find some joints running north and south on the western side of Pen-y-bryn, and 200 yards east of Coetia-mawr, we pass the Caleb Bell Cross-course,* which is popularly believed to run the whole length of the county. This cross-course has been worked across the limestone-hill of Pen-y-bryn, and seems to have been the site of the Pen-y-bryn Mine referred to by Pennant as having been "remarkable for the quantity of refracting spar, *spatum Islandicum*, of great purity and transparency; and often elegantly infected with marcasite finely disposed in lines,"† a spar which is common in the cross-courses on parts of Halkin Mountain. The cross-course then traverses Coed-y-fron and ranges nearly due north under the Red Lion in Holywell towards St. Winifred's Spring, of which it is supposed to be the principal feeder. The most northerly shaft upon it lies at the northern margin of Coed-y-fron, and was sunk to a depth of 87 yards, the workings extending to within 21 yards of the level of the spring without finding water. South of the Milwr Vein it has not been worked for about 500 yards.

The next cross-course, known as the Bryniau, lies 200 yards west of Coetia-mawr. It runs from near Ffrith, where it was worked in the Valentine Mine, near the Capel Saron, Brynford, through the Ashton Mine, to some shafts in the Chert Beds 100 yards east of Halfway House. The Pedol Aur Shaft, 200 yards west of Coetia-mawr, was sunk on this cross-course to a depth of 105 yards. The Sir Edward Lode, already mentioned on p. 165, crosses the Milwr Vein 400 yards north-west of Coetia-mawr, and has been worked southwards for about 700 yards. The Frame Shaft, 120 yards south of the Milwr Vein, was sunk on it to a depth of about 100 yards. Near Brynford the Coetia Ball branches out from the Sir Edward Lode, crosses the Milwr Vein close to Smithy Gate, runs through the Picton Mine (180 yards deep), and thence down to Holloway (p. 165). In the Picton Mine a cavern full of water was cut into with so little warning that the miners barely escaped with their lives. The water disappeared in a short time, but St. Winifred's Spring was temporarily discoloured. The Coetia Ball is described as a double lode, No. 1 lode lying to the east, and No. 2 to the west, the two running together a few yards south of the Pant-y-rhedyn Shaft. This shaft, which lies 120 yards south of Smithy Gate, intersects the Beili-gwyn (or Clwt Militia) Vein at 60 yards depth, the vein ranging W 15° N., and hading south. At 86 yards depth, and 14 yards south of the shaft, the Coetia Ball, Nos. 1 and 2, intersect the Beili-gwyn. On the eastern side

* Frequently referred to as the Galop, or Galopell Cross-course.

† History of Holywell Parish, 1796, p. 254.

of the Coetia Ball lodes the Beili-gwyn, if correctly identified, is shifted 15 yards southwards, but the true continuation of the vein is probably yet to be found, for the Coetia Ball fades to the east, and should therefore shift the vein northwards. In the 106-yard level also the Coetia Ball Lode cuts off the Beili-gwyn Vein, but seems itself also to make a slight shift of 2 yards at the intersection. The Milwr Vein, ranging E. 35° S., is intersected in the 86-yard level at 86 yards distance from the shaft, and in the 106-yard level at 70 yards distance, the southerly slope of the vein therefore amounting to 4 in 5, an unusually low hade. The Coetia Ball at its junction with the Milwr Vein ranges N. 20° W. A supposed continuation of the Beili-gwyn Vein runs through the Pedol Aur Shaft at 70 yards, but underlies north. The water rises in the winter in the Pant-y-rhedyn Shaft to the 106-yard level, that is, about 200 feet above St. Winifred's Spring, but quickly runs off in dry weather, while in the Picton Mine the water is said to stand at about 540 feet below the surface, or only 30 feet above St. Winifred's Well. The 20-yard level in the Pant-y-rhedyn Shaft runs in Black Limestone dipping south-east. The vein-stuff in the Beili-gwyn and Milwr Veins consists principally of white sand and spar, a decomposed siliceous deposit; that in the north and south lodes of clay with lumps of calc-spar.

We now reach the Old Pant-y-nef Cross-course, which runs from Eyton's Shaft (p. 165) through the Milwr Vein at Coetia Butler, between the two Black Limestone quarries at Clwt Militia, 100 yards east of Ffrith, and so southwards. The cross-course throws the strata down a few feet to the west, and thus introduces a small patch of Black Limestone on the northern side of the Milwr Vein. The Milwr Vein runs on the southern side of a quarry in this patch, the Old Pant-y-nef lying on the eastern side, and a branch from the Milwr Vein, known as the Smith's Bellows Lode, on the northern side of the quarry.

Between this quarry and those at Clwt Militia, two east and west veins are termed the Seven Stars and the Clwt Militia.* The latter was worked up to the New Pant-y-nef, and there lost. It crosses the Old Pant-y-nef, but is shifted by it 3 yards southwards on the eastern side of the cross-course, as might have been expected from the fact that it underlies south, at an angle of about 40° from the vertical. In the upper part of the mine the vein throws the Black Limestone on the southern or downthrow side against white limestone in the northern side, and contains cherty vein-stuff in the upper part, but calc-spar at a greater depth. The Engine Shaft on the Clwt Militia Vein is 80 yards deep, and ends 4 yards south of the vein; an engine-shaft on the Old Pant-y-nef, now disused, passes 20 yards north of the Clwt Militia Vein at 80 yards depth. The richest parts of the vein lay at 40-60 yards depth, and especially under a bed of shale, about a foot thick, in the limestone; it was noticed also that the vein was rich where it was joined by "feeders," or vertical joints, some of which descended from the hading or foot-wall, while others ascended from the hang-

* The information regarding these veins was supplied by Capt. Davies, of the Clwt Militia Mine.

ing wall, but in neither case carried ore at any distance from the vein. The average yield of silver to the ton of lead was 10 ounces in this mine. Another vein known as the Beili-gwyn runs a few yards north of the Clwt Militia. The Seven Stars was also cut off by the New Pant-y-nef Cross-course, but is said to pass the Old Pant-y-nef, with a shift, however, similar to that undergone by the Clwt Militia. The New Pant-y-nef runs from near Ffrith between the Clwt Militia Office and the Engine Shaft of that mine, across the Milwr Vein 40 yards west of the Black Limestone Quarry previously alluded to, and thence to Holloway (p. 165); it has been worked in a shaft near the top of Pen-y-ball to a depth of 120 yards.

The Milwr Vein so far has had Black Limestone on its hanging or downthrow side, but in the angle made by this vein and the supposed Lord Hill Cross-course some shafts have been sunk in chert and shales with nodules of ironstone, an outlier apparently of Millstone Grit and Lower Coal-Measures. The Gladstone Mine, a few yards south of the Crecas white limestone quarry, reached the Milwr Vein, here rich in calamine, at 52 yards depth, and the Cambria Mine, 140 yards further west, at 85 yards, both mines being 120 yards deep. The Hopewell and the Golch Hill lodes are supposed to pass through these mines, and to range towards the Clwt Militia Office. The Milwr Vein then runs under the northern side of the Pantasa Monastery, passing the St. David's Mine, which is 80 yards deep. Three hundred yards west of the monastery it is crossed by the Pantasa Fault (p. 63), and seems then to divide into two or more parallel veins, one of which keeps its course straight for Pant Wacco, and has proved rich in calamine, while another runs further south, forming the northern boundary of the Black Limestone of Bryn-y-gaseg, and a third branches off at that spot to the Wacco Mine. At Pant Wacco the Milwr Vein runs into the Pant Wacco Fault, nearly at the same point as the Old Holloway Vein, and ceases to be recognisable.

(2.) Halkin Mountain.

Of the number of cross-courses which meet near Brynford, the Old Pant-y-nef alone runs on further south. It has been worked at Pen-y-ffordd in the Hazel Grove Mine, the shaft of which was 70 yards deep, and from which a cross-cut was driven westwards to within a few yards of the range of the New Pant-y-nef, before the mine ceased working through litigation. Thence the Old Pant-y-nef has been proved as far southwards as Berthen Farm, a distance of $3\frac{1}{4}$ miles from Eyton's Shaft. In a field near Gelli Fowler, where the cross-course intersects an east and west vein, two men are reported to have raised ore to the value of 40,000*l.* in a few years. Near Plâs-Captain the cross-course follows the crest of a small anticline in the limestone.

The few mines lying to the west of the Old Pant-y-nef call for no particular notice. A small vein running nearly north-east has been tried near Foel-dda, and another having the same direction on the old Race-Course. At Bryn-cloddiau some ore was raised from a small depth about the year 1810, but no regular vein was

ever found. The Gors Mine, a quarter of a mile further south, was started with the object of finding the Pant-y-pydwew Vein, but no vein has been met with. The Plasau Mine (1 mile east of Ysceifog) was worked about 1840, on a vein running nearly north-east, and a shaft was sunk 40 yards vertically to it and 20 yards further slanting down it, the vein hading south at the rate of 1 in 3. Three levels, at 30, 40, and 60 yards depth, were driven in it westward for a few yards. A shaft further east was commenced by chance on a swallow-hole, which had merely to be cleared out to serve the required purpose. Water stands at the 40-yards level in the winter. The Tyddyn Shepherd Mine lies on a vein running about east-north-east.

On the eastern side of the Old Pant-y-nef, and between it and the Caleb Bell Cross-course, we find the Pant-y-pydwew Vein, the Silver Rake, the Thorntree, and the Wagstaff Veins. The Pant-y-pydwew Vein runs from near Pen-yr-hwylfa nearly due west across the Caleb Bell Cross-course, hading, and throwing the strata down, to the south. Its course is marked by many shafts, one of which, the Pulley Shaft, lies just west of the Black Limestone outcrop, and another, the Engine Shaft, 120 yards west of the Caleb Bell. They intersected the vein at 60 yards depth, and encountered water at about this level, that is, about 410 feet above St. Winifred's Spring. A sump was sunk in the vein for about 30 yards below the Engine Shaft, the vein hading south at 2 in 3. In the field north of the shaft the course of a flat, in which ore was imbedded in blue clay, is marked by a line of hillocks. The Silver Rake is mentioned by Pennant, as having yielded a green lead-ore. "Only a small quantity was found, which yielded about thirteen hundred and a quarter from a ton of the ore. It was of a very stubborn quality, and resisted the greatest powers of the blast furnace before it would yield any metal."* The ore referred to may have been Anglesite (sulphate of lead).

The Silver Rake has been worked opencast from the Caleb Bell westwards for about 300 yards. It has never been proved to run through that cross-course, but a vein having about the same direction was worked 250 yards east of it in the North Prince Patrick Mine, with, however, a different spar from that of the Silver Rake, which is a clear amber colour. The Silver Rake Shaft is 60 yards deep, and the water stands at about 40 yards depth. The Llwyn-y-cosyn Vein runs parallel to the Silver Rake, but further west, and 100 yards south of it. The mine of that name was worked in 1877 to a depth of 65 yards and a cross-cut driven northwards at 40 yards depth in an ineffectual search for the Silver Rake. The course of the Thorntree Vein is marked by a few shallow workings from the Caleb Bell for about 600 yards westwards. A shaft 150 yards west of the cross-course was sunk 60 yards, and a cross-cut of 20 yards driven from it to the Thorntree. The Wagstaff Vein crosses the old Pant-y-nef at Plas-Captain, and is shifted by it a few yards northwards on the eastern side; it has been followed for about 750 yards, but not up to the Caleb Bell Cross-course.

* Tours in Wales, vol. 2, p. 68. 1810.

The Caleb Bell Cross-course, which we have already traced as far south as the Milwr Vein, can be followed without difficulty through the ground just described. Near Brynford it is accompanied by a string known as the Cornel-llwyd, which has yielded some ore; thence it runs 120 yards east of the Pant-y-pydw Engine Shaft, and carries off the water from that mine. The water is popularly supposed to issue at St. Winifred's Well, but some chemical preparation poured into the Pant-y-pydw swallow-holes to test this point failed to re-appear at the spring.* The workings on the Coetia Ball Lode, however, are said to have discoloured the water. The Caleb Bell Cross-course completely divides the veins on its western from those on its eastern side, the Pant-y-pydw, and perhaps the Silver Rake, alone crossing it. From Pant-y-pydw it runs 180 yards west of Nant-y-fuwch, past Pwll-melyn, and 370 yards west of Christ Church, Rhos-y-cae, south of which point it cannot be traced.

The belt of ground between the Caleb Bell Cross-course and the Lower Coal-Measures includes the richest part of the mineral tract of Halkin Mountain. Commencing at the point where we left it, after describing the Milwr Mine, we first meet the Pen-yr-hwylfa Vein, which runs nearly north-east from Pen-yr-hwylfa to Derwen. It has been worked in and below the Chert to a depth of 80 yards at its western end, and of 110 yards at the North Henblas Mine. An engine-shaft commenced at Derwen-fawr traversed the following beds:—

	FEET.
Gravel and clay [Glacial]	15
Black shale	6
Two bands of cement-stone [black argillaceous lime-stone], and three of bastard cement-stone, separated by beds of black shale	about 15
Black bastard chert	—
	36

The shales with cement-stones (Holywell Shales) are exposed to view in the lane close by, and contain *Calamites*, *Lepidodendron*, *Posidonomya*, and *Goniatites*, like the similar beds of Nant-hil-brwc. Roskell's Day-level, which runs through the Herward Mine, passes under Derwen-fawr at a depth of about 90 yards.

The Pant-y-pydw Vein also runs past Pen-yr-hwylfa, turning to the south-east between Pen-y-Garreg and Henblas farms to the Caeau and Llongle Mines, each of which passes through Holywell Shales with cement-stones into the Chert Beds to a total depth of 120 yards. A cross-cut was driven from a point in the vein 300 yards north-west of the Caeau Engine Shaft towards the termination of Roskell's level at Hwylfa-fer, but at 30 yards above it.

The portion of the Chert-escarpment known as Pen-yr-Henblas has proved exceedingly rich in lead-ore, and has been riddled with the mining of the irregular joints and cracks into which the veins

* This mischievous experiment was made during the opposition to the Halkin Deep Level, which was considered likely to tap the supply of St. Winifred's Well.

so often split on entering the chert. There seem to have been four leading veins running about north-east, and two running nearly east and west, all hading to the north. Of the former the Garregllwyd or Hugh Pierce Vein in the north was worked on the hill from a shaft 140 yards deep; the Cross Leavings and the True Blue, a little further south, have been trenched on the surface; while the Old Henblas Vein was worked in Hooson's Shaft, and in a shaft, 160 yards deep, at the old mine-buildings on the eastern side of the hill. Mather's or Sankey's Vein runs a little south of east, 50 yards south of these buildings, and the South Vein, a little north of east, 100 yards south of the same point. In the hollow between this hill and the Caleb Bell Vein, a cross-course has been worked, in part in open trenches, under the name of Pwll-y-gaseg. It follows the township-boundary from near Pant-y-pydw to Nant-y-fuwch, where it joins the Caleb Bell. It was proved under the township-boundary in the North Prince Patrick Mine, and seemed to cut off the Silver Rake altogether, for a cross-cut driven from Bishop's Whim Shaft near by, for 200 yards along the eastern side of the Pwll-y-gaseg, failed to prove any vein.

Parry's Mine lies in a flat running north and south across the high-road 600 yards west of Halkin Hall. The shaft (now fallen in) by the road-side was 110 yards deep, and from it the flat was followed northwards for about 250 yards to a depth of 140 yards, when it was lost, the solid rock closing in on all sides. The old hillocks of this and other mines near contain crystals of transparent spar with needles of copper-pyrites embedded in them. Further east lies a nearly east and west vein, which many years ago was worked 200 yards north-west of Halkin Hall, under the name of Parry's Vein, to 125 yards depth. Grainger's Vein runs a little south of east on the northern side of the Hall.

The Pant Vein runs from the Caleb Bell Cross-course, 50 yards south of Halkin Hall, through Sir George's Field at Pentre Halkin, a distance of about $1\frac{1}{2}$ mile. Towards the west it falls nearly into a line with the Thorntree Vein, and like it hades to the south. Its course is marked as far as the Engine House of the Prince Patrick Mine (at the base of the Chert Beds) by a hollow studded with innumerable hillocks, the result of shallow workings along the "back" of the lode. From the Engine Shaft it was explored about 200 yards westwards at 120 yards depth, but was found to be heavily watered. From the same shaft a level was driven about 80 yards eastwards at a depth of 100 yards, and served to conduct the water from the Prince Patrick Mine to some swallow-holes in the Pant Lode; the vein-stuff consisted chiefly of white sand and "tuft" (a decomposed siliceous vein-deposit), while the vein haded south at about 1 in 3. Little or no ore was obtained in these workings in the Pant Lode. Sir George's Field, however, yielded a vast quantity of lead-ore, and seems to be the spot alluded to by Pennant, who says "the richest vein was discovered about fifty years ago, [about 1728] at Rowley's rake, or *Pant y Pwll dwr* on Halkin mountain, continued with some interruption into a small inclosure, the property of Sir George Wynne . . . ; which in less than thirty years yielded to different proprietors, adventurers, and smelters, above a million of money."*

The field alluded to lies 400 yards east of Halkin Hall; the workings were drained by a day-level opening into Nant-y-Flint, near Plâs-isaf (Bryn-y-gwyn on the one-inch map). The Engine Shaft (now filled up) was situated 180 yards south-south-west of Springfield, nearly on the junction of the Pant Lode with a string which runs east-north-east from Billins. No ore has been raised of late years from the Pant Lode, but rich flats close to it have been worked with considerable profit in the Prince Patrick Mine.* The ore lay in pipes, or enlargements along a joint running north and south. The first pipe discovered was exhausted previously to 1877, and is now referred to as the Old Flat. The New Flat, found soon after, was worked out in 1880. The two fall into the same line and form in reality one continuous flat. Taken as a whole this flat, or pipe, slopes down towards the north with a gradient of 1 in 8, the depth to it at Hughes' Shaft being about 80 yards, and at the Engine Shaft 105 yards. It intersects the Pant Lode a little east of the Engine Shaft, and was followed a few yards north of the lode, but there lost, though search was made for it to a depth of 170 yards. It falls nearly into a line with Parry's Flat previously described, but would, if continued, pass below it. Similar pipes have been partially explored further south also, in the Queen of the Mountain Mine, but without the discovery of another body of ore. The pipe, where it had been opened to view in the Prince Patrick Mine in 1879, was bounded on all sides by rounded walls of solid limestone, except in the roof and floor, where could be seen a joint, to which no doubt the cavity owed its existence. The pipe was about 8 yards wide and was filled with beautiful calc-spar (sometimes stalagmitic), more or less transparent, and containing needles of copper-pyrites †; while down its centre ran a band of galena, somewhat irregular, but reaching a thickness of 2 feet. The band of galena, lying as a bed in the pipe (not as a vertical rib), followed it at a distance of about 4 feet from the floor, so as to present much the same appearance as a coal-seam in a colliery-level. It tapered away, however, on either side towards the walls of the limestone. The flat lies at about 100 yards below the base of the Chert Beds, in dark-grey limestone.

The Prince Patrick Mine yielded the following quantities of ore:—

YEAR.	TONS.	YEAR.	TONS.	YEAR.	TONS.
1872	117	1877	220	1881	23½
1873	214	1878	79	1882	31½
1874	510	1879	625	1883	12½
1875	606½	1880	240	1885	16½
1876	204½				

Some small east and west strings, known as Taylor's, Phillips', the Maen-bras, and Bolly's Lodes, run through the southern

* The examination of this mine was made under the guidance of Capt. Verchoe.

