28. *The ORDOVICIAN ROCKS of WESTERN CAERMARTHENSHIRE.*

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[PLATE XLVI—MAP.]

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I. INTRODUCTION.

THIS little contribution to the geology of Caermarthenshire is the result of leisure-work done during some years' residence in the district.

The ground dealt with is practically identical with that examined by the late Thomas Roberts, M.A., whose notes were published in the Quarterly Journal of this Society for May 1893 (vol. xlix): that is, from the River Cywyn on the east to the Tawe on the west, and from the base of the Old Red Sandstone on the south to the top of the *Dicranograptus*-Shales on the north—roughly, a rectangular tract of country 11 miles long by 6 miles wide.

(1) Previous work done.—George Owen, of Henllys, as long ago as the year 1595, had given some attention to the economic geology of the district, and in a manuscript, an extract from which is appended to Richard Fenton's 'Historical Tour through Pembroke-shire,' refers to certain limestone-bands that occur here, noting, by the way, the proximity of limestones to the coal-deposits of the country. This inference has, from time to time, led to much expenditure of labour and money in a futile search for coal. Levels were driven and pits were sunk; but, of course, no coal was found—except in the fertile imagination of credulous though well-meaning people.

The district was examined by the officers of the Geological Survey in 1842, and the results of their labours are recorded in Sheets xli (Map) and 13 (Sections).

John Phillips, in his Memoir on the Malvern and Abberley Hills, records a fairly-long list of fossils collected here. The graptoliticiferous rocks of the district have had the attention of Prof. Lapworth; and the late Thomas Roberts, M.A., of Cambridge, had proceeded some way with the working-out of the ground when his valuable life was cut short, leaving the task unfinished. His notes, however, fell into competent hands, and were placed on record, as stated above. They have proved of great help to me, and may be considered as the basis of this humble effort.

Between the years 1885 and 1899, I got together a fairly-large and representative collection of fossils. The graptolites were exhibited at the meeting of the Royal National Eisteddfod held at Merthyr Tydvil in the summer of the latter year; and again, a general collection was exhibited at the meeting held at Llanelly in 1902.

A portion of the area is now being surveyed by the officers of H.M. Geological Survey—Messrs. T. C. Cantrill, B.Sc., and H. H. Thomas, M.A., B.Sc.; with them I have had the pleasure of going over much of the ground, and to them I am indebted for much kind encouragement and valuable advice.

(2) References.—

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II. GENERAL REMARKS.

(1) Physical Structure.—The dips and the general relation and arrangement of the various rocks prove that the area is, in the main, a denuded anticlinal fold of considerable extent, with an east-and-west axis. The ground has, however, been much complicated by inner and minor folds accompanied by a great deal of faulting and crushing. There is abundant evidence that the main fold was thrown over to the south, and that further complications have been brought about by subsequent fractures and thrusts among the minor, subsidiary folds, with the result that, in some instances, older beds have been brought to the surface and pushed some distance over newer ones. Examples of overfolding and thrusting are numerous and perplexing, especially when they occur in shales of *Tetragraptus*- and *Didymograptus-bifidus* age.

As a natural outcome of these great closing-up movements, rocks that had been deposited over wide areas and under very different conditions have been brought together within the comparatively-narrow limits of the district under consideration. In other words, points that are now within 3 or 4 miles of one another were, previous to the movements, four or five times that distance apart. Certain beds in the northern limb of the fold are lithologically distinct from corresponding beds, that is, beds of the same age, in the southern limb; and, what is of greater significance, there is considerable difference in the character of the faunas. For instance, on the south the *Didymograptus-Murchisoni* Beds, if at all present, are very poorly developed; the *Asaphus-tyrannus* Beds are highly calcareous, and in one instance thickly-bedded limestones; and the Bala-Caradoc rocks are well developed, and contain two or three strong bands of limestone. While on the north the *D.-Murchisoni* Beds are well-formed and persistent; the *Asaphus-tyrannus* Beds are thin and ashy, with hardly a trace of calcareous matter; and the Bala-Caradoc rocks are represented by some blue-black mudstones which make but a poor show. On the north, there is also a calcareous development in the *Dicranograptus*-Shales with a rich graptolite-fauna—features which are entirely absent on the south. (See figs. 1 & 2, p. 600.)

(2) Faulting.—The majority of the faults, as might be expected, are strike-faults, running east and west. Those on the north usually hade northward at various angles, many of them being thrusts. On the south there are but few thrusts, the majority of the faults being normal. There are very few dip-faults, and where they occur they are of small extent.

The rocks forming the core of the anticline are much crushed. Especially is that the case along a line traced from near Banc-y-felin to Llangynin Church, and thence to Aberdeunant. Near that place, the line of disturbance probably splits, forming faults which account for the features of the country farther west; that is, the bringing to the surface of older and more gritty beds north of Whitland—these latter having also suffered much from folding and faulting.

There is another line of disturbance running from near Asgood, past Blue Boar and Llainedlyn to a point south of Clôg-y-frân. This disturbance presumably accounts for the disappearance eastward of the Woolston and Clôg-y-frân ashes.

The ground round Clôg-y-frân and Forest has been much affected by faulting. At the former place, strata of *Didymograptus-bifidus* and *Asaphus-tyrannus* age, and two types of Bala-Caradoc rocks, can be studied in the farmyard; and at the latter Bala-Caradoc rocks have been sandwiched between two slices of *D.-bifidus* Beds in one locality, and between *D.-bifidus* beds and Lower Llandovery (?) beds in another close by, while the *D.-bifidus* Beds themselves, including the ashes, have been very much cut up.

The Bala-Caradoc rocks west of Llanddowror have also suffered a

Fig. 1.—Semi-diagrammatic section from north to south, near Caerllion.
(Marked on the map, Pl. XLVI, as 'Section V'.)

Fig. 2.—Semi-diagrammatic section from north to south, near Clôy-ŷ-fân.
(Marked on the map, Pl. XLVI, as 'Section IV'.)

great deal, so much so in fact, that only an imperfect idea of the actual conditions can be gleaned from what can be represented on a 1-inch map.

North of the main axis, a line of extensive disturbance commences near Castell-gorfod, and runs slightly north of west, past Penlan and Nant-yr-eglwys to Llanboidy, and thence to Llanglydwen, the structure of the ground increasing in complexity as it passes westward. Some of the ground near Penlan, Nant-yr-eglwys, and south of Eglwys-fair-a-churig is very obscure and difficult of interpretation.

(3) Cleavage.—The rocks in the northern limb of the fold are more or less affected by cleavage. In the lower beds it is slight, but very pronounced in the upper, increasing in intensity as it is traced northwards. Thus the *Didymograptus-bifidus* Beds are only slightly affected, the *D.-Murchisoni* Beds more so, and the *Dicranograptus*- and higher beds so much at some points as to become quite slaty.

The faulting was anterior to the cleavage, for the latter is quite independent of the former. Dips vary a great deal both in inclination and in direction, but the cleavage-planes are tolerably uniform and constant, running east and west with an inclination of about 45° north, or, occasionally, a little east of north.

On the south there is an almost complete absence of cleavage; only in one or two localities—in black *Dicranograptus*-Shales—can its occurrence be suspected.

(4) Igneous Rocks.—North of Llanboidy and extending from a point about a quarter of a mile west of Maesgwynne House to the Fenni Valley, near Maencoch, there is an intrusion of diabase. This 'dyke' crosses outcrops of *Didymograptus-bifidus* Beds, *Asaphus-tyrannus* Beds, and, for some distance, penetrates into *Dicranograptus*-Shales. It also crosses at least one of the main faults, without appearing to be in the least displaced by it. In some places, the rocks in contact with the dyke show evidence of slight baking, but the portion affected is only a few inches thick.

At Glyntaf House, a mile south of Llanglydwen, are two exposures of diabase extending for a short distance east of the Tave, the bed of which is here much encumbered by huge masses of the rock. The northernmost is seen in section in a railway-cutting near the round cottage, as well as in the old quarry behind the cottage itself. There it is seen to cut obliquely through cleaved ash of a greyish-green colour. The other exposure also abuts on the railway, but about a quarter of a mile farther south. This dyke has been somewhat extensively quarried immediately west of Glyntaf, but seems to die out at no great distance to the east. West of the Tave both dykes are much more developed, and seem to be an eastward extension of the volcanic rocks of the Prescelly country farther west.

(5) Contour, etc.—The district is drained by the River Tave and its feeders, which have hollowed out for themselves numerous deep valleys and dingles. The general direction of these valleys

is across the strike, and they have thus cut up the country into a series of ridges and hummocky hills, few of which reach an altitude of 600 feet. These dip-valleys afford numerous rock-exposures, but none too many to enable the geologist to interpret so complex a structure with any degree of confidence.

