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MOIRS OF THE GEOLOGICAL SURVEY.
ENGLAND AND WALES.

THE GEOLOGY OF THE
SOUTH WALES COAL-FIELD.

PART X.

THE COUNTRY AROUND
CARMARTHEN.

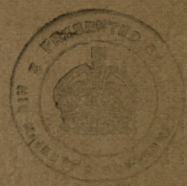
BEING AN ACCOUNT OF THE REGION COMPRISED IN
SHEET 229 OF THE MAP.

BY

AUBREY STRAHAN, M.A., Sc.D., F.R.S., F.G.S.,
T. C. CANTRILL, B.Sc., F.G.S.,
E. E. L. DIXON, B.Sc., F.G.S., AND
H. H. THOMAS, M.A., B.Sc., F.G.S.

(With Notes by B. S. N. WILKINSON).

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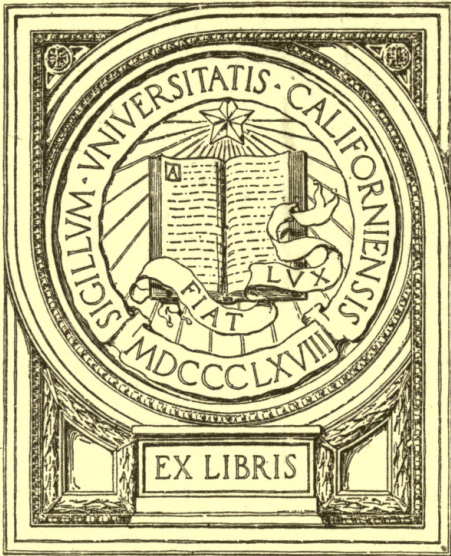
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PREFACE.

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THE country around Carmarthen, which is described in the tenth part of the Memoir on the Geology of the South Wales Coalfield, is illustrated in Sheet 229 of the New Series One-inch Map.

The original survey was made by Sir H. T. De la Beche, [Sir] W. E. Logan, [Prof.] John Phillips and [Sir] A. C. Ramsay on the Old Series One-inch Maps 37, 38, 40 and 41, and was published in 1844-5. Some additions were made to the Silurian areas by W. T. Aveline in 1857.

The re-survey was made on the six-inch scale under the superintendence of Dr. Strahan and the new edition of the one-inch map based on this re-survey was published in 1909. The areas surveyed by the members of the staff engaged are as follows:—

Dr. A. Strahan—Carm. 54 S.W.; 53 S.W. and S.E. (part).

Mr. B. S. N. Wilkinson—Carm. 44 S.E.; 45 S.W. and S.E.; 46; 51 N.E. and 52.

Mr. T. C. Cantrill—Carm. 47 N.W. and S.W.; 45 N.E. and N.W.; 44 N.E.; 38 S.W.; 37 N.E. and S.E.

Mr. E. E. L. Dixon—Carm. 53 N.W., N.E. and S.E. (part); 54 N.W.

Mr. H. H. Thomas—Carm. 38 N.W., N.E. and S.E.; 39; 40 N.W., S.W.

In the present volume each surveyor has supplied a description, as full as space will permit, of the ground surveyed by himself, the whole being edited by Dr. Strahan.

On the original edition of the Old Series map the tract occupied by the Lower Palæozoic rocks was shown as undivided 'Lower Silurian,' but in the later edition some of the beds were differentiated by symbols. The present re-survey has shown that Cambrian rocks extend westward as far as the centre of the area. The Ordovician rocks, which correspond to the 'Lower Silurian,' have been divided into Arenig, Llanvirn, Llandilo and Bala, and the minor sub-divisions of each have been separated on lithological and palæontological grounds. Lower Llandovery rocks have been distinguished on the western margin of the area. This detailed mapping has furnished the means of unravelling the folds and faults affecting the district, and brings out the marked overstep at the base of the Old Red Sandstone.

The overstep of the Old Red Sandstone by the Carboniferous rocks has become apparent, in the region described, by the disappearance successively of the Brownstones and Senni Beds. West of the Towy the Carboniferous Limestone rests on the

Lower Old Red Sandstone. Though the existence of Upper Old Red Sandstone is proved by the occurrence of certain plant-remains in a quartzite near Kidwelly, some doubt still remains as to the precise limit between it and the Lower Old Red Sandstone.

In the Carboniferous Limestone the zones established by Dr. A. Vaughan have been identified, and the principal grouping indicated on the six-inch map. A remarkable break in the sequence, however, accompanied by the formation of contemporaneous conglomerate, has been detected at Pendine and elsewhere.

The part of the Coalfield represented in Sheet 229 belongs to the south-west extremity of the anthracitic region. Of the Pennant Series, only the lower part is present, and this contains no seams of much value, but the Lower Coal Series is fully developed, all the seams except some of the higher seams in the Trimsaran district being anthracitic. Near that place a powerful east-and-west disturbance crosses the coalfield; south of this the ground is imperfectly known, but it seems certain that it is cut up by faults, ranging in an east-and-west, or west-south-west direction, and accompanied by much overthrusting and disturbance of the strata.

The disturbances to which the strata have been subjected periodically from pre-Cambrian down to post-Carboniferous times form one of the most interesting features in the geology of South Wales. That many of those in the Ordovician rocks came into existence before the deposition of the Old Red Sandstone is clearly proved by the manner in which that formation is superimposed upon them. These range generally east-and-west and are accompanied along the northern margin of the map by cleavage having the same general direction. On the other hand other disturbances run through the Old Red Sandstone and Carboniferous rocks, ranging, however, in the west-south-west direction which was observable in the post-Carboniferous disturbances of the Neath, Tawe and Loughor Valleys.

The observations on the Glacial phenomena prove that almost the whole region described in this volume was crossed by ice moving in a general southerly or south-westerly direction, and that the flow was of sufficient energy to maintain its direction obliquely across the valleys and escarpments. In the western part, however, there are indications of the existence of an ice-sheet which must have travelled eastwards or south-eastwards, the proof lying principally in the distribution of boulders from North Pembrokeshire in the adjoining map and to a small extent in the map under description.

In Chapter XV will be found an account of the lead-mining, manufacture of fire-bricks, and other economic developments, exclusive of coal.

A complete list of the fossils which have been collected is given in an Appendix. The specimens are preserved in the Survey Collection unless otherwise stated, and the exact localities from which they were obtained are marked on a set of six-inch maps deposited for public reference in the Survey Office.

The map is issued in two editions. On the edition for Solid Geology the glacial deposits are omitted, while on an edition for Superficial or Drift Geology those deposits are shown by colour, as well as the Solid Geology where it is not concealed by them.

Our thanks for assistance rendered are due to Mr. W. O'Connor in the Pont-Henry district, to Messrs. Llew. Jacob and Jas. Hansard in the Carway district, and to Messrs. John Roberts and Thos. Arnold in the neighbourhood of Trimsaran.

Miss G. L. Elles, D.Sc., visited some of the principal sections and by means of her intimate knowledge of graptolites was able to render much assistance in determining the sequence of zones in the Dicranograpthus Shales.

Acknowledgment must also be made of the assistance received from specialists in naming the fossils mentioned in this memoir. Mrs. Shakespear is responsible for the determination of the graptolites, Mr. P. Lake has named the trilobites, and Dr. C. A. Matley has dealt with the brachiopods from the Lower Palæozoic rocks. Nearly all the remainder of the fossils mentioned in the following pages have been named in the Palæontological Department, principally by Dr. Ivor Thomas. The few exceptions are some specimens from the Carboniferous Limestone, not in the Survey Collection, the names of which have been supplied by Dr. A. Vaughan, and the remains of plants which were examined by Dr. R. Kidston. A large proportion of the fossils was collected by Mr. John Pringle, Assistant for Survey Collections.

J. J. H. TEALL,
Director.

*Geological Survey Office,
28, Jermyn Street,
London.
19th January, 1909.*

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CHAPTER I.

INTRODUCTION.

Sheet 229 includes that part of the western margin of the Carmarthenshire Coalfield which lies between Pontyberem and Llandyry, and the tract of Old Red Sandstone which separates the Carmarthenshire and the Pembrokeshire Coalfields. The northern part of it is occupied by the Lower Palæozoic rocks which crop up on both sides of a great anticline.

In the space between the two coalfields the Rivers Gwendraeth-fâch, Towy and Tâf break through the Old Red Sandstone and reach the sea in Carmarthen Bay. Generally speaking, the rivers disregard the geological structure of the country and maintain a southerly direction across folds, faults, and escarpments, but the Gwendraeth, the Towy above Carmarthen, and the Tâf above St. Clears, form exceptions to this rule and follow the strike for several miles. A tendency of the southward-flowing drainage to concentrate on Carmarthen Bay suggests that there was a weakness in the Old Red and Carboniferous escarpments somewhere between Kidwelly and Laugharne, and that it was in consequence of this that the two coalfields were separated by denudation. The detection of certain disturbances belonging to the W.S.W. system, and cutting obliquely across the head of the bay, lends support to this view.

The highest ground is formed by the Pennant rocks, which rise to 760 feet near Brondini. The Millstone Grit and Carboniferous Limestone make a bold escarpment which reaches but rarely exceeds 600 feet, while the Old Red Sandstone seldom rises to 500 feet, and touches 600 feet in one spot only. The Lower Palæozoic rocks form a tract diversified by countless undulations and little impersistent scarps, but generally keeping at a low level. Most of it lies below 300 feet and it rarely reaches 500 feet. The outcrop of the oldest rocks is followed by a more or less continuous valley, such as that of the Towy above Carmarthen, or a depression such as that of which advantage has been taken for the Great Western Railway from Carmarthen westwards. This low tract is crossed, and not followed, by the various rivers which are collected by the Tâf.

The mining is wholly confined to the working of coal along the Gwendraeth Valley, the few metalliferous mines which have been opened in the Ordovician rocks being now at a standstill. The lower coals are anthracitic, but begin to show the change by which they pass southwards into bituminous coals.¹ The highest

¹ 'The Coals of South Wales, with special reference to the Origin and Distribution of Anthracite' (Mem. Geol. Surv.), 1908.

seams existing in the tract under description are in the intermediate condition of steam-coal. The quarrying of the purely quartzitic basal sandstone of the Millstone Grit for the manufacture of fire-bricks is an important industry. The 'silica-sand,' as it is called, is got upon Mynydd-y-Gareg and made into bricks at Kidwelly.

Limestone was energetically quarried in former days at Fan and on Mynydd-y-Gareg for lime-burning. The industry is locally almost extinct. The Coygan limestone is much worked for road-metal and other purposes.

Lead-ores, and to a very small extent copper-ores, were formerly raised, but the mines are now all inactive.

The great tidal flats laid dry at low water off the mouth of the Gwendraeth, Towy and Tâf rivers yield an abundance of cockles, the gathering of which gives employment to a number of women. For the rest the population is engaged in agriculture.

The water-supply is obtained chiefly by the impounding of streams, or from springs and shallow wells, in no case from deep wells.

The following formations are distinguished by colour upon the Map :—

Blown Sand	}	Recent and Post-Glacial	}	Superficial
Alluvium				
Peat				
River Gravels (Deltas and Terraces)				
Boulder Clay	}	Glacial	}	
Sand and Gravel				
Pennant Series with the Brondini or Gyswcm Vein at its base	}	Coal Measures	}	
Lower Coal Series with Cockshot and other sandstones, and the principal coal-seams				
Farewell Rock, imper-sistent	}	Millstone Grit	}	Carboniferous
Shales with sandstones				
Basal Grit				
Upper Limestone Shales	}	Kidwellian	}	Carboniferous
Main Limestone				
Lower Limestone Shales	}	Clevelandian	}	Limestone Series
Penlan Quartzite	}	Upper Old Red Sandstone	}	Old Red Sandstone
Brownstones				
Senni Beds				
Red Marls with Green Beds at base	}	Lower Old Red Sandstone	}	

Mudstones, grits, and conglomerate	} Lower Llandovery		Silurian
Slade and Redhill Beds	Upper Bala	} Bala	} Ordovician
Shoalshook Limestone	Bala limestones		
Robeston Wathen Limestone	} Dicranograptus Shales	} Llandilo	
Mydrim Shales				Llandilo Flags.
Mydrim Limestone	} Upper Llanvirn	} Llanvirn	
Hendre Shales				Lower Llanvirn
Llandilo limestone and flags.	} Tetragraptus Beds	} Arenig	
Asaphus Ash			
Didymograptus murchisoni Beds			
Didymograptus bifidus Beds			
Didymograptus hirundo Beds*			
Didymograptus extensus Beds*			
Peltura punctata Beds		Tremadoc	Cambrian
Dolerite	} Intrusive	} Igneous Rocks	
Porphyry			
Andesite	} Extrusive		
Rhyolite			

The identification in the western end of the coalfield of the seam known as No. 2 Rhondda in Glamorganshire has proved difficult. The Brondini Vein has been taken to be the same as a vein which, under the names of Garnswllt and Ynysarwed, ranges eastward along the north crop to a point where its identity with the No. 2 Rhondda Seam becomes fairly certain. So far as regards the southern side, the Gyswcm is regarded as being the same as the Penlan Vein of Gower, the Dyvatty Vein of Swansea, and the Wernddu Vein of Neath. This further east becomes the Rockfawr, which is believed to correspond to the No. 2 Rhondda Seam. That the Gyswcm corresponds to the Brondini Vein is highly probable, and consequently the tracing of this horizon from the eastern end of the coalfield along the north and south crops has resulted in a fairly satisfactory reunion in the western end. The seam, however, no longer forms the downward limit of massive sandstones. Rocks not differing from Pennant sandstone appear below it, with a tendency to expand westwards. These, which have to be included in the Lower Coal Series, are distinguished under various local names, such as Llynfi, Tormynydd, or Cenrhos Rock.

The Coal Measures pass down into the Millstone Grit here as elsewhere. Some sandstones in the top of the latter may represent the Farewell Rock but are impersistent, and in their absence the lowest seam, the Rhâs-fâch, forms an arbitrary base to the Coal Measures. The Millstone Grit belongs to the type which prevails along the north side of the coalfield rather than to that which is developed in Gower. Quartzitic sandstones predominate in the lower part.

* Not separated on the Map for the reasons given on p. 10.

The Old Red Sandstone here begins to show that diminution through which, further west, it disappears. The Brownstones and Senni Beds are present in the eastern part, but in the western part of the map the Carboniferous Limestone Series oversteps them and rests on the Red Marls, though no discordance is visible. Near Kidwelly some outliers of quartzite have yielded plants of Carboniferous affinities. The relation of the quartzite to the Limestone Series above and to the Lower Old Red below is obscure, but the plants show that it cannot be older than Upper Old Red Sandstone. The unconformity at the base of the Old Red Sandstone is most pronounced.

The faults and disturbances belong chiefly to the west-south-west system which passes down the Vale of Towy. Movement was renewed along the same general line of country at more than one period, for while the majority of the faults by which the Ordovician rocks are sliced up pass under the Old Red Sandstone without affecting it, a certain number shift also the Old Red and the Carboniferous rocks most conspicuously. Among these may be noticed a number of faults at Kidwelly, the remarkable faulted monocline of Llandyfaelog, the faults which repeat the Old Red outcrops near Llanddarog, and the crush which cuts through the Old Red marls south-west of St. Clears. These later movements differ in no way from the earlier. Their age is unknown further than that they are post-Carboniferous, but their effect upon the physiography of the region suggests that they are, in part at least, of quite a late date. To some of them may be attributed the existence of Carmarthen Bay, as before mentioned. The west-south-west disturbances are accompanied by cleavage, which sets in along the northern margin of the map.

The glaciation of the region shows proof of the existence of two ice-systems. One, of which we had evidence in the adjoining area on the east (Sheet 230), moved from a little east of north, and was sufficiently powerful to scour Mynydd-y-Gareg to its summit, carrying boulders from it to the shore near Kidwelly. The other, which just reached this region, introduced boulders the source of which lay to the west or north-west.

CHAPTER II.

CAMBRIAN ROCKS.

TREMADOC SERIES.

PELTURA PUNCTATA BEDS.

INTRODUCTION.

The Tremadoc rocks, which are brought to the surface near Llanarthney¹ by a series of anticlinal folds, continue their westerly course into the area represented by the map under description. They were first recognised and mapped in the Carmarthen district by the Misses Crosfield and Skeat,² who relegated them to the stage 3a of Brögger³ and suggested their possible correlation with the Shineton Shales. Mr. Fearnside⁴, however, remarked that he was unable to correlate them with any known deposits of Tremadoc age.

Collection by the Survey has resulted in the discovery of the two well-known Scandinavian forms *Dikelocephalus serratus* Boeck and *Parabolinella rugosa* Brög. These are confined to the *Ceratopyge* Limestone of the Christiania district and are referred by Brögger⁵ to his stage 3a⁷ or the uppermost member of the Tremadoc series.

In the memoir on the Country around Ammanford it was shown that the Tremadoc rocks of Carmarthenshire occupy a high position in the series inasmuch as they appear to pass gradually into the Arenig rocks and contain in common with the Arenig certain fossils such as *Ogygia selwyni* (Salt.) [*O. marginata*⁸ Crosfield and Skeat].

The Tremadoc series of this district is characterised by *Peltura punctata* Crosfield and Skeat. Other fossils are rare but include *Orthoceras*, several lamellibranchs, and species of the genera *Dikelocephalus*, *Ogygia*, *Parabolinella*, and *Erinnys*.

The lower part of this series is nowhere exposed, but the upward passage into the overlying Arenig rocks may be studied at several localities. Where fossils are scarce the line of separation is most indefinite. We include in the Tremadoc series all beds in which *Peltura punctata* has been detected, for with the disappearance of this form *Ogygia selwyni* becomes more abundant and the Arenig genera *Phyllograptus* and *Tetragraptus* with extensiform species of *Didymograptus* appear for the first time.

¹ H. H. Thomas in 'The Country around Ammanford' (*Mem. Geol. Surv.*) 1907, pp. 6 and 7.

² *Quart. Journ. Geol. Soc.* vol. lii, 1896, p. 523.

³ 'Die Silurischen Etagen 2 und 3 Kristianiagebiete,' 1882.

⁴ *Geol. Mag.*, 1907, p. 203.

⁵ *Op. cit.* pp. 14-18.

⁶ 'The Country around Ammanford,' footnote on p. 7.

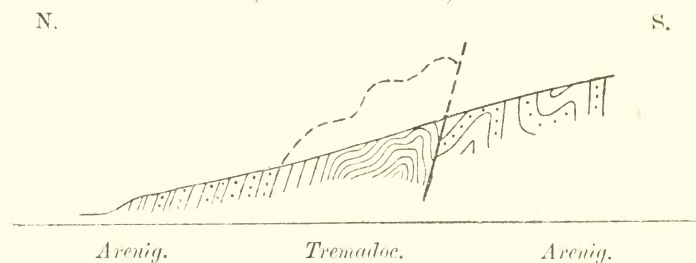
Lithologically the Tremadoc beds are dark blue-grey shales and mudstones, with occasional dark-blue conglomeratic grits and thin sandstones. The harder beds preponderate upwards, but reach their maximum development in the lower part of the Arenig deposits.

LOCAL DETAILS.

The most easterly Tremadoc rocks form two almost parallel outcrops, continuations of those shewn on Sheet 230. The northern band is faulted on the south, but passes naturally under the Arenig rocks towards the north. The best exposure is in the Abbey Farm dingle which crosses the strike from the farm to the Towy.

Fig. 1.—Generalised Section along the Abbey Farm Dingle.

(H. H. Thomas.)



Horizontal scale, 6 inches to 1 mile; vertical scale, twice the horizontal.

The steepness of the southern limbs of the folds suggests that the folding and thrusting resulted from movement in a southerly direction. In the Tremadoc rocks the flexures are more shallow than in the grit-beds of the Arenig.

At a point in the dingle, east of Pen-y-banc-isaf, 100 yards south of the Carmarthen road, and again just south of the road, Tremadoc mudstones yielded¹:—*Orthoceras perannulatum?* Portl., *O. sp.*, *Ogygia schryni* (Salt.), *O. sp.*, *Fellura punctata* C. & S., and *P. sp.* West of the dingle similar beds are met with in the road below Pen-y-banc-isaf Farm, having a general strike of W. 30° S.; further west the outcrop is conjectural. The second outcrop referred to, that of Cwm-du, also occupies the centre of an anticlinal fold, but to the west of the Porth-y-rhyd road it is extremely obscure.

Another anticlinal mass of grits, shales, and mudstones is brought to the surface south of the Carmarthen road, the nose of the anticline being about 300 yards south of Pont-Rhwnws. In the absence of fossils their relation to recognisable Arenig beds indicates that these strata are probably Tremadoc; possibly, however, they include some Arenig rocks.

¹ Appendix, 1.

A small mass of Tremadoc rocks is exposed in a stream which runs parallel to the road from near the school, south of Capel Dewi, to the Towy, south-west of Capel-Dewi-isaf (Fig. 5, p. 26); mudstones 250 yards west of Ty-mawr yielded¹ *Asaphus* sp., *Ogygia selwyni* (Salt.), and *Peltura punctata* C. & S. They are faulted against Arenig rocks on the west and south. The most important and uninterrupted outcrop is that which was discovered by the Misses Crosfield and Skeat²; its most easterly exposure occurs in Nant-y-caws, where, at a point 70 yards below the bridge, Arenig rocks are faulted against Tremadoc mudstones, of which the outcrop is about 50 yards in width (Fig. 2, p. 12). Ten yards below the fault *Peltura punctata* C. & S.³ was obtained. Half a mile to the west, in Allt-Pen-y-coed dingle, the outcrop is 100 yards wide, with Arenig sediments dipping off it on either side. Here two fossil localities occur; one, just below three well marked grit-bands, 230 yards south-east of the lane leading from the main road to Beaulieu-fawr, yielded⁴ *Ogygia selwyni* (Salt.), *O. sp.*, and *Peltura punctata* C. & S.; another, 60 yards up the stream, yielded⁵ *Dikelocephalus serratus* Boeck, *Ogygia selwyni* (Salt.), *O. sp.*, and *Parabolinella rugosa* Brögger (p. 5). The outcrop of these rocks when next seen in the Nant-y-glasdwr and Nant-cwm-ffrwd is not less than 400 yards in width, the expansion being due to repeated undulations. The best exposure is in Nant-y-glasdwr, a tributary of Nant-cwm-ffrwd, where the beds dip at 60° to 80° southwards and are unconformably overlain by the Old Red Sandstone. At the eastern end of the old road south of Gwyniondale (east of Aber-Cyfor),⁶ the mudstones yielded abundant *Peltura punctata* C. & S. with *Ogygia selwyni* (Salt.), and *Aeglina*? From this locality the Misses Crosfield and Skeat collected the type-specimens⁷ of *Peltura punctata* together with *Parabolinella sp. nov.* In Nant-y-glasdwr *Peltura* is the most abundant genus, but in Nant-cwm-ffrwd *Ogygia* is the more prevalent. The Cwm-ffrwd section extends from the base of the Old Red Sandstone to within 100 yards of Cwm-ffrwd House. To the west, at Moelfre, a spur which runs out from the Old Red Sandstone is composed of shales which are visible only in the farmyard, and have yielded no fossils.

The western flanks of the Towy valley show the solid rock breaking through the drift at several points. At Pwntan, on the Llanstephan Road, 2¼ miles from Carmarthen, mudstones have yielded⁸ *Ogygia selwyni* (Salt.) in abundance and *Peltura punctata* C. & S., and thus resemble the beds exposed in the Nant-cwm-ffrwd. Tremadoc shales with thin grits may be traced from near Cwrt-hir to Ystrad-Walter, where they appear to swing round towards the Old Red Sandstone.

¹ Appendix, 2.

³ Appendix, 3.

⁵ Appendix, 5.

⁷ Specimens preserved in the Sedgwick Museum, Cambridge.

⁸ Appendix, 7.

² *Op. cit.* p. 525 and pl. xxv.

⁴ Appendix, 4.

⁶ Appendix, 6.

In an inlier of Tremadoc rocks faulted into the Old Red Sandstone, blue grits and mudstones are visible in a cart-road 250 yards south by west of Brigwellt-y-coed, and at Llwyn-melyn the lowest beds of the Old Red Sandstone may be seen resting on dark shales. In a small stream, 100 yards E.S.E. of Bwlch-garw, mudstones yielded *Peltura punctata* C. & S.¹ Similar beds appear at intervals from under the drift along the south side of the road running west from Bwlch-garw, but are much crushed.

H. H. T.

¹ Appendix, 8.

CHAPTER III.

ORDOVICIAN ROCKS.

The Ordovician rocks under description are divided and grouped as follows :—

Slade and Redhill Beds	}	Upper Bala	}	BALA.
Shoalshook Limestone	}	Bala limestones	}	
Robeston Wathen Limestone	}			
Mydrim Shales	}	Dicranograptus Shales		}	LLANDILO.
Mydrim Limestone	}			
Hendre Shales	}			
Llandilo limestone and flags	}	Llandilo Flags	}	LLANVIRN.
Asaphus Ash	}	Upper Llanvirn		
<i>Didymograptus murchisoni</i> Beds	}	Lower Llanvirn.		
<i>Didymograptus bifidus</i> Beds	}	Tetragraptus Beds	}	ARENIG.
<i>Didymograptus hirundo</i> Beds*	}			
<i>Didymograptus extensus</i> Beds*	}			

ARENIG SERIES.

TETRAGRAPTUS BEDS.

INTRODUCTION.

The Arenig deposits of the Carmarthen district, until recent years, have received but little attention. The first mention of them was made by Murchison¹ in 1839 when he described and figured the type of *Ogygia murchisonae* [= *Stygina*] and recorded several other fossils from the 'black schists' of Mount Pleasant and Pensarn (p. 15). He referred these beds to part of his great 'Llandeilo Series' but gave little or no indication of the position they occupied in that series. A few years later De la Beche² and Phillips³ recorded the presence of conglomerates with igneous rocks and dark shales in the district west and south-west of Carmarthen. From the shales, Phillips⁴ during the original survey (*circ.* 1841) collected fossils from many localities, a few of which we have been able to recognise, namely, Castell-y-waun (p. 18), near Llanllwch (p. 16), and Mount Pleasant (p. 15). Some of the original fossils are preserved, and Salter and Davidson in their Monographs⁵ on the Trilobites and Brachiopods described and figured some of the specimens collected by Murchison from Pensarn.

* Not separated on the map for the reasons given on p. 10.

¹ 'Silurian System,' 1839, p. 664, and pl. 25, fig. 3.

² *Mem. Geol. Surv.*, vol. i, 1844, p. 25.

³ *Ibid.*, vol. ii, part i, 1848, p. 219.

⁴ *Op. cit.*, p. 323.

⁵ 'Monograph Brit. Trilobites,' 1864-1883, p. 173, pl. xviii, fig. 11, and pl. xxv, fig. 4 (*Pal. Soc.*), and 'Mon. Brit. Foss. Brach.', 1869, p. 232, pl. xxxiii, fig. 17 (*Palæont. Soc.*).

It was not until the year 1896 that Arenig rocks were proved to exist in the neighbourhood of Carmarthen, although they had been previously detected by Hicks in West Wales, by Hopkinson and Lapworth in the St. David's district, and by Roberts at Henllan Amgoed near Whitland. In 1896 the Misses Crosfield and Skeat¹ recognised and mapped a series of trilobite mudstones of Arenig age, and described and figured their type of *Ogygia marginata* (p. 5). Some graptolitic shales were referred by them to the Tetragraptus Beds but while rightly assigning the mudstones and shales to their proper horizon they failed to recognise in the conglomerates a part of the same Arenig Series (p. 15). During the re-survey of this district in 1903 and the following years it appeared² that some beds mapped by Misses Crosfield and Skeat as belonging to the Zone of *Didymograptus bifidus* should be referred to the Tetragraptus Shales, with the result that the Arenig area was much extended. In 1904 Miss Elles³ first stated that fossils collected from the south of Carmarthen (p. 16) indicated the presence of the zone of *Didymograptus hirundo*. Later, during the re-survey, this and the zone of *D. extensus* were recognised over a large area to the west and south-west of Carmarthen, though it was impossible to separate them lithologically.

In 1906 Mr. D. C. Evans⁴ published the results of his many years' work on the stratigraphy and palaeontology of the neighbourhood of St. Clears, and in 1907 an account of the most easterly extension of the Arenig rocks in the neighbourhood of Llanarthney was published in the Geological Survey Memoir on 'The Country around Ammanford.'

The Arenig rocks as represented in Sheet 229 are blue-black shales and mudstones with grits and conglomerates strongly developed towards the base. In the eastern part trilobite-mudstones predominate, but westward these alternate with, and pass laterally into, graptolite-shales which form the group known as Tetragraptus Beds. The weathered shales generally show an iridescent chocolate or purple surface-film, due to iron or manganese, but are devoid of the bright vermilion surface-colouring which is frequently found in the *D. bifidus* Beds. The grits and conglomerates where unweathered have usually a dark matrix; the pebbles, which occasionally reach one or two inches in diameter, are generally rounded fragments of siliceous igneous rocks. The Arenig rocks appear to pass down gradually into the Tremadoc and their base has been drawn above all the beds which have yielded *Peltura* (p. 5). The summit is marked by the incoming of graptolites of the 'tuning-fork' type, such as *Didymograptus bifidus* and other species of the dependent series of Elles and Wood⁵.

¹ *Quart. Journ. Geol. Soc.*, vol. lii, 1896, p. 523.

² 'Summary of Progress' for 1904 (*Mem. Geol. Surv.*), 1905, p. 36.

³ *Geol. Mag.*, 1904, p. 199.

⁴ *Quart. Journ. Geol. Soc.*, vol. lxxii, 1906, p. 597.

⁵ 'A Monograph of British Graptolites,' 1901, p. 7. (*Palaeont. Soc.*)

The fauna of the trilobite-mudstones is extremely limited in species, the most frequent form being *Ogygia selwyni* (Salt.). The graptolite-shales on the contrary are rich in forms, chiefly Dichograptids, and locally contain also the characteristic fossils of the trilobite-mudstones. The Dichograptids include representatives of the genera *Tetragraptus*, *Phyllograptus*, *Dichograptus*, *Clonograptus* and extensiform species of *Didymograptus*, the vertical distribution of which has enabled us to refer the beds to the two well-known zones of *Didymograptus hirundo* and *Didymograptus extensus*.

The *D. extensus* Zone includes the greater part of the Arenig Series. Its upper limit is placed below all occurrences of *D. hirundo*, and it extends downwards at least as far as the top of the main mass of grits. In the grits no graptolites have been detected, so that their zonal position is undetermined, but on general grounds we include them within the Tetragraptus Beds. The shales are not rich in fossils, but in addition to *D. extensus* have yielded many other forms characteristic of this horizon in other districts.

The *D. hirundo* Zone is probably only about 200 feet thick; it has yielded *D. hirundo*, with abundant specimens of *Aeglina binodosa*. On this horizon, and possibly ranging a short distance upwards into the *D. bifidus* Beds, occurs a new species of *Didymograptus* which in its distal part resembles *D. acutidens* Lapw. but is specifically distinct (p. 25).

T. C. C. and H. H. T.

LOCAL DETAILS.

South and East of the R. Towy.—The Arenig deposits enter the map as three more or less parallel outcrops. The most northerly forms the southern side of the Towy valley near Waun-hîr. The beds are well exposed in the Abbey Farm dingle (Fig. 1, p. 6) and in another which passes west of Waun-hîr. In the Abbey Farm dingle the lowest beds succeed the Tremadoc on the north side of the main road and closely resemble them. In the Waun-hîr dingle and in the main road opposite the inn are good sections in mudstones and grits. Near the Abbey Farm and Cwm-difa the rocks are poorly exposed but they may be seen to advantage in the upper part of the Abbey Farm dingle. To the west they are next seen in the dingle west and south of Cwm-difa; they are traversed by several small strike-faults and fossils are scarce, but *Ogygia selwyni* (Salt.)¹ was found.

The fact that the Arenig rocks are dark and often give off ferruginous water has led to a profitless search for coal; in the last century trial-pits were sunk about 100 yards south of Cwm-difa.

Grits and conglomerates, interbedded with shales, form conspicuous ridges and are visible south of the fault which runs east and west, south of Ty-hîr, but the best exposure around the

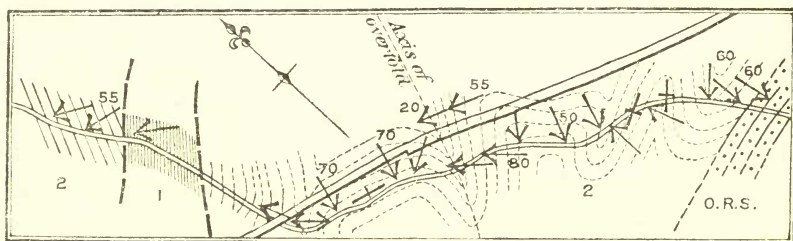
¹ Appendix, 9.

Tremadoc area of Hafod-hîr is in that part of the Waun-hîr dingle which lies south of the Carmarthen-Llandilo road. Here shales in the form of an anticline pass under grits similar to those met with in the Abbey Farm dingle. A good exposure occurs in the road-bank 200 yards north by west of New Lodge Inn. The beds of the northern limb of the anticline pass to the south-east of Pont-rhwnws, and then turning north towards the river are to be seen in the road-bank at the foot of the hill. At the bridge (Pont-rhwnws) they resume their westerly strike, making a curve, 50 to 100 yards in radius, shown in the river-bed by the bridge. In a small stream at the foot of the hill south of the bridge, mudstones contained fragments of *Ogygia selwyni* and obscure lamellibranchs. Grits and shales are exposed at several points on the steep slope to the south and east of Capel-dewinachaf.

South of the Pibwr similar beds are exposed in the lane leading from Ty-hîr to Coed-gain, also at Pen-y-lan in the yard and in the lane to the south. A dingle north-east of Pen-y-lan gives a good section of shales which dip northwards and presumably overlie the grits to the south. At the head of a dingle, a third of a mile north of Pound Farm, iridescent mudstones yielded¹ abundant *Ogygia selwyni* (Salt.).

Fig. 2.—Map of Nant-y-caws Dingle.

(H. H. Thomas.)



Scale Twelve Inches to One Mile.

1. Tremadoc. 2. Arenig.

O.R.S.—Old Red Sandstone.

The whole of Nant-y-caws dingle is occupied by these rocks (Fig. 2) except for a small mass of Tremadoc beds below the bridge (p. 7). They are much folded, apparently by movement from the north, for the southern limb of an over-fold, seen in the dingle and in the road-bank above, is inverted to the extent of 35° . In the dingle most of the mudstones contain *Ogygia selwyni*. Misses Crosfield and Skeat obtained *Orthoceras sericeum* and a *Conularia* from this section, and suggested the possible occurrence of Tremadoc rocks.

¹ Appendix, 10.

The Pen-y-coed dingle (p. 7) gives another section through Arenig rocks which dip normally off the Tremadoc. In the dingle, at a point 50 yards above the road to Beaulieu-fawr, mudstones yielded *Ogygia selwyni* (Salt.),¹ and close to the northern boundary of the Tremadoc we obtained² the same form with *Lingula* cf. *brevis* Portl., *Conularia* sp. nov., and fragmentary lamellibranchs.

South of Beaulieu-fawr a small stream runs for some distance along the junction of the Old Red Sandstone with the older rocks but then turns north-west along a fault. The stream, in the lower part of its course, as it bends to the east or west, cuts alternately into the Arenig and Old Red Sandstone. The two formations have the same dip and appear at first sight as faulted alternations.

Eighty feet below a water-fall which marks the natural base of the Old Red Sandstone, Arenig mudstones yielded³ *Ogygia selwyni* (Salt.).

A faulted mass of Arenig rocks forms the southern part of Capel-Dewi Hill (Fig. 5, p. 26), and passes up into *D. bifidus* Beds. South of a fault which ranges along the main road, a stream 150 yards south-west of Capel-Dewi-isaf reveals an excellent section, from the road-bridge for 250 yards southwards, in highly fossiliferous shales containing a mixed graptolite and trilobite fauna. At a point 150 yards south of the bridge shales yielded⁴ ? *Didymograptus hirundo* Salt., *Hyalolithus* sp., *Aeglina* sp., and *Cheirurus* sp. Several long dichograptid stipes occur, some broader than others; the wider stipes are probably *D. hirundo*. Twenty-five yards further south we obtained⁵ :—

Dichograptid (stipes of)	Siphonotreta micula? M ^c Coy
Tetragraptus cf. <i>reclinatus</i> E.	Aeglina binodosa Salt.
& W.	" sp.
Tetragraptus sp.	Calymene sp.
Lingula sp. or	Trinucleus gibbsi Salt.
Siphonotreta sp.	

Still 20 yards further south the shales yielded⁶ ? *Monobolina plumbea* (Salt.), *Palaearca*?, *Aeglina grandis* Salt., *Ae.* sp., and *Asaphus* sp.

At the southern end of the section, about 20 yards from the last locality, shales like *D. bifidus* Beds yielded⁷ *Siphonotreta micula*? M^cCoy, *Asaphus* cf. *laticostatus* (M^cCoy), and *Asaphus* sp.

Similar shales are met with at Pen-ddaulwyn-fawr. At the pond they contained⁸ only *Lingula* cf. *attenuata* J. de C. Sow., but in a small stream 80 yards north by east of this locality some mudstones contained⁹ *Obolella*? and abundant *Ogygia selwyni* (Salt.).

¹ Appendix, 11.

³ Appendix, 13.

⁵ Appendix, 15.

⁷ Appendix, 17.

⁹ Appendix, 19.

² Appendix, 12.

⁴ Appendix, 14.

⁶ Appendix, 16.

⁸ Appendix, 18.

Proceeding westwards along the strike we descend in the series by reason of the easterly pitch of the folds which compose the anticlinal area of Bolahaul and Cystanog. Grits come to the surface in ridges east and west of Wenallt, but still further west the lower ground is occupied by shales and mudstones. The grit boundary follows a remarkably sinuous course, due to a succession of east and west folds with inverted southern limbs. The shales, which are inverted and appear to dip beneath the grits, were cut through by the shaft of the new lead-mine (Fig. 18, p. 153). As these beds yielded only a few forms to Misses Crosfield and Skeat, they were regarded by them as of Bala age; but the fossils since obtained, and the structure of the district, prove that they must belong to the Arenig group.

The following¹ have been collected from the mudstones in the new shaft:—

<i>Cf. Lingula attenuata</i> <i>J. de C.</i>	<i>Orthoceras</i> sp.
<i>Sow.</i>	
<i>Monobolina plumbea</i> (<i>Salt.</i>)	<i>Asaphus rectifrons</i> ? (<i>Portl.</i>)
<i>Orthis alata</i> (<i>J. de C. Sow.</i>)	" sp.
" <i>cf. alata</i> (<i>J. de C. Sow.</i>)	<i>Calymene cambrensis</i> <i>Salt.</i>
" <i>calligramma</i> <i>Dalm.</i> , var.	" sp.
<i>Bellerophon</i> ?	<i>Ogygia selwyni</i> (<i>Salt.</i>)
<i>Maclurea</i> sp.	" sp.

Shales are again well seen near Erw-wen and in the lane to the north. In a road-section, 250 yards east of Cilwaunydd, *Ogygia selwyni* (*Salt.*) was observed, while mudstones in the south bank of the Pibwr, 100 yards above a weir to the south of Cilwaunydd,² yielded *Ogygia selwyni* (*Salt.*) and *O. sp.*

A more important section occurs on the north side of the river, extending from the mill westward to Glan Pibwr Cottage, and down the lane to the river. This lane-section was made the type-locality by Misses Crosfield and Skeat. An excavation in the north side of the lane, on the southern side of a small anticline and 50 yards west of the Cottage, yielded³ *Phyllograptus angustifolius* Hall, *Ctenodonta*?, *Palaearca*?, and *Ogygia selwyni* (*Salt.*). At no other locality has *Phyllograptus* been detected in these beds, but its presence helps to refer these mudstones to their proper horizon. On the south side of the Pibwr Valley, at 200 yards E.S.E. of Glan Pibwr⁴, mudstones yielded *Lingula*?, *Orthis* sp., *Ctenodonta*?, *Conularia* sp., *Ogygia selwyni* (*Salt.*), and *Trinucleus sedgwicki* *Salt.*; and at 300 yards east of Glan Pibwr,⁵ *Lingula cf. petalon* Hicks, *Ogygia selwyni*? (*Salt.*), *O. sp.*, and *Primitia*? Arenig mudstones occur also in the main road south of Ty-gwyn,⁶ near Carmarthen, and their upward passage into *D. bifidus* shales may be observed in a small stream which rises 200 yards east of the Intrenchment. In the upper part of the stream and in a cart-road 150 yards south of the main road they yielded *Ogygia selwyni* (*Salt.*).

¹ Appendix, 20.

³ Appendix, 22. The *Phyllograptus* may be *P. densus* Tornq.

⁴ Appendix, 23.

² Appendix, 21.

⁵ Appendix, 24.

⁶ Appendix, 25.

The section afforded by the Roman road at Pensarn was noted by Murchison, who recorded amongst other fossils the type of *Styгина murchisonae* (Murch.).¹ He regarded the mudstones as occupying a low position in his 'Silurian,' placing them provisionally at the base of his 'Llandeilo.'² Misses Crosfield and Skeat,³ partly on the indefinite evidence afforded by the brachiopods,⁴ and influenced by the occurrence of a *Styгина*, identified as *S. murchisonae*, in the Drygill Shales,⁵ placed the Pensarn mudstones in the Bala group.

The road-cutting behind the cottage at the foot of the hill yielded⁶ *Ogygia selwyni* (Salt.), and the same form was also detected just south of the spring⁷; it occurred also together with *Orthis* cf. *alata* (J. de C. Sow.) and *Bellerophon* sp.⁸ at the back of Capel-y-babell.⁹

Grits and gritty shales, the lowest Arenig rocks exposed south of Carmarthen, form a conspicuous dome-like mass between Wenallt and Bolahaul; they are sharply folded, as may be seen near the mines and south of the smithy at the foot of Llan-gunnor Hill. Their northern boundary appears to be a fault which cuts out part of both the grits and the overlying mudstones. In a lane behind the Star Inn, shales and mudstones dip off massive grits and contain ochreous casts of fossils among which Misses Crosfield and Skeat recorded *Lingula tenuigranulata*, *L. laevis*, *Orthis alata* and *Nucula laevis*. South-west of the Inn, sections in grits and shales are exposed in a large quarry near the bend in the Swansea road and in a dingle east of the road.

On the south side of the anticline the grits and shales are sharply folded east of Nant (Fig. 18, p. 153). North of Erw-wen, on the south side of Banc-yr-hendy a quarry shows grits with strong joints holding quartz-crystals with the face *s* (1121) well developed. North of Cilwaunydd and at Bolahaul the beds are inverted. A lane leading from Cilwaunydd to the north of Bolahaul exposes a good section; and the shales in a small quarry

¹ The obverse is preserved in the museum of the Geological Society (No. 6822) and the reverse in the Survey Museum (No. 18988). It was figured by Murchison in 'Silurian System' (p. 664, and pl. 25, fig. 3), and later by Salter (*Mon. Pal. Soc.*, pl. xviii, fig. 11.). Mr. P. Lake, however, is convinced that it is merely a crushed specimen of *Ogygia selwyni* (Salt.). Other specimens from the same locality mentioned by Murchison and preserved in the museum of the Geological Society are:—*Ogygia selwyni*, *Orthoceras* sp. *Orthis alata* (J. de C. Sow.)—Figured by Davidson, *Mon. Pal. Soc.*, pl. xxxii, fig. 17—and *Bellerophon perturbatus*?

² 'Silurian System,' p. 358, and footnote.

³ *Op. cit.* p. 534.

⁴ The *Lingula* mentioned by them may be *L. cf. attenuata* J. de C. Sow. which commonly occurs in these Arenig beds.

⁵ Marr and Nicholson, *Geol. Mag.* 1887, p. 342. Elles and Wood, *ibid.*, 1895, p. 246.

⁶ Appendix, 26.

⁷ Appendix, 27.

⁸ Evidently the species called *B. perturbatus* (see above, footnote 1), by Murchison.

⁹ Appendix, 28.

150 yards north-west of Cilwaunydd yielded¹ *Linnarssonina* ?, *Davidia* ?, *Bellerophon* sp.,² *Conularia* ?, and *Ogygia selwyni* (Salt.).

From the R. Towy to Llangynog.—The mudstones of the northern limb of the Bolahaul anticline become more shaly west of the Towy, and the fauna, except for an occasional *Ogygia selwyni* and a few other trilobites, consists chiefly of graptolites. The anticline again makes itself evident near Llangynog,³ where grits and sandstones similar to those of Bolahaul reappear.

At Hafod-wen shales are exposed at the spring, in the middle of the field, 100 yards south of the house. Misses Crosfield and Skeat⁴ here collected fossils proving the beds to be Tetragraptus Shales, and Miss Elles⁵, examining the material, recognised the presence of the *D. hirundo* Zone (p. 10). To the Survey this locality has yielded⁶ only *Diplograptus* (*Mesograptus*) sp. and *Aeglina binodosa* Salt.

In the road south of Waun-cornngam-fawr, 400 yards south of the farm, and north-east of Ffordd, some shales succeeded by grits yielded⁷ *Aeglina binodosa*? Salt., and just behind Ffordd house⁸ *Caryocaris* sp.; fragments of *Ogygia selwyni* were seen.

A good section occurs along the road from College to Penplâs, for about 100 yards on either side of Cwm-Crymlyn; the road-bank 50 yards south-west of the stream yielded⁹ *Clonograptus* ?, ? *Lingula attenuata* J. de C. Sow., *Linnarssonina belti*? (Dav.), and *Obolella* cf. *salteri* Holl; and during the original survey (circ. 1841)¹⁰ *Lingula attenuata* J. de C. Sow., *L. granulata* Phill., cf. *Obolella salteri* Holl, *Siphonotreta micula* M^cCoy, and *Asaphus* sp.

Shales, interbedded with grits, are exposed at Glôg, and close to the well yielded¹¹ *Orthis calligramma* Dalm., var. *carausi* Salt., and *O. sp.*; while beds on the same horizon in a quarry at the northern end of the grit ridge running north-east from the chapel contained¹² *Dictyonema*?, *Lingula* cf. *attenuata* J. de C. Sow., *Orthis calligramma* Dalm., *Orthis* sp., and a lamellibranch.

H. H. T.

¹ Appendix, 29.

² Same as from Pensarn (p. 15).

³ Cantrill and Thomas, *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 227.

⁴ *Op. cit.* p. 533.

⁵ 'Graptolite zones in the Arenig Rocks,' *Geol. Mag.*, 1904, p. 210.

⁶ Appendix, 30.

⁷ Appendix, 31.

⁸ Appendix, 32.

⁹ Appendix, 33. *Llan-y-gors*.

¹⁰ Registered in the Geol. Survey books as P. S. 338-348, *Panteg*, west of Carmarthen. This seems to be Phillips's locality 'Near Llanllwch,' see p. 9.

¹¹ Appendix, 34.

¹² Appendix, 35. S.E. of Llaethdy.

The shales are much disturbed at the gates of Llangynog Vicarage, but have yielded¹ *Acrotreta* cf. *nicholsoni* Dav., *Acrotreta* cf. *sabrineæ* (Call), *Siphonotreta micula*? M^cCoy, *Hyolithes*?, and *Primitia*? Farther south, about Llangynog Church, some intercalated grits and conglomerates give rise to higher ground. An exposure at a junction of three roads, 700 yards south-east of the vicarage, yielded² *Lingulella* cf. *davisi* (M^cCoy). Other sections may be found in the brook west of Waun-dâs, and on the road between Nant-Jago and the Plough-and-Harrow Inn.

At 450 yards west of Glôg-ddu a quarry shows conglomerate, chiefly of rhyolite pebbles set in a felspathic and sandy olive-green matrix. This appears to be the quarry referred to by Murchison³ as exhibiting a downward passage from conglomerate, the only rock now visible, into a compact and concretionary felspathic rock. His description suggests that the lowest rock he saw was rhyolite, in which case the 'passage' must be supposed to indicate a gradual increase downward in the proportion of the felspathic detritus, derived doubtless from the breaking-down of the surface of a rhyolitic lava-flow.

The conglomeratic grits of Glôg, Pen-y-graig and Pen-y-moelfre form several more or less disconnected masses, each of which has an anticlinal structure. They correspond in character and age to those of Bolahaul. On the north side of the Pen-y-graig ridge, close to an old windmill, a quarry shows conglomeratic grits, and either here or near by Murchison has indicated upon his map a mass of 'trap,' which, however, we failed to find. A quarry 100 yards east of Llangynog Vicarage shows buff sandstones (with occasional pebbles) and some shale-partings, the former containing *Orthis calligramma* Dalm.⁴ A coarse but non-conglomeratic grit exposed at Ffald is allied to the thinner grits occurring in the Tetragraptus Beds.

T. C. C.

From Carmarthen to Banc-y-felin.—Arenig beds occupy the core of the main anticlinal region of the Ordovician tract (p. 138). This region is probably composed of a series of flexures with inverted southern limbs. Dark shales form the hill on which the County Asylum stands, and cleaved shales are exposed at Trefechan-fawr. In the stream 500 yards to the west they yielded⁵ *Didymograptus* cf. *extensus* (Hall) and *Aeglina* sp. A few hundred yards further west shales in a lane south-east of Pentre-r-hydd dip north at 8°, the cleavage dipping north at 40° to 50°. To the south they are well shown in Trebersed farmyard

¹ Appendix, 36.

² Appendix, 37.

³ 'Silurian System,' 1839, p. 365.

⁴ Appendix, 38.

⁵ Appendix, 39.

and in the lane to the north. On the western side of Nant-y-ci, near Cymau, the country has been carved into low but conspicuous mounds, giving many exposures of shales. To the west, shales are exposed near Derllys-cwrt. Good sections occur at Parc-y-berllan and in the lane to the west, but by far the best is that in the road north of Llethrach, where, however, the beds yield no fossils. A quarry¹ on the western slopes of the hill crowned by Castell-y-gaer yielded wide dichograptid stipes, an extensiform *Didymograptus* sp., and *Lingula* cf. *attenuata* J. de C. Sow. The 'Via Julia,' east of Pont Cywyn, shows a continuous section up the hill from the bridge, and cuts across the junction of the *D. bifidus* Beds with the Tetragraptus Beds; at a point 330 yards east of the bridge the highest horizon of the latter yielded² *Didymograptus* sp. nov.,³ and *Aeglina binodosa* Salt. On the west of the Cywyn the highest beds are met with east of Gwarwenallt; and at the top of a lane leading to Dan-y-coed, just below the buildings, they yielded *Trinucleus fimbriatus*? Murch.

Near Gwar-wenallt and Wenallt several elliptical shale-hills, like those of Cymau (*supra*), flank the western side of the river between Pont Cywyn and the railway. From the railway cutting 300 yards north of Banc-y-felin, on its southern side and 110 yards from its eastern end, we obtained⁴ dichograptid stipes, *Didymograptus hirundo* Salt., *Ambonychia*?, *Hyolithus* sp., abundant *Aeglina binodosa* Salt., and *Ae.* sp., and at 65 yards east of the road-bridge⁵ broad dichograptid stipes and *Didymograptus nitidus*? (Hall).

In the main-road, 50 yards south-west of the entrance to Castell-y-waun, we obtained⁶ Dichograptid stipes, *Didymograptus* cf. *uniformis* E. & W., *Aeglina*?, and *Trinucleus* sp. This locality is mentioned by Phillips⁷, but his record of *Dalmannia caudata* is obviously incorrect.

South of the Carmarthen-Pembroke road the Arenig rocks form the southern limb of the Llanllwch-Llangynin anticline and occur to the west of Llanllwch. They are inverted and pass into inverted *D. bifidus* Beds towards the south. At 400 yards south of Llanllwch a footpath leading up Allt-waun-corngam exposes shales which, at 100 yards from the gate at the entrance to the wood, yielded⁸ ? *Dichograptus octobrachiatus* (Hall),⁹ *Didymograptus* cf. *extensus* (Hall), *Ctenodonta*?, and *Aeglina binodosa* Salt.

¹ Appendix, 40. Crosfield & Skeat's 'Castell-y-gaer.'

² Appendix, 41.

³ Shows affinities in part to *D. acutidens* Lapw. (p. 11).

⁴ Appendix, 42.

⁵ Appendix, 43.

⁶ Appendix, 44.

⁷ Phillips, *op. cit.* p. 323.

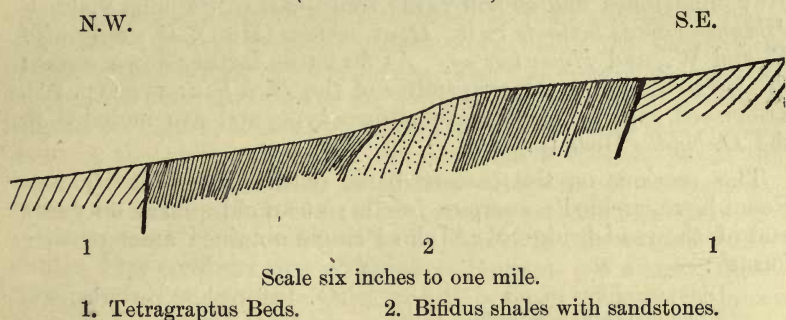
⁸ Appendix, 45.

⁹ May be a young *Clonograptus*.