† Out of the masses of calc-spar thrown out on the billocks, it is easy to break perfect and transparent rhombohedra, through which the needles of copper-pyrites run in bands, each needle being usually placed at right angles to its band. The bands seem to have no relation to any of the cleavage-planes of the rhombohedron, but they are probably parallel to one of the planes of accretion of the original crystal of which the rhombohedron forms a fragment. The bands occasionally cross one another obliquely.

part of the mine, and have yielded small bunches of ore here and there at slight depths. The Maen-bras is intersected in the Rule Shaft (80 yards deep), but has not been thought worthy of exploration. A cross-cut driven into Bolly's Lode was continued along the lode to its intersection with the flat (60 yards south of Rule Shaft), proving it to be here 4 or 5 yards wide, but to contain clay and spar only. Bramwell's Vein is another small string which has been worked to a shallow depth; its continuation into the chert has been unsuccessfully sought in two shafts, and in a cross-cut which was driven at 90 yards depth towards Billins from a shaft 200 yards west of Halkin Terrace.

The China Rake, which forms one of a cluster of nearly east and west veins, underlies north. It is supposed to cross the Caleb Bell at Pwll-melyn, but has not been worked further west than the Grosvenor Mine, which was 100 yards deep. Eastwards it branches into the New and Old Chwarel-las Veins, the former of which was worked under the Black Limestone outcrop to 91 yards, the latter near the same spot to 180 yards depth. Some small north and south joints, filled with spar with needles of copper, cross the veins here and there. The Dogpit Vein ranges from near the Grosvenor Mine, a little south of east.

The Union Vein, underlying south, runs from near Fron rather south of west, 250 yards north of the Foel-ddu fireclay-pit. It has been worked both in open trenches and to a depth of 80 yards at its western end, and yielded calamine. At 150 yards west of the Chert-boundary it is intersected by the Wagstaff Lode, and at that boundary by the Vein Crwn (or Pwll-gwyn-llan), both of which contain spar with needles of copper-pyrites, and have been traced southwards as far as the Long Rake, the principal shafts on the former being 60 and 80 yards, and on the latter 110 yards deep. The Union Vein runs on the eastern side of the Vein Crwn through the Mary Jane Shaft to an old whim-shaft (now fallen in) near Fron.

The Long Rake underlies north and runs from the Long Rake Engine Shaft, 300 yards north-east of Christ Church, Rhos-y-cae, to an intersection with the Vein Crwn, a distance of about two thirds of a mile, or twice that distance if the Gin Vein, Catch Lode, and Long Rake be all considered as one lode. It has yielded ore both at a depth (180 yards at the Long Rake Mine) and up to the surface, and its position is marked for most of its course in the limestone by open trenches, some of which are attributed by tradition to the Romans. Where it is crossed by the Vein Crwn it branches into several strings, which yielded ore for about 12 yards down from the surface. Three strings also branch off towards the west-north-west, the central of which is known as the Rhyd-y-goleu. East of the Vein Crwn a lode, falling nearly into a line with the Long Rake, has been worked under the name of the Gin Vein, and is still partly open to the day. At Pen-y-bryn the Gin Vein meets the Pant-y-ffrith Cross-course, and is either cut off or displaced by it, for the Catch Lode, which seems to be the same vein, lies 30 or 40 yards further north. The Catch Lode has been worked at Pen-y-bryn and was intersected at 120 yards depth in a shaft 100 yards north-west of the Wesleyan Chapel (Fig. 19, p. 180). Fluorspar occurs at Pen-y-bryn in the east and west veins.

The chert and limestone of the neighbourhood of Halkin have yielded large quantities of ore from some north and south lodes, the productiveness of which may be due to the fact of their crossing the strike of the strata obliquely, so as to pass from limestone under Lower Coal-Measures towards the north. The cross-courses of the limestone-tracts west of Mold and Nerquis on the other hand, which run along the strike, and in limestone for their whole length, have proved barren. The principal lodes are the Hên Rake (Old Rake), the Pant-y-ffrith, and Crockford's or the Deep Level Lode.

The Old Rake underlies west and runs from Pen-y-bryn northwards, 100 yards east of Fron, where it was known as the Dingle Vein. The old shafts upon it are all either filled up or fallen in. At Pen-y-bryn the workings are reported to have been drowned out at 140 yards depth. Crockford's Shaft, 200 yards south of the building known as Hên Rake, reached the vein at 140 yards depth. The old Engine Shaft lies 100 yards north of Hên Rake. At Fron the vein was worked in the Dingle Shaft, which lies nearly on the line of the Bryn Parade Vein, a small vein nearly parallel to but 100 yards south of, the Union Vein. The last shaft on the Dingle Vein lies 180 yards north-east of Fron, the shafts south-east of that spot having been sunk on strings running about north-east through the fields on the northern side of Old Hall. The Pant-y-ffrith Cross-course underlies west north of Pen-y-bryn, but east, at the rate of 1 in 8, at Pant-y-gôf further south. The southernmost trial upon it, known as the Wern Shaft, lies in an inlier of limestone near Wern-y-Gaer, and passed through six yards of white clay and loose ground into limestone. At the chert-boundary the vein has caused the hollow filled with clay described on p. 123. It then crosses the Pant-y-gôf and California Veins, and runs 60 yards west of Pen-y-bryn, 250 yards south of which house a whim-shaft was sunk to a depth of 140 yards. At Pen-y-bryn the Pant-y-ffrith Lode seems to fall into a line with the Old Rake, but according to the miners keeps further west, passing 100 yards west of Hên Rake.

The Pant-y-ffrith Cross-course and the Old Rake have long been noted for the occurrence in them of tree-trunks at great depths. Such discoveries seem to have been not uncommon before the shallower portion of the veins had been exhausted, for Pennant remarks, that "we have been often surprised with finding great rude logs of timber at the depth of twenty-five or forty-five yards underground. They are quite rough, and totally freed from any suspicion of having been used in the mines, even had they not been met with in new or unworked ground, in blue clay and amidst tumblers. They are firm and strong when first taken up, and of a black color, as if they had been burnt."* On Greenough's Geological Map, in an edition subsequent to 1819, the following note appears:—"Pant-y-ffrith Cross Course. In the loose gravel of this cross-course was found in Cashole [? Cat Hole] Mine a large trunk of a tree slightly mineralized by pyrites at a depth of 90 fathoms," in which statement the Cat Hole Cross-course near Mold

* The History of the Parishes of Whiteford and Holywell, 1796, p. 132.

seems to have been confused with the Pant-y-ffrith Cross-course of Halkin, in consequence of trees having been found in both. None have been found of late years, but a miner, who witnessed its discovery, stated that a tree with some branches attached was found in "live" (unworked) ground in the Old Vein at a great depth near Crockford's Shaft, the vein here between Crockford's and Dutton's sets being about 10 yards wide, with the boundary between the two properties running along its centre. By the same authority another tree was stated to have been found in the Pant-y-ffrith Cross-course a little north of the Pant-y-gôf Engine Shaft, also at a great depth. The discoveries made in the Cat Hole Vein will be described on p. 190. The Cornel-y-cae Shaft was sunk on a supposed cross-course 100 yards east of the Pant-y-ffrith, near the clay-filled hollow mentioned above.

The Pant-y-gôf Vein runs from the northern side of the mound of Moel-y-Crio in a north-easterly direction through the Pant-y-gôf Mine, to the Deep Level Lode (Fig. 19). Near the Engine House it throws off on its northern side a branch which, under the name of the California Vein, runs nearly east and west. The principal shafts upon the Pant-y-gôf Vein are the Trustees, near the Engine House, the Pant-y-gôf Shaft, 200 yards north-east of the Engine House, and Eaton's Shaft at the eastern end of the vein. From Eaton's Shaft a level was driven at 174 yards depth through in the one direction to the Pant-y-ffrith Cross-course (about 600 yards), and in the other to the Deep Level Lode (70 yards); the deepest workings extended to 230 yards depth. The Pant-y-gôf Shaft was 208 yards in depth. From the bottom of the Trustees Shaft (in the 174-yard level) to the Pant-y-ffrith Lode is 100 yards, while from the top of the shaft to the top of that lode measures 122 yards, from which data the underlie of the cross-course, as previously given, has been calculated. The Pant-y-gôf Vein runs eastwards into the Deep Level Lode, which takes its name from the fact of the Halkin Mountain Deep Level having been driven along it. The level lies 216 yards below the surface at Lewis's Shaft, 150 yards north-east of Eaton's Shaft. The Pant-y-gôf Vein is shifted 5 yards northwards on the eastern side of the Deep Level Lode, as might have been expected from the fact that the lode underlies west.

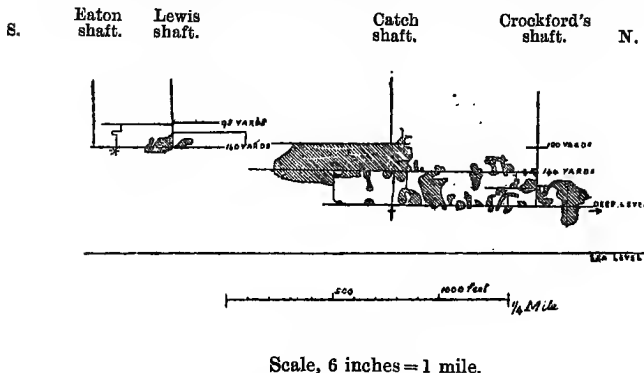
The Deep Level Lode runs from near Berth-ddu to a point about 100 yards east of Halkin Castle. It was worked in the Bryn-y-mawn Shaft, 140 yards deep, in Lewis's Shaft, which cuts it at 86 yards depth, and in Crockford's Shaft (about 200 yards south of Halkin Castle), which was 240 yards deep. The day-level from which the lode takes its name was commenced in the year 1818, and was driven from the stream at Bryn-moel, near Coed-y-cra, at a height of 200 feet above Ordnance Datum, running into the Deep Level Lode near Crockford's Shaft at a depth of about 190 yards (Fig. 19).

In 1875 a new company was formed for the purpose of extending the level, and an Act of Parliament obtained giving them power to levy a rate on the various mines benefited. By this company the level has been extended along the Deep Level Lode and southwards in the same line for 1,000 yards, and thence in a

direction about S. 24° W. to a point 30 yards north of the South Pant-y-gôf Shaft, near Wern-y-Gaer. From this shaft the level has been continued in the same direction for about 360 yards, while a branch, of more immediate importance, runs south-eastwards to Rhosesmor. The level lies 200 yards below the surface at South Pant-y-gôf, and the shaft sunk to it passed through 25 yards of Millstone Grit, before reaching the limestone.

FIG. 19.

Section showing the distribution of Ore in the Deep Level Mine.



* Junction with the Pant-y-gôf Vein.

† Junction with the Catch Vein.

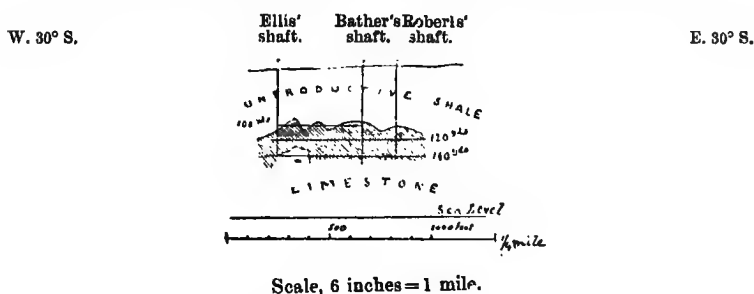
At a point 970 yards south of Lewis' Shaft the level intersected a well-defined east and west fault with a downthrow south, and containing blende and galena. The evidence for this fault on the surface has been already on p. 51, where it was shown to throw the Millstone Grit of Moel-y-Gaer against the limestone; in the level, at more than 200 yards depth, both walls of the fault consist of limestone. The workings in this vein since its discovery in the Deep Level have met with great success.

The Rhosesmor Mine (Fig. 20) lies in the inlier of limestone on the southern side of Moel-y-Gaer. The strata assume the structure of a gentle anticline or arch, so that the levels, which are driven in massive limestone in the central part of the mine, pass into higher beds, consisting of unproductive shale and argillaceous limestone, at either end. The principal vein runs about east-north-east and underlies north, but is at times vertical, or even underlies south. It has been worked by the Engine (or Ellis') Shaft (146 yards deep), at the western end, by Bather's Shaft (158 yards deep) 150 yards further east, and by Roberts' Shaft (about 145 deep) at the eastern end of the mine, the workings extending a distance of about 400 yards. Ellis' Shaft which has fallen in since 1879, was 12 yards north of the 100-yard level in the vein, and 8 yards north of the 120-yard level. The 100-yard level followed approximately the junction of the shaly unproductive strata with the productive massive limestones, but the former are thrown down

by the vein to a slightly lower level on its northern than they lie on its southern side. In the shaly beds the vein is ill-defined, but in the massive limestones shows cleanly cut hanging and hading walls. About 35 yards west of Ellis' Shaft the shaly beds descend below the 100-yard level and cut off the vein, but at the lower levels the productive beds extend further west. Similarly the shaly beds intersect this level at the eastern end of the mine near Bather's Shaft, and the 120-yard level about 50 or 60 yards east of Roberts' Shaft. Levels have been driven through the mine also at 120 yards and 140 yards depth, proving the vein to be rich at these depths, but below 140 yards the water became too copious for further exploration, and the mine remained inactive until the completion of the Halkin Deep Level. From the 100-yard level a cross-cut was driven northwards, with the result of proving other veins nearly parallel to the main vein, the principal being the Grosvenor, which ranges about south-west, and hades to the south-east. A cross-cut driven southwards from the 120-yard level for about 24 yards led to no discovery. The crown of the anticlinal arch formed by the strata lies about 50 yards west of Bather's Shaft, and the depth of shale and black limestone at that point is 97 yards. The proportion of silver in the ore of this mine varied from 10 to 13 ozs. per ton.

FIG. 20.

Section showing the distribution of Ore in the Rhosesmor Mine.



The Pen-yr-orsedd Mine lies about 300 yards south of Rhosesmor on a nearly parallel vein. The workings extend to a depth of 100 yards.

(3.) From Bryn-gwiog to Rhydymwyn.

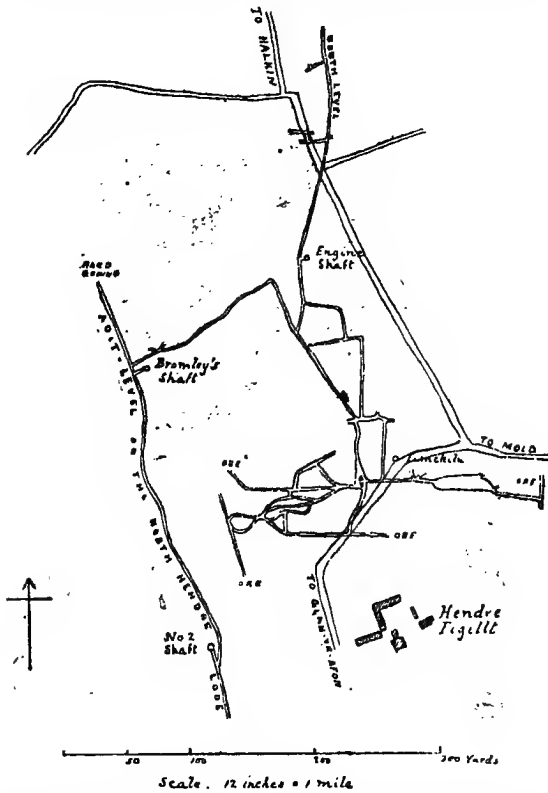
We now cross the fault and deep syncline of Nant-figillt (Fig. 4, p. 28) and mount the escarpment of limestone which includes the Hendre and Mold Mines. The Bryn-gwiog Mine lies at the northern end of this tract, near the commencement of Nant-figillt. The vein runs nearly due east and west, and throws the strata down on its northern side, shifting the outcrops

thereby about 550 yards. As a consequence the Millstone Grit and Lower Coal-Measure shale in the northern or hanging side are brought face to face with limestone in the southern or hading wall of the vein, so as to render the tracing of the vein on the surface an easy matter. At its western end the vein appears first as a number of strings in the limestone near Hersedd, but about 300 yards further east becomes a well-defined fissure, underlying north at about 2 in 5. The lowest level lay at 225 yards depth, and the Engine Shaft to it, commencing in shale, passed through the Millstone Grit, here very thin (p. 52), and cut the vein at 140 yards. A second Engine Shaft, 200 yards further west, was sunk in the limestone and met the vein at 120 yards depth. Towards the east the vein disappears in the Lower Coal-Measures of Nant-figillt, the point at which the 200-yard level ran into the shale lying 200 yards east of the Engine House. An attempt was made to find the vein on the eastern side of the Nant at a point 250 yards south-west of Plás Winter; a shaft was sunk to 80 yards depth, and a cross-cut driven from it to the south-west, but without success. Fluorspar, sometimes blue, and barytes occur abundantly in the old hillocks of this mine and blende or calamine seem to have been more plentiful than galena, blende being especially abundant in the eastern and calamine in the western end of the deeper levels.

Three hundred yards north of the Bryn-gwiog Vein we find surface-indications of a fault, presenting many points of similarity to it. The ground has remained unexplored, the only cross-cut driven north from Bryn-gwiog stopping short of the supposed line of fault. South of Bryn-gwiog lies the Bryn-coch Vein, and to the south-west the Fron Vein, neither of much importance. The latter is crossed by the small cross-course of Rhewl, and by a bed of shale with nodules of ironstone, which crops out west of Hersedd. It ranges towards Pen-y-gelli, where some large open spaces in the limestone are by some taken as evidence of the continuation of the Caleb Bell Cross-course. The neighbourhood of Hendre has produced large quantities of lead-ore till within the last few years. The Coed Hendre Vein runs a little north of east on the northern side of the Hendre Valley. It underlies south and throws the strata down in that direction about $1\frac{1}{2}$ feet, as may be seen in the little cliff near the Engine House, where the walls of the vein show the striations and cuttings of slickenside in a nearly horizontal direction. From the brow of the cliff eastwards the course of the vein is marked by old open trenches. Eastward the vein is lost in the Lower Coal-Measure shale, but westwards it has been worked under the bottom of the valley, the Engine Shaft being in the alluvial flat, and reaching a depth of 90 yards, while the Victoria Shaft lies 200 yards further west again. The mine was brought to a standstill by the abundance of water.

FIG. 21.

Plan of the workings in the North Hendre Flat, 1879



The North Hendre Mine (Fig. 21) is situated on a lode, which underlies west, and runs a little west of north, 100 yards west of Hendre Figillt. Bromley's Shaft, 300 yards north-west of that farm, cut the lode at 68 yards depth. The lode dies out north of the shaft, but southwards runs out into the Hendre Valley 100 yards below the Mill-pool, in a ravine caused by the outcrop of a bed of shale, perhaps the same bed that was noticed near Hersedd. A day-level was driven to the mine from this point. The mine derived nearly the whole of its large yield of galena from a flat lying on the eastern side of the lode. As seen in 1879 the flat consisted of a number of pipes or caverns hollowed out in one of the beds of limestone, and running in various directions, each pipe following a small joint visible in the roof, and coming to an end when the joint died out. They contained much brown calc-spar in clusters of radiating crystals, but "tuft," a siliceo-calcareous vein-stuff, was usually associated with the richest deposits of galena. The galena contained 5 to 7 ozs. of silver per ton and occurred generally in great lumps, while in the eastern and western workings black oxide of manganese lay as a bed in "tuft" and yellow clay. Some of the spar contained needles of copper-pyrites. The strata, and the

system of pipes forming the flat, sloped generally towards the east or east-south-east at a gradient of 1 in 7. Access was gained to the flat by means of an Engine Shaft 110 yards deep, 300 yards north of Hendre Figillt, the shaft, according to a statement by Capt. Ellis, traversing strata of approximately the following thicknesses:—

The North Hendre Engine Shaft.