The peculiar hollow extending west of Caermarthen by way of Llanllwch traverses the whole length of the district with a few slight variations, falling in with the Tave Valley west of St. Clear's. On the south, the ground rises towards the Old-Red-Sandstone ridge; and on the north it forms a broken upward slope to the high ground, which here may be considered as the eastward continuation of the Prescelly Hills.

(6) Drifts.—On the whole, the country is fairly free from surface-accumulations, such as Boulder-Clay and other drifts. There is some alluvium in the valleys, especially as they approach the sea; but in their upper reaches, where they are generally very narrow, the quantity is practically negligible.

In the vicinity of St. Clear's, some Boulder-Clay and gravel are found. A patch of the former near Morfa-bach is in places impregnated with ferruginous matter, deposited probably by spring-water rising from the underlying pyritous shales. This feature has led to much fruitless endeavour to find coal.

Near Trefanty, Morfa-bach, and Mylet, a considerable quantity of sand and gravel occurs. In a pit near the first-named place there is a fair sample of oblique and contorted bedding.

Gravel is also dug on the high ground north-east of Glyntâf, as well as near Maesgwynne, and at two or three points in the Gynin Valley.

III. THE SUCCESSION AND DETAILED DESCRIPTION OF THE ROCKS.

TABLE I.—THE SUCCESSION IN THE NORTHERN LIMB OF THE ANTICLINE.

BALA-CARADOC. ¹	(?).....	{ Brown-grey mudstones, shales, and grits.
		{ Black slaty beds, with <i>Dicranograptus</i> .
		{ Ashy black shales, with lenticular bands of limestone, containing <i>Dicranograptus</i> , <i>Leptograptus</i> , etc.
	{ <i>Dicranograptus</i> -Beds.	{ Black shales and mudstones weathering buff and yellow, containing graptolites and trilobites.
		{ Black shales, with crowds of <i>Diplograptus</i> and shells.
LLANDEILO.	{ <i>Asaphus-tyrannus</i> -Beds.	{ Ashy beds and sandy flags, with <i>Asaphus tyrannus</i> , etc.
		{ Striped gritty flags, with abundance of <i>Didymograptus Murchisoni</i> .
	{ <i>D.-Murchisoni</i> Beds.	{ Blue-grey ash, weathering rusty brown.
		{ Soft mudstones, with crowds of <i>Didymograptus Murchisoni</i> .
LLANVIRN.	{ <i>D.-bifidus</i> Beds.	{ Shales, mudstones, and bands of ash, with graptolites and trilobites.

¹ 'Bala-Caradoc' includes beds of the Shropshire type and Sedgwick's 'Upper Bala.'

TABLE I. (*continued*).

ARENIG.....	} <i>Tetragraptus</i> - Beds.	(Blue-black shales and mudstones containing <i>Tetragraptus</i> and trilobites.
		Striped flaggy shales, with <i>Ogygia marginata</i> , etc.
		Gritty beds, with <i>Dictyograptus</i> and <i>Dendrograptus</i> .
		<i>Orthis</i> -mudstones.
		Grits and conglomerates, with <i>Orthis</i> and trilobites.
		Black ashly shales, with local bands of blue ash.
		Blue-black shales, with few fossils.

TABLE II.—THE SUCCESSION IN THE SOUTHERN LIMB OF THE ANTICLINE.

LOWER LLANDOVERY		{ Grey sandstones and flags, with black mudstone-partings—very few fossils.
		Grey grit and conglomerate.
	Slade Beds.	{ Blue-grey mudstones, with bands of shelly limestones—usually rotten.
	Redhill Beds.	{ Blue-grey mudstones, with trilobites and brachiopods (<i>Trinuclius seticornis</i> , etc.).
BALA-CARADOC.	Shoeshook Beds.	{ Arenaceous limestones, with many fossils.
	Robeston-Wathen Limestone.	{ Black limestones, with calcareous shale-partings.
	<i>Dicranograptus</i> -Shales.	{ Black shales, with graptolites, etc.
LLANDEILO	<i>Asaphus-tyrannus</i> Limestone.	{ Black limestones, with <i>Asaphus tyrannus</i> and <i>Ogygia Buchii</i> .
	<i>D.-Murchisoni</i> Beds.	{ Black mudstones, with <i>Didymograptus Murchisoni</i> (?)
LLANVIRN	<i>D.-bifidus</i> Beds.	{ Black shales and mudstones, with bands of ash, and containing <i>Didymograptus bifidus</i> , etc.
ARENIG	<i>Tetragraptus</i> -Beds.	{ As in Table I.

(a) Arenig Rocks.

These are the oldest rocks exposed within the area, and occupy a belt of ground extending from Banc-y-felin on the east, to Login on the west. East of the Fenni Valley the ground is generally low—being part of the peculiar hollow referred to on p. 602, but to the west the ground is more hilly and broken. This variation is accounted for, principally by a difference in the character of the deposits. The beds in the lower ground consist almost entirely of shales and mudstones, while in the high ground west of the Fenni there is a considerable development of grits and conglomerates.

The shales and mudstones are usually black and iron-stained. The staining varies from deep chocolate to iridescent black. Concretionary structure is very common; and, on splitting, the surfaces of slabs present numerous wavy concentric lines of light and dark tints. This characteristic feature is a very useful means

of recognizing the beds in the absence of fossils—and these are generally very scarce. Without some such guide, it would be often impossible to distinguish these beds from others higher in the succession.

The grits and conglomerates west of the Fenni vary considerably in thickness, colour, and texture. All the evidence available points to their being a local development in the *Tetragraptus*-Beds, and there are strong reasons for believing that their real is much greater than their apparent extent, for they have been subjected to much folding and faulting. One very noticeable feature which they present is that they are exposed on the higher ground much more extensively than in the valleys—capping the hills in gentle folds which do not often reach the lower ground.

(1) The Lowest Shales.—The lithological character of the very lowest beds is that of the usual *Tetragraptus*-Shales of the district, but they contain fossils very sparingly, so sparingly that it is difficult to fix their age definitely. In the absence of sufficient proofs to the contrary, they are here placed at the base of the Middle Arenig—or *Didymograptus-extensus* zone.

These shales are well and abundantly exposed in the neighbourhood of Whitland Abbey. They are seen all along the road leading from that place to Pass-by Cottages on the north-west. They contain very few fossils here, and those that do occur are in a very fragmentary state. Among others are trilobites—probably *Æglina*, a *Palæarca*, and an *Orthoceras*. Similar beds are seen at Cwmfelin-boeth, near the small bridge on the Whitland road. These have yielded an *Orthoceras*, a *Trinucleus*, and some small fragments of an unidentifiable graptolite. The blue-black mudstones in the quarry on the roadside a short distance farther south, undoubtedly belong to the same series. Some trilobite-fragments have been collected here, but were so badly distorted that only with hesitation could they be assigned to the genus *Æglina*.

These beds also come to the surface at frequent intervals in the valley of the Gronw, and here they have yielded some extensiform graptolites a little to the north of the Old Cottage, north-east of Llwyngwydd. The graptolites here are associated with *Orthoceras* sp., *Caryocaris*-tails, and *Orthis Carausii*, Salt. A few graptolite-fragments were collected also from the small section immediately south of Penyglog, and were associated with *Æglina*, *Theca*, and *Orthoceras*.

Certain shales are abundantly exposed near Pantgwyn and Aberdauddwr in the Nantclomendy valley. Some of them undoubtedly belong to this horizon, but whether those occurring in Aberdauddwr farmyard are of this age may be questioned. As regards texture and colour, these are much like the Upper *Tetragraptus*-Beds; but graptolites, though present, are very scarce and fragmentary. Other fossils collected here are:—*Æglina* sp., *Trinucleus* sp., *Agnostus* cf. *M'Coyii*, Salt., *Beyrichia*, *Orthis* cf. *Menapica*, Hicks, and *Lingula* sp.

(2) Ashy Mudstones, etc.—Passing upwards, the blue-black shales become coarser in texture, and take on the character of ashy mudstones, becoming gritty as they near the base of the grits. They are sparingly fossiliferous, except in some bands in which specimens of *Orthis Carausii*, Salt, are fairly numerous. They yield a few dendroid graptolites—the forerunners of the great profusion which was to appear later. Within these beds are several igneous bands, some of which attain a thickness of between 3 and 4 feet. These are best seen in the old quarry on the brow of the hill north-east of Blaenweneirch. They are also seen in an old quarry on the roadside about 100 yards to the west. Here the mudstones have yielded several specimens of dendroid graptolites, but nothing else. This bit of ground has been disturbed by faulting, and the structure is difficult to make out. The ash-bands with their associated striped mudstones are traceable for some distance westward, and surface-evidence suggests that they have been disturbed by two faults before they reach the vicinity of Pantyffynnon Farm, where they are cut off altogether.