Shales occur near Berth-lwyd, at Parc-newydd, and are well exposed in the northern part of Cwm-Crymlyn¹ (Fig. 3). In the Cwm, at 170 yards south-east of Felin-fâch, we obtained *Dichograptus* aff. *separatus* Elles, and *Didymograptus extensus* (Hall).

Fig. 3—Section along Cwm-Crymlyn.

(H. H. Thomas.)



1. Tetragraptus Beds.

2. Bifidus shales with sandstones.

H. H. T.

West of Banc-y-felin.—The Great Western Railway provides several sections. Another, at a stable 100 yards south of Bron-y-gaer Farm, in the upper part of the Tetragraptus Beds, yielded² a fragment of a broad dichograptid stipe (possibly *Didymograptus hirundo*), cf. *Aeglina* sp. and *Primitia*? On the south side of the anticline a shallow pit 30 yards north of Rushmoor afforded³ *Didymograptus* cf. *uniformis* E. and W., together with *Dichograptus*?, *Serpulites* sp., *Ptilodictya*?, *Orthis* sp., *Beyrichia wilckensiana* Jones, and *Primitia* sp. Possibly the shales at Parc-yr-abbot (p. 33) also should be included in the Tetragraptus Beds.

North of St. Clears the shales, cut through by a road north of Llain-llwyd, are in places red-stained; at 180 yards north of Parc-newydd they yielded⁴ *Diplograptus* (*Glyptograptus*) *dentatus* (Brongn.) and *Aeglina binodosa* Salt. Mr. D. C. Evans, who records from this section *Didymograptus extensus* Hall, *D. patulus* Hall, *Tetragraptus ami* Lapw. and *T. serra* Brongn., is probably correct in regarding the junction with the *D. bifidus* Beds as a fault. The cutting east of St. Clears station yielded⁵, on its north side, at 250 yards east of the station-buildings, ? *Didymograptus euodus* Lapw., *D. extensus*? (Hall), *Tetragraptus fruticosus* (Hall), etc.

Some soft mudstones in the Cynin, under Ostrey on the northern outskirts of St. Clears, yielded to Mr. D. C. Evans fragments of *Didymograptus hirundo* Salt., and are probably very near the top of the subdivision; they may be paralleled with the beds in Sabulon Brook (p. 20). At Pwll-trap the

¹ Appendix, 46. Cwm-Crymlyn.

² Appendix, 47.

⁴ Appendix, 49.

³ Appendix, 48.

⁵ Appendix, 50.

occurrence of a fragment of a wide dichograptid stipe,¹ referable possibly to *Didymograptus hirundo* Salt., accords with the conclusion, founded on independent evidence, that we have here the upper part of the Tetragraptus Beds. Still farther west the junction with the *D. bifidus* Beds is crossed by a stream (not shown on the one-inch map) which flows south-eastward from Sabulon. The uppermost Tetragraptus Beds are soft blue-grey mudstones and at 550 yards south-east of Sabulon yielded² *Didymograptus hirundo* Salt., *D. cf. nitidus* (Hall), *D. uniformis* ? E. and W., and *Hyolithus sp.* At 50 yards farther down stream the beds exposed yield graptolites of the *D. bifidus* type (p. 24), associated with others of extensiform type, and are included in the *D. bifidus* Beds (p. 34).

The sections on the eastern bank of the Fenni at Pont-y-Fenni have yielded numerous fossils; at an old quarry 60 yards east of the road-bridge Mr. John Pringle obtained among other forms³ :—

<i>Didymograptus sp. nov.</i>	<i>Cf. Bellerophon perturbatus</i>
<i>Trigonograptus ensiformis</i> (Hall)	(<i>J. de C. Sow.</i>)
<i>Palæarca cf. oboloidea</i> Hicks	<i>Aeglina binodosa</i> Salt
„ <i>socialis</i> Salt.	„ <i>caliginosa</i> Salt.

Mr. D. C. Evans obtained at the same locality extensiform graptolites, *Tetragraptus serra* (Brongn.), and *T. quadribrachiatus* (Hall). Farther north, a quarry in soft fissile shales, 200 yards east-south-east of Llwyn-crwn, has yielded to Mr. D. C. Evans a number of extensiform graptolites and several species of *Tetragraptus*. Among others we have collected⁴ *Didymograptus cf. nitidus* (Hall), *D. cf. sparsus* Hopk., and *Tetragraptus bigsbyi* (Hall). Farther north, at Coedllys-isaf, shales exposed at a sharp bend in the road, 140 yards south-south-east of the house,⁵ yielded *Didymograptus hirundo* ? Salt.

At Cefn-Meurig some grits and sandy shales produce locally a marked ridge; their relations are obscure, but probably they are older beds brought up by a combination of folding and faulting.

South of Regwm, the roadside sections, 80 yards east of the bridge at Nant-yr-allwyn on the Whitland-St. Clears road, have yielded⁶ *Aeglina binodosa* Salt., *Hyolithus*, *Didymograptus extensus* (Hall), *D. cf. extensus* (Hall), and *D. cf. uniformis* E. and W. Farther to the north-east, shales, exposed in a lane 50 yards west of Glan-dwr cottage (250 yards south-east of Pant-y-grûg), have yielded⁷ *Dictyonema* ? *Didymograptus hirundo* ? Salt., *D. nitidus* (Hall), and *Tetragraptus cf. quadribrachiatus* (Hall),

¹ Appendix, 51.

² Appendix, 52.

³ Appendix, 53. The *Trigonograptus ensiformis* is registered in the Museum Collection as No. 22456, and figured by Elles and Wood, 'A Monograph of British Graptolites, pt. vii, p. 302, fig. 202b, and pl. 35, fig. 1b.

⁴ Appendix, 54.

⁵ Appendix, 55.

⁶ Carm. 37 SE.W λ 4.—T.C.C. 894-900. See introductory matter, Appendix, p. 159.

⁷ Appendix, 56.

in addition to which Mr. D. C. Evans has recorded *D. extensus*. The flaggy shales in a quarry on the eastern side of the Gronw valley, 400 yards east of Beili-mawr (and south of Cil-hirwydd) contain among other forms¹ *Didymograptus* sp. nov., and Mr. D. C. Evans has recorded also *D. hirundo* Salt., and *D. patulus* (Hall).

The grits and conglomerates which are shown on the western edge of the map, are believed to be older than the shales lying east of the Fenni, for they appear only where the anticline is widening and where, in consequence, older beds might be expected to emerge. But at Regwm, the grits appear to overlies other, and presumably older, shales; if they do so they ought to take ground again in the southern limb of the anticline before we reach the base of the *D. bifidus* Beds at Forest. But they do not do so; therefore either a fault intervenes or, as is perhaps less likely, the grits die out. The evidence to be found in the Gronw valley (Sheet 228) confirms that obtained at Regwm. We must, therefore, admit the probable existence of a fault. That the lower limit of the *D. bifidus* Beds is itself a fault is possible, and it is shown as such by Mr. D. C. Evans² on his map; but as the position of the supposed fault is uncertain, no line for it has been drawn upon our map.

North of the grit area shown on the map, small and indefinite outcrops of grit may be found near Pen-glôg; they yield occasional specimens of *Orthis* and trilobite-fragments.

The general anticlinal structure of the Tetragraptus Beds is clear from their relations to the newer rocks. To the north they pass normally under the *D. bifidus* Beds, but along their southern boundary they are inverted; the anticline, therefore, has been overfolded from the north. But it is not a simple overfold, for at many points the dip is low and there are minor folds of small amplitude.

T. C. C.

IGNEOUS ROCKS.

Near Llangynog some igneous rocks consisting of extrusive andesites and rhyolites, with intrusive masses of porphyry and diabase, rise up among the Ordovician sediments. They were described in 1839 by Murchison,³ and were shown as ash-beds and 'greenstone' on the Geological Survey Map and Section.⁴ T. Roberts⁵ in 1893 noticed that one of the areas marked as ash on the Old Series Map is a diabase. In 1906 a detailed account⁶ of the rocks was given before the Geological Society, and to that paper the reader is referred for fuller particulars.

¹ Appendix, 57.

² *Op. cit.* pl. 46, and p. 612.

³ 'Silurian System,' p. 365.

⁴ Old Series One-inch Map, Sheet 41 (1845); Horizontal Sections, Sheet 2, Section 6 (1844).

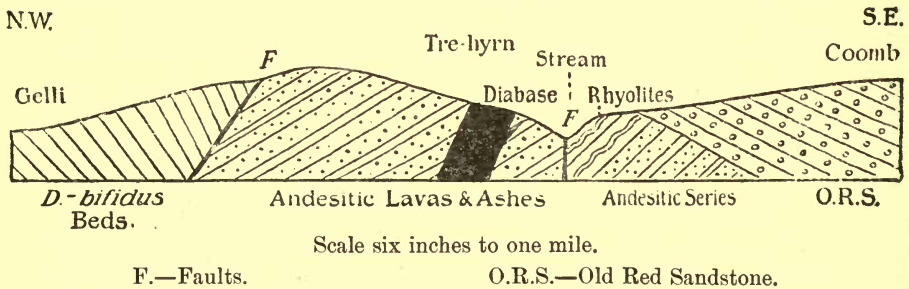
⁵ *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 170.

⁶ Cantrill and Thomas, *ibid.*, vol. lxii, 1906, pp. 223-252, and pls. xxiii-xxvi.

The igneous rocks occur in three separate areas: (1) near Coomb; (2) at Capel Bethesda, west of Glôg; and (3) at Lambstone, Llangynog.

Coomb.—Here the igneous rocks are overlain unconformably on the south by the Old Red Sandstone, but on the north and west are faulted against Tetragraptus and *D. bifidus* Beds. The area is dissected by a dingle, the subject of Nos. 380 and 381 in the Survey Collection of Photographs. On the eastern side of this dingle there are two similar series of andesitic tuffs and lavas separated by rhyolites; on the western side, to the south, lies a mass of rhyolites crowned by the ramparts of Castell Cogan, while to the north is a series of andesitic rocks into which diabase has been intruded at Trehyrn (Fig. 4). Another small patch of intrusive diabase crops up at the extreme south-west, near Pentre-newydd.

Fig. 4.—Section across Coomb Dingle.
(T. C. Cantrill.)



On the eastern side of the dingle the lower of the two andesitic series emerges, with northerly dip, from beneath the Old Red Sandstone (p. 74), and continues northward for about 200 yards. The rocks consist of buff and green tuffs, with occasional vesicular lava-flows, and are at least 350 feet thick. The rhyolites which succeed are pale-yellow and white-weathering rocks, often spherulitic; they are terminated by a fluxion-breccia and are about 150 feet thick. The upper andesites also dip north and are about 900 feet thick; they can be traced northward along the side of the dingle as far as the boundary-fault; they are chiefly tuffs, but contain some vesicular and compact andesites.

The rhyolites of Castell Cogan resemble those of the eastern side and locally exhibit spherulitic and fluxion structures; their thickness is estimated to be at least 1150 feet. North of the rhyolites, and probably faulted against them, lies a series of andesitic rocks, chiefly olive-green tuffs—some of which contain fragments of rhyolite identical in appearance with that of Castell Cogan—the whole estimated at 900 feet in thickness. Some conspicuous crags opposite Llwyn-celyn consist of hornblende-andesite.

The diabase of Trehyrn is intruded into the andesitic series; it varies from a dark green finely crystalline rock to a more compact variety not unlike some of the andesitic tuffs. It is

well-exposed south-east of Trehyrn and farther north breaks across the andesites and continues its course as a thinner sheet at a higher horizon. The diabase of Pentre-newydd is exposed only in the road east of that farm; it is a pale blue or dark greenish-grey rock which, in the hand-specimen, exhibits pyrite-crystals, lath-shaped feldspars, and patches of chlorite. At a bend in the road it includes some grit, having either caught up a mass, or intruded on both sides of a bed. A little farther north the junction of the intrusive rock with the rhyolites may be detected within narrow limits.

Capel Bethesda.—The igneous rocks here consist of rhyolites and diabase. The rhyolites are best exposed in the road immediately east of the chapel, where they dip north of west at 70° ; they are tough, blue-grey weathering to white, contain small pyrite-cubes, and are estimated to be at least 400 feet thick; they are probably on the same horizon as the rhyolites of Coomb. The diabase has been quarried at the cross-roads north of Pen-gelli-uchaf, but is rotten and full of calcite-veins and patches; it contains some inclusions of shale.

Lambstone.—This mass of porphyry is faulted on its western and southern sides against Bifidus and Tetragraptus Beds respectively. At Lambstone Farm the faulted junction may be narrowly located, the shales striking almost at right angles to the margin of the igneous mass. On the eastern and northern sides the shales strike parallel to the igneous margin and appear to pass underneath it. The way in which the shales curve round the northern end and dip toward the igneous rock suggests that this is a sill-like mass resting within a syncline in the Tetragraptus Beds. In hand-specimens it is pale-blue, weathering grey and white; the microscopic characters of the rock, the absence of flow-structure, its massive jointed appearance and the seeming induration of some of the surrounding sediments, combine in suggesting that the Lambstone porphyry is intrusive.

Microscopic details.—The vesicular varieties of the andesite-flows (E. 4137-8-9, 4130) are vesicular hyalopilitic augite-andesites, with soda-lime feldspars of two generations. In the hornblende-andesites (E. 4153, 4156) hornblende is inferred from pseudomorphs, of an indeterminable micaceous mineral, having the requisite external form. The andesitic tuffs are fine-grained well-banded rocks of buff or yellowish-green colour; under the microscope they are composed of alternating coarser and finer bands of sedimentary material consisting of grains and fragments of quartz and feldspar in a finer matrix of feldspar-microliths and broken crystals. The rhyolites present both perlitic and spherulitic structures; the few phenocrysts present are of acid plagioclase feldspar; the ground-mass was once glassy but is now completely devitrified, the matrix consisting of crypto-crystalline quartz and feldspar. The diabase of Trehyrn is dark-green in colour and, in pieces from the inner parts of the area, the constituents are visible to the naked eye. Under the microscope a specimen (E. 4131) proves to be coarsely ophitic, and shows large crystals of pale augite enclosing laths of feldspar intermediate in composition between oligoclase and andesine. The diabase of Pentre newydd also, though much decomposed, appears to have been ophitic; that at the western end of the Capel Bethesda tract is too rotten for identification. The Lambstone porphyry is considerably decomposed, but can be shown under the microscope (E. 4171) to have consisted of fairly large idiomorphic crystals of oligoclase and orthoclase, with minute hornblendes, set in a fine felsitic groundmass. The hornblende is now represented by chlorite-pseudomorphs.

Sequence and Age.—At Coomb the sequence appears to have been (1) augite-andesites, (2) rhyolites, (3) augite-andesites, including a small flow of hornblende-andesites, (4) intrusion of diabase and porphyry. In the surrounding districts ash-beds have been met with (1) near the top of the *D. purchisoni* Beds, (2) below the middle of the *D. bifidus* Beds, and (3) low in the Arenig Series. The extrusive rocks of Llangynog are not to be referred to the first two of these horizons, for on the south side of the Llanllwch-Llangynin anticline neither is, in this district, accompanied by ash. We are therefore led to the conclusion that the igneous rocks belong to the lower part of the Arenig group, or, failing that, to some much older group of rocks not visible elsewhere in the neighbourhood.

LLANVIRN SERIES.

The Llanvirn Series consists of blue-black shales with occasional ashes, flags and sandstones, characterized by didymograptids of 'tuning-fork' type which constitute the 'dependent series' of Elles and Wood. It was included by Murchison¹ in his 'Llandeilo Schists,' which he placed below the Llandilo Limestone. In 1879, Hicks², in the St. David's district, separated it from the Llandilo Series above and from the Arenig (Tetragraptus) Beds below under the name 'Llanvirn,' and it was mapped as a single group by Marr and Roberts³ in East Pembrokeshire and West Carmarthenshire. In 1896 Misses Crosfield and Skeat⁴ first mapped out the respective areas occupied by the *D. purchisoni* and *D. bifidus* Beds near Carmarthen, but included with the latter much of the underlying subdivision. The Geological Survey in 1901⁵ detected these zones in the Llandilo district, and since then has traced them into Pembrokeshire, while Mr. D. C. Evans⁶ has lately mapped them around St. Clears.

LOWER LLANVIRN (DIDYMOGRAPTUS BIFIDUS BEDS).

INTRODUCTION.

These consist of blue-black soft shales and mudstones, with bands of felspathic ash and sandstone well-developed in the lower half. They are characterized by the smaller species of 'tuning-fork' graptolites such as *Didymograptus bifidus*, *D. artus*, *D. nanus* and *D. stabilis*, while *D. purchisoni* var. *geminus* is common on certain horizons. The base is taken below the lowest occurrence of 'tuning-fork' graptolites and the top below the

¹ 'Siluria,' ed. 4, 1867, pp. 50 *et seqq.*

² *Pop. Sci. Rev.*, N.S., vol. v, 1879, pp. 302-3.

³ Marr and Roberts, *Quart. Journ. Geol. Soc.*, vol. xli, 1885, p. 480; Roberts, *ibid.*, vol. xlix, 1893, p. 166.

⁴ *Quart. Journ. Geol. Soc.*, vol. lii, 1896, p. 523.

⁵ 'Summary of Progress' for 1901 (*Mem. Geol. Surv.*), 1902, p. 35; 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 12, 15-18, and 227.

⁶ *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 597.

lithologically dissimilar beds in which the true *D. purchisoni* (Beck) first appears. In the more shaly beds graptolites predominate, but the mudstones yield many species of trilobites such as *Phacops llanvinnensis*, *Ilænus hughesi*, *Placoparia cambrensis* and *Trinucleus gibbsi*, all species characteristic of Hicks's Lower Llanvinn. Some of the extensiform graptolites of the Tetragraptus Beds survived, and among them the peculiar form referred to on p. 11.

The summit of the subdivision is marked by a thin band of black shales¹ in which *Didymograptus purchisoni* var. *geminus* abounds. Farther west (in Sheet 228) these beds are probably represented at Llan Mill near Lampeter Velfrey by similar black shales which must be referred to an upper part of the *D. bifidus* Beds characterized by *Didymograptus acutidens* Lapw. As these immediately underlie the Llandilo Limestone the *D. purchisoni* Beds appear to be missing. At Llandilo² *D. acutidens* was found at the top of the soft black *D. bifidus* Shales, below the sandy micaceous beds which we now believe to represent the *D. purchisoni* Shales of the Carmarthen district.

The shales are frequently stained a bright-red, but weather to a buff tint. The ashes are never agglomeratic, but are often exceedingly fine-grained; where unweathered the less siliceous bands retain a pale blue-grey tint, but near the surface frequently pass into a friable ochreous rottenstone. Ashes occur on the northern side only of the main anticline (p. 138), their place being taken on the south by ashy sandstones, though these, when followed west of St. Clears, are replaced by ashes similar to those of the north crop.

T. C. C. and H. H. T.

LOCAL DETAILS.

East of Carmarthen.—South of the Towy, an old quarry, 200 yards N. by W. of Ffynnon-Dewi, shows these beds to be overridden by the Dicranograptus Shales (p. 49), and in a small cliff 120 yards north of Ffynnon-Dewi they yielded³ *Didymograptus bifidus* (Hall) and *Ampyx*? Similar shales, probably belonging to a separate outcrop, may be seen at the cross-roads south of Capel-Dewi-isaf. In the Llangunnor Hill outcrop they are best exposed west of the church. In the churchyard, opposite the west door of the church, they yielded⁴ fragments of a tuning-fork *Didymograptus*. Ashy grits and interbedded shales run north-east from a quarry 300 yards north of Ty-gwyn. From the quarry Misses Crosfield and Skeat obtained a fragmentary graptolite, which by some mistake appeared in Prof. Lapworth's manuscript list as *Dicranograptus* cf. *ramosus* Hall, and led to the beds being placed

¹ D. C. Evans (*op. cit.* p. 620) places these shales in the *D. purchisoni* Beds.

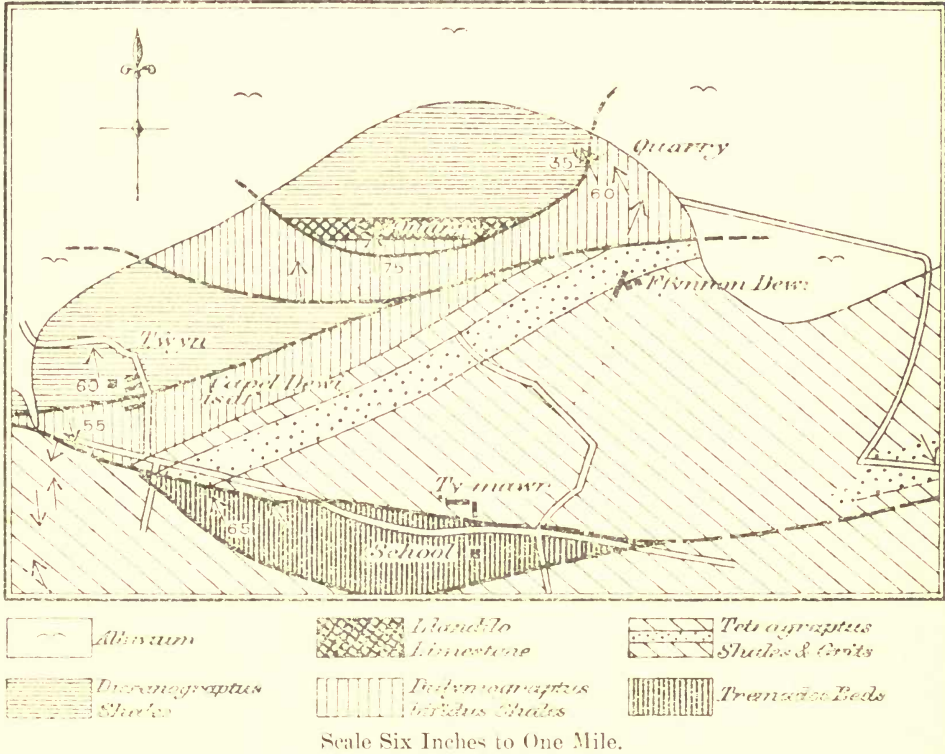
² 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 12, 16.

³ Appendix 58.

⁴ Appendix 59.

with the *Dicranograptus* Shales. We have examined this specimen and find it to be a dichograptid stipe probably of *Didymograptus acutidens* Lapw., a form common in the *D. bijidus* Beds.

Fig. 5.—Map of Capel-Dewi Hill.
(H. H. Thomas.)



South of Ty-gwyn the passage of the *D. bijidus* Beds into the *Osgia* mudstones may be seen in a stream south of the main road (p.14). Shales are exposed in the high road-bank below Pen-y-morfa; they are much crushed, but 150 yards east of the turning to Pen-y-morfa yielded¹ 'tuning-fork' graptolites and *Aeglina* sp.

North of the R. Towy, near Abergwili, shales are exposed along the main road and dip beneath a sigmoidal outcrop of banded ashes. Just north of the map, andesitic ashes run from Pen-y-graig to Pen-y-banc, and may be seen in several old quarries, especially in one south-west of Cwm, from the shales of which Crosfield and Skeat recorded *Acidaspis buchi* Barr. and *Ampyx* sp. Specimens of the ashes² from a quarry 300 yards east of Lletty Henry (Sheet 211) show signs of shearing, and are composed of broken crystals of oligoclase-andesine feldspar and fragments of

¹ Appendix 60,

² E. 4043-4045.

shale in a partly clastic silicified matrix. A rather unusual feature is the occurrence, throughout the mass, of extremely minute pyramidal crystals of anatase.

In this district the cleavage dips steeply, with the bedding, to the north, and fossils are rare except in thin bands. A band six inches thick crosses a stream, 300 yards S.W. of Pen-y-graig, and at a small fall over a thin ash we obtained a great number of specimens¹, mostly *Didymograptus bifidus* (Hall), with possibly *D. stabilis* E. & W.

North and West of Carmarthen.—Shales occupy the floor of the road leading north from Carmarthen to Pen-lan, and are next seen in the road north of Carmarthen Cemetery. They are cleaved, but on the roadside 300 yards south of Parc-glâs yielded² fragments of graptolites, and *Lingula attenuata* J. de C. Sow. On the south flank of Trevaughan Hill they pass under the ashy beds of the Murchisoni Shales (Fig. 7), and are well exposed in the lane behind Trevaughan House, where both bedding and cleavage dip north. They reappear in the core of an overfold, which runs the length of Trevaughan Hill, 30 yards north of the large quarry in ashes (p. 37).

The fault forming the northern boundary of Trevaughan Hill brings in another outcrop of *D. bifidus* Beds, which in its westerly prolongation forms part of the Llanllwch-Llangynin anticline (p. 138). To the west, near Ffynnon-y-saint, we obtained³ fragments of graptolites, and *Aeglina binodosa* Salt. At 100 yards north of Capel Farm we obtained⁴ stipes of *Didymograptus sp. nov.*, *Aeglina binodosa* Salt., and *Ampyx nasutus* Dalm.

The road-section in the Via Julia mentioned on p. 18 exposes the passage into the Arenig Beds. At 265 yards east of the Cywyn bridge the upper beds yielded⁵ dichograptid stipes and *Aeglina binodosa* Salt., while imperfect 'tuning fork' graptolites were seen.

The ashes form the best guide to the structure of the area, for they render evident faults and disturbances not visible in the softer beds. They form a conspicuous ridge leading to a quarry 600 yards west of Nant-y-bwla, and present the usual characters as described on p. 26. Their outcrops between Nant-y-bwla and Merthyr are much broken by strike-faults; at Merthyr and to the east a fault duplicates their outcrops for 900 yards. Shales are well seen near Nant-y-Ci (Merthyr), and their relation to the ash-beds may be studied in a quarry 300 yards east of the house, where they yielded⁶ a 'tuning fork' *Didymograptus* and *Diplograptus* (*Glyptograptus*) *dentatus* (Brongn.).

¹ Appendix 61. The specimens are much compressed and simulate *D. geminus*, *D. nanus*, and *D. artus*. Mrs. Shakespear, however, considers that they are mostly *D. bifidus* (Hall).

² Appendix 62.

³ Appendix 63.

⁴ Appendix 64. The *Didymograptus* is the same as that mentioned on p. 11 as allied to *D. acutidens* Lapw., and is common on the dividing line between the Llanvirn and older rocks.

⁵ Appendix, 65.

⁶ Appendix, 66.

A good section in shales is exposed along a footpath, and beyond in a lane, leading from Merthyr to Cwm Farm (Sheet 211). In the lane, at 500 yards south-west of the farm, we obtained¹ *Didymograptus* cf. *bifidus* (Hall), *Ampyx* sp., *Cheirurus* (*Cyrtometopus*) *primigenus* (Ang.), *Phacops llanvirnensis* Hicks, and *Trinucleus* sp.

In a quarry, 250 yards west by south of Merthyr Church, ashy mudstones, which pass normally beneath the ashes, yielded specimens² identified as *Didymograptus bifidus* (Hall), *D. purchisoni* (Beck) and *D. cf. purchisoni* (Beck). There is, however, no doubt that these mudstones are low in the *D. bifidus* Beds and far removed from the Zone of *D. purchisoni*. It is probable that the form identified as *D. purchisoni* is a variety or a new species and identical with that found on similar horizons to the west (*infra*). The highest *D. bifidus* Shales (p. 25) occur at Felin Ricket; behind a cottage, just above the road, between 10 and 20 yards south of the quarry in the *D. purchisoni* Ash (p. 37), they yielded³ *Didymograptus bifidus* (Hall), a species intermediate between *D. bifidus* and *D. artus* E. and W., *Ampyx nasutus* Dalm., and *Trinucleus gibbsi* Salt.

Shales below the ashes may be seen at several points, e.g., east of Pen-rhiw, at Pant-y-deri, Bron-y-gaer, and Pen-tywyn. The ashes make good ridges and have been quarried in many places.⁴ Shales and mudstones above the ashes are exposed near Llys-onen, in the drive and in the lane north of the house; to the west, at Hafod, in the farm-yards of Cefn dau-fynydd and Lan, and in several roads. From a road bank 50 yards south-east of Pant-glâs we obtained⁵ *Didymograptus bifidus*? (Hall).

West of the Dewi Fawr and east of the Cynin the ashes are repeated many times by strike-faults. North of Esgair a good quarry shows the ashes to be hard silicious banded rocks⁶ and hornstones passing up into ashy shales with hornstone courses.

Shales and mudstones are well exposed along the St. Clears-Mydrim road, and Mr. D. C. Evans has obtained fossils from several localities, one of which was an exposure at a bend in the road, 150 yards N.E. of Pen-coed.⁷ In a quarry 400 yards north of Plâs-parciau (Plâs-parciau quarry of Evans), shales, just above the ashes, yielded⁸ *Didymograptus* cf. *bifidus* (Hall), *D. bifidus*? (Hall), *D. purchisoni*? (Beck), and *D. purchisoni* var. *geminus* His. This peculiar assemblage is similar to that found at Merthyr (*supra*) in shales below the ashes; it seems to be connected with lithological conditions. The var. *geminus* His.

¹ Appendix, 67.

² Appendix, 68.

³ Appendix, 69.

⁴ For details of exposures see six-inch manuscript maps deposited in the Geological Survey Office.

⁵ Appendix, 70.

⁶ Microscope-slide E. 4406.

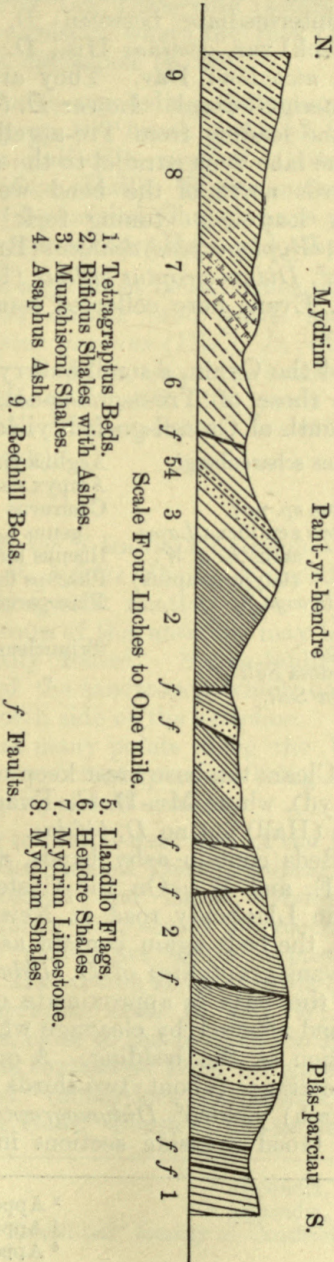
⁷ Evans, *op. cit.*, p. 617. This is probably the locality erroneously referred to by Roberts (*Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 168), as "Pen-coed, $\frac{1}{2}$ mile north-east of Whitland."

⁸ Appendix, 71.

of *D. murchisoni* (Beck) is of no zonal value, for it occurs as frequently low down in the *D. bifidus* Beds as it does in the *D. murchisoni* Shales.

Fig. 6.—Section from Mydrim to Plas-parciau.

(H. H. Thomas.)



The above section is practically that exhibited by the St. Clears-Mydrim Road, and shows the general Ordovician succession to the north of the main anticline. The apparent thickness of the Bifidus Beds is greatly increased by repeated strike-faulting; some of the faults being normal down-throws, while others are of an overthrust-nature. There is reason to believe that all the Bifidus Ashes shown in the section are dislocated portions of the same bed.

mudstones and shales are exposed north-east of Craig-yr-eiryn, and, at 100 yards north-north-west of Wheelabouts, yielded¹ *Didymograptus bifidus* (Hall) and a specimen of *Dichograptus octobrachiatus* (Hall) with only six stipes.

East of Lan there are three outcrops of ash, due to repetition of one band by faulting. One of the crops is quarried for roadstone near the Fox Inn, Llangynin (south-west of Eithen), and again at Rhyd-y-ceisiad, where the rock (E. 4428) has the usual character of *D. bifidus* ash (p. 26).

The *D. bifidus* shales succeeding the ash-group can be examined by following up the brook south of Cethin; near the site of Pen-sarn (a half-mile west of Cethin) they yielded *Didymograptus* cf. *bifidus* (Hall). Shales on the Llanboidy road, on the hill near Rhyd-y-ceisiad Chapel, have yielded to Mr. D. C. Evans *Didymograptus bifidus* (Hall) and other graptolites.

Some debris of the uppermost black shales, at the western end of the Castell-gorfod outlier (450 yards south of Pen-lan) yielded² *Didymograptus geminus* (His.), *D. cf. geminus* (His.), and *Diplograptus* sp. Beds on about the same horizon crop out in the road at altitude-point 492 (500 yards west-by-north of Pen-lan), and yielded³ *Didymograptus murchisoni*? (Beck) and *D. cf. murchisoni* (Beck).

T. C. C.

The south side of the Llanllwch-Llangynin Anticline.—The lower part of the *D. bifidus* Shales is mostly inverted, and faulted on the south against another outcrop of Tetragraptus Beds; the Arenig group of the anticline may be partly inverted and perhaps isoclinally folded. Strike-faults also frequently repeat the outcrop of the sandstones, which occupy the horizon of the ashes of the north side of the anticline. These sandstones have been quarried at many points along the Ystrad and Pen-plás ridge, the most important quarries being those of Ystrad, Pen-lan, Waun-corngam, and Wern-ddu.

In the lane leading to Hafod-wen, west of the Towy, at 50 yards east of the house, shales yielded⁴ *Didymograptus* cf. *bifidus* (Hall), and to Misses Crosfield and Skeat *Diplograptus dentatus* (Brongn.). In the farm-yard, shales are succeeded by a thick speckled sandstone; shales are again exposed at a spring, 300 yards N.N.E. of Hafod-wen and 200 yards S. of Ystrad-isaf, and yielded⁵ *Didymograptus artus* E. and W. On the north side of the sandstones, close to the footpath in Allt-Waun-Corngam (p. 18), 200 yards south-west from the gate, shales yielded⁶ dichograptid stipes and 'tuning-fork' graptolites, at 50 yards from the outcrop of Arenig Beds. South of the sandstones, shales and

¹ Appendix, 78.

² Appendix, 79.

³ Appendix, 80.

⁴ Appendix, 81.

⁵ Appendix, 82. The 'Ystrad-isaf' locality of Crosfield and Skeat.

⁶ Appendix, 83.

mudstones, at a point marked 'spring' on the six-inch map, 200 yards W.S.W. of Wernddu, yielded ¹*Diplograptus* sp., *Aeglina* sp. nov., *Ampyx nasutus* Dalm., *Barrandia homfrayi* Hicks, and *Ogygia* sp. At 50 yards to the west we obtained ²*Didymograptus* cf. *bifidus* (Hall), and at 90 yards, the same fossil with an *Ampyx* sp. At Bryn-glâs, $\frac{1}{3}$ of a mile south of Berth-lwyd, shales behind the house and just below the sand-stones yielded ³*Didymograptus* cf. *bifidus* (Hall).

North of Pen-plâs the sandstones have been extensively quarried and they are well exposed in the Crymlyn dingle (Fig. 3, p. 19). At their extreme westerly point they have been quarried for 150 yards along the outcrop; the quarry is now disused.

The southern margin of the sandstones running west from Cwm-côch is marked by a deep dingle in shales which show signs of overthrusting from the north, but the shales at the waterfall 330 yards south-west of Cwm-côch yielded ⁴*Didymograptus artus* E. and W. and *Orthoceras* sp., while 50 yards down stream we obtained *Didymograptus bifidus* (Hall) and *Diplograptus* sp.

In Cwm Crymlyn all the shales both above and below the sandstones are fossiliferous and, 20 yards down stream from the sandstones, we obtained ⁵*Didymograptus bifidus* (Hall). South of the sandstones the fossils observed were mostly trilobites.

Red-stained shales in a small quarry, at the point where the cart-road from Pen-lan (S. of Cywyn Grove) crosses the stream to the north-east, yielded ⁶*Didymograptus* cf. *bifidus* (Hall); and 50 yards down stream we obtained ⁷*Didymograptus bifidus* (Hall), *D.* cf. *bifidus* (Hall), and *Aeglina binodosa* Salt. Shales in a stream, $\frac{1}{4}$ mile south of Penlan, afforded ⁸*Didymograptus bifidus* (Hall) and *Trinucleus* cf. *sedgwicki* Salt.

Close to the western side of the Lambstone porphyry, shales exposed in the roadway, 500 yards south-west of the cross-roads, yielded a single specimen of *Didymograptus bifidus* (Hall)⁹, and the same fossil was observed in debris on the hill-slope to the west.

H. H. T.

The hill between Croes-y-ceiliog and Gelli appears to be formed by an anticline, in grit, pitching westward. The rock has been quarried 230 yards north of the Trigonometrical Point. Under the microscope (E. 4149) it is seen to contain fragments of felspar, quartzite and devitrified rhyolite, which give it a white-speckled aspect. A brook-section 350 yards north-west of Gelli yielded ¹⁰*Didymograptus* cf. *bifidus* (Hall), *Didymo.* cf. *stabilis* E. & W., *Diplograptus* (*Glyptograptus*) cf. *dentatus* (Brongn.), as well as species of *Ampyx* and *Trinucleus*. A thick grit at Gelli is probably on the same horizon as that described above.

¹ Appendix, 84.

³ Appendix, 86.

⁵ Appendix, 88.

⁷ Appendix, 90.

⁹ Appendix, 92.

² Appendix, 85.

⁴ Appendix, 87.

⁶ Appendix, 89.

⁸ Appendix, 91.

¹⁰ Appendix, 93.

Red-stained shales, well-exposed in a road-cutting 550 yards south-west of Asgood, yielded among other forms¹ *Didymograptus artus* E. & W., and *Euomphalus cordensis* J. de C. Sow. A small quarry 100 yards north-east of a new house (Bron-heulog) shows 6 feet of dark grit, on shales containing² *Didymograptus affinis* Nich. and *Placoparia*? At Plas-y-gwer several grit-bands, on about the same horizon, crop up in red-stained shales which, in a lane south of the farmyard, yielded³ *Didymograptus artus* E. & W., *D. bifidus* (Hall), *Diplograptus* cf. *dentatus* (Brongn.) and *Hyalolithus* sp. At St. Clears a fault appears to shift the base; it may be the cause of the disturbance, visible in a road-section 100 yards south of the Blue Boar Inn, which manifests itself as a belt of contorted beds traversed by several overthrusts accompanied by shattering, rotting and bleaching. South of this belt the beds assume a regular dip and yield⁴ *Didymograptus bifidus* (Hall), or *D. nanus* Lapw. North of the disturbance the shales are well exposed along the main road west of the Blue Boar. At 30 yards north-east of Sion Chapel we obtained⁵ from them *Didymograptus bifidus* (Hall) or *D. stabilis* E. & W., and the disturbance mentioned above is seen again at the chapel. Farther west the shales are exposed at Llain-delyn, a quarter-mile south-east of Pwll-trap, and are traversed by what is probably a continuation of the same crush-belt. They here yielded⁶ *Phyllograptus anna* Hall, while Mr. D. C. Evans obtained also *Didymograptus bifidus* (Hall) and *Phyllograptus typus* Hall. The lowest beds occur in Sabulon Brook (p. 20).

The lane running along the bank of the Tâf above St. Clears Bridge yields several sections; at 170 yards north-west of the bridge were collected:—⁷

<i>Didymograptus artus</i> E. & W.	<i>Euomphalus</i> cf. <i>cordensis</i> J. de
" <i>bifidus</i> (Hall)	C. Sow.
<i>Diplograptus</i> (<i>Glyptograptus</i>)	<i>Aeglina binodosa</i> Salt.
<i>dentatus</i> ? (<i>Brongn.</i>)	" <i>grandis</i> ? Salt.

One of several thin hard bands has a pisolitic structure. At the New Bridge over the Tâf, on the Pembroke Road, the sections recommence and may be examined along the road to Backe; some pisolitic hard bands and examples of cone-in-cone structure may be observed. At Backe Farm shales with thin ashy bands are exposed.

The southern of the two ash-beds shown on the map has been quarried behind Woolstone; under the microscope, the rock (E. 4433) is seen to consist of broken oligoclase crystals set in a matrix of broken plagioclase felspars with secondary quartz and felspar; pyrites cubes are now represented by limonite. The northern band has been quarried at several points, and in a small old quarry 200 yards north of Woolstone the mudstones associated with it contain *lapilli* a quarter-inch in diameter. Shales

¹ Appendix, 99.

³ Appendix, 101.

⁵ Appendix, 103.

⁷ Appendix, 105.

² Appendix, 100.

⁴ Appendix, 102.

⁶ Appendix, 104.

are exposed in the brook flowing at the north-west foot of Woolstone Hill, and yield specimens¹ of *Didymograptus* of '*bifidus*' type, notably among the shale-tips from several old trial pits and levels in search of coal, one of which had in 1904 been recently re-opened.

A quarry 400 yards east-by-south of Clôg-y-frân shows shale passing down into fine-grained pale flaggy ash; under the microscope the rock (E. 4431) is found to be a crystal-tuff like E. 4433 described above. Shales in Clôg-y-frân farmyard have yielded² the following:—

<i>Didymograptus</i> cf. <i>artus</i> E. & W.	Cf. <i>Calymene brevicapitata</i>
" <i>bifidus</i> (Hall)	Portl.
<i>Ampyx nudus</i> (Murch.)	<i>Trinucleus concentricus</i> (Eaton),
" cf. <i>salteri</i> Hicks	cf. var. <i>favus</i> Salt.
<i>Asaphellus</i> ?	" cf. <i>fimbriatus</i> Murch.
	" <i>murchisoni</i> ? Salt.

From Clôg-y-frân an ash runs as far as a wood bordering the alluvium of the Fenni; on each side of it there is an old trial-shaft sunk in the shales in search of coal.

West of the Fenni the outcrop of *D. bifidus* Beds is much faulted (Fig. 8, p. 42). The ashes are best exposed in a large roadstone quarry 300 yards south-east of Forest. The rock is a light-blue ash, generally fine-grained except for one or two pebbly bands, one of which in particular contains rolled pieces of hard black shale up to 6 inches in length, while its finer parts contain pisolitic grains. Under the microscope a slice of this variety is thus described by Mr. H. H. Thomas:—

E. 4429.—*Crystal Tuff*. Large broken oligoclase-crystals decomposed into secondary quartz and calcite, fragments of andesitic glass crowded with microlites, and possibly pumice with chlorite-filled vesicles. These larger fragments are set in a fine sedimentary matrix originally felspathic but now largely silicified. A secondary structure involving the formation of pisolitic grains (? phosphatic) has affected the matrix, and the whole has become impregnated with pyrites. Particles of pyrites are noticeable in the pisolitic grains.

Access to the quarry is gained by a cutting in red-stained *D. bifidus* Shales which dip steeply southward. At the northern end of the cutting a bed of pugged-up shale, 3 feet 6 inches thick, separates the shales from the ash, the surface of which is slickensided. This quarry forms the subject of No. 363 in the Survey collection of photographs.

The structure of the *D. bifidus* outcrop west of St. Clears presents difficulties. It appears to exhibit a continuous succession, with a high northerly dip. This would imply a thickness of some 3,500 feet of rock between the fault at St. Clears Bridge and the summit of the *Tetragraptus* Beds near Gors, whereas the thickness is not likely to exceed 2,000 feet. There is reason therefore, to suspect repetition by faulting or folding. The manner in which the ash-beds of Woolstone and Clôg-y-frân disappear eastward, along the strike, suggests faulting, though it is not conclusive, as ash-beds are not developed east of St. Clears.

¹ Appendix, 106.

² Appendix, 107.

But while there is no reason to doubt that the two Woolstone outcrops are distinct beds, it is probable that the Clôg-y-frân outcrop is one of the Woolstone bands repeated by a disturbance which presumably traverses the dingle between the two places. Such a fault if prolonged eastward would account for much of the exaggerated thickness. The occurrence, too, of dips of 10° or 20° , in association with the more usual high dips, suggests the existence of many isoclinal folds with one limb inverted.

T. C. C.

UPPER LLANVIRN (*DIDYMOGRAPTUS MURCHISONI* BEDS).

INTRODUCTION.

These beds were typically developed, north of St. Clears, consist of about 230 feet of striped ashy and flaggy shales containing abundant specimens of *Didymograptus murchisoni* (Beck). At their base there appears locally an ash, the *D. Murchisoni* Ash, which reaches 40 feet in thickness, but is frequently wanting. This ash-band is on the same horizon as that which Hicks took as the base of his Upper Llanvirn at Abereiddy Bay, north of St. Davids. Upward the shales pass into a fossiliferous ash, the Asaphus Ash, which we regard as the representative of the Ffairfach Grit of Llandilo, where it forms a natural base to the Llandilo Flags¹.

East of Carmarthen the shales are more purely argillaceous and there is no *D. murchisoni* Ash. They thus more closely resemble the sandy and micaceous shales lying between the *D. bifidus* Beds and the Ffairfach Grit, at Llandilo, which, through lack of evidence, we were compelled (in 1907) to regard as the upper part of the *D. bifidus* Beds.

T. C. C. and H. H. T.

LOCAL DETAILS.

At Felin-wen, near the eastern margin of the map, dark shales marking the junction of the *D. bifidus* and *D. murchisoni* Beds are exposed in the road-bank opposite the Corn-mill and have yielded² graptolites intermediate in character between *Didymograptus bifidus* and *D. murchisoni*, var. *geminus*, together with *D. cf. bifidus* (Hall), *D. murchisoni*? (Beck), and *D. murchisoni*, var. *geminus* (His.). Northwards they may be followed in upward succession, along the mill race to an old quarry in the Asaphus Ash (p. 40).

In an old quarry at the western end of Merlin's Hill we obtained³ *Didymograptus* sp. ('tuning fork') and *Trinucleus* sp.

¹ 'Geology of the Country around Ammanford,' (*Mem. Geol. Surv.*), 1907, p. 19.

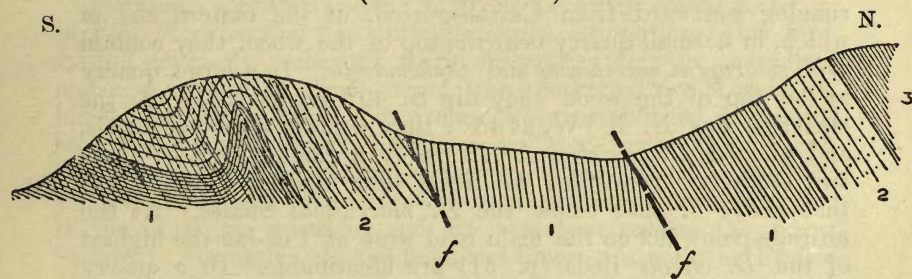
² Appendix, 108.

³ Appendix, 109. A locality mentioned by Misses Crosfield and Skeat.

On the north side they are faulted against *D. bifidus* Beds (Sheet 211) which pass into another outcrop of *D. murchisoni* Beds extending westwards to Tre-Vaughan. North of the map this outcrop is well seen at the eastern end of Allt-Castell-Pigyn and north of Abergwili; behind a cottage, 250 yards north of Glangwili Bridge, striped shales yielded abundant *Didymograptus murchisoni*¹ (Beck), and are immediately succeeded by agglomeratic ash-beds (Asaphus Ash). This outcrop enters the map north of the old reservoirs, north-east of Carmarthen. In an old quarry 500 yards north of Pen-lan cleaved shales yielded fossils to Misses Crosfield and Skeat, and to the west there are several good exposures on the hill leading down to Tre-Vaughan. The same beds, together with the *D. murchisoni* Ashes, are quarried on the eastern flank of Tre-Vaughan Hill (Fig. 7 below). The

Fig. 7.—Section across Tre-Vaughan Hill.

(H. H. Thomas.)



Scale Six Inches to One Mile.

- | | |
|--|----------------------------------|
| 1. <i>Bifidus</i> Beds. | 3. <i>Dicranograptus</i> Shales. |
| 2. <i>Murchisoni</i> Shales and Ashes. | f. Faults. |

main outcrop of the *D. murchisoni* Shales runs almost parallel to, but north of, the margin of the map for some distance from north of Tre-Vaughan, by way of the Plough and Harrow, to Cwm north of Merthyr, where it is faulted out by a disturbance which brings *Dicranograptus* Shales over on to *D. bifidus* Beds.

The outcrop re-enters the map at Felin Ricket between the rivers Cynnen and Cywyn. At the base, ash-beds immediately succeed the black *D. bifidus* shales, and are well exposed in a large roadside quarry, 50 yards N.N.W. of the Mill. The associated shales yield characteristic graptolites. The thickest ash-bed (E. 4819) as seen in the quarry is several feet in thickness and has a pale blue colour when unweathered. About 20 yards north of the quarry, debris of the Asaphus Ash was detected in the soil. On the other side of the valley the *D. murchisoni* Shales, and the lower part of the Asaphus Ash, are exposed in a large quarry on the hill-side, and the position of

¹ Appendix, 110. Fossils from many other localities north of the map are preserved in the Survey Collection.

the *D. purchisoni* Ash can be inferred from debris to the south. Pale ashy and black shales in the quarry yielded crowds of *Didymograptus purchisoni* (Beck).¹

At Cefn-crwth the same shales and ash are well seen in the farm-yard and in a quarry 50 yards west of the house; the shales are crowded with *Didymograptus purchisoni* (Beck), and the commonly associated *Diplograptus (Orthograptus) calcaratus*, Lapw., var. *priscus* E. and W. occurs.²

Followed to Pant-glâs, the shales strike across the Dewi to a large quarry (Pant-yr-hendre quarry)³, $\frac{1}{3}$ of a mile south of Mydrim. The lowest beds in the quarry are striped flaggy shales with *Didymograptus purchisoni* (Beck). The junction of these shales with the *D. bifidus* Beds is visible at many points, but to best advantage in the road west of Pant-yr-hendre.

H. H. T.

West of the Cynin the *D. purchisoni* Beds form a bold ridge, running westward from Castell-gorfod, at the eastern end of which, in a small quarry near the top of the wood, they contain *Didymograptus purchisoni* and *Siphonotreta*. In a large quarry at the top of the wood they dip S. 40° W. at 75°, while the cleavage dips N. 10° W. at 45°; they contain some ash-bands, and yielded *D. purchisoni*. Probably a fault separates these two sections. Westward the fields show debris of ash, either that above or that below the *D. purchisoni* Shales. At the altitude-point 492 on the main road west of Pen-lan the highest of the *D. bifidus* Beds (p. 31) are identifiable. In a quarry just north of the map the *D. purchisoni* Beds contain⁴ *Didymograptus purchisoni* (Beck) and *Diplograptus sp.*

On the south of the anticline it is doubtful if the *D. purchisoni* Beds are present. Mr. D. C. Evans has recorded from a deep well at Croft Lodge, St. Clears, black mudstones, crowded with forked graptolites, which he describes under the head of *D. purchisoni* Beds, and correlates with some black mudstones underlying the *Asaphus* limestones of Llan Mill near Narberth (Sheet 228). The Llan Mill mudstones, however, on the evidence of the contained graptolites, are certainly to be referred to the *D. bifidus* Beds.

T. C. C.

¹ Appendix, 111. $\frac{1}{3}$ mile north of Llys-onen.

² Appendix, 112.

³ 'Pant-rhendref,' Roberts *op. cit.* p. 169.

⁴ Appendix, 113.

CHAPTER IV.

ORDOVICIAN ROCKS (CONTINUED).

LLANDILO SERIES.

INTRODUCTION.

The 'Llandeilo Formation,' as originally described by Murchison in his 'Silurian System,'¹ was evidently intended to include only the typical calcareous flags and limestones of Llandilo, and other beds, in which he had found the characteristic fossils *Asaphus tyrannus* and *Ogygia buchi*. It is equally clear that he originally meant to exclude the shales which occur above and below the flags and limestones, for he placed these with Sedgwick's 'Cambrian.' Subsequently, however, in other districts, by a process of expansion and through faulty correlations, this formation gradually embraced rocks differing widely in character and age. Some of these errors were corrected by Murchison himself or others, and new groups were established, but until recent years no attempt had been made to revise the typical Llandilo area. During the re-survey of the Llandilo district we have found that Murchison's original definition of these rocks is the only one possible, and we therefore confine the term 'Llandilo Formation' to the flags and limestones with the Ffairfâch Grit at their base.

In the sheet under description the place of the Ffairfâch Grit² is taken by the Asaphus Ash, which, like its equivalent at Llandilo, is characterised by the form *Asaphus tyrannus*. On the northern side of the main anticline, west of Carmarthen, the Asaphus Ash averages about 70 feet in thickness and passes up into calcareous flags with *Ogygia buchi*. Its lower limit is drawn at the summit of the ashy shales with *Didymograptus murchisoni*. On the southern side of the anticline the Asaphus Ash is absent and the Llandilo limestone rests directly on Llanvirn shales. On the north, the main mass of the Llandilo Flags of Llandilo has passed into graptolitic shales (Hendre Shales), leaving only a thin series of flagstones immediately above the ash; but east of Carmarthen and south of the anticline massive Llandilo limestone occurs above the Llanvirn shales and ranges up to 150 or 200 feet in thickness.

The graptolitic facies of the Llandilo Flags will be discussed under the heading of *Dicranograptus* Shales (p. 44).

T. C. C. and H. H. T.

¹ 'Silurian System,' p. 355.

² 'Geology of the Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 12, 19-22.

LOCAL DETAILS.

THE ASAPHUS ASH.