	FEET.
Gravel [Glacial]	15
Black limestone	8
Grit	24
Black limestone, the same rock which is blasted in the quarry at Hendre	60
Shale	17
Black limestone	60
White limestone, the rock which forms the lower part of the quarry	120

West of, and nearly in a line with the Coed Hendre runs the Tyddyn-y-barcud Vein, which has been worked from the southern side of the high road near the Mill-pool, by Efail Percy, at a point 150 yards south of the Royal Oak, and through Cwt Coed. It seems to be a strong vein, underlying north, but no particulars concerning it are forthcoming.

The new Garreg-boeth Vein which runs through the wood of that name, and about 300 yards south of the Tyddyn-y-barcud, underlies north, and ranges about 15° north of east, like the rest of the veins in this portion of the limestone-escarpment. At its eastern end it is lost in the Coed-du Cross-course, while 300 yards to the west it splits up into strings, and has not been followed. The Engine Shaft upon it was 120 yards deep, and was drained into a day-level, which opens into the Hendre stream, near the Independent Chapel, Glau-yr-afon. In the débris at the western workings may be seen blende, and in that from the Coed-du Cross-course traces of copper.

Next on the south to the New Garreg-boeth, and 180 yards from it, lies the Old Garreg-boeth Vein, which runs through the Mwyn-bwll Mine, and is known by that name towards its western end. This vein underlies south, and has been traced for about 1,400 yards, to a point 500 yards west of Mwyn-bwll. At Mwyn-bwll the vein is crossed by a north and south lode, which runs down to Hesp Alyn, and is believed by the miners to be the Caleb Bell Cross-course (p. 32). The Cross-course underlies east, and the vein south, the result therefore being that the vein is shifted to the north (about seven yards) on the eastern side of the Cross-course. Farther east the vein has been worked from shafts of a depth of 75 to 80 yards, the Engine Shaft being situated near the eastern side of the Coed-du Cross-course. The mine was drained by a day-level driven eastwards in the vein to a point under the road 250 yards north of Plâs Wilkin, where a third cross-course (probably the Nant Alyn Cross-course) was encountered, running a little east of north, underlying east, and shifting the vein 10 yards northwards. From this point the level turns north to the New

Garreg-boeth. Tradition attributes the old workings on the Mwyn-bwl Vein to the Romans.

The next veins to be described lie between the so-called Caleb Bell on the west and the Coed-du Cross-course on the east. The Joint-y-pydw is marked by a line of hillocks in the wood, 200 yards north-west of Coed-du. The Coetia-yr-ysgall lies 50 yards south of the joint, and has been trenched out at the surface; the white calc-spar of the so-called Caleb Bell lode is exposed to view at the western end of this vein. The Vein Susan lies 200 yards south of the Coetia-yr-ysgall, and runs from near the Caleb Bell 400 yards eastwards. The Cefn Cilcain or Coed-du Vein, a more important lode, runs from the Caleb Bell through the wood to a point in the Coed-du Cross-course 250 yards south of the house of that name, a great open trench, supposed to have been made during the last century, marking its course all the way. Lastly 250 yards further south runs a string, nearly parallel to the Coed-du Vein, and containing barytes towards its eastern end.

The Cefn Cilcain Vein was being explored in 1880 by means of a level from the river near Nant Alyn. The level is driven along a fault running W. 12° S., with a downthrow north, in shale and black limestone. At 200 yards distance from the road it passes a fault running N. 25° W., on the western side of which the east and west vein is shifted 5 yards northwards. The Coed-du Cross-course, known here under the name of the Llwyn-traus, crosses the level 100 yards further west, near the margin of the wood. It runs nearly due north, is nearly vertical, and is filled with smashed limestone and calc-spar. The Coed-du Vein leaves the western side of this fault at first with a direction W. 10° N., as though it had been dragged (or the whole mass of rock bent) southwards by the cross-course, but in a few yards resumes its normal direction of W. 10° S. Shale forms the hanging (eastern) side of the cross-course and lies over a sandstone, more than 30 feet thick, which crops out a little further south. The same bed of shale which crops out at the mouth of the North Hendre day-level runs on through the limestone in this belt of ground also, passing a little east of Mwyn-bwl, through the Coetia'r-ysgall, midway between the two cross-courses, and, as far as can be judged by the contents of the old hillocks, through the western end of the Coed-du Vein.

The Erw Felin Vein has been explored for a short distance in the calcareous sandstone series on the northern bank of the Alyn, west of Rhydymwyn. It is supposed to be the same as the Vein Susan, but underlies south. The section of the shaft is given on p. 33.

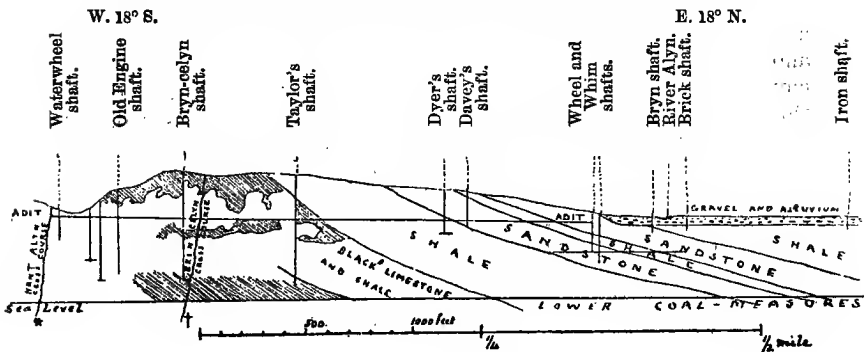
(4.) From Rhydymwyn to Gwern-y-mynydd.

The Bryn-celyn Vein, which also underlies south, runs from the river at Nant Alyn to Rhydymwyn Foundry. Towards the west it was lost under the bed of the river at its intersection with the Nant Alyn Cross-course, and towards the east in Lower Coal. Measures, but proved rich in the intermediate ground (Fig. 22).

Near the top of the hill the Bryn-celyn Cross-course, a powerful downthrow to the west, shifts the vein 40 yards southwards on the eastern side. Near the Bryn-celyn and Taylor's Shafts, situated 30 yards west and 150 yards east of the cross-course respectively, the vein seems to have been worked to a depth of about 200 yards. The adit-level lies about 75 yards below the surface at the Bryn-celyn Shaft, and runs as far as the Nant Alyn Cross-course, where the water was raised to the surface by water-power in the Waterwheel Shaft. The Old Engine Shaft was sunk on the eastern slopes of the valley at Nant Alyn. Further east several old whim-shafts have been sunk in the Lower Coal-Measures, in a belt of ground which is separated from the limestone and sandstone worked in Taylor's Shaft by unproductive shaly strata. The easternmost shaft is situated at the eastern margin of the alluvial flat of the Alyn, and is known as the Iron Shaft from the fact of its being lined with iron cylinders in the alluvial gravel. A strong stream of water now flows from the mouth of this shaft.

FIG. 22.

Section showing the distribution of Ore in the Bryn-celyn Vein.



Scale, 6 inches = 1 mile.

- * The Lode has not been found west of this Cross-course.
- + This Cross-course heaves the Lode 40 yards southwards.

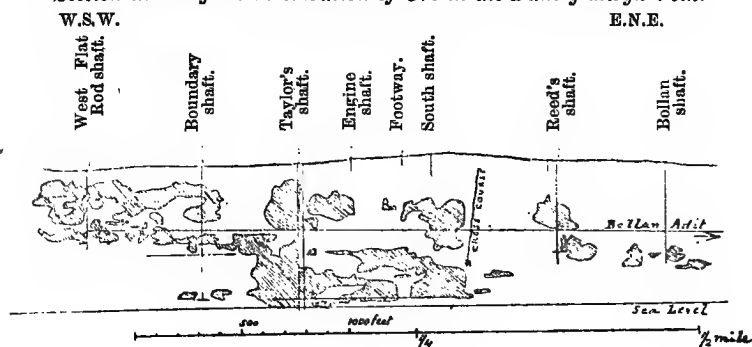
The Llyn-y-pandy Vein lies about one third of a mile south of Bryn-celyn. It underlies north, and runs from near Hesp Alyn as far as the Bryn-celyn Cross-course, east of which it has never been discovered. The vein has yielded no ore west of the Alyn, but proved so rich on the eastern side of the river, that a large sum of money was expended in constructing a water-channel along the cliffs on the eastern bank of the Alyn for more than two miles, in order to work the pumps, &c. by water-power. The Garth Level, described on p. 53, was commenced in search of the Llyn-y-pandy Vein towards the east. The Rhyd Alyn Vein is a nearly vertical joint, which was discovered by a cross-cut driven south for about 230 yards from the Llyn-y-pandy Vein. This joint or fissure, filled with spar and galena, was worked eastwards into the Nant Alyn

Cross-course, here of great width and packed with smashed-up limestone and calc-spar. A smaller cross-course further west, perhaps that of Coed-du, shifts the joint 5 yards southwards on its eastern side. The ore of the Rhyd Alyn joint yielded 7 oz. of silver per ton.

The Pant-y-mwyn Vein (Fig. 23) can be traced through nearly the whole breadth of the Limestone and Millstone Grit outcrops, and is believed to run on for some distance into the Coal-field. It underlies south and throws the strata down many yards in that direction, the horizontal shift in the outcrops thereby produced amounting to 400 yards. The vein appears in the old water-channel on the eastern bank of the Alyn near Pen-y-sarn with a width of 21 feet of white calc-spar, and runs thence to near the Crown Inn; but a branch of it, which starts from the river opposite Plâs-yr-ogob, is considered by some the main vein. From the Crown Inn eastwards the vein runs in two, known as the North and South Lodes, both underlying south. The workings in this part seem to have been shallow, and much of the ore was obtained in the form known as Gravel Ore, that is, as boulders imbedded in Glacial Sand and Gravel and loosened no doubt from the vein by the weathering away of the walls of limestone. The Nant Alyn Cross-course passes the vein 300 yards east of the Crown Inn and shifts it southwards on the eastern side. The West Flat Rod Shaft, near this point, was 120 yards in depth, the end of the Bellan adit-level lying at about 100 yards in depth in it. The Boundary Shaft, about 160 yards further east, was 200 yards deep; and Taylor's Shaft, at Bryn-coch, was 256 yards deep, cutting the vein at 140 yards, while the day-level lay here at 104 yards depth. The Bellan adit-level opens on to the Alyn, south-west of Pen-y-garth, at a height of about 390 feet above the sea, and supplied the evidence on which the eastern part of the section forming (Fig. 6, p. 35) has been drawn. A comparison of Fig. 6 with Fig. 23 shows that the bulk of the ore lay in the limestones below the Hendre sandstones.

FIG. 23.

Section showing the distribution of Ore in the Pant-y-mwyn Vein.



Scale, 6 inches = 1 mile.

* This Cross-course heaves the Lode 7 feet.

A second cross-course, passing the vein between the South Shaft and Reed's Shaft, is said to have shifted it 7 feet, the position assigned to this fault lying nearly in the range of the Bryn-celyn Cross-course. The proportion of silver in the Pant-y-mwyn ore reached only 5 oz. per ton.

The Bwlch-y-ddafryn Vein underlies north, and runs from Trinity Church, obliquely across the road, into the Nant Alyn Cross-course near Pen-y-parc, west of which it is not known.

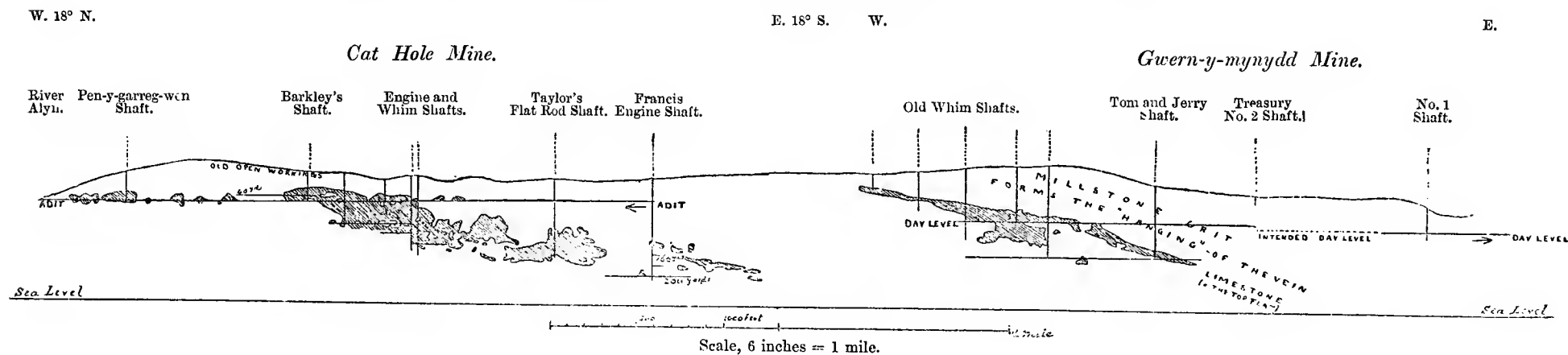
The Pant-y-buarth Vein also underlies north, and throws down the strata a considerable distance in that direction. It can be traced from the Silurian area at Craig (so named on the one-inch map), where it shifts the boundary of the limestone, all across the Lower Carboniferous rocks, eventually losing itself eastwards in the Millstone Grit. In the valley of the Alyn it lies hidden under Boulder Clay, but several shafts have been sunk on a nearly vertical string lying south of the main vein, and ranging towards Pen-lan. At 300 yards distance from the river, this string is crossed by a north and south joint (by some supposed to be the Caleb Bell Cross-course), the point of intersection being marked by a large swallow-hole at 40 yards depth. A shaft 100 yards northwards passed into a hollow in the joint, filled with tufa and pebbles of Wenlock Shale. From Cefn-bychan the main vein runs without interruption to Pant-glâs, its course being easily traced by the fact of its throwing calcareous sandstone down on its northern side, against the limestone of its southern side. The principal workings on the vein seem to lie between Park Farn and Pant-glâs, the Engine Shaft, 350 yards east of the former, being 120 yards deep, and cutting the vein at 60 yards depth. The easternmost shaft at Pant-glâs was sunk into a mass of broken and confused sandstone, in which no definite vein could be distinguished.

The Pant-y-buarth Vein seems to be crossed by several north and south faults, concerning which, however, but little information has been forthcoming. One west of Cefn-bychan, already referred to, crosses the river with several others opposite Bryn-y-castell, and is filled for a width of 10 to 12 feet with coarsely crystallised white calc-spar; another, 100 yards further west, runs about N. 20° E. At Bryn-hyfyrd the Nant Alyn Cross-course cuts through the vein, and at Fron-haul a cross-course, possibly the continuation of that of Bryn-celyn, passes southwards towards Moel Findeg.

The Fron Fawnog Mine was worked in a flat, the ore of which followed the bedding down a dip-slope of about 1 in 4 eastwards. The flat included two runs of ore, known as the North and Main Runs, 13 yards apart and ranging about magnetic east and west, with a few small strings between.

The "runs" occupied pipes hollowed out principally in the base of a calcareous sandstone, but partly also in the underlying limestone. The pipes were filled with sand, in which the ore lay as a bed; while the sandstone was soft and honeycombed, a compact roof invariably implying poverty in the run. Though unaccompanied by a vein or fault, such pipes usually follow a small leader of spar in the limestone. They are evidently old underground water-channels, choked up with the insoluble residue of the calcareous sandstone series. The name "flat" is

Section showing the distribution of Ore in the Cat Hole and Gwern-y-mynydd Mines.



The Cat Hole Cross-course intersects the Cat Hole Vein between Taylor's Flat Rod Shaft and Francis Engine Shaft. Trees in a semi-fossil condition were discovered at 180 and 205 yards depth near the intersection. The run of ore worked in the Cat Hole Mine occurred in the "middle white limestone," that worked in the Gwern-y-mynydd Mine in the "top-flat limestone" and the associated calcareous sandstones. A third deposit of ore not shown in this section occurred in the Millstone Grit.

commonly applied to a bed of limestone in the Calcareous Sandstone series, and from the description of that series in this neighbourhood, given on pp. 36, 37, it will be seen that there are several flats at different depths in the same mine. At Fawnog two have yielded all the ore, the lower flat in the old mine, and an upper flat, 25 yards higher in the series, in the later workings. The pipes sometimes "jumped" southwards in their course down the dip-slope, apparently in consequence of slight shifts of the strata by north and south faults, and eventually were cut off eastwards by a joint running about N. 12° E., and marked with nearly horizontal slickenside, beyond which little or no ore has been found.

The upper flat lies at a depth of 160 yards at the Engine Shaft, but, rising westwards with the strata, both flats crop out about 100 yards west of the Millstone Grit boundary. There they have been worked up to daylight, the whole surface of the ground along the outcrop of each band of limestone having been turned over in search of loose lumps of galena. The confusion of the strata has been increased by the weathering away of the limestones along the outcrop; and the consequent breaking up of the sandstones above them. An inclined plane 300 yards south of the road at Pant-glâs still affords means of access to the lower flat. The ore of Fron Fawnog yielded about 6 oz. of silver per ton.

Several small trials break the surface of Cefn-mawr, between the Nant Alyn and the Cat Hole Cross-courses, the principal vein being the Deborah, which runs nearly south-west near Cefn-mawr Farm. A more powerful vein crosses the Millstone Grit, 100 yards south of Hafod, and has been followed in a direction a little north of east for a short distance westwards through the "flat-measures" (the calcareous sandstone series). The Deborah Shaft, sunk near the line of the fault, and at a point 300 yards west-south-west of Hafod, supplies the following notes. The chert, which here forms the middle division of the Millstone Grit, extends to 12 yards depth, and rests upon sandstone with quartz-pebbles. The sandstone, at 52 yards from the surface, contains a band of limestone, which is probably the "small flat" of Fron-haul, and at 87 yards depth rests upon the upper "flat-limestone." Explorations were made at this depth along the junction of the sandstone and limestone, a level driven northwards showing the surface of the limestone to be unevenly eroded, or eaten into, by percolating water, while a cross-cut driven 18 yards southwards encountered a fault running W. 5° N. and underlying north. North of the fault the strata dip eastwards at 4 inches to the yard, but south of it dip north-eastwards at 8 inches to the yard. The shift effected by the fault on the outcrops amounts to about 300 yards.

The Gwern-y-mynydd and Cat Hole Mines (Plate III.) are situated on a powerful fault which ranges rather south of east and throws the strata down about 110 yards to the north, thus shifting the outcrops about 600 yards. At its western end the vein runs into the Nant Alyn Cross-course, the intersection of the two giving rise to a large cavern filled with white sand (p. 123), but it cannot be traced further under the Drift Gravel of Pwll-y-blawd. Eastwards from Glan Alyn it can be followed by a line of old shafts to Cat Hole, crossing the road at Parc Arthur Farm, where it was worked so

near the surface as to cause the road to fall in. Near this point it throws off a string on the south, known as Pilkington's Vein, which, with some others, has been worked through the wood on the northern side of the road as far as the river. The adit-level runs from the Alyn to Francis Engine Shaft (east of Parc Arthur Farm), which it enters at a depth of about 50 yards. This shaft is 200 yards deep and cuts the vein at 180 yards; the Old Engine Shaft near Cefn Mawr Hall, 140 yards deep, reaches the vein at 100 yards. A run of ore extended from near the surface between 200 and 300 yards west of the Engine Shaft to a depth of about 200 yards at the Francis Shaft, sloping down eastwards with the dip of the strata (Plate III.).