East of the first-mentioned quarry these beds are traceable down the slope with a north-easterly strike due to dip, and are seen in the bed of the stream. They are again observed along the Blaencediw Lane east of the dingle. Here the dips indicate a small anticline, for, where the beds are last seen in place in a small quarry, they dip southward at about 45°. Near this point they are cut off by an east-and-west fault—probably a thrust. This igneous band has not been seen anywhere else in the district.

(3) Grits with *Orthis* and Trilobites.—The grits, as stated above, are very variable, both in thickness and in texture. They are more or less ashy in some localities, and again at no great distance they assume the character of coarse conglomerates. This variation is accompanied by a rise and fall in the number, as well as by a change in the character, of the fossils.

These beds, again, are well represented in the neighbourhood of Whitland Abbey, where grits have been extensively quarried. They form the crest of the ridge that separates the valleys of the Gronw and Fenni from near the Abbey to Penyglôg. Fossils occur only in certain thin bands, and these are seldom exposed. Trilobite-fragments and a few specimens of *Orthis* have been collected near the last-named place, and near Pantyderi, as well as at several points in the Gronw Valley.

There is, behind the Abbey mansion, a peculiar tump rising more than 100 feet above the valley-floor. This is made up largely of grits and thick beds of coarse conglomerate, but they are much disturbed by faulting—several fractures being visible in section. The displacement, however, cannot be great. A short distance to the north there are two outcrops, and quarries have been opened in both. The dips here indicate a shallow synclinal fold. Fossils are very rare in these—fossil-bearing bands, presumably, not being exposed at this point. North of Pound-glas in the immediate

neighbourhood, however, where some members of the series are found, fossils are very common. These beds, which here consist of bands of grit alternating with shales, are well seen striking across the road immediately north of the farm, and trilobite-fragments and *Orthis* are fairly abundant both in grits and shales. Heads and tails of *Ogygia marginata* are met with, and *Orthis Carausii* (Salt.) is common.

There are apparently three isolated patches of these grits in the neighbourhood of Pound-glâs and Llwyngwydd, in which several small quarries have been opened. Their presence is indicated by the abundant loose débris and the character of the soil. The small quarry in the wood north-east of Llwyngwydd shows these grits dipping under higher beds.

Another isolated patch of these grits caps the hill south of Pass-by, and a quarry has been opened in them at Pencilpost. The coarsest bed here has yielded an *Orthis*; a few trilobite-fragments and bits of dendroid graptolites have also been found here. Some of the beds crop out with a southerly dip, at the bend in the old lane north of Pencilpost, and here they are fairly crowded with fossils, including a large *Lingula*, *Ogygia* cf. *marginata*, Crof. & Skeat, *Trinucleus* cf. *Sedgwickii*, Salt., *Orthis Carausii*, Salt., *O. Menapiae*, Hicks, etc.

The hollow between this section and Pass-by Cottages is in shale; but immediately north of the Cottages the grits are again seen striking across the road with a northerly dip, and containing fossils of the usual type. The abundant débris along the crest of the hill to the north, extending from Cwmfelin-boeth to Nant-clomendy Dingle, indicate their presence and strike, and small quarries have been opened in these grits in several places. They are seen passing under higher beds at Cwmfelin, where they have been considerably disturbed. A fault of some magnitude is seen in a quarry on the west of the valley, and its effects are shown behind a cottage on the east side also. This fault probably accounts for the non-appearance of the grits in the Nant-clomendy dingle.

Farther north are two outcrops of the same series of beds. One extends from a point a little north of Aberdauddwr, where it is exposed in a small quarry in gorse-grown ground, to another point a little west of Pantyffynnon. They are seen crossing the stream by the Old Cottage in the dingle—east of Blaenweneirch, and passing westward they form the feature south of that place. They also form the hog-backed ridge west of Pantyffynnon. Some of them are seen in the yard at that place, where they and their associated beds show signs of considerable disturbance. North of Aberdauddwr they have yielded *Orthis Carausii*, Salt., and *Dendrograptus*-fragments. South of Blaenweneirch similar fossils occur.

The other and northernmost outcrop, a little farther north, is more extensively developed, and is slightly different in character. The beds are exposed in the dingle east of Blaenediwr—200 yards or so below the springs. Many small quarries have been opened in them in the immediate neighbourhood—one at the bend in the

lane and another in the dingle to the north-west. They are traced westward across the hill north of Blaenweneirch, and have been extensively quarried for road-metal on the side facing Henllan-Amgoed. Some of the beds here, as well as at Blaencediw Quarry, are crowded with *Orthis Carausii*, Salt. Occasional trilobite-fragments have also been found here. At this quarry the fossil-bearing bands weather buff and mottled grey.

A short distance south of the quarry these beds appear to be faulted-out, and are not seen in the dingle to the west; but on the small ridge south of Henllan Church they come to the surface again, and the lower beds are exposed in a quarry at the southern extremity of that ridge. Few fossils occur here, consisting of *Orthis Carausii*, Salt., and doubtful fragments of *Dendrograptus*.

Along the western flank of this ridge the grits disappear, partly by faulting, and partly by passing under higher beds.

(4) *Orthis*-Mudstone and *Dictyograptus*-Beds.—At Blaencediw Quarry the grits are seen passing up into gritty black mudstones abounding in *Orthis Carausii*. Some hard bands in these are crowded with graptolites of *Dictyograptus* and *Dendrograptus* types. A small collection of fossils from this section was submitted to Miss G. L. Elles, D.Sc., and she identifies the following:—

Callograptus radiatus, Hopk.
Callograptus Salteri, Hall.
Callograptus Salteri, var. *attenuatus*,
 Elles MS.
Dictyograptus cf. *Homfrayi*, Hopk.
 (possibly new).

Dictyograptus Homfrayi, Hopk.
Climacograptus implicatus, Hopk.
Dendrograptus flexuosus, Hall.
Dendrograptus sp. (possibly new).
Orthis Carausii, Salt.
Lingula sp.

There are several faults in this quarry, but none appears to be of great extent.

Farther up the dingle, the beds become more flaggy, and gradually change their texture, passing up into finer-grained mudstones with *Tetragraptus* at no great distance. These flaggy beds contain *Callograptus*, etc., in abundance.

Orthis-mudstones come to the surface on the road near Penlanfach, where they are fairly fossiliferous, but they have not yielded anything besides *Orthis Carausii*, Salt. Farther south, flaggy beds are seen on the roadside lying nearly horizontal. These have yielded an *Orthoceras* sp. (possibly new), *Lingula* sp., *Ogygia marginata*, *Trinucleus* sp., *Siphonotreta* (?), etc.

There is a good section of black shales and mudstones along the lane leading to Henllan grit-quarry. The beds are somewhat flaggy in places, but are disappointing as regards their fossil contents. In the lower part of the road there are some lenticular masses of weathered grit packed with *Orthis Carausii*, Salt.; *Orthoceras* sp., *Theca* sp., and some obscure dendroid forms also occur.

Higher in the series are some shales and flags rich in trilobites.

These beds are well exposed east of the ford at Rhyddenllan—up the hill towards Llwynderw—near the mill—and on the road immediately south of Henllan Church: they have yielded:—

<i>Dendrograptus</i> sp.	<i>Orthis Carausii</i> , Salt.
<i>Callograptus</i> sp.	<i>Orthis Menapiæ</i> (?) Hicks.
<i>Ogygia marginata</i> , var.	<i>Siphonotreta</i> sp.
<i>Ogygia Selwynii</i> , Salt.	<i>Obolella</i> sp.
<i>Trinucleus</i> sp.	<i>Lingula</i> sp.
<i>Amplex</i> sp.	<i>Orthoceras</i> sp.
<i>Æglinia</i> sp.	<i>Theca</i> sp.

Beds of the same age occur at Blaenweneirch, and they have yielded *Ogygia marginata* var. and *Callograptus Salteri* var. *attenuatus* Elles (MS.). They are also seen in the dingle east of Blaenweneirch, but have not yielded any fossils there.

The grits of Cwmfelin-boeth pass up into gritty mudstones seen on the road south of the entrance to Llangan Vicarage (Talvan). These beds are very unfossiliferous, and have yielded only a few fragments of dendroid graptolites, too imperfect for identification. However, there is no reason to doubt that they are what they appear to be from their position.

Mudstones of the same type occur near Penyglôg, Cefnmeurig, Llwyntreharn, and Pistyllgwyn, all of which have yielded fragments of dendroid graptolites, and occupy a similar position in relation to the grits.