The ashes and agglomerates which constitute the Asaphus Ash everywhere succeed the *D. purchisoni* shales, and are usually followed by a thin series of Llandilo flags. At Felin-wen (p. 36) an old quarry on the west side of a little valley exposes the ash and the overlying calcareous flags and limestones; the upper beds, however, are better displayed on the high ground east and north of Nantgaredig (Fig. 15, p. 138). To the west, the Asaphus Ash forms the summit of Merlin's Hill, which owes its form to its synclinal structure and to the hardness of the ash-bed.

North of the map the ashes and agglomerates (E. 4047-4053) are well exposed in an old river cliff on the east bank of the Gwili, 300 yards north of Glan-Gwili Bridge, and consist of andesitic tuffs, agglomerates, and silicified ashy sediments. They are also laid open by a quarry west of the river. The main outcrop commences at Felin-Ricket (p. 37), and to the west quarries have been opened north of Llys-onen (p. 37), at Cefn-crwth (p. 38), Pant-glâs, Pant-yr-hendre (p. 38) on the Mydrim road, and to the west of the Oernant road, 100 yards west of the altitude point marked 495. At Pant-yr-hendre quarry the ash has a thickness of about 80 feet.

FLAGS AND LIMESTONES.

On the north side of the anticline, a thin series of flags is exposed above the Asaphus Ash in an old quarry 250 yards west of Pen-y-bigwrn House and yielded¹ *Ogygia buchi* (Brongn.), and *Trinucleus* sp. To the west, the northern side of Pant-yr-hendre quarry (p. 38) is occupied by about 50 feet of these flags similar to the Llandilo flags of Llandilo; they pass up into the Hendre Shales (p. 48), and yielded² *Calymene cambrensis*? Salt., *Ogygia buchi* (Brongn.), and *Trinucleus* cf. *concentricus* (Eaton).

South of the Towy, Llandilo limestone, with a thickness of 90 to 100 feet, and a length of outcrop of not more than 350 yards, occupies the summit of Capel-Dewi hill (Fig. 5, p. 26); it is faulted on three sides, but northwards is succeeded normally by Dicranograptus Shales. In an old quarry 300 yards north of Ffynnon-Dewi it yielded³ :—

Lingula sp.	Plectambonites cf. sericea (<i>J. de C.</i>
Orthis (Dalmanella) testudinaria <i>Dalm.</i>	<i>Sow.</i>)
Orthis cf. porcata <i>M^cCoy</i>	Rafinesquina llandiloensis? (<i>Dav.</i>)
„ sp.	„ cf. semiglobosa (<i>Dav.</i>)
	Asaphus sp.

This quarry was referred to by Murchison⁴ in 1839, and later by Phillips⁵ who recorded the occurrence of *Asaphus tyrannus* Murch. and *Ogygia buchi* (Brongn.).

H. H. T.

¹ Appendix, 114.

² Appendix, 115. Mr. Evans has given an extensive list from this quarry (*op. cit.*, p. 625); see also Roberts, *op. cit.*, p. 169.

³ Appendix, 116.

⁴ 'Silurian System,' p. 357.

⁵ *Op. cit.* pp. 236 and 239.

The Llandilo Limestone is next visible in a quarry, 500 yards north-north-east of Lower Court, which shows six feet of yellow rotten sandstone over 29 feet of black flags and limestones, with the following fossils¹ :—

<i>Lingula tenuigranulata</i> M ^c Coy	<i>Plectambonites</i> sp.
<i>Orthis</i> (<i>Dalmanella</i>) <i>elegantula</i> Dalm.	<i>Rafinesquina</i> cf. <i>semiglobosa</i> (Dav.)
<i>Orthis</i> (<i>Dalmanella</i>) <i>testudinaria</i> Dalm.	<i>Asaphus tyrannus</i> Murch.
<i>Orthis</i> (<i>Hebertella</i>) <i>vespertilio</i> J. de C. Sow.	" sp.
<i>Orthis</i> cf. <i>patera</i> Dav.	<i>Calymene cambrensis</i> Salt.
	<i>Trinucleus</i> sp.
	<i>Beyrichia</i> sp.

Mr. D. C. Evans, who records among other forms *Ogygia buchi* (Brongn.) and *Trinucleus favus* Salt., is disposed to regard the beds as inverted. The dip is toward the *D. bifidus* Beds of Dan-yr-allt (p. 33) and away from the *D. bifidus* Beds which are presumed to underlie Lower Court. At least one boundary of the outcrop must therefore be a fault. If the strata are not inverted the northern must be the faulted boundary—a supposition expressed on the map. At 200 yards north of Pant-dwfn, thin-bedded black limestone is quarried to a thickness of about 30 feet. From this locality John Phillips² recorded several fossils; a specimen of *Orthis testudinaria* Dalm. is preserved in the Geological Survey Collections and has been figured.³ T. Roberts⁴ also collected here. We have obtained the following forms :—

<i>Orthis</i> sp.	<i>Asaphus tyrannus</i> ? Murch.
<i>Plectambonites sericea</i> (J. de C. Sow.)	" sp.
<i>Plectambonites sericea</i> , var.	<i>Trinucleus</i> sp.
<i>Rafinesquina</i> cf. <i>deltoidea</i> (Conr.)	<i>Beyrichia complicata</i> Salt.

The limestone reappears at Clôg-y-frân (Figs. 8 and 9, pp. 42–3) as a lenticle faulted on the north against *D. bifidus* Beds (p. 35) and on the south against Bala limestone and Redhill Beds (p. 61). The rock has been deeply quarried and burnt for lime, and was mentioned as long ago as 1595 by George Owen of Hênlllys in his Description of Pembrokeshire.⁶ Murchison⁷ recognized the rock as belonging to the Llandilo Flags. At the south-eastern end of the outcrop the rock has been worked-out up to the boundary-faults; the quarry shows thick-bedded coarsely-crystalline grey limestone, full of fossils, chiefly *Orthis*, together with pieces of *Asaphus* and *Trinucleus*. Many of the joint-faces and bedding-planes are studded with small angular

¹ Appendix, 117.

² 'The Malvern Hills,' *Mem. Geol. Surv.*, vol. ii, pt. 1 (1848), p. 323.

³ As *O. testudinaria* Dalm. in *Mem. Geol. Surv.*, vol. ii, pt. 1 (1848), pl. 27, fig. 8, and as *O. striatula* Conrad, *ibid.*, vol. iii, ed. 2 (1881), pl. 13, fig. 10.

⁴ *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 166.

⁵ Appendix, 118.

⁶ First published in 1799 in the 'Cambrian Register' for 1796, vol. ii, pp. 53–230. Re-issued in 1892 as No. 1 of the Cymmrodorion Record Series.

⁷ 'Silurian System,' p. 385.

Fig. 8.—Map of Clog-y-frán and Forest.

(T. C. Cantrill.)

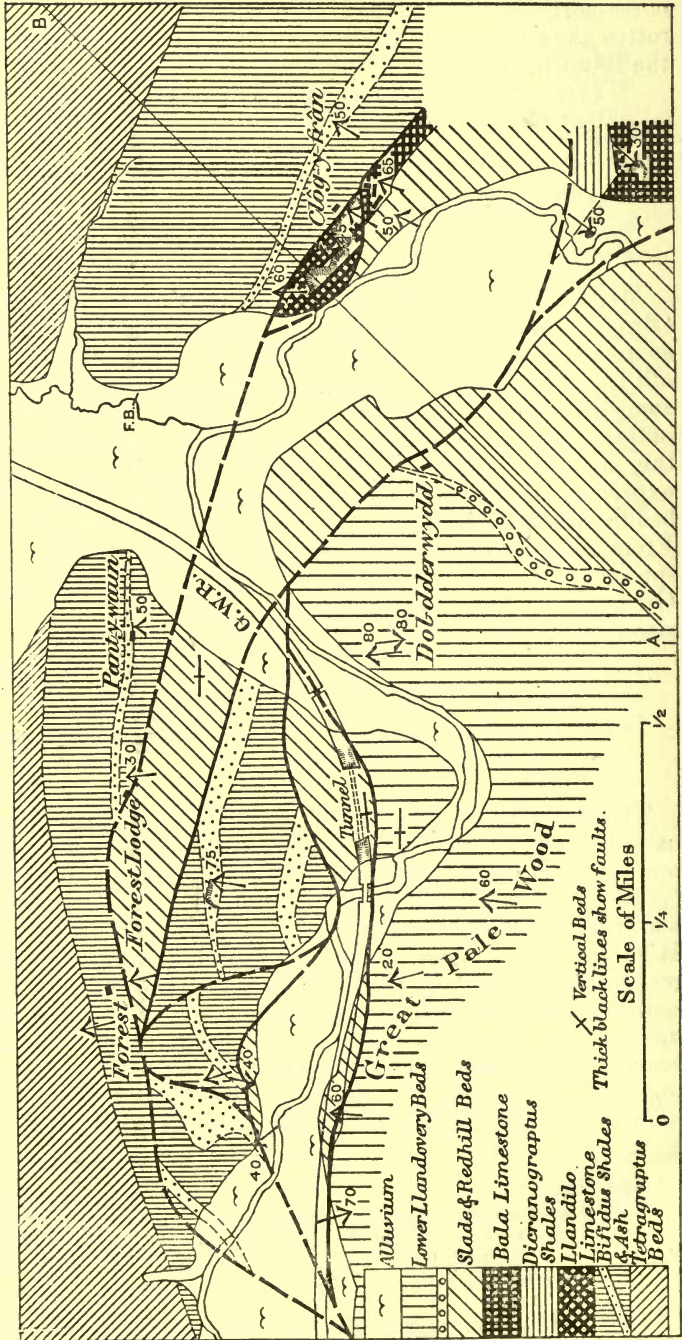
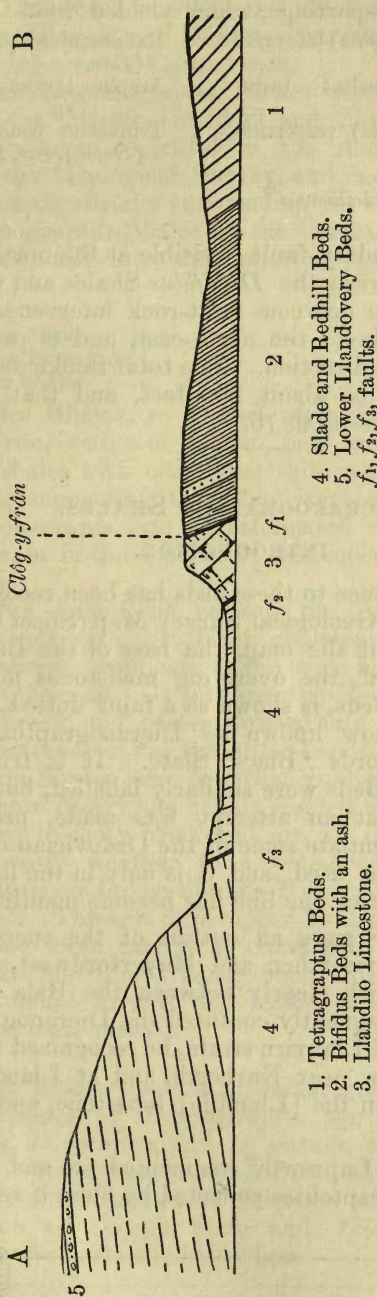


Fig 9.—Section through Clòg-y-frân along line A—B of Fig. 8.

(T. C. Cantrill.)



Horizontal scale, six inches to one mile; vertical, twice the horizontal.

At its south-western end (A) the line of section begins at the escarpment of the Lower Llandoverly (5) of Pale Mountain. Descending a considerable thickness of Slade and Redhill Beds (4) and crossing a fault (f_3) it reaches the alluvium of the River Taf, on the north-eastern side of which the Llandilo Limestone (3) of Clòg-y-frân is faulted in. It then crosses the Bifidus Beds (2) (with an ash), and ends on the outcrop of the Tetragnostus Beds (1), where the strata are isoclinally folded and inverted.

fragments of quartz. A spur on the western side of the entrance to the quarry shows thin-bedded limestones, separated by black sandy shale-partings, which yielded¹:—

Orthis (Platystrophia) biforata? (Schloth.)	Rafinesquina cf. llandeiloensis (Dav.)
Orthis (Dalmanella) testudinaria Dalm.	Asaphus tyrannus Murch.
Orthis (Hebertella) vespertilio J. de C. Sow.	Trinucleus concentricus (Eaton), var. favus Salt.
Plectambonites sp.	
Rafinesquina llandeiloensis (Dav.)	

The northern boundary-fault is visible at the north-east corner of the quarry; between the *D. bifidus* Shales and the limestone a foot or so of brown ochreous fault-rock intervenes. The fault dips at a high angle to the north-east, and is presumably an overthrust from that direction. The total thickness of limestone exposed appears to be about 200 feet, and that of the more northerly band not less than 70.

T. C. C.

DICRANOGRAPTUS SHALES.

INTRODUCTION.

The earliest reference to these beds has been recognized on the Old Series one-inch Geological Survey Map (Sheet 40) published in 1845. On parts of the map, the base of the Bala limestone, or, in its absence, of the overlying mudstones now known as Redhill and Slade Beds, is shown as a faint dotted line, and the underlying rocks, now known as Dicranograptus Shales, are marked with the words 'Black Slate.' It is true that some tracts of *D. bifidus* Beds were similarly labelled, but allowing for this, it is clear that an attempt was made, presumably by J. Phillips, to differentiate some of the Ordovician deposits. No distinctive colour was used, and it is only in the light of recent work that the import of the line has become manifest.

In 1848 Phillips² gave an outline of the succession in the district between Carmarthen and Haverfordwest, and although he did not distinguish clearly between the Bala and Llandilo limestones, and consequently confused the Dicranograptus Shales with the Arenig and Llanvirn strata, he recognized that "in some places, as at Crinow near Narberth, and at Llandewi Velfrey, black shales lie upon the [Llandilo] limestone, and also contain graptolites."

In 1879 Prof. C. Lapworth³ commented on, and gave a list of the species of, the graptolites collected by himself from St. Clears Bridge (p. 51).

¹ Appendix, 119.

² *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, pp. 219, 220.

³ 'On the Geological Distribution of the Rhabdophora,' *Ann. Mag. Nat. Hist.*, ser. 5, vol. iv, 1879, p. 333.

Messrs. Marr & Roberts¹ in 1885 appear to have been the first to apply the name '*Dicranograptus*-shales' to the beds between the Llandilo Limestone and the Bala limestones of the Haverfordwest district, and Roberts² identified the same shales in the ground lying west of Carmarthen.

In 1896 the *Dicranograptus* Shales were mapped near Carmarthen by the Misses Crosfield and Skeat,³ and from 1903 onwards have been described in the Annual Summaries of Progress of the Geological Survey, and in 1906 by Mr. Evans⁴ in his paper on the district surrounding St. Clears.

The *Dicranograptus* Shales in the Carmarthen district, where best developed, fall into the following groups in descending order:—

						Ft.
Mydrim Shales	..	..	..	..	..	700
Mydrim Limestone		..	..	..	..	0—150
Hendre Shales	..	..	..	..	..	500

The Hendre Shales, so named after Pant-yr-hendre Farm west of Mydrim, consist of brown-, buff-, and yellow-weathering black sandy shales with occasional thin ashy bands, their mode of weathering suggesting that they were originally calcareous. They pass downwards into an attenuated representative of the Llandilo flags, or in the absence of this succeed the *Asaphus* Ash without break.

The Mydrim Limestone consists of thin-bedded dark-grey impure limestones with soft black shale-partings, and, although occasionally absent, reappears at the same horizon at intervals in the district to the west. It succeeds the Hendre Shales abruptly but without break, and passes upward into the Mydrim Shales by the disappearance of the limestone-bands.

The Mydrim Shales are somewhat rubbly in their lower part but become more flaggy and evenly bedded upwards. They vary from dark-grey to sooty-black and are all more or less pyritous. They occasionally weather to a pale-grey, especially around organisms, but never brown like the Hendre Shales, except in the highest 90 feet. Towards their upper limit they tend to weather yellow, become more sandy in character, and pass gradually upward into the Shoalhook Limestone (p. 51). At about 90 feet from their summit several thin bands of decalcified crinoidal limestone have been noticed.

The Hendre Shales contain abundant graptolites of Glenkiln character. Species of *Dicellograptus* are common, especially *D. divaricatus*, *D. intortus*, and *D. sextans*, while with these may be mentioned *Climacograptus scharenbergi*, *Cryptograptus tricornis* and *Lasiograptus bimucronatus*. Certain of the Llandilo Flag trilobites, such as *Ogygia buchi* and *Trinucleus concentricus*, var. *favus*, survived into the lower beds.

¹ *Quart. Journ. Geol. Soc.*, vol. xli, 1885, p. 476.

² *Ibid.*, vol. xlix, 1893, p. 166.

³ *Ibid.*, vol. lii, 1896, p. 523.

⁴ *Ibid.*, vol. lxii, 1906, p. 597.

The Mydrim Limestone is characterised by an abundance of the well-known Glenkiln forms *Didymograptus superstes* and *Nemagraptus gracilis* which, as far as this district is concerned, are confined to the limestone-horizon. With these are associated *Climacograptus scharenbergi*, *Leptograptus validus*, &c.

The Mydrim Shales in their lower part contain a mixture of Glenkiln and Lower Hartfell graptolites, but towards their summit they yield the characteristic forms of the Zone of *Dicranograptus clingani*, and may even include the lower portion of the Zone of *Pleurograptus linearis*. They are then succeeded by the Bala limestone. At about 300 feet above the Mydrim Limestone more flaggy shales contain an abundance of *Diplograptus* (*Mesograptus*) *multidens* and *Climacograptus lineatus* (Mesograptus Beds). These forms become less abundant upward and their place is taken by varieties of *Diplograptus* (*Orthograptus*) *calcaratus*, of which var. *vulgatus* is the most conspicuous (Vulgatus Beds.) The upper part of the shales characterised by this variety clearly belongs to the Zone of *Dicranograptus clingani*, a form which is itself found in some abundance.

The shales with *D. clingani* pass upward into yellow-weathering shales, about 100 feet thick, and characterised by Lower Hartfell forms, such as *Climacograptus minimus* and *Diplograptus* (*Orthograptus*) *truncatus*, which lead us to place these beds in the uppermost part of the *D. clingani* Zone, or low down in that of *Pleurograptus linearis*.

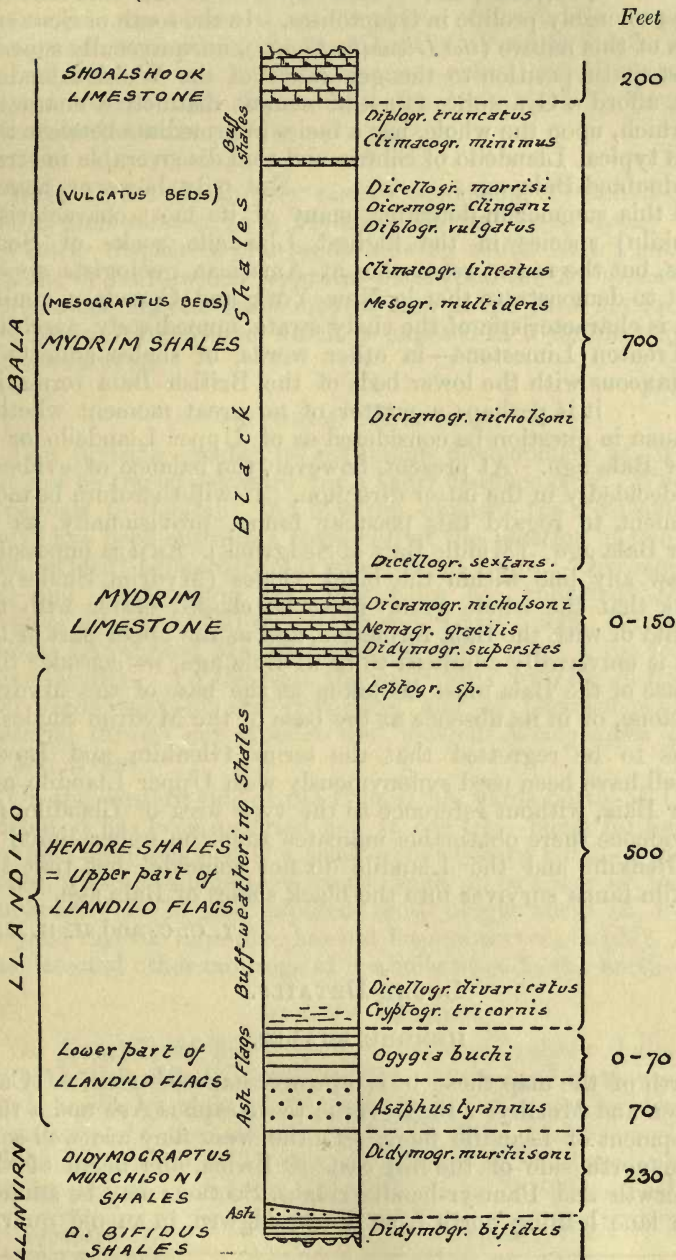
In the typical district of Llandilo (Sheet 212) the Llandilo Flags pass up into black shales which are identical with the Mydrim Shales, and in their lowest beds contain *Climacograptus scharenbergi*, *Dicellograptus sextans* and *Nemagraptus gracilis*. These lowest beds we consider to be on the same horizon as the Mydrim Limestone, and thus conclude that the Hendre Shales represent a graptolitic facies of the Llandilo Flags of Llandilo.

At Llandilo the base and summit of the Llandilo Flags are marked by striking lithological changes, and there is no justification on any grounds for placing in the Llandilo Series any other beds than the flags and limestones with their natural basement-bed the Ffairfach Grit or Asaphus Ash, especially as these constitute the only portion of Murchison's 'Llandilo Formation' of which the upper and lower limits are well defined. It is now possible to define the Llandilo Flags of Llandilo as those beds which lie below the black shales with *Didymograptus superstes* and *Nemagraptus gracilis* and above the Zone of *Didymograptus murchisoni* (p. 36).

Although the lower part of the Mydrim Shales contains a mixture of Glenkiln and Lower Hartfell graptolites, the upper portion is everywhere recognised as being of Bala age. On palæontological considerations, a dividing line between Glenkiln and Hartfell has been suggested at a horizon about half-way up in the Mydrim Shales. This line is not accompanied by any marked lithological change, and cannot be accepted as a practicable boundary between the Llandilo and Bala formations.

Fig. 10.—The Llandilo-Bala Succession.

(T. C. Cantrill and H. H. Thomas.)



This diagram serves to show the relative positions of the various subdivisions ; it is not drawn strictly to scale.

In discussing the line of separation between these two formations Professor Lapworth¹ makes the following statement:—“The Upper Llandeilo [of Lapworth] and Lower Bala rocks both consist, in great part, of dark and more or less carbonaceous shales, tolerably prolific in Graptolites. In the south of Scotland, strata of this nature (*the Glenkiln Shales*), unequivocally superior in systematic position to the generality of the Welsh Llandeilo rocks, afford a Graptolite fauna of a most distinctive character, but which, upon the whole, has a facies intermediate between that of the typical Llandeilo of Siluria and that discoverable in strata of undoubted Bala age. . . . Not only, however, have I failed this summer in detecting many of its most characteristic [Glenkiln] species in the highest Llandeilo rocks of South Wales, but the recent researches of American geologists appear almost to demonstrate that in New York and Canada a similar fauna is characteristic of the shaly strata immediately overlying the Trenton Limestone—in other words, of shales admittedly homotaxeous with the lower beds of the British Bala formation . . . it is perhaps a matter of no great moment whether the fauna in question be considered as of Upper Llandeilo or of Lower Bala age. At present, however, the balance of evidence leans decidedly in the latter direction. It will therefore be more convenient to regard this peculiar fauna, provisionally, as of Lower Bala age” [Middle Bala of Sedgwick]. As it is impossible to draw any line within the black shales (Mydrim Shales), it follows that the whole group must be classed either with the Llandilo or with the Bala formation, and as the upper part of the shales is universally admitted to be of Bala age, we consider that the base of the Bala must be taken at the base of the Mydrim Limestone, or in its absence at the base of the Mydrim Shales.

It is to be regretted that the terms Glenkiln and Lower Hartfell have been used synonymously with Upper Llandilo and Lower Bala, without reference to the type area of Llandilo, for the evidence there obtainable indicates that the upper limits of the Glenkiln and the Llandilo do not coincide, but that the Glenkiln fauna survives into the black shales of Bala age.

T. C. C. and H. H. T.

LOCAL DETAILS.

HENDRE SHALES.

North of the map these beds are well exposed north of Carmarthen and Merthyr: they overlie the Asaphus Ash and a thin development of Llandilo flags. To the west they are well seen on the north side of the hill east of Bwlech, and north of the Cefn-crwth and Pant-yr-hendre ridges. Sections may be studied in the lane leading north from Pen-y-bigwrn, in an old quarry

¹ ‘Distribution of the Rhabdophora,’ *Ann. Mag. Nat. Hist.*, ser. 5, vol. iv. p. 423.

300 yards north of Lan Farm, and in the road between Penllwyn-plain and Mydrim. In Lan quarry we obtained¹ *Dicellograptus* cf. *divaricatus* Hall, *D. sp.*, *Diplograptus* (*Mesograptus*) *foliaceus* Murch., var., and *Lingula attenuata* J. de C. Sow. *Trinucleus* was observed in abundance west of the Dewi-fawr. Shales are exposed in the road between Pant-yr-hendre quarry and Mydrim, to the south of Oernant-uchaf, and in the stream to the west of the farm. All the beds yield characteristic Glenkiln forms.

H. H. T.

West of the Cynin they can be seen west of Castell-gorfod, and at their summit, as at Mydrim, contain *Leptograptus*. They are better displayed, in a brook flowing south from Pen-lan, on the line of fault which separates them from the *D. bifidus* Beds. At Pen-lan cleaved shales may be seen in the yard, not far below the Mydrim Limestone which is exposed in a dingle a little to the north-west.

T. C. C.

MYDRIM LIMESTONE.

This division reaches its maximum development at Mydrim, but can be traced eastward for a short distance only. Westward it persists to Pen-lan. At Mydrim, opposite the Post-office, the beds have been cut into a steep cliff at the junction of two roads, and yielded² *Climacograptus scharenbergi* Lapw., *Dicranograptus sp.*, and *Leptograptus sp.* Miss Elles has collected³ *Didymograptus superstes* Lapw., *D. euodus* Lapw., and *Leptograptus validus* Lapw., and Mr. Evans⁴ in his paper gives a list from the same locality. To the west the same beds crop out in the road, 250 yards west of the lych-gate, and at Oernant-uchaf the material thrown out from a well yielded *Nemagraptus gracilis* to Mr. Evans.

On the western side of the Cynin, 300 yards north of Castell-gorfod, it has been quarried and at one time burnt for lime. It has also been quarried in a small wooded scarp north of the same house, where the limestone bands range up to about six inches in thickness. It is also exposed in a dingle north of Pen-lan. Beyond this the limestone has not been observed, but Mr. Evans⁵ has detected other outcrops of it a mile or so to the north-west.

MYDRIM SHALES.

On Capel-Dewi hill (Fig. 5, p. 26) dark rubbly shales overlying the Llandilo limestone (p. 40) are exposed in a quarry 200 yards north by west of Ffynnon-Dewi; they are evidently on approximately the same horizon as those which overlie the Llandilo limestone of Ty-newydd quarry⁶ at Nantgaredig village, and are thrust over from the north on to *D. bifidus* Shales, the

¹ Appendix, 120.

² Appendix, 121.

³ Elles collection.

⁴ *Op. cit.*, p. 631.

⁵ *Op. cit.*, p. 631.

⁶ 'Country around Ammanford' (*Mem. Geol. Surv.*), 1907, p. 30.

thrust being visible in the quarry. They yielded¹ only unidentifiable species of *Climacograptus* and *Diplograptus*. The shales in the quarry at Ty-newydd contained² :—

<i>Climacograptus</i> <i>implicatus</i>	<i>Dendrograptid</i>
<i>Hopk.</i>	<i>Dicranograptus nicholsoni?</i> <i>Hopk.</i>
<i>Climacograptus antiquus</i>	<i>Diplograptus</i> (<i>Amplexograptus</i>) <i>cf.</i>
<i>Lapw., var.</i>	<i>coelatus</i> (<i>Lapw.</i>)
<i>Climacograptus antiquus</i>	<i>Diplograptus</i> (<i>Mesograptus</i>) <i>sp.</i>
<i>Lapw., var. lineatus</i>	<i>Orthis</i> (<i>Dalmanella</i>) <i>argentea</i> <i>His.</i>
<i>E. & W.</i>	<i>Paterula balcletchiensis</i> (<i>Dav.</i>)

It is practically certain that these shales lie at least 200 feet above the horizon of the Mydrim Limestone (p. 45), and that therefore part of the Mydrim Shales, the Mydrim Limestone, and the Hendre Shales are wanting in this section.

West of Carmarthen at Felin Ricket the Mydrim Shales are faulted against *D. bifidus* Beds, but further west succeed the Hendre Shales on the north side of Llys-onen Hill. They are well exposed in an old quarry and road section north of Sarnau Farm (Mydrim), in the grounds of Pen-yr-heol House, and in a quarry 120 yards to the north-east; also at Drefâch north-east of Mydrim village. At Drefâch, by the roadside, 50 yards south-west of a small stream which crosses the road, *Mesograptus* Beds yielded³ *Diplograptus* (*Mesograptus*) *multidens* *E. & W., var. compactus* *Lapw.*, and *D. (Amplexograptus) perexcavatus* (*Lapw.*). Still higher beds, at the corner of a road 100 yards to the north-east, contain⁴ *Orthis* (*Dalmanella*) *argentea?* *His.*

To the west black shales are met with in the Dewi-fawr, and the *Mesograptus* Beds contain⁵ *Dicranograptus brevicaulis* *E. & W., Diplograptus (Mesograptus) multidens* *E. & W., D. (Orthograptus) calcaratus* *Lapw., var. acutus* *E. & W., and Climacograptus scharenbergi* *Lapw.*

Cleaved shales belonging to the same horizon are seen by the roadside north of the chapel, but one of the most complete sections is to be found in the dingle 100 yards south-east of Llan-garth-Gynin. The lowest beds exposed in the dingle appear to be about 100 to 130 feet above the Mydrim Limestone, and the section is almost continuous for 400 yards, representing a thickness of at least 400 feet. The highest beds are exposed along the road west of Llan-garth-Gynin. The fossils⁶ include species of *Dictyonema* or *Callograptus*, *Diplograptus* (*Mesograptus*), and *Lasiograptus*, collected from the lower half of the dingle-section.

H. H. T.

West of the Cynin the Mydrim Shales are well exposed along a drive leading north-west from Castell-gorfod, and also in some roadside quarries at the western end of Castell-gorfod Wood, 400 yards north-north-east of Pen-lan.

At Llandilo-Abercowin the Mydrim Shales are exposed in the river-bank, near an old limekiln north-west of the farm, where

¹ Appendix, 122.

³ Appendix, 124.

⁵ List kindly supplied by Miss Elles from specimens in her collection.

⁶ Appendix, 126.

² Appendix, 123.

⁴ Appendix, 125. *Pen-rhosyn.*

they contain several sandstone bands and have yielded a few ill-preserved specimens of *Diplograptus*, and, to Mr. D. C. Evans, *Orthis argentea* His. A bed of sandstone north-west of Pentre-newydd has yielded specimens¹ of *Orthis* (*Platystrophia*) *biforata* (Schloth.), *Orthis* (*Dalmanella*) *testudinaria* Dalm., *Orthis* sp., and *Plectambonites* sp. From the left bank of the Tâf, 70 yards above the bridge at Lower St. Clears, Prof. C. Lapworth² has recorded '*Dicranograptus formosus* Hopk.,' *Dicellograptus sextans*? Hall, *Diplograptus foliaceus* Murch., '*Climacograptus coelatus*? Lapw.' and '*C. perexcavatus* Lapw.'

Miss G. L. Elles has recently collected the following from this section :—*Dicranograptus brevicaulis* E. & W., *Dicranograptus ziczac* Lapw., *Dicellograptus sextans* (Hall), *Diplograptus* (*Mesograptus*) *multidens* E. & W., *Amplexograptus perexcavatus* Lapw. These graptolites indicate that the beds are referable to the Mesograptus Beds. South of St. Clears, at Moelden, a cottage a quarter-mile north-west of Moor Farm, the shales are shown in contact with the Bala limestone (p. 56).

The best section in this district, however, is that afforded by a road-cutting a quarter-mile south-west of Mylet. The lower part of the Bala limestone (p. 56), in the form of yellowish-brown sandstone, passes downward into the Dicranograptus Shales, which are themselves sandy and appear to have been once calcareous. Graptolites³ were collected at various points along the road. The highest, which were got at 6 yards from, and 10 feet below, the base of the limestone, are specimens of *Diplograptus* (*Orthograptus*) *truncatus* Lapw. One is described by Mrs. Shakespear as typical, and she remarks that the beds containing it are probably at the base of the Zone of *Pleurograptus linearis*. More specimens were found at 13 yards from the limestone; at 26 yards occurred *Dictyonema*?; at 42 yards, *Climacograptus minimus* (Carr.); at 44 yards, a bed full of unusually small specimens of the same. At 52 yards an ostracod-band occurs on the south-east side of the road, as shown in the following descending section :—

	Ft.	In.
Ochreous band, ? a rotten ferruginous limestone	...	3
Shales, black, weathering yellow	...	2 0
Ostracod-band ⁴	...	2
Shales, blue	...	3
Limestone, rotten	...	8
Shales, black, weathering yellow	...	5 0
Limestone, rotten...	...	4
Shales, black, weathering yellow	...	2 0
Limestone, rotten, brown, crinoidal	...	1 0
	11	8

This calcareous group is estimated to lie about 80 or 90 feet below the base of the Bala limestone, and if that is the Shoalshook, this may be the Robeston Wathen Limestone. At

¹ Appendix, 127.

² *Ann. Mag. Nat. Hist.*, ser. 5, vol. iv, 1879, pp. 339-40.

³ Registered in the Geol. Survey Books as T.C.C. 1263-79.

⁴ Specimen registered in the Geol. Survey Books as T.C.C. 1278.

71 yards distance from the Bala limestone was found a band full of *Dicellograptus morrisoni* Hopk., a graptolite which is common in the zones of *Dicranograptus clingani* and *Pleurograptus linearis*. Miss G. L. Elles has identified the following also from this road-section:—*Dicranograptus clingani* Carr., *Diplograptus* (*Mesograptus*) *multidens* E. & W., *D.* (*Orthograptus*) *calcaratus*, var. *vulgatus* Lapw., *D.* (*O.*) *calcaratus*, var. *basilicus* Lapw., *D.* (*Glyptograptus*) aff. *teretiusculus* (His.).

Lower down the road a large quarry has been opened in black shales which appear to dip a little west of south at 45°, though they have been affected by a nearly horizontal cleavage; they have yielded¹ *Diplograptus* (*Mesograptus*) *multidens* E. & W., *Diplograptus* (*Mesograptus*) *multidens*, var. *compactus* Lapw., *Lasiograptus costatus*? Lapw., and belong to the Mesograptus Beds.

Another view of the passage up into the Bala limestone is afforded along the road from Llandowror to Pentre-Howel (see Fig. 11, p. 54). In Tal-fan farm-yard the shales are beautifully displayed on the crest of an anticline and can be traced thence to Cwm-cae-du (p. 56).

T. C. C.

BALA SERIES.

INTRODUCTION.

The earliest writers on the geology of this district failed to distinguish between the Llandilo and Bala limestones, and it was not until 1857, on the second edition of the Geological Survey map, that the ages of some of the limestones were differentiated by symbols. The first detailed account of the Bala Beds of South Wales was given by Marr and Roberts² in 1885, followed in 1893 by Roberts³, and later by the officers of the Survey⁴ and D. C. Evans⁵, who have adopted the subdivisions laid down by Marr and Roberts in their paper.

The Bala rocks of this area are divisible into the Slade and Redhill Beds above, the Bala limestones in the middle, and the Mydrim Shales and Limestone below.

The Mydrim Shales and Limestone have already been considered under the heading of *Dicranograptus* Shales (pp. 45, 49).

The Bala limestones include the Robeston Wathen and Shoals-hook Limestones of Marr and Roberts, which occur usually alone, but perhaps in some places associated together. In the absence of any unconformity at their base they rest on shales referable to the lower part of the Zone of *Pleurograptus linearis* (p. 46), but in the district to the west they come down onto beds of a lower horizon. We have to travel westward of the area at present under description to see the two limestones typically exposed, but we may perhaps regard a blue-black comparatively pure limestone at Foxhole (p. 56) and Cwm-cae-du (p. 56), as belonging to

¹ Appendix, 128.

² *Quart. Journ. Geol. Soc.*, vol. xli, 1885, p. 476.

³ *Ibid.*, vol. xlix, 1893, p. 166.

⁴ 'Geology of the Country around Ammanford' (*Mem. Geol. Surv.*), 1907.

⁵ *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 597.

the Robeston Wathen type, while some more sandy limestones at Trefanty (p. 56) and Llandowror (p. 56) are comparable with that of Shoalshook.¹

The Robeston Wathen type of limestone weathers to a fine dark-grey mealy rottenstone, and is characterised more especially by the presence of *Halysites catenularia* (Linn.). The Shoalshook type is especially remarkable for the abundance of trilobites, brachiopods, and cystids.

In this district the Bala limestones attain an aggregate thickness of about 300 feet.

The Slade and Redhill Beds were divided by Marr and Roberts into a lower portion termed Redhill Beds, and an upper and thinner portion named Slade Beds. Though it is sometimes possible to distinguish these two stages in a broad way, no line between them can be drawn on the map. On the southern side of the Llanllwch-Llangynin Anticline they present the following characters in ascending order. The lowest beds immediately following the Shoalshook Limestone are chiefly barren mudstones (Faynor, p. 60) which, at about 300 feet above the limestone, contain several bands of *Favosites fibrosus* (Cwm-dwr, p. 60). Next follow more grey mudstones with occasional fossils. These are succeeded by thinly-bedded sandstones (Morfa-bâch, p. 60), which in turn give place to another series of mudstones marked by several bands of *Favosites*.

The Redhill Beds of the southern outcrop have a thickness of some 1,200 feet, and pass gradually up into the Slade Beds which here have a thickness of about 300 feet.

The Slade Beds are more fossiliferous; they are occasionally red-stained, and present other appearances on weathering which, together, enable them to be distinguished from the mudstones below. *Phacops* (*Chasmops*) *macroura* has now been obtained from this subdivision, as well as from the Shoalshook Limestone.²

On the northern side of the main anticline the Redhill Beds have a thickness of at least 2,500 feet. They consist, with little variation from top to bottom, of barren dark-grey mudstones with spots and streaks of a still darker tint, and may represent a type of sediment intermediate between the shelly facies displayed to the south and the graptolitic facies seen in Central Wales.

T. C. C. and H. H. T.

LOCAL DETAILS.

BALA LIMESTONES.

At Llandilo-Abercowin³ a quartz-vein, probably a small fault, separates the Bala limestone from the Dicranograptus Beds. The limestone next the fault appears as a gritty decalcified rock weathering to an orange colour and containing trilobites; next follow dark flags with rotten limestones which contain scattered pebbles. One of the pebbles (E. 5120) was found under the microscope to be a rhyolite with some resemblance to

¹ See also D. C. Evans. *op. cit.*, pp. 633-7.

² See J. E. Marr, 'On the Ashgillian Series,' *Geol. Mag.*, 1907, p. 59.

³ Appendix, 129,

Fig. 11.—Map of Llandowror and Faynor.
(T. C. Cantrill.)

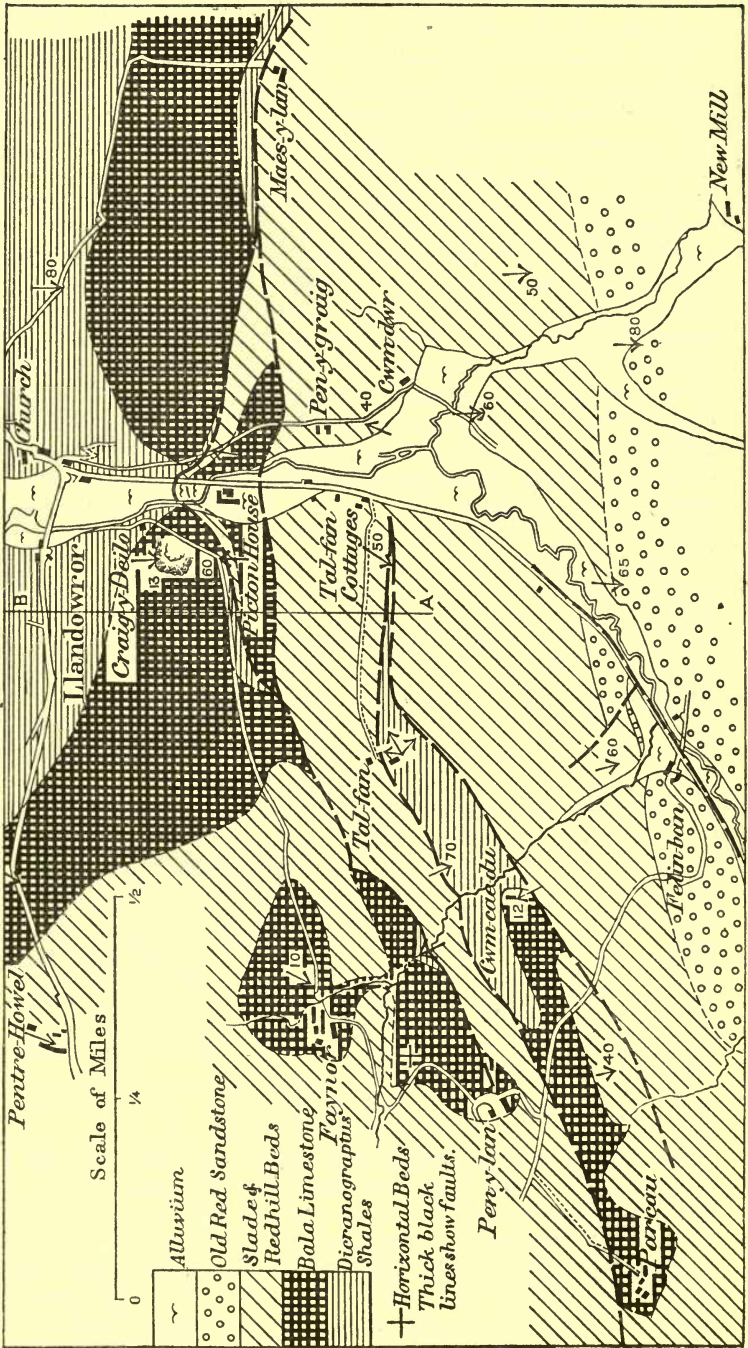
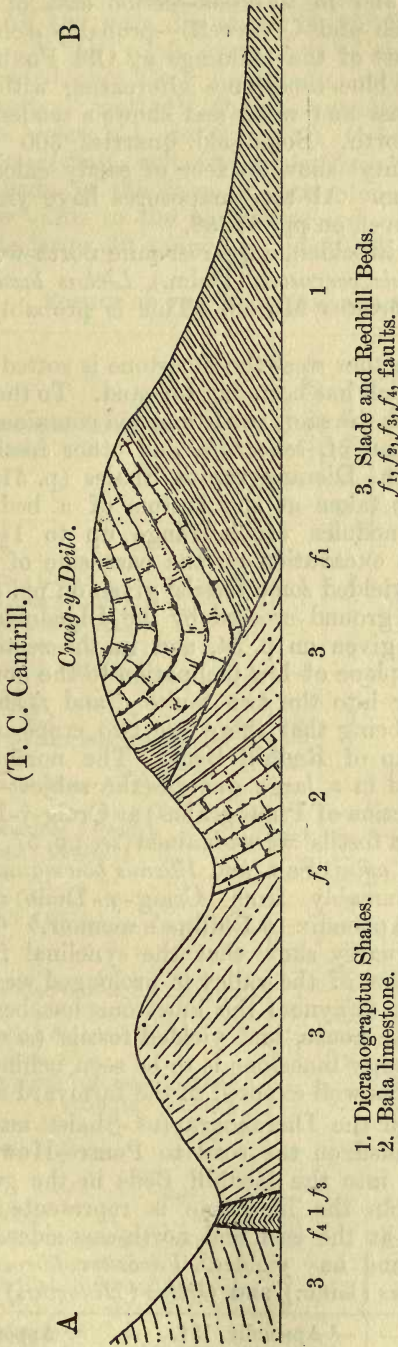


Fig. 12.—Section at *Ilandowror* along line A—B of Fig. 11.



Horizontal scale, 12 inches to one mile; vertical, twice the horizontal.

At the southern end (A) the section crosses a narrow outcrop of Dicanograptus Shales (1) brought up by two faults *f*₁ and *f*₃ along the axis of an anticlinal tract of Slade and Redhill Beds (3). The fault *f*₂ introduces an overthrust outcrop of Bala limestone (2) overlain by Slade and Redhill Beds (3). These are themselves over-ridden along the fault *f*₁ by a syncline of Dicanograptus Shales (1), capped by the Bala limestone of Craig-y-Deilo.

the rhyolites of Coomb (p. 22). The limestone is to be seen in an old quarry and in a brook-section east of Bron-haul¹ (between Morfa-bâch and Cresswell)—probably John Phillips's 'Moor.' To the east of the buildings at Old Foxhole² a small anticline brings up blue limestones alternating with calcareous flags. It ranges east and west, and shows a tendency to overfolding from the north. Some old quarries 300 yards west-south-west of Trefanty³ show 30 feet of sandy calcareous flags and rotten limestone. All these exposures have yielded fossils of which lists are given on pp. 57, 58.

The exposure at Moelden, a quarter-mile north-west of Moor Farm, yielded⁴ *Cybele verrucosa* (Dalm.), *Lichas laeatus* M^cCoy, and *Trinucleus fimbriatus* Murch. This is probably Phillips's locality 'Molden.'

A quarter-mile farther west the limestone is rotted into yellow coarse sandstone which has been dug for sand. To the south-west of Mylet it is in much the same condition, and contains *Encrinurus sexcostatus*, *Trinucleus* cf. *seticornis*, and other fossils. Downward it passes into the Dicranograptus Shales (p. 51), the plane of separation being taken at the bottom of a bed containing black phosphatic nodules which range up to 1½ inches in diameter. A small excavation on the east side of the road a little farther south yielded some fossils⁵ given on pp. 57, 58.

The complicated ground crossed by the Llandowror valley is shown in the map given on p. 54, and in the section forming Fig. 12. A thrust-plane of low inclination to the north splits as it crosses the valley into the two faults f_1 and f_2 shown in the section, the result being that there are two crops of limestone separated by a strip of Redhill Beds. The northern crop is excellently displayed in a large quarry (the subject of No. 360 in the Survey Collection of Photographs) at Craig-y-Deilo Farm, and from this section fossils⁶ were obtained (see pp. 57, 58). Specimens of *Dalmannia affinis* Salt. and *Ilænus bowmanni* Salt. from 'Llandowror,' presumably from Craig-y-Deilo quarry, are figured in Salter's Appendix to Phillips's memoir.⁷ The dips in and south of the quarry show that the synclinal form of the limestone outcrop east of the valley is prolonged westward. In the inlier at Baynor (Faynor) the limestone has been quarried 100 yards east of the house, and yielded fossils⁸ (see pp. 57, 58). Good blue-black flaggy limestone is to be seen behind the ruins of Cwm-cae-du, and is well exposed in the farmyard at Parcau.

The passage from the Dicranograptus Shales into the limestone can be examined on the road to Pentre-Howel, and that from the limestone into the Redhill Beds in the gorge of the Tâf. At Clôg-y-frân the limestone is represented by rotten sandstone, exposed at the east and north-east sides of the pond in the farmyard, and has yielded⁹ *Favosites fibrosus* (Goldf.), *Heliolites interstinctus* (Linn.), and *Orthis* (*Dinorthis*) *flabellulum*?

¹ Appendix, 130.² Appendix, 131.³ Appendix, 132.⁴ Appendix, 133.⁵ Appendix, 134.⁶ Appendix, 135.⁷ 'The Malvern Hills . . .', *Mem. Geol. Surv.*, vol. ii, pt. i, 1848, pl. v, fig. 5; pl. viii, fig. 1.⁸ Appendix, 136.⁹ Appendix, 137.

J. de C. Sow. South-east of the pond it rests on Redhill mudstones. All the beds dip about N. 25° E. at 60°, *i.e.*, they are inverted. A few yards north-west of the pond somewhat lower thin-bedded blue-black limestones, only a few bands of which are rotten, yielded¹ *Orthis actoniae* J. de C. Sow., *Plectambonites sericea* (J. de C. Sow.), *Cybele rugosa* (Portl.), *Iliaenus bowmanni* Salt., and *Stygina latifrons* (Portl.).

The same beds, in the form of rottenstones, crop out in the rickyard a few yards to the north-west and are then cut off on the edge of the large old quarry in Llandilo Limestone (p. 41).

FOSSILS OF THE BALA LIMESTONES.

GENERA AND SPECIES.	Llandilo-	Bron-	Old	Trefanty.	Mylet.	Craig-y-Deilo.	Baynor.
	1.	2.	3.	4.	5.	6.	7.
Cyathophyllum ?	—	—	3	—	—	—	—
Favosites fibrosus (<i>Goldf.</i>)	1	2	—	4	—	6	7
Halysites catenularia (<i>Linn.</i>)	1	2	3	—	—	—	—
Heliolites inordinatus (<i>Lonsd.</i>)	1	2	3	—	—	6	—
„ interstinctus (<i>Linn.</i>)	—	2	3	—	—	—	—
„ megastoma (<i>McCoy</i>)	—	—	3	—	—	—	—
„ sp.	—	—	—	—	5	—	—
Petraia sp.	1	2	3	—	5	—	—
<i>Cf. Corylocrinus pyriformis von Koenen</i>	—	2	—	—	—	—	—
„ ?	—	—	—	—	—	6	—
Echinospaerites balticus <i>Eichw.</i>	—	—	—	—	—	—	7
„ ?	—	—	—	—	—	6	—
Monticulipora favulosa (<i>Phill.</i>)	—	—	—	—	5	—	—
„ lens (<i>McCoy</i>)	—	—	3	—	—	—	—
„ sp.	—	—	—	4	—	—	—
Ptilodictya acuta (<i>Hall</i>)	—	2	—	—	—	—	—
„ acuta? (<i>Hall</i>)	—	—	3	—	—	—	—
„ sp.	—	2	—	—	—	6	—
„ ?	—	—	—	4	—	—	—
Leptaena rhomboidalis (<i>Wilck.</i>)	1	2	3	4	—	6	—
<i>Orthis actoniae J. de C. Sow.</i>	—	2	—	4	—	—	—
„ (<i>Dalmanella</i>) <i>argentea? His.</i>	—	—	—	4	—	—	—
„ <i>balechensis Dav.</i>	1	2	—	—	5	6	—
„ (<i>Platystrophia</i>) <i>biforata (Schloth.)</i>	—	2	3	4	5	—	—
„ <i>biforata? (Schloth.)</i>	—	—	—	—	—	6	—
„ <i>calligramma Dalm.</i>	—	—	3	4	—	—	—
„ <i>calligramma? Dalm.</i>	—	2	—	—	—	—	—
„ „ <i>var. carausi Salt.</i>	—	—	—	4	—	—	—
„ <i>crispa McCoy</i>	1	—	—	—	—	—	—
„ (<i>Dalmanella</i>) <i>elegantula Dalm.</i>	1	—	—	—	—	6	—
„ „ <i>elegantula? Dalm.</i>	—	—	3	—	—	—	—
„ (<i>Dinorthis</i>) <i>flabellulum J. de C. Sow.</i>	—	2	3	4	5	—	—
„ „ <i>flabellulum? J. de C. Sow.</i>	—	—	—	—	—	6	—
„ <i>cf. hirnantensis McCoy</i>	—	—	—	4	—	—	—
„ (<i>Plaesiomys</i>) <i>porcata McCoy</i>	—	—	—	4	—	—	—
„ <i>rankini Dav.</i>	—	—	—	4	—	—	—

¹ Appendix, 138.

REDHILL AND SLADE BEDS.

No Bala limestone appears between the Redhill Beds and the Mydrim Shales along the northern margin of the map. East of Mydrim the junction is probably a fault, but west of Mydrim it is normal. The Redhill Beds here succeed the lower part of the Zone of *Dicranograptus clingani*; the higher beds of the Dicranograptus Shales which occur on the southern side of the anticline are therefore wanting, and there must be a slight break at the base of the Redhill mudstones in this northern development. The mudstones are barren except for traces of *Orthis*, though they yielded fossils farther east.¹ They are generally cleaved, streaked, and present a somewhat blotched appearance. They are well-exposed along the road going north-west from the Cywyn at Rhyd-aber-wern, in the neighbourhood of Cil-coed, in the Dewi-fawr, along the road going northward from Mydrim, and to the north of Llan-garth-Gynin. The faulted junction with the Mydrim Shales is best seen in the yard of Pen-rhosyn, half-a-mile north-east of Mydrim, and the normal junction, by the roadside, 350 yards east-by-north of Llan-garth-Gynin.