The Cat Hole Cross-course intersects the vein close to Parc Arthur Farm, and disorders the hanging and hading walls for a short distance. Near the point of intersection several trunks of trees resembling those of Pant-y-ffrith (p. 178) occurred. The first, found about the year 1840 at a depth of 180 yards, 60 or 70 yards west of the Francis Shaft, had portions of branches attached to it, and was hard enough to bear carving. About the year 1868 the Cat Hole Company, having deepened their shaft 25 yards and driven westwards in the Cat Hole Vein, came across several trees at 205 yards depth. One of the trunks having been cut up with a saw, it was found that the heart had rotted away, and that the cavity and cracks in the wood had been filled with "yellow sulphur" (by which miners usually mean iron-pyrites); the wood was dark-brown and very heavy, but would burn in a candle when dry. The trunks attained a girth of about $1\frac{1}{2}$ feet. The "ground," at the spot where the trees lay, consisted of blue-black shale, like Coal-Measure shale; above them occurred a deposit of ore in such a position that the trees could not have reached the spot, after the deposition of the ore, without having travelled 50 yards eastward along the vein. The trees stood nearly upright with the roots downwards.*

Between the Cat Hole Vein and Cefn-mawr Hall a fissure in the limestone, running nearly parallel to the main vein, lies open to a depth of 30 or 40 yards; at the time of the falling in of the trees the Cat Hole Vein seems to have been in a similarly empty condition, but at what date this occurred we have no evidence to show.

At its eastern end the Cat Hole Vein runs through the Gwern-y-mynydd Mine. It follows the road closely from Parc Arthur to a point 200 yards east of the Rainbow Inn, where it divides into the Fron-isaf Vein running a little south of east, and a number of strings branching off a little north of east. The Fron-isaf Vein was worked in the wood 200 yards north of Fron-isaf, and yielded ore in the chert, but not in the "flat-measures." A shaft just above the wood reached the vein at 60 yards and a flat (probably the Little Flat) at 80 yards, over which lay six or eight yards of shale. The strings further north were numerous in the field above the wood, and yielded ore in the chert. The workings in these were drained by a day-level, the mouth of which lies 300

* These notes were supplied by Capt. Williams, late of the Cat Hole Mine. None of the wood was forthcoming at the time of the survey of the district.

yards south-west of the old County Gaol, and which was described on p. 70. The level traverses shales and sandstones, and passes two or more north and south faults, in one of which green and slightly phosphorescent grains of copper-ore occurred. Nearly under the road some strong joints, perhaps the strings referred to, range about west-south-west along the level, while 112 yards west of the cross-cut to the old Engine Shaft, limestone rises into the level, sinking again out of sight in about 40 yards. At 161 yards from the cross-cut it reappears for a distance of 6 or 7 yards, the level keeping nearly along the strike of the beds, so as to touch the limestone in the crest of each fold in the strata. The limestone, which is coarsely crystalline and lies next below a yellow sandstone, seems to be the Little Flat of Fron-haul. On the northern side of the road, at 350 and 250 yards respectively west of the Turnpike, the Tom and Jerry, and the Treasury shafts have been sunk in the Millstone Grit; the latter passed through hard rocky shale with black and white sandstone to a depth of 60 yards, with a 9-inch seam of coal at 30 yards, and then entered cherty sandstone. At 60 yards depth a cross-cut was driven to meet the day-level from Fron-isaf, and a continuation of the level was carried westwards for about 360 yards, passing the Tom and Jerry Shaft at about 70 yards depth.

The Tom and Jerry Shaft was sunk to a depth of 140 yards to intersect a run of ore which followed the top-flat on the northern side of the vein, and came to near the surface 300 yards west of the Rainbow Inn. The day-level was driven as far as a shaft 150 yards north-west of the Rainbow Inn. It will be observed that the vein described above bore lead at three horizons, firstly, and most abundantly in the massive limestones that form the hill of Cefn Mawr; secondly, in the overlying limestones and sandstones which form the "flat-measures" of the miners; thirdly, in the chert and cherty sandstone which form the middle portion of the Millstone Grit. The proportion of silver in the ore reached only about 5 oz. per ton.

(5.) From Gwern-y-mynydd to Maes-y-safn.

Several shafts have been sunk through the Millstone Grit of Bryn-gwyn into the top-flat, one of them, 100 yards south-east of Fron-uchaf, proving this bed (the limestone worked in the quarries close by) to be 18 yards thick. The Fron-haul Mine is situated on a vein 250 yards south of, but parallel to, the Fron-isaf Vein. The Little Flat, reached at a depth of 50 yards in the Engine Shaft, varies from 1 to 3 feet in thickness, while the coal-seam previously alluded to lies at about 8 yards depth, and appears also in the day-level. The Whim Shaft west of the Engine Shaft cuts the vein at 60 yards, and a limestone, which is not shifted by the vein, at 80 yards depth. The limestone, coarsely crystalline in texture, lies below 7 or 8 yards of shale, and therefore corresponds rather with the Little Flat than with the top-flat as seen in the Bryn-gwyn quarries. The greater depth to it in this shaft seems to indicate the existence of a fault, not improbably running through the Engine Shaft, the strata in which are nearly vertical. Such a fault would

explain also a feature which runs in a north-north-west direction from Pentre-bach, and of which the steep bank of Fron-haul and Fron-isaf forms part. The Little Flat has been found also at 20 yards depth in a shaft 350 yards south-west of Fron-haul, on which evidence its outcrop is indicated on the map.

The Coed Cynric Vein underlies north and runs through the Fireclay Pit, near Colomendy, as described on p. 124. The lead-ore in the pit occurred in the form of lumps of carbonate, formed by the decomposition of lumps of galena. The 112-yard level below the pit passed through swallow-holes filled with sand and clay, but in the 66-yard level these materials occurred in abundance. The Engine Shaft touches the vein at 112 yards depth. Eastwards the vein is known no further than the road past Aberdine, though a whim-shaft has been sunk by the side of the Mold Road, at London, to a depth of 80 yards, chiefly through black limestone and shale, with a good deal of fluorspar.

The East Maes-y-safn Mine lies nearly on the line which the Coed Cynric Vein might be supposed to take, but the workings have disclosed no vein, though ore has been raised from the flat-measures. The top-flat has been followed down its dip eastwards in a succession of shafts for about 550 yards beyond the boundary of the Millstone Grit. The older shafts, near this boundary, reached the top-flat at 13 and 30 yards; Pellew's Shaft, 100 yards west of the road, at 90 yards; the Old Shaft, 30 yards east of the road, at 100 yards; the flat then dips rapidly to a depth of 144 yards, but rises slightly again eastwards to the Engine Shaft, 200 yards east of the road, the mine thus occupying a gentle syncline in the strata. The Engine Shaft passed through the following beds:—

East Maes-y-safn Shaft.

	FEET.
Chert, &c. - - - - -	345
Shale - - - - -	6
Chert - - - - -	9
Sand - - - - -	9
Shale, thinning out westwards - - -	6
Grit - - - - -	12 to 15
Shale, clay, and sand mixed, forming the "hanging" of [or the bed overlying] the flat	45
	<hr/> 432 <hr/>

The strata dip westwards in the top of the shaft at a gentle angle, but steeply at 100 yards depth, while they lie nearly flat in the bottom of the shaft. Fifty yards west of the shaft the flat dips east.*

Between this mine and Bryn-gwyn two runs of ore have been worked in the top-flat. The one known as the Mount Pleasant Run starts from the road 220 yards east of the Owen-Glyndwr Inn, and runs for about 500 yards towards Fron-haul, nearly, but not quite, along a fault with a downthrow of 18 yards to the north-west; the

* The information regarding this shaft was supplied by Mr. Thomas Miners.

other, or the Bryn-gwyn Run, starts 50 yards north-west of that inn, and runs 200 yards to Bryn-gwyn Farm, where it lies at 80 yards depth. A shaft, 150 yards north-east of the farm, met the flat at 110 yards depth, and showed the strata to dip westwards, as at East Maes-y-safn. Both the Mount Pleasant and Bryn-gwyn runs terminated in a cross-course which passes under Bryn-gwyn Farm, a little west of north, but which is stated not to shift the strata, and is probably of little importance. The top-flat limestone has so far perished along the Mount Pleasant Run, so as to occur in boulders only, not as a solid bed.

South-west of East Maes-y-safn lies the Jamaica Mine, in which a rich flat was worked. The limestones have here completely perished along the outcrop, and the Millstone Grit and the sandstones of the flat-measures have fallen together. No vein was ever discovered, but drivings down the dip-slope, and along the horizon of the top-flat, disclosed rich bunches and runs of ore, as far as a depth of 70 yards, below which the ground became barren. The flat crops out near the house called America, but from the reason stated no limestone appears, and the Millstone Grit reposes on sand for a distance of about a quarter of a mile. The productive ground, however, extends only about 300 yards west of that house. Much of the ore of this mine occurred in the form of carbonate of lead.

The Maes-y-safn Mine (Fig. 24) attained a greater depth than any other in Flintshire, namely, 390 yards.* The vein runs nearly parallel to the Gwern-y-mynydd Vein, and, like it, throws the strata down to the north. It traverses the whole limestone-outcrop, but cannot be traced in the Wenlock Shale on the west, or far into the Millstone Grit on the east. It was drained by a water-wheel and day-level into the Alyn below Llanferres, the level running eastwards to a point about 200 yards beyond the Grosvenor Shaft, or 1,400 yards in all.

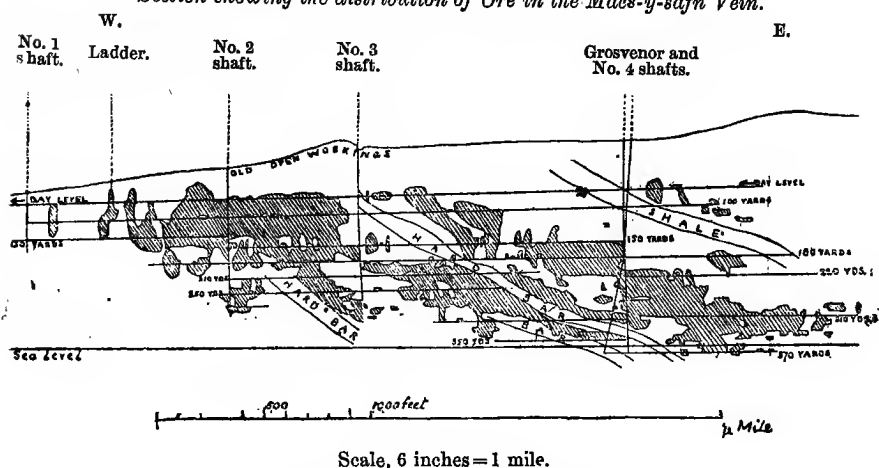
The position of the vein at the surface can be traced with ease, partly by old surface-workings still open, partly by its effect in bringing face to face strata of different character. The vein underlies at a low angle, with the consequence that its intersection with the undulating surface of the ground forms a somewhat sinuous line when drawn upon a map, but the day-level, driven for all its length in the vein, keeps a nearly straight course. The underlie of the vein at different points is given by the following figures:—At No. 2 Shaft, 66 in 100; at No. 3, 112 in 100; at the Grosvenor Shaft, 110 in 100. No. 1 Shaft, situated 300 yards from the intersection of the vein and the River Alyn, was sunk to 150 yards, passing through the vein at 130 yards; No. 2 Shaft, 600 yards from the same point, was 270 yards deep and intersected the vein at 54 yards; No. 3 Shaft, 770 yards from the same point, met the vein at 100 yards and was continued down the incline of the vein to a depth of 310 yards; the Grosvenor Shaft, situated 1,180 yards from the same point and at the foot of Moel Findeg, entered the vein at 180 yards and was sunk in it to 390 yards from the surface; No. 4 Shaft, lying 100 yards south of the Grosvenor Shaft, caught

* The greatest depth reached in the Talargoch Mine was 365 yards.

the vein at 70 yards depth, from which the underlie, as given above for this point, has been calculated. The workings extended 360 yards east of the Grosvenor Shaft at 310 yards depth, but not so far at a less depth. The 310-yard level probably ended in, or close to, the Cat Hole Cross-course, which traverses Moel Findeg, throwing the strata down westwards (Fig. 8, p. 40). The vein continues its course eastwards, nearly along the road, and a few shafts have been sunk upon it in the Millstone Grit, but without any noteworthy result.

FIG. 24.

Section showing the distribution of Ore in the Maes-y-safn Vein.



The Maes-y-safn Vein proved to be richest in the same beds which contained the lower of the two runs of ore in the Cat Hole Vein, namely, the massive limestones of Cefn-mawr. In working eastwards the ore became abundant between Shafts Nos. 1 and 2 and continued so to about 100 yards east of Shaft No. 3, the old surface-workings showing that the vein was productive here up to day-light. From this tract the ore ran downwards towards the east at an angle corresponding to the dip of the strata (about 1 in $1\frac{1}{2}$). The deepest workings, however, near the Grosvenor Shaft, reached the upper part only of this productive belt, for the lower part should occur at a depth of 400 to 600 yards in that part of the mine. The increasing cost of pumping, combined probably with decreasing richness in the lode, precluded any further deepening of the mine. Experience of the Flintshire veins has not been such as to encourage deep mining.

(6.) From Maes-y-safn to near Llanarmon.

The next veins to be described lie about two thirds of a mile south of Maes-y-safn, running nearly parallel to it and like it throwing the beds down to the north. Towards the east a well-defined

fault shifts the Millstone Grit boundary as much as 700 yards (or vertically about 114 yards), while towards the west we find a dislocation of the limestone-boundary at Llanferres, nearly in the same line. Between these two points several minor veins and faults appear, none of much importance. Commencing in the west we trace the Llanferres Fault through a small hollow (filled with Drift Sand and Gravel) in the limestone east of the Alyn. Thence it runs through the Waen-lâs Mine, east of which in the wood it has been cut clean out to the surface, and still remains open; about a hundred yards north of it, a line of small trial-shafts mark the course of the Waen-lâs-bach Vein, while 150 yards south of it lie old workings on the Garreg-y-cochion Vein. Nearly along the eastern margin of the wood, a cross-course cuts through these three veins, and seems to shift each a few yards southwards. The Waen-lâs Vein runs under the northern margin of the little marshy flat of Pant-du, under the name of the Pant-du Vein, and was worked there in a shaft 140 yards deep (60 yards to reach the vein and 80 yards in it). The Garreg-y-cochion Vein crosses the marsh and has been worked up to day-light, under the name of the Pentre-hobin Vein, on the southern side of the road. A third vein, known as the Goodwin, also traverses the hollow, and has been worked open across the hill on the northern side of the road. The Pentre-hobin and the Goodwin veins join at the cross-roads, and have been worked to a depth of about 120 yards. From this point there is no further working on the vein till we reach Nerquis Mountain, where the East Pant-du Shaft, sunk on the line of fault, reaches the top-flat at 114 yards depth. It will be observed that the surface-workings in this group of veins lie in the same zone of limestone as those on the Maes-y-safn Vein, and indicate a run of ore in a corresponding position. The ore, however, in this case was distributed among a number of minor veins, instead of being concentrated along one fissure.

The Belgrave Vein, lying half a mile south of the Waen-lâs, runs parallel to it and also throws the strata down (and accordingly underlies) northwards. It forms a single and nearly straight line of fracture from the Alyn to the Millstone Grit at Pant-terfyn, where it is lost in thick sandstones. An old level marks the point at which it issues in the valley of the Alyn; thence it runs 350 yards to a cross-course, on the eastern side of which it seems to be shifted southwards. Reappearing at Bryn-yr-orsedd, it may be followed across terraces of bare limestone to Pwll Iwrach, a pot-hole filled with sand (p. 124), and thence by the Belgrave Mine to Gors, near which it passes through, or near, three peat-filled hollows in the limestone. It seems to have been mined chiefly at Bryn-yr-orsedd (in shafts and levels driven into the hill-side), and in the Belgrave Mine; but east of this to have been left almost untouched. On its northern side, and at a distance of 300 yards from it, runs Taylor's Vein, a small lode, underlying north, on which two or three trial-shafts have been sunk.

The Blaen-y-nant Vein, a fault with a downthrow north, runs parallel to those described above, at a distance of about 650 yards from the Belgrave Vein. It can be readily traced up from the valley of the Alyn to the cross-course mentioned above, by which

it undergoes a shift similar to that of the Belgrave Vein. Thence it runs to Erryrys, passing along the southern margin of the peaty hollow in that village, and eventually becoming lost in the calcareous sandstone series (flat-measures) further east. Half a mile west of Erryrys it throws off the Craig-y-bryniau Vein on the north, the course of which is marked for about half a mile by a line of old shafts. A small string on the southern side of the vein has been worked at Pwll-heli. There are two shafts on the Blaen-y-nant Vein in or near Erryrys, and one 700 yards further west, but little work seems to have been done in any part of the vein.

The Westminster Lode shows a similar character, both in direction and throw, to the Blaen-y-nant Vein, and lies about 600 yards south of it. It starts in the eastern side of the valley of the Alyn and runs in two branches to the cross-course previously mentioned, the more northern of the two being visible as a rib of spar 3 feet broad. This has been worked in a level and in open trenches, and is known as the Bryn-haidd Vein. East of the cross-course the two branches continue their course, running at first about 40 yards apart. The more southern of the two, known as the Pant-y-gwlanod, keeps a nearly straight course, but the northern branch, or the Westminster Lode, makes a bend northwards till it reaches a distance of about 240 yards from the southern branch, in which relative positions the two traverse the rest of the limestone-area. The Westminster Lode has been worked to a small extent in the Bog Mines, near the outcrop of a band of black limestone ("bastard Aberdo" limestone), runs of ore occurring both above and below this band. Thence eastwards the vein has been explored at intervals through the flat-measures as far as the Llanarmon Mine, on the Millstone Grit of Mynydd-du, the section of which follows:—

*Section of the Engine Shaft, Llanarmon Mine.**

	FEET.
Strata sunk through by a previous company	138
Yellow and brown coarse sandstone	85
Yellow and white sand with a little chert	3
"Pudding-bed" [sandstone with pebbles of white quartzite]	5
White sandstone	21
"Horse-clay" [stiff reddish clay]	7
"Blacking" and dark-coloured chert	4
Light-coloured chert	15
"Tuftan"	2
Soft white sand	13
Hard white sandstone	24
Soft red sand	28
Stiff reddish-yellow clay	1
Tumblers [loose blocks] of limestone in thin layers with thin layers of soft brown shale between	8
Dark thin-bedded limestone	42
	396

Near Waen-dyllog the vein seems to split, for there are indications of a fault running through Maes-y-droell, and south of the

* Section supplied by Mr. J. A. Ede.

Pen-y-foel sand-pit (p. 59). In the Pant-y-gwlanod Vein a run of ore commenced near the hamlet of that name, and below the black limestone alluded to above. To the east of that band the vein has been worked up to the surface, but has not been mined further east. These veins all cease to be recognisable on entering the area of the Millstone Grit.

The Tan-y-graig Lode crosses the southern margin of this map. It has been worked for a short distance by an open trench, and towards its eastern end by an engine-shaft; it runs parallel to the last-described, but can be followed for about 400 yards only, and not so far east as the most productive zones of the limestone. It is worth noting that the limestone forming the hanging side of the vein is bent down towards the lode for a few feet, while that in the hading is bent up towards it, that is, in both cases in the opposite direction to what would have happened had the bending been due to friction between the two faces of the fault. Some large open spaces and old washing-floors found in the underground-workings in the vein seem to indicate that the ore was washed by the "old men" before being raised to the surface, where water is scarce. A quarry about 400 yards east-south-east of the Tan-y-graig Mine shows fluorspar in a north and south joint.