(5) *Tetragraptus*-Beds.—The lane leading up to Cilhenrhôs from Rhyddenllan, exposes a continuous section in shales and mudstones, showing the *Ogygia-marginata* Beds passing up to *Tetragraptus*-Shales. Near Llebach a roadside-exposure in blue-black shales has yielded *Tetragraptus quadribrachiatum*, Hall, *T. Headi*, Hall, *Didymograptus extensus*, Hall, *Æglinia* (?) *binodosa*, Salt., *Trinucleus* sp., *Theca*, etc.

Similar beds are seen near Henllan Farm, but here fossils are generally scarce. About Penyback, on the western side of the dingle, beds of the same age are frequently exposed, but fossils rarely occur.

Along the hill between Gellidiogyn lane and Cadwgan, shales are continuously exposed, but fossils occur sparingly in them. Their general character, however, is such as to render their identification as *Tetragraptus*-Beds fairly certain. Beds of the same horizon are also abundantly exposed on both sides of the dingle east of Gellidiogyn. Fossils have been collected at several points between Castell-draenog and Blaencediw, especially along the west side of the ridge. The beds consist chiefly of blue-grey mudstones and shales, and their fossil contents include:—

<i>Tetragraptus Headi</i> , Hall.	<i>Æglinia</i> sp.
<i>Tetragraptus Amii</i> , Lapw.	<i>Trinucleus Sedgwickii</i> , Salt.
<i>Didymograptus patulus</i> , Hall.	<i>Orthis calligramma</i> , Dalm.
<i>Dichograptus</i> sp.	<i>Lingulella</i> sp.
<i>Æglinia binodosa</i> , Salt.	

The roadside-exposure at the entrance to Llangan Vicarage is presumably the 'north of Talvan' locality of the late Thomas Roberts. These beds succeed the gritty mudstones mentioned above, apparently without a break, and this agrees with the succession elsewhere. The fossils collected here include the following, most of which were recorded by Mr. Roberts :—

Dictyograptus sp.
Dendrograptus sp.
Didymograptus nitidus, Hall.
Didymograptus patulus, Hall.
Tetragraptus Headi, Hall.
Tetragraptus serra, Brongn.
Callograptus Salteri, Hall.

Callograptus persculptus, Hall.
Dichograptus sp.
Æglina sp.
Trinucleus Sedgwickii, Salt.
Orthis calligramma (?) Dalm.
Palæarca.
Obolella.

The old lane at Pontygraig, east of Trefach, cuts through the same beds, which contain a fair number of fossils. Among others, the following occur :—*Didymograptus extensus*, Hall ; *D. patulus*, Hall ; *Tetragraptus Amii*, Lapw. ; *Dendrograptus* sp. ; *Æglina*, and other trilobite-fragments.

The old road-section at Penparc-uchaf is in shales of the same age, and fossils are fairly abundant, especially graptolites. The following were collected :—

Didymograptus extensus, Hall.
Didymograptus sparsus, Hopk.
Didymograptus patulus, Hall.
Didymograptus nitidus, Hall.
Tetragraptus Headi, Hall.
Tetragraptus Bigsbyi, Hall.

Dendrograptus sp.
Dictyograptus sp.
Dichograptus sp.
Several species of small trilobites
and an *Orthis*.

Extensiform graptolites have been collected at Pwllyrhwyaid and Foxhall, north of Whitland.

In the old quarry north-east of Llanlliw there are some thickly-bedded mudstones, with the beds almost vertical and much crushed. Some bedding-planes are covered with graptolites, but the material crumbles to pieces on being handled, making it difficult to secure a good identifiable specimen. Some large trilobites also occur here, but they are much distorted and broken. Among the graptolites the following have been made out :—*Didymograptus extensus*, Hall ; *D. nitidus*, Hall ; *Tetragraptus Headi*, Hall ; *T. Bigsbyi*, Hall ; and *Dichograptus* sp.

The shales at Sarulās near Llangan Church, though abundantly exposed, contain few fossils. Those that do occur lead to the conclusion that these beds are at the top of the *Tetragraptus*-series, or at least very near the top. The fossils include fragments of *Didymograptus* (?) *hirundo*, Salt. ; *Diplograptus dentatus*, Brongn. ; *Climacograptus confertus*, Lapw. ; *Æglina* sp. ; *Obolella plumbæa*, Salt.

There are also numerous exposures of shales at Blaenwernddu. These present the characteristic weathering of the *Tetragraptus*-Beds, but fossils occur very sparingly. The specimens found are

of the *Didymograptus-extensus* type. The beds are probably the same as those exposed north of Talvan.

About three-quarters of a mile to the west the same beds are seen in some roadside-sections. That near Rhydywrach has yielded *Didymograptus extensus*, Hall; *Tetragraptus serra*, Brongn.; *Æglina* sp.; *Obolella* sp., etc. There is some obscure faulting in the locality, for immediately to the south are *Didymograptus-bifidus* Beds, which appear to dip under *Tetragraptus*-Beds. Also, at a short distance to the north, there are shales of *D.-bifidus* type.

The Rhydywrach stream, to the south, has cut through shales and mudstones at several points. Fossils have been collected in these, which fix their age as Upper *Tetragraptus*; and their general strike and dips suggest that they pass up into higher beds in the immediate vicinity.

In the railway-cutting north of Llanfallteg Station are seen good sections in *Tetragraptus* and *Didymograptus-bifidus* Beds, with a fair abundance of characteristic fossils. The dips at the southern end of the section suggest a small anticlinal fold showing Upper-*Tetragraptus* passing up into *Didymograptus-bifidus* Beds. The former here contain a fair abundance of *Diplograptus dentatus*, Brongn., and *Climacograptus confertus*, Lapw.: *Didymograptus patulus*, Hall; *D. hirundo*, Salt.; but no *D. bifidus*. Trilobites also occur, including *Barrandea* sp., *Æglina linodosa*, Salt., and *Æglina* sp.: and *Comularia*, *Theca*, and *Orthoceras* have been obtained. The beds in this section have been disturbed by several faults—probably the westward continuation of Rhydywrach conditions.*

North of the small dingle (the southernmost of the two) the beds have yielded the following fossils:—

<i>Dendrograptus</i> sp.	<i>Tetragraptus quadribrachiatas</i> ,
<i>Schizograptus</i> sp.	Hall.
<i>Didymograptus extensus</i> , Hall.	<i>Æglina</i> sp.
<i>Didymograptus patulus</i> , Hall.	<i>Trinucleus Sedgwickii</i> , Salt.
<i>Tetragraptus serra</i> , Brongn.	<i>Lingulella</i> sp., etc.

The same series of beds—mudstones and shales—are exposed at intervals along the railway near Gwarmacwydd, and continue northwards as far as Login, but are very sparingly fossiliferous. Even where fossils occur they are not easy to find, and then to identify, owing to cleavage.

There is a continuous section up Penclipin Hill and down Mount-Pleasant Hill, in both of which fossils are exceedingly scarce. The beds at Mount Pleasant are more arenaceous than the usual type, are badly cleaved, and have not yielded a trace of fossils. These beds are also exposed about Bryntaf and Penyrallt.

East of the Gronw at Glandwr, near Pantygrug, there are several exposures of graptoliteiferous shales and mudstones, which have yielded *Didymograptus extensus*, Hall; *Tetragraptus quadribrachiatas*, Hall; *T. Bigsbyi*, Hall; *Schizograptus* sp.; *Æglina* sp.;

Trinucleus sp., etc. The relation of these beds to the grits of the immediate neighbourhood is rather difficult to make out. Taking the evidence of the dips, the most probable interpretation is that the graptolite-beds are folded down here and cut off by a fault immediately to the south.

About $1\frac{1}{2}$ miles to the north, in the gorse-grown ground south of Cilhirwydd, is a small quarry in shales, with some hard bands. The shales contain a fair number of graptolites, but three bedding-planes in one hard gritty band are especially crowded with them: *Didymograptus hirundo*, Salt., and *D. patulus*, Hall, can be recognized. Some trilobites of the genus *Eglina* and a *Lingula* also occur. This exposure is within a short distance of a *Didymograptus-bifidus* ash outcrop.

The late Thomas Roberts reported the occurrence of 'tuning-fork' graptolites at Penycod, east of Whitland. The shales here are very barren, and from their texture and colour could be taken for *Tetragraptus*-Beds; further, at Nant-yr-allwyn, close by, shales of exactly the same character are fossiliferous, and have yielded *Didymograptus* (?) *hirundo*, Salt.; *D. patulus*, Hall; *D. gibberulus*, Nich.; *Lingula*; and *Palæarca*. (It may be suggested that Penycod near Mydrim was meant, for at that place tuning-fork graptolites do occur.)