H. H. T.

On the south side of the anticline, west of the Tâf, some beds near the base are exposed in Lower Cresswell farmyard (350 yards north of Cresswell), a locality from which, under the name 'Great Creswell,' John Phillips² records sundry fossils; and Mr. D. C. Evans has added others. We have obtained the following³:—

Favosites fibrosus (<i>Goldf.</i>)	Plectambonites sericea (<i>J. de C. Sow.</i>), var. rhombica <i>McCoy</i>
Halysites catenularia (<i>Lim.</i>)	Plectambonites sericea (<i>J. de C. Sow.</i>) [alate var.]
Petraia sp.	Plectambonites scissa (<i>Salt.</i>) [transverse var.]
<i>Cf.</i> Corylocrinus pyriformis <i>von Koenen</i>	Rafinesquina sp.
<i>Cf.</i> Placocystites sp.	Scenidium grayiae <i>Dav.</i>
Monticulipora sp.	" shallockiense <i>Dav.</i>
Phyllopora <i>cf.</i> hisingeri (<i>McCoy</i>)	<i>Cf.</i> Strophomena grandis (<i>J. de C. Sow.</i>)
Ptilodictya acuta (<i>Hall</i>)	Modiolopsis orbicularis (<i>J. de C. Sow.</i>)
<i>Cf.</i> Catazyga anticostiensis (<i>Bill.</i>)	Orthoceras sp.
Leptaena rhomboidalis (<i>Wilck.</i>)	Cheirurus subquadratus <i>Reed</i>
Lingula sp.	Encrinurus multisegmentatus (<i>Portl.</i>)
Meristella?	Lichas laxatus <i>McCoy</i>
Orthis (Platystrophia) biforata (<i>Schloth.</i>)	Phacops (Chasmops) macroura <i>Sjögr.</i>
Orthis calligramma <i>Dalm.</i>	Staurocephalus unicus (<i>Wyr. Thoms.</i>)
" (Dalmanella) elegantula <i>Dalm.</i>	Trinucleus seticornis (<i>His.</i>)
Orthis (Dalmanella) testudinaria <i>Dalm.</i>	
Orthis unguis (<i>J. de C. Sow.</i>) var. ?	

¹ 'The Country around Ammanford,' *Mem. Geol. Surv.*, 1907, pp. 35, 36, 229.

² *Op. cit.* p. 323.

³ Appendix, 139.

In addition, the following forms collected by De la Beche and Phillips are preserved:—*Hemicosmites rugatus* Forbes, *Ptilodictya dichotoma* Portl., *Orthis crispa* M^cCoy and *Acidaspis*?. The first two are in the Museum Collection.

At Morfa-bâch somewhat higher beds form a ridge running westward, and a quarry shows 30 feet of blue-grey shaly mudstones with bands of decalcified limestone and hard micaceous grits. The limestones and grits yield a few specimens of *Tentaculites*, *Favosites*, *Strophomena* and crinoid columnals. Just south of the quarry the beds are traversed by a thrust-plane dipping north.

The dips at Maes-y-lan and its neighbourhood are northerly, while farther south they are all southerly; so that here we may recognize the anticlinal structure first made evident in the ground lying between Llandilo-Abercowin and Trefanty. Some of the beds in its southern limb, probably about 300 feet above the base, have been quarried 150 yards south-south-west of Cwm-dwr; they are crowded with *Favosites fibrosus* (Goldf.) Mr. D. C. Evans has recorded also, among other forms, *Trinuclaus seticornis* (His.).

In a lane 100 yards south-west of Baynor a band of rotten limestone, 5 feet thick, and 40 or 50 feet above the Bala limestone, yielded¹ *Cybele verrucosa* (Dalm.).

An ascending sequence is crossed by the road from Llandowror to Cnyciau. The gritty beds of Morfa-bâch are recognizable 250 yards west of Pentre-Howel; in higher beds on a path 200 yards north-east of Cwm the following² were collected:—

<i>Favosites fibrosus</i> (Goldf.)	<i>Orthis</i> (<i>Dalmanella</i>) <i>testudinaria</i> Dalm.
<i>Petraia</i> sp.	<i>Plectambonites sericea</i> (J. de C. Sow.)
<i>Leptaena rhomboidalis</i> (Wilck.)	<i>Rafinesquina cf. expansa</i> (J. de C. Sow.)
<i>Orthis</i> (<i>Platystrophia</i>) <i>biforata</i> (Schloth.)	? <i>Triplecia insularis</i> (Eichw.)
<i>Orthis</i> (<i>Dalmanella</i>) <i>elegantula</i> Dalm.	<i>Tentaculites cf. anglicus</i> Salt.
<i>Orthis</i> (<i>Dinorthis</i>) <i>flabellulum</i> ? J. de C. Sow.	<i>Orthoceras</i> sp.
<i>Orthis</i> (<i>Plaesiomys</i>) <i>porcata</i> M ^c Coy	<i>Iliaenus</i> sp.
<i>Orthis cf. rankini</i> Dav.	<i>Phacops</i> (<i>Chasmops</i>) <i>macroura</i> Sjögr.

The above is probably Phillips's³ locality 'Cwm.'

The best section of the Slade Beds is afforded by a roadside exposure at Cnyciau, where mudstones with rotten sandstone bands crowded with fossils are exposed. The sandstones are snuff-coloured and show spheroidal colour-bands; the mudstones in places shew a vermilion stain, which is characteristic in the Haverfordwest district. The following forms⁴ were collected

¹ Appendix, 140.

³ *Op. cit.*, p. 323.

² Appendix, 141.

⁴ Appendix, 142.

here, the horizon lying about 250 feet below the base of the Lower Llandovery at Greystones:—

Heterocrinus?	Orthis (Dalmanella) elegantula
Cornulites serpularius <i>Schloth.</i>	<i>Dalm.</i>
<i>Cf.</i> Catazyga anticostiensis	Orthis (Dalmanella) sp.
(<i>Bill.</i>)	<i>Cf.</i> Orthotetes pecten (<i>Lim.</i>)
Christiania tenuicincta (<i>M^cCoy</i>)	Plectambonites sericea
Orbiculoidea sp. [<i>with ornamentation. Cf.</i> Pholidops implicata	(<i>J. de C. Sow.</i>)
<i>J. de C. Sow.</i>]	Rafinesquina sp.
Orthis (Bilobites) biloba (<i>Lim.</i>)	Calymene senaria (<i>Conrad</i>)
	<i>Salt.</i>

Another good section of above 200 feet of mudstones is afforded by a cart-road running south-west from Old Pale; the beds are nearly devoid of fossils and presumably overlie the fossiliferous grits of Cnyciau. At the top of the section, a few yards below the altitude-point 544 on the map, a thin bed full of *Rafinesquina cf. llandiloensis* (*Dav.*)¹ crops out, only a few feet below the basal conglomerate of the Llandovery.

Farther north, two faulted strips of Redhill and Slade Beds appear near Forest (*see* Fig. 8, p. 42). In the southern one good sections are afforded by the railway-cuttings; at the eastern end of the tunnel the mudstones contain bands full of casts of *Favosites fibrosus* with *Orthis*, *Petraia* and *Tentaculites*, and resemble the beds of Lower Cresswell (p. 59) and Cwm-dwr (p. 60). There are also bands of partly decalcified limestone. At the western end of the tunnel the beds at the foot of the bank on the north side of the line are highly fossiliferous and dip north-west at about 40°; but higher up the bank they are bent back so as to dip south at 70° or 80° and are presumably inverted. Over the arch the bedding becomes vertical, while on the south bank they appear crushed and contorted and dip about north at 60°. As Llandovery sandstones crop-out low down in the valley side only a few yards to the south it is clear that there is a fault between the two formations.

The beds in the northern strip may be seen by the side of a pond at the southern end of Forest farmyard, and as *D. bifidus* Beds are exposed a few yards farther north the northern boundary fault can be narrowly located. At Clôg-y-frân the Redhill Beds dip under the Bala limestone (p. 57) owing to the inversion; they are exposed between the farm buildings and the Tâf and maintain a steady dip of 40° to 60° to the north-east. In the lane leading south-eastward they become vertical, probably in a synclinal axis; south of this again an anticline is revealed in a small quarry below the lane, after which they are soon cut off by a fault.

¹ Appendix, 143.

CHAPTER V.
SILURIAN ROCKS.

LOWER LLANDOVERY.

These beds form the moorland known as Pale Mountain, west of Llandowror. At Greystones, near Cnyciau, the basement conglomerate, which is there not easily distinguished from the basement beds of the Old Red Sandstone, is succeeded by brown quartzitic sandstone and blue shales. West of Old Pale the blocks of conglomerate contain quartzite-pebbles which range up to six inches in length. In the higher part of the sequence sandstones have been quarried in Great Pale Wood, in the loop of the river Taf south of Forest Tunnel, and about Pen-y-graig (just west of the altitude-point 152 on the edge of the map). Two localities only, both in mudstones, have yielded fossils; one is a small opening in débris, nearly in place, 100 yards south of Great Pale, which afforded one or two specimens¹ of *Plectambonites* cf. *quinquecostata* (M^cCoy); the other locality (marked in Fig. 8 with a dip-arrow of 60°) is by the side of a footpath in Great Pale Wood, 450 yards east-north-east of Great Pale; this yielded the following:—²

<i>Favosites fibrosus</i> (Goldf.). <i>Cornulites serpularius</i> Schloth. <i>Camarotoechia</i> cf. <i>nucula</i> (J. de C. Sow.) <i>Coelospira scotica</i> ? (M ^c Coy) <i>Leptaena rhomboidalis</i> (Wilck.) <i>Orbiculoidea</i> cf. <i>rugata</i> (J. de C. Sow.) <i>Orthis</i> (<i>Dalmanella</i>) <i>elegantula</i> Dalm. <i>Orthis</i> (<i>Dalmanella</i>) <i>testudinaria</i> Dalm. <i>Orthis</i> (<i>Dalmanella</i>) cf. <i>testudinaria</i> Dalm. <i>Orthotetes pecten</i> ? (Linn.) <i>Plectambonites quinquecostata</i> (M Coy) <i>Plectambonites</i> cf. <i>scissa</i> (Salt.)	<i>Plectambonites sericea</i> (J. de C. Sow.) <i>Plectambonites</i> cf. <i>transversalis</i> (Linn.) <i>Siphonotreta scotica</i> Dav. <i>Stropheodonta</i> cf. <i>compressa</i> (J. de C. Sow.) <i>Ctenodonta</i> ? <i>Modiolopsis</i> sp. <i>Cyclonema</i> ? <i>Loxonema</i> ? <i>Pleurotomaria</i> sp. <i>Hyalolithus</i> sp. <i>Tentaculites</i> sp. <i>Acidaspis</i> cf. <i>prevosti</i> Barrande <i>Calymene blumenbachi</i> Brongn. <i>Cyphaspis rastritum</i> Törnq. " sp. <i>Phacops</i> (<i>Dalmanites</i>) <i>weaveri</i> Salt.
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The fossils are preserved in limonite in grey-green mudstones. The section lies in a hollow, evidently occupied by soft beds, which extends westward under Great Pale, and thence down a valley towards Pen-y-graig. This valley exhibits dips suggesting a synclinal axis. The fossiliferous mudstones, therefore, are probably some of the highest beds present in the district. If this be so, the succession here can be roughly paralleled with that at Haverfordwest (Sheet 228).

T. C. C.

¹ Appendix, 144.

² Appendix, 145.

CHAPTER VI. OLD RED SANDSTONE.

INTRODUCTION.

The Old Red Sandstone consists of the following subdivisions in descending order :—

	Feet.
Upper :—Penlan Quartzite	0-50
Brownstones, including Pebbly Beds (10-300 feet)	
at top	0-500
Lower :—Senni Beds	0-750
Red Marls, including Green Beds (500 feet)	
at base	3600-4400

Red Marls.—The basal green beds consist of calcareous green marls with micaceous sandstones, conglomeratic cornstones and occasional conglomerates; these pass by alternation into red marls with some red and brown sandstones, and grey limestones (cornstones), some of which are compact and some conglomeratic. Some of the beds have yielded *Pteraspis*.

Senni Beds.—In the lower part these are green micaceous sandstones with marls and conglomeratic cornstones; in the upper they are red and purple micaceous sandstones and red marls. West of the Towy they are overstepped by the Carboniferous. The green sandstones have yielded *Pteraspis* and *Cephalaspis*.

Brownstones.—These consist of bright-red marls and brown gritty sandstones in the lower part, followed by a group of pebbly red and olive-green grits above. The outcrop of the latter is in places too narrow to be shown on the one-inch map, but is actually continuous. The whole of the Brownstones are overstepped near Kidwelly by the Carboniferous.

Penlan Quartzite.—Some bands of quartzite near Kidwelly have yielded plants which prove them to be of Upper Old Red Sandstone age at the earliest. Their relations to the rest of the Old Red and to the Carboniferous rocks are extremely obscure.

T. C. C. and E. E. L. D.

East of the Towy.

At the eastern edge of the map, to the north of Llanddarog, the basal green beds are repeated by faulting and enclose a lenticular mass of Tremadoc mudstones (p. 8) between the two outcrops. In the more northerly outcrop the junction with the older rocks can be studied in the upper parts of the Nant-y-caws (Fig. 2, p. 12) and Pen-y-coed dingles, in the stream south of Beaulieu-fawr (p. 13) and in the Nant-cwm-ffrwd (p. 7). In Nant-y-caws the base of the Old Red Sandstone becomes conglomeratic, a character which it does not possess farther east; the pebbles are small but become larger westwards.

The lower beds of the Red Marls, which are well exposed in the neighbourhood of Llanddarog, and in the Nant-pant-wen north of Llethr-llestri, occasionally contain hard green and red sandstones, one of which has been extensively quarried for local building purposes at and near Pant-y-cwarau, north of Gilfach. To the west all the higher ground consists of red marls which are well displayed in the neighbourhood of Moelfre-uchaf and Croes-y-ceiliog. Their downward passage into the basal green series may be examined in the Nant-cwm-ffrwd.

H. H. T.

At Blaenau east of Llangyndeyrn some chocolate-coloured sandstone has been quarried. A small thrust, dipping south more steeply than the bedding, is visible on the west side of the dingle north of the buildings. At Pen-y-banc (two-thirds of a mile farther west) and at Coed-Wgan-fawr, marls with thin sandstones are exposed. Brown sandstone has been quarried east of Plás-bâch, while a small north-westerly fault, visible in the farmyard and millrace, throws chocolate sandstones on the east against red marls on the west. The brook flowing thence to Pont-Llangyndeyrn crosses an ascending series, of red marls with brown sandstones, typical of the Red Marl subdivision.

Higher beds are exposed in a lane ascending the scarp above Tor-y-coed-canol, and at Tor-y-coed-fâch (nearly half-a-mile to the south-west), where they consist of purple-red rocky marls and micaceous sandstone, overlain by the green Senni Beds. Similar rocks are exposed at Tor-y-coed-fawr, and red sandy marls with 'race' crop up in a lane a quarter-mile south-west of Pant-têg.

The Senni Beds enter the eastern margin of the map as a narrow outcrop, the lower (northern) half of which consists of green beds, and the upper (southern) half of purple-red beds. A quarry just south of Cil-yr-ynys (on the edge of the map, east of White Hall) has been opened on the dividing line in purple-red marls, passing down into green sandstone, while a lane south of Tor-y-coed-canol shews red bands intercalated in the green series. At Tor-y-coed-fâch the lower part of the Senni Beds consists of green sandstone with some marl and thin conglomeratic cornstone. Green sandstones are exposed in the road at Ffrwd-gainc (300 yards west of Lan), and in the farmyard pass upwards into the red upper beds. A brook-section a quarter-mile south-west of Crwbin crosses the Senni Beds from their base upward; at the base green and red beds alternate. In a quarry on the south-west side of the brook a green conglomeratic cornstone band, 3 feet 6 inches thick, overlies green sandstone, and in another, 20 yards higher up stream, dull-red marls overlie green flaggy sandstone. Above these sections the stream descends over the purple-red micaceous sandstones and marls with some conglomeratic cornstones which form the red upper part of the Senni Beds.

The bright-red marls with red gritty sandstones which form the lower part of the Brownstones are to be seen in the road ascending the escarpment south-east of White Hall, and the Pebbly Group at the top also can be detected there. Near the ruins of Ffynnon-cadachog (five furlongs south-west of White Hall), red marls and sandstones, some of which are coarse, while others are soft and brick-red, are followed by olive-green and yellow sandstones referable to the Pebbly Group. Some pebbly olive-green sandstone referable to the same group has been quarried 200 yards east-south-east of Lan; the rock contains traces of green and blue copper carbonates.

The whole of the Brownstones, including the Pebbly Group, are exposed in the dingle a quarter-mile south-west of Crwbin. The lower part consists of bright-red marls with bands of coarse gritty red and pale-yellow sandstone, one of the red bands containing rolled flakes of bright-red marl. At the top of the dingle, 50 yards south-east of Store House, the coarse and pebbly red and yellow sandstones of the Pebbly Group have been quarried. In the stream at Felindref bright-red marls and brown sandstone are visible below the mill, while the Pebbly Group may be traced from the mill southward along the west side of a fault-valley toward Fan.

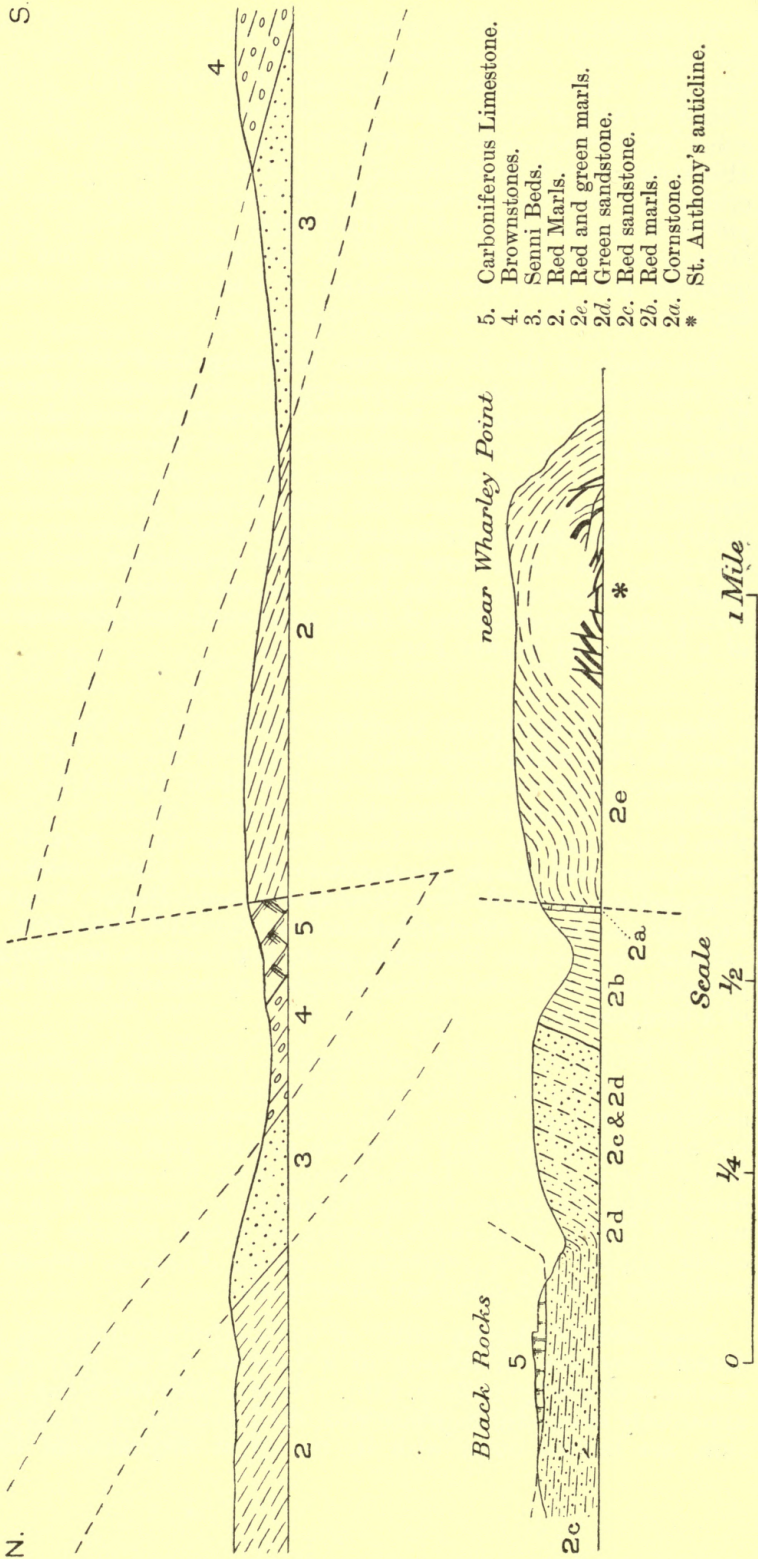
T. C. C.

Near Llandyfaelog and along the North Crop to the coast at Tan-y-lan the Senni Beds retain their general character of green, micaceous flags, though to the south-west of Pont-Antwn the thickness of strata to which this description applies is greater than to the east, the change being due to the upper part of the underlying Red Marls passing laterally into green, micaceous flags, indistinguishable from those of the Senni Beds. A similar lithological change affects much more of the Red Marls than the extreme top, for near Ferryside green flags form a considerable proportion of this subdivision, though they are rare to the north of Llandyfaelog.

The Brownstones show considerable variations in character along their outcrop. Thus near Felindref some red and greenish sandstones at their top are thickening westwards so rapidly that one mile further on they form the greater part of the group. Below them, north of Llech-dwnny, there are red marls to a considerable thickness, but at Gledwyn, a quarter of a mile north of Cenfu, these marls become very thin and the Brownstones appear to be represented mainly by red and green sandstones in which marls are subordinate.

Near Llandyfaelog an outlier of Carboniferous Limestone was detected by Mr. Wilkinson in a position which proved the existence of a huge fault (p. 140). Brownstones and Senni Beds, apparently in natural sequence with the limestone on its northern side, are faulted down with it, the great displacement being

Figs. 13 and 14.—Sections across the Llandyfaelog Disturbance at Llandyfaelog (E. E. L. Dixon), and near Llanstephan (A. Strahan).



obviously on the southern side of the outlier (see Fig. 13). The mapping of these divisions of the Old Red Sandstone to the south also has brought to light the existence of some other faults which appear to connect this Llandyfaelog disturbance with the Kidwelly disturbance described on pp. 140-1. The chief of these faults leaves the Llandyfaelog disturbance where the River Gwendraeth-fâch itself turns southwards. For a short distance it lies along the course of the river, but continues its southerly course where the river turns west again. It has a westerly downthrow, sufficient to cut out the whole of the Senni Beds north-east of Llech-dwnny, of at least 500 feet. The course of the fault bends gradually to south-south-west, but is soon lost in low ground, beyond which, however, one of the Kidwelly faults appears so exactly in the same line that it is difficult to suppose that the two, though of opposite downthrow, are not connected. Though running in part nearly north and south, there is further reason to think this line of fault forms part of the Llandyfaelog and Kidwelly set of disturbances rather than of the north-north-west system of faults. For at Gwempa it is accompanied by an anticline running north-north-west, of which the axial plane is inclined to the east, and which can be traced for a considerable distance to the south parallel to the fault. Again, this anticline appears to be a buckle in the centre of a much larger syncline. Although to this fold the presence of Carboniferous Limestone and of the higher beds of the Old Red Sandstone north of the Llandyfaelog disturbance is probably in part due, both syncline and the accompanying buckle die out at the major disturbance, to which the outcrops to the north are parallel. This association of the fault with folding distinguishes it from the series of simple north-north-west breaks, and the folding is such as to suggest a connection with the Llandyfaelog disturbance.

The Old Red Sandstone between Kidwelly and Ferryside may be referred with certainty to the Red Marls and to the Senni Beds, the Brownstones which as mentioned above are present at Gledwyn (north of Cenfu) disappearing between that place and Kidwelly. The Red Marls, as is clearly shown in the railway-cutting south of Ferryside, include green micaceous flags indistinguishable lithologically from the Senni Beds. This division itself, moreover, is linked with the Red Marls by the fact of its containing subordinate bands of that material, though it consists chiefly of green micaceous flags. Its thickness probably reaches 750 feet near Kidwelly, where it forms high ground, as in the neighbourhood of Allt-cyn-Adda. Thence its crop passes to the coast near Tan-y-lan, but an outlier occurs to the north of that place. Previously no fossils had been recorded from this district, but a number of shields of cephalaspid fish have now been obtained from a greenish sandstone low down in the Senni Beds at Pen-y-gau¹. They have been identified as *Cephalaspis*

¹ Appendix, 153.

cf. *powriei* Lank., *Pteraspis crouchi*? Lank. [*Scaphaspis recta* Lank.¹], *Pteraspis rostrata*? (Ag.), including the ventral shield "*Scaphaspis lloydi*"? (Ag.), and *P. sp.*

In the Red Marls exposed in the railway-cutting² between St. Ishmael's Church and Ferryside, there have been found a rostrum and a dorsal shield of *Pteraspis crouchi* Lank. Remains of a pteraspid fish have also been found near Llanstephan. The occurrence of these forms leaves no doubt that the strata are of Lower Old Red Sandstone age.

E. E. L. D.

The structure of the ground near Ferryside and Llanstephan is dominated by the Llandyfaelog disturbance. After the Gwendraeth-fâch leaves the line of fault, as mentioned on p. 67, the course of the disturbance is still marked by a slight depression past Llandyfaelog. A short distance further on the depression catches the local drainage and develops into a deep ravine which leads past Is-coed. The bottom of the ravine shews marls and red sandstones in an intensely broken state.

Before reaching the estuary the stream winds away from the disturbance, which keeps a straight course across the hill to Ferryside. Near Tre-Cor to the south of the fault there appear two or more compact limestones or 'cornstones,' generally of a pale-green tint and associated with green mudstones, grits, and conglomerates; to the north of it there are red marls and flags.

A. S.

The Penlan Quartzite is known only near Kidwelly and is nowhere completely exposed; it consists, so far as is known, of tough, grey quartzites, light or dark, fine-grained to conglomeratic. The coarser parts often contain flakes of grey shale, and less frequently fragments of hematite. At various places it has yielded the following plant-remains, which have been identified by Dr. R. Kidston:—*Artisia approximata* (Brongn.), a Calamitic pith-cast, *Stigmaria jicoides* (Sternb.), and probably var. *inequalis* Göpp., and silicified wood.

It was thought at first³ that this group occurred in the upper part of the Senni Beds and was therefore part of the Lower Old Red Sandstone, but its flora shows, according to Dr. Kidston, that it cannot be older than the Upper Old Red Sandstone. He says: "I doubt if *Stigmaria* have ever been found below this horizon [Upper Old Red Sandstone]. In Britain, in neither the

¹ Ventral shields of *Pteraspis* were formerly called *Scaphaspis*, but their true nature has been demonstrated by A. von Alth. "*Scaphaspis recta*" Lank. is probably the ventral shield of *Pteraspis crouchi* Lank., and "*S. lloydi*" (Ag.) that of *P. rostrata* (Ag.). (See A. Smith Woodward, Cat. Foss. Fishes Brit. Mus., pt. ii, 1891, pp. 161, 164, 167, 168.)

² Appendix, 151-2.

³ E. Dixon in 'Summary of Progress' for 1903- (*Mem. Geol. Surv.*), 1904, p. 37.

Middle nor Lower Old Red, have any *Stigmaria* ever been found, nor has there been discovered in these horizons any stems which one has any reason to believe possessed such roots.

“In the Upper Old Red Sandstone, on the other hand, the presence of the arborescent lycopods, such as *Bothrodendron* (*Cyclostigma*) and *Lepidodendron*, infers the presence of *Stigmaria*, an inference confirmed by the discovery of such fossils [at Kidwelly].”

In consequence of this correlation we now think that the group rests in turn on Brownstones and Senni Beds, and is immediately overlain by the Lower Limestone Shales. It appears to be overlapped in places by the shales, but elsewhere emerges, possibly to a thickness of 50 feet.

Quartzites belonging to this group form crags a quarter of a mile north-east of Llech-dwnny¹, which have yielded *Stigmaria ficoides* (Sternb.) The structure hereabouts is obscure, but apparently the group rests on Brownstones which are exposed on both sides at no great distance. No Carboniferous rocks are visible within a distance of three-quarters of a mile, but it is, nevertheless, possible that they underlie the obscure ground around the crags.

Another outcrop ranges west-south-westward from the Corporation Arms Inn, 550 yards north of Rogerlay, to some crags 340 yards south-east of Pen-lan-uchaf (6-inch map), and at the latter place² has yielded *Artisia approximata* (Brongn.), a calamitic pith-cast, and *Stigmaria ficoides* (Sternb.), probably var. *inaequalis* Göpp. Bare rock in a garden³, a furlong west-south-west of the inn, contained some pieces of silicified wood in which the tissue is perfectly preserved. For the most part the quartzites dip towards the Senni Beds which lie to the south, but must be separated from them by a fault with a northerly downthrow. They should take ground again further south, between the Senni Beds and Lower Limestone Shales, and as a fact quartzites occur in both formations where exposed near the Gwendraeth-fâch, a quarter of a mile north of Rogerlay. These quartzites, however, differ from the Penlan Quartzite in several respects, notably in having originated as calcareous rocks. In both formations intermediate stages are found, between quartzite and conglomeratic cornstone in the one case, and between quartzite and sandy limestone with brachiopods in the other. The Penlan Quartzite itself is not present, however, though the junction of the two systems, which is its probable horizon, is clearly exposed; this we regard as due to overlap by the Lower Limestone Shales. Westwards the quartzite becomes nearly horizontal and forms two outliers⁴ near Pen-lan-isaf, which have yielded *Stigmaria ficoides* (Sternb.),

¹ Appendix, 146.

² Appendix, 149.

³ Appendix, 150.

⁴ Appendix, 147-8.

probably var. *inequalis* Göpp. Senni Beds crop out close by and appear to lie next or almost next below the quartzite. Here again the quartzite fails to reappear in its proper position further south, and is presumably overlapped by the Lower Limestone Shales.

Nevertheless it crops out further west along the hill-side between Upper Arles and Pen-allt, with a thickness that may amount to 50 feet. Along this range it is followed southwards by an outcrop of Lower Limestone Shales, from beneath which it appears to emerge, though the relations of the two are nowhere seen.

E. E. L. D.

Between the Towy and the Tâf.

The Llandyfaelog disturbance intersects the western shore of the Towy to the north of Llanstephan Castle. Here, as at Tre-Cor (p. 68), massive limestones dip towards the fault at high angles on its southern side. Crossing the promontory along an obvious line of weakness, with broken rock showing here and there, the disturbance reaches the Laugharne estuary about half-a-mile west of Wharley Point. The cliff, keeping further south, exhibits an anticline which runs parallel to the fault and is obviously due to the same movement. The northern limb is shown between Llanstephan and St. Anthony's Well. The strata dip at 35° to 50° northwards, the axis of the fold running a few yards south of the cliff. Three fractures may be detected in the part of the cliff which lies to the east of the Castle, and faces east. One is a nearly vertical crush, but the others are well defined overthrusts dipping northwards at a slightly lower angle than the beds.

In the part of the cliff which faces south, and at a point about 70 yards west of the steps south-west of the Castle, a normal fault cuts through the beds and the structures of the east-and-west system, throwing them all down one foot to the west. A little further on there is a considerable overthrust which dips north at a steeper angle than the beds, and the effect of which in cutting out some green sandstone and marl can be traced step by step on the foreshore.

At St. Anthony's Well the cliff again turns southwards, and cuts through the anticline at right angles. For the first 150 yards it shows the northern limb. Here, again, in this limb we find a series of overthrusts dipping north. All rise at a slightly higher angle than the bedding, and probably in none does the movement exceed three or four feet. The structure is indicated diagrammatically in Fig. 14.

The crest of the anticline takes the form of a gentle arch. In the crest and within a space of a few yards there are five or more small overthrusts. Those on the north side of the crest dip north, those on the south side dip south. The structure therefore resembles what would be produced by the crushing of an

arch and the thrusting upwards of the sides over the crown. South of the crest the strata dip gently southwards, and we find several overthrusts all dipping in the same direction, but whereas those of the northern limb are all at high angles, those of the southern limb are generally at low angles or even horizontal. One of them is conspicuously shown by the fact of its displacing some purple marl and green sandstone as much as 25 yards horizontally. But a more remarkable structure is shown at the turn of the cliff westwards on approaching Wharley Point. Here the strata curve rapidly from a gentle to a high southerly dip. An undulating, but on the whole horizontal, thrust cuts through the curve and shifts strata with a high dip on to the top of strata with a low dip, the displacement being about 11 yards horizontally. The fracture can be traced for a considerable distance in the lower part of the cliff, and then descends southwards below the beach. At the point of disappearance a subsidiary fracture, with an overthrust of about 4 yards, rises from it at a steep angle, as shewn in Fig. 14.

The following points are established by this section. On the north side of the anticline, the dip is steep and the overthrusts are nearly vertical; all are thrusts from the north. On the south side of the anticline, wherever the dip is low, the overthrusts are nearly horizontal; all are thrusts from the south. Anticline and overthrusts are parallel, and obviously contemporaneous. The structure illustrates how a combination of folding and overthrusting may afford relief from lateral pressure, and proves that overthrusts of opposite hade may be produced simultaneously by the same movement.

The structure of the Llandyfaelog disturbance is shewn more clearly to the west of Wharley Point than elsewhere. The strata suddenly become vertical and a rib of compact limestone standing up like a dyke in the foreshore, slickensided in every direction, leaves no doubt that the fault is close by. This is followed by a mass of red marl, extending for 200 yards, and mostly vertical, though bedding-planes are hard to recognise. For the next 350 yards a great series of sandstones, some of a green colour, follow in ascending order with a dip of 55° to the north-west. A few yards to the south-east of Black Rocks the beds suddenly become horizontal.

The general effect of the disturbance here is therefore that of a monocline. The relative share of displacement due to fracture and fold cannot be determined, but the net result is the introduction of the higher beds of the Old Red Sandstone and of the Carboniferous outlier which rests upon them. The structure bears but a distant resemblance to that of the same line of disturbance as developed at Bryn-yr-odyn and Castell Careg Cennen (Sheet 230).¹

¹ 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 183, 184.

It is far from easy to piece together a section of the Old Red strata shewn in these cliff-sections. Those which support the Carboniferous outlier of Black Rocks are obviously the highest existing in the neighbourhood. It may be assumed also that those exposed to the north of the disturbance are all newer than those to the south of it. Commencing therefore with the newest we may construct a table shewing the strata in order of age, but with gaps of unknown amount as follows :

Descending Section of part of the Red Marls sub-division of the Old Red Sandstone between Laugharne and Llanstephan.

<i>Black Rocks :—</i>	Feet.
Carboniferous Limestone Series (<i>See p. 80.</i>)	
Hard green micaceous sandstones, green marl and red marl	41
Green sandstones with irregular shale-partings, thin green and red constones, followed by red sandstones and marls with green flags, about	740
Red marl, partly vertical and greatly smashed, occupying a width of about 200 yards (<i>2b</i> in Fig. 14).	
Massive limestone (cornstone), much slickensided, and vertical, forming a rib in the foreshore (<i>2a</i> in Fig. 14).	

The great fault ; gap of unknown amount.

East of Llanstephan Castle to Wharley Point :—

Red and green marls, base not seen.	
Green sandstone and rocky marls—pteraspidian fish... ..	30
Red and green marls, 10 feet of red marl at base	28
Green laminated sandstone, plant-remains in the lower part	5
Green sandstones and marls with thin constones	20
Red marl, with large calcareous concretions in the lower part	26
Green marl.	

A small overthrust.

Green sandstone	4
Sandstone, conspicuously streaked red and green	6
Red marl with calcareous concretions in lower part	21

A small crush.

Red marl with bands of concretions or of concretionary cornstone : streaked with green in the lower part ...	30
--	----

A small overthrust.

Red concretionary marls	14
Green sandstone and cornstone	12

At this point there are steps down the cliff.

Massive rock, full of white calcareous concretions in a green, or occasionally red, matrix. The longer axes of the concretions are vertical to the bedding	7
The same, but the concretions so large and close as to constitute an almost solid limestone. The structure due to the vertical arrangement of the concretions is conspicuous	10
Red parting of similar rock	1
Massive greenish limestone as above	9
Limestone, solid in places, but occasionally showing a little green matrix between vertically placed concretions.	
Seen to	20

At this point the cliff runs along the strike and is formed by the same strata for about 400 yards. At St. Anthony's Cottage

the coast trends southwards, and the descending section is continued as follows :—

Section from St. Anthony's Well to the Wharley Point anticline.
(2e in Fig. 14. In descending order).

	Feet.
Green sandstone at foot of wall, part seen	—
Mottled marl	10
Green sandstone	3
Green conglomeratic cornstone	1
Red and green laminated marl, "streaky beds"	4
Deep-red and mottled marl	12
Green and mottled streaky beds	6
Green sandstone	4
Red and green streaky marl	10
Green shales, with concretions in the upper, plant-remains in the lower part	12
<i>A small overthrust.</i>	
Green sandstone, cornstone, and marl	10
Red marl, with concretionary cornstone at top	12
Green sandstone	7
<i>An overthrust of 2 feet.</i>	
Deep-red marl with 4 feet of green sandstone in it	32
Red cornstone, formed of concretions vertical to bedding	6
<i>An overthrust.</i>	
Red marl	50

The dip, so far, is northwards, but in the next 60 yards the beds become horizontal, and, after undulating gently for 40 yards, begin to dip south. At this point the red cornstone last mentioned appears at the foot of the cliff, and is followed by what must be the same strata as in the above section but in ascending order. It is difficult, however, to recognise the details. The total thickness of strata cropping out to the south of the disturbance is probably about 900 feet.

The most noticeable feature in this section, apart from the evidence of subsequent disturbance, is the occurrence of the massive limestones to the south of Llanstephan Castle, and of the calcareous concretions in the associated marls. They probably correspond to the limestones formerly quarried near Tre-Cor, but in the cliff their structure and that of the marls are more fully exhibited than in any quarry. The concretions vary in size from a pea to six or eight inches in length. In some of the smaller bands of cornstone they appear to have been rolled and are associated with rolled fragments of other rocks, but in the massive limestones they evidently stand in the position in which they were formed. It is especially to be noted that some of them were formed as rudely-shaped cylindrical masses, with an upward growth which kept pace with the deposition of marl around them. In this respect, and in the fact that they were dotted over the bottom in varying closeness, they recall the arrangement of certain cylindrical flints in the Chalk. One of these concretions has been sliced (E. 4035), and proved to be an undolomitised crystalline limestone.

The limestones from a quarry 200 yards north-west of Tre-Cor and from another south of Pen-y-bont (E. 3657 and E. 3658) are more or less nodular, and at times brecciated or veined with calcite. They usually contain quartz, mica, and other impurities, but no organic structures.

A. S.

Red marls with occasional bands of red and green sandstone, into which the basal green beds graduate, are exposed to the south of Green Castle along and near the main road. A large quarry is worked in a hard green sandstone, 300 yards south-east of Green Castle. In this neighbourhood, and on the ridge extending to Glôg-ddu, conglomeratic courses occur at more than one horizon in the basal green series. Two small outliers of these beds occur at Moelfre, near Llangynog; they are faulted on all sides except on the north, where they rest uncomfortably upon Arenig rocks.

H. H. T.

Near Llangynog a small patch of felsite-conglomerate in which a roadstone quarry¹ has been opened 80 yards west of Capel Bethesda (a quarter-mile west of Glôg) is referred to the basal green beds, though it may possibly belong to the *Tetragraptus* grits (p. 17). Other conglomerate-bands occur in the green and buff basal beds of this neighbourhood, and have evidently been derived from the adjacent igneous rocks; the junction with the underlying andesites and rhyolites can be examined at several places. Green marls with a foot of ashy brown breccia at their base rest on the Bifid Beds in the road south-west of Pentre-newydd. Red marls with sandstones are especially well-exposed in the streets at Llanybre.

West of the Tâf.

At Halfpenny Furze (500 yards east of Maes-gwrda) some red beds are intercalated in the green basal beds, especially at the top. Sandstones have been quarried near Felin-ban (on the Pembroke road at the 12th milestone from Carmarthen), and a lane leading thence toward Pen-y-lan shows the green marls resting on the Redhill Beds, from the debris of which they are made up.

South-west of Parciau the green beds are exposed on the main road, and they have been quarried for roadstone a quarter-mile south-west of Cnyciau. At Pale Gate, between the last place and Brunant, the basement-bed can be seen resting on Llandoverly rocks.

Red marls with sandstones are exposed in the dingle west of Woodhouse Farm, south of Llandowror, where there is evidence

¹ T. C. Cantrill and H. H. Thomas, *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 231. This is not the same quarry as the one in the *Tetragraptus* conglomerate west of Glôg-ddu described on p. 17.

of a strike-fault. In a stream east of Gelli-felen a mass of decomposed yellow quartz-conglomerate probably marks the outcrop of a thin bed which reappears at Cyffic (Sheet 228).

T. C. C.

The basal green beds are well seen on the Pembroke road near the 14th milestone. Here, according to Mr. Wilkinson, are shewn greenish mudstones, much disturbed and slickensided along the Red Roses disturbance. Another set of green strata, including red and green flags, crops out at Rhyd-y-frân, where they dip southwards at 60° and strike towards Pant-y-hâd. Here there are two outcrops, to the east and south of the house respectively, both showing blue-green sandstones, and elsewhere in the neighbourhood there are red sandstones and soft or hard green flags, sometimes abundantly micaceous. The high and variable dips render it difficult to determine an exact sequence, but Mr. Wilkinson concludes that these green strata do not belong to the basal green series. At Honey-cors, and again at Pendine, red marls with red sandstones pass up into highly-micaceous grey and green sandstones, sometimes with thin shale-partings.

A. S.

CHAPTER VII.

CARBONIFEROUS ROCKS.

CARBONIFEROUS LIMESTONE SERIES.

INTRODUCTION.

The subdivisions established farther east extend into the area now under description, and consist of the following in descending order :—

General Section of the Carboniferous Limestone Series

		Feet.
Upper Limestone Shales	}	Dark shales with black, impure limestones (eastern part), and black, impure limestone with chert and shale-partings (western part).
	}	20-35
	}	Kidwellian.
	}	3. Dark sandy limestone and oolite with nodules of black chert toward the top; becoming massive and light-grey westward. About 300 feet.
	}	2. Light-grey oolite, about 30 feet; the 'honeycombed sandstone' at its base locally; in the west inseparable from group 3, the total thickness being 280 feet.
Main Limestone	}	1. Dark limestone and oolite, 210-310 feet.
	}	550-590
	}	<i>Unconformity.</i>
	}	Clevelandian.
	}	Light-grey, partly oolitic, and dark limestones (western part only).
Lower Limestone Shales	}	Shales, with thin limestones some of which are red.
	}	0-70
	}	40-80

The Lower Limestone Shales, though continuous, make an outcrop too narrow to be shewn on the one-inch map east of Crwbin. The 'honeycombed sandstone,' which formed the base of the grey oolite (2) in the Ammanford district¹ is absent as far west as Felindref, but reappears near Kidwelly and Coegen. The Upper Limestone Shales thin westward and have nowhere been worked for rottenstone.

The palæontological zones corresponding to these subdivisions have been determined at Kidwelly by Dr. A. Vaughan, by whom they were originally established in the neighbourhood of Bristol²; subsequently they have been examined at Pendine by Messrs. Dixon and Jones.

¹ 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 67, &c.

² *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, pp. 181, 254.

Upper Limestone Shales	Dibunophyllum Zone D:—horizon ϵ and upper part (D_3).
	" " middle (D_2) and lower (D_1) parts (groups 3 and 2 of previous table).
Main Limestone	Seminula Zone S (group 1 of previous table).
	Syringothyris Zone C { Upper part C_2 . Caninia Oolite. Laminosa Dolomites.
	Horizon γ
	Zaphrentis Zone Z
	Horizon β
Lower Limestone Shales	Cleistopora Zone K, including horizon α

Over much if not all of the area under description the Syringothyris Zone and horizon γ are missing, while in most parts the Zaphrentis Zone also is absent. Consequently the Seminula Zone rests on beds belonging to the Zaphrentis or Cleistopora Zone; it is based, wherever the junction is visible, by a conglomerate partly, if not entirely, composed of fragments derived from those beds.

T. C. C. and E. E. L. D.

LOCAL DETAILS.

The dark limestone and oolite (No. 1) has been extensively quarried north-east of Garn-bwll, and is succeeded by the light oolite (No. 2), exposed in the road. The top of this is marked by a thin bed of rubble, overlain by yellow marl visible at a spring by the roadside. The dark limestone with chert (No. 3) crops out at Ty'r-garn, 400 yards north-east of Garn-bwll. A slice (E. 5121) of the chert shows it to be an almost completely silicified foraminiferal limestone. The Lower Limestone Shales are exposed at Tor-y-coed-uchaf, and the overlying limestone has been much quarried and burnt for lime. At Ffynnon cadachog (5 furlongs south-west of White Hall) the Lower Limestone Shales are exposed at a powerful spring, and may be observed in detail immediately south of the ruins. Their thickness is 38 feet 6 inches. By proceeding southward across the limestone-outcrop at this point all the beds may be examined in order. At Crwbin the light colour of No. 2 descends into the upper beds of No. 1 and ascends into the base of No. 3; and along the road thence toward Felindref the Lower Limestone Shales may be detected; at the last place they are 50 feet thick.

T. C. C.

In continuing this account Mr. Wilkinson notes that at Fan quarries the limestone forms a fine escarpment. This, however, ends at a N.N.W. fault which runs up a hollow to the west, though the limestone, thrown southwards by the fault, re-appears at Greenhall, whence it runs south-westwards as a fine ridge. In the Fan quarries several masses of spar and fault-rock,

ranging about N. 10° W., have been left standing like so many dykes. Many of the beds are oolitic; all belong to No. 1 of the Table on p. 76. Much limestone was quarried here in past times.

The Main Limestone of Fan includes beds attributable to the Seminula Zone only, both sub-zones being represented.¹ From the absence of higher zones it is inferred that the limestone is thrown against Millstone Grit to the south-east by a strike-fault, but the lower zones are wanting for a different reason. Along the Carmarthen road it is seen that the Seminula Zone directly succeeds the Lower Limestone Shales (Cleistopora Zone). Here and for many miles along the North Crop, the intermediate zones are absent, and at Pendine we are able to see that their absence is due to an unconformity. At the same time they may not have been well developed originally. In the region under description Seminula Beds of a low horizon rest upon the plane of unconformity, but in South Pembrokeshire the upper part of the Syringothyris Zone² intervenes between the Seminula Zone and the corresponding plane. Subsidence, therefore, recommenced, and the regular deposition of limestones was resumed, in the middle of the Syringothyris Zone, not in the Seminula Zone as the development at Fan would suggest.

The subdivisions of the limestone (p. 76), which show signs of breaking down east of Llangyndeyrn, become more indefinite nearer Kidwelly, where also the sequence is interrupted by strike-faults. The Lower Limestone Shales consist of shales, sandstones, and earthy, oolitic limestones, etc. In the banks of the Gwendraeth-fâch above Rogerlay they rest directly upon Lower Old Red Sandstone (Senni Beds). There must, therefore, be an unconformity, though the junction is marked merely by a line of pebbles and no discordance of dip is visible. In adjacent exposures the Lower Limestone Shales include near their base calcareous sandstones which have in places been converted into quartzite [E. 4063] by secondary silicification. One of the oolitic limestones³ has yielded, among other fossils, *Camarotæchia mitcheldeanensis* Vaughan, *Spirifer* aff. *clathratus*⁴ McCoy, and *Syringothyris* aff. *cuspidata*⁴ (Mart.), and from another limestone, in a stream⁵ 180 yards west of Rogerlay, we have *Athyris roissyi*⁴ (L'Eveillé) and *Camarotæchia mitcheldeanensis*⁴ Vaughan. This fauna shows that in part at least the group belongs, as elsewhere, to the Cleistopora Zone.

The lower zones of the Main Limestone are probably absent, and from the same cause as at Fan. The lowest part (No. 1 of

¹ Vaughan, *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, p. 254.

² 'Summary of Progress' for 1906, 1907, p. 55, and 'The Country around Haverfordwest' [in preparation], *Mems. Geol. Surv.*

³ Appendix, 154.

⁴ Originally identified by Dr. A. Vaughan.

⁵ Appendix, 155.

the Table on p. 76) of the Main Limestone which is present is dark and fine-grained, sometimes oolitic. Higher in the sequence the rock is less dark and the oolitic grains are larger. The whole group belongs to the Seminula Zone, and chiefly if not entirely to the upper subzone. In quarries¹ near Four Roads and to the south-west it has yielded to Dr. Vaughan and ourselves: *Alveolites septosus*² (Flem.), *Carcinophyllum* θ Vaughan,² *Lithostrotion martini*² Edw. & Haime, *Syringopora* cf. *ramulosa* Goldf., *Cyrtina carbonaria*² (M^cCoy), *Productus corrugatus* M^cCoy), *P. giganteus*² Mart., *P. aff. hemisphaericus* J. Sow., *Seminula ficoides*³ Vaughan.

The succeeding group (No. 2 of the Table on p. 76) consists of light-grey oolite, with occasional thin bands only of darker rock each generally underlain by a thin shale. At its base lies the 'honeycombed sandstone,' sometimes coarse-grained, and about seven feet thick. This group belongs to the lower part, D₁, of the Dibunophyllum Zone, for which the sandstone makes a convenient base. From quarries⁴, south-east of Mount Pleasant and elsewhere on Mynydd-y-gareg, it has yielded to Dr. Vaughan and ourselves:—*Alveolites septosus*² (Flem.), *Cyathophyllum purchisoni*² Edw. & Haime, *Productus corrugatus* M^cCoy, *P. hemisphaericus*³ J. Sow. Two of the co-types of the last species came from Mynydd-y-gareg, probably from one of the quarries in the light oolite.

Upwards the oolitic character gradually disappears and the uppermost fifty feet of the limestone consists largely of corals, crinoids and bryozoa in an amorphous paste. No trace of chert was seen anywhere. These uppermost beds are referable to the middle part, D₂, of the Dibunophyllum Zone, and in quarries⁵ east and south of Horeb Chapel have yielded:—*Chatetes* sp., *Cyathophyllum purchisoni*² Edw. & Haime, *Dibunophyllum* ψ Vaughan,³ *Lithostrotion irregulare*³ (Phill.), *L. junceum*³ (Flem.), *L. martini*² Edw. & Haime, *L. portlocki*² (Bronn) Edw. & Haime, *Lonsdalia floriformis*³ (Flem.), *Syringopora geniculata*? Phill., *Fistulipora* aff. *incrustans*³ (Phill.), *Orthothetes* cf. *crenistria* (Phill.), *Productus* cf. *burlingtonensis* Hall, *P. giganteus*² Mart., *P. hemisphaericus*? J. Sow., *P. aff. scabriculus* (Mart.), *Seminula* sp., *Phillipsia* sp.

Evidence of the existence of the soft shales and earthy limestones which constitute the Upper Limestone Shales has been obtained on Mynydd-y-gareg. They are rarely exposed, but were traversed by the shaft of a small lead-mine⁶ east of the

¹ Appendix, 156.

² Identified by Dr. Vaughan but not represented in the Survey collection.

³ Originally identified by Dr. A. Vaughan.

⁴ Appendix, 157 and 158.

⁵ Appendix, 159 and 160.

⁶ Appendix, 161.

old limeworks. That they correspond to horizon ϵ , at the top of the Dibunophyllum Zone, is shown by the following fossils obtained from the tip:—*Zaphrentis enniskilleni?* Edw. & Haime, *Productus* aff. *scabriculus*¹ (Mart.). The tip contains many fragments of light-grey chert, apparently devoid of radiolaria.

E. E. L. D.

The cliff under the Black Rock Quarry, near Llanstephan, exhibits the junction of the Carboniferous Limestone and Old Red Sandstone in one of the shoots by which the limestone was sent down to the beach. The complete section follows:—

		Ft.	
<i>Black Rocks.</i>			
Lower Limestone Shales.	{	In the quarry, thin-bedded limestone and shale formerly worked for building and agricultural purposes ...	40
		Beds not seen, but chiefly shale	25
		In the shoot, thin bands of dark earthy limestone in shale	4
		Dark limestone with smooth fracture	2
		Shales with thin limestone: greenish or buff in the lower part	6
		Soft friable grit with quartz-grains and small included lumps: greenish	½
Old Red Sandstone.	}	See p. 72.	

Though no discordance can be detected between the two formations, there is little to suggest a passage. On the contrary the junction is sharp, and definitely separates rocks of two characteristic types. There is moreover some appearance of erosion. The section compares in this respect with those further west, but on the other hand differs greatly from exposures of the same junction in Gower, where the Upper Old Red Sandstone is present.² According to Dr. Vaughan “the *Cleistopora*-Zone and Horizon β are typically developed in the ‘Black Rocks.’”³

A second outlier occurs at the Coegen Lime Rocks⁴ at Honey Cors Farm, in a position relative to the Llandyfaelog disturbance corresponding to that of Black Rocks. It includes, according to Mr. Wilkinson, massive blue and light-grey limestones, which are largely quarried for burning and road-metal. The Lower Limestone Shales are represented by shale and impure limestones. The ‘honeycombed’ sandstone mentioned on pp. 76, 79 has been observed in the southern end, and the ‘Pendine conglomerate’ at the northern end of the quarries.

At Pendine also the shales exhibit a normal aspect, and the Main Limestone, consisting of evenly bedded, often massive blue limestones, forms a bold cliff west of the village. Immediately

¹ Originally identified by Dr. Vaughan.

² ‘The Geology of West Gower’ (*Mem. Geol. Survey*), p. 8, 1907.