South of the Tan-y-graig Vein, and distant from it 180 yards and 470 yards respectively, lie the Creigiawg Lode and the Maes-y-pwll Lode, with a lode running east and west obliquely from one to the other, known as the Vein Ganol.* The two first-named have the south-easterly direction and northerly underlie common to all the veins in the tract of limestone south of Maes-y-safn, but the Vein Ganol underlies south. The Creigiawg Lode runs from Plâs-du as far as the outcrop of the black limestone spoken of above, where an Engine Shaft has been sunk to a depth of 100 yards. The Maes-y-pwll Lode has been trenched across the limestone-hill, north-east of Llanarmon Mill, and then appears in the bend in the high road 500 yards east of the Mill, where a swallow-hole in the vein serves for the reception of the drainage off the road. The Vein Ganol joins it near the black limestone outcrop, and has been worked both in open trenches and at a depth of 60 yards. A few yards further east lies the Engine Shaft on the Maes-y-pwll Vein, which is 130 yards deep, and passed through 50 yards of black limestone ("bastard Aberdo"). Ore occurs in two runs in these veins, the one above and the other below the black limestone, as in the Westminster Lode. The Maes-y-pwll Lode runs on through the calcareous sandstones and into the Millstone Grit near the north end of Llyn Cyfynwy, where it disappears. Sulphate of baryta occurs at that spot, but more probably in connection with some north and south faults than with the vein.

HEMATITE, COPPER, AND MANGANESE ORES.

The ores of iron lie in the lower beds of the limestone only, and never occur in the same vein as the ores of lead and zinc. They

* These veins lie in Quarter-sheet 74 N.E., just south of the margin of the map now under description.

sometimes contain, on the other hand, traces of copper, and usually occupy chambers or irregularly widened-out spaces in north and south joints. The ore seems to have been formed by the replacement of the carbonate of lime of the limestone by carbonate of iron, which has subsequently by weathering, and the escape of the carbonic acid, become converted into an oxide. The only mines within the present Quarter-Sheet lie within a mile of Ysceifiog. At Bryn-Sion, west of Ysceifiog, the ore occurs in a joint running a little west of north for about 100 yards, and was worked for a short time for the Brymbo Ironworks. At Pant-gwyn, north-east of Caerwys, it lies in a small north and south fault crossing a ravine. Two shafts in the bottom of the ravine attain a depth of 31 yards and one on the top of 44 yards, with a cross-cut 21 yards westwards into the vein. The vein at the bottom of the shafts underlay west, was 7 feet broad, and composed of a layer of iron-ore on either side, and of loose blocks in the centre. Little or no ore was ever sold from here, and the works were abandoned about the year 1873. The Gledlom Iron Mine lies south-east of Caerwys. A vein runs north and south and underlies west, but the ore occurred in pockets and was worked partly in open trenches, while the shafts reach a depth of 52 to 55 yards. The ore, which amounted to about 150 tons a month for nine years, was sent to Darwin. The Llwyni Iron Mine lies 300 yards north-west of the last-described. The vein, or rather cavity, runs north-west, and has been dug completely out for about 40 yards, while at either end of it a shaft has been sunk to a depth of about 50 yards. A strong north and south joint brought in a different ground at the north end of the cavity.

Copper-pyrites occurs commonly in small grains or needles in the calc-spar of north and south lodes, and was found in greater mass in the West Holloway Mine. Pennant also remarks that "About 50 years ago, about 17 cwt. of copper-ore was discovered in a tenement of my father's called Catherine George's; which on being assayed was found to be very rich: but none has been discovered since, notwithstanding the ground has been diligently searched."* In no case within the limits of this Quarter-sheet has copper-ore occurred in sufficient bulk to be marketable.

Manganese occurred in the North Hendre Flat, as noticed on p. 183, but not elsewhere within the district now under description.

* History of the Parishes of Whiteford and Holywell, p. 123. 1796.

APPENDIX I.

(1.) COLLIERIES AND BOREHOLES IN THE FLINTSHIRE COAL-FIELD.

<i>Bagillt Colliery.</i>	<i>Ewloe Mine.</i>
<i>The Bagillt Coal-seams on the west side.</i>	<i>Cheapside Colliery, Ewloe.</i>
<i>Coleshill.</i>	<i>Northop Borings.</i>
<i>Flint Colliery.</i>	<i>Northop Green.</i>
<i>Marsh Colliery, Flint.</i>	<i>The Oak Pits, Mold.</i>
<i>Connah's Quay Boring.</i>	<i>Broncoed Colliery.</i>
<i>Eleanor Pit, Hawarden.</i>	<i>Bron-wylfa Colliery, Mold.</i>
<i>Queen's Ferry Colliery and Boring.</i>	<i>Banner Pit, Old Pentre Hobin.</i>
<i>Aston Colliery Boring.</i>	<i>Nerquis Colliery.</i>
<i>Mancot Bank Borings.</i>	<i>Coed Talwrn Iron-Works.</i>
<i>The Rake, Hawarden. Shaft and Boring.</i>	<i>Leeswood Iron-Works.</i>

(2.) BORINGS IN THE ESTUARY OF THE DEE.

<i>Latchcroft.</i>	<i>Sandycroft Borings.</i>
<i>Gorst's Farm Borings.</i>	<i>Saltney Borings.</i>
<i>Sealands Borings.</i>	

(3.) WELLS NEAR THE WELSH BORDER.

(4.) ST. WINIFRED'S WELL, HOLYWELL.

(5.) ECONOMIC GEOLOGY.

Hydraulic Cement.
Lime.
Building Stone, Chert, &c.

(1.) COLLIERIES AND BOREHOLES IN THE FLINTSHIRE COAL-FIELD.

This portion of the Appendix supplements Vertical Sections, Sheets 77 and 78, which contain the following sections situated in this map.

Sheet 77:—

Nos.

1. Borehole made by the River Dee Company at Gorst's Farm on the north side of the River Dee, opposite Sandycroft Ironworks.
2. Boring at the Rector's meadow, Hawarden.
3. Rake Pit, and boring, near Harding's Farm, Hawarden.
4. Eleanor Colliery, No. 2 Pit.
5. Latchcroft Colliery.
6. Flint, No. 2 Sinking Pit, on Sir J. Trelawney's Estate.
7. Bettisfield Colliery, No. 1 Pit.
16. Boring below Crockford's Buildings, Queen's Ferry
17. Sandycroft, Sir S. Glynn's Borings, "No. 2."
18. " " " " "No. 1."

Sheet 78:—

Nos.

1. Treiddyn Colliery, Flintshire Oil Cannel Co.
2. Coed Talon Colliery, No. 3 Cannel Pit and No. 3 Upcast Pit.

Nos.

3. Coed Talon Colliery, South Level.
4. " " " The Deep Pit.
5. Leeswood Green Colliery.
6. Coppa Colliery, No. 3 Pit.
7. Borehole at Bronwylfa Colliery, Tyddyn, Mold.
- 9 & 10. Boreholes on Plas-isaf Estate, E. of Mold.
11. Mare Hay Engine Pit.
12. Mount Pleasant Colliery, the Engine or Wood Pit.
- 13, 14, 15. Aston Colliery Shafts.
16. Great Mancot Colliery.
17. Mancot Bank Colliery.
18. New Pit, Castle Hill, Northop.
19. Dublin Main Colliery, Northop.

Bagillt Colliery.

(A reduction of about $\frac{1}{10}$ th should be made for the dip, which was probably 12°.)

		THICKNESS.		DEPTH FROM SURFACE.	
		Ft.	In.	Ft.	In.
Glacial Drift.	Sand	24	0		
	Gravel	2	7		
	Red clay	33	0		
	Grey clay	6	0	65	7
Coal Measures:—					
	Freestone	15	5		
	Blue shale	5	1		
	Freestone	22	3		
	YARD COAL	3	0	111	4
	Clay	1	0		
	Freestone	1	6		
	Blue shale	8	6		
	Freestone grits	12	2		
	Hard white rock	2	9		
	Freestone grit	8	6		
	Ironstone	0	2		
	Freestone grit	0	3		
	COAL (Three Quarter Coal of Mostyn)	2	0	148	2
	Clay and warrant	6	0		
	Ironstone	2	2		
	Blue shale	23	8		
	Freestone, hard	2	6		
	Grey shale	4	0		
	Hard white rock	8	0		
	Grey shale	18	0		
	Hard freestone	4	0		
	Blue shale	12	0		
	FIVE YARD COAL	12	0	240	6
	Clay and warrant	18	0		
	Ironstone	1	0		
	Grey shale	1	0		
	THREE YARD COAL	6	0	266	6
	Hard stone	7	6		
	Grey shale	1	6		
	Grey soft shale	30	0		
DOUBLE COAL.	COAL	1	6		
	Clay and warrant	2	0		
	COAL	1	6	310	6

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Grey shale	-	9	0	
Hard stone	-	3	0	
Grey shale	-	26	0	
Black shale	-	3	0	
Ironstone	-	1	6	
Grey shale	-	8	4	
Ironstone	-	0	6	
Black shale	-	11	0	
Ironstone	-	0	6	
Black shale	-	6	0	
LOWER DOUBLE COAL {				
COAL	-	1	6	
Clay and warrant	-	3	0	
COAL	-	0	6	384 4
Clay and warrant	-	4	0	
Grey shale	-	11	3	
YARD COAL	-	3	6	403 1
Clay	-	5	0	
Grey shale	-	11	0	
Black shale	-	3	3	
COAL	-	1	6	423 10
Clay	-	6	8	
Black shale	-	1	6	
White clay	-	4	6	
Black shale	-	18	0	
FOUR FEET COAL	-	3	6	458 0
Black clay	-	0	3	
Black shale	-	5	0	
Curly rock	-	12	0	
Black shale	-	12	0	487 3

The Bagillt Coal-seams on the west Side.

(Abstract of section.)

Measures	-	26	0	
COAL	-	4	0	30 0
Measures	-	79	0	
COAL	-	2	0	111 0
Measures	-	129	0	
FIVE YARD OR MAIN COAL	-	12	0	252 0
Measures	-	47	0	
THREE YARD COAL	-	7	0	306 0
Measures	-	99	2	
DOUBLE COAL	-	2	10	408 0
Measures	-	62	9	
YARD COAL (Two Yard Coal ?)	-	3	3	474 0
Measures	-	59	0	
COAL and CANNEL (Durbog Coal ?)	-	7	0	540 0
Measures	-	45	3	
NEW THREE YARD COAL (Stone Coal ?)	-	5	9	591 0
Measures	-	52	6	
HARD FIVE QUARTER COAL	-	4	6	648 0
Measures	-	103	3	
FIVE FEET COAL (Soft Five Quarter Coal)	-	4	9	756 0
Measures	-	79	5	
BOTTOM COAL (Bychton Coal)	-	4	7	840 0
Measures	-	118	4	
SMALL COAL (Three Quarter Coal)	-	1	8	960 0

Coleshill.

(The letters A, B, &c. refer to the table on p. 76.)

	THICKNESS.		DEPTH FROM SURFACE.		
	FT.	IN.	FT.	IN.	
Measures	196	0			
COAL "I"	2	0			
Measures	8	8			
COAL "H"	0	4	207	0	
Measures	46	6			
COAL "D"	1	6	255	0	
Measures	17	0			
COAL "C"	1	0			
Measures	10	8			
COAL "B"	1	4	285	0	
Measures	52	6			
DIRTY COAL "A" {	COAL	2	4		
	Parting	1	0		
	COAL	1	6	342	0
Measures	23	6			
BRASSY COAL	3	6	369	0	
Measures	53	9			
DIRTY COAL {	COAL				
	Parting	3	3	426	0
	COAL				
Measures	56	6			
FIVE FEET COAL	3	6	486	0	

Flint Colliery.

(The letters A, B, &c. refer to the table on p. 76.)

Drift	30	0		
Red rock	390	0		
Shaly rock (fossils)	42	0		
Red shale	56	0		
THREE YARD COAL	10	0	528	0
Warrant	7	0		
Red clunch, with ironstone	18	0		
Blue shale	7	0		
Black shale	3	6		
COAL (BRASSY COAL)	7	6	571	0
Hard flag-rock	12	0		
Shale	16	6		
COAL "I"	1	3	600	9
Dark shales, with bands of ironstone	4	7 P		
COAL "H"	1	0	606	4
Dark shales	7	6		
COAL "G"	1	6	615	4
Dark shales	10	6		
COAL "F"	0	4	626	2
Shales, with ironstone	12	0		
COAL "E"	0	2 P	638	4
Dark shales, with ironstone	42	0		
COAL "D"	2	0	682	4

Marsh Colliery, Flint.

(Abstract of section. The letters A, B, &c. refer to the table on p. 76.)

Drift and measures	488	0		
THREE YARD COAL	10	0	498	0

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Measures	40	0		
BRASSY COAL	5	0	543	0
Measures	32	0		
COAL "I" } DOUBLE COAL?	0	10	575	10
COAL "H" }	4	11		
Measures	1	1	581	10
Measures	70	6		
COAL "D"	1	6	653	10
Measures	19	0		
COAL "C" (YARD COAL)	2	0	674	10
Measures	20	6		
COAL "B"	1	6	696	10
Measures	77	2		
COAL AND CANNEL	3	0		
Parting } "A"	1	0		
COAL AND CANNEL	2	0	780	0
Measures	5	0		
COAL AND CANNEL	2	0		
Measures	0	9		
COAL AND CANNEL	1	3	789	0
Measures	13	0		
NEW THREE YARD COAL	6	0		
Parting	0	9		
COAL	1	3	810	0

Boring at Connah's Quay, west of the Railway.

Light freestone rock	8	2		
Very light freestone	7	5		
Dark freestone.	9	9		
Light-grey shale	50	2		
Light-blue shale	35	3		
Ironstone	0	2		
Dark-blue shale	24	1		
Dark band	13	10		
Ironstone	0	3		
Dark band	7	9		
Hard shaly grey rock	5	3		
Grey rock, very hard	4	8		
Ironstone	0	1		
Grey rock, very hard	13	1		
COAL	0	3	180	2
Dark metal	14	6		
COAL	2	9	197	5
Warrant, soft	1	3		
Light bluish freestone	8	7		
Dark freestone	14	2		
Ironstone	0	7		
Freestone and shale	3	3		
Soft freestone, much shale	8	0	233	3

Details of remainder of boring not given.

No. 1 Pit, Eleanor Colliery, Hawarden.

	Soil and subsoil	4	0			
Glacial Drift.	{	Purple clay	1	6		
		Quicksand	20	0		
		Brown clay	19	0		
		Gravel (water)	7	6		
		Brown clay	4	0	56	0

	THICKNESS.		DEPTH FROM SURFACE.	
	FT.	IN.	FT.	IN.
Coal Measures :—				
Light fireclay	25	5		
COAL	0	3		
Dark shale	2	4		
COAL, with 3 partings, 5 inches in all	9	5	93	5
Fireclay	6	0		
Sandy rock	3	0		
Dark shale	16	6		
TOP FOUR FEET COAL, good	4	0	122	11
Black shale interspersed with coal	5	0		
Grit-stone and black shale	9	6		
Strong black shale	15	6		
Argillaceous ironstone	0	6		
Dark shale	12	6		
Black shale	1	6		
Dark shale	0	6		
YARD COAL, with 6 inches of CANNEL on top	3	6	171	5
Dark fireclay	1	0		
Light fireclay, with ironstone-nodule	13	0		
Hard yellow sandstone	5	6		
White sandstone	5	0		
Dark shale intermingled with sandstone	25	6		
Strong dark shale	12	6		
Black shale	20	0		
LOWER FOUR FEET COAL	4	0	257	11
Fireclay	8	0		
COAL	0	6	266	5
Strong dark shale	4	0		
White sandstone	18	6	288	11

No. 4 Pit, Queen's Ferry Colliery.

Drift and measures	128	0		
MAIN COAL	10	0	138	
Fireclay	4	0		
Blue metal	18	0		
COAL	1	0	161	0
Fireclay	7	0		
Dark metal	29	0		
COAL	1	0	198	0
Fireclay, with bass	7	0		
White rock	2	6		
Blue metal	0	6		
White rock	1	6		
Blue metal, with ironstone	25	2		
"Slag" (shale)	3	6		
Grey rock	2	6		
Grey metal	8	3		
COAL	2	0	250	11
Fireclay	2	6		
Light rock	16	0		
Black "slag"	1	3		
Metal	0	6		
COAL	1	3	272	5
Fireclay	7	0		
Metal	19	0		
Black "slag"	1	0		
COAL	0	9	300	2

Queen's Ferry Colliery. Borehole No. 1.
From Mr. Lowery, M.E.

		THICKNESS.		DEPTH FROM SURFACE.	
		FT.	IN.	FT.	IN.
	Soil	-	1	6	
Glacial Drift.	Brown clay	-	17	0	
	Coarse sands and gravel	-	8	6	
	Brown clay	-	4	0	31 0
Coal Measures :—					
	Hard grey sandstone	-	3	2	
	Soft grey sandstone	-	23	11	
	Grey linstey	-	1	4	
	Light sandstone	-	6	7	
	Light linstey and sandstone	-	7	2	
	COAL	-	0	7	73 9
	Light linstey and sandstone	-	4	7	
	Light fireclay	-	1	6	
	COAL - - 4 4	-	-	-	
	Brassy stone - 0 4	-	8	10	88 8
	COAL - - 4 2	-	-	-	
	Light fireclay	-	5	2	
	Soft light metal and fireclay	-	4	8	
	Light metal	-	4	0	
	Darker metal	-	7	2	
	Hard dark linstey	-	1	6	
	COAL	-	3	7	114 9
	Soft dark-grey fireclay	-	1	0	
	Dark-grey linstey	-	3	6	
	Dark-grey linstey and metal	-	6	0	
	Dark-grey linstey	-	2	8	
	Dark sandstone	-	6	0	
	White bedded sandstone	-	3	8	
	Grey linstey and sandstone	-	9	6	
	Light metal, with <i>ironstone-nodules</i>	-	6	3	
	Darker metal	-	10	10	
	Dark linstey, with <i>ironstone-nodules</i>	-	3	5	
	Light soft metal	-	3	6	
	Dark linstey, and <i>ironstone-nodules</i>	-	2	8	
	Dark metal	-	4	7	
	COAL	-	1	4	179 8
	Light fireclay	-	1	8	
	White sandstone	-	6	1	
	Hard white sandstone	-	1	8	189 1

Borehole at Aston Colliery, three-quarters of a mile south-west of Queen's Ferry Station.*

(Above Ordnance Datum, about 100 feet.)

Clay, sand, loam, and gravel [Glacial]	-	86	4	86	4
Metal and <i>ironstone</i>	-	2	4		
Grey rock	-	2	0		
Metal and <i>ironstone</i>	-	5	0		
Linstey	-	2	0		
Light-blue metal	-	0	6½		
<i>Ironstone</i>	-	0	3		
Metal and <i>ironstone</i>	-	6	0		
<i>Ironstone</i>	-	0	1½		
Blue metal	-	1	1		
Black metal	-	4	8		
Measures, with some seams of COAL	-	390	0	500	4

* Information from Mr. W. G. Shrubsole, F.G.S.