The shales in the bed of the stream south of Nant-yr-allwyn Bridge have yielded extensiform and dendroid graptolites in several localities. Extensiform graptolites have also been collected near Tynewydd (east of Whitland), and at Forest.

East of the River Fenni the beds are abundantly exposed, but, as elsewhere, are sparingly fossiliferous except in certain localities. The old quarry at Llwynerwn has yielded the greatest variety of fossils. Here some bands are crowded with graptolites, the following having been collected and identified:—

Didymograptus extensus, Hall.
Didymograptus nitidus, Hall.
Didymograptus patulus, Hall.
Didymograptus sparsus, Hopk.
Didymograptus hirundo, Salt.
Tetragraptus serra, Brongn.
Tetragraptus Amii, Lapw.
Tetragraptus Bigsbyi, Hall.
Callograptus Salteri, Hall.
Callograptus sp.
Dendrograptus persculptus, Hopk.
Dendrograptus flexuosus, Hall.
Dendrograptus sp.
Ptilograptus Hicksii, Hopk.
Dictyograptus cf. *cancellatus*, Hopk.
 (possibly new).

Dichograptus sp.
Asaphus sp. (large and possibly new).
Eglina caliginosa.
Eglina sp.
Trinucleus cf. *Sedgwickii*, Salt.
Orthis sp.
Lingula cf. *petalon*, Hicks.
Obolella sp.
Siphonotreta.
Conularia.
Theca.
Orthoceras cf. *sericeum*, Salt.
Caryocaris; etc.

At Pont-y-fenni, two-thirds of a mile due south, shales and mud-stones are exposed in several good sections. In the old quarry above the bridge there seems to be a slight displacement. Highly-

slickensided slabs have been dug up about the middle of the quarry, and south of this spot the following fossils occur :—

Didymograptus extensus (?) Hall.
Didymograptus pennatulus, Hall.
Didymograptus patulus, Hall.
Tetragraptus serra, Brongn.
Tetragraptus quadribrachiatulus,
 Hall.
Ampyx cf. *Salteri*, Hicks.
Eglina caliginosa, Salt.
Eglina cf. *boia*, Hicks.
Trinucleus sp.

Agnostus sp.
Lingula.
Obolella.
Palaearca.
Conularia margaritifera, Salt.
Conularia cf. *Hemifragi*, Salt.
Theca sp.
Caryocaris sp.
Orthoceras sp.; etc.

North of the break there is a slight lithological difference, and the fossils indicate a higher horizon, probably the higher beds of the *Tetragraptus*-Series. The following fossils have been found :—*Diplograptus dentatus*, Brongn.; *Clamacograptus confertus*, Lapw.; *Placoparia cambrensis*, Hicks; and a few fragments of extensiform graptolites, but no *Didymograptus bifidus*. The roadside-sections have yielded *Didymograptus* cf. *extensus*, Hall; *D. patulus*, Hall; *Tetragraptus serra*, Brongn.; *Conularia* sp.; *Bellerophon multi-striatus*, Salt.; and an *Orthoceras*.

Extensiform graptolites have been collected from the mudstones in the watercourse south of Bwlchymmen. *Eglina* and other trilobite-fragments also occur here, near the junction of the *Tetragraptus*-Beds and the *Didymograptus-bifidus* Beds.

The dips here strongly suggest an inversion due to overfolding or faulting—probably to both. The crushed state of some black shales seen in a ditch west of Sabulon, and the watery condition of the ground near by, confirm the suggestion as to the occurrence of a fault.

The mudstones in Gors farmyard have yielded some isolated *Tetragraptus*-stipes, and the exposures about Pwlltrap contain few fragments of *Dendrograptus* and *Eglina*. A *Dictyograptus* was obtained from a well at Ostrey, and fragments of *Didymograptus hirundo*, Salt., from the mudstones in the bed of the Gynin close by. Some fragments of extensiform graptolites have been collected from the crushed mudstones at Melin Cleifon and the railway-cutting near St. Clear's Station. *Eglina* also occurs at the latter place.

A small opening in shales at Parkyrabat and the roadside-section near Castell-y-waun have yielded graptolites of *extensus*-type. The latter locality has, in addition, yielded a crushed specimen of *Tetragraptus* cf. *quadribrachiatulus*, Hall; *Didymograptus extensus* (?) Hall; and tails and eyes of *Eglina* have been collected from the mudstones of the railway-cutting north of Banc-y-felin.

Near Llainlwyd, a mile north of St. Clear's Station, there is a good road-section in shales. These are fairly fossiliferous at certain points. At the lowest end of the section the beds are nearly vertical and barren, but at the turning in the road higher up extensiform graptolites occur, which are usually very fragmentary. Half way up the hill the following have been collected :—

Didymograptus extensus, Hall.
Didymograptus patulus, Hall.
Tetragraptus Amii, Lapw.
Tetragraptus serra, Brongn.

Ampyx sp.
Trinucleus cf. *Salteri*, Hicks.
Æglina binodosa, Salter (large).
Palæarca sp.; etc.

Still higher up, at Tynewydd, some mudstones dug out of a well were crowded with *Didymograptus extensus*, Hall. Associated with these were *Barrandeia* sp.; *Trinucleus* cf. *Murchisoni*, Salter; *Illænus* (?); *Lingula* sp.; *Palæarca*, etc. *Didymograptus-bifidus* Beds are exposed a few yards farther north; and it is almost a certainty that the junction is a faulted one, and that a portion of both series has been cut out here.

(6) Conclusions.—Reviewing the stratigraphical and fossil evidence, the conclusion is reached that the Arenig rocks of this district are the equivalents of the *Tetragraptus*-Beds of St. David's and are of Middle and Upper Arenig age. There is not sufficient evidence to prove that the Lower Arenig rocks are represented in Western Caermarthenshire.

The Middle Arenig strata (the equivalent of Hicks's 'Lower Arenig') here naturally divide themselves into two sub-groups—(α) the Blaencediw *Dictyograptus*-Beds with their associated grits, and the Henllan Trilobite-Beds; and (β) the higher shales and mudstones with *Tetragraptus* and *Didymograptus extensus*, etc.

The Upper Arenig of this district includes all other beds with *Didymograptus hirundo*, and other extensiform graptolites, up to and including beds with *Diplograptus* and *Olimacograptus* without *Didymograptus bifidus*.

The complexity of the ground is such, that no attempt has been made to draw definite lines separating the Upper from the Lower Arenig rocks of the district.

(b) Llanvirn Group: *Didymograptus-bifidus* Beds.

The *D.-bifidus* Beds of the district consist of a series of blue-grey and blue-black mudstones and shales, thin grits, and bands of ash. The mudstones and shales are often stained light chocolate. They weather in irregular patches of light buff and fawn, and when viewed edgewise they present an irregular streaky appearance. Where they are cleaved they assume a peculiar sheeny lustre, probably due to shearing. The grits are blue-grey in colour and much jointed. The ashes, freshly fractured, are light blue, but on weathering they present a buff or cream-coloured groundmass with specks of rusty material, formed probably by the decomposition of pyrites and other minerals containing iron. Some of the weathered beds are quite vesicular, owing to the decomposition of minerals containing lime. Calcareous pea-like masses are found in half-weathered samples.

The rocks have been subject to a great deal of folding and faulting, and the beds are frequently repeated, the ash-bands suffering with the rest. There are, however, at least two distinct

bands of ash. Cone-in-cone structure is very common in the grit-bands, as well as in nodules embedded in the mudstones and shales; this is especially the case in the neighbourhood of St. Clear's.

Beds of this age occupy a considerable space, both north and south of the *Tetragraptus*-belt.

(1) The Southern Outcrops.—These beds are much in

Fig. 3.—Section from north to south, near Forest, on the scale of 6 inches to the mile. (Marked on the map, Pl. XLVI, as 'Section III'.)

evidence at St. Clear's. The main road cuts through them at Blue Boar, and there is a good section up the hill leading to Lower St. Clear's. This latter exposure shows the disturbance mentioned above (p. 613). There are good sections also in the old lane near Croft Lodge, and along the Cliff, where the *Didymograptus-bifidus* Beds are faulted against black *Dicranograptus*-Beds.

The general dip about here suggests an overfold from the north, as *Didymograptus-bifidus* shales appear to pass under older beds. This is the case not only here, but all along the strike. Fossils are fairly common. The main-road section and that in the 'old lane' are perhaps the best places for collecting.