³ *Quart. Journ. Geol. Soc.*, vol. lxi. p. 254, 1905.

⁴ “Coegen Lime Rock” of the Old Series Map.

to the west of Dolwen Point it contains a remarkable conglomerate, the descending sequence of strata being as follows :—

At Pendine Steps.

Even-bedded black limestone, in beds of one to three feet thickness ; the base undulating so as to fill up inequalities in the underlying surface, the top straight.

Lumps of black compact limestone imbedded in a granular calcareous matrix, with some lenticular seams of yellow calcareous sand and passing down into

Yellow calcareous rock, containing large and small lumps of various kinds of limestone, some red, some coarsely crystalline, some oolitic, and including sandy bands. In places the rock is laminated ; in others it contains bands which are disturbed and broken, and which are truncated by the black limestone above, as though by an unconformity. Much of the rock has a gravelly aspect, and in its upper part there is some gravelly conglomerate full of well-rolled limestone-fragments.

Massive light-coloured limestone of saccharoid texture.

The thickness of this 'Pendine conglomerate' amounts to about ten feet, but its base is ill-defined, owing to the breaking-up and piping of the surface of the massive limestone below it. The folding and breaking-up of parts of the yellow rock suggest, at first sight, subsequent movement, but the abundance of well water-worn fragments of limestone, and the manner in which the overlying strata adjust themselves to the uneven surface on which they were deposited, prove the contemporaneous age of the conglomerate. A specimen of the conglomerate was found by Dr. Flett to shew under the microscope (E. 3627) rounded pebbles of oolitic limestone, and of a finely granular dark limestone containing grains of quartz, in a rather coarsely crystalline calcareous matrix. In it there are also fragments of limestone which were partly dolomitised before inclusion.

A. S.

Subsequently with the help of Mr. O. T. Jones this section was examined with the object of measuring the zones. It appears that the Cleistopora Zone and the lower part of the Zaphrentis Zone are determinable and are followed by current-bedded detrital and oolitic limestone with occasional lines of fossils, generally broken and unrecognisable, but apparently belonging to no higher horizon than the upper parts of the Zaphrentis Zone. This is overlain by the conglomerate mentioned above. In two pebbles from the conglomerate fossils were found, the species of which point to their having been derived from a horizon probably not higher than a low part of the Zaphrentis Zone. The limestone that succeeds the conglomerate belongs undoubtedly to the Seminaula Zone, and it is followed by the Dibunophyllum Zone, both having the same lithological and palæontological development as at Kidwelly. Consequently the Syringothyris Zone and possibly a small part of the Zaphrentis Zone, though present in force close by to the south-west (at Tenby), as well as in the Bristol area, are absent in this intervening locality. The conglomerate,

consisting as it does of more or less rolled fragments of limestone derived from different bands, points to the locality having been within reach of wave-action at the close, at least, of the period of those zones, and it is to be noted that this local movement has taken place in the interval separating the two volcanic outbursts at Weston-super-Mare described by Mr. Sibly.¹

The total thickness of the limestone above the conglomerate is rather more than 600 feet, that is, about the same as that of the corresponding zones near Kidwelly, which it will be remembered there constitute the whole of the 'Main Limestone.' Also the highest beds are referable to the same horizon, ϵ , as at Kidwelly. At Pendine, therefore, we have a mass of limestone which palæontologically and lithologically corresponds closely to the 'Main Limestone' of the western end of the North Crop, but to the upper half only of the limestone of Tenby; further this limestone rests with some unconformity on the limestone below.

At Ragwen Point the uppermost limestone is visible under the section of Millstone Grit described on p. 85. It consists of 21 feet of thin-bedded, black limestone with nodules of black chert and thin partings of shale, and belongs to horizon ϵ .

The following thicknesses were measured at Pendine :—

	Feet.
Horizon ϵ	21
Dibunophyllum Zone	280
Seminula Zone	310
Zaphrentis Zone with possibly part of the Syringothyris Zone	70
Cleistopora Zone	50

E. E. L. D.

¹ *Quart. Journ. Geol. Soc.*, vol. lx, 1904, p. 147.

CHAPTER VIII.

CARBONIFEROUS ROCKS (CONTINUED).

MILLSTONE GRIT.

The subdivisions described in the Ammanford Memoir are distinguishable in this district; they are as follows:—

General Section of the Millstone Grit.

	Feet.
<i>Farewell Rock.</i> —Brown, olive-green and greyish-white sandstone and quartzite, impersistent. Thickness 0 to 100 ft.	50
<i>Shales.</i> —Dark barren shales with impersistent bands of brown, olive-green, and greyish-white sandstone and quartzite up to 80 feet thick; one or two thin coals toward the top.	
Thickness	1000
<i>Basal Grit.</i> —Grit and quartzite, fine-grained, with some bands of shale; on the eastern margin of the map passing down into a series of fine-grained sandstones and cherts about 15 feet thick, which by decomposition yield 'plastic-clay.'	
Thickness 170–350 feet	250
	1300

The Plastic Clay Beds crop out at Garn (a few yards east of the map), but have not been seen farther west in the decomposed condition in which they yield 'plastic-clay.'¹

The overlying grits and quartzites which make up the bulk of the Basal Grit are finely displayed on Mynydd Cerig and Mynydd Llangyndeyrn, and may be examined at the places shown on the map by dip-arrows. South-east of Ffynnon-cadachog (pp. 65, 77) the fine siliceous sandstone forming the lowest grit passes down into grey bedded chert, which, under the microscope (E. 5122), appears as a very fine-grained sandstone, now silicified, but possibly once calcareous. This very likely represents the Plastic Clay Beds; below it are black shales, probably the Rottenstone Beds.

The middle or shale-subdivision may be examined in Nant-Berem; some of the bands of quartzite and flaggy sandstone have been quarried for building and flags (as at Maensant); sections are indicated by dip-arrows on the map. A seam of coal two feet thick and known as the Grafel-du-bâch or Little Black Gravel, some 300 feet below the base of the Coal Measures, has been worked in this subdivision at Pant-y-gerdinen (one-third of a mile south-east of Gwndwn-mawr) and at Maensant-uchaf.

¹ 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, p. 75.

The Farewell Rock is quarried in Nant-Berem, but appears to thin out on the east side of Cwm-Lledley, and again south-west of Pont-Henry, where the Rhâs-fâch Vein serves as the base of the Coal Measures.

T. C. C.

Near Meinciau (Meincian) Mr. Wilkinson finds that the Basal Grit consists of white quartz-sandstones often much stained, succeeded by massive quartzites. The basal sandstones are often weathered into a friable sandstone or sand, the incoherence of which is due to the siliceous cementing material being less abundant between the grains (E. 3976 and 3977).

As exposed in numerous quarries on Mynydd-y-gareg, a bold ridge north-east of Kidwelly, the Basal Grit consists of white, tough quartzite, with subordinate bands of buff or black shale rarely as much as five feet thick and sometimes mixed with powdery coal for a thickness of a foot. But near faults or in swallow-holes the quartzite is friable and may even pass into the condition of loose sand. Some of the swallow-holes which are filled with this material are huge and very old, as may be judged by their distance from the Millstone Grit scarp and from the fact that they are overlain by Boulder Clay. Logan has recorded in his notes (1836-42) that west of Llyn (half-a-mile east of Cenfu) limestone was obtained in a timbered pit 20 yards deep through Millstone Grit debris. This debris, which lies at some distance from the Millstone Grit outcrop, is evidently the infilling of an old swallow-hole, and is possibly part of the same mass as that which has been quarried for making fire-bricks a short distance north-west of Llyn. This and other uses to which the quartzites and sands of Mynydd-y-gareg are put are described on pp. 156, 157.

Of the shale-subdivision which lies above the Basal Grit only the higher beds are open to examination. It passes up into current-bedded, shaly sandstone, the base of the Farewell Rock. In the dingle at Cae-tir, and about 50 yards below the base of this sandstone, there is a coal four inches thick with a typical underelay. A seam, six inches thick, which may be on the same horizon, has been worked by levels from the dingle above Morfa-bâch, and possibly also along the ridge to the south-west, but has not been found elsewhere. The ridge just mentioned is caused by a sandstone in the shales just below the horizon of the coal. To these shales probably belong the strata of the river-bluff on which Kidwelly Castle stands.

The shales are generally overlain by fine-grained, olive-green sandstone, 10 to 20 feet thick, which passes up by intercalation into the lowest beds of the Coal Measures and is evidently the Farewell Rock. Though wanting near Pont-Yates, it can be seen at intervals to the south-west on the north-west side of the Gwendraeth-fawr, and is well exposed below Cae-tir. A sandstone exactly resembling it crops out on the north side of the

Morlais River at Tal-carn, near Moat, and like the Farewell Rock near Cae-tir, is underlain by a current-bedded sandstone resting on shales. Its identification with the Farewell Rock is supported by the character of the Coal Measures immediately above (p. 122).

E. E. L. D.

The basal grits and their superposition upon the limestone are finely shewn at Ragwen Point. The uppermost limestone is thin-bedded, with shale-partings and chert-nodules, and resembles the 'Black Lias' of Oystermouth.¹ Upon this rest the following strata in descending order:—

Ragwen Point.

		Feet.
Millstone Grit (Basal Grit).	{ Quartz-grit, top not seen	20
	{ Shale with septaria of smooth blue limestone at the base, and a band of pyritous stone. <i>Posidoniella lewis</i> (Brown) and <i>Pterinopecten carbonarius</i> ? Hind. ² ...	12
	{ Quartz-grit	8
	{ Dark sandy shale, impersistent	4
	{ Quartz-grit, coarse, with small pebbles in part	10
	{ Shale with dark calcareous bands and a line of septaria of smooth black limestone in the upper part. <i>Lingula</i> (fragment), and <i>Posidoniella lewis</i> (Brown). ³ 8 feet to	10
	{ Quartz-grit, some parts dark and carbonaceous	20
Carboniferous Limestone (p. 82), seen to		10

It is to be noted that the basal grit here shews the type which prevails along the North Crop, and not that which is observable in Gower. In many respects it recalls the Monmouthshire development, though not in its poverty in fossils.⁴

A. S.

¹ 'The Country around Swansea' (*Mem. Geol. Surv.*), 1907, p. 25.

² Appendix, 162.

³ Appendix, 163.

⁴ 'The Country around Abergavenny' (*Mem. Geol. Surv.*), 1900, p. 47.

CHAPTER IX. CARBONIFEROUS ROCKS (CONTINUED).

COAL MEASURES.

INTRODUCTION.

The small part of the coalfield which is included in Sheet 229 contains representatives of the Lower Coal Series and of the lower part of the Pennant Series. It forms part of the anthracitic region as far as regards the bulk of the coal contained in it, but is situated not far from the South Crof where all the seams lose their purely anthracitic character. The Pennant seams, in accordance with the general rule that the higher seams are the more bituminous in any one section, are the first to show the change, and have assumed the character of steam-coals in the region under description.¹

The argillaceous ironstone which occurs as 'pins' (bands) or 'balls' (nodules) in 'mine-ground' (shale with ironstone) was formerly more in demand than the coal, but none is now worked. The courses of mine-ground so frequently lie just above the seams of coal in the Lower Coal Series, as to suggest a definite sequence of events, leading to the deposition of fireclay, coal, shale with ironstone, in the order named. This sequence is illustrated by the Rhâs-fâch, the Pumpquart and the Two-foot Veins.

The base of the Coal Measures is drawn at the top of the Farewell Rock, wherever that bed is recognisable; elsewhere the Rhâs-fâch Vein is taken as a convenient line. The base of the Pennant Series is formed by the vein known as the Gysewm near Burry Port, and that known as the Brondini Vein near Pont Yates, those appearing to be correlative with the No. 2 Rhondda Seam of Glamorganshire.

In their general characters the measures resemble those of the more central parts of the coalfield. The principal productive belt of the Lower Coal Series occupies about the same horizon as the 'Aberdare Seams,' the massive sandstones in the upper part of that series correspond to the Llynfi Rock, and quartzitic rocks, or 'cockshots,' appear at about the same level as the 'cockshots' of the Maestég neighbourhood. In detail correlation becomes most difficult. Not only is it impossible to identify individual seams with those of other parts of the coalfield, but it is difficult to correlate those of neighbouring villages, such as Pontyberem, Pont-Yates and Trimsaran. The thickness of the Lower Coal Series, moreover, which throughout the coalfield tends to increase westwards and southwards, here reaches at least 2950 feet, a figure greatly in excess of that attained in the Rhondda Valleys.

The following section gives the sequence of the seams and their distance apart, so far southwards as Pont-Yates. In the

¹ On this subject reference should be made to 'The Coals of South Wales, with special reference to the Origin and Distribution of Anthracite' (*Mem. Geol. Surv.*), 1908.

much disturbed ground south of Pont-Yates both identification of the seams and measurements of the strata are doubtful, as will be gathered from the following pages. The section has been drawn up by Mr. Cantrill from observations on the ground north of Pont-Henry, and by Mr. Dixon from observations in the neighbourhood of Pont-Yates:—

General Section of the Lower Coal Series between Pontyberem and Pont-Yates.

	Thickness.		
	Yds.	Ft.	Ins.
Brondini Vein (base of the Pennant Series) 3 ft. ...		—	
Shale	40	0	0
Pennant-like sandstone, with little shale	80	0	0
Measures	140	0	0
Cockshot-rock	8	0	0
Measures	80	0	0
Cwm-cobbler Vein		1	6
Measures	150	0	0
Carway-fawr Vein		3	6
Measures	20	0	0
Carway-fâch Vein		1	6
Measures	100	0	0
Upper Felen or Yellow Vein		1	6
Measures	12	0	0
Lower Felen or Yellow Vein		1	3
Measures	30	0	0
Big or Fawr Vein, absent? to 9 ft., average, say		3	0
Measures, 3 to 20 yds., average, say	14	0	0
Green or Wyrdd Vein, absent? to 2 ft. 8 in., average, say		2	0
Measures	24	0	0
Ddugaled Vein, absent? to 3 ft., average, say		1	6
Measures, 18½ yds. } 22 to 32 yds., average, say	27	0	0
Hwch Vein, 1 ft. 6 in. } Measures, 3 yds. }			
Stanlyd Vein (probably the Big Vein of Carway Coll.), variable, average, say		6	0
Measures, 10 to 24 yds., average, say	17	0	0
Grâs-uchaf, or Upper Grâs Vein		3	0
Measures	7	0	0
Grâs-isaf, or Lower Grâs Vein, absent? to 1 ft. 6 in., say		1	0
Measures	28	0	0
Brasslyd Vein		2	6
Measures	30	0	0
Gwendraeth Vein		3	0
Measures	30	0	0
Triquart Vein		2	0
Measures	35	0	0
Little Vein		1	0
Measures	10	0	0
Pumpquart Vein		3	9
Measures	18	0	0
Low Vein		1	6
Measures	51	0	0
Rhâs-fâch Vein... ..		1	6
Measures	15	0	0
Farewell Rock		—	
Total thickness of Lower Coal Series	979	2	0

The Trimsaran region is isolated by faults and unproved ground. The sequence differs greatly from that of adjacent districts, and correlation is difficult. The following section¹ has been drawn up by Mr. E. E. L. Dixon :—

General Section of the Lower Coal Series in the Trimsaran and Llandyry District.

		Thickness.		
		Yds.	Ft.	Ins.
Gyswem Vein (base of Pennant Series)	...		3	0
Shales	... ..	24	1	6
Rhengog-fâch Vein, with parting	... ..		1	6
Shales	... ..	17	1	6
Rhengog-fawr Vein, with two partings	... ..		2	10
Sandstone (Cenrhos Rock)	... ..	144	0	0
Cenrhos Vein, with several partings	... ..		4	4
Chiefly shales, with the Coed Rhyal or Caerhedyn Veins, the lower about 2 feet 9 inches high, with				
a parting	... ..	90	0	0
Sandstones	... ..	70	0	0
Cockshot rock	... ..		
Sandstones	... ..	70	0	0
Shales with sandstones and the Bancog Vein	... ..	80	0	0
Upper Mountain Vein...	... ..		2	0?
Measures	... ..	60	0	0
Lower Mountain or Golden Vein	... ..		2	0
Measures, including a thick sandstone near base ;	... ..	125	0	0
Waunffynnonau or Trimsaran Vein	... .. about		3	6
Measures	... ..	73	0	0
Cockshot rock	... ..		
Drap Vein, with a parting 12-18 inches,	... .. about		5	0
Cockshot rock	... ..	60	0	0
Measures with the Mole Vein, about 20 inches,	... ..		
Big Vein group.	Graigog Vein, with a parting ;	... 3 ft. 3 in. to	4	0
	Measures	... .. about	10	0
	Green or Wyrdd Vein, with a parting ;	3 ft. 6 in. to	4	0
	Measures	... ..	9	0
	Little or King's Vein, with a parting ;	... ..	2	2
	Measures	... .. 15 yards to	20	0
	Big Vein, with two partings	... ..	9	0
	Measures	... .. about	35	0
	Yard Vein	... ..	3	0
	Measures	... ..	15	0
Two-foot Vein	... ..	2	0	
Measures	... ..	64	0	0
Possibly a strike-fault hereabouts separates the above from the following beds.				
Measures	... ..	63	0	0
Probably a strike-fault hereabouts separates the above from the following beds.				
Measures, disturbed, with veins known as the 'Gräs-uchaf,' 'Garwed,' 'Cwm Cathan,' and others ;				
unknown.				
A disturbance along the strike separates the above from the following beds.				
Stanlyd Vein ?	... ..	unknown.		
Measures	... ..	unknown.		
Gräs-uchaf Vein ?	... ..	4	0	
Measures	... ..	unknown.		

¹ That part of the section above the Cenrhos Vein is based on information obtained near Burry Port by Dr. A. Strahan.

	Thickness.		
	Yds.	Ft.	Ins.
Gras-isaf Vein? with a parting ;		3	6
Measures	42	0	0
Brasslyd Vein in three coals		3	7
Measures	49	0	0
Gwendraeth Vein, with two partings ; coal 1 in. to 15 ft. average		4	0
Measures	52	0	0
Pumpquart Vein... .. 2 ft. 6 in. to		3	3
Measures 10 yards? to	19	0	0
Low Vein... .. 1 ft. 8 in. to		2	0
Measures	50	0	0
Rhâs-fâch Vein		1	3
Measures	25	0	0
Farewell Rock (top of Millstone Grit)		—	—

The names applied to the veins below the Stanlyd accord with the most recent correlation with the Pont-Yates district (p. 124). A noteworthy point is the large number of veins which contain partings, especially in the case of the Big Vein group, and of some higher veins which are almost unrepresented at Pont-Yates.

Here also the veins first begin to assume the bituminous character which prevails farther south. The lowest coals in which the change is distinct are those immediately above the Big Vein group. For further information on the distribution of anthracite and the analyses of coals, reference should be made to 'The Coals of South Wales' (*Mem. Geol. Surv.*), 1908.

Fossils (not including plants).

The following fossils have been collected during the re-survey of this region :—

From the tip of an old shaft on the Pumpquart Vein, 150 yards N.E. of the Red Lion, Pont-Henry¹ :—*Carbonicola acuta* (J. Sow.), *C. obtusa*? Hind, *C. robusta* (J. de C. Sow.).

From the tip of a slant on the Pumpquart Vein, 120 yards E. of the Square and Compass Inn, Pont-Yates² :—*Carbonicola aquilina* (J. de C. Sow.).

From the tip of a recent slant, Plâs-bâch Colliery, Pont-Yates³. The roof of the Stanlyd Vein yielded :—*Anthracomya*?, *Carbonicola sp.*, *Posidoniella*?

From the north bank of the River Morlais, near site of Trimsaran Ironworks⁴ :—*Carbonicola aquilina*? (J. de C. Sow.).

LOWER COAL SERIES.

NORTH OF THE TRIMSARAN FAULT.

The following general notes refer to the neighbourhoods of Pontyberem, Pont-Henry, and Pont-Yates. The Rhâs-fâch Vein overlies a 7-foot bed of good fireclay, and is succeeded by several courses of 'mine,' once extensively worked. The Low Vein is

¹ Appendix, 164.

² Appendix, 167.

³ Appendix, 166.

⁴ Appendix, 165.

overlain by sandstone. The Pumpquart Vein has been extensively worked at the old Capel-Ifan, Pont-Yates (Glan-Gwendraeth), and Plâs-bâch Collieries; it yields a good coal and has a hard roof characterized by the occurrence of lamellibranch shells (*Carbonicola spp.*), and above it some courses of mine have been wrought, though not so largely as those above the Rhâsfâch. The Little Vein and the Triquart Vein are not worked. The Gwendraeth Vein has been got at the old Caepontbren and Plâs-bâch Collieries at Pont-Yates, and is now being worked at Capel-Ifan by the Pentre-mawr Colliery, and at Pont-Henry. The Brasslyd Vein, which derives its name from its containing iron pyrites, is a good coal with a hard roof, and is now worked at Capel-Ifan and Pont-Henry. It is by some correlated with the Charcoal Vein of the Llandybie district. Of the Grâs-isaf no reliable information has been obtained, but it is said to be separated from the Grâs-uchaf by shale containing a number of 'pins of mine.' The Grâs-uchaf yields good coal, but has not been extensively wrought. The measures between the Grâs-uchaf and the Stanllyd thicken south-westward from about 11 yards at Pontyberem to 24 near Pont-Yates. The Stanllyd is very variable in quality and thickness (*e.g.*, up to 15 feet at Pont-Yates), and proved to have a bad roof and to be unworkable at Pontyberem; at Pont-Yates, where it is soft and crumbling throughout, it has been dug, but only for culm. It is probably represented by the so-called Big Vein of old Carway Colliery, which has been extensively worked, and had a thickness of nine feet of sound coal except where disturbed; near Pont-Yates the Stanllyd is overlain by a thick sandstone. The Hweh Vein is closely associated with the Stanllyd; some 'mine' above it was got near Capel-Ifan. West of that place it is unworkable; between Capel-Ifan and Pont-Henry it is overlain by a thick sandstone. Near Pont-Yates it dies out, or, as generally supposed, merges into the Stanllyd, from which it is separated at Pontyberem and Pont-Henry by merely three yards of soft measures. The Ddugaled, though present at Pontyberem, is not known with certainty at Pont-Yates; the vein is not now worked, unless it be the so-called Green Vein of the present Caepontbren Colliery.

The Green Vein is wrought at Pontyberem, where it has a soft roof, but farther west this becomes a sandstone. The 'Green' Vein of old Carway Colliery probably corresponds to one of the Grâs Veins. The measures above the Green Vein thicken south-westward from three yards at Pontyberem to 14 or more at Pont-Yates. The Big Vein is worked at Pontyberem where it is 9 feet thick, but not to any great extent to the south-west; at Pont-Yates it is not more than 2 feet thick, and it possibly dies out beyond. The 'Big' Vein of old Carway Colliery is probably the Stanllyd.

The Felen or Yellow Veins, so called on account of their associated pyrites, are known with certainty only between Capel-Ifan and Ynys-Hafren; at the latter place the underclay of the upper vein was formerly much in request.

The Carway-fâch Vein is known with certainty only between Pont-Yates and Carway; the Carway-fawr first appears south of Pontyberem and was worked at the Ty'n-y-cwm, Ty'n-y-wern and Ffou Collieries, and is still being got at the Gelli-gelynog slant near Pont-Yates, in which neighbourhood a thick sandstone, indistinguishable from Pennant, occurs not far above it.

The thickness of the measures between the Carway Veins and the lower coals is not known with certainty. An estimate at Capel-Ifan gives 165 yards as the thickness between the Big Vein and the Carway-fawr, a figure somewhat impaired in value by the possibility that a fault (p. 96) crosses the line of section. Better data are obtainable at Pont-Henry, where the Gwendraeth Vein is 320 yards below the Carway-fawr; and as there the Big Vein is probably about 160 yards above the Gwendraeth Vein, the Carway-fawr would thus be 160 yards above the Big Vein.

This value is in agreement with estimates made near the Gelligelynog slant on the Carway-fawr, south of Pont-Yates, down to the base of the sandstone mentioned on p. 117 as probably overlying the Big Vein.

At Pontyberem the average dip of the veins is towards S. 37° E. at about 8 to 9 inches per yard; at Capel-Ifan S. 29° E. at 7 inches per yard; at Pont-Henry S. 31° E. at $7\frac{1}{2}$ inches per yard; at Pont-Yates S.E. at 5 to 12 inches per yard; at Carway E. 40° S. at 9 inches per yard.

The Cwm-cobbler or William Edmond's Little Vein is known only near Pont-Yates. The hard quartzitic rock known as 'cockshot' has a thickness of over 20 feet wherever exposed, but is probably impersistent. It is overlain by sandy shales with a few thin coals, about 140 yards in all, followed by 80 yards of sandstones, part of which may, however, pass laterally into shale. These sandstones correspond in position with the Llynfi Rock of Maestêg, where, however, a 'cockshot' marks their base. They are similar in all respects to the sandstones above the Brondini Vein, and might well have been included in the Pennant Series but for the fact that that vein appears to correspond to the seam which lay at the base of the Pennant Sandstone of the east end of the coalfield.

T. C. C. and E. E. L. D.

(1.) *Pontyberem and Pont-Henry.*

North of Pontyberem¹ the Farewell Rock passes up into shales which we include in the Coal Measures, but it becomes difficult to recognise in Cwm Lledley, and the position of the base of the Coal Measures is consequently uncertain. A rock, at least 25 feet thick, which crops to the west of Clyn-hîr appears to lie some distance up in the Coal Measures. South-west of Pont-Henry the supposed Farewell Rock dies out, and consequently the base of the Coal Measures has been drawn at the Rhâs-fâch coal for about two miles.

¹ See also 'The Country around Ammanford,' (*Mem. Geol. Surv.*), 1907, pp. 137, 138.

Above the Rhâs-fâch coal, which is 1 foot 6 inches thick, there are four courses of mine in four yards of ground. A coal supposed to be the Rhâs-fâch is said to have been found in an excavation below the water-wheel at Cil-carw, but this would lie not far enough below the Pumpquart, and is therefore possibly the Low Vein. A coal, said to crop in a dingle north-east of Maen-sant, possibly represents the Rhâs-fâch. West of the Pont-Henry Fault the mine above the coal was extensively 'patched,' from the dingle above the Red Lion south-westward towards Rhâs-fâch. In a shaft 160 yards north-north-west of Hendy, north of Pont-Yates, not long abandoned in 1903, the coal is said to have been reached at 30 yards, and to dip at 7 or 8 inches per yard. There are three courses of mine above the coal, in 6 feet of shales.

Of the Low Vein little is known; it may be that found at Cil-carw as mentioned above; it may be represented also by a thin smut overlying fireclay visible in a brook 100 yards east of Cae'r-clovers, Pont-Henry.

The Pumpquart Vein is worked by the Pontyberem Collieries Company at their Clyn-hebog slopes (Sheet 230), and there is an old pit to the vein at Maes-mawr. It was worked in the old Pontyberem pit and was reached at 28 yards in a shaft 400 yards north-east of the bridge (Pont-y-Berem) at the confluence of the Berem and Gwendraeth.

The vein was formerly got at the old Capel-Ifan colliery, where it is reported to crop under the screens now used by the Pentre-mawr colliery. It is presumably thrown northward by the Crwbin Fault, on the west side of which it is said to have been seen in the yard at Syddyn. We next hear of it at an old pit on the crop 150 yards north-east of Clyn-hîr, while between that farm and the Red Lion it was presumably got in several old drifts and pits. On the tip from two old shafts for ironstone (probably the mine which is found in three courses 5 feet above the coal), 150 yards north-east of the inn, were found¹ *Carbonicola acuta* (J. Sow.), *C. obtusa?* Hind, and *C. robusta* (J. de C. Sow.).

West of the Pont-Henry Fault the Pumpquart is said to crop under the bottom of the river Gwendraeth, 13 feet vertically below a sluice a few yards west of the bridge (Pont-Henry), and it has been worked on the crop south of Cae'r-clovers.

A Little Vein 10 inches or, by other accounts, 18 inches thick, is supposed to lie 10 yards above the Pumpquart in Pontyberem old colliery; it is not worked anywhere.

The Triquart Vein is not now worked west of Cross Hands (Sheet 230); formerly it was got at the old Capel-Ifan colliery.

The Gwendraeth and Brasslyd Veins may be conveniently described together. Near Pontyberem the crop of the former

¹ Appendix, 164.

on the south-east side of the Gwendraeth valley can be traced by old crop-holes ; it passes about 40 yards north of the ruins of Fancy, a few yards west of which it is being worked at the present Pentre-mawr colliery at Capel-Ifan. The Brasslyd crop has been worked from the Llanelly road at Pontyberem to the Pont-Henry road, and is visible 150 yards south-west of the railway-bridge, at the mouth of an old slant by which it was worked by the old Pentre-mawr colliery ; the shales in the mouth of the slant dip at 9 inches per yard. It is probably the coal to be seen in a roadway by the side of a wood 50 yards south of the present Capel-Ifan colliery¹ (Pentre-mawr Colliery Company). The main slope of this colliery is in the Gwendraeth Vein, 2 feet 9 inches thick, driven full-dip ; the dip varies from 6 to 9 inches per yard, the average is about 7 inches. The Brasslyd Vein is 2 feet 8 inches thick, and lies about 32 yards above the Gwendraeth.

Recently a cross-measure drift, ascending in the beds, has been driven at this colliery from the crop of the Gwendraeth Vein to get the Green and Big Veins. The following is a summary of the beds passed through in the first part of the drift in descending order ; of the beds between the 'Ddugaled' and the end of the drift we have obtained no record :—

Cross-measure Drift at Capel-Ifan Colliery.

						Yds.	Ft.	In.
11.	Coal, 'Ddugaled' ...	...	...	...	...		15	4
	Measures ...	...	...	...	...	36	1	1
10.	{ Coal } 'Hwch' {	...	...	...	...		1	6
	{ Rashes } {	...	...	...	...		15	0
	{ Coal } {	...	...	...	...		1	0
	Measures ...	...	...	...	...	9	1	1
9.	{ Coal } 'Stanlyd' {	...	...	...	...		3	5
	{ Clod } {	...	...	...	...			9
	{ Coal } {	...	...	...	...		2	6
	Measures ...	...	...	...	...	5	2	6
8.	Coal, 'Gräs'	...	...	...	...		2	7
	Measures ...	...	...	...	...	7	2	0
7.	Coal ...	...	...	...	...			8
	Measures ...	...	...	...	...	1	2	1
6.	Coal ...	...	...	...	...			8
	Measures ...	...	...	...	...	7	2	8
5.	Coal ...	...	...	...	...		1	0
	Bottom Stone ...	...	...	...	...		1	3
4.	Coal ...	...	...	...	...			1
	Measures ...	...	...	...	...	2	0	10
3.	Coal ...	...	...	...	...			3
	Measures ...	...	...	...	...	7	0	7
2.	Brasslyd Vein ...	...	...	...	...		2	8
	Measures, about ...	...	...	...	...	24	0	0
1.	Gwendraeth Vein ...	...	...	...	...		2	9

Before we can discuss this section and compare it with the ground at Pontyberem it will be necessary to give the details of

¹ To the Manager, Mr. R. G. Griffiths, we are indebted for much information on the Capel-Ifan district.

the old Pontyberem colliery at Coalbrook. This colliery worked all the veins from the Lower Pumpquart to the Big by two shafts and a connecting drift; the Gwendraeth Pit, on the north, commenced just above the Grâs-uchaf and was sunk to the Lower Pumpquart; the South Pit was begun well above the Big Vein and was sunk to the Ddugaled; while the cross-measure drift was cut from one pit to the other through the Hwch and lower veins to the Gwendraeth Vein. All the coals were thus proved, and the following is a summarized form of the section in descending order:—

Old Pontyberem Colliery.

<i>South Pit:—</i>		Yds.	Ft.	In.
Gravel ...	... ..	11	2	0
Measures ...	... ..	31	0	1
Big Vein ...	... ..	3	0	0
Measures ...	... ..	3	0	10
Green Vein ...	... ..	1	0	0
Measures ...	... ..	31	1	11
Ddugaled Vein ...	... ..	1	1	0
Measures ...	... ..	2	0	0
<i>Drift:—</i>				
Measures ...	... ..	16	2	0
Hwch Vein ...	... ..		1	0
Soft rubbish ...	... ..	3	0	0
Stanlyd Vein ...	... ..	1	0	0
Measures ...	... ..	10	2	0
<i>Gwendraeth Pit:—</i>				
Grâs-uchaf Vein ...	... ..	1	1	0
Measures ...	... ..	9	1	9
Grâs-isaf Vein ...	... ..	1	1	0
Measures ...	... ..	25	2	6
Brasslyd Vein ...	... ..		1	6
Measures ...	... ..	26	0	4
Gwendraeth Vein ...	... ..		2	9
Measures ...	... ..	32	2	2
Triquart Vein ...	... ..		2	3
Measures ...	... ..	31	2	2
Little Vein ...	... ..			10
Measures ...	... ..	10	1	5
Pumpquart Vein ...	... ..	1	2	0

A comparison of the two sections leads to the following considerations:—Taking the Brasslyd as a datum-line, the supposed Grâs (No. 8) of Capel-Ifan agrees approximately in position with the Grâs-isaf at Pontyberem, and the supposed Stanlyd (No. 9) of Capel-Ifan is probably the Grâs-uchaf of Pontyberem. The next vein, said to be the Hwch, 9 yards 1 foot 1 inch above, consists of coal 1 foot, 'rashes' 15 feet, and coal 1 foot 6 inches; while in the Pontyberem section in about the same position we have "Stanlyd Vein 3 feet, soft rubbish 3 yards; Hwch Vein 1 foot." This 'soft rubbish' at Pontyberem may well be the 'rashes' at Capel-Ifan. It seems likely, therefore, that the so-called Hwch (No. 10) at Capel-Ifan corresponds to the combined Stanlyd and Hwch of Pontyberem.

At about 5 yards horizontally beyond the top of No. 10 the beds in the drift are traversed by a thrust-fault dipping south, and, at 42 yards beyond the top, by a similar thrust accompanied by a roll ranging about east and west. The effect of these disturbances would be to repeat some of the beds. The next coal, No. 11, supposed to be the Ddugaled, consists of coal 1 foot 4 inches, rashes 2 feet, and coal 12 feet. But at Pontyberem the Ddugaled, which is generally about three feet thick (and under Capel-Ifan is said to be a good coal 3 feet 9 inches to 4 ft. thick), is 19 yards above the Hwch, whereas in the drift at Capel-Ifan the supposed Ddugaled is 36 yards above. The supposed Ddugaled Vein in the drift, therefore, may be the combined Hwch and Stanllyd, repeated by the overthrusts mentioned above. If this view is correct we must look for the Ddugaled some 22 yards higher; but no coal in such a position is mentioned in the record. The drift was ultimately abandoned at a distance of about 600 yards from its mouth, and 237 yards beyond the so-called Ddugaled Vein (No. 11 of the Section), ending in the crop of a coal which is supposed to be the Green Vein. It is remarkable, in view of the faults found in the drift, that no disturbance of greater throw than 10 feet has been proved in the Gwendraeth Vein workings of the Capel-Ifan colliery between Gwal-yr-hwch on the north-east and Carnwallon-fawr on the south-west.

The Pont-Henry colliery¹ is working the Gwendraeth and Brasslyd Veins by means of two drifts descending in the measures and a cross-cut from one vein to the other. The main slant is driven full-dip in the Gwendraeth. The crops of both veins lie north of the mouths of the drifts. The average dip of both veins is $7\frac{1}{2}$ inches per yard. At a point in the main slope in the Gwendraeth 12 chains east of Cae-pontbren Farm the dip decreases to about three inches per yard, the direction of full dip changing from S. 40° E. to a little west of south. At about the same point two westerly downthrows of 30 feet and 26 feet respectively were encountered. These are probably connected with some faults and disturbed ground, ranging about north and south, proved in the easterly workings of the same vein; the disturbance appears to affect the crops of the Big and Green Veins also (p. 98). On the west side the workings in the Gwendraeth Vein have touched some disturbance ranging about north and south, 6 chains east of Ynys-Hafren Farm; this lies 10 chains east of the probable line of the Pont-Henry Fault, an easterly downthrow supposed to be 60 yards.

The fact that the Pont-Henry main slope in the Gwendraeth Vein has reached to within 70 yards of a point vertically below the crop of the Carway-fawr Vein affords a means of calculating the thickness of measures between those veins. The end of the

¹ To Mr. W. O'Connor, F.G.S., and to Mr. J. F. Bell, we are indebted for much information on this district.

slope in the Gwendraeth Vein was determined by Mr. J. F. Bell to be 726 feet below ordnance datum. The dip being here about 3 inches per yard we must add 17 feet for the increased depth of the slope when projected 70 yards so as to underlie the Carway crop, making the total depth 743 feet below ordnance datum. The crop of the Carway is about 220 feet above that datum and therefore 963 feet above the end of the level which, corrected for dip, gives a thickness of 960 feet between the Carway and Gwendraeth Veins. This may be thought to be slightly too high an estimate, as the dip has been assumed to be only 3 inches per yard through the whole thickness from the Gwendraeth to the Carway. But if we take it as $7\frac{1}{2}$ inches throughout, the thickness works out at only 5 yards less. A section given by Logan¹ of the ground between Pant-y-parchell and Cwm-gelwr and crossing the Gwendraeth Valley half-a-mile above Pont-Yates makes the thickness from the Carway to the Gwendraeth to be 354 yards.

The next five veins—the Grâs-isaf, Grâs-uchaf, Stanllyd, Hweh, and Ddugaled—may be taken together. At Pontyberem old colliery the Grâs veins were proved in the Gwendraeth Pit; the Stanllyd and Hweh in the cross-measure drift connecting the Gwendraeth Pit with the South Pit; and the Ddugaled in the South Pit. There were also slants on the last-named vein. Between the Llannon road and Pentre-mawr Farm at Pontyberem and thence south-westward, there are old pits and patches on the veins, but the exact crops of some of them are uncertain, and the Stanllyd appears to have been unworkable. At 130 yards west of Capel-Ifan Farm an old shaft proved 4 yards depth to the Ddugaled and 18 to the Hweh. About 20 yards farther west there is a large patch supposed to have been for the mine above the Hweh Vein. The Ddugaled Vein probably crops a little below the top of the patch and the Hweh a little below the bottom. At about 50 yards farther to the south-west there is evidence of a disturbance: shales dipping south-west at 40° are exposed at the top of a wooded escarpment, while immediately on their south-west side, and presumably faulted in, there appear abruptly the Hweh rock and vein. As the coal is brought almost in line with the Ddugaled, there appears to be a small northerly downthrow. What is supposed to be the Hweh rock has also been quarried 200 yards south of Capel-Ifan Farm. It dips S.S.W. at 36° , and 50 yards east of the quarry there is an old descending drift said to be to the Stanllyd Vein. This drift is in line with the crop of the Big Vein, a fact which has given rise to an erroneous idea that the Big Vein of Pontyberem is the same as the Stanllyd of Pont-Henry.

The northerly downthrow mentioned above, however, intervenes and partly explains the difficulty. The two faults met with in the

¹ In a MS. note-book, preserved in the Geological Survey Office.

Capel-Ifan drift (p. 95) would reach the surface at about the position required. It is remarkable, however, that on the plans of the Capel-Ifan workings no faults are shown in the Gwendraeth Vein of greater throw than about 4 feet, and that under Capel-Ifan Farm no disturbances at all, in the requisite direction, were proved. It seems therefore that the two faults cut by the drift die out to the dip.

The Hwch rock, of which there is no evidence north-east of Capel-Ifan Farm, forms a good feature south-westward past the ruins of Bath, with a line of old holes at its base on the crop of the coal. North-west of Carnwallon-fawr a more recent drift ascending in the measures is said to have got the Stanllyd, Hwch, and overlying mine. The Hwch rock runs along the upper part of Allt-ysgrech and has been quarried 400 yards west of Carnwallon-fâch.

In the Pont-Henry colliery what is supposed to be the Grâs-isaf Vein crops in the mouth of a slant made in 1902. The Grâs-uchaf probably crops about 100 yards farther to the south-east. At the south-west end of Allt-ysgrech the Stanllyd and Hwch both crop, and the rock above is exposed in a quarry. But it is poor in quality and has probably begun to thin-out or pass laterally into shale. A little above the quarry a trial shows some 'rashings' which may represent the Ddugaled Vein. Nothing appears to be known of the Hwch and Ddugaled Veins as workable coals between Pont-Henry and Capel-Ifan Farm. South-west of the end of Allt-ysgrech little is known of the crops of this group of veins; the Grâs-uchaf is said to have been seen under a cottage 70 yards south-east of the railway-bridge in Pont-Henry.

We have now to trace the crops of the Green and Big Veins from Pontyberem.¹ Here at the Pontyberem Colliery Company's slopes near Llaethdy, nearly half-a-mile north-east of the old colliery at Coalbrook, the Grâs-uchaf, Green and Big Veins are worked; the main slope (full-dip) is in the Green Vein; the two others are got by cross-cuts. The average dip in the Green Vein is S. 37° E. at 8 inches in the yard. The slope commences a little north of the crop and extends as far as the Llanelly and Mynydd-Mawr Railway. The Big Vein crops about 120 yards south-east of the mouth of the Green Vein slope, and 180 yards south-east of Llaethdy according to a MS. note by Logan. The crops then cross two dingles at Pontyberem. Logan states that in the eastern dingle two faults, about 8 yards apart, were proved in the Big Vein; between them a trough is let down 17 feet, and in the trough the Hwch, Stanllyd, and Grâs-uchaf Veins were found to run together with a thickness of 31 feet of coal in three layers. From an account of the faults proved at the old Pontyberem colliery there seems to be a fault running northward along

¹ See also 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 137, 138.

the same dingle, but its throw is said to be about 17 yards in the Pumpquart and Grás-uchaf. The two accounts appear to refer to the same fault. In one of the two, possibly yards should be taken as feet.

The workings of the old Pontyberem Colliery in the lower veins have been mentioned already (p. 94). In the fields east of Pentre-mawr and Pentre-bâch farms there are old cropworks on the Big Vein, and 100 yards north-east of the latter the old Pentre-mawr Colliery had a slope on it, the crop running somewhere under the farm-buildings and thence towards St. John's Church (Capel-Ifan). The coal is said to be 9 feet thick. There are old crop-works in the field immediately north of the graveyard, and as the church stands on shales, there appears to be no rock above the coal, such as overlies the Hwch and Stanllyd at Capel-Ifan Farm (pp. 96, 97).

South-west of this point there are no workings for nearly half-a-mile, but on the south side of the northerly downthrow described on pp. 96, 97, at 350 yards south-east of Capel-Ifan Farm, a small trial was made, in which the Green Vein crop is supposed to have been proved, and about 40 yards farther to the south-east a shallow pit marks the end of the Capel-Ifan cross-measure drift (p. 93). West of the Pont-Henry road both Green and Big Veins have been cropped and to the east of Carnwallon-fawr the former is overlain by a thin sandstone. At Carnwallon-fâch the Big Vein is said to have been only 2 feet thick; there are also several old pits to the Green Vein. At 180 yards west of the last-named farm both crops appear to be shifted slightly northward, presumably by a small westerly downthrow which may be the same as some small north and south faults proved in the Gwendraeth Vein in the Pont-Henry workings a little farther south. In about the same line and still farther south two downthrows west of 10 yards and 9 yards have been proved in the same colliery's main slopes in the same vein. West of this line of fault there are old cropworks on the Big Vein where it crosses the top of Allt-ysgrech. The evidence as to the crops of the lower veins at the south-west end of this wood has been described already (p. 97); toward the higher part of the wood what is thought to be the Green Vein has been exposed in a trial-hole, where the beds dip S. 10° E. at 15° and afford the following details:—

		Ft.	In.
Sandstones and shales (bottom of Green Vein rock) ...		10	0
Shale ...	...	1	9
Coal ...	...		6
Shale ...	} GREEN VEIN		9
Coal ...			9
Underclay, seen for ...	...	2	0

The Big Vein crop must cross the corner of the wood a few yards above this trial; at the trigonometrical station (316 feet), 130 yards south-east of the corner, there is an old pit said to be 60 yards deep to the Green Vein. At about 200 yards south-west of the wood there are several old pits to the Green and Big

Veins ; one within 20 yards of the west side of the road at Penderw is about 60 yards to the Green.

The Big Vein is the highest of the more important lower coals, but between it and the base of the Pennant Series several smaller seams have been worked. Between Capel-Ifan Farm and Pont-Henry the two Felen or Yellow Veins appear. The Upper Felen Vein is said to have been got in an old slope 170 yards north-north-west of Pen-derw, and both veins were worked in the angle where the Pontyberem road is joined by the road from Pont-Henry, near Pont-Henry village.

A vein known as the Purple Vein, 2 feet thick, and 22 yards above the Felen, is mentioned by Logan. Nothing now seems to be known of it, but a coal 1 foot thick in shale is visible in a ditch one-third of a mile east-by-north of Pen-derw, and what may be the same coal has lately been dug at Temple, a cottage by the brook side 70 yards above Cwm-buchle bridge near Pont-Henry. The position of the seam with respect to the Felen Veins corresponds with that of Logan's Purple Vein.

The Carway is a more important vein. In a dingle 200 yards south-south-west of Marchog-llwyn (Sheet 230) south of Pontyberem there are small old workings on a coal, with a sandstone, apparently below it, which has been quarried close by. A quarter of a mile to the south-west, in another brook, and opposite the end of the road from Ty'n-y-cwm, coal débris and an underclay are visible, and there are some old pits hard by. All these probably relate to the Carway Vein, which thence runs nearly along the road to Ty'n-y-cwm Colliery, where it was got by shallow pits and by a slope on the crop. Thence numerous old pits not far from the crop lead us to Ty'n-y-wern Farm, 230 yards south-west of which the coal was got by pits and a slope.

About 200 yards of measures, chiefly shales, succeed the Carway Vein. We then reach a band of 'cockshot' rock which introduces a group of shales and sandstones, some quartzitic, but generally resembling pennant, which corresponds in position with the Llynfi Rock of other districts. This 'cockshot' rock, which is shown upon the map to the east of Ty'n-y-cwm, forms a cascade in a brook 200 yards south-east of that farm and is about 20 feet thick. Above it there follow about 130 yards of beds, chiefly shales, exposed in the Llanelly and Mynydd-Mawr Railway, succeeded by a band of sandstone which crops to the east of Ffynnon-y-menyn.

T. C. C.

(2.) *Pont-Yates.*

Near Pont-Yates, in the absence of recognisable Farewell Rock, the Rhâs-fâch Vein affords the only traceable base to the Coal Measures. The coal was less in requisition than the ironstone-courses in the shales above, of which the following information is given in one of Logan's note-books :—

“The Blue Mine in three courses :—upper, $3\frac{1}{2}$ inches ; middle, 4 inches ; lower, 5 inches, [making] $12\frac{1}{2}$ inches in 4 feet of

ground. In another level the Yellow Mine two courses :— upper, $2\frac{1}{4}$ inches ; lower, $2\frac{1}{2}$ inches.”

Fuller details are given by the Llwyn-hebog pit-section (see p. 102) recorded in ‘Vertical Sections,’ Sheet 3, *Geol. Surv.* From Logan’s MS. note, it appears that ironstone-bands, called the Poor Robin (a South Staffordshire term), Blue and Black Mine, and Mwyn Llawr, and respectively $2\frac{1}{2}$, 4, 5, and 5 inches thick, together with another, unnamed, $4\frac{1}{2}$ inches thick, occur in $23\frac{1}{2}$ feet of ground, the base 5 feet above the coal. In the vertical section the coal is 1 foot 8 inches thick, and ‘Unios’ are recorded in ‘Black carbonaceous shale’ containing the Black Mine and lying 10 feet above the coal.

The ironstone was worked near the outcrop by means of levels and shafts, which are characterised by their large shale-tips. The coal was proved at a depth of 12 yards in a shaft a short distance to the south of Rhâs-fâch farm, whence the vein takes its name.

Near the head of the dingle above Ty’n-y-cwm, about half a mile west of Port-Yates, ironstone is exposed which appears to be that above the coal, whilst what appears to be the outcrop of the coal itself is seen beneath boulder-clay about 100 yards north-east of Whitehall. A small N.N.W. fault intervening between these two exposures is evidenced by a tilt in the strata in the stream about 40 yards north of Ty’n-y-cwm. Though the direction of the tilt suggests a westerly downthrow, the disturbance is probably the same as a fault, apparently an easterly downthrow, proved in the Pum-cwart Colliery, which is possibly the fault at “Tynardy” (Tanerdy) referred to by Fairley¹ as being 16 yards downthrow to the east. But the strongest evidence of the fault is obtained south of the Gwendraeth (p. 106).

In the Ty’n-y-cwm dingle the Farewell Rock is not known, but it reappears to the west in the dingle below Glyn-fâch. The Rhâs-fâch Vein, as proved in small shafts, lies a few yards above the rock, and about 350 yards south-south-east of Glyn-fâch the ironstone in the shale above has been worked by levels. At Cwm-bâch Colliery, at the mouth of the dingle, where a considerable area of mine-ground to the north-east was tapped by a descending drift, the following section was proved according to Mr. D. Lewis :—

	Ft.	Ins.
Shale with three pins of ironstone up to 4 inches thick and also scattered balls	7	0
Shale	7	0
Rhâs-fâch Vein	1	9
Fireclay, the upper half worked for bricks and for lining furnaces	7	0

Work has also been carried on from a shaft at Ty’n-y-coed, said to be about 40 yards deep, but to the west of the Glyn-fâch

¹ ‘Practical Observations on the South Wales Coal-field,’ fol., n.d. (c. 1869), p. 22.

dingle it appears to have been limited by a north-north-west fault, probably connected with several small sharp folds running N. 10° W. which are visible near Cwm-bâch. The ground immediately to the west has been little, if at all, proved, but the fault appears to be a small easterly downthrow, unknown to the south, but ranging northward toward a break in the Carboniferous Limestone (p. 77). Further on, again, the coal and ironstone have evidently been reached by means of a cluster of small shafts midway between Glyn Abbey and Pont-newydd, about 600 yards to the south. At Pont-newydd itself Logan records¹ that the coal crops in the side of the road. The shales a short distance below are seen resting on Farewell Rock in the Cac-tir dingle, about 100 yards to the north-west. As Farewell Rock is exposed at Morfa-bâch, the lowest measures would be expected to cross to the south side of the Gwendraeth some distance below that place, whereas they are supposed to crop out at Glassberry, to the east of which a trial-shaft is said to have passed through the following :—

	Yds.	Ft.	Ins.
Clay with stones [Boulder Clay]	4	0	0
Measures, at their base three pins of ironstone up to 4 inches thick	20	0	0
Shale with balls of ironstone	3	0	0
Coal	1	8	
Fireclay.			

That the coal here proved was the Rhàs-fâch Vein is supported by the alleged occurrence of the Pumpquart Vein at Ty'r-eithin, about 350 yards to the south-east (p. 105). South-west of Glassberry, in a tract covered by boulder clay, the outcrop must be interrupted by the Trimsaran Fault. Its occurrence at Moat to the south will be described under Trimsaran (p. 122).

The Pumpquart Vein has in the past been much worked, both along the level-course, and towards the deep at the Pont-Yates (Glan-gwendraeth) Colliery, north of the river, and the Plâs-bâch Colliery, on the south. As these collieries, though they have operated on both sides of the river, have not apparently worked all the coal beneath the alluvial flat, it is important to enquire whether some faults which range from Tre-gôch up the river towards the unproved ground, continue as far as Pont-Yates. The outcrop, where the vein dips at 12°, has been proved in a trial-slant 120 yards E. of the Square and Compass. In the shaft of the Pont-Yates Colliery the vein is 44 yards down; whilst in the southern colliery, where its dip is generally about 12°, its depth in the Pumpquart pit is variously given as 120 to 148 yards, but may be taken as being 143 yards in accordance with the section given on p. 106. From these data it is found to dip on an average at 11° between its outcrop and the first colliery, but at 14° in its further fall to Plâs-bâch. The dip

¹ MS. Section-book : section near New Bridge.

therefore in the unproved strip, 200 yards wide, is not much greater than in the ground to the north and south, and there is no reason to suspect its interruption by faults.

The workings of these collieries have also proved that cross-faults belonging to the north-north-west set are few and trifling, the best defined, 250 yards east of the Pumpquart pit of Plâsbâch Colliery, being a westerly downthrow. Fairley (*op. cit.* p. 22) mentions "a fault down west 4 yards, near Mr. Evans' house [probably Glan-gwendraeth]; 300 yards up the valley a downthrow east of 8 feet which decreases to 18 inches in going to the deep; and a downthrow east of 3 yards a little to the west of the chapel at Pont-Yates," which were probably proved in Pont-Yates Colliery.