*Borehole at Mancot Bank, one mile south-south-east of Queen's Ferry Station.**

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Red clay [Boulder Clay]	36	0	36	0
Red sandstone	18	0		
White sandstone	27	0		
Light metal	18	0		
Linstey	3	0		
Light and dark shale	12	0		
Sandstone	3	0		
Shale and ironstone	1	4		
Shale	1	4		
BIND COAL	2	9	122	5
Measures	216	7	339	0
MAIN COAL.				

Mancot Bank. No. 2 Borehole.

Drift and measures	91	4		
MAIN COAL	10	9	102	1
Measures	36	0		
Fireclay	5	9		
Grey linstey	24	6		
Rock	1	0		
Grey linstey	14	2		
Rock	13	0		
Fireclay	4	6		
Metal	2	0		
COAL and bass	1	1	204	1
Warrant	3	0		
Hard rock	6	0		
Soft rock	5	0		
Grey linstey	12	0		
Hard rubble	10	0		
Grey linstey	5	0		
COAL	1	11	247	0
Fireclay	15	0		
Sandstone	1	9		
Measures	28	0		
COAL	3	10	295	7
Fireclay	1	6		
COAL	3	9	300	10
Fireclay	7	0		
COAL	6	0	313	10

Shaft and Borehole at the Rake, Hawarden.†

(Above Ordnance Datum about 50 feet.)

Glacial De- posits.	Soil and clay	4	0		
	Strong marl [Boulder Clay]	30	0		
	Blue "chuck" with particles of coal	1	6		
	Strong marl	27	0		
	Loam and sand	2	0		
	Strong marl	26	0		
	Gravel and sand	2	6		
	Strong marl	33	0		
Sand and gravel	4	0	130	0	

* Information from Mr. W. G. Shrubsole, F.G.S.

† Information from Messrs. Townsend and Barker.

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Coal Measures:—				
Dark metal and <i>ironstone</i>	-	3	4	
Soapy metal	-	4	9	
COAL	-	2	9	140 10
Warrant	-	2	0	
Blue metal	-	1	8	
White earth	-	2	0	
Light metal	-	8	0	
COAL	-	0	6	155 0
Warrant and metal	-	3	8	
Blue metal	-	2	0	
Rock and linstey	-	16	6	
Blue metal, with bands of <i>ironstone</i>	-	5	10	
Linstey and metal	-	2	6	
Linstey and rock	-	4	9	
Metal and linstey	-	17	10	
Blue and dun metal	-	13	3	
Black bass	-	0	5	
COAL	-	3	0	
Light and dark metal	-	0	7	
MAIN COAL	-	13	6	238 10
Boring from the bottom of the pit:—				
Warrant	-	9	0	
Light soapy metal	-	20	3	
Strong rock	-	1	11	
Light metal	-	10	4	
Soapy metal	-	5	0	
Strong burr-rock	-	1	0	
Light metal	-	5	8	
Burr-stone	-	0	5	
Light metal	-	4	9	
Metal and <i>ironstone</i>	-	2	10	
Strong linstey	-	3	6	
Light metal	-	4	0	
Mild linstey	-	3	6	
Strong light metal	-	10	3	
Metal and <i>ironstone</i>	-	1	0	
Light metal	-	5	0	
Brown burr-stone	-	3	8	330 11
Blue soapy metal	-	10	0	
Grey linstey	-	1	1	
COAL	-	1	4	343 4
Warrant	-	1	4	
Rock	-	8	3	
Burr-stone	-	2	8	
Light metal	-	15	5	
COAL and bass	-	3	4	
Warrant and metal	-	6	9	
Soft metal	-	32	3	
White burr-stone	-	1	4	
Dark and light metal	-	4	1	
COAL and CANNEL	-	4	1	422 10
Warrant	-	1	11	
Metal	-	2	4	
Dark metal	-	7	9	
COAL	-	3	9	438 7
Warrant	-	4	7	
Hard rock	-	9	0	
Metal	-	2	0	
Hard rock	-	13	3	

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Grey linstey	-	-	3	3
COAL	-	-	5	8
Warrant, proved to	-	-	0	11
			476	4
			477	3

Ewloe Mine, 1855.

	THICKNESS.		DEPTH FROM THE BINE COAL.	
	Ft.	In.	Ft.	In.
BOYNE, or BINE COAL.	-	-	2	3
Hard stone	-	-	6	0
HOLLIN COAL	-	-	7	0
Blue metal	-	-	18	0
Hard sandstone	-	-	15	0
Metal	-	-	3	0
THIN COAL	-	-	1	6
Metal	-	-	12	0
Stone	-	-	16	0
Metal	-	-	12	0
BRASSY COAL	-	-	3	0
Metal	-	-	23	0
Hard stone	-	-	8	0
Metal	-	-	18	0
ROUGH COAL	-	-	3	0
Metal	-	-	14	0
Hard stone	-	-	26	0
Metal	-	-	9	0
MAIN COAL	-	-	10	0
Stone	-	-	27	0
LITTLE COAL	-	-	0	9
Strata, details unknown	-	-	177	0
NEW COAL (WALL and BENCH)	-	-	4	6
			145	6
			93	6
			204	6
			232	3
			413	9

No. 2 Pit of the Cheapside Colliery, Ewloe Green.

(From a section preserved in the Home Office.)

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Soil and clay	-	-	9	0
Blue metal	-	-	7	0
Sandstone	-	-	3	0
Blue metal	-	-	8	0
Linstey rock	-	-	9	0
Metal (nodules)	-	-	18	0
Ironstone	-	-	0	3
Bass	-	-	1	6
COAL	-	-	0	2
Blue metal	-	-	4	0
Bass	-	-	0	3
MAIN COAL	-	-	11	0
			71	2

The measures dip at 12° in a direction E. 17° N. in this colliery. The workings in the Main Coal were abandoned on October 31st, 1874, and those in the Brassy Mine in August, 1876. The latter was much traversed by "crushes," and by a fault with a downcast eastwards, in two steps of 2 feet and 1½ feet respectively, and ranging N. 15° W. magnetic, or nearly due north, true.

Northop Borings, &c.

Communicated by Mr. J. Alexander.

Borehole at Mine 2.

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Glacial Drift.	Gravel	6	0	
	Loamy clay	6	0	
	Gravel	1	6	
	Sand	3	0	
	Clay, not got through	3	0	19 6

Borehole at Mine 3.

Glacial Drift.	Dark clay.	3	6	
	Gravel	1	0	
	Clay	4	0	
	Rock [P a boulder]	2	0	
	Dark clay.	7	6	
	Fine sand, not got through	38	6	56 6

Borehole at Mine 4.

Glacial sand	66	0	66 0
Rock	75	3	
Shale	57	9	199 0

No. 2 Sinking Pit on Sir John Trelawney's Estate, Northop, 1865.

Glacial Drift.	Soil	1	0	
	Clay	9	0	
	Gravel	2	0	
	Red sand	8	10	
	Red clay	0	4	
	Red sand	6	10	
	Quicksand	3	7	
	Large boulder	5	0	
Measures	Gravel	3	9	40 4
	COAL	264	5	
		10	6	315 3

Northop Green.

Borehole.

Glacial Drift.	Soil	1	6	
	Gravel	4	6	
	Loamy clay	6	0	
	Sand	3	0	
	Clay	3	0	
	Gravel	1	6	
	Clay	4	0	
	Rock [P a boulder]	2	0	
	Black clay	3	0	
	Clay	4	6	
	Sand	7	0	
	Gravel	2	0	
	Clay	2	0	
	Sand	19	0	63 0

		THICKNESS.		DEPTH FROM SURFACE.	
		Ft.	In.	Ft.	In.
Coal Measures :—					
	Rock	75	3		
	Metal	68	5		
	Ironstone	0	7		
	Metal	45	0		
	Ironstone	0	5		
	Metal	5	7		
	Rock	18	2		
	Dark metal	3	5		
	COAL	0	5		
	Dark metal	2	8		
	COAL	0	6	283	5
	Warrant	2	0		
	Rock	5	6		
	Ironstone	0	6		
	Dark rock	9	0		
	Metal	21	0		
	Rock	15	0		
	Linstey	24	0		
	Blue metal	8	0		
	Ironstone	0	2		
	Metal	53	1		
	Light rock	36	0		
0 88	Shale	17	0		
	Linstey	30	0		
0 991	Rock	10	0		
	Metal and shale	101	0		
	COAL	1	8	617	4

N orthop; boring on the western side of the road, near the Church.

Communicated by Mr. J. Alexander.

Glacial	{ Soil and clay	.	.	.	10	0		
Drift.		{ Sand and gravel	.	.	.	12	0	22 0
Coal-	{ Rock		.	.	.	46	0	68 0
Measures.		{ Metal	.	.	.	.	.

The Oaks Pits, Mold.

(A bstract of Section.)

Measures	.	.	.	.	.	288	4		
BIND COAL	.	.	.	.	.	2	8	291	0
Measures	.	.	.	.	.	8	5		
HOLLIN COAL	.	.	.	.	.	6	7	306	0
Measures	.	.	.	.	.	42	4		
BRASSY COAL	.	.	.	.	.	2	8	351	0
Measures	.	.	.	.	.	68	8		
MAIN COAL	.	.	.	.	.	6	4	426	0
Measures	.	.	.	.	.	101	0		
STONE COAL	.	.	.	.	.	4	0	531	0
Measures	.	.	.	.	.	22	3		
COAL AND CANNEL	.	.	.	.	.	2	9	556	0
Measures	.	.	.	.	.	43	6		
COAL	.	.	.	.	.	1	9		
Parting	{ WALL AND BENCH COAL	.	.	.	.	1	0		
COAL		1	9	604	0

Broncoed Colliery.

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Measures	93	0		
BINE COAL	3	0	96	0
Measures	6	0		
HOLLIN COAL	6	0	108	0
Measures	42	9		
BRASSY COAL	2	3	153	0
Measures	53	0		
ROUGH COAL	1	0	207	0
Measures	14	0		
MAIN COAL	7	0	228	0

This colliery was formerly worked from three shallow shafts on the crop, and afterwards from three shafts on the deep, carried to the Main Coal.

Shaft No. 2 of the Bron-wylfa Colliery, Mold.

(From a section preserved in the Inspector of Mines Department of the Home Office.)

The dip being 24° in the upper part of the shaft, and 18° in the lower, the following thicknesses will be about $\frac{1}{10}$ th in excess above the Main Coal, and about $\frac{1}{10}$ th in excess, below it.

Glacial Deposits.	Clay and marl	35	0	61	0
	Quicksand	25	0		
	Clay	1	0		
Coal Measures:—					
	Soft metal	19	0		
	Brown rock	2	0		
	White rock	18	0		
	Metal	16	0		
	Rock	2	0		
	BIND COAL	4	0	122	0
	Warrant	6	0		
	HOLLIN COAL	6	6	134	6
	Warrant	5	0		
	Metal	15	6		
	Rock	5	0		
	Rock-binds	6	0		
	CRANK COAL	1	9	167	9
	Warrant	1	6		
	Metal	13	3		
	BRASSY COAL	3	6	186	0
	Metal	24	0		
	Hard brown rock	3	0		
	Hard white rock	21	0		
	ROOF COAL	2	0		
	Warrant	4	0		
	BAD COAL	0	6	240	6
	Metal	7	6		
	Rock-binds	3	0		
	COAL	2	6		
	Strong rock-binds	0	6		
	COAL	0	9	254	9
	Metal	6	3		
	Dark metal	4	0		
	MAIN COAL	5	0	270	0

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Warrant	6	6		
Strong metal	6	6		
" Busty COAL "	1	0		
Dark warrant	2	0		
COAL	0	9		
Warrant	4	9		
COAL	1	6	293	0
Dark warrant	17	0		
Strong metal	21	0		
Bass and COAL	0	9		
Metal and rock-bands	5	3		
Linn and wool, and bands of rock	9	0		
Soft metal	12	0		
Black bass	0	9		
BUSTY COAL	1	3	360	0
Light warrant	5	0		
Linn and wool, bands of rock	2	0		
Strong metal	41	0		
COAL	0	8	408	8
Light warrant	6	4		
Rock-band	2	0		
Soft metal	5	0		
COAL	2	0	424	0
Dark warrant	9	0		
Linn and wool, and bands of rock	24	0		
Soft metal	18	0		
COAL	1	0	476	0
Dark warrant	5	0		
Rock-bands	3	0		
Linn and wool-bands, rock-bands	6	0		
Metal	6	0		
Blackstone shales	5	0		
COAL	0	6		
Shale	1	6		
CANNEL	2	0		
COAL	1	0	506	0
Warrant	6	0		
White rock	13	0		
Grey linsey	23	0		
Ironstone	2	0		
Black metal	8	0		
Dark shale	13	0		
COAL	3	0		
Warrant	1	0		
COAL	2	0	577	0
Warrant	4	0	581	0

Banner Pit, Old Pentre Hobin.

Communicated by Major Vickers, Hawarden Estate Office.

Measures	221	0		
BINE COAL	3	0	224	0
Measures	6	0		
HOLLIN COAL	8	0	238	0
Measures	60	0		
BRASSY COAL	4	6	302	6
Measures	54	0		
ROUGH COAL	3	0	359	6
Measures	66	0		
MAIN COAL	10	0	435	6

Nerquis Colliery.

(Abstract of Section.)

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Measures	238	0		
HOLLIN COAL	5	0	243	0
Measures	207	0		
MAIN COAL	5	0	455	0
Measures	126	3		
CANNEL	2	9	584	0

Coed Talwrn Iron-Works.

Collected by Mr. D. H. Williams.

Soil, clay, and gravel (Glacial Drift)	52	6	52	6
Soft grey sandstone	60	0		
Hard sandy blue shale	30	6		
Hard shale	15	0		
Hard sandstone	12	6		
Blue sandy shale, with balls of <i>mine</i> (ironstone)	18	0		
POWEL COAL	2	0	190	6
Soft underclay	3	0		
TWO YARDS COAL (or HOLLIN-COAL)	5	0	198	6
Fireclay	3	0		
LITTLE COAL	1	2	202	8
Balls of <i>iron-mine</i>	0	2		
Underclay	3	0		
Hard sandy shale	30	0		
Sandstone	12	2		
<i>Mine</i>	0	2		
CRANK COAL	1	0	249	2
Fireclay	2	0		
Hard shale	12	4		
Hard sandstone	9	0		
Strong blue sandy shale	6	0		
Hard sandstone	5	0		
Shale, with <i>mine</i>	9	0		
BRASS VEIN COAL	5	0	297	6
Fireclay	3	0		
Hard shale, with white <i>mine</i>	13	6		
Hard white sandstone	6	0		
Blue shale	8	0		
Shale, with <i>mine</i>	1	0		
Black carbonaceous <i>iron-mine</i> , with shells	0	10		
BLACK VEIN COAL	0	10	330	8
Hard underclay	9	0		
Hard white sandstone	4	0	343	8
Hard blue shale	7	0		
Shale, with new <i>mine</i>	4	0		
Hard dark shale	10	6		
Dark shale and <i>mine</i>	4	0		
Shale	19	0		
Dark shale and <i>mine</i>	3	6		
Shale, with balls of <i>mine</i>	8	0		
TOP COAL	3	0		
FURNACE COAL (soft)	3	6		
BOTTOM COAL	4	0	410	2

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Black carbonaceous shale and COAL	2	3		
LITTLE COAL	2	3	414	8
Grey underclay, with <i>mine</i>	4	5		
Grey sandstone	4	5		
<i>Mine</i>	0	1½		
Shale	2	6		
COAL	2	2		
<i>Mine</i> } FOUR FOOT COAL, 1 yd. 1 ft. 2 in.	0	8		
COAL	1	4	430	3½
Fireclay	1	3		
Grey underclay	10	4		
Soft light sandstone	5	11		
Dark sandstone, with "stairs" of COAL	6	6		
<i>Mine</i> (poor)	0	2		
Dark shale	3	5		
<i>Mine</i>	0	1		
Grey shale and balls	3	5		
Dark shale	12	6		
<i>Mine</i>	0	2		
Shale	0	6		
<i>Mine</i>	0	2		
Shale	2	0	476	8½
<i>Mine</i>	0	3		
Black carbonaceous shale	0	6		
Grey shale	1	0		
Hard sandstone	2	3		
Dark-grey shale	9	0		
COAL. STINKING VEIN (red ash)	1	6	491	2½
Soft grey underclay	2	3		
Hard white sandstone	0	9		
Shale } said to have been sunk through subse-	27	0		
COAL } quently	3	0	524	2½

Leeswood Iron-Works.

Collected by Mr. D. H. Williams.

Clay and gravel (Glacial Drift)	39	0	39	0
Shale	53	6		
Hard sandstone	30	3		
Shale	3	0		
Hard white sandstone	27	0		
Shale	20	9		
<i>Mine</i> (ironstone)	0	4		
Shale	2	0		
POWER COAL	2	1	177	11
Soft blue underclay	3	0		
TWO YARDS COAL (or Hollin Coal)	6	0	186	11
Fireclay	1	6		
LITTLE COAL	2	3		
Hard underclay	11	6		
COAL	1	6		
Underclay	3	0		
Hard shale	25	6		
<i>Mine</i>	0	3		
Shale	1	0		
CRANK COAL	0	11	234	4

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Fireclay	3	0		
Soft sandstone	12	0		
Shale	1	0		
Hard white sandstone	7	0		
Shale, with <i>Brass Mine</i>	8	0		
BRASS VEIN COAL	4	0	269	4
Fireclay	3	0		
Shale, with white <i>mine</i>	9	0		
Hard sandstone	15	0		
<i>Mine</i>	0	4		
Shale, with five bands of <i>mine</i>	16	0		
Black carbonaceous <i>mine</i> , with shells	0	6	313	2
Shale	2	0		
BLACK VEIN COAL	2	0	317	2
Soft blue underclay	6	0		
Shale	13	6		
Black shale	21	0		
Hard sandstone	22	6		
Blue shale	13	6		
Balls of <i>ironmine</i>	0	4		
MAIN COAL	9	0	408	0
Underclay				

(2.) BORINGS IN THE ESTUARY OF THE DEE.

*Borehole at Latchcroft, on the west side of the London and North-Western Railway, at 7½ miles from Chester.**

(Above Ordnance Datum, about 17 feet.)

Sand [estuarine] and clay [Boulder Clay]	54	0	54	0
Slate-clay	45	0		
Light-coloured sandstone	1	0		
Slate-clay	17	0		
Light-coloured sandstone	7	6		
Slate-clay, with micaceous sandstone	27	0		
Dark slate-clay, with bands of <i>ironstone</i>	9	0		
DIRTY COAL, with pyrites	6	0	166	6
Slate-clay	12	0		
COAL	0	2		
Dark and white clay	15	0		
Slate-clay	1	6		
YARD COAL	3	0	198	2
Measures	65	0		
FIVE QUARTER COAL	3	9	266	11

*Borehole about a third of a mile south-south-east of Gorst's Farm, and 20 yards from the north bank of the Dee.**

(Above Ordnance Datum, about 15 feet.)

Estuarine Deposits.	Sea-sand	72	0		
	Gravel	3	0	75	0
Glacial Drift.	Clay with stones [Boulder Clay]	58	0		
	Sand and gravel	14	0	147	0

* Information from Mr. W. G. Shrubsole, F.G.S.