The following occur on the main road:—

- Didymograptus bifidus*, Hall.
- Didymograptus euodus* (?) Lapw.
- Didymograptus Nicholsoni*, Lapw.
- Didymograptus Nicholsoni*, var. planus, Elles & Wood.
- Agnostus M' Coyi*, Salter.
- Eglina binodosa*, Salt.
- Eglina* (young?).
- Calymene parvifrons*, Salt.
- Placoparia cambrensis*, Hicks.
- Illæmus Hughesii*, Hicks.
- Orthoceras cf. caereesiense*, Hicks.
- Theca* sp.
- Conularia* sp.
- Ophileta*.
- Bellerophon multistriatus* (?) Salt.

The 'old lane' has yielded the above, and also the following:—
Didymograptus (?) *geminus*, His.;
Phacops llanvirnensis, Hicks; *Bellerophon* sp. (young?).

East of St. Clear's, at Plasgygyr and Bronheulog, these mudstones are associated with a series of

harder arenaceous beds. The softer material contains *Didymograptus bifidus*, Hall, and *D. Nicholsoni*, var. *planus*, Elles & Wood. *D. bifidus*, Hall, as well as *Dinobolus Hicksii*, Dav., occurs in the shales on the roadside west of Asgood.

The old quarry near Danrallt has also yielded a fair number of fossils, including *Didymograptus bifidus*, Hall; *D. indentus*, Hall; *D. Nicholsoni*, Lapw.; *Diplograptus dentatus*, Brongn.; *Climacograptus confertus*, Lapw.; *Ilænus Hughesii*, Hicks; and *Barrandea Homfrayi*, Hicks. The beds here are nearly vertical, and contain some hard bands.

West of St. Clear's the beds are much exposed in road-sections and otherwise. The road-section at Llaindelyn, south of Pwlltrap, is on the line of the Timber-Yard disturbance, and the mudstones here have yielded :—

Didymograptus bifidus, Hall.
Didymograptus indentus, Hall.
Diplograptus dentatus, Brongn.
Phyllograptus typus, Hall.

Phyllograptus anna, Hall.
Eglina binodosa, Salt.
Bellerophon (?) *multistriatus*, Salt.
Orthoceras cf. *encrinale*, Salt.

Didymograptus bifidus has been collected at Heol-cerrig, several localities on the Backé, and in the dingle between the Woolston-Ash ridge and Castle Hill. Some 'mining' (*sic*) operations have been carried on in this dingle, the blackness of the shales being thought a certain indication of the occurrence of coal. Several pits were sunk here, and the débris has yielded *D. bifidus*, Hall, in fair numbers.

A short distance north of Clôg-y-frân two other pits have been sunk in similar beds, one of which is within a few yards of the fault which here cuts off the *Asaphus-tyrannus* Limestone. Reference has already been made to *Didymograptus-bifidus* Beds in Clôg-y-frân farmyard. The beds are fairly fossiliferous; and *D. bifidus*, Hall, *D. indentus*, Hall, *Eglina binodosa*, Salt., *Eglina* sp., *Barrandea* cf. *Homfrayi*, Hicks, and *Bellerophon* have been collected here.

There are two outcrops of *Didymograptus-bifidus* rocks in the vicinity of Forest, separated by a slice of Upper Bala Beds, and the southern outcrop is again faulted against beds of the same age near the tunnel. Fossils are exceedingly scarce, only a few specimens of *Climacograptus* having been found, and all of them in one locality. Had it not been for the ashes, of which there are three well-developed bands here, it would be difficult to recognize the beds with any degree of certainty.

West of Forest, the beds seem to be cut off entirely by a fault which appears to bring Bala Beds against Arenig. It cannot be made out exactly what takes place for some distance west, for the ground is obscured by alluvium. But, in the neighbourhood of Whitland, *Didymograptus-bifidus* Beds again occupy a considerable space. *D. bifidus* has been collected from a roadside exposure 100 yards north of the Intermediate School. The dips up this

hill vary a great deal in inclination, but are always northward, both in the *Didymograptus bifidus* and in the Arenig Beds exposed here. From this fact it may be inferred that the overfold indicated at St. Clear's is continued thus far west. The beds are also seen at Middleway, and up the Llwynbrain Hill, where they are faulted against beds of Lower Llandovery (?) age: fossils are, however, rare, consisting of an occasional fragment of graptolite or trilobite. They are exposed abundantly in the lane leading up the hill from Trevaughan. The ashes come out on this hill, and huge boulders are profusely scattered about. Ash-débris is traceable eastward along the brow of the hill for some distance, but then ceases abruptly, owing, presumably, to the beds being cut off by a fault, or to their being overlapped by the Old Red Sandstone. There is certainly some faulting here, but the paucity of good sections renders the structure difficult of interpretation.

The only fossil-locality of any value hereabouts is on Gallt-y-beili Farm, south of the Tave, and nearly opposite the railway-station. This section has yielded:—

Didymograptus bifidus, Hall.
Didymograptus indentus, Hall.
Diplograptus dentatus, Brongn.
Eglina sp.
Ilænus Hughesii, Hicks.

Trinucleus cf. *Murchisoni*, Salt.
Barrandea Homfrayi, Hicks.
Orthis sp.
Obolella (?) *plumbea*, Salt.
Bellerophon; etc.

This outcrop runs westward into Messrs. Marr & Roberts's ground, and possibly some distance up the valley of the Tave, but there are no exposures here.

In the neighbourhood of Llanfallteg, however, is another small area occupied by these beds. A railway-section immediately north-west of the Rhydywrach stream has yielded *Didymograptus bifidus*, Hall, and *Trinucleus* cf. *Etheridgii*, Hicks. A small quarry in mudstones, 100 yards or so north of Llanfallteg Station, has produced a fairly-good series of fossils, including:—

Didymograptus bifidus, Hall.
Didymograptus Nicholsoni, Lapw.
Didymograptus affinis, Nich.
Didymograptus sp.
Diplograptus dentatus, Brongn.

Climacograptus cf. *confertus*, Lapw.
Glossograptus (?).
Phacops llanvirnensis, Hicks.
Barrandea Homfrayi, Hicks.
Theca.

Mudstones at Penybont, west of the Tave, have yielded *Didymograptus bifidus*, Hall, and *Ampyx* cf. *Salteri*; and at Bwlchmelyn similar beds occur, where *D. bifidus* and an *Eglina* have been collected. The beds here have been somewhat disturbed, especially west of the well, but the dips are generally low.

About a mile to the east is Rhydywrach, where there are several exposures of shales and mudstones. That in the yard at Cefnmaen-llwyd is particularly rich in fossils. The beds here are very soft and of a light colour, the weathered portions being light fawn.

Some bands are crowded with graptolites. Trilobites also are fairly numerous. The following fossils occur :—

Didymograptus bifidus, Hall.
Didymograptus Nicholsoni, Lapw.
Didymograptus Nicholsoni var.
planus, Elles & Wood.
Didymograptus affinis, Nich.
Didymograptus acutidens, Lapw.
Diplograptus dentatus, Brongn.
Climacograptus teretiusculus, His.
Climacograptus confertus, Lapw.

Phacops llanvirnensis, Hicks.
Barrandea Homfrayi, Hicks.
Æglina sp.
Ilænus Hughesii, Hicks.
Placoparia cambrensis, Hicks.
Calymene parvifrons, Salt.
Ophileta.
Bellerophon; etc.

(2) The Northern Outcrops.—The *Didymograptus-bifidus* Beds on the north of the anticline differ lithologically, to some extent, from their equivalents on the south, and (taken altogether) they are not so fossiliferous. Having been affected more or less by cleavage, the fossils that do occur are neither so easy to find nor so well preserved.

On entering the district on the east, the first or main outcrop extends from Melin-ricket to a point about a quarter of a mile south of Pont-gowyn; and, on reaching the Tave, it occupies the ground between Login and Llanglydwen, a distance of about $3\frac{1}{2}$ miles.

Didymograptus bifidus, Hall, occurs in a small quarry near Penrhiw (Thomas Roberts's 'Penllwyn-bach' locality). Several little quarries have been opened here in one of the ash-bands. *D. bifidus* has also been collected at Pantglas and Pantybrodryr.

The ground between the Cywyn and the Dewi-fawr has been much cut up by faults which go on splitting westward. This is well shown by the behaviour of the ash-bands (see Pl. XLVI, map).

The road between Plas-parcau and Mydrim affords an almost continuous section across the beds, showing much of their intricate plication. Dips here change their inclination and direction at very frequent intervals. The mudstones at Plas-parcau Quarry have yielded a fair number of graptolites, including *Didymograptus bifidus*, Hall; *D. Murchisoni*, var. *geminus*, His. (or a large *D. bifidus*); *D. cf. hirundo* (?), Salt., etc. There is some obscure faulting in the immediate neighbourhood of this quarry; and, weighing the evidence of the fossils, it may be questioned whether the succession is normal here.