Elsewhere in the district the coal has hardly been worked to the deep, but it is probable that most of the ground drainable by adits has been exhausted, though in places few signs of old workings are to be seen at the surface. The outcrop from Pont-Yates to the old Pum-cwart Colliery, about half a mile down the river, is covered by boulder-clay, but its position is given by the trial-slant, previously mentioned, and by numbers of old shafts, some of which, however, were sunk north of the outcrop of the Pumpquart Vein to get the Low or Little Vein below. The slant proved the boulder-clay there to be 20 feet thick, and its tip yielded *Carbonicola aquilina* (J. de C. Sow.)¹, presumably, as elsewhere, from the roof of the vein. A trial-shaft, 30 yards to the north-west, proved a vein, said to be the Little Vein, at an estimated depth of 7 yards below the Pumpquart. One of the disused shafts to the south-west, evidently sunk earlier than 1840, is recorded in detail in 'Vertical Sections,' sheet 3, *Geol. Surv.* It is stated to be at Llwyn-hebog, the locality being more exactly 350 yards W. 5° N. of Pont-Yates bridge. Upon this section are largely based various versions of the sequence from above the Pumpquart down to the Rhâs-fâch Vein, such as that published by Fairley (*op. cit.*, p. 20). Another section, recorded by Logan in 'Vertical Sections,' sheet 1, *Geol. Surv.*, gives the measures immediately above and below the 'Pimp' (Pumpquart) Vein. It is clear that the whole sequence was not proved in the Llwyn-hebog Pit, for the highest measures there proved were below the Pumpquart. It is certain, however, that the source of his information regarding the measures above that vein lay hard by, and that he considered that the top of the pit was on a level with the bottom of the Pumpquart underlay. In the pit-section he mentions a vein of culm, 1 ft. 6 ins. thick, at 16 yards depth below the Pumpquart, and in the mine-ground above the Pumpquart several ironstone-bands, including the "Top Vein, 4 inches" and the "Llower [? Llawr or Lower] Vein, sometimes 9 inches." If, as Logan supposed, the Pumpquart Vein was close above the Llwyn-hebog Pit, the thickness of measures between that vein

¹ Appendix, 167.

and the Rhâs-fâch must be 70 yards. Other records vary, up to 74 yards, but a calculation based on the dip and width of outcrop points to its being rather less.

The old Pum-cwart Colliery, for information about which we are indebted to Mr. David Lewis, was worked in the coal, and possibly in the ironstone above to a slight extent. The winding-pit, at a depth of 28 yards, passed through 2 inches of "black rashings," supposed to represent the coal. The total depth reached was 35 yards, the measures being chiefly "blue stone with pins of mine." Apparently the coal was worked at about the same depth for a short distance eastward, but it appears to have been lost 250 yards east-north-east of the winding-pit, probably having been cut off by an easterly downthrow (see p. 100). West of the pit little is known of the vein north of the river.

Evidence of it is next obtained south of the river, west and north-west of Tre-gôch. For much of the information regarding this complicated ground we are indebted to Mr. Hansard, who has proved the measure by means of three slants, the first at 100 yards E. 13° N. of Bryn-y-fforest; the second 160 yards W. of Tre-gôch; and the third 280 yards E. 17° S. of Pwll-y-llygod. The disturbed nature of the ground may be gauged from the failure of these three attempts to find workable coal. The first slant was sunk on a vein which had been worked in the past from small shafts to-the south-west and which was at first thought to be the Gwendraeth Vein, but was afterwards regarded as the Pumpquart, because it was associated with measures such as characterise that vein at Plâs-bâch Colliery (p. 101). It underlies mine-ground with three pins, and as proved in a trial-well at Bryn-y-fforest, overlies at a short distance sandstone resting on a thin coal. An east-north-easterly fault or fold must separate the outcrop at Bryn-y-fforest from that of the Rhâs-fâch near Glyn Abbey to account for the distance of 800 yards between them. In the slant the coal dips to the south at $16-18^{\circ}$ for about 70 yards, flattens for 30 yards more, and finally plunges down sharply against a fault with an east-north-easterly course but unknown hade. The slant was continued in its original direction past the fault for a further 110 yards through rolling ground with merely a thin coal, and was finally abandoned without reaching a recognisable horizon or proving the throw of the fault. It is probable, however, that there is a considerable downthrow north, for the Pumpquart crops out again about 300 yards south of the mouth of the slant.

This second occurrence of the vein has been proved in Mr. Hansard's third slant. There the coal dips in a south-south-easterly direction, at 4° near the outcrop, but at 14° or more at distances of more than 100 yards to the deep. Though the roof is quite sound and the dip steady on the whole with the exception of one trifling overfold with an east-north-east axis, the coal bears evidence of strong lateral compression. Over considerable

areas it is traversed by many slickensides, and, in places, by 'overlaps' or overthrust-faults, as a result of which its thickness varies between $2\frac{1}{2}$ and 6 feet, though it is normally about 4 feet. During previous workings it had been drained by an adit which opened on the river 140 yards north-east of Pwll-y-llygod, and much of it had been removed, even below the adit-level. The adit received also an old water-level from the Little or Low Vein: this old level has been cleared for over 300 yards and found to run at first due east and then north-east, to a point not far from the end of the first slant. An old shaft close to the bend and a quarter of a mile west of Tre-gôch reached the Pumpquart Vein at 12 yards and the Low Vein, 16-20 inches thick, at 22 yards depth. Between the two a hard sandstone, 7 feet thick, had been wrought as well as the coal.

On reopening the adit it was found that there was a second crop of the Pumpquart, 200 yards north of that described above. Commencing at the outfall, horizontal or gently rolling sandstones were traversed for 200 yards, the Pumpquart Vein taking ground about 30 yards from the outfall, and then keeping about two yards above the adit, as may be seen in shafts at 100 and 160 yards. At 200 yards the vein descended to the adit, and, after reappearing in it several times in a disturbed condition with a steep south-easterly dip, terminated at a fault at 220 yards from the outfall.

This fault, which dipped to the south-east at 20° , was proved to be an overthrust from the south by the fact that it brings a sandstone, two or three yards below the Low Vein, against the Pumpquart. Passing through the fault the adit traversed a gentle anticline, and intersected the Low Vein at 270 yards from the outfall. There a shaft was sunk to it at 18 yards depth, which, passing through the Pumpquart close to its outcrop, proved it to lie 15 yards above the Low Vein. Hence we see that the vertical shift effected by the overthrust is 17 or 18 yards. The second outcrop of the Pumpquart is that worked in Mr. Hansard's third slant, where, as mentioned above, the vein assumes a gentle dip near the surface, evidently because it passes into the anticline to the south of the overthrust.

This structure is evidently what was referred to by Logan in a note in his MS. that "Near Pwll Llygad there is a hump on the Gwendraeth, and in the middle of it the Low Vein comes to within 3 fathoms of the surface." He further adds that "the 10-fathom fault is to the east of this, and to the east of it the Gwendraeth Vein was found to be 11 feet and more. At 50 fathoms some say it was 18 feet. (Bowen.)" Here he has confused the Gwendraeth and the Pumpquart Veins as explained later (pp. 122-3). Nothing is now known of the 10-fathom fault (*see* p. 107).

The overthrust has not been located on either side of the adit, but it is presumably the same as that proved in the first slant. If so, it ranges E. 30° N. and passes, in a short distance on either side, below the alluvial meadows of the Gwendraeth.

As regards the two outcrops of the Pumpquart Vein, little further evidence has been obtained. The northern outcrop disappears beneath gravel to the east of the first slant, and to the west though it is presumably continuous with the outcrop at Pwll-y-llygod, there are no signs of workings in it across most of the intermediate ground. West of the adit it is said to crop out about 80 yards north-east of Pwll-y-llygod, and has been worked by means of small shafts east of the farm. The southern outcrop is not traceable continuously to the east of the water-level mentioned above, but several old shafts lead in that direction to an abandoned trial, 500 yards north of Tre-gôch, known as Berkenshaw's slant,¹ which has been driven for about 130 yards along what may have been the Pumpquart Vein, in a disturbed and unworkable condition. The vein contained pyrites ('brass') whence it was once thought to be the Brasslyd, and afterwards was for a time thought to be the Gwendraeth Vein. To the west of the water-level the outcrop of the Pumpquart, traceable for a short distance by means of old workings, must soon turn sharply southward, for about 200 yards south of Pwll-y-llygod the sandstone which overlies the Low Vein, is said to have been quarried for Kidwelly Quay. At Ty'r-eithin the coal itself, with an average thickness of $3\frac{1}{2}$ feet, is said to have been proved for 90 yards towards the deep by a slant, while at the 'Old Shaft' engraved on the six-inch map, 50 yards to the north-east, it appears to have been much thicker and overlain by 12 yards of boulder-clay. Both these trials have long been abandoned, and the identity of the coal they proved is uncertain on account of their isolated position, but the view that it is the Pumpquart Vein is supported by its position relative to the outcrop of the Rhâs-fâch Vein at Glassberry. Southward nothing further is known of it till the neighbourhood of Llandry is reached (see p. 122).

The Triquart, with a thickness 2 feet 3 inches, is said to have been proved at Plâs-bâch. The Gwendraeth and Brasslyd Veins were worked in the old Caepontbren Colliery on the south-east bank of the Gwendraeth-fawr, near Pont-Yates. For the following information of the shaft-section we are indebted to the Stepney Estate Office, through Mr. Thomas Jones:—

Caepontbren Shaft-section.
(Dip, 15° to 20°).

	Yds.	Ft.	In.
Measures	16	2	8
Brasslyd Vein	1	0	0
Measures, including 2 riders	30	0	0
Gwendraeth Vein	2	10	

The upper vein was worked but slightly, the lower to a considerable extent to the east, south-east and south, the following faults being proved. Of the north-north-westerly group a downthrow east of 7 yards lies about 350 yards N.E. of the shaft,

¹ Mr. F. E. Burnell has kindly supplied us with information about this trial.

and a downthrow west of 3 yards about 350 yards S.E. of the shaft. A belt of disturbed ground was met beneath the Carmarthen road, which apparently belongs to the east-and-westerly group, and is probably continuous with a similar belt proved in the Green Vein of the present Cae-pontbren Colliery to the east (p. 117).

The Gwendraeth Vein was also worked extensively from Plâs-bâch Colliery. The following section is based on information supplied by Mr. Burnell, and the foreman, Mr. Lloyd:—

Middle or Gwendraeth Pit, Plâs-bâch Colliery.
(Dip, 12°).

						Thickness.		
						Yds.	Ft.	In.
Made Ground	}	...	...	...	...	1	1	0
Grâs-isaf Vein	...	...	...	...	...	47	2	0
Measures	...	...	...	...	...	1	0	0
Brasslyd Vein	...	...	...	...	...	29	0	0
Measures, including 3 small coals	...	...	...	...	...	1	0	0-6
Gwendraeth Vein	...	...	...	...	...	80	0	0

The section of the lower or Pumpquart Pit of the same colliery, which proved the measures down to the Pumpquart Vein, is not known with certainty, but the following outline is the most reliable version and is based on information from the same sources:—

Lower or Pumpquart Pit, Plâs-bâch Colliery.

						Thickness.		
						Yds.	Ft.	In.
Measures, etc.	...	...	...	...	...	34	0	0
Brasslyd Vein	...	...	...	...	...	29	0	0
Measures	...	...	...	...	...	77	0	0
Gwendraeth Vein	...	...	...	...	...	143	0	0
Measures, said to include the Triquart Vein	...	...	...	...	...
Pumpquart Vein	...	...	...	...	...
Depth	...	...	...	...	...	143	0	0

The upper, or Grâs-uchaf Pit, will be given later (p. 108). No distinct faults are known in the Gwendraeth Vein at Plâs-bâch, but a gentle syncline ranges in an easterly direction about 100 yards south of the middle shaft.

The workings on the Gwendraeth Vein at Plâs-bâch Colliery extend south-westwards as far as the dingle at Ynys-fawr, beyond which nothing is known of the coal for about 400 yards. But from a wood about 330 yards north-west of Fforest the outcrop is continuously traceable to Fforest-fâch, 800 yards west of Fforest. Between this and the workings at Plâs-bâch there must be an easterly downthrow. Evidence of such a fault is obtained north of the river also (p. 100), and to the south as far as Ty-canol at least. As it must pass close to Fforest it may be referred to as the Fforest fault (*see also* pp. 110, 120).

Several fruitless attempts have been made to open up the coal along the outcrop mentioned above. In one of them, known as

Lambert's Colliery, 450 yards W.N.W. of Fforest, a slant was driven along the vein for about $7\frac{1}{2}$ chains and continued through the overlying measures for another $5\frac{1}{2}$ chains. It proved three riders, 10 inches, 2 feet, and 10 inches thick respectively, and ended, it was thought, within a short distance of the Brasslyd.

Two main folds were encountered in the coal, and a series of them in the beds above, their general tendency being to lean to the north and throw down the measures in that direction. The disturbed nature of the ground hereabouts is also evidenced by the shales exposed in a cutting about 50 yards south-west of the mouth of the slant, movement along bedding-planes being especially noticeable. The Gwendraeth Vein is said to have 3 inches of 'bast' on top, both hereabouts and at Plâs-bâch Colliery.

The Brasslyd also has been worked along an outcrop which runs for 300 yards at a distance of 60 to 110 yards south-east of the Gwendraeth workings. A trial-hole about 300 yards W.N.W. of Fforest proved the vein to be 4 feet thick with 3 inches of pyrites in the middle.

In the ground between the Gwendraeth-fawr and the Morlais Rivers which lies to the south and west of Fforest-fâch, the identification of the veins becomes a matter of the greatest difficulty on account of disturbances, of which, however, little beyond the existence is known. Of the few records of underground evidence now available the most notable is that of the adit known as the Fforest-fâch Level, described on p. 113, which probably passed through both the Brasslyd and Gwendraeth Veins. These veins have been mentioned in connection also with Mr. Hansard's and Berkenshaw's slants (pp. 103, 105). The second of Mr. Hansard's slants, that at Tre-gôch, was probably in the Gwendraeth Vein, though at first thought to be in the Grâs-uchaf. It followed the coal from the outcrop at a dip of 14° or less, at first through old workings. At 150 yards an old adit-shaft on the coal, 32 yards deep, was passed, and untouched ground was proved for about 50 yards to the deep. The coal, however, was rolling, and varied in thickness from $1\frac{1}{2}$ to 6 feet, and at 200 yards from the entrance was lost at a fault and never regained, though the drift was continued for another 180 yards through some thin coals. One of these, which was followed for a few yards, consisted of two parts, each $1\frac{1}{2}$ feet thick, separated by $2\frac{1}{2}$ feet of stone.

In reference to this neighbourhood, Logan noted that "there is a fault throwing down to the east 10 fathoms near Tre-gôch. It was met with in the 4 feet Vein above the Fawr. Between the Fawr and the 4 feet there is a small vein of 1 ft. 6 in. at the place (Bowen). This is between Syddyn Mawr¹ and Gelli-rhwyth." The fault referred to is shewn on the Old Series map as running in a N.N.W. direction near Tre-gôch, but nothing is now known of it (cf. p. 104).

¹ 'Syddyn-melyn' on the New Series map.

Near Syddyn-melyn two trial-holes were sunk by Mr. Hansard, one of which, 70 yards north of the house, traversed seven yards of boulder-clay and 23 yards of measures, including one or two thin coals.

The next group of veins includes the Grâs-uchaf and -isaf, of which only the upper is known with certainty, the Stanllyd, with which the Hwch is generally supposed to have united, and the Ddugaled. The Grâs-uchaf was worked to the deep for about 130 yards by a slant at the old Woodbridge Colliery, 250 yards from the Carmarthen road at Pont-Yates along the Ynys-hafren lane; its outcrop follows the lane as far as the village. Judged by the distance of this outcrop from the old Caepontbren Colliery (p. 105), and the data afforded by the shaft through the Brasslyd, the vein must lie about 35 yards above the Brasslyd.

The Stanllyd was formerly in great demand at Pont-Yates in the form of culm, into which practically the whole vein, in places 12-15 feet thick, had passed. It was dug in almost continuous open trenches from about 200 yards east of the Rhwyth Inn in a south-westerly direction past Plâs-bâch Colliery to Plâs-bâch farm. The Ddugaled is not known with certainty at Pont-Yates, though it is believed by some to be the vein now being worked under the name of the Green at Caepontbren Colliery, 450 yards east of the Rhwyth Inn, and, in fact, the latter vein has been recently found, in an exploration at Plâs-bâch (p. 109), to lie next above the Stanllyd. But it is doubtful whether the Ddugaled exists as a workable seam south of Pontyberem, whereas the Green Vein persists. Moreover, the outcrop of the Green Vein trends in the direction of the Caepontbren vein. If the two are the same, a vein which has been exposed in chance excavations near the school, a short distance south-west of Caepontbren Colliery, may be the Ddugaled.

At Plâs-bâch Colliery the old workings, including three shafts, appear to have proved the greater part of the measures between the Stanllyd and Pumpquart Veins, but few details have been preserved, and of these the accounts are conflicting. Sections of two of the shafts have been given on p. 106. The third shaft, known as the Upper or Grâs-uchaf Pit, according to Mr. Harry of Pont-Henry, and the foreman, Mr. Lloyd, reached the Stanllyd at 12 yards and the Grâs-uchaf at 37 yards depth, while a vein thought to be the Grâs-isaf may have been touched below. But the existence of the Grâs-isaf Vein is uncertain, though it is said to average 2½ feet in thickness and to crop out in the gravel at the Middle Pit, where in fact it would be expected. The Brasslyd would thus be 45 yards below the Grâs-isaf and 55 yards below the Grâs-uchaf Vein, a figure which considerably exceeds that obtaining at Caepontbren and Pontyberem. The distance from the Grâs-uchaf to the Stanllyd is also greater at Plâs-bâch than at Pontyberem.

The measures above the Stanllyd have been proved in a recent exploratory drift, for the information concerning which, and for

facilities for examining it, we are indebted to the manager, Mr. D. Meredith. The drift started in the Stanlyd, and was driven in a south-easterly direction for about 150 yards, where it was abandoned. It was found that the Stanlyd, with a southerly dip of 17° , was followed by dark shale, 4 feet thick, with scattered balls of ironstone; similar shales in the tip, said by the manager to come from the roof of the coal, yielded with some plants an abundance of badly-preserved *Anthracomya?*, *Carbonicola sp.*, and *Posidoniella?* These will be referred to later, but we may note that the association of the marine form *Posidoniella* with *Carbonicola* is unusual and requires confirmation. The shale passes up into fine-grained, micaceous sandstone with little shale, 80-90 feet thick, which doubtless represents the Hwch rock (p. 97) of higher parts of the valley. In this sandstone the drift passed through a syncline, followed southward with no visible fault by an anticline, the middle limb dipping N. 15 W. vertically. In the southern limb of the anticline and at about seven yards from the crest Vein A, dipping at about 30° , was passed through, and higher still, Veins B and C were reached before work was abandoned. Vein A was about 3 feet thick, in two coals separated by 5 inches of rashing, but died out above when followed, nor did it take its place in the syncline, presumably in consequence of some small faulting. Veins A and B were separated by about 20 feet of sound ground. Vein B is 2-3 feet thick, and has been proved toward the deep for a short distance, continuing uniform and undisturbed. It is followed by disturbed ground, and Vein C consists in the drift of 7 feet of mixed coal and shale, but becomes 21 inches of coal at about 30 yards distance to the deep. The downward sequence therefore appears to be:—

Cross-measure drift, Plâs-bâch Colliery.

	Thickness.		
	Yds.	Ft.	Ins.
Vein C	variable		
Measures, disturbed, said to be	12	0	0
Vein B	2 feet to	1	0 0
Measures	7	0	0
Vein A, with a parting 5 inches,	1	0	0
Measures, chiefly sandstone	32	0	0
Stanlyd Vein.			

The identification of these veins is difficult. Vein A is regarded with some confidence by the late manager of Caepontbren Colliery and others as being the "Green" Vein of that colliery. This he believes to be the Ddugaled, but, as we shall see (p. 116), its correlation with the Green Vein is probably correct. Its distance above the Stanlyd (+ Hwch) at Plâs-bâch is about 32 yards, while at Pontyberem the Green Vein must lie about 42 yards above the Hwch, assuming it to occupy its usual position of 24 yards above the Ddugaled. The Plâs-bâch vein therefore occurs at an intermediate distance. If, as Mr. Meredith believes, Vein A is the Green Vein, the Ddugaled Vein has either coalesced with the Stanlyd, as he is

inclined to think, or disappeared entirely, for its place is occupied by a continuous mass of sandstone. As to the Big Vein for which the drift was in search, it may be represented by Vein C as supposed by Mr. Meredith, or by Vein B, which appears to be the more likely. In any case it appears to have been unworkable, and the absence of a vein comparable with the 'Big' Vein of Carway Colliery proved.

Of the disturbances proved at Pläs-bâch, those in the lower veins are mentioned on pp. 102, 106, and the only noteworthy point about the upper is the character of the Stanlyd Vein. It combines with a variability in thickness (average $4\frac{1}{2}$ feet, but sometimes wanting) such a friable condition that it is not worth working. Almost any fragment crumbles to dust, or "culm," when merely squeezed in the hand. At the same time the roof, of hard shale or mudstone, has been polished and faintly slickensided along one clean-cut plane, which is either in contact with the coal or separated from it merely by some "clod" or 'pugged up' shale. This plane is so even that it affords a good roof for considerable areas, while it reflects light like a mirror.

The 'washing-out' movement thus evidenced was found in one case to have taken place in a direction E. 5° N.-W. 5° S. It would account for the friability of the coal, though the frequency of this character in the Stanlyd suggests some original peculiarity in the seam itself. More irregular movements have, in addition, affected both the Gräs-uchaf and Stanlyd Veins.

South-west of Pläs-bâch these veins may be traced by crop-workings as far as the dingle at Ynys-fawr where they are cut by the Fforest Fault (p. 106). Beyond this fault they are almost unknown under these names, but are probably represented by the so-called Green and Big Veins as will be shown.

The Gräs-uchaf is said to have been cropped 180 yards N.W. of Fforest, at 100 yards from the crop of the Brasslyd Vein (p. 107), an unusual distance which may be due to disturbance. At Fforest, at an unknown height above the Gräs-uchaf, the 'Big' Vein of Carway Colliery is first evidenced. Thence it ranges south-westward to a point a quarter of a mile S.E. of Tre-gôch. All along this range it was worked near the out-crop, and, in Carway Colliery, to a great extent to the deep, also. Little is known about the seam in the crop-workings, except that towards the south-western end it is said to have reached a thickness of 18 yards in places but to have been soft, thus resembling the Stanlyd at Pläs-bâch. In the colliery¹ it is generally 9 feet thick, in three coals according to some accounts; the roof, which is generally good, consists of grey mudstone with balls of ironstone and abundant plant-remains, overlain by sandstone. The dip, averaging 14° along the slant, is fairly steady down to a point about 300 yards south-east of Carway farm, and

¹ For most of the information relating to Carway Colliery and for facilities for examining it we are indebted to the present and late managers, Messrs. F. Llewellyn Jacob, Meachem, and Lewis.

the coal sound except for a few faulty tracts, or 'wash-outs,' ranging in the direction of level-course. Over these 'wash-outs' there is evidence of overthrusting along the bedding. It has been found also that within them the coal varies considerably in thickness, up to 32 feet, and is soft in part; it is crossed by gently dipping planes, called 'flats,' which often include a 'clod' or shale torn from the roof or floor of the seam, while a gently rolling dip, or a polishing of the lower surface of the roof also points to inequality of movement. It was found during the former working of the colliery that, near the bottom of the slant, the vein flattened and then rose sharply for 8 or 9 yards to a fault at 820 yards from the mouth, where it was lost. No particulars regarding the fault were ascertained, but there is reason to think that it must range approximately in the direction of level-course, and that it is likely to be an overthrust with the upthrow on the south.

The so-called Green Vein was also worked in the old colliery and yielded large coal. It lay about 38 yards below the 'Big,'¹ and was 3 feet 4 inches thick, with a 'criggling' (bast) 1½ inches thick, on top, and a strong bottom. It was worked under a small area near Carway farmhouse, and from the surface down to an old water-level on both sides of Pwll-y-baw, which stood about 500 yards west of the same house. In this neighbourhood, according to information given to Logan by Bowen, "on the Wirdd [Green] there is a saddle and the crop to the eastward appears twice," the fold extending "all the way from the Tycoch [or Tre-gôch] 10 fm. fault," referred to on p. 107. This "saddle" is probably the same as a 'leaf' (or repetition by overthrusting) which, according to local information, was proved in the 'Green' Vein in the old working above the water-level, extending for about 350 yards in the direction of level-course.

The Big Vein of Carway is generally regarded as being the same as the Big Vein of Pontyberem, but we with some others correlate it with the Stanllyd. Our evidence is given on the following pages (pp. 111-115).

The Big Vein of Pontyberem is not known in the immediate neighbourhood, but its overlying rock is exposed close by in the dingle south of Ynys-fawr (p. 117). In the eastern bank the rock is in line with the outcrop of the Carway Big Vein, a fact which doubtless partly led to the latter being identified with the Big Vein itself; but to the west, nearer Carway, it turns southward on account of a gentle fold, and is cut off by a westerly upthrow, the Fforest Fault. As a result of both the fold and fault it would pass to the south of the Carway Big, which, therefore, apparently occupies some lower horizon. What the exact horizon is now remains to be determined.

As previously mentioned, a vein, which is supposed to be the Grâs-uchaf, but lies at an unknown distance below the Big Vein, has been worked near Fforest. The distance appears to be so large as to invalidate the correlation of the 'Big' Vein with the

¹ Or 30 yards, according to Logan (p. 113).

Stanlyd, but this may be due to overthrusting. The supposed Gräs-uchaf Vein has not been worked for many years, but to the south-west a coal, occupying apparently the same horizon, has recently been opened up, which there is good reason to believe, from its distance above the Brasslyd and Gwendraeth Veins described on pp. 106-7, to be the Gräs-uchaf. The coal was found at a depth of 30 yards in re-opening an old shaft, 300 yards west-south-west of Fforest, where the ground below had been proved in Lambert's Colliery (p. 107), and it was also worked to a certain extent in a trial slant,¹ 500 yards west by south of Fforest and a short distance south of some crop-workings on it. In both the shaft and slant, however, it was identified, with good reason, with the 'Green' Vein of Carway Colliery. Its thickness was the same, and it had a similar 'criggling' on top. The fact that in the slant it lay 40 yards farther below the 'Big' Vein, which cropped out close by, than the 'Green' Vein lay in Carway Colliery, was explained when it was further found that it was separated from the 'Big' Vein, both by an overthrust, cutting it out at 125 yards down in the slant, and by much faulting beyond. But the vein in the slant and in the old shaft is known, in the one place, to lie so close to the Gwendraeth Vein and, in the other, to the measures, probably near the Brasslyd Vein, proved in Lambert's Colliery, that we further conclude that it, and consequently the vein worked as the 'Green' in Carway Colliery is the Gräs-uchaf Vein. Thus we see that the 'Big' of Carway holds a position corresponding to that of the Stanlyd in being the first noteworthy seam above the Gräs-uchaf.

Before leaving the trial-slant it should be added that it was driven south-south-westward for a total distance of 390 yards, about 100 of which lay under the crop of the 'Big' Vein; the latter was undisturbed but faults were encountered in the slant to the end. Several veins besides the 'Green' were proved, both near the mouth and beyond the overthrust which cut out the 'Green,' but were not identifiable. Two coals, separated by eight yards of mine-ground, and some coal with rashing were thought to be the two Gräs Veins and the Stanlyd. This would disprove our hypothesis that the 'Big' is the Stanlyd, but the measures were so disturbed that no continuous section could be constructed, and the identification was therefore unreliable. The overthrust was found, in workings on the 'Green' Vein, to have a wavy east-and-west course, but was not proved elsewhere.

Some evidence is afforded also by the old Fforest-fäch adit-level mentioned on p. 107, which was driven southwards from near the mouth of the Fforest-fäch stream to the water-level on the 'Green' Vein near Pwll-y-baw (p. 111), along a course which was pointed out to us by Mr. T. Edwards of Bryn-y-fforest. Logan in his MS. gives an account and a longitudinal section of the

¹ Our thanks are due to the late manager Mr. Jacob, for much help in this neighbourhood, and for information about the slant and other explorations made by the New Carway Colliery.

level, on which was based a section published in 'Vertical Sections,' Sheet 4, *Geol. Surv.* The following are the important points passed :—

Fforest-fâch Level.

From notes by Logan.

	Distance from mouth of level in feet.
Coal (Gwendraeth Vein) ; 2 ft. 3 in. to 2 ft. 11 in. Dip 12°	185
Measures ¹	
Coal (Brasslwyd or Bot-y-cy) ; sulphurous, 1 ft. 4 in. ...	300
Measures with a thin coal ¹ .	
Disturbed ground with some thin coals	500 to 613
Measures with some thin coals ; dip 18° to 45° in places	
Pit, with Lower Graces Vein, 3 ft. thick, at a height of 25 ft.	823
Measures. Dip near fault 40°	
Fault	860
Measures ¹	
Coal (Lower Graces Vein) ; 2 ft. 6 in. Dip 27°	910
Measures ¹	
Coal (supposed to be Upper Graces Vein), 2 ft. Dip 27° ...	1030
Measures partly disturbed and rolling	
Pit	1180
Measures, including a repetition of beds. Dip 16° to 30° in places	
" Pit, on the entrance to the wood. In it, about 7 fathoms up, is the Brasslid, 4 ft. thick "	1660
Measures with a thin coal. Dip 22° to 45° in places	
Fault, " an upthrow south "	1812
Measures ¹	
Coal (Little Vein), 6 ins. Dip 15°	1970
Measures ¹	
Coal (Braslid Vein), 1 ft. 4 ins. Dip. 18°. " A pit 18 fms. in which occurs the Cwar Mawr at 5 fms. up, 4 ft. ; the Dugaled at 3½ fms. more, 4 ft. thick."	2158
Measures, ¹ part faulted or dipping at 32°	
Coal (" supposed to be the Cwar Mawr, usually 4 ft. thick "), 9 ins. Dip 50°	2408
Measures	
Fault	2418
Measures. Dip in part 18°	
Coal (Cwar Mawr Vein), 2 ft. A pit 21 fathoms to the surface, in which occur the Wyrdd at 10½ fathoms depth and the Dugaled at 17½ fathoms depth	2638
Measures ¹	
Coal (Dugaled Vein), 2 ft. 2 in. A pit 23 fathoms to the surface, in which the Wyrdd is half-way down. Dip low ²	2961
Dugaled Vein sinks below the level at	3268
Dip here very low, becoming normal immediately to the south ²	
Measures ¹	
Coal (Wyrdd Vein), 3 ft. Dip 14° to 15°	3468
Measures	
" Pit in Carwed [Carway] field 24 fms. deep. From Wyrdd to Fawr is 15 fms. The ground between is chiefly shale with some balls and courses of mine." [Apparently by an oversight the distance is shewn on the MS. and published sections as 15 yards].	

¹ Further details are given in 'Vertical Sections,' Sheet 4, *Geol. Surv.*

² The level, between these points, passes beneath the saddle or 'leaf' in the 'Green' Vein, mentioned on p. 111.

Unfortunately none of the pits mentioned have been identified with certainty, and the course of the level itself towards the end is not known. The last pit, however, is probably one of two to the north-west of Waun-green, between the farm and the road. We cannot therefore fix precisely the positions of the coals below the "Fawr" and "Wyrdd" (the 'Big' and 'Green'), but we may gain, nevertheless, some evidence bearing on the correlation of these two seams. Logan correlated the "Cwar Mawr" and "Braslid" of Fforest-fâch with the Hwch and Stanllyd of Pontyberem, but even in the light of this knowledge the published section cannot be brought into line either with the outcrops at Fforest-fâch or the development at Pont-Yates. In a note on that section he remarks himself that the distance from the Fawr to the Gwendraeth Vein appears to be too small, and that the ground is much disturbed. There is reason, also, to believe that the Gwendraeth Vein is really represented by one of the higher veins of his section, which would diminish the already meagre distance between that vein and the Big. The Gwendraeth and "Brasslyd" (Brasslyd) Veins near the mouth of the level must be, either one or both, wrongly identified.

The "Upper Graces," as proved in the level, falls into line with the crop of the Gwendraeth Vein (p. 106), and probably is that vein. If so, the next vein, called by Logan the "Braslid," may be the Brasslyd, though the disturbed condition of the intervening strata introduces uncertainty as to the distance between the two. On this hypothesis the "Cwar Mawr" and "Dugaled" should represent the Grâs-isaf and Grâs-uchaf, which indeed they resemble in their distance apart and in being separated by mine-ground. They appear to lie 10 yards above the supposed Brasslyd as compared with 25-30 yards at Pont-Yates. The Grâs-uchaf should be followed by the Stanllyd Vein, but according to Logan is followed by the "Wyrdd" and "Fawr," *i.e.*, by the Carway 'Green' and 'Big' Veins. The "Wyrdd" in no respect resembles the Stanllyd, but is generally admitted to be either the Green or the Grâs-uchaf of Pont-Yates.

If the "Wyrdd" is the Green Vein, we have to suppose the existence of a southerly downthrow cutting out a considerable thickness of strata between it and the "Dugaled" of the level, of which there is no evidence in the adjacent ground. If on the other hand it is the Grâs-uchaf, the "Dugaled" of the level, we have merely to admit repetition by overthrusting, a structure which is prevalent in the region, and of the existence of which at this spot we have evidence in the "leaf" proved in the 'Green' Vein above the level. Assuming then that the "Wyrdd" is the Grâs-uchaf, we find that the "Fawr," or Carway 'Big' Vein, above it, corresponds fairly well in position with the Stanllyd.

Before leaving the subject of the level it should be added that the coals proved in it have been worked close by from many old

¹ "Cwarmwr" appears as a synonym for Stanllyd on a MS. map made by Messrs. Maxby in 1839, which is preserved among the Logan MSS.

shafts, but that no reliable local information about these workings is now obtainable. The following notes are extracted from Logan's note-book :—

“Near Tycoch there is a leaf in the Lower Graces not far from the 10 fathom fault (Bowen).” Logan shows the “leaf” in a diagram and states that the width of the overlap is 50 yards and the vertical distance between the overlapping edges, as proved in a shaft, is 8 yards. The fault is mentioned on p. 107.

“In the Fforest-fawr wood [south of Fforest-fach; Old Series sheet 37] there is a pit called the canal pit in which a dip-hole was driven down 120 fathoms. The coal was between 2 faults; it was 12 feet wide and 8 feet high. The roof and floor had reverse bends and all the coal was worked out. . . . It was in the Stanllid Vein which is there called the Brassllid.”

A detailed comparison of the strata of Carway with those of Pont-Yates is difficult, and so far as it goes throws little further light on the correlation of the seams. The ‘crigging,’ which is the most characteristic feature of the Carway ‘Green’ Vein, is not known in either the Green or the Grâs-uchaf Vein higher up the valley. The distance between the ‘Green’ and ‘Big’ at Carway (30 yards or 38 yards according to Logan and Mr. Jacob respectively) is greater than that between either the Grâs-uchaf and Stanllyd or the true Green and Big Veins. On this account it has been suggested that the Carway ‘Green’ may correspond to the Pontyberem Ddugaled, which lies at a greater distance from the Big, and in support of this it is said that in the old Carway Colliery a good coal, 1½ feet thick, was proved between the ‘Big’ and the ‘Green,’ which may have been the true Green Vein. But we have already found reason for believing that the Ddugaled has no separate existence close by, at Plâs-bâch (pp. 109-10).

The ‘Big’ Vein at Carway has a constant thickness of about 9 feet where undisturbed, but the true Big Vein has no such thickness this side of Pontyberem. At Plâs-bâch it is either unknown or represented by a thin coal (p. 110). On the other hand the Stanllyd, while it agrees with the ‘Big’ in thickness and composition,¹ differs from it in character, in respect of its comparative softness. Near Pont-Yates the softness is attributable to movement, but it is not known to what extent this is the case higher up the valley.

The Stanllyd, the true Big Vein and the Carway ‘Big’ Vein are alike in being overlain in places by thick sandstone. The actual roofs of the coals differ but slightly from one another; that of the Stanllyd is generally bad. At Plâs-bâch it consists of dark shale with numerous shells (*Anthracomya?* and *Carbonicola*) together with plants, whereas that of the Carway ‘Big’ is a light-grey shale with many plants, but devoid of shells. Finally, there is evidence (p. 117) that the true Green Vein is present at Carway, but above, not below, the so-called Big Vein.

¹ For an analysis of the Stanllyd see ‘The Coals of South Wales’ (*Mem. Geol. Surv.*), 1908, pp. 14, 15, No. 10 [under Big Vein]; for an analysis of the Carway ‘Big’ Vein, *ib.*, pp. 24, 25, No. 178.

The next group of veins, the true Green (or Wyrdd) Vein and the Big (or Fawr) Vein have been worked by small slants or shafts from Pont-Henry to Ynys-Hafren, the distance between them in two of the shafts being said to be 14 and 20 yards respectively. An adit to the Green Vein emptied at a point 200 yards south-west of Ynys-Hafren farm, and probably all the vein which lay above the level of the adit was taken out, though, apparently, there were no workings to the deep. Logan has made the following note on these veins:—

“The Wurd [Wyrdd] Vein has the best coal at Penyderw [p. 99] and Ynys-Hafren, and Caepontbren [6-inch map: 250 yards south-west of Ynys-Hafren]. It is there 4 feet thick with a good top and works well. In Mr. Wrey's Colliery at Ynys-Hafren the Great Vein is only 2 feet thick.” Another record of the Green Vein at Ynys-Hafren, for which we are indebted to Mr. T. Jones, of the Stepney Estate Office, shows 2 feet of coal with ‘bluestone’ above and fireclay below. A rock said to occur above this coal is exposed in the road at Ynys-Hafren. Locally the Big Vein is said to be only 20 inches thick and it is certainly less valuable than the Green Vein. As we shall see it thins away still more to the south-west, showing that the thinning which sets in this side of Pontyberem is, largely at least, due to conditions of deposit and not to subsequent disturbances.

Several faults, all belonging to the north-north-westerly set, were proved in the water-level in the Green Vein, according to information supplied by the late Mr. Griffiths, of Pont-Henry. Several easterly downthrows of a few feet were passed through north of Ynys-Hafren, and in the dingle immediately south of the farm the Pont-Henry fault (p. 95) was crossed. Its proximity is indicated also by steep easterly dips in an old shaft 50 yards south of the farmhouse and elsewhere. The throw of the actual fault is unknown but is less than the 60 yards recorded at Pont-Henry. The horizontal shift in steeply-dipping beds appears to have amounted to 15 yards at Ynys-Hafren.

South of Ynys-Hafren the outcrop of the Big Vein is lost for some distance. That of the Green Vein is traceable along old workings past Caepontbren in the direction of the present Caepontbren slant at Pont-Yates, but is lost before reaching that place. The vein which is there being worked is said by some to be the Ddugaed, but as that vein is not known elsewhere S.W. of Pont-Henry where it appears to be unworkable (p. 97), the generally-accepted view that it is the Green Vein is probably correct. The following section was communicated by the manager:—

Green Vein, Caepontbren Colliery.

						Ft.	In.
Clift (thickness proved)	...	...	...	...	...	4	0
Fine grained sandstone, 18 inches to	...	...	...	...	...	2	0
Clift, making a good roof	...	...	...	...	...	2	6
Green Vein	{	Coal	...	...	...	2	8
		Shale and Clod	...	...	...	1	8
		Coal
Underelay.							

An air-pit, 100 yards E.S.E. from the mouth of the slant was sunk 43 yards to the Green Vein and passed through the Big Vein. The workings in the Green Vein showed frequent small disturbances, but no large faults, in 1904. An east-and-west belt of disturbance beneath the Carmarthen road may be continuous with one in the Gwendraeth Vein to the west (p. 106); 200 yards south-east of the slant there is an easterly downthrow of 20 feet.

The Big Vein is said to have been seen in the road south of the slant and to have been cropped in a garden immediately to the south again, but here evidence of its existence as a workable seam ceases. About 200 yards south of the Caepontbren slant a coal has been worked, said to be one of the Felen Veins apparently because fireclay as well as coal has been obtained. The value of the coal, however, as evidenced by the extent of the workings along its outcrop to the south-west, and its position relative to the Big Vein rock, show that it is probably the Green Vein. This is supported by a note of Logan's, that one of the shafts reached the Green Vein at 4 fathoms. South-westwards, in the dingle east of Plâs-bâch, the crop lies about 90 yards west of a group of sandstones which probably constitute the Big Vein rock. That rock has been more positively recognised, by local miners, in a quarry in the next dingle, about 400 yards east by south of Ynys-fawr. A thickness of about 15 feet of hard fine-grained sandstone is shewn, but the Big Vein is either thin or absent. The position of the supposed Green Vein, as given by crop-holes, lies 15 yards below the rock. It must be added, however, that these measures are not recognisable in the sequence above the Stanllyd Vein, as proved close by from Plâs-bâch Colliery (p. 109).

Further to the south-west the supposed Green Vein, as was the case with the Big Vein, becomes less important, but the horizon can be traced, by help of an exposure of the Big Vein rock at a waterfall 300 yards north-east of Fforest, as far as some old workings nearer the farm. Hereabouts, however, the outcrops trend more nearly southwards and run into the Fforest fault (p. 106). The vein in consequence should reappear beyond the fault to the south of its former course, and hence is probably to be identified in a vein which has been got in a number of shafts south of Fforest, above the Carway 'Big' Vein. Again, at Waun-green and Dyffryn there is a coal in about the same position, which has, however, been called the Felen, but the existence of that vein south-west of Ynys-Hafren is questionable (p. 118). The veins above the 'Big' at Tre-gôch, referred to by Logan (p. 107), are no longer known.

Of the Felen or Yellow Veins, the Upper Felen has been worked near Ynys-Hafren, but the material in most demand was the fireclay.

The following particulars have been communicated by Mr. T. Jones, of the Stepney Estate Office :—

Upper Felen Vein at Ynys-Hafren.

									Thickness.	
									Ft.	In
Rock ...	...	...	...	...	...	...	...	...	4	0
Cliff ...	...	...	...	...	...	...	...	...	4	0
Coal (Upper Felen Vein)	...	...	...	...	...	...	...	...	1	8
Fireclay	...	...	...	...	...	...	...	...	3	0
Shale...	...	...	...	...	...	...	...	...		6
Rock.										

The clay was worked, chiefly in cross-measure drifts, about the northern or Afon-Hafren dingle at Ynys-Hafren. To the south-west the coals have not been definitely recognised anywhere except in the instance recorded by Logan¹ thus: "The crop of the Felen crosses the road from Ty'n-y-cwm to Plâs-bâch on a line 250° [E. 20° N.] from Forest Fawr." This spot would lie some distance above the crop of the Green Vein, and may well mark the outcrop of the Felen.

The measures above the Felen Veins, as exposed in several old quarries or elsewhere along the northern dingle at Ynys-Hafren, include some fine-grained sandstones and dip rather irregularly.

Several veins, such as the Gelly-fâch and Gelly-fawr Veins², and the Purple Vein³ (p. 99) have been recorded between the Felen and Carway Veins, but are thin or non-existent.

The Carway Veins are not easily traced at the surface from Port-Henry southwards on account of disturbances and the general absence of crop-workings. At Ffou and elsewhere the upper vein, the Carway-fawr, is said to consist of two coals separated by a parting. The disturbances, which were proved from the Ffou Colliery slant in the Carway-fawr Vein, consist both of small faults ranging W.N.W. and of a complete fold (syncline and anticline) ranging N.N.E. The faults lie a short distance south of the Ffou valley, and the middle limb of the fold crosses the slant 200 yards from its mouth. Southwards, where clear of these disturbances, the crop of the upper vein is distinct as far as the dingle⁴ near Dan-y-banc, and two shafts, 170 yards E. by N. and 100 yards S.W. of the bridge at the farm, are said to have reached the Carway-fawr at 60 and 28 yards respectively. The lower vein, the Carway-fâch, which is much less valuable, has been worked near Ffou, where it lies about 15 to 22 yards below the upper. A sandstone, 25 feet thick and indistinguishable from fine-grained Pennant, occurs a little above the upper coal and is quarried at Dan-y-banc bridge. Other details of

¹ Logan MS. notebook.

² Fairley, *op. cit.*, diagram No. 28; 'Vertical Sections,' Sheet 59 (*Geol. Surv.*).

³ Logan, quoting Messrs. Martin, Daniell and Bowen, in an MS. notebook.

⁴ "Cwm-cobbler" of the Old Series Ordnance Map, Sheet 41.

the measures above the Carway-fâch Vein were obtained here and published by Logan in 'Vertical Sections,' Sheet 3, *Geol. Survey*.

The Carway-fawr is visible in a lane S.W. of Dan-y-banc, and in the dingle beyond the overlying sandstone is exposed. Near here the Gelli-gelynog slant¹ of the Gwendraeth Anthracite Collieries Company has been driven on the Carway-fâch Vein for a short distance and then, after drifting 'cross-measure,' on the Carway-fawr; both veins had been worked near the crops. The upper, dipping south-east, at first at 9 inches to the yard (14°), becomes horizontal at 330 yards from the mouth, but shortly resumes its normal dip, the inclination at half a mile from the mouth being 12 inches to the yard (18°). At 400 yards from the mouth a 'wash-out' was traversed in which the coal varied in thickness, was crushed and mixed with other material, while the roof shewed the usual polishing. Like the other 'wash-outs' described on pp. 110 and 111, the structure was clearly due to movement along the bedding, and the direction of the slickensides shewed the movement to have been north-westerly or north-north-westerly and nearly at right angles to the northern limit of the 'wash-out.'

An air-hole, 210 yards E. 30° S. from the mouth of the slant, proved the following sequence:—

Air-shaft near Gelli-gelynog.

	Thickness.		
	Yds.	Ft.	In.
Soil; boulder-clay, 3 yards; and measures	13	0	0
Clift and rock	21	0	0
Coal		1	1
Fireclay, with balls of mine in lower part	2	2	6
Rock [probably the Dan-y-banc sandstone]	6	0	3
Clift, with some pins of mine	17	0	11
Carway-fawr Vein	1	0	6
Rashings		2	3
	62	1	6

The vein is said to have a good clift roof, and its floor is apparently a thick fireclay in places.

In the western part of the workings some faults range northwards, about 700 yards east of Carway farmhouse. Those of which the throw has been proved are trifling easterly downthrows of 5 yards or so, but these are probably merely offshoots of an easterly downthrow of about 50 yards, the presence of which in the neighbourhood is evidenced by the fact that the Carway-fawr Vein, at a depth of 60 yards in the colliery, lies only 150 yards from its outcrop further west, almost in the direction of level course. The fault was not met in working the Gwendraeth Vein in Plâs-bâch Colliery to the north, and its direction is a matter of doubt, but it seems likely that the

¹ For information about this colliery we are indebted to the manager, Mr. D. Meredith.

greatest disturbance ranges north-west along the dingle which passes east of Fforest to Ynys-fawr. For in that direction it would pass for some distance along a line where the workings, both at the surface and to the deep, on the so-called Big Vein from Carway Colliery came to an end, and would then fall into line with the Fforest Fault already described (pp. 106, 110, 117). Southward it possibly runs west of Ty-canol to meet the Trim-saran disturbance.

West of the fault the outcrop of the Carway-fawr mentioned above, which lies 600 yards east of Carway farm, continues to a spot about 700 yards south-by-east of the farm. Old surface-workings on it are almost continuous, and hereabouts the lower vein with a thickness of 2 feet is said to have been got at several places. The two veins then turn abruptly and the upper runs rather north of east for about 300 yards, the dip of some overlying sandstone being seen in one place to be northerly at 75° . At the end of the continuous crop-workings which bear witness to this part of its course small scattered shafts have proved that it turns abruptly to a course a little west of south for nearly 250 yards with a greatly reduced dip. It then disappears beneath boulder-clay, under the edge of which, 300 yards north-east of Allt-ysgrâch (6-inch map), it has been won by the more recent shafts. This complete fold in the Carway Veins which is mentioned in the Logan MS. and shown on the Old Series map, sheet 37, brings the Carway outcrops to within such a short distance of the Llynfi Rock, east of Ty-canol, as to point to the existence of a considerable easterly downthrow in the intervening ground.

It is difficult to see where this fault can run except below a tongue of boulder-clay which ranges northwards about 150 yards west of Ty-canol. That this is the course taken is confirmed by the fact that it also forms the only possible continuation of the Fforest Fault mentioned above. South of Ty-canol the ground is unproved and drift-covered as far as the Trimsaran disturbance; the position thereabouts of neither the Carway Veins nor the fault is known.

Above the Carway Veins the Lower Coal Series is practically barren in the Pont-Yates district. The measures are most completely exposed in the Ffou valley which for about a quarter of a mile above Ffou Colliery traverses shales with some fine-grained sandstones rolling gently in all directions. About 600 yards above the colliery another thin coal, the Cwm-cobbler or William Edmond's Little Vein, crops out in the valley, and though worked for but a short distance to the north, near Cwmgelwr, may be traced to the south-west for nearly a mile. It is said to be 15-18 inches thick and impure, having been chiefly used for lime-burning. A shaft, 400 yards N.W. of Ty-gwyn, which was about 35 yards deep, worked a considerable area of the coal.

Others, all disused, lead from the Ffou valley across Cwmcobbler to Herber-dêg, and the coal is visible about 250 yards

east of Dan-y-banc. A section along Cwm-cobbler between a higher vein and the Carway-fâch has been published by Logan in 'Vertical Sections,' Sheet 3, *Geol. Surv.* About 550 yards south of Dan-y-banc all traces of the coal cease.

The 'cockshot-rock,' described on p. 91, recurs at approximately one horizon above the coal. It forms a waterfall, 350 yards west of Ffynnon-y-menyn, and two waterfalls in the Ffou valley, N.N.E. of Ty-gwyn. It is exposed to a thickness of about 20 to 25 feet and consists of very hard fine-grained quartzite. It crops again past Herber-dêg, and there lies about 650 feet vertically above the Carway-fawr Vein in the Gelliglynog slant (Gwendraeth Colliery).

It is separated from the sandstones which constitute the upper part of the Lower Coal Series (the Cenrhos, Tormynydd or Llynfi Rock) by sandy shales with thin sandstones and small coal-seams of no value, worked slightly at Ffynnon-y-menyn and Ty-canol. The thickness of these intervening measures amounts to 140 or 150 yards according to calculations made at Ffynnon-y-menyn and Dan-y-quarry, but to only 95 yards by measurements made in the Ffou valley.

The sandstones above form two bands giving rise to ridges. The lower passes into shales south-west of Ffynnon-y-menyn, whereas the upper is more persistent. What appears to be the lower band reappears, however, at a quarry in the head of the Ffou valley, and passing Dan-y-quarry, forms a bold, unbroken feature. The total thickness of sandstones at Ffynnon-y-menyn is about 80 yards as compared with about 117 yards near the Ffou valley and there is little doubt that shales and sandstones replace one another, so that the thickness of each varies, though the aggregate is fairly constant.

To the sandstones succeed about 40 yards of shales which cover a considerable area about Cynheidre, Brondini and Ty-mawr. These are followed by the Pennant Series.

CHAPTER X.

CARBONIFEROUS ROCKS.

COAL MEASURES (LOWER COAL SERIES)—*continued.*

SOUTH OF THE TRIMSARAN FAULT.

The Trimsaran and Llandry area is more or less isolated and we may commence by ascertaining the sequence within it. The Farewell Rock of Talcarn (p. 85) is succeeded by about 25 yards of shales, which are exposed on the north side of the Morlais at Moat. The Rhâs-fâch Vein is said to have been proved about 10 yards west of the bridge, and, close above, some ironstone has been worked. The coal, according to Logan, was 15 inches thick and lay 220 feet below the "Gwendraeth Vein," or what we now identify as the Pumpquart Vein.

The Low Vein underlies sandstone which has been quarried 300 yards E.N.E. of Moat. According to Logan the sandstone is 12 feet thick and the vein is "five fathoms below the Gwendraeth [Pumpquart] Vein and its common thickness is 2 feet. In the quarry it was 10 feet thick." In another quarry near Moat what may be the same vein underlies a similar sandstone, and it appears to have been got, again beneath sandstone, in a slant 250 yards S.S.W. of the farm.

A vein, locally known as the Pumpquart Vein, has been reached at 12 yards depth 170 yards N.E. of Cil-rhedyn Bridge, where it is 3 feet 3 inches thick and is overlain by three pins of mine. Though referred to by Logan as the Gwendraeth Vein, the coal is doubtless the Pumpquart, on account of both its character and its position as regards the Rhâs-fâch and Low Veins. The same vein probably has been worked under the name of Cwt-y-ci or Bwt-y-ci¹ in a copse S.W. of the bridge.

This vein has also been worked to the deep in the long-abandoned Cil-rhedyn colliery. It is reported to have been got in the Llandry pit, which lies 170 yards east of Cil-rhedyn Bridge, but little would be known of this working were it not for some MS. notes by Logan, and for evidence brought to light in the course of a recent attempt to reopen the ground under the name of the Llandry Colliery by Mr. Samborne.²

As regards the workings on the Pumpquart and adjacent veins, Logan says : "The lower work [of the colliery] was on the Gwendraeth [Pumpquart] Vein. The engine pit [Llandry Pit] was 24 fathoms to the vein. A drift was cut across the measures 600 yards to the southward. It stopped 10 to 12 yards

¹ Near Pont-Yates this name has been applied to the Brasslyd Vein.

² For this evidence we are indebted to Mr. T. Arnold.

southward of the 4 feet Vein. Coal was worked in the lower work for one year . . ." The vein called by Logan the Gwendraeth is evidently the Pumpquart as before. On this and other notes he constructed the section of the measures between the "Gwendraeth" and "Upper Graces" Veins which appeared in 'Vertical Sections,' Sheet 1, *Geol. Surv.* He estimated the distance of the "Gwendraeth" above the Low Vein to be 19 yards, from the evidence of "a cross-drift from the Gwendraeth northward of 120 feet," to the Low.