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Coal Measures :—				
Red "crocker-rock" [sandstone]	2	10		
"Faky" [shaly] fireclay	16	2		
Grey sandstone	5	10		
Grey "fakes" [shale]	13	0		
Shale	0	4		
COAL	0	10		
Fireclay	3	0		
Grey "fakes"	15	0		
Sandstone	24	0		
ROUGH { COAL	3	2		
{ SOFT COAL	0	8		
{ Fireclay	1	4		
{ COAL	1	7	234	9
Sandstone	7	0		
Laminated fireclay	7	9		
COAL	0	6		
Fireclay	4	0		
Sandstone	92	0		
Dark shale	15	0		
MAIN COAL	11	2	372	2

*Borehole half a mile east of Gorst's Farm.**

(Above Ordnance Datum, about 15 feet.)

This is said to have passed through 100 yards of sand, gravel, and clay.

*Borehole on Sealand Marsh, about one mile south-west of Shotwick.**

(Above Ordnance Datum, about 15 feet.)

This boring is said to have passed through 170 yards of "rock" and to have left off on the top of the Coal-Measures.

*Borehole at the cross-roads one and a half mile south-south-west of Shotwick.**

(Above Ordnance Datum, about 15 feet.)

This is said to have passed through 64 yards of gravel and sand, and to have been abandoned on the top of the Coal-Measures.

Sandycroft Borings.

(Information from Mr. H. E. Taylor.)

Borehole No. 1, by the side of the London and North-Western Railway, was sunk for coal, but afterwards used for water, which rose from a bed of gravel, the lower part of the hole having been enlarged by exploding in it a charge of powder.

Borehole No. 2, 10 yards further from the railway, is used as a source of water. The section is given below.

Borehole No. 3, by the gasworks, was abandoned in the estuarine sand.

* Information from Mr. W. G. Shrubsole, F.G.S.

Borehole No. 4, a few yards east of the cross-roads by the New Inn, Duckworth's Row, was sunk some years ago to a considerable depth in search of coal, and proved the section given on p. 219.

The quality of water yielded by the Glacial Sand and Gravel tapped in these boreholes is indicated in the following analysis by Mr. W. F. Lowe, of Chester. The water overflows freely at the surface:—

Borehole No. 2.

In parts per 100,000 of water:—

Free ammonia	-	-	-	-	021
Albumenoid ammonia	-	-	-	-	006
Oxygen required to oxidise the organic matter in					
3 hours	-	-	-	-	009
Chlorine	-	-	-	-	7.6
Total solid matter (principally carbonate of lime)	-	-	-	-	53.8
Temporary hardness	-	-	-	-	15.7
Permanent hardness	-	-	-	-	8.9

The water was considered by Mr. Lowe to be well suited for drinking purposes, but not for use in steam-boilers, on account of the large quantity of solid matter that is deposited on boiling.

A sample of water from Borehole No. 4 was found by Mr. Lowe to be yellowish-green in colour and turbid. It contained a large quantity of solid matter, consisting principally of sulphate of lime with much iron, and was not suitable for either steam-boilers or household use.

*Borehole (No. 2 of the Sandycroft borings) by the side of the London and North-Western Railway at Sandycroft.**

(Above Ordnance Datum, about 17 feet.)

		THICKNESS.		DEPTH FROM SURFACE.		
		Ft.	In.	Ft.	In.	
Estuarine Deposits, &c.	Surface-soil	-	1	6		
	Sea-sand	-	41	0	42	6
Glacial Drift.	Brown clay [Boulder Clay]	-	75	0		
	Sand, with water	-	12	0		
	Sand and gravel, yielding 40 gallons of water per minute	-	18	0		
	Clay and sand	-	8	0		
Middle Coal Measures:—	Sand	-	9	0		
	Clay and stones	-	31	0	195	6
	Hard red sandstone	-	5	0		
	Reddish fireclay	-	7	0		
	Hard red linstey	-	16	6		
	Red sandstone	-	14	9		
	Linstey and fireclay	-	18	3		
	Reddish linstey	-	4	7		
	Red sandstone	-	2	9		
	Red and grey sandstone	-	12	10		
	Red linstey and fireclay	-	3	6		
Light blue fireclay	-	1	2			
Red linstey-sandstone	-	8	10			
Red linstey	-	5	11			

* Information from Mr. W. G. Shrubsole, F.G.S.

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Red and grey fireclay	-	10		3
Red linstey	-	3		0
Red linstey-sandstone	-	4		0
Red metal	-	2		0
Red and blue linstey	-	3		0
Red linstey and fireclay	-	4		6
Red linstey	-	10		3
Red sandstone	-	2		0
Red and blue linstey and fireclay	-	5		0
Red and blue linstey	-	9		6
Red and blue metal	-	4		0
Red linstey	-	4		10
Red metal	-	1		0
Red linstey-sandstone	-	7		3
Dark-blue metal	-	4		2
COAL and light fireclay	-	2	374	0
Light metal and fireclay	-	12		3
Red and grey linstey	-	0		10
Red sandstone	-	3		4
Red and grey linstey	-	11		0
Red sandstone	-	2		6
Red and grey linstey	-	5		0
Red sandstone	-	2		4
Red metal	-	3		0
Light metal	-	3		9
Limestone (?) and linstey	-	1		4
Red and blue linstey and fireclay	-	18		9
Red linstey	-	5		0
Red and grey linstey and fireclay	-	3		4
Red and grey sandstone	-	1		8
Red linstey	-	6		0
Red sandstone	-	7		6
Red linstey and fireclay	-	2		0
Red linstey-sandstone	-	5		4
Red and blue linstey and fireclay	-	15		2
Light linstey and fireclay	-	8		8
Light sandstone and red fireclay	-	10		6
Light linstey, sandstone, and fireclay	-	8		7
White sandstone	-	3		10
Light linstey and fireclay	-	14		4
Sandstone	-	9		11
Grey linstey	-	0		11
Light fireclay	-	1		3
Dark metal	-	1		5
COAL	-	2	546	3
Light fireclay	-	1		2
Dark metal	-	11		0
Grey linstey	-	0		10
Light linstey and fireclay	-	3		2
Dark linstey and fireclay	-	11		4
Dark metal and linstey	-	11		8
Light linstey and metal	-	6		6
Light fireclay	-	1		0
Light linstey and fireclay	-	8		0
Dark metal	-	0		3
COAL	-	0	601	9
Light metal	-	3		6
Fireclay and linstey	-	9		4

	THICKNESS.		DEPTH FROM SURFACE.		
	Ft.	In.	Ft.	In.	
Metal and linstey	-	-	7	4	
Metal, with <i>ironstone</i>	-	-	12	5	
Light metal	-	-	2	6	
Linstey, with bands of sandstone	-	-	3	6	
Light metal	-	-	1	6	
Hard grey sandstone	-	-	2	10	
Grey linstey and dark metal	-	-	7	6	
COAL	-	-	2	4	654 6
Dark-grey fireclay	-	-	0	6	
Light sandstone	-	-	14	0	
Grey linstey-fireclay	-	-	5	1	
Light linstey-fireclay, with <i>ironstone</i>	-	-	5	9	
Dark fireclay	-	-	1	1	
Bass	-	-	0	5	
Dark fireclay	-	-	1	0	
Bass	-	-	0	10	
Dark metal	-	-	0	9	
Linstey-sandstone	-	-	2	6	686 5

*Sandycroft, No. 4 Boring.**

Drift and measures	-	-	-	228	11	228	11
MAIN COAL	-	-	-	9	6	238	5
Soft light-fireclay	-	-	-	0	9		
Linstey-fireclay	-	-	-	8	9		
Dark-blue metal	-	-	-	3	9		
Dark "slag" [shale]	-	-	-	0	6		
Dark-grey fireclay and metal	-	-	-	8	4		
COAL	-	-	-	1	4	261	10
Dark-grey fireclay	-	-	-	1	0		
Grey fireclay	-	-	-	4	6		
<i>Ironstone</i>	-	-	-	0	7		
Linstey-fireclay	-	-	-	4	8		
Light-blue metal and linstey	-	-	-	19	6		
Hard dark linstey	-	-	-	11	0		
Light linstey	-	-	-	1	0	304	1

*Sandycroft, No. 5 Boring.**

Drift and measures	-	-	-	334	11		
COAL	-	-	-	1	2	336	1
Linstey	-	-	-	3	9		
Blue metal	-	-	-	3	6		
Blue metal and linstey	-	-	-	4	9		
Blue linstey	-	-	-	4	8		
Blue metal and <i>ironstone</i>	-	-	-	1	0		
Blue linstey, metal, and coal-smuts	-	-	-	4	6		
Blue metal	-	-	-	3	2		
Light fireclay	-	-	-	1	6		
COAL	-	-	-	3	9	366	8
Grey and blue metal	-	-	-	1	7		
Blue metal, with <i>ironstone</i>	-	-	-	6	0		
Linstey, blue metal	-	-	-	3	4		
Light-blue metal	-	-	-	5	2		
COAL	-	-	-	0	6	383	3

* Communicated by Mr. W. G. Shrubsole, F.G.S.

	THICKNESS.		DEPTH FROM SURFACE.	
	Ft.	In.	Ft.	In.
Light fireclay	3	9		
Light-blue metal, with coal-bands	4	6		
Linstey, metal, and ironstone	6	1		
Linstey, ironstone	6	2		
Very hard linstey, with ironstone	1	4		
Dark-grey sandstone, linstey	1	6		
Dark linstey	1	9		
Linstey-fireclay	0	7		
Linstey	2	11		
Blue metal, ironstone	10	0		
Blue linstey and metal	3	9		
Dark linstey-fireclay, with coal-bands	4	8		
Dark-grey linstey	4	4		
Blue metal, with coal-bands	8	2		
ght linstey-sandstone	3	4		
Light-blue metal	4	6		
Dark ironstone-balls	4	6		
Dark linstey-metal	2	0		
Blue metal, ironstone	1	0		
Very dark grey rock	2	6		
Very dark soft grey rock	0	8		
Dark metal, hard linstey	1	3		
Dark metal	6	0		
COAL	1	9	470	3
Linstey-fireclay	0	10		
White sandstone	6	0	477	1

*Boring at the Anchor Works, Saltney, 1885.**

(Above Ordnance Datum, about 17 feet.)

	Ashes	1	6		
Estuarine Deposits.	Alluvial soil	4	8		
	Sand	19	11		
	Shingle	1	0	27	1
	Red clay	16	1		
	Sand	1	0		
Glacial Drift.	Red clay	5	4		
	Boulder	1	3½		
	Red clay	39	6		
	Boulder	0	8½		
	Red clay	20	0		
	Boulder	1	7		
	Red clay	28	3		
	Boulder	1	2		
	Clay and stones	9	6	151	6
	Red sandstone] and stones	7	3		
Arenaceous clay	20	9			
New Red Sandstone.	Red sandstone	17	1	196	7

* Communicated by Mr. W. G. Shrubsole, F.G.S.

*Borehole in the Dea Oil Company's Candle Works, Saltney.**

(Above Ordnance Datum, about 17 feet.)

		THICKNESS.		DEPTH FROM SURFACE.	
		Ft.	In.	Ft.	In.
Estuarine Deposits.	Sand	39	0	39	0
	Fine brown clay	15	0		
	Sand, with bands of clay	8	0		
	Sandy clay, with stones	18	0		
	Brown clay	6	0		
Glacial Drift.	Sand and gravel	1	0		
	Clay, with sand and gravel	19	0		
	Sand and gravel	4	0		
	Sand, with water	3	0		
	Fine clay, with bands of sand	1	0		
	Sand and gravel, with water	3	0		
	Clay	3	0	120	0
New Red Sandstone.	Red sandstone	1	9	121	9

(3.) WELLS NEAR THE WELSH BORDER.

In the following wells water, not always of good quality, was obtained in abundance by sinking through the impermeable sheet of Boulder Clay of the Cheshire plain to the underlying sand, and in some cases to the New Red Sandstone. The water generally rose with some force up to or above the surface of the ground.

Broughton.—Well-house Farm. Information from Messrs. Townsend and Barker.

Above Ordnance Datum, about 22 feet.

	FEEET.
Sea-sand and loam [Estuarine Alluvium]	12
Marl [Boulder Clay]	72
Gravel. Water overflowed at the surface	—
	84

Hawarden.—Manor Farm. Information from Messrs. Townsend and Barker.

Above Ordnance Datum, about 30 feet.

Borehole in sand. Water rose to the surface, but afterwards became discoloured and was disused.

Bretton.—Information from Mr. Samuel Beckett.

Above Ordnance Datum, about 26 feet.

	FEEET.
Umber-coloured clay, with few stones [Boulder Clay]	57

The water rose with great force and overflowed at the surface.

Dadleston.—Well near the centre of the village. Information from Mr. Samuel Beckett.

	FEEET.
Clay; water rises to the surface	51

* Communicated by Mr. W. G. Shrubsole, F.G.S.

Dodleston.—Public Well. Information from Mr. Samuel Beckett.

	FEET.
Clay; water does not reach the surface	- about 50 or 55

Dodleston.—Rectory Well. Information from Mr. Samuel Beckett.
Above Ordnance Datum, about 55 feet.

	FEET.
Clay and sand	- - - - - 145
Rock	- - - - - —
	145

Water overflows all the year round.

Kinnerton.—Above Ordnance Datum, about 50 feet.

	FEET.
Clay	- - - - - 75

Pulford.—Information from Mr. Samuel Beckett.
Above Ordnance Datum, about 50 feet.

	FEET.
Red brick-clay [Boulder Clay]	- - - - - 60-70

The water had an offensive odour [presumably of sulphuretted hydrogen].

Pulford, Cheaveley, and Poulton.—In all these villages some wells, sunk through Boulder Clay to a depth of 60 or 70 feet, have yielded water with an offensive odour. An analysis of the Cheaveley supply by Mr. G. W. Shrubsole showed the presence of 204 grains of solid matter to the gallon. The smell was partly removed by laying a filtering bed of sand and gravel in the bottom of the well. In two instances, however, namely, at Mr. Challon's and at Mr. Hartshorn's farms, on the south side of the Rake Lane (Quarter-Sheet 80 S. W.), good water was obtained. This was the more remarkable inasmuch as at three other farms, about half a mile to the west, a quarter of a mile to the north, and about one mile to the east, bad water was found in similar situations.

In no instance has any cause for the impurity been detected by the well-sinkers. The strong offensive smell is probably due to sulphuretted hydrogen, and the solid impurity was stated to contain a large proportion of the salts of magnesia. Such impurities are scarcely known in water from Drift Sand or New Red Sandstone, but are common in springs from Coal-Measures. It is possible that there are such springs here rising along the line of the Bala Fault, and impregnating the overlying beds.

(4.) ST. WINIFRED'S WELL, HOLYWELL.

This great spring issues from the upper beds of the Chert, near the line along which this formation dips under the impermeable shales of the Lower Coal-Measures (the Holywell Shales). It lies at a height of about 210 feet above Ordnance Datum, and, according to an estimate by Mr. Bostock,* yields 4,400 gallons per minute (= nearly twenty tons). It varies, however, according to the weather, and after heavy rain becomes swollen and turbid. Miraculous properties are attributed to the water, and the well is much frequented by cripples and others, but the following analysis by Mr. Barrat † shows that "there is nothing remarkable in its composition, as regards either the quantity or the quality of the substances dissolved in it, excepting perhaps its freedom from organic matter."

* *Proc. Liverpool Geol. Soc.* Sess. ix., p. 69. 1868.

† *Quart. Journ. Chem. Soc.*, vol. xii., p. 52. 1860.

Analysis of the water of St. Winifred's Well.

Temperature, 52° Fahr.*

Specific gravity, 1·0015.

	PER IMPERIAL GALLON (GRAINS).
Carbonate of lime - - - -	13·685
Carbonate of magnesia - - - -	2·688
Protocarbonate of iron - - - -	traces
Sulphate of lime - - - -	5·202
Chloride of sodium - - - -	·851
Chloride of potassium - - - -	traces
Chloride of calcium - - - -	3·094
Carbonate of soda - - - -	1·432
Sulphate of magnesia - - - -	traces
Silicio acid - - - -	2·737
	29·689
Direct determination of fixed constituents - - - -	30·450
Cubic inches of free carbonic acid - - - -	21·874

Another analysis is given in the 6th Report of the River Pollution Commission, 1874 (p. 112), as follows:—

St. Winifred's Well, May 19th, 1873.

(Results of Analysis expressed in Parts per 100,000.)

Temperature.	Total Solid In- purity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Ni- trates and Ni- trites.	Total combined Nitrogen.	Residue Previous and Animal Contamination.	Chlorine.
11·1° Cent. [=51·98° Fahr.]	36·44	·045	·009	0	0	·009	0	6·30

Hardness:—Temporary, 19°·1, permanent, 5°·4, total, 24°·5.

Slightly turbid; palatable.

The total hardness is 7°·1 in excess of the average of 12 samples from the Mountain Limestone.

“On the outside of the great well, close to the road, is a small spring, once famed for the cure of weak eyes.”†

(5.) ECONOMIC GEOLOGY.

Hydraulic Cement.

Cement possessing the property of “setting” under water is obtained from three sources in this part of Flintshire, viz., by mixing white limestone with clay, by burning the Black Limestone (“Aberdo stone”), and by burning the cement-stones (argillaceous limestone) of the Holywell Shales.

At the Maes-y-coed Cement Works, Caerwys, a dark limestone from a quarry at Cserwys is ground up and mixed with rather less than a quarter

* The temperature is given by Dr. Traill as 57° Fahr. in 1820, 59° Fahr. some years previous to 1820, and generally as 58° Fahr. *Edin. Phil. Journ.*, vol. iv., p. 250. 1821.

† Pennant's History of Holywell Parish, 1796, p. 223.

of its weight of red clay (Boulder Clay), the mixture being passed under grindstones, through sieves, and finally mixed in a water-mill. It is then dried, cut up into blocks while soft, burnt, and then ground again. Wenlock Shale from a quarry south of Maes-y-coed Farm is sometimes used in place of, or mixed with, the red clay. The cement is sold at 35s. a ton.*

At Holywell white limestone is ground up and mixed with surface-clay from Pen-y-maes Farm in the proportion of three parts of clay to one part of limestone, the clay being required to be free from sand or grit. The mixture is then ground under chert-blocks in a water-mill, run off into pans, and dried over fires. It is then cut up into blocks while soft, and burnt in a kiln to partial fusion, and finally ground between French millstones. This cement fetches 40s. a ton, or 9s. a cask of 3 cwt.†

The Black Limestone ("Aberdo" stone) is sold at 14s. a ton in lump, or burnt, fine-ground, and packed in sacks at 11. a ton. In the raw state it is loaded at Greenfield at 6s. 6d. a ton.

Roman Cement is made from the Lower Coal-Measure cement-stones of Nant-hill-brwc and the levels by the side of the Bagillt Road and Holywell Road, and sells at 35s. a ton, the value of the stone being 12s. a ton.

An analysis of the Holywell "Blue Lias" (probably the Black Limestone), was made by Dr. J. Muspratt, with the following result:—

Analysis of the "Holywell Blue Lias."

Carbonate of lime	-	-	-	71·55
" magnesia	-	-	-	1·35
Alumina	-	-	-	3·52
Silica	-	-	-	20·10
Water and loss	-	-	-	0·50
Iron-oxide	-	-	-	2·21
Alkalies	-	-	-	0·79
				100·02

The following analysis of the Black Limestone of Whitford was made by Dr. E. D. Clarke for the Committee appointed to decide on the most suitable stone of which to build the Houses of Parliament.‡

Analysis of one hundred parts of a dark bitumenous limestone . . . from Whitford.

Specific gravity, estimated in pump-water at 50° Fahr. = 2·670.

Lime	-	-	-	-	49·65
Carbonic acid	-	-	-	-	40·10
Alumine	-	-	-	-	8·80
Silex	-	-	-	-	0·60
Bitumen	-	-	-	-	0·60
Water	-	-	-	-	0·25
					100·00

Soluble in acids, 74·73. Insoluble, 25·27.