Fossils have also been collected from a roadside section near Penycoed, where *D. bifidus*, Hall, *D. Murchisoni* (?), Beck, and a several-branched form of graptolite occur. The graptolite-bearing rock here is quite different in character from the usual type of *D.-bifidus* Beds, consisting of thin, hard, flaggy, striped bands embedded in black shales. There is a complication of faults here again, and these beds may not be in their right place, for between this section and the true base of the *D.-Murchisoni* Beds, a little farther north, some indisputable *D.-bifidus* mudstones occur.

D. bifidus occurs in Penwch farmyard, and near Salem Chapel.

The road between Treasgell Gate and the top of the hill exposes a continuous section in shales. Typical *Didymograptus-bifidus* fossils have been collected from the lower part, and the characteristic lower *D.-Murchisoni* Beds are seen coming on about 100 yards from the top. It is worthy of remark that these upper *D.-bifidus* Beds do not include any ash-bands.

Shales and mudstones are extensively exposed along the lane west of Treasgell, and the following fossils occur :—

Didymograptus bifidus, Hall.
Didymograptus Nicholsoni var.
 planus, Elles & Wood.
Didymograptus patulus, Hall.
Diplograptus dentatus, Brongn.
Ilænus Hughesii, Hicks.

Trinucleus cf. *Etheridgei*, Hicks.
Barrandea cf. *Homfrayi*, Hicks.
Theca.
Orthoceras cf. *caereesiense*, Hicks.
Lingula sp.; etc.

The shaly mudstones in the small quarry west of Melin-castell have yielded all the above, and in addition a *Placoparia* sp., *Calymene parvifrons*, Salt., and an *Æglina*.

Didymograptus bifidus and fragments of several species of trilobites have been collected from the mudstones on the Castellgorfod road near Efel-wen. *D. bifidus* also occurs farther north at Mount Pleasant, and at Pensarn west of Cethin, where it is associated with a *Bellerophon* and trilobite-fragments.

Again, farther north near Rhydyceisiaid Chapel there are numerous sections in shales. The exposures on the roadside have yielded *D. bifidus*, Hall; *D. Murchisoni* (?) var. *geminus*, His.; *D. Nicholsoni* var. *planus*, Elles & Wood; *D. patulus*, Hall, or *D. hirundo*, Salt.; *Diplograptus dentatus*, Brongn.; *Climacograptus confertus*, Lapw.; *Barrandea* cf. *Homfrayi*, Hicks; and *Trinucleus* sp. These shales are cleaved, and the fossils are slightly distorted. In shales at Wheel-about, *Didymograptus bifidus* and a six-stiped *Dichograptus* have been found.

The mudstones at Penybont and Penybach are very much cleaved, and the fossils—trilobites chiefly—which occur in them are hopelessly distorted and broken. Farther north and west fossils become very rare. A few graptolite-fragments have been collected at Cilanw, and on Felin-isa Hill. In a roadside exposure near Llanboidy Bridge, however, graptolites are tolerably plentiful: *Didymograptus bifidus*, Hall, and *D. Murchisoni*, var. *geminus*, His., occur.

Search for fossils in the *D.-bifidus* Beds west of the Gronw has not been attended with much success: only a few fragmentary specimens of graptolites have been found. A crushed specimen of *D. bifidus* was obtained from shales in the railway-cutting, a quarter of a mile north of Login; another of the same description in the dingle east of Maencoch-yr-wyn, and a few more at Llanglydwen, a short distance from the base of the *Didymograptus-Murchisoni* Beds.

In the absence of fossils, the general character of the beds renders them fairly easy to recognize; besides, the ash-bands which are associated with them supply useful landmarks.

The second outcrop is isolated from the first by a belt of newer beds faulted down or folded in. It extends from a point a short distance east of Clyngwynne House to another point a short distance south-west of Cwrtau-bach. *Didymograptus bifidus* was collected from the following localities:—A well in Clyngwynne field; the road-section at Cross-in; roadside exposures near the Parsonage; Parsonage Quarry; Common Quarry; Wern-oleu-fawr; roadside north of Post-gwyn; and Cwrtau-bach.

A diabase-dyke cuts obliquely through the outcrop near Parsonage Farm, and is quarried for road-metal in the Parsonage Quarry. The beds roll about a good deal near Cwrtau-bach, owing no doubt to much faulting in the immediate neighbourhood. On the north the beds pass up normally, except from Wern-y-berni westward, where the succession seems to be broken by a fault—probably a thrust.

(3) Conclusions.—The occurrence of *Didymograptus Murchisoni* var. *geminus* in certain sections suggests the propriety of separating those beds from the *D. bifidus*, and including them in the *D.-Murchisoni* Series; but certain considerations make that arrangement inconvenient and illogical, so far as the two faunas are represented in this district.

In the first place, *D. Murchisoni* var. *geminus* appears rather low down in the series, associated with a fair number of graptolites—extensiform and others—of true *D. bifidus* age; in the second place, much higher beds have yielded series of fossils of true *D. bifidus* facies; and in the third place, there is in this district a natural well-defined line of demarcation between the *D.-Murchisoni* Beds and those of *D. bifidus* age—a line characterized by lithological and faunal conditions, and easily traced wherever the two series occur in normal succession.

(c) Llanvirn Group: *Didymograptus-Murchisoni* Beds.

(1) South of the Anticline.—In the absence of a single exposure, it is doubtful whether these beds occur at all on the south of the anticline. A few fragments of striped flags, containing isolated stipes of 'forked' graptolites, have been found in the soil, near a small quarry in *Asaphus-tyrannus* Limestones north of Lower Court. The general aspect of the specimens suggests *Didymograptus-Murchisoni* Beds.

Black mudstones containing crowds of 'forked' graptolites, associated with great numbers of *Siphonotreta micula* and a few specimens of *Orthoceras*, have been dug out of a well at Croft Lodge. These beds, with their fossil contents, bear a striking resemblance to black mudstones underlying and passing up into *Asaphus*-Limestones near Lan Mills.

The graptolite-mudstones at Croft Lodge underlie *Didymograptus-bifidus* Beds, and do not come to the surface anywhere in the neighbourhood—a fact which adds force to the view that there is an extensive overfolding here.

(2) North of the Anticline.—The *Didymograptus-Murchisoni* Beds are, however, well developed on the north of the anticline, and form a definite and useful stratigraphical landmark.

The series is made up of three members. The lower member consists of black mudstones which, on weathering, become fawn and cream-coloured, easily distinguishable from the underlying *D. bifidus* Beds. Incipient striping is observable in the very lowest beds, but this characteristic becomes more pronounced towards the top. The beds are crowded with 'forked' graptolites; but, with one solitary exception, no other kind of fossil has been found. The black mudstones in Frowen Dingle have yielded one trilobite-tail which probably belonged to an *Ogygia*. The graptolites include *Didymograptus Murchisoni*, Beck, and *D. Murchisoni* var. *geminus*, His.

The middle member is made up of several beds of blue ash, with interbeddings of ashy shales. Neither ashes nor shales have yielded any fossils.

The upper member consists of striped flags, and thickly-bedded arenaceous mudstones, rather highly cleaved. The fossils, and even the bedding, are sometimes obscured by the cleavage; but the beds are, as a rule, readily recognized from their characteristic texture and striping. Under normal conditions fossils are abundant and typical, and include:—*Didymograptus Murchisoni*, Beck; *D. Murchisoni* var. *geminus*, His.; *D. cf. indentus*, Hall; *D. foliaceus*, Murch.; *D. cf. dentatus*, Brongn.; *Climacograptus colatus*, Lapw.; *Siphonotreta micula*, M'Coy; *Lingula cf. attenuata*, Sow., etc.

These beds enter the district at Melin-ricket, where they are well exposed near the mill. The upper and middle members are clearly shown in a quarry, where the beds are vertical. The lower division is seen in a garden adjoining the quarry on the south, where they pass down rather abruptly into *Didymograptus-bifidus* Beds with a fair abundance of typical fossils.

They are again seen in the wood on the west of the valley, and in a quarry on the brow of the hill above. Only the upper division, however, is exposed here. From this quarry their débris is traceable to a point a little south-west of Bwlch, where they are cut off by a fault and thrown southwards, again appearing in the dingle north-east of Cefn-crwth. Passing under the house at that place they appear in a quarry in the rickyard, where typical fossils are abundant. They run west along the ridge, and are again well seen in the Dewi-fawr Valley, a third of a mile south of Mydrim. On the eastern side there are several good sections, but presumably only the upper division is again seen. In Pant-yr-hendref Quarry opposite, these beds are merely uncovered by quarrying operations in higher beds. Westward from here again they run along the crest of the ridge, cropping out on the Salem Road south of Oernant and make for the Gynin Valley, but before reaching it they are cut out by a fault which brings *D. bifidus* Beds against *Dicranograptus*-Beds. On the hill south of Castell-gorfod they are again seen in quarries and otherwise, but here and along the ridge westward

there is evidence of their being inverted. This was probably brought about by an overfold from the north developed into a thrust. Here begin the complicated overfolding and faulting that have so much disturbed the country farther west. This outcrop is cut off by a low-hading fault—the thrust, in the dingle south of Penlan; but it comes to the surface again about a furlong farther west, abundant striped fossiliferous débris in the soil indicating its whereabouts.

The beds are exposed on the main road north-west of Penlan, and a quarry has been opened in them on the side of the hill south of Caerlleon. Higher beds are exposed on the top of the hill, but on the northern slope a thrust has brought up the *Didymograptus-Murchisoni* Beds and has carried them forward so as to overlap some of the higher beds. Both outcrops are cut off on the slope overlooking Melin Nant-yr-eglwys, *Didymograptus-bifidus* Beds being exposed at several points on the slope below.

At Nant-yr-eglwys there are at least four distinct outcrops. One passes through the yard, and is flanked on both sides by higher beds—a fact which suggests a small anticlinal fold, but a much broken one. The other outcrops are formed of dismembered portions of the main outcrop, cut up by buckling and faulting.

Down in the valley, south-east of Nant-yr-eglwys, is a small opening in the upper division of the beds, with some ash-débris below. From here the outcrop sweeps in a curve along the brow of the hill above Llethr-madyn and Fronboeth, to a point about a furlong north of Clynpwyll, where it is cut off by a fault. There is a short break in the outcrop due south of Nant-yr-eglwys, where the beds are shifted northwards for a distance of about 200 yards, and are seen in the lane.

From the point where the *D.-Murchisoni* Beds disappear near Clynpwyll to another point near Hafod Llanboidy, higher beds, including *Dicranograptus*-Shales and *Asaphus-tyrannus* Ash, are faulted against *Didymograptus-bifidus* Mudstones; but at the latter place *D.-Murchisoni* Beds come to the surface once more, and are traceable as far as a point a short distance south of Maesgwyn-isaf, where they enter a fault—not to appear again between this spot and the Tave.

On the north, another outcrop comes out of a fault at Pengaerfach, a quarter of a mile west of Llanboidy, where the *D.-Murchisoni* Beds form a peculiar and prominent feature in a field near the quarries in the ash. This outcrop strikes west, passing under Maesgwynne House and appearing in the southernmost of the Pensarn Quarries. The beds are again seen crossing the road to the west, and in the Frowen Wood, where there is a complete section across them. They are also seen in the dingle, and are traceable up the hill on the west. They sweep northward with the contour of the hill on the western slope, producing an unmistakable and continuous line of débris. But west of Frowen they are cut off by an east-and-west fault, which displaces the outcrop for about 400 yards, and renders the structure somewhat obscure.

Fig. 4.—Section from north to south, near Nant-yr-eqlwys, on the scale of 6 inches to the mile. (Marked on the map, Pl. XLVI, as 'Section VI.')

Fig. 5.—Section from north to south, near Llanboïdy, on the scale of 2 inches to the mile. (Marked on the map, Pl. XLVI, as 'Section VII.')

About 100 yards south of Cefn-pant Chapel there is another short outcrop let out by an east-and-west fault, seen in section in Canerw Quarry. (The *Didymograptus-Murchisoni* Beds are not seen at the quarry.) This outcrop strikes into *D.-bifidus* Mudstone at Trehir-isaf, and no more of it is seen farther west.

There is yet another extensive, but much broken outcrop, let out by the complicated faulting of Nant-yr-eglwys. The easternmost exposure in this outcrop is seen in a field, at the end of the lane south of Maencoch. The beds are also exposed in the lane itself, and there is much débris in the soil for some distance south, but not in line with the strike of the beds in the lane; besides, the lane-beds strike into *Dicranograptus*-Beds in the immediate neighbourhood. North-westward these beds are traceable to a point some little distance south of Llain (Lleinau), where the lower division is seen in a road-exposure, and the whole in the bed of the river to the west. A small quarry has been opened in them south of Trebleiddiau, and they are seen crossing the road close by. There is no other exposure, but débris is traceable a quarter of a mile farther along the same strike, which ends abruptly in *D.-bifidus* Beds, the *D.-Murchisoni* Beds being thrown about 200 yards to the north, and cropping out in the lower part of Wern-berni farmyard. From here they strike due westwards, and are seen again at Cwrtau-bach, in the lane near the well; but here the beds are much cleaved, and are disturbed by a fault which causes a slight displacement. A quarter of a mile to the west they are faulted down, and pass under higher beds.

The ground round Llwynllwyd is very complicated, owing to much faulting. Although lower and higher beds are abundantly exposed, there is no well-defined outcrop of *D.-Murchisoni* Beds. Slight traces of them have been detected in several localities, but there is not a single exposure. A little farther north, however, the whole series is again seen in the dingle north of Tycod, and is traceable westward to Abertigan, being faulted on the south against *Dicranograptus*-Shales. The beds are well seen in the watercourses south of Abertigan and on the road at Tigan, immediately north of the ford near Llanglydwen Station.

On the west of the river there is a complete section across them near the bridge, where the three divisions are well represented. The ash has been quarried here, just where the limestone-mark is on the Survey-map. There are calcareous lumps in the ash, and some attempts have been made to burn them. The kiln built for that purpose was standing until very recently. It cannot be made out, however, on what grounds it was thought that there are limestone-rocks here in contact with a cupriferous vein. There are some old workings a little distance to the south, but there are no limestone-rocks, neither was any copper found.

The *Didymograptus-Murchisoni* Beds run westward through the 'Castell' and come out on the road near the mill, and at the junction of the roads south of Pengawsai, where the ash is extensively quarried for road-metal, and the striped beds are exposed in the roadway.

(3) Conclusions.—These beds seem to have been deposited under conditions exceedingly suitable for the preservation of 'forked' graptolites. Many of the bedding-planes are covered with a perfect mat of these fossils, while biserial and other types of twin graptolites are comparatively rare.

The lighter stripe is due to a thin layer of more ashy material, and the ash-band is presumably a 'light' stripe of larger dimensions, owing to greater activity in the production of the material.

(d) Llandeilo Group: *Asaphus-tyrannus* Beds.

(1) South of the Anticline.—The beds occurring on the south of the anticline are of the typical description, and consist of black limestones and calcareous black shales. The fossils are of the usual type, and include:—

Asaphus tyrannus, Murch.
Ogygia Buchii, Brongn.
Homalonotus.
Trinucleus Lloydii, Murch.
Trinucleus fimbriatus, Murch.
Trinucleus fucus, Salt.
Calymene brevicapitata, Portl.
Calymene cambrensis, Salt.
Acidaspis cf. *Jamesi*, Salt.
Beyrichia complicata, Salt.
Favosites sp.
Orthis striatula, Emm.
Orthis vespertilio, Sow.

Orthis calligramma, Dalm.
Orthis testudinaria, Dalm.
Orthis elegantula, Dalm.
Orthis bifurcata, Schloth.
Orthis triangularis, Sow.
Strophomena corrugatella, Dav.
Strophomena compressa var. *Ilan-*
deiloensis, Salt.
Siphonotreta micula, M'Coy.
Lingula granulata, Phill.
Lingula cf. *attenuata*, Sow.
Leptæna cf. *sericea*; etc.

There are only three localities where these beds come to the surface, and all of them lie on the line of an extensive east-and-west fault, which accounts for the paucity of exposures.

In a quarry north of Lower Court the beds are well seen, and are very fossiliferous, having yielded specimens of all the species mentioned in the foregoing list. The more arenaceous beds exhibit the typical striping of the *Didymograptus-Murchisoni* Beds. (These beds are not exposed here, but are believed to be present immediately north of the quarry.) The beds here dip northward at about 45°, and appear to pass under the *D.-Murchisoni* and the *D.-bifidus* Beds of Danrallt; a fact which leads to the conclusion that the strata are here upside down, by reason of the overfolding already referred to.

North of Pant-dwn there is another quarry in these deposits; but the dip is here a little west of south, and the beds are in their normal position. This is, seemingly, the only fossil-locality known to earlier writers.

Immediately west of this quarry the beds are cut off by the fault which brings the black *Dicranograptus*-Shales against *Didymograptus-bifidus* Beds near St. Clear's Bridge. The effects of this fault are seen in several places between St. Clear's and Clôg-y-frân, where the *Asaphus*-Beds are again well exposed, in several quarries which have, in years gone by, supplied much stone for lime-burning.

This is the limestone-locality mentioned by George Owen more than three centuries ago.

The beds are well developed here, some of them being upwards of