The sequence proved by the drift or level to the southward commences with shale below the vein called by Logan the Hwch. His record, summarised, follows:—

Cil-rhedyn Level.

	Distance from mouth of level in feet.
Measures partly walled; dips 24°, 35°.	
Hwch Vein (three coals, sometimes running together, sulphurous); dip 65°, 50°	140
Measures; dip 50°.	
"Fault, throwing a coal forward in the level"	191
Measures, dip 50°, 62°, 34°.	
Lower Graces Vein (three coals); dip 28°	348
Measures; dip 60°, 46°.	
Upper Graces Vein (two coals); dip 40°	524
Measures; dip 40°. No information beyond	600

The only information available about the nature of the coals in the level is afforded by the same record:—

Section of the 'Hwch' [Gwendraeth] Vein in Cil-rhedyn Level.

	Thickness.	
	Ft.	In.
Coal	1	0
Underclay	1	6
Coal; sometimes 1 inch and sometimes 15 feet	4	0
Underclay	14	0
Coal	1	4

Section of the 'Lower Graces' [Brasslyd] Vein in Cil-rhedyn Level.

	Thickness.	
	Ft.	In.
Coal	1	0
Coal	1	6
Coal ... ..	...	9
Rubbish ... ..	...	4
	3	7

Section of the 'Upper Graces' [Grás-isaf] Vein in Cil-rhedyn Level.

	Thickness.	
	Ft.	In.
Coal	1	3
Rubbish ... ..	...	3
Coal	2	0
	3	6

In the following table are given the relative distances of the veins, as determined by Logan, and our suggested correlation :—

<i>Cil-rhedyn.</i>	<i>Pont Yates.</i>
Upper Graces Vein 42 yards.	Grâs-isaf Vein 28 yards.
Lower Graces Vein 49 yards.	Brasslyd Vein 30 yards.
Hwch Vein 52 yards.	Gwendraeth Vein 76 yards.
Gwendraeth Vein 19 yards.	Pumpquart Vein 18 yards.
Low Vein.	Low Vein.

It is important to note that the Cil-rhedyn veins, while they were being worked, were compared with the coal-measures as developed at Pont-Yates, and not with those of Trimsaran. Logan notes that a downthrow east, of five yards, called the East Bar, was met 100 yards east of the Cil-rhedyn pit, and that a north-and-south fault with a downthrow east of 4 fathoms caused a "leaf" in the "Gwendraeth" Vein. The latter fault, he says, is exposed in the Cil-rhedyn bridge quarry.

By the Llandyry Colliery (p. 122) the old level was found to be 320 yards long. Beyond the ground described by Logan, it traversed what appears to have been an overfold leaning to the north, and having the effect of a southerly upthrow. Further on it proved three coals; the thickest, at 864 feet from the mouth, being 4 feet thick, with a roof of hard clift according to Mr. R. Thomas. This was correlated, with some doubt, with the Grâs-uchaf. The coals described by Logan received the same names as their probable equivalents at Pont-Yates, suggested in the table above.

The ground to the south of the old level was explored by a slant which was opened 100 yards north-west of Cil-rhedyn farm and driven in a direction S. 12° E. to Wern, a distance of 550 yards. Starting at 9 inches in the yard it passed at 50 yards through old workings in the Brasslyd of the table given above. At 140 yards it flattened to 3 inches in the yard, and cut the supposed Grâs-uchaf at 500 yards. This was worked and found to dip on the average at 8° in a direction S. 38° E., but to be disturbed by rolls which increased in places to sharp overfolds leaning to the north. Working to the deep was soon stopped by a fault, the throw of which was not determined, but which, in view of the nature of the neighbouring folds, is likely to bring in lower beds to the south. The slant cut the so-called Grâs-uchaf at a depth of 65 yards from the surface about 100 yards west of Wern; it immediately encountered the fault and was stopped 33 yards beyond.

The Gwendraeth Vein is said to crop under the smoke-stack of the Llandyry Colliery, and a sink, 140 yards north-west of Cil-rhedyn, marks the position of old workings in it above the level. The Brasslyd crops out, above the level, about 65 yards

to the south-south-east, and the Grâs-isaf probably about 55 yards beyond. The Grâs-uchaf does not appear, which may be accounted for by the southerly upthrow, south of Logan's section, mentioned above. To the south-west some of the veins should come to the surface near Llandry House, where in fact coals are in evidence in a brook south of the house and in old crop-workings. One, 110 yards south of the house, is mentioned by Logan as "supposed to be one of the Graces." A vein, of which the name was unknown to Logan but which may be the Grâs-uchaf Vein of the Llandry Colliery, crops out 80 yards further south, and appears to have been worked by a shaft, said to be 20 fathoms deep, which lies 53 yards to the south again.

The identification of the veins above the Grâs-uchaf is extremely difficult. The Stanllydd is said by Logan to have been worked in the Cil-rhedyn Colliery. This colliery, it appears, "was divided into the upper and lower work. The principal pit of the upper work was 24 fathoms to the Stanllid Vein and 12 fathoms more in the strata below. From the Stanllid Vein at 24 fathoms a drift was cut to the north across the measures, which intersected the little vein above the Grâs-uchaf Vein and came to within 6 yards horizontal of the Grâs-uchaf itself. The colliery was worked 3 or 4 years." (The lower work has been described in the preceding pages.) The pit referred to may be identified with considerable probability as the Burgage pit, 380 yards east of Cil-rhedyn. The supposed Grâs-uchaf Vein of the Llandry Colliery should crop out a short distance to the north-west of the Burgage pit, so that the Stanllyd may well occur in the pit. However this may be, none of the higher seams are identifiable, for, although numbers of old workings are dotted about the ground for a space of about 400 yards south of the Burgage pit, there is reason to believe that the highest measures exploited lay little, if at all, above the Stanllyd and Grâs Veins. For the workings are situated in a coal-bearing belt which follows the strike of the measures from Morlais Bridge past Wern and contains the presumed Grâs-uchaf at Llandry Colliery. The structure and relations, also, of this belt were proved in the same colliery. The measures are characterised by a low average dip and frequent small folds with southerly upthrows, and are separated from the steadily-dipping ground to the north by the southerly upthrow previously mentioned. This disturbance runs W. by S. and is evidenced both in the Morlais, south of the Burgage pit, and along the stream near Llandry House. Near the Morlais several coals in the belt have received names peculiar to the district, such as Garwed, and Upper and Lower Cwm Cathan. Their true sequence, however, is unknown on account of the disturbances which have affected them and which are patent along the Morlais above Morlais Bridge. The measures associated with these veins were described by Logan¹

¹ Vertical Sections, Sheet 1, *Geol. Surv.*

from exposures near the bridge; they include a considerable amount of mine-ground which has been 'patched' to the east and has also, probably, been wrought by small shafts to the west. Of the coals local information is now limited to a possible outcrop of the Garwed Vein near the higher bridge, south of Cilau.

South of this belt follows a barren strip of ground extending from Trimsaran past Wern. Though parallel to the general strike it is probably introduced by a line of fault ('Probable Fault,' p. 132), for the Grâs-uchaf in the Llandyry Colliery to the north is lost by faulting on approaching it, and the measures in a stream south-west of Wern are contorted by strike-disturbances. It was crossed by the New Inn level (the Pen-y-groes adit of Logan), which was driven east-south-eastwards from the productive belt through the barren strip and the Big Vein group. This drains into a brook at Morlais, and runs between this brook and the main street of Trimsaran. All remembrance of what it proved is now lost, but Logan has preserved the details which were available about 60 years ago, and on which he based the sequence published on Sheet 1 of Vertical Sections. In the following summary of his notes the bearings, other than those in square brackets, are possibly magnetic, and the term 'measures' has been substituted for shale, sandstone, etc.; the notes in square brackets were made in 1904 when the adit was still partly accessible.

New Inn or Pen-y-groes Adit-level.

	Distance from mouth in feet.
Arching	to 80
Shale; partly arched in, level-course along adit, ...	" 140
Arching	" 260
Underclay and thin coal; level-course along adit,	" 386
Shale with ironstone and a thin sandstone ...	" 488
Underclay	" 500
[Shaft; the direction here changes from E. 2° N. to E. 24° S. Dip west of the turn, S.S.E. at 30° to 45°; east of the turn, S. 35° E. at 15°.]	
Underclay and thin coal; level course N. 45° E. ...	" 518
Shale with ironstone	" 548
Sandstone with shale	" 596
Underclay	" 608
Coal, 2 feet thick.	
Shale with sandstone-bands	" 740
Shale; partly arched in	" 923
Gravel; arched in	" 938
Shale and clay; partly arched in	" 1,082
" Airpit on drift" [360 yards W.N.W. of turning to Ffos-lâs.]	
Shale with sandstone-bands; level course N. 45° E.	" 1,292
Measures with a thin coal	" 1,412
Coal, 20 inches thick.	
Shale with ironstone, and underclay	" 1,463
Coal, 2 feet thick; dip 35°, level-course N. 70° W.	
Measures	" 1,556
Shale with a coal, 30 inches thick, repeated 3 times,	" 1,604

	Distance from mouth in feet.
Shale; dip 75°, level-course, N. 60° W.	to 1,658
Coal, Stinking, with 2 inches of rubbish, 2 feet 3 inches.	
Shale and sandstone; dip 52°, level course N. 60° W.	,, 1,673
Measures	,, 1,790
"Balance Pit" [or Landab Pit, 115 yards W.N.W. of turning to Ffos-lâs]; dip beyond to Big Vein, 20°.	
Shale with sandstone bands	,, 1,990
Measures with several coals up to 14 inches thick	,, 2,210
Gregog-fâch Vein, hard, 1 foot 9 inches thick (given as 1 foot on "Vertical Sections," Sheet 1).	
Measures	,, 2,370
Two-foot Vein, 2 feet thick.	
Ironstone in large balls, 4 to 9 inches thick.	
Shale with ironstone	,, 2,510
Yard Vein, 3 feet thick,	
Sandstone	,, 2,557
Measures	,, 2,810
Big Vein, 9 feet thick	
"Dip, Big to —, 30°; to Gregog, 18°."	
Sandstone	,, 2,825
Measures	,, 2,900
King's Vein, 2 feet 2 inches thick.	
Measures	,, 3,004
Green Vein, 4 feet thick.	
Shale with ironstone	,, 3,110
Gregog Vein, 3 feet 3 inches thick.	
Shale and sandstone, 5 feet thick.	

The adit throws little light on the structure of the district. For the first 500 feet it traversed mine-ground, probably that associated with the Cwm Cathan and Garwed Veins (p. 126). The whole of the sequence proved beyond is recorded on the above-mentioned sheet of Vertical Sections, commencing with the underclay and thin coal, 52 feet above the Upper Cwm Cathan Vein. Beyond this the adit entered thick shales with no workable coals or ironstone, evidently the barren strip referred to above, and though no mention is made of faults, it is probably more than a coincidence that it had to be arched thereabouts, from 740 to 1,040 feet. Evidently, however, it gave no clue as to the throw of the 'Probable Fault' introducing the barren measures. The latter extended to 2,370 feet from the mouth and were supposed by Logan to be 380 feet thick. The strata are disturbed as far as the Landab pit, as is evident from the repetition of a coal three times between 1,556 and 1,604 feet, and from the high and unusual dips. Beyond the pit they dip steadily at 20°, the sudden change suggesting a fault thereabouts, but of this there is little other evidence. The thickness of those beds which dip steadily is 192 feet; this, therefore, is the minimum estimate allowable for the barren group.

These unproductive measures are succeeded, apparently without faulting, by the Big Vein group, the following summaries of

which are taken from "Vertical Sections," Sheet 1, and, as regards Trimsaran Colliery, from information supplied by Messrs. Graham and Albert Jones.

	<i>New Inn Level.</i>			<i>Trimsaran.</i>		
	Thickness.			Thickness.		
	Yds.	Ft.	In.	Yds.	Ft.	In.
Gregog (Graigog) Vein	1	0	3	1	0	6
Measures	11	0	0	10-12	0	0
Wyrdd (Green) Vein	1	1	0	1	0	9
Measures	9	0	0	10	0	0
Little or King's Vein... ..		2	2		2	0
Measures	15	0	0	23	0	0
Big Vein	3	0	0	3	0	0
Measures	34	1	0	35	0	0
Yard Vein	1	0	0	1	0	0
Measures	15	0	0	11	0	0
Two-feet Vein... ..		2	0		2	0

At Trimsaran Colliery the Trimsaran slant starts on the Graigog and descends to the Big; the Waunhir slant is wholly in the Big Vein.

The Two-feet Vein, also called the Double Two-feet and possibly identical with the Waunhir of some accounts, was formerly worked, especially for the mine above it. This, according to Logan, occurs in large balls, some upwards of 3 feet in diameter and 4 to 9 inches thick. The coal has been cropped 120 yards S.S.E. of Waunhir, and worked by slant 100 yards west of the turning from the main-road to Ffos-lâs.

The Yard Vein, according to a note made by Logan of a report dated 1830, "produces a great quantity of stone-coal of a superior quality." It is said to be 120 yards deep in the Cae'r-plwmp Colliery, locally known as the Caeduon pit, and crops at a slant 260 yards N.N.W. of the Star inn. The underclay, apparently 12 feet thick in Pen-y-groes adit, was worked in drifts for white bricks, made at Trimsaran; the roof is sandstone, 12 feet thick, according to Logan forming good building stone.

The Big Vein at the present Trimsaran Colliery is 9 feet thick, according to Mr. Albert Jones, with a roof of "blue clift," and consists of three coals containing iron-pyrites ('brass') in parts. It dips S.S.E. at 9 inches to the yard, but at Cae-ffaldre is cut off by a west-north-westerly fault connected with the Trimsaran disturbance. An exploration, for an account of which we are indebted to Mr. T. Arnold, was here made for the purpose of proving the fault. The Big Vein turned to dip steeply east at a point 200 yards north-north-west of Cae-ffaldre. It was followed down for 40 yards and then left. A heading was driven northwards through disturbed ground for about 30 yards into another vein, which was bent up against the disturbed ground or fault. This vein was followed along level-course for about 150 yards and found to swing round from an easterly dip to a southerly one at 16° to 21°. Near the fault the coal was soft and showed an overlap, but where working ceased, in

undisturbed ground, it consisted of top coal 3 feet 3 inches, clod 3 inches, bottom coal 9 inches, and had a cliff-roof, a section which led to its being identified by Messrs. Ed. Daniel and T. Arnold as the Carway-fawr; the latter is known about half a mile to the north-north-west, near Allt-ysgrâch (p. 120). By others it was regarded as the Green Vein of Trimsaran. In either case the fault would be a downthrow north, but it is unknown whether it constitutes the whole of the Trimsaran disturbance thereabouts, or whether a greater but similar fault lies still further north.

South-west of Trimsaran village the crop becomes uncertain, though the position of the Big Vein group is indicated by old workings for another 1,000 yards, to Syddyn. The Big Vein is said to have been got again 400 yards to the west of Syddyn, for a distance of 150 yards but a good deal to the north of its expected range, an effect which may be due to the 'Hypothetical Fault' described on p. 132. In the New Inn level a hard sandstone, 5 feet thick, is said by Logan to overlie the Big Vein.

The Little or King's Vein according to Logan consists of coal and carbonaceous shale 2 inches, top coal 4 inches, sandstone or shale 2 inches, bottom coal 1 foot 6 inches. It does not appear to have been worked. The Green or Wyrdd Vein is from 3 feet 6 inches to 4 feet thick, the lowest 6 inches being separated from the rest by a clod, in which and in the character of its roof (cliff) and floor (fireclay) it resembles the Carway-fawr. It has been much worked at Trimsaran. Mine-ground with three courses of ironstone up to 5 inches thick is said by Logan to lie above it.

The Graigog or Gregog Vein, also, consists of two coals; in the New Inn level it shewed top coal 1 foot, carbonaceous shale 3 inches, bottom coal 2 feet, and in the present Trimsaran Colliery, the slant of which enters in its outcrop, it is $3\frac{1}{2}$ feet thick. The fireclay below it is $1\frac{1}{2}$ to 2 feet or 9 feet thick, according to different accounts, and has been worked for white bricks at Trimsaran. The Caeduon pit (p. 128) is said to have reached the Graigog at a slight depth; another pit, 60 yards S.S.W. of The Star, at 55 yards; and a third, 150 yards S.W. of The Star, at 40 yards and the Green at 49 yards depth.

In the overlying measures extending up to the top of the Lower Coal Series there are more workable coals than at Pont-Yates, but few of much importance. Sandstones, similar to the Llynfi Rock of Maestêg, but setting in at a lower horizon, predominate in the upper part. Details of the whole series have been published by Logan in the sheet of Vertical Sections previously mentioned; they were obtained chiefly from surface-exposures described in his MS. note-books.

The Drap Vein is shewn by Logan as lying 68 yards above the Graigog. The shaft above-mentioned, which reached the Graigog at 55 yards, started a little below the Drap; and again,

the crop of the Drap near Waun-ffynnonau is about 98 yards vertically above the Big in Trimsaran Colliery. The Graigog being 45 yards above the Big, a distance of 52 yards is left between the Drap and the Graigog. Some of the ground between them, in a pit dug for red bricks 150 yards north of Trimsaran House, consists of 40 feet of shale, with a coal 1 foot thick and 2 feet of underclay in the middle. A vein which was noticed by Logan in a lane to the east of Trimsaran House as being 1 foot 8 inches thick, is probably the Mole Vein. It is said to be 2 feet 8 inches in an old working 300 yards N.E. of Caedrim. The Drap Vein is distinctly less anthracitic than the coals of the Big Vein group, and is reported to have produced culm, but little stone-coal. It is about 5 feet thick, including 12 to 18 inches of stone in the middle, and is accompanied both above and below by quartzitic sandstones, much like 'cockshot,' which may be regarded as highly siliceous coal-seats. They resemble the 'cockshot' of the Ammanford district in being speckled in places with particles of coal. On account of their hardness they make a ridge along the outcrop of the Drap Vein. The band above the coal varies in thickness, up to 34 feet according to Logan.

The Drap Vein has been proved in some trial-holes 200 yards E.N.E. of Trimsaran House, and was worked for a time by a slant 250 yards north of Waun-ffynnonau, where, according to Mr. D. Lloyd, it consisted of top coal 1 foot 1 inch, soft shale 1 foot 3 inches, bottom coal 2 feet 6 inches. In an adjacent quarry the overlying quartzites are visible to a thickness of 8 feet. An old level on the vein 80 yards S.E. of The Star is said to throw out the ochreous water seen thereabouts; old slants 200 yards E.N.E. of Caedrim expose the overlying quartzite; and the coal may be traced with certainty thence as far as a slant in Bryn-hwthau garden, a short distance beyond which all trace of it is lost.

The Waun-ffynnonau or Trimsaran Vein lies 70-80 yards above the Drap, the intervening measures being chiefly shales. It is from 3 feet 3 inches to 3 feet 9 inches thick, and has apparently been worked all along its known outcrop, and also to the deep; at Bryn-dias it is slightly but distinctly bituminous. It was worked at the old Star Colliery¹ about 300 yards S. of The Star, and, in 1830, at Bryn-dias. It has more recently been wrought from a slant which descended to it through the overlying measures 100 yards N.E. of Bryn-dias. Here it dipped S.S.E. at 16 inches in the yard, but in an adjacent working to the west turned to dip deeply S.W., and, close by, yielded much water; the disturbance thus evidenced is probably the "Hypothetical Fault" described on p. 132. Beyond an old adit to the vein, 350 yards W.S.W. of Bryn-dias, all evidence of it ceases, unless it were reached in the Tymawr pit (p. 133).

¹ For particulars see W. Fairley, *op. cit.*, p. 6.

The Golden Vein is about 350 feet above the Waunffynnonau, according to Logan, or about 400 feet by a more recent measurement. In the lower part of this ground there are sandstones of a fine-grained Pennant type which have been quarried 250 yards S.E. of Trimsaran House. Here they are supposed to contain a Quarry Vein, 1 foot 8 inches, which, however, is not known elsewhere. South-westward of a quarry in them, situated 600 yards S.W. of the house, they become thin, a fact which leads to difficulty in tracing the Waunffynnonau Vein below them. Near Waun-y-clyn they were only 4 feet thick in a pit on the Waunffynnonau recorded by Logan. Still further south-westward they reappear, and at Bagland a quarry shews 10 feet of these rocks, while at Bryn-dias Logan records two sandstones at 16 and 40 yards respectively above the Waunffynnonau Vein. In a quarry the upper dips S.S.W. at 35° , whereas the average dip to the south and east is S.S.E. The turn thus evident, which is paralleled in the Waunffynnonau Vein below, and the occurrence of north-north-easterly faults in the quarry suggest the proximity of the similar but larger "Hypothetical Fault" described on pp. 129, 132.

The Golden or Lower Mountain Vein (Williams Vein of Fairley) is supposed to be 2 feet thick. There are almost continuous holes upon its crop from near Waunffynnonau to a point 200 yards S.E. of Bryn-dias. About 60 yards above lies the Upper Mountain Vein, the intervening ground consisting chiefly of sandy shales. According to Logan it is 12 to 20 inches thick, and, like the Golden Vein, fit only for lime-burning or coal-balls. It has been worked by crop-holes along the same ground as the Golden Vein; at the western end it appears to have been proved in a level, 240 yards S.W. of Bryn-dias. Hereabouts, like the rest of the series, it turns to dip S.S.W., at 32° , instead of S.S.E.

Above these come about 80 yards of shales with sandstones, which crop in the steep face of Mynydd Pen-bre, and contain a thin and unworkable seam known as the Bancog. These are succeeded by about 140 yards of sandstones of Pennant type which form the crest of the hill and contain a cockshot about 70 yards above their base. The sandstones are followed by shales containing the Coed Rhyal or Caerhedyn Veins.

The Lower Coed Rhyal Vein has been recently worked by a level in the northern corner of Coed Rhyal. It is described by Mr. Thomas Evans of Burry Port as a binding coal about 2 feet 9 inches to 3 feet thick, with 7 inches of clod in the middle. Work in it was stopped by a fault which had been met also in the Cenrhos Vein. In the same wood there are several other old workings for the two Coed Rhyal veins of which, however, the upper is said to be too thin to pay.

The Cenrhos Vein lies about 80 yards above the Lower Coed Rhyal Vein, or according to Logan, rather less. At Ffrwd the

vein has been worked down to the level of an adit, which opens hard by the farm ; it yielded the following section :—

	<i>Cenrhos Vein.</i>								Ft. Ins.
Roof (rock).									
Coal	11
Shale	3
Coal	8
Shale	0½
Coal	1 0
Shale	2
Coal	1 3
Shale	1
Fireclay.									

The coal is bituminous, but not sufficiently so for use as a house coal. For these details we are indebted to Mr. Lloyd.

E. E. L. D.

None of these sandstones or the coal-seams below them down to the Big Vein are known to cross the line marked on the map 'Hypothetical Fault.' This is especially noticeable in the massive rocks from Tan-y-lan south-westwards through Coed Rhyal. There the level-course is north-westwards ; the hill-face nevertheless persists in its south-westerly course, the crest keeping a height of 300 to 400 feet above the low ground to the north-west. There is a strong presumption, therefore, that a fault runs near the foot of the bank ; the face of Mynydd Pen-bre, though physically a continuous feature, is accordingly in one part of its course an escarpment but in the other part a fault-feature. The same change of level-course to a north-westerly direction is shown in the veins below, near Bryn-dias.

A second disturbance, the 'Probable Fault' beneath Ty-cornel on the map, has been discussed on pp. 126-7. These two between them account for an unexpected width of outcrop between the Big Vein group and the Llandyry seams.

The Trimsaran disturbance, which runs north of the Morlais at Llandyry, has been proved at one point only, but has been traced for upwards of five miles by surface-evidence. It commences in an anticline near Trefanau (Sheet 230) and passing thence westwards up a hollow suggestive of broken measures, runs to the south of Five Roads, and between Cil-feri-isaf and Cae-ffaldre. Here, again, it coincides with an anticline, as proved by dips observable at these two places. Though the principal overthrust is not visible, a remarkable view of a subsidiary fracture is afforded by a quarry 600 yards S.S.E. of Horeb. The quarry has been opened through a few feet of completely ground-up rock into a hard thin-bedded sandstone below. The plane between the two is clean-cut, and slants down southwards at 16° ; the rock beneath it dips north at 12°, but in places, just below the plane, the edges of the beds have been doubled back. The fracture ranges east and west, and the overthrust has obviously been from the south.

In the workings in the Big Vein the disturbance was explored near Cae-ffaldre, as described on pp. 128-9. It is assumed

to run close by but on the north side of some greatly disturbed strata near Ffos-lás. There, in the bed of the Morlais, the strata are sharply folded, vertical and repeatedly overthrust. Half-a-mile west of Trimsaran village on the other hand a fairly uniform dip of normal direction prevails along the river. The Trimsaran disturbance consequently is shown as lying well to the north of this tract. Further west it seems to account for the termination of the outcrop of Farewell Rock between Tal-carn and Pen-y-bont. In this, as in the case of the other 'faults' previously mentioned, there is no single line of fracture, but a belt of plication and overthrusting. The lines of fault on the map, therefore, are only diagrammatic indications of the position of disturbed belts.

A. S.

Of the broad tract covered by boulder-clay and alluvium near Ty-mawr and Towyn-mawr, and by the Towyn Burrows, little is known. In 1820 a trial-shaft was sunk at a spot 400 yards E. 8° N. of Ty-gwyn, which was abandoned in 'blue-stone' (shale) at a depth of 32 yards.¹ This is doubtless the pit referred to in a note by Logan as being 200 yards south of Glan Morfa and as having passed through 3 fathoms of gravel and 7 fathoms of clay with thin leaders of coal. In the same year an unsuccessful attempt was made to sink through the sand 1,150 yards south-east of Towyn-mawr.¹

Recently a trial-shaft, 280 yards N.E. of Ty-mawr, has proved gravel 20 yards, measures including 6 yards of rock at the base 20 yards, and coal 2 to 4 feet. The coal is described as dipping southwards but as being disturbed. According to another account the measures were chiefly rock, but shale lay immediately above the coal, while the coal was 2 feet 9 inches to 5 feet thick, and an inferior anthracite. A heading driven to the west for 50 yards met no fault. The coal was supposed to be the Waun-ffynnonau Vein. Water overflows from the shaft.

The correlation of the Trimsaran and Llandyry coals with those of other regions is difficult. We have already suggested a correlation of the Llandyry sequence with that of Pont-Yates (p. 124), but the Trimsaran seams differ greatly from those of either place. Logan placed them at a much higher horizon. He regarded the Garwed of Trimsaran as synonymous with the Carway-fawr of Pont-Yates, on which theory the Big Vein group of Trimsaran would correspond with the Cwm-cobbler Vein. He noticed also that the cockshot above the Cwm-cobbler Vein resembled and was supposed to be the "Hard Sandstone of the Drap Coal." But the Garwed is connected in no way with the Carway Vein, while the Drap rock lies about 770 yards below the top of the Lower Coal Series whereas the cockshot lies at a depth of merely 260 yards.

It is generally held in the district that the Trimsaran Big Vein group corresponds with the Pont-Yates group, for the reason that this is the only persistently productive part of the coal-series,

¹ For this information we are indebted to Mr. G. G. Williams, of the Ashburnham Estate Office.

and the only one where a nine-foot seam could be expected. One difference between them lies in the position of the 'Big Vein.' The vein so-called at Pont-Yates is at the top of its group, that at Trimsaran is in the middle. But the Pont-Yates Big Vein disappears southwards towards Trimsaran, and the Big Vein of Carway, half-way between, is probably the Stanllyd (p. 111); the Trimsaran Big Vein should be compared with the Stanllyd as regards its position, and with the development at Carway rather than with that at Pont-Yates as regards its character. Compared on this basis the two groups present several points of resemblance. The Two-feet and Yard Veins correspond with the Grâs-isaf and Grâs-uchaf. The Grâs-uchaf is probably the 'Green' Vein of Carway, and this resembles the Yard Vein in yielding much large coal. Again the Big Veins of Trimsaran and Carway, as pointed out to us by Mr. A. Jones, are each 9 feet thick in three coals, with the Yard Vein 35 yards below in the former case, and the Green Vein 38 yards below in the other; both Big Veins have a blue clift-roof. At the same time the Trimsaran Big Vein is said to be more friable and to contain more ash and more bands of inferior coal. In the higher veins a difference is more apparent, for the Ddugaled, Green and Big Veins of Pont-Yates diminish south of that place.

The Waun-fynnonau Vein, on this correlation, falls into line with the Carway-fawr, which it resembles in thickness, and in lying not far below the lowest sandstone which resembles Pennant. Again, a cockshot, evidenced on Mynydd Pen-bre, would correspond with a cockshot which occurs midway between the Carway-fawr and the Brondini Vein. Finally, the Cenrhos Vein, which marks the base of the Llynfi Rock group, and the corresponding horizon near Pont-Yates, lie at about the same distance above these cockshots.

Various difficulties, however, remain unexplained. Neither the Brasslyd nor Gwendraeth Veins were found in the position they should occupy in the barren measures below the Two Feet Vein, the suggested equivalent of the Grâs-isaf in the New Inn level described on pp. 126-8. Again, a throw is postulated for the Trimsaran fault which appears to be excessive, for the Carway Big Vein ranges more than three-quarters of a mile from the Trimsaran Big Vein across the strike, though the horizontal shift attributable to this fault in the outcrop of the Pumpquart is certainly trifling in comparison.

Again, some of the Pont-Yates coals, as proved at Llandry, would be repetitions of the Trimsaran veins, caused by the 'Probable Fault' and 'Hypothetical Fault' shown upon the map. Yet they present a different facies, as though they had been brought into proximity from a distance by the faulting. To account for both this difference and the inequality of the effects of the Trimsaran fault on the Big and Pumpquart Veins, the faults in question must be assumed to be large, notwithstanding that they failed to attract attention in the New Inn level.

If, as an alternate theory, we grant that these faults and the Trimsaran disturbance are small, and place the Trimsaran

coals above those of Llandry and Pont-Yates, we must suppose that they occupy the horizon of the Carway-fawr and Carway-fâch Veins, a correlation which is attended with most serious difficulties. For though the Green Vein of Trimsaran matches the Carway-fawr, the only other horizons which would fall approximately into line would be the Waun-ffynnonau and Cwm-cobbler Veins. The distance up to the base of the Pennant Series would also differ greatly in the two districts. We therefore adopt the correlation of the Trimsaran with the Pont-Yates group as according best with the evidence available.

Since writing the above account of the Lower Coal Series we have received from Prof. W. Galloway details of a boring 400 yards north-west of Pen-y-bedd farm (2½ miles south-west of Trimsaran), of which the following is a summary :—

<i>Boring near Pen-y-bedd Farm.</i>		Thickness (not corrected for dip).	
		Ft.	In.
Soil, sand and clay [probably blown sand and alluvium]		70	0
Strong clay and gravel [probably glacial]		8	6
Shale		9	7
Thin coal-partings in 'black stone'		5	8
Shale with some sandstone and an ironstone		34	3
Coals, 9 inches and 1 foot 4 inches, and shale		5	6
Shale with coal-traces and quartz-veined sandstone		52	7
Coal, soft dirty		1	1
Shale, chiefly hard and sandy, with ironstone		43	6
Coal, dirty			7
Sandstone with quartz-veins, and shales		6	3
Shale with ironstone-balls		10	6
Coal			8
Shale with ironstone-balls and sandstone		45	5
Coal			8
Grit and shale		4	1
Coal			4
Sandstone with hard grit and shale		6	8
Shale with sandstone-partings, and ironstone-balls		45	5
Coal			7
Shale, with grit in upper part		32	9
Coal, dirty		1	8
Shale with ironstone-balls... ..		33	3
Coal		2	5
Shale with ironstone-balls... ..		55	2
Coal			10
Shale with ironstone-balls... ..		21	1
Coal		1	0
Shale		17	0
Coal			9
Shale with ironstone-balls... ..		3	3
Coal with a band 1 inch thick		3	2
Shale		27	9
Coal		1	3
Shale		3	4
Total depth		556	6

CHAPTER XI.

CARBONIFEROUS ROCKS.

COAL MEASURES—*continued.*

PENNANT SERIES.

The recognition of the seam which has elsewhere been taken as a conventional base of the Pennant Series has proved difficult in the western end of the coalfield. In the district north of Five Roads a coal, named after Brondini, is regarded as the representative of No. 2 Rhondda Vein, inasmuch as it is continuous with veins which have been correlated with that vein in the area to the east (Sheet 230) and because its position relative to thick sandstones above and to the 'cockshot' some distance below corresponds with that of the Ynysarwed Vein in the Ammanford district¹. In Sheet 229 it occurs only in the two outliers forming hills at Cynheidre and Brondini, in both of which its dip is low or horizontal, and from both of which the coal has been largely cleared out. In the first outlier little is known of the workings except that one shaft, 500 yards east-north-east of Cynheidre-fawr, is said to have found the coal, 3 feet thick and horizontal, below 15–20 yards of sandstone. In the other outlier the coal was seen, in a level 150 yards north of Brondini, to be 15 inches thick, with sandstone above and fireclay below. Nearer Brondini, an old quarry, now exposing merely horizontal shales, once yielded flags, the complete sequence below the shales being:—

				Ft.	Ins.
Soft building-stone (worked)	...	...	6 feet to	9	0
Flagstones (worked)	...	...	... about	15	0
Soft sandstone	...	...	...	9	0
Brondini Vein, including a band of 'stone';	...	...	...	3	0
Underclay (worked with the shales above for making bricks).				1	6

According to Logan the Brondini Vein includes top coal, 1 foot 6 inches, and bottom coal, 1 foot 3 inches, with 8 inches of shale between; he remarks that the flags above are "said to be slightly pliant,"² and in his MS. notes has recorded that "if exposed to the sun when bent they will remain so."

An upper seam, sometimes called the Cap Vein, lies in the shales above the sandstones, but is no longer visible. According to Logan, this "Upper Brondine Seam" consists of two coals separated by 4 feet of shale and clay.

The lower coal is traceable by old workings round the outlier. Much of it was worked from a slant 300 yards N.E. of Brondini-fawr, but along the southern margin it is said to have been poor, with a thick stone in the middle. The upper vein has been

¹ 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, p. 154.

² Vert. Sects. of the *Geol. Survey, Sheet 3.*

worked in places. Both the Cynheidre and Brondini hills include some Pennant sandstone. On the former the rock is quarried 700 yards E.N.E. of Cynheidre-fawr, and shows both the fine-grained and conglomeratic types; on Brondini hill the rock overlies the shales visible in the quarry already mentioned.

E. E. L. D.

For reasons given in the Memoir on West Gower (Sheet 246), we believe the Gysewm Vein to correspond to the Brondini Vein and to the No. 2 Rhondda Seam of Glamorganshire. The crop of the Gysewm runs to the head of Cwm Ierman¹, north of Burry Port, but then becomes wholly indefinite. Its position in the Lliedi Valley (Sheet 230) is got by calculation only², so that nearly the whole of the boundary of the main tract of Pennant in Sheet 229 is conjectural.

One workable seam only occurs within that tract, namely, the Cwm-mawr Vein. Such others as occur are enumerated, with the distances between them, in another volume³; one of them, said to be 1 foot thick, crops near Pant-y-llydu-fâch, and another which has been tried 100 yards south of Cilau-gwyn is supposed to be the vein which was called 'Cille No. 4' in the Cille Level, 1,080 yards from its mouth. None of them have been discovered under Soho and Cencoe. The ravine between the two places shows nothing but boulder-clay, and probably coincides pretty closely in position with the Stradey Fault. That fault is a downthrow east of about 290 yards in the Llanelly syncline (Sheet 246), but it has not been recognised at Five Roads, and no doubt dies away northwards, as do the other north-and-south faults which are developed in the syncline.

To the west of the supposed line of the Stradey Fault the Cwm-mawr Vein has been worked in the drift of that name. It is described as a steam-coal, 23 inches thick, with a clod 9 inches thick below it, and 9 inches of inferior coal below this again. The workings lie chiefly to the westward of the dingle, but the vein has been followed eastwards also to within 100 yards of the Soho dingle. A sandstone which crops out in the Soho dingle just to the south of these workings presumably lies above the coal, and the fault consequently may be assumed to run to the east of both the sandstone-outcrop and the workings⁴. The Cwm-mawr Vein appears to lie at a distance of 185 yards below the Pwll Vein, which is supposed to correspond to the Hughes Vein of Swansea.

A. S.

¹ 'Ferman' on the Six-inch map, Edition 1905.

² 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, p. 169.

³ 'West Gower' (*Mem. Geol. Surv.*), 1907, pp. 21, 30, 31.

⁴ This information was obtained after the publication of the Memoir on West Gower.

CHAPTER XII.

FAULTS AND DISTURBANCES.¹

WEST-SOUTH-WESTERLY DISTURBANCES.

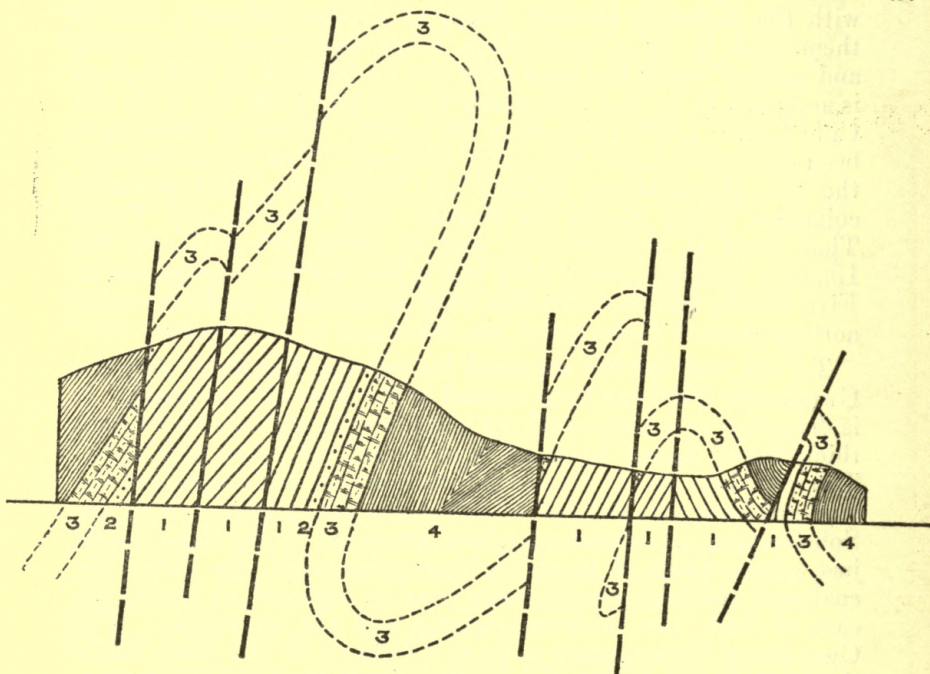
The dominant structures of this region range generally west-south-westwards, both in the Lower and Upper Palæozoic rocks. In the older rocks a main anticline, with a slight easterly pitch, runs along the Towy Valley, and is continued west of Carmarthen past Llanllwch and Llangynin. Several small dome-shaped anticlines are apparent in the Tremadoc rocks south of Nantgaredig, while a larger fold brings up the Arenig grits of Cystanog and Llangynog. The southern limbs of these folds are generally inverted by overfolding from the north, as for instance is the

Fig. 15.—Section North of Nantgaredig.

(H. H. Thomas.)

N.

S.



Scale Six Inches to One Mile.

1. Murchisoni Shales.
2. Asaphus Ash.

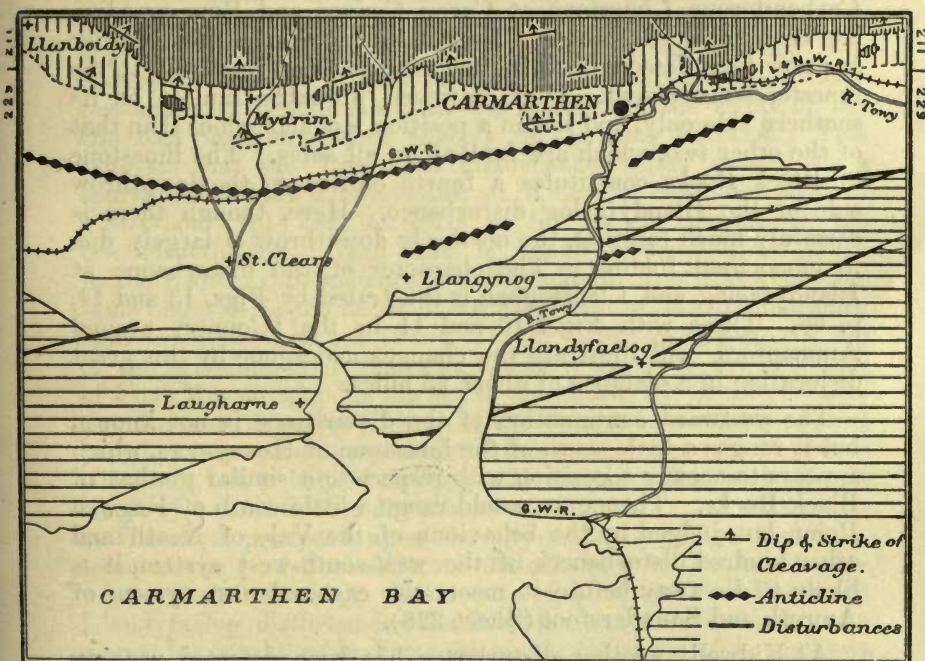
3. Llandilo Limestone.
4. Dicranograptus Shales.

case with the lowest *Bifidus* Beds from Llanllwch westwards. The great compression which the northern part of the area has undergone has resulted in the bringing into juxtaposition of sediments which were deposited at a considerable distance apart, and often differ in type, as illustrated by Fig. 15.

¹ In this chapter each author contributes notes on the structure of the region surveyed by himself.

The faults in the same tract may be distinguished as west-south-west strike-faults, north-north-west faults, and faults of no definite direction separating hard from soft beds, such as those between the Arenig grits and the shales at Bolahaul and Llangynog, or those between the igneous rocks and shales. In the last class the faults tend to enclose an elliptical mass of the harder rock. The west-south-west faults generally hade to the north, and are in most cases presumably overthrusts. They usually dip more steeply than the beds and have caused repetition, e.g., south of Mydrim, south of Llanllwch, and near Llandowror. Some, however, have the effect of normal northerly downthrows. They are usually devoid of vein-rock. That most of them, and the folds associated with them, are of earlier age than the Old Red Sandstone is shown by their comparative scarceness in that formation, and by the great unconformity at its base. Definite proof of the earlier age of some of them is obtainable near Llandilo-Abercowin.

Fig. 16.—Map to illustrate Distribution of Cleavage.
(H. H. Thomas.)



The close vertical hatching indicates areas where the cleavage is intense: the open vertical hatching shows regions where the cleavage is incipient. Over the rest of the map the beds are uncleaved, rocks of Lower Palæozoic age being left blank, while the Old Red Sandstone and newer rocks are indicated by horizontal shading. Faults and overthrusts in the Lower Palæozoic rocks are omitted for the sake of simplicity. The map includes a small part of Sheet 211.

Slaty cleavage makes its appearance somewhat suddenly towards the north, in the northern limb of the Llanllwch-Llangynin anticline. It strikes generally parallel to the main

folds, and dips with fair constancy northwards at 40° to 70° . Increasing in intensity northwards it suffices, locally, to obliterate bedding, but nowhere to produce good slates. It cuts across many east-and-west folds, but is never visibly involved in subsequent folding. Its southern margin, as shown in Fig. 16, is somewhat irregular in consequence of the varying susceptibility of the rocks to take the structure.

The existence of post-Carboniferous faults having the same direction as those of earlier date is well illustrated in this district. Certain disturbances cut through the Old Red Sandstone margin north-west of Llanddarog, and introduce within it an inlier of Tremadoc rocks (p. 8). Others have left outliers of Old Red Sandstone among the Arenig rocks at Llangynog (p. 74), while a third disturbance breaks through the escarpment south-west of Llandowror and has led to the formation of a valley which is followed by the Pembroke road.

The most remarkable, however, is the dislocation which traverses the middle of the outcrop of the Old Red Sandstone. Its existence in the adjoining ground on the east, where it throws in outliers of Carboniferous Limestone at Careg Cennen and Bryn-yr-odyn, has been noted elsewhere.¹ Near Llandyfaelog a third outlier has now been detected holding the same position relatively to the limestone-escarpment. It is, however, probably faulted on its southern side only, and lies in a position less anomalous than that of the other two, which are faulted on all sides. The limestone of Black Rocks constitutes a fourth outlier on the downthrow side of the Llandyfaelog disturbance. Here, though there is certainly much faulting, the northerly downthrow is largely due to monoclinical folding. The character of the disturbance at Llandyfaelog and Llanstephan is illustrated by Figs. 13 and 14, p. 66. These with Figs. 10 and 11 in the 'Country around Ammanford' will illustrate the changes undergone by this great dislocation in a distance of about 23 miles.

The westward continuation of the disturbance is not known, but it ranges a little south of the limestone of Honey-cors, which appears to occupy a position with respect to it similar to that of Black Rocks. Thence it would range a little south of Ragwen Point, but, judged by the behaviour of the Vale of Neath and other kindred disturbances of the west-south-west system, it is likely to die away before it meets the east-and-west system of Amroth and Saundersfoot (Sheet 228).

At Kidwelly another disturbance has been detected ranging along the valley of the Gwendraeth-fâch in approximately the same direction as the Llandyfaelog fault. It consists of a sheaf of faults, most of which are southerly downthrows, though the north-westernmost, which brings down the Penlan Quartzite on the north against Senni Beds, clearly has a northerly downthrow. A noticeable feature is the tendency of the beds near

¹ 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 183, 184.

the faults to swing round from their normal south-easterly inclination and dip to the south-west. At the southern end of Mynydd-y-gareg what appears to be the south-easternmost fault throws the upper part of the Basal Grit against Carboniferous Limestone, but dies away a short distance to the north-east. A more important member of the group, however, is that which at Kidwelly cuts out the whole of the Main Limestone and throws the Basal Grit, which is exposed 200 yards north-east of Garddau, against the Lower Limestone Shales, which are seen in the lane to the north-west. To the west it lies at the foot of rising ground, and, although it is still flanked by Lower Limestone Shales on the north-west, it appears to bring in higher and higher beds on the south-east. In the foundations of the railway bridge over the Gwendraeth-fâch the beds to the south-east of it were found to be shales with some clay-ironstone (p. 151), without doubt belonging to the shales which form the middle member of the Millstone Grit.

The connection between the Llandyfaelog and Kidwelly disturbances by means of a fault, leaving the former where the river Gwendraeth-fâch turns south out of the chief fault-line, has already been described (p. 67). The Kidwelly disturbance appears, further, to connect the Llandyfaelog disturbance with that of Trimsaran. West of Kidwelly it curves into a more east-and-west direction, and at the same time the strike of the Old Red Sandstone bends sharply in the same direction. This suggests that the Trimsaran disturbance, which ranges for a course about half a mile south of Kidwelly, continues west of Pen-y-bont (p. 133) at least as far as the mouth of the Gwendraeth-fâch. Near here it would presumably be joined by the Kidwelly disturbance, which would run into it at about the same angle as do the small overthrusts east of the Gwendraeth-fawr, mentioned on pp. 103-4, 111-2. The south-westerly dip of the Millstone Grit Shales at Kidwelly suggests the existence of Coal Measures under the sea to the south, but in this connection the possible presence there of the Trimsaran disturbance must be taken into account, especially as this disturbance is not a simple slip-fault, but a belt of folding and overthrusting, with the net result of a considerable downthrow north.

The effect produced upon the physiography of the region by some of the post-Carboniferous disturbances of the west-south-west system is marked. In the case of both the Red Roses and Llandyfaelog disturbances the fault-line can be picked out at a glance for considerable distances by the character of the hollows they produce. The behaviour of the Gwendraeth-fâch with respect to the latter fault is described on p. 67.

NORTH-NORTH-WESTERLY FAULTS.

The north-north-westerly faults are of less importance. A few in the eastern part of the district affect only the older rocks, and three, crossing the Arenig Grits of Cystanog, carry lead-ore. In the Old Red Sandstone and Carboniferous rocks, faults of

this direction are usually the more prevalent, but in the region included in Sheet 229 the Crwbin, Pont-Henry, and Fforest faults alone are of any magnitude.

A smaller fault, however, which crosses the Millstone Grit north-west of Goetre can be followed in a meandering northerly course across the quartzites of Mynydd-y-gareg, which it throws down to the east. Just past the crest of the ridge the fault comes to an end, but 80 yards further to the east a similar easterly down-throw commences, the appearances strongly suggesting that the fault has been broken through by another and shifted. On further search it was found that there is evidence of such a cross-fault occupying a pronounced hollow which crosses the ridge in a north-west direction. This north-west fault would thus appear to be later than the northerly fault, but on the other hand, though not agreeing with the north-east faults in direction, it may belong to that system of disturbances. It differs from the north-north-west system in the fact that its course across the scarp is marked by a conspicuous hollow. A clue to the nature of the movement is furnished by the slickensiding accompanying it, which slants down south-east at nearly the same angle as the general dip of the beds. Though, therefore, its displacement of the outcrops is small its presumed large shift of the northerly fault is intelligible. Again, in its neighbourhood the sandstones with an interbedded shale show a form of dislocation which suggests compression and overthrusting rather than normal faulting.

Some of the veins in the Carboniferous Limestone and to a less extent those in the Old Red Sandstone contain small quantities of copper-pyrites, galena and chalybite, associated with quartz. These lodes occur in vertical fissures having a north-west or north-north-west direction, or in slickensided bedding-planes. Though they show no definite connection with the north-east system of disturbances they are confined to the area affected by it.

CHAPTER XIII.

SUPERFICIAL GEOLOGY.

RAISED BEACH.

The existence of a Raised Beach in South Wales is described elsewhere,¹ and proof is given that it underlies all the deposits in which glacial action is evidenced. Three possible representatives of this Beach have been noted in the district now under description. One occurs in the cliff east of Llanstephan Castle. Under 20 feet of boulder-clay there lies a fine deep-red stratified loam with fine gravel composed chiefly of Old Red Sandstone detritus. The deposit is several feet thick and is but slightly above the present storm-beach. No shells occur in it, and though it possibly represents the Raised Beach, it is at least as likely to be a stratified band in the Glacial Drift. The second example occurs immediately west of Ragwen Point at the western end of a small cliff of boulder-clay. Concreted sand with small pebbles and with blown sand, appears from beneath the Drift just above high-water mark. No shells were observed. The third, at Pendine, is referred to on p. 151.

A. S.

GLACIAL DEPOSITS.²

The evidence for the passage of an ice-flow down the Towy Valley westwards, and for its tendency to escape southwards wherever the form of the ground permitted, has been given elsewhere.³ The region now under description furnishes striking evidence of the south-westward path which was followed by the ice, regardless of many, if not of all, of the physical features.

The Towy Valley, which as far as Carmarthen runs nearly west, turns southward at that town. Above the town it was crossed by the glaciation at an oblique angle from north to south; below the town it was crossed from east to west, as shewn by the composition of the drift near Llanstephan and Laugharne; the ice therefore pursued its general W.S.W. course across the windings of the valley.

The Gwendraeth-fâch (above Llandyfaelog) and the Gwendraeth-fawr Valleys furnish still more complete evidence. They run for some distance parallel, in a direction about W. 30° S., and both follow the strike of the rocks, the one keeping to the Old Red Sandstone on the north side of the Millstone Grit escarpment, while the other occupies a strike-valley in the Coal Measures on the other side of that feature. The scarp in places reaches a height of 800 feet.

¹ 'The Country around Swansea' (*Mem. Geol. Surv.*), 1907, pp. 118-20.

² Each author contributes observations on the region surveyed by himself.

³ 'The Country around Ammanford' (*Mem. Geol. Surv.*), 1907, pp. 188-194.

In the lower part of the Gwendraeth-fâch Valley the drift is made up chiefly of Old Red Sandstone, while that of the Gwendraeth-fawr is chiefly of Coal Measure origin, facts which, taken alone, would have led to the conclusion that the glaciation followed the valleys. But the further observation that the drift on the divide at Meinciau is composed almost exclusively of material derived from the Gwendraeth-fâch, prepares us for what is most conclusively proved by striæ. These have been preserved in abundance on the top of the scarp, and all cross the feature obliquely from the Gwendraeth-fâch to the Gwendraeth-fawr, in an average direction S. 40° W. The ice-sheet did not precisely follow the valleys, deep as they are, but kept its course at an extremely oblique angle across them, and across the intervening scarp. Nearly the same direction is indicated by some striæ pointing W. 40° S. on the crags of the Penlan Quartzite north of Kidwelly. Also the fact that the boulder-clay of the low cliffs south-west of the railway-station contains much quartzite, but less of the Lower Old Red sandstone which crops out with the Penlan Quartzite close to the north, leads to the inference that the quartzite has come from elsewhere; Mynydd-y-gareg is the only other possible source.

Again in the little cliffs of boulder-clay south of Kidwelly Station the quartzite-boulders occur in profusion, though they are absent further to the south-east. The spot to which they have been carried lies W. 30° to 34° S. of the centre of the Mynydd-y-gareg range, and some striæ situated on low ground at Moat, in a position where the direction of ice-flow was not influenced by the local configuration, run W. 29° S.

The direction of the ice, however, varied at times, for much quartzite occurs in the boulder-clay fringing the coast between Kidwelly and St. Ishmael's Church. The only possible sources of the boulders are the Millstone Grit and the Penlan Quartzite, both of which lie to the east, or very little north of east. The direction thus evidenced is in agreement with an observation that there are on the Penlan Quartzite some exceedingly faint striæ pointing nearly due west, in addition to those previously mentioned. But to the south-east, on the high ground south of Five Roads, the gravel-ridges indicate a southerly or south-westerly flow.

So far as regards the western portion of the map under description, such evidence as has been obtained indicates that it was reached by the westward or south-westward glaciation. The adjoining district, however (Sheet 228), furnishes proof of the existence of another and distinct glacial system in which the advance was towards the east or south-east. Probably a relic of glaciation preserved on the Millstone Grit west of Pendine records nearly the farthest point reached by the westward-travelling ice. There a block shews good glacial striæ; though fallen over, it is sufficiently nearly in place to shew that the striæ must have pointed in a general westward direction. On the

other hand some sand and gravel east of Eglwys-Cymmyn bear internal evidence of derivation from a source lying to the north-west or west (p. 147).

The boulder-clay of some extensive tracts lying in the north-easterly part of the map keeps chiefly to the valleys and the low ground. It is somewhat local in character, but contains masses of conglomerate and other sediments, which are unlike any present in the area surveyed and which have probably had a northerly derivation. In Nant-cwm-ffrwd blue till is exposed to a thickness of 20 feet or more, which shews little sign of local derivation. To the west it becomes less prevalent, and in places difficult to separate from hill-wash. Striæ have rarely been preserved, but the Arenig grits are occasionally bevelled, and, in one instance on the flank of a valley at Pant-yr-yn, north-east of Nant-y-caws, they showed striations ranging W. 40° S.

In the Gwendraeth-fâch valley above Llangydeyrn the boulder-clay consists chiefly of Old Red material with a few boulders of older rocks; a good section of it is afforded by a dingle at Tor-y-coed-isaf, one-third of a mile north-west of Crwbin.

At Llangydeyrn the deposit becomes more gravelly and loamy and tends to assume a moundy form. A large and typical mound of sand and gravel was observed on the south bank of the river a third of a mile below Pont Antwn, and the gravelly character of the drift is well shewn in a river-cliff west of Wenallt. To the south, and again east of Rogerlay, the gravel forms a terrace rising 20 to 30 feet above the alluvium, but assumes a characteristic hummocky surface about Gwenllian. The Gwendraeth-fawr below Pontyberem cuts into an elongated mound and shows 8 feet of coarse gravel on 20 feet of loam.

Similar gravels and loams are dotted about over the upland near Brondini and Five Roads. They form ridges or mounds standing up above the boulder-clay and swamps, and in the majority of cases they trend nearly southwards. In one of them, south of Horeb, sand and blue loam were visible with thick boulder-clay above and below. Boulders of Old Red Sandstone occur in the drift all over these uplands.

Gravels are well-developed as terrace-like accumulations at Carmarthen and at the mouth of the Gwili. The lowest terrace reaches an elevation of 50 feet above O.D. near Carmarthen, but northward the gravels slope gradually upward to 100 feet and continue westward as somewhat moundy deposits flanking the old valley which leads from the Towy Valley to the Cywyn Valley at Banc-y-felin. The bottom of this depression is lined with boulder-clay, and the gravels suggest the existence of glacial drainage from east to west. Good sections are displayed in the railway-cuttings at Abergwili and Carmarthen Junctions, in the river-cliffs west of Carmarthen Junction, and in old ballast-pits by the side of the railway north-east of Llanllwch.

In the eastern river-cliff the gravels rest on blue till, but more often they lie directly on the solid rock. They are made up chiefly of shale- and grit-fragments, often almost entirely of shale; they contain exceedingly little quartz, no fragments of Old Red Sandstone or of the minerals andalusite, &c., thus differing markedly from the clean loamy sands and gravels of Eglwys-Cymmyn described below. Their contents are such as may have been derived from the Palæozoic districts lying to the north and north-east.

Near Llangynog the drift west of Glôg-ddu contains very little Old Red material, but rapidly acquires it toward the south, so that in some gullies near Maes-gwyn there is very little other material than Old Red debris. Near Coomb the ice had a strong westerly movement, for fragments of Old Red marl occur in a trace of gravel under Llangynog church, are sprinkled over a field immediately west of Trehyrn, and are abundant in the boulder-clay between Gelli and Llandilo-Abercowin. Near St. Clears the boulder-clay is a blue clay packed with rounded pebbles of Ordovician shale, sandstone and grit. Occasionally it becomes more sandy and loamy, and forms mounds with a light soil. Much of the ground lying east of St. Clears is occupied by a thin coating of this gravelly drift, and gravel-pits have been opened in mounds at Waun ($1\frac{1}{2}$ miles north-east of St. Clears), Plas-y-gwer and Trefanty. South-west of St. Clears similar gravel has been dug at Maes-oland and Mylet; and is exposed at the Rectory (half-a-mile east of Llangynin Church), at Parc-glâs (south of Pwll-trap) and on the Laugharne road between Lower St. Clears and Morfa-bâch. North of the low ground followed by the Great Western Railway the drift rapidly thins away, so that in the deep valleys west of Mydrim there is little or none. At Faynor (near Llandowror) the small patch of gravel shown on the map is made up of Ordovician shale derived from immediately local sources.

Boulder-clay probably of north-eastern derivation has been distributed freely along the lower parts of the valleys of the Towy, the Tâf, and their tributaries. Many of the boulders have been derived from the Old Red Sandstone, but some coarse grits or conglomerates resemble the older beds which crop out to the north-east. Much of the deposit is so gravelly that the distinction of 'Boulder Clay' from 'Sand and Gravel' becomes most difficult.

Two patches of sand occur at an altitude of more than 500 feet above sea-level east of Eglwys-Cymmyn. They appear to lie in hollows in the Old Red Sandstone, as their margins are not marked by any change in the surface-gradient. The larger of the two, south of Castle-tôch, has long yielded sand and gravel in a pit by the side of the main road at the entrance to Castle-tôch. In view of the unusual position and character of the deposit a shaft was sunk, in June 1906, to ascertain its thickness and to throw some light on its age. The shaft proved

alternations of yellow loamy sands with bands of fine and coarse gravel, to a thickness of at least 32 feet, at which depth water rose to a height of 1 foot 6 inches and prevented further sinking.

The following is a summary of the beds passed through:—

							Ft.	In.
Sand and loam	...	...	...	...	...	...	10	2
Gravel, coarse	...	...	...	...	...	...	3	8
Sand and loam	...	...	...	...	...	...	2	4
Gravel	...	...	...	...	...	...	8	1
Sand, clean, base not seen	...	...	...	...	...	...	7	0
							<hr/>	<hr/>
							31	3

The lower layer yielded the sand best suited for building purposes. Some of the gravel was cemented and coated with iron-compounds.

The seams of gravel are made up of a great variety of rocks, the presence among which of Dicranograptus shales, Lower Llandovery sandstones, quartz-porphry, rhyolites, &c., undoubtedly points to the source of the material having lain to the north-west or west. Chalk-flints also are not infrequent.

The sands are loamy, somewhat micaceous, yellow, buff, or grey, and contain an assemblage of minerals almost identical with that which characterises the Lower Pliocene sands of Cornwall (St. Erth and St. Agnes).¹ The chief minerals other than quartz are strongly-pleochroic rose-pink andalusite, together with brown tourmaline, a little cyanite, and staurolite.

In the smaller outlier a pit which has been opened in the lane north of Ebenezer Chapel shows about 7 feet of red and yellow mottled sands, the mineralogical composition of which is identical with that of the sands of Castle-tôch.

These sands and gravels both in their elevated situation and in their composition are quite distinct from all the other sands and gravels to the north and east; on the other hand they are similar to those of undoubted glacial origin met with to the north-west and west.

Chalk-flints in the gravels and certain minerals (*e.g.*, andalusite) in the sands prove that much of the material was primarily derived from areas outside the Principality; the choice lying between Ireland or Devon and Cornwall. It is suggested therefore that either Irish rocks have entered directly into the composition of this drift or, as is more probable, a certain amount of material has been supplied by Tertiary deposits closer at hand, which had their origin in the Cretaceous and older rocks of the West of England.

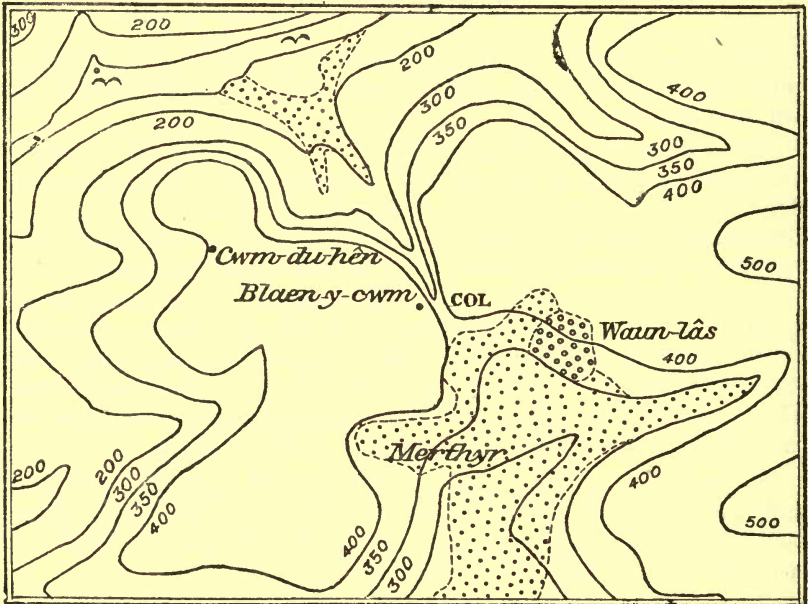
A good example of an overflow-valley may be studied at Cwm-du-hên, north of Merthyr village (Fig. 17). The drainage passed

¹ H. H. Thomas, *Quart. Journ. Geol. Soc.*, vol. lviii, 1902, p. 630.

northward over the east-and-west ridge, on which the village stands, by a *col*, the lowest part of which corresponds in level with a patch of gravel on the 400-foot contour. The gorge to the north was presumably formed by an overflow in a northerly direction when the main valley to the south was filled with ice to the 400-foot level. Similar valleys occur north of Carmarthen beyond the region of the map.

Fig. 17.—*Map of Overflow-Valley at Merthyr.*

(H. H. Thomas.)



Contours are shown in feet. Fine stipple indicates boulder-clay, and open stipple gravel.

In the neighbourhood of Banc-y-felin, behind several elliptical hills of Arenig shales (p. 18), is a cleanly-cut dry valley. It leaves the Cywyn Valley about 400 yards south of the bridge (Pont-Cywyn), passes underneath Gwar-wenallt and Wenallt, ultimately opening out into a tributary valley of the Cywyn to the west of Banc-y-felin. It is probable that this dry valley running almost parallel to the Cywyn marks an overflow channel of late-Glacial age, connected with the present drainage-system.

COEGEN (COYGAN) BONE-CAVE.

This cave is situated near the top of the outlier of Carboniferous Limestone at Honey-cors. The occurrence of bones in it was first noticed in 1866 by Mr. J. R. Allen, and a partial exploration of it was made in 1867 by Dr. Hicks. The cave, according to Dr. Hicks, is about 250 feet above the sea. The entrance

measured 4 feet by 3 feet and led, by a low tortuous passage descending at 30°, to a loftier bifurcating chamber. Sufficient evidence was obtained to prove that the cave had been a hyæna-den.¹

In 1881 a complete exploration was made by Mr. E. L. Jones, in company with Mr. Edward Laws, from whose paper the following account is abstracted.² The bifurcations ended in spouts at 130 feet and 117 feet respectively from the entrance. The floor was covered with stalagmite which had been broken through in one spot only, and which was 12 inches thick in places. Under the stalagmite lay a breccia or cave-earth in which the following remains were discovered :—

Hyæna spelæa, most abundant and of all ages ; coprolites in incredible abundance, many in flattened layers as though trampled on. Many splinters and fragments of bone bearing tooth-marks.

Equus caballus, extremely plentiful ; almost all teeth, a few bones much gnawed.

Elephas primigenius, teeth, varying in age, and a few bones.

Elk (*Cervus alces* ?), a number of teeth, portions of jaws, antlers, and a few bones.

Red Deer and Roe Deer (*Cervus elaphus* and *C. capreolus*).

Reindeer (*C. tarandus*), plentiful teeth, bones, and portions of antlers.

Cave Bear (*Ursus spelæus*), several split and gnawed bones, fine molars and large canines.

Cave Lion (*Felis spelæus*), portion of a fine canine.

Bos (probably *B. primigenius*), three teeth.

Wolf and Fox (*Canis lupus* and *C. vulpes*).

Two flint-flakes evidently chipped by man. These lay beneath 10 inches of stalagmite *in situ*, embedded with bones of mammoth and rhinoceros, and had been oxidised to a white colour.

Several bones which appeared to have been cut by man, one appearing to have been intended for an awl. The awl lay under rhinoceros-bones, which were overlain by stalagmite, and alongside of the two flint-flakes.³

¹ *Geol. Mag.*, 1867, p. 307.

² E. L. Jones, *Quart. Journ. Geol. Soc.*, vol. xxxviii, 1882, p. 282.

³ E. Laws, 'History of Little England beyond Wales,' 1888, p. 7.

CHAPTER XIV.

SUPERFICIAL GEOLOGY (CONTINUED).¹

POST-GLACIAL AND RECENT DEPOSITS.

TERRACES AND DELTAS.

Terraces occur in the Vale of Towy at the points where tributary streams enter it from the north, but should probably be regarded as deltas of the tributaries rather than as high-level terraces of the main stream. Such accumulations are well displayed at the mouth of the Cothi, and to a less degree at that of the Gwili. In the former case the gravels rise sharply from the alluvial level of the Towy, especially to the south-east of the Railway Station, but northwards up the Cothi Valley merge into the alluvial level, the Cothi having cut into its own alluvial flat in order to gain the lower level of the Towy. The terrace at Abergwili is chiefly derived from the glacial sands and gravels, which partially dam the entrance to the Gwili Valley. Small deltas and terraces of gravel mark the mouths of some of the tributaries of the other rivers. The materials are generally derived from the sweeping-out of glacial drift from the valleys by late Glacial and post-Glacial torrents.

PEAT.

Peat occurs frequently in the water-logged hollows between the outcrops of Arenig grits south of Nantgaredig, and a considerable mass occupies a fault-hollow in the Old Red Sandstone south-east of Bwlch-mynydd. The largest mass, about half a square mile in area, has overspread the boulder-clay which forms the water-parting in the Llanllwch Valley; it drains eastward into the Towy with a fall of about 75 feet, and westward into the Cywyn with a fall of not more than 30 feet. Two extensive peat-bogs occur on the Tetragraptus Beds north-east of Llangynog, and many small patches rest on the shales of the Millstone Grit. None of the peat is at present put to any economic use.

Peat consisting of leaves and twigs, with roots of trees in position of growth, occurs on the foreshore south of St. Ishmaels, in a position corresponding to that of the peat-bed of Swansea Bay² and many other parts of the coast of South Wales.

BLOWN SAND.

The Towyn Burrows extend from the mouth of the Gwendraeth in a direction slightly east of south, and are formed of sand-ridges which show a general tendency to assume that

¹ In this chapter each author contributes his observations on the region surveyed by himself.

² 'The Country around Swansea' (*Mem. Geol. Surv.*), 1907, p. 148.

direction. The dunes rise to a little over 50 feet in height, and formerly enclosed shallow pools. These are now all dry. There appears to be a slight tendency for the sand to extend north-westwards from Towyn Point.

The Pendine and Laugharne Burrows range nearly due east and west, and attain a height of 50 feet above sea-level. Like the Towyn Burrows, they are separated from the mainland by a level tract of estuarine silt, which is now drained and cultivated.

The Laugharne sand is uniform in grain with little impalpable material, but it contains abundant fragments of the more delicate shells such as *Tellina*, &c. Although consisting mostly of quartz, it contains the minerals which have been detected in the Glacial sands of Castle-tôch (p. 147), and, in addition, abundant grains of pink garnet, augite, green hornblende, and epidote. The source of the garnet is unknown, for it is absent from all the drift-sands of this sheet of the map, but the other minerals may have been furnished by the igneous rocks or drifts of north and west Pembrokeshire.

Some blown-sand piled against the limestone-cliffs at Pendine has become compacted into a calcareous sand-rock, partly by solutions emanating from the limestone and partly by the redistribution of calcareous matter originally contained in the sand. This cementing is most commonly seen in the blown sand which forms part of the Raised Beach series of deposits, but is not in itself sufficient evidence of the Pendine sand being of that age.

ALLUVIUM.

Very little is known of the thickness of the alluvium of the rivers in this district; in the case of the Gwendraeth-fâch, however, this information has been obtained, in sinking the foundation-cylinders of the railway-bridge which crosses the mouth of the river a short distance N.W. of Kidwelly station.¹

The material passed through was as follows :—

Grey clay with occasional stones and, at a depth of about 30 feet, the trunk of a tree; its contents and the ease with which it was penetrated show that the clay was alluvium, not boulder-clay. Thickness 50–65 feet.

Rubble or gravel, a few feet thick.

Grey shale. (In the debris a piece of clay-ironstone, some plant-remains and an ostracod (?) were found.) Probably referable to the middle or shale-subdivision of the Millstone Grit (p. 83).

¹ For this information we are indebted to Messrs. W. Jones and Stephens.

CHAPTER XV.

ECONOMIC PRODUCTS.

LEAD-ORE.

In the Vale of Towy, east of Carmarthen, several north-and-south veins have been worked or tried for lead-ores, which in some cases have yielded a fair proportion of silver.

At Pont-rhwnws on the Towy, south of Nantgaredig, an old level in Arenig mudstones and grits runs southwards under the road from a point just above the bridge, and on the bank above a shaft was sunk on the vein. From superficial evidence, the vein seems to be on a line of crush in the centre of an anticline, and to be unaccompanied by any displacement. It bears north-east to south-west, but the direction of hade is unknown. The ore appears to have been galena, but it is impossible to learn how much was raised.

On the north side of Merlin's Hill a level has been driven into the hill from a point 150 yards north-west of Merlin's Grove Farm, and a shaft sunk to a depth of about 12 to 13 fathoms on the vein, 100 yards south-west of the adit-mouth. The vein runs north-east to south-west in the Asaphus Ash and Murchisoni Shales (p. 40), but no definite information concerning the date of working or the character of the ore is obtainable.

The most productive veins of the Carmarthen district range, approximately, N.N.W.-S.S.E. across the anticline of Cystanog (Fig. 18). They are fault-fissures, and may be newer than the anticline, which, from analogy to the Llangynog anticline, is of pre-Old-Red-Sandstone age. The chief vein occupies a depression in the grit-ground, and runs in a direction S. 20° E. from the main road to a point east of Nant, then swinging round gradually to the south-east. Its surface-position is marked by old workings, and it is accompanied by a lateral displacement of the rocks. The main portion of the lode underlies east at an angle of 10° to 30° with the vertical, but to the north two shafts sunk on the western side of its surface-position suggest either that it has changed its underlie or has thrown off a westerly branch from a point about 100 yards north of Nant.

The vein consisted of galena, to a certain extent argentiferous, with a little copper-pyrites and zinc-blende, in a gangue of barytes and vein-quartz.

The first authentic records of the mining of this lode appear under the name of the 'Vale of Towy' Mine, and mining returns show that for the fourteen years 1852-1865, 6,286 tons of dressed ore were sold, corresponding to 4,410 tons of metallic lead. The best output for any year was in 1856, when the yield was 838 tons of ore, corresponding to 599 tons of lead. For the six years 1857 to 1862 the yield of metallic lead was 2,623 tons

For four years only during this period, and those not consecutive, did the mine sell ore, and the total amount raised was only 34 tons, giving 24 tons 13 cwt. of lead.

Two other veins have been worked to the east; they underlie east, and their most productive parts lie, as with the 'Vale of Towy,' in the Arenig grits. The more westerly vein was worked by an adit (known as the 'West Level') driven in from the level of the main-road for a distance of about 110 yards; an air-shaft was formed by working the vein to the surface at a point 65 yards from the adit mouth. The easterly vein runs S. 5° W. for about half its course, and then swings round to S. 20° E. in a similar manner to the 'Vale of Towy' lode; this change of direction is due in a small part to the form of the ground. In the grits and conglomerates the vein carries galena, usually argentiferous, in a gangue of barytes and vein-quartz with a little copper-pyrites, zinc-blende, and fahl-ore. In the shales, however, especially in depth, the ore is mixed and consists of galena with an increased proportion of copper-pyrites and zinc-blende, in a gangue of chalybite and vein-quartz. The old workings consisted of shallow pits on the outcrop and of a level driven in on the vein from the main-road. This property constituted the Cystanog Mine, which was closed in 1864.

In 1890 the Carmarthen Lead Mining Syndicate recommenced work on the east lode, and during the period from 1890-1902 drove several levels into Cystanog hill from the north and south. The deep adit (No. 1) was continued for a distance of 570 yards from its entrance, and two levels were driven in on the vein on the north side of the hill, one above the other. The lower level starts 100 yards south of the road and extends 400 yards along the lode; the upper (No. 3) is shallow and driven only for a distance of 65 yards.

On the south side of the hill the 'Penlan levels' were driven northward. 'Penlan No. 1' is higher in the vein than No. 2 of the north side, and has a length of 120 yards. 'Penlan No. 2' is very shallow and 80 yards in length, having been worked to the surface on the top of the bank. Subsequently a shaft was sunk on the eastern side of the vein, at about 55 yards from its surface-position, and was carried to a depth of 52 fathoms in mudstones. At 40 fathoms a cross-cut was made to the deep adit (No. 1), and from the bottom of the shaft a cross-cut struck the vein at a point 30 yards on the western side of the shaft. The vein was followed at this level in a north and south direction for 110 yards. The ore consisted largely of galena, with an average of six ounces of silver to the ton of metallic lead.

The first returns of ore sold were made in 1892, and the output continued fairly steady till 1902, but in 1903 work ceased. For the 11 years 1892 to 1902 the amount of dressed ore totalled 2,700 tons, corresponding to 2,062 tons of lead, and in addition, in the five years 1898 to 1902, the mine yielded 8,392 ounces of silver. The total value of the dressed ore at the mine was £22,122. The greatest yield of lead and silver was in the year

1901, when 444 tons of ore gave 338 tons of lead and 2,225 ounces of silver. The greatest sum realised in any one year was £4,350 in 1900, representing the price of 392 tons of dressed ore containing 298 tons of lead and 1,960 ounces of silver; in this year the silver average rose to 6·7 ounces to the ton of lead. There are no returns after 1902 and at the time of surveying the ground (1904) the mine was inactive.

Several trial-levels and holes have been made, and a certain amount of galena discovered in 1902 on a line of fault north-west of Penlan, but its extent was then unproved.

H. H. T.

Lead-ore has been obtained by means of small shafts at several places along a lode crossing Mynydd-y-gareg in a north-westerly direction, half a mile north-west of Goetre.¹ The country-rock is the upper part of the Carboniferous Limestone, including the Upper Limestone Shales, and the base of the Millstone Grit. The lode appears to have been proved for a course of about 170 yards; in a recent trial-drift at about the mid-point it underlies slightly to either side of the vertical, and contains, according to Messrs. Stephens, 5-6 ounces of silver per ton of lead. The gangue is quartz and calcite.

COPPER-ORE.²

A copper-lode which has been worked by means of several small shafts follows a south-south-easterly course through the Main Limestone of Mynydd-y-gareg from the Lamb and Flag Inn. A few yards north-west of the trial-drift previously mentioned it joins the lead-lode and runs with it for some distance to the south-east. In the combined lodes it is said to occur along the north-east wall. In the drift it was seen that the copper-ore was originally copper-pyrites, and was deposited apart from the lead-ore, but part was subsequently diffused in the form of malachite.

Copper-ore also occurs in other fissures in the Main Limestone of Mynydd-y-gareg, such as bedding-planes, and sometimes to a workable extent, as in drifts, 150 yards south-east of Cenfu and 130 yards south-east of the Lamb and Flag Inn respectively.

E. E. L. D.

IRONSTONE.

Reference has already been made to the clay-ironstone of the Coal Measures (p. 86). The ore was smelted with charcoal in the 17th century at a farm called Furnace, where remains of the blast-furnace and piles of scorïæ were to be seen in 1903. In the early part of the 19th century there were blast-furnaces at Pontyberem and other places.

¹ For information about the old workings we are indebted to Mr. Williams, of Plâs-Antwn.

² For information about the various deposits of copper-ore on Mynydd-y-gareg we are indebted to Mr. Williams, of Plâs-Antwn.

LIME AND LIMESTONE.

Lime was formerly burnt all along the outcrop of the Carboniferous Limestone; at Tor-y-coed (north of Pontyberem) the kilns were extinguished about 1900, at Crwbin about 1888; and at Fan, near Meinciau, one kiln only was working in 1903. The dark limestone and oolite (No. 1, p. 76) has been the part of the limestone most quarried.

The Llandilo Limestone was extensively quarried and burnt at Clôg-y-fran, and the Mydrim Limestone at Castell-gorfod.

The old kilns along the Tâf, Cywyn and Cynin rivers below St. Clears burnt Carboniferous Limestone brought up by boat from Honey-cors (Coegen) or Black Rocks. Limestone (cornstone) from the Old Red Sandstone was formerly quarried near Ferryside (p. 74).

ROTTENSTONE AND PLASTIC CLAY.

These deposits¹ may extend into the eastern part of the area, but have not been worked.

SAND.

A little rotten grit has been dug for building-sand along the outcrop of the basal grit of the Millstone Grit, but apparently is unfit for fire-brick purposes. The best sand for building purposes is yielded by some of the patches of Glacial drift, such as the sands of Castle-tôch and others mentioned on pp. 143-7.

BRICKS AND TILES.

Red bricks and drain-pipes are made from alluvial clay at Lower St. Clears. The farm-houses of Lower Court and New Foxhole have been rebuilt with red bricks imported from Waterford.

Ordovician mudstones are made into bricks at Glan-Gwili, Abergwili.

DINAS FIREBRICKS.

T. C. C.

The Basal Grit of Mynydd-y-gareg, near Kidwelly, is wrought extensively for Dinas or Silica Firebricks. The stone, which is the prevalent tough quartzite, is known locally as 'silica stone,' and is obtained from quarries either in the undisturbed rock or in material that has collapsed into large swallow-holes in the Carboniferous Limestone. The crushed stone is by far the chief constituent of the bricks, but is mixed with sufficient 'clay' and milk-of-lime to render the bricks coherent before being burnt, and durable afterwards.² The 'clay' is shale, free from iron and alkalis, which occurs in the Basal Grit, both in place and as debris in the swallow-holes mentioned above.

The bricks, which are very porous, are speckled with rust derived from particles of iron introduced during manufacture. They are highly resistant if their temperature, though high, remains fairly constant, but crumble readily under alternations

¹ See also 'The Country around Ammanford,' and 'The Country around Merthyr Tydfil' (*Mems. Geol. Surv.*)

² See also 'The Country around Merthyr Tydfil' (*Mem. Geol. Surv.*), 1904, p. 124; further information and Economic Specimens, C. 392 a-i, have been deposited in the Geological Survey Office.

of heat and cold; consequently they are only used for the hottest furnaces, as in the manufacture of steel or glass, or the smelting of copper.

For the following analyses we are indebted to Messrs. H. and H. E. Smart, and Messrs. Stephens and Co. :—

	Stone.		Brick.	
	(1)	(3)	(2)	(3)
SiO ₂	97·5	97·7	96·78	96·15
Al ₂ O ₃	1·4	0·96	0·80	1·79
Fe ₂ O ₃	1·0	0·57	0·71	(FeO) 0·73
CaO	—	0·22	1·71	1·06
MgO and alkalies	trace	—	trace	—
H ₂ O or loss on ignition ...	0·5	0·40	—	0·25
	100·4	99·85	100·00	99·98

(1) Analysis by Mr. W. Morgan.

(2) Analysis by Messrs. W. Morgan and Seyler.

(3) Analyses by Mr. J. S. Merry.

Soft sandstones in the Basal Grit are ground up with a little 'clay' to form the 'cement' in which the bricks are laid when a furnace is being built, and, with the addition of some crushed silica-stone, to form the 'gannister' for the floor of the furnace.

The undisturbed silica-stone is quarried at the following places :—near Greenhall; south-east and south of Llyn (6-inch map); 450 yards north-north-west of Goetre-isaf; 650 yards west of Goetre-isaf. Stone, which has collapsed into a huge swallow-hole, is wrought 200 yards south-west of Graig (6-inch map). Shale, used as 'clay,' occurs interbedded with the quartzites in the quarries near Greenhall and Llyn, and with comparatively soft sandstones in a quarry 300 yards south-west of Llyn. It is also obtained from the quarry near Graig, and from another, in Millstone Grit filling a second swallow-hole, at Glan-hiraeth (6-inch map). The sandstones in the quarries are used for 'cement' and 'gannister.'

POLISHING POWDER.

Polishing powder is made to a slight extent by crushing very fine the Basal Grit of the Millstone Grit from Mynydd-y-gareg.

E. E. L. D.

BUILDING STONES AND ROADSTONE.

Building-stone has been got for local purposes from sandstones in the Old Red Marls; from flaggy green sandstones in the basal beds of the Old Red Sandstone and in the Senni Beds, and from the Pebbly Group at the top of the Old Red series. All varieties of the Carboniferous Limestone have been used on occasion and a black oolitic limestone has been quarried for 'marble' at Laswern near Felindref. Various grits and sandstones in the Millstone Grit and Coal Measures have been quarried for building, and also, as at Maensant, for flags. The only prominent sandstone in the Coal Measures between Pontyberem and Pont-Henry is the Hwch Rock (p. 90). The

Cenrhos Rock and the sandstones of the Pennant Series occur in the south-eastern part of the map, and are quarried further south. Rough building-stone is obtained from the *Tetragraptus* grits and conglomerates, and from the grits and ashes¹ in the *Bifidus* Shales. The Llandilo and Bala limestones² yield flags and building material, and the Lower Llandovery sandstones have been quarried extensively for similar uses. The Bala Limestone at Llandowror is crushed for roadstone.

All the rocks which yield building-stone yield also roadstone; near Llanybre beach-pebbles were being used in 1903. The porphyry of Llangynog³ is employed locally.

WATER SUPPLY.

Carmarthen at one time was dependent on a supply of water derived from wells sunk in the alluvium close to the river Towy, but now receives an excellent and pure supply from impounded streams which drain the Ordovician shale- and grit-country several miles north-east of the town.

Pontyberem and Pont-Henry depend on impounded streams; Trimsaran on water issuing from an old coal-level. St. Clears uses shallow wells and springs; a well at the vicarage, in *Bifidus* Shales, is said to be 73 feet deep; it yields a constant supply, and the water-level stands at 60 feet from the surface. Another fairly deep well has been sunk in the same beds at Croft Lodge close by; at New Foxhole, also, a well 63 feet deep appears to be almost wholly in Glacial sand.

Kidwelly gets its water-supply⁴ from a strong spring, yielding about 25,000 gallons a day, at the base of the Lower Limestone Shales at Capel Sul, 350 yards east-north-east of Arles, and from a spring on a fault at Cae-cefn, north-west of Mynydd-y-gareg. It has been proposed to utilise a strong issue of 70,000 to 80,000 gallons a day from an old drift on a lode at Maes-Gwenllian.

Ferryside is supplied by a spring from the Old Red Sandstone, and Pendine derives its water from a spring which issues at a high level. A powerful stream issues from the base of the Carboniferous Limestone at Felindref; and another strong spring at Cae-gwyllt, nearly a mile to the south-east, arises on the drift-covered shale-subdivision of the Millstone Grit.

A borehole of 11½ inches diameter was made in 1907 for the Great Western Railway Company by the side of the line about two miles north-east of Ferryside. It passed through red and green marls, with conglomerate and grey sandstone, to a depth of 400 feet, and yielded practically no water. All the rocks were hard, close-grained and impervious.

¹ Economic Specimen, 409, of ash from Rhyd-y-ceisiad, St. Clears, has been deposited in the Geological Survey Office.

² Economic Specimens, 408a, 408b, and M. 174, of the Bala Limestone from Llandowror have been deposited in the Geological Survey Office.

³ Economic Specimen, M. 465.

⁴ For this information we are indebted to the District Surveyor.

APPENDIX I.

LIST OF FOSSIL-LOCALITIES IN THE PALÆOZOIC ROCKS OF SHEET 229.

The localities from which the fossils of the Palæozoic rocks of much of this area have been obtained are numerous and difficult to describe. They have therefore been marked upon the MS. coloured copies of the six-inch geological maps preserved in the Geological Survey Office, by symbols, *e.g.*, Wλ3, Eλ3, &c. These maps can be consulted at the office or the fossil-localities on them transcribed on to plain Ordnance maps at the cost of the plain map and the transcription.

In the following list the sheet of the map is indicated by its county and number, *e.g.*, Carm. 40 NE., and the half of the sheet in which the locality occurs by the letter E or W.

Each locality is shown by the Greek letter λ and a number, *e.g.*, λ1, λ2, &c.

The specimens are identifiable by numbers, as registered in the MS. books in the Palæontological Department, *e.g.*, J.P. 1090-5.

Thus the complete entry, Carm. 40 NE. Wλ3, J.P. 1090-5, signifies that the specimens bearing the registered numbers J.P. 1090-5 were found at locality 3, in the western half of the six-inch sheet Carmarthenshire 40 NE.

TREMADOC.

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| 1. Carm. 40 NW. Eλ3 and 4.—H.T. 18-21, 37-45. | 5. Carm. 39 SE. Eλ5.—J.P. 4696-700. |
| 2. Carm. 40 NW. Wλ4.—H.T. 51-3, 123-5. | 6. Carm. 39 SE. Wλ2.—H.T. 109-15, 132-52, 188-204, 364-5. |
| 3. Carm. 39 SE. Eλ9.—J.P. 4730-9. | 7. Carm. 39 SW. Eλ1.—H.T. 76-92, 121-2. |
| 4. Carm. 39 SE. Eλ6.—J.P. 4713-27. | 8. Carm. 39 SE. Eλ3.—H.T. 279. |

ARENIG.

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| 9. Carm. 40 NW. Eλ5.—H.T. 105. | 22. Carm. 39 SE. Wλ1.—H.T. 54-75, 240, 317-9, 377. |
| 10. Carm. 40 NW. Wλ8.—H.T. 168-9, 206-8. | 23. Carm. 39 SE. Wλ5.—J.P. 4654-79. |
| 11. Carm. 39 SE. Eλ8.—J.P. 4707-12. | 24. Carm. 39 SE. Wλ6.—J.P. 4680-5 |
| 12. Carm. 39 SE. Eλ1 and 7.—H.T. 116-8; J.P. 4701-6. | 25. Carm. 39 NE. Wλ5 and 6.—H.T. 205, 271-4. |
| 13. Carm. 39 SE. Eλ4.—J.P. 4692-5. | 26. Carm. 39 NE. Wλ7.—H.T. 278. |
| 14. Carm. 40 NW. Wλ5.—J.P. 3526-38. | 27. Carm. 39 NE. Wλ2.—H.T. 131, 275-6. |
| 15. Carm. 40 NW. Wλ9.—J.P. 3493-525. | 28. Carm. 39 NE. Wλ3.—H.T. 127-30, 254-9. |
| 16. Carm. 40 NW. Wλ6.—J.P. 3539-68. | 29. Carm. 39 SE. Wλ3.—H.T. 183-7, 241-53. |
| 17. Carm. 40 NW. Wλ7.—J.P. 3569-75. | 30. Carm. 39 SW. Eλ2.—H.T. 153-62. |
| 18. Carm. 39 NE. Eλ2.—H.T. 176-8. | 31. Carm. 39 SW. Wλ8.—H.T. 455. |
| 19. Carm. 39 NE. Eλ5.—J.P. 3396-401 <i>b</i> . | 32. Carm. 39 SW. Wλ9.—H.T. 463. |
| 20. Carm. 39 NE. Eλ3.—H.T. 179-82, 209-39, 457, 554; J.P. 3356-95. | 33. Carm. 38 SE. Eλ3.—H.T. 434-7. |
| 21. Carm. 39 SE. Wλ7.—J.P. 4686-91. | 34. Carm. 39 SW. Wλ2.—H.T. 415-6. |
| | 35. Carm. 39 SW. Wλ3.—H.T. 441-6. |
| | 36. Carm. 45 NE. Eλ2.—T.C.C. 643-54 <i>b</i> . |

ARENIG—cont.

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| <p>37. Carm. 45 NE. Eλ3.—T.C.C. 655-62.</p> <p>38. Carm. 45 NE. Eλ1.—T.C.C. 444.</p> <p>39. Carm. 39 NW. Eλ3.—H.T. 448 ; J.P. 3791-3.</p> <p>40. Carm. 38 NE. Eλ4.—H.T. 387-90 ; J.P. 3799-804.</p> <p>41. Carm. 38 NE. Wλ6.—J.P. 4740-8.</p> <p>42. Carm. 38 SE. Wλ3.—H.T. 326-48.</p> <p>43. Carm. 38 SE. Wλ2.—H.T. 349-50.</p> <p>44. Carm. 38 SE. Wλ4.—H.T. 401-9, 462.</p> <p>45. Carm. 39 SW. Wλ4.—H.T. 320, 439-40, 450.</p> <p>46. Carm. 38 SE. Eλ1.—H.T. 352, 718-21.</p> <p>47. Carm. 38 SW. Eλ1.—T.C.C. 739-40 ; J.P. 4937-47.</p> | <p>48. Carm. 38 SW. Eλ5.—T.C.C. 750-64 ; J.P. 4877-84.</p> <p>49. Carm. 38 SW. Wλ14.—J.P. 4924-9.</p> <p>50. Carm. 38 SW. Wλ2.—T.C.C. 769-81.</p> <p>51. Carm. 38 SW. Wλ6.—T.C.C. 789-91.</p> <p>52. Carm. 37 SE. Eλ6.—T.C.C. 836-48.</p> <p>53. Carm. 37 SE. Wλ6.—Pr. 573-605.</p> <p>54. Carm. 37 SE. Wλ3.—T.C.C. 888-93 ; Pr. 606-25.</p> <p>55. Carm. 37 NE. Eλ6.—Pr. 525-31.</p> <p>56. Carm. 37 SE. Wλ5.—T.C.C. 901-7.</p> <p>57. Carm. 37 NE. Wλ2.—Pr. 509-20, 555-60.</p> |
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LLANVIRN.

Didymograptus bifidus Beds.

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| <p>58. Carm. 40 NW. Wλ11.—J.P. 4930-5.</p> <p>59. Carm. 39 NE. Wλ13.—J.P. 4936.</p> <p>60. Carm. 39 NE. Wλ1.—H.T. 166-7.</p> <p>61. Carm. 39 NE. Eλ4.—H.T. 282-316.</p> <p>62. Carm. 39 NW. Eλ2.—J.P. 3490-2.</p> <p>63. Carm. 39 NW. Wλ4.—J.P. 4768-9.</p> <p>64. Carm. 38 NE. Eλ5.—J.P. 4754-67.</p> <p>65. Carm. 38 NE. Wλ7.—J.P. 4749-53.</p> <p>66. Carm. 39 NW. Wλ3.—J.P. 4728-9.</p> <p>67. Carm. 38 NE. Eλ6.—H.T. 564-7 ; J.P. 4795-800.</p> <p>68. Carm. 38 NE. Eλ1.—H.T. 391-3 ; J.P. 3486-9.</p> <p>69. Carm. 38 NE. Wλ4 & 9.—H.T. 458-90 ; J.P. 4772-94.</p> <p>70. Carm. 38 NW. Wλ7.—H.T. 551.</p> <p>71. Carm. 38 NW. Wλ1.—H.T. 383-5, 418-20.</p> <p>72. Carm. 38 NW. Wλ12 & 13.—J.P. 4851-65.</p> <p>73. Carm. 38 NW. Wλ10.—H.T. 556-60.</p> <p>74. Carm. 38 NW. Wλ9.—H.T. 482-7.</p> <p>75. Carm. 38 NW. Wλ8.—H.T. 491-512 ; J.P. 4809-50.</p> <p>76. Carm. 38 SW. Wλ15.—J.P. 4948-50.</p> <p>77. Carm. 37 SE. Eλ2.—T.C.C. 822-3.</p> <p>78. Carm. 37 NE. Eλ7.—Pr. 561-4.</p> <p>79. Carm. 37 NE. Eλ1.—T.C.C. 713-16b.</p> | <p>80. Carm. 37 NE. Eλ2.—T.C.C. 717-8.</p> <p>81. Carm. 39 SW. Eλ4.—H.T. 417, 458, 464-5.</p> <p>82. Carm. 39 SW. Eλ3.—H.T. 163-5.</p> <p>83. Carm. 39 SW. Wλ11.—J.P. 3796-8.</p> <p>84. Carm. 39 SW. Wλ5.—H.T. 353-60.</p> <p>85. Carm. 39 S.W. Wλ6 & 7.—H.T. 400, 459-60.</p> <p>86. Carm. 39 SW. Wλ10.—H.T. 470.</p> <p>87. Carm. 38 SE. Eλ4 & 5.—H.T. 322, 351 ; 321, 362-3.</p> <p>88. Carm. 38 SE. Eλ2.—H.T. 452.</p> <p>89. Carm. 38 SE. Wλ9.—H.T. 394.</p> <p>90. Carm. 38 SE. Wλ6.—H.T. 361, 396-7.</p> <p>91. Carm. 38 SE. Wλ1.—H.T. 410-4.</p> <p>92. Carm. 38 SE. Wλ8.—H.T. 386.</p> <p>93. Carm. 45 NE. Wλ4.—T.C.C. 453-9 ; J.P. 3407-19.</p> <p>94. Carm. 45 NE. Wλ9.—T.C.C. 730-4.</p> <p>95. Carm. 45 NE. Wλ1.—T.C.C. 445-7, 1141-2 ; J.P. 3420-69.</p> <p>96. Carm. 45 NE. Wλ2.—T.C.C. 448-51 ; J.P. 3470-85 ; Pr. 1648-61.</p> <p>97. Carm. 45 NW. Eλ4.—T.C.C. 467-71 ; J.P. 4952-78.</p> <p>98. Carm. 38 SW. Eλ2.—T.C.C. 741-2 ; J.P. 4885-900.</p> <p>99. Carm. 38 SW. Eλ6.—J.P. 4868-76.</p> |
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LLANVIRN—cont.

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| 100. Carm. 38 SW. Eλ3.—T.C.C.
743-5; J.P. 4916-23. | 104. Carm. 38 SW. Wλ10.—T.C.C.
807. |
| 101. Carm. 38 SW. Wλ7.—T.C.C.
792-7; J.P. 4901-15. | 105. Carm. 45 NW. Wλ10.—T.C.C.
546-65, 664-6. |
| 102. Carm. 38 SW. Wλ1.—T.C.C.
765-8. | 106. Carm. 44 NE. Eλ6.—T.C.C.
672-4. |
| 103. Carm. 38 SW. Wλ9.—T.C.C.
803-6. | 107. Carm. 37 SE. Wλ1.—T.C.C.
856-81. |

Didymograptus murchisoni Beds.

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| 108. Carm. 40 NW. Wλ1.—H.T.
6-11, 93-5. | 111. Carm. 38 NE. Wλ1.—H.T.
429-30. |
| 109. Carm. 39 NE. Eλ1.—H.T. 106,
126, 170. | 112. Carm. 38 NW. Eλ3.—H.T. 380,
426-8. |
| 110. Carm. 31 SE. Wλ2.—H.T.
260-2. | 113. Carm. 37 NE. Eλ3.—T.C.C. 719. |

LLANDILO.

Llandilo Flags.

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| 114. Carm. 38 NW. Eλ4.—H.T.
372-3, 548-9. | 117. Carm. 45 NW. Eλ5.—T.C.C.
472-80. |
| 115. Carm. 38 NW. Wλ4.—H.T.
431-3. | 118. Carm. 45 NW. Wλ15.—T.C.C.
596-604. |
| 116. Carm. 40 NW. Wλ10.—J.P.
4171-85, 4212-8; P.S. 27. | 119. Carm. 37 SE. Wλ9.—Pr. 642-
59. |

Hendre Shales.

120. Carm. 38 NW. Eλ5.—H.T. 366-8, 550.

BALA.

Mydrim Limestone and Shales.

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| 121. Carm. 38 NW. Wλ5.—H.T.
323-5; J.P. 4801-8. | 125. Carm. 38 NW. Eλ6.—H.T.
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| 122. Carm. 40 NW. Wλ3.—H.T. 46-
50; J.P. 4186-8. | 126. Carm. 38 NW. Wλ2 & 3.—H.T.
369-70, 447. |
| 123. Carm. 40 NW. Eλ2.—H.T.
13-17, 30-6, 119-20; J.P.
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720-5. |
| 124. Carm. 38 NW. Eλ1.—H.T.
374-6, 421-2. | 128. Carm. 45 NW. Wλ2.—T.C.C.
513-8, 1140. |

Bala Limestone.

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| 129. Carm. 45 NW. Eλ1.—Pr. 466-
500; T.C.C. 460-2. | 134. Carm. 45 NW. Wλ1.—T.C.C.
508-12; Pr. 37-54. |
| 130. Carm. 45 NW. Wλ14 & 17.—
T.C.C. 583-95; Pr. 201-51. | 135. Carm. 44 NE. Eλ10.—Pr. 287-
329. |
| 131. Carm. 45 NW. Eλ9.—T.C.C.
495-502; Pr. 55-100. | 136. Carm. 44 NE. Eλ9.—Pr. 269-
86. |
| 132. Carm. 45 NW. Eλ7 & 8.—T.C.C.
484-7, 488-94; J.P. 4979-93,
4994-5000; Pr. 1-36. | 137. Carm. 37 SE. Wλ8.—Pr. 638-
41. |
| 133. Carm. 45 NW. Wλ13.—T.C.C.
579-82; Pr. 101-6. | 138. Carm. 37 SE. Wλ7.—Pr. 626-
37. |

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| 139. Carm. 45 NW. Wλ5.—T.C.C.
526-8; Pr. 107-200. | 142. Carm. 44 NE. Wλ4.—Pr. 350-81. |
| 140. Carm. 44 NE. Eλ3.—T.C.C. 667. | 143. Carm. 44 NE. Wλ1.—T.C.C.
677-8. |
| 141. Carm. 44 NE. Wλ5.—Pr. 435-65. | |

LOWER LLANDOVERY.

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| 144. Carm. 44 NE. Wλ2.—T.C.C.
679-80. | 145. Carm. 44 NE. Wλ3.—T.C.C.
681-712; Pr. 382-434. |
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OLD RED SANDSTONE.

Upper.

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| 146. Carm. 46 SE. Wλ1.—Pr. 1599. | 149. Carm. 53 NE. Wλ9.—E.D. 241-5. |
| 147. Carm. 53 NW. Eλ1.—E.D. 246. | 150. Carm. 53 NE. Wλ13.—Pr.
1596-8. |
| 148. Carm. 53 NW. Eλ2.—E.D. 247-9. | |

Lower.

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| 151. Carm. 53 NW. Wλ1.—E.D. 232. | 153. Carm. 53 NW. Wλ3.—E.D. 233-
40, 304, 306-9; J.P. 3770-7,
3787-90. |
| 152. Carm. 53 NW. Wλ2.—E.D. 296-
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|--|---------------------------------------|
| 154. Carm. 53 NE. Wλ5.—E.D. 250,
252-62, 681-4, 938-46. | 155. Carm. 53 NE. Wλ6.—E.D.
685-7. |
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Seminula Zone.

156. Carm. 46 SE. Eλ2.—Pr. 1628-47.

Dibunophyllum Zone.

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|--|---|
| 157. Carm. 53 NE. Wλ4.—E.D. 266-
7, 480. | 160. Carm. 53 NE. Wλ3.—E.D. 276-
7, 458-9. |
| 158. Carm. 53 NE. Wλ7.—E.D. 264-
5; Pr. 1600-3. | 161. Carm. 53 NE. Wλ1.—E.D. 282,
436-7, 947-8. |
| 159. Carm. 53 NE. Wλ2.—E.D. 268-
74, 455-7, 460; Pr. 1604-27. | |

MILLSTONE GRIT.

Basal Grit.

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| 162. Carm. 51 NE. Wλ1.—E.D. 423;
Pr. 2361-71. | 163. Carm. 51 NE. Wλ2.—E.D.
424-8. |
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COAL MEASURES.

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|---------------------------------------|---|
| 164. Carm. 47 SW. Wλ1.—T.C.C.
618. | 166. Carm. 54 NW. Wλ2.—E.D. 950-
64; Pr. 3890-5. |
| 165. Carm. 53 SE. Eλ1.—E.D. 291. | 167. Carm. 54 NW. Wλ3.—E.D. 290. |

LLANDILO.

Llandilo Flags and Limestones.

- Lingula tenuigranulata *M^cCoy*, p. 41.
 Lingula sp., p. 40.
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 Orthis *cf.* porcata *M^cCoy*, p. 40.
 Orthis sp., pp. 40, 41.
 Orthis (*Dalmanella*) elegantula *Dalm.*, p. 41.
 Orthis (*Dalmanella*) testudinaria *Dalm.*, pp. 40, 41, 44.
 Orthis (*Hebertella*) vespertilio *J. de C. Sow.*, pp. 41, 44.
 Orthis (*Platystrophia*) biforata (*Schloth.*), p. 44.
 Plectambonites sericea (*J. de C. Sow.*), p. 41.
 Plectambonites *cf.* sericea (*J. de C. Sow.*), p. 40.
 Plectambonites sericea (*J. de C. Sow.*), *var.*, p. 41.
 Plectambonites sp., pp. 41, 44.
- Rafinesquina *cf.* deltoidea (*Conr.*), p. 41.
 Rafinesquina llandiloensis (*Dav.*), p. 44.
 Rafinesquina llandiloensis? (*Dav.*), p. 40.
 Rafinesquina *cf.* semiglobosa (*Dav.*), pp. 40, 41.
 Beyrichia complicata *Salt.*, p. 41.
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 Asaphus tyrannus *Murch.*, pp. 41, 44.
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 Calymene cambrensis *Salt.*, p. 41.
 Calymene cambrensis? *Salt.*, p. 40.
 Ogygia buchi (*Brongn.*), p. 40.
 Trinucleus *cf.* concentricus (*Eaton*), p. 40.
 Trinucleus concentricus, *var.* favus *Salt.*, p. 44.
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- Dicellograptus *cf.* divaricatus *Hall*, p. 49.
 Dicellograptus sp., p. 49.
- Diplograptus (*Mesograptus*) foliaceus *Murch.*, *var.*, p. 49.
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Mydrim Shales.

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 Climacograptus antiquus *Lapw.*, *var.*, p. 50.
 Climacograptus implicatus *Hopk.*, p. 50.
 Climacograptus minimus (*Carr.*), p. 51.
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 Diplograptus (*Mesograptus*) multidentens *E. & W.*, p. 52.
 Diplograptus (*Mesograptus*) multidentens *E. & W.*, *var.* compactus *Lapw.*, pp. 50, 52.
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- Favosites fibrosus (*Goldf.*), p. 56.
 Heliolites interstinctus (*Linn.*), p. 56.
 Orthis (*Dinorthis*) flabellulum? *J. de C. Sow.*, p. 56.
 Plectambonites sericea (*J. de C. Sow.*), p. 57.
- Cybele rugosa (*Portl.*), p. 57.
 Cybele verrucosa (*Dalm.*), p. 56.
 Illaenus bowmanni *Salt.*, p. 57.
 Lichas laxatus *M^cCoy*, p. 56.
 Stygina latifrons (*Portl.*), p. 57.
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Heterocrinus?, p. 61.
Hemicosmites rugatus Forbes, p. 60.
Cf. Placocystites sp., p. 59.
Cornulites serpularius Schloth., p. 61.
Monticulipora sp., p. 59.
Phyllopora cf. hisingeri (McCoy), p. 59.
Ptilodictya acuta (Hall), p. 59.
Ptilodictya dichotoma Portl., p. 60.
Cf. Catazyga anticostiensis (Bill.), pp. 59, 61.
Christiania tenuicincta (McCoy), p. 61.
Leptaena rhomboidalis (Wilck.), pp. 59, 60.
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Orthis calligramma Dalm., p. 59.
Orthis crispa McCoy, p. 60.
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Rafinesquina cf. expansa (J. de C. Sow.), p. 60.
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Cheirurus subquadratus Reed, p. 59.
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LOWER LLANDOVERY.

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OLD RED SANDSTONE.

Lower.

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- Chætetes sp., p. 79. Orthothetes *cf.* crenistria (*Phill.*), p. 79.
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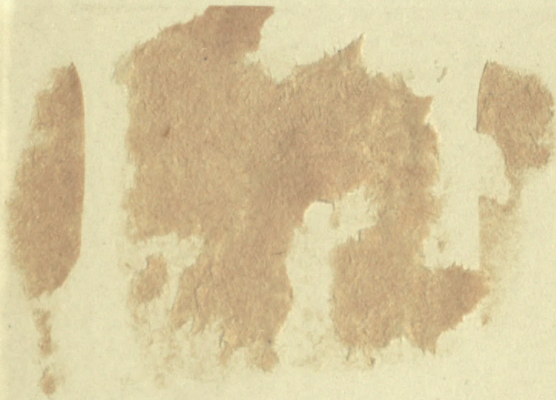
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