Lime.

The principal limestone quarries are enumerated below:—

Coed-y-Garreg, near Whitford:—Thick-bedded white encrinital limestone.

* This information was supplied by Mr. Morris.

† These works were visited under the guidance of the late Mr. Parry of Holywell.

‡ *Trans. Geol. Soc.*, vol. iv., p. 432. 1817.

Chwarel Pen-y-gelli, near Holywell:—Thick-bedded white encrinital limestone.

Upper Holloway, near Crecas:—Thick-bedded white encrinital limestone, burnt for lime and taken by tram to Holywell, where it is crushed and sieved in revolving screens for use in chemical works.

Catch, Halkin Mountain:—Massive grey limestone, burnt for agricultural purposes, and the more thinly-bedded strata worked into window-sills.

Hendre:—Massive grey limestone, burning to a strong lime, used in chemical works at Flint, Widnes, and St. Helen's. A Hoffman's kiln is in use here. A bed of shale runs through the middle of the quarry (p. 31), below which lies a massive white limestone, not worked at present.

Cat Hole:—The limestone worked at Colomendy is white and pure, the proportion of carbonate of lime reaching 98 to 99 per cent., and is used for chemical works. The darker stone at Gwern-y-mynydd provides lime for building and agricultural purposes, and costs about 2*d.* a ton more to work on account of the impurity in the stone blunting the tools, and from the larger amount of coal required to burn it.

Building Stone, Chert, &c.

A bed of pale-yellow sandstone, quarried on the east side of the Black Brook valley, west of Soughton, constitutes a fair building-stone. Not less than 60 feet are exposed, but the total thickness of the rock is not known. It contains traces of *Stigmaria*, and other plant-remains, and resembles the Gwespyr Sandstone of Mostyn, both in appearance and in forming the uppermost member of the Lower Coal-Measures. Its eastward prolongation is cut off by the Soughton Fault, on the downthrow side of which Middle Coal-Measure sandstones are quarried. Some thin-bedded sandstones, half a mile to the north-east, near Tyn-twl, have been used for paving-stones and gate-posts; the quarry is traversed by a joint running E.S.E., and hading to the south at 25° from the vertical. North of Plas-isaf, near Llong, a quarry exposes 30 feet of yellow fine-grained sandstone, traversed by bands of dark micaceous shale.

Near Hartsheath a large quarry in Millstone Grit yields a coarse white grit of loose texture; at Hope and Caergwrle the same formation has been largely dug as a source of white quartz-sand.

The extraction of blocks of chert from the Millstone Grit of Halkin Mountain for the Staffordshire Potteries has been already referred to (pp. 48-50). The blocks are used in forming a pavement, on which larger masses of a cherty limestone, obtained in Derbyshire, are dragged round. The use of the encrinital chert of Halkin Mountain as a substitute for buhr-stone in the manufacture of mill-stones, as described on p. 51, seems to have been soon abandoned. The Halkin "Marble" is referred to on page 27.

APPENDIX II.

TABLES OF FOSSILS.

TABLE I.

WENLOCK SHALE.

These specimens were identified by Mr. R. Etheridge, senior.

Localities.

1. North-west side of Moel-y-parc, near Ty-newydd.
2. The upper of two bands of sandstone, south of Tremerchion. (Quarter-Sheet, 79 S.W.)
3. Mynydd bychan, near St. Michael's Chapel, St. Beuno's. (Quarter-Sheet, 79 S.W.)
4. South side of Moel-y-Gaer, Llanbedr.

Actinozoa.

Heliolites, 1.
Favosites (Stenopora) fibrosa, Goldf., 1.
Monticulipora, 3.

Echinodermata.

Glyptocrinus basalis, McCoy, 1.

Crustacea.

Calymene (or Phacops), 3.

Brachiopoda.

Orthis calligramma, Dalm., 1.
" " (fine-ribbed), 3.
" " (small), 1.
" elegantula (F), Dalm., 1.
Strophomena (or Orthis), 2.

Lamellibranchiata.

Cardiola interrupta, Brod., 4.
Ctenodonta (or Palæarca), 3.

Cephalopoda.

Orthoceras primævum, Forbes, 4.

TABLE II.

CARBONIFEROUS LIMESTONE, MILLSTONE GRIT, AND LOWER COAL-MEASURES.

This list of fossils includea the specimens collected and identified by Mr. G. H. Morton,* as well as those collected during the progress of the Survey, the identification of which was made in part by Mr. Etheridge, senior, but completed by Messrs. Sharman and Newton.

The letter M denotes the specimens recorded by Mr. Morton, and the letter S those by the Survey. The localities are indicated by the following numbers:—

- | | | |
|--|---|---|
| 1. Everywhere.
2. Golch Hill.
3. Holloway.
4. Holywell.
5. Pen-y-ball.
6. Clwt Militia.
7. Pen-y-gelli-bach.
8. Gorsedd.
9. Brynford.
10. Bryn-y-berthen.
11. Halkin Mountain.
12. Moel-y-Crio.
13. Berth-ddu.
14. Ffagnallt.
15. Bodfari. † | 16. Caerwys.
17. Bron-fadog.
18. Nannerch.
19. Gelli Loveday.
20. Nant-figillt.
21. Hendre.
22. Llyn-y-pandy.
23. Heep Alyn.
24. Pont Newydd.
25. Rhyd Alyn.
26. Cilcain.
27. Mold.
28. Cefn-mawr.
29. Bryn-gwyn.
30. Tir-y-coed.
44. Nant-y-ffrith. ‡ | 31. Pwll Iwrach (Belgrave Hill of Mr. Morton).
32. West Bog Mines.
33. Nerquis Mountain.
34. Mynydd-du.
35. River Terig.
36. West of Tryddyn.
37. Tryddyn.
38. Hope.
39. Llanarmon. †
40. Berth-y-chwarel. †
41. Llandegla. †
42. Graianrhyd. †
43. Cae Rhinallt. † |
|--|---|---|

	Lower Brown Limestone.	Middle White Limestone.	Upper Grey Limestone.	Calcareous Sandstone Series. Black Limestone. Partly contemporaneous.	Millstone Grit.	Lower Coal-Measures (Holywell Shales).
<i>Plantæ.</i>						
Calamites	-	-	32 M.		43 S.	
Lepidodendron	-	-		32 S.	11, 22, 38 S.	4 S.
Plant-remains	-	13 S.			2, 4, 11, 37, 38, 43 S.	
Sagenaria	-	-			11 S.	
Sigillaria	-	-			22 S.	4 S.
<i>Spongida.</i>						
Spicules‡	-	-			4, 11	

* The Carboniferous Limestone and Cern-y-Fedw Sandstone of Flintshire, Svo. *Liverpool*, 1852. (Reprinted from *Proc. Liverpool Geol. Soc.*, Sess. 1881-2.)

† Quarter-Sheet, 79 S.W.

‡ Quarter-Sheet, 74 N.E.

§ Hinde. *Geol. Mag.*, Dec. 111, vol. iv., p. 435. 1888.

	Lower Brown Limestone.	Middle White Limestone.	Upper Grey Limestone.	Calcareous Sandstone Series.	Black Limestone.	Millstone Grit.	Lower Coal-Measures (Holywell Shales).
<i>Hydrozoa.</i>							
Palæocoryne scoticum, <i>Young and Young.</i>					27 M.		
Palæocoryne sp. - - -					27 M.		
<i>Actinozoa.</i>							
Alveolites septosa, <i>Flem.</i> - -	M.	16, 28, 29 M.	12, 21 S.				
<i>Chaetetes.</i> See Monticulipora.							
Clisiophyllum bipartitum, <i>M' Coy</i> -		40 M.					
" turbinatum, <i>M' Coy</i>		28, 40 M.	31 M.		4 M.		
Cyathophyllum paricida (?), <i>M' Coy</i>			21 S.				
" regium, <i>Phil.</i> -			27 M.				
" Stutehburyi, <i>M. Edw.</i>		40 M.	27 M.		4 M.		
" sp. - - -		16 M.	12 S.				
Cyclophyllum sp. - - -		40 M.					
Lithostrotion basaltiforme, <i>Conyb. and Phil.</i>			9 M.	14 S.	4 M.		
" cespitosum, <i>Mart.</i>		40 M.					
" irregularc, <i>Phil.</i> -		28, 40, 41 M.	9, 21, 31 M.				
" junceum, <i>Flem.</i> -		41 M.	31, 32 M.				
" <i>Martini.</i> See <i>L. cespitosum.</i>							
" <i>M'coyanum, M. Edw.</i>					4 M.		
" Portlocki, <i>M. Edw.</i>		40 M.	27 M.				
Lonsdaleia duplicata, <i>Mart.</i> -			27 M.				
" floriformis, <i>Mart.</i> -			21 M.				
" rugosa, <i>M' Coy</i> - -			27 M.				
Monticulipora (Stenopora) tumida, <i>Phil.</i>			12 S.	27 M.	8 S.		
Phillipsastræa radiata, <i>Woodw.</i> -			21 S.				
Syringopora geniculata, <i>Phil.</i> -	18 M.	24, 28, 41 M.	27 M.		4 M.		
" reticulata, <i>Goldf.</i> -	18 M.		27 M.				
Zaphrentis Bowerbanki, <i>E. & H.</i> -				27 M.			
" cylindrica, <i>Scouler</i> -			31 M.		4 M.		
" Enniskilleni, <i>E. & H.</i> -				27 M.			
" sp. - - -		40 M.			8 S.		
<i>Echinodermata.</i>							
Archæocidaris Ürei, <i>Flem.</i> - -				27 M.	4 M.		
Encrinurus (various) - - -						1 S.	
Phænoscisma (Pontremites) acutum, <i>Phil.</i>					4 M.		
Potriocrinus crassus, <i>Miller</i> -				27 M.	4 M.		
" nuciformis, <i>M' Coy</i> -				27 M.			

	Lower Brown Limestone.	Middle White Limestone.	Upper Grey Limestone.	Calcareous Sandstone Series.	Black Limestone.	Millsstohe Grit.	Lower Coal-Measures (Holywell Shales).
<i>Annelida.</i>							
<i>Serpulites carbonarius, M' Coy</i> -					11 M.		
Tracks " " " "						50, 34 S.	
<i>Crustacea.</i>							
<i>Brachymetopus auralicus (?)</i> , <i>De Verneuil.</i>				21 S.			
" sp. " "				12 S.			
<i>Griffithides seminiferus, Phil.</i> -					4 M.		
<i>Leperditia suborbiculata, M'net</i> -	18 M.						
<i>Phillipsia, sp.</i> - " "					8 S.		
<i>Polyzoa.</i>							
<i>Carinella</i> , see <i>Goniocladia</i> .							
<i>Fonestella halkanensis, Shrubsole</i> -					4*		
" <i>membranacea, Phil.</i> -					4 S.		
" <i>nodulosa, Phil.</i> -				27 M.	4*		
" <i>plebeia, M' Coy</i> -			32 M.	27 M.	4 S.		
" <i>polyporata, Phil.</i> -					4*		
" sp. - " "					7, 8 S.	43, 44 S.	
<i>Glauconome bipinnata (?)</i> , <i>Phil.</i> -					6 S.		
" sp. - " "					27 M.		
<i>Goniocladia cellulifera, Eth., Jur.</i>					27 M.		
<i>Retepora</i> - " "					8 S.		
<i>Rhabdomeson gracilis, Phil.</i> -					27 M.		
<i>Brachiopoda.</i>							
<i>Athyris ambigua, Sow.</i> -	19 S.		21 M.		8 S.		35 S.
" <i>expansa, Phil.</i> -	39 M.			27 M.	4 M.		
" <i>planosulcata, Phil.</i> -				27 M.	4 M.		
" <i>Royssii, L'Eveillé</i> -				12, 21 S.			
<i>Chonetes laguessiana, De Kon.</i> -			81, 82 M.	82, 83 S.	3, 11, 12, 13 S.	11 M.	
" <i>papilionacea, De Kon.</i> -	17 M.		82 M.		4 M.		
<i>Crania sp.</i> - " "					4 M.		
<i>Discina nitida, Phil.</i> -					4 M.		
<i>Lingula squamiformis, Phil.</i> -					4 M.		

* Shrubsole, *Quart. Journ. Geol. Soc.*, vol. xx xv, p. 275, 1870, and vol. xxxvii., p. 178, 1881.

	Lower Brown Limestone.	Middle White Limestone.	Upper Grey Limestone.	Partly contemporaneous.		Millstone Grit.	Lower Coal-Measures (Holywell Shales).
				Calcareous Sandstone Series.	Black Limestone.		
<i>Orthis Michelini, L'Eveillé</i>	-	-	21 M.	-	8, 12 S.	-	-
" <i>resupinata, Mart.</i>	-	-	21, 32 M.	21 S. ?	4 M. 3, 8, 8 S.; 4 M.	-	-
<i>Productus aculeatus, Mart.</i>	-	-	-	27 M.	-	-	-
" <i>comoides, Sow.</i>	18 M.	-	-	-	-	-	-
" <i>cora, D'Orb.</i>	18, 26 M.	16, 23, 26, 28, 40, 41 M.	31, 32 M.	-	-	-	-
" <i>costatus, Sow.</i>	-	-	32 M.	-	4 M.	30, 42 S.	-
" " <i>var. muricatus</i>	-	-	-	-	-	-	-
" <i>fimbriatus, Sow.</i>	-	-	32 M.	27 M. 21 S.	4 M.	-	-
" <i>giganteus, Mart.</i>	-	39, 40 M.	21, 31, 32 M.	9, 27 M. 27 M.	5, 9 M.	-	-
" " <i>var. hemisphericus, Sow.</i>	-	-	-	21 S.	-	-	-
" <i>latissimus, Sow.</i>	-	-	32 M.	27 M.	4 M.	-	-
" <i>llangollensis, Dav.</i>	-	-	-	-	8 S.	-	-
" <i>longispinus, Sow.</i>	-	-	21, 32 M.	12 S.; 27 M. 32, 33 S.	8 S.; 4 M.	11 M.	-
" " <i>var. lobatus, Sow.</i>	-	-	-	-	-	-	-
" <i>margaritaceus, Phil.</i> (<i>var. pectinoides, Phil.</i>)	-	-	31, 32 M.	-	4 M.	-	-
" <i>Martini, Sow.</i> See <i>semireticulatus.</i>	-	-	-	-	-	-	-
" <i>muricatus, Phil.</i> See <i>costatus var. muricatus.</i>	-	-	-	-	-	-	-
" <i>punctatus, Mart.</i>	-	-	27 M.	27 M.	-	-	-
" <i>semireticulatus, Mart.</i>	-	28, 41 M.	21, 27, 31, 32 M.	27 M.	4 M.	36 S.	-
" <i>youngianus, Dav.</i>	-	-	32 M.	27 M.	-	-	-
" <i>sp.</i>	-	-	-	-	-	30 S.	-
<i>Retzia radialis, Phil.</i>	-	-	-	-	4 M.	-	-
<i>Rhynchonella pleurodon, Phil.</i>	-	-	-	-	4 M.	-	35 S.
" <i>sp.</i>	-	-	-	-	-	35 S.	-
<i>Spirifera crassa, De Kon.</i> See <i>trigonalis var. bisulcata.</i>	-	-	-	-	-	-	-
" <i>elliptica, Phil.</i>	26 M.	17, 40 M.	-	-	-	-	-
" <i>glabra, Mart.</i>	-	19 S.; 26, 40 M.	-	-	8 S.; 4 M.	-	-
" <i>lineata, Mart.</i>	18 M.	16 M.	-	12, 21 S.; 27 M.	4 M.	-	-
" <i>pinguis, Sow.</i>	-	-	-	-	-	42 M.	-
" <i>trigonalis, Mart.</i>	-	-	-	14, 33 S.; 27 M.	8, 11 S.	42 S.	-
" " <i>var. bisulcata, Sow.</i>	-	16, 41 M.	27 M.	27 M.	4 M.	36, 42 S.	-
<i>Spiriferina cristata, Schloth</i>	-	-	-	12 S.	-	-	-
" <i>laminosa, M' Coy</i>	-	-	-	12 S.	-	-	-
<i>Streptorhynchus crenistria, Phil.</i>	-	-	-	-	4 M.	42, 43 S.	35 S.

	Lower Brown Limestone.	Middle White Limestone.	Upper Grey Limestone.	Calcareous Sandstone Series. Partly contemporaneous.	Black Limestone.	Millstone Grit.	Lower Coal-Measures (Holywell Shales).
<i>Streptorhynchus crenistria</i> , var. <i>radialis</i> , <i>Phil.</i>				27 M.			
" " var. <i>senilis</i> , <i>Phil.</i>				27 M.			
<i>Terebratula hastata</i> , <i>Sow.</i>		40 M.		27 M.	4 M.		
" <i>sacculus</i> , <i>Mart.</i>				12 S.	4 M.		
<i>Lamellibranchiata.</i>							
<i>Aviculopecten granosus</i> , <i>Sow.</i>					4 M.		
" <i>micropterus</i> , <i>M' Coy</i>			31, 32 M.		4 M.		
" <i>papyraceus</i> , <i>Sow.</i>							4 S.
" <i>plicatus</i> , <i>Sow.</i>					4 M.		
" sp.		41 M.			4 M.		
<i>Myalina</i> , sp.				27 M.			
<i>Pinna flabelliformis</i> , <i>Mart.</i>					4 M.		
<i>Posidonomya Gibsoni</i> , <i>Brown</i>						44 S.	4, 35 S.
<i>Sanguinolites curtus</i> , <i>M' Coy</i>			32 M.				
<i>Solemya puzosiana</i> , <i>De Kon.</i>			32 M.				
<i>Gasteropoda.</i>							
<i>Euomphalus Dionysii</i> , <i>Goldf.</i> (<i>E. rotundata</i> , <i>Sow.</i>)				25 S.			
" sp.		10 S., 16, 28 M.			4 M.		35 S.
<i>Murchisonia kendalensis</i> , <i>M' Coy</i>			32 M.				
<i>Heteropoda.</i>							
<i>Bellerophon tenuifascia</i> , <i>Sow.</i>			27 M.	27 M.			
" sp.				32 S.			4 S.
<i>Cephalopoda.</i>							
<i>Goniatites sphaericus</i> , <i>Mart.</i> (or <i>crenistria</i> , <i>Phil.</i>)			32 M.			43 S.	4, 20, 37 S.
sp.							
<i>Nautilus</i> sp.				27 M.			
<i>Orthoceras giganteum</i> , <i>Sow.</i>			11 S.*				
" sp.						43 S.	
<i>Pisces.</i>							
<i>Cladodus</i> sp. (teeth)				27 M.			
<i>Coprolites</i> and bones	17 S.						4 S.

* A specimen obtained by Mr. Morton measures 4 feet in length.

TABLES OF FOSSILS.

	Lower Brown Limestone.	Middle White Limestone.	Upper Grey Limestone.	Calcareous Sandstone Series.	Black Limestone.	Millstone Grit.	Lower Coal-Measures (Holywell Shales).
				Partly contemporaneous.			
<i>Cladodus mirabilis</i> , <i>Ag.</i>				29 M.			
<i>Petalodus hastingsia</i> , <i>Owen</i> (teeth)					4 M.		
" sp. (tooth)					11 S.		
<i>Psammodus porosus</i> , <i>Ag.</i> -	15 S.						
" sp.					4 M.		
<i>Psephodus</i> sp. (teeth)			27 M.				
<i>Streblodus oblongus</i> , <i>Ag.</i> (teeth) -					4 M.		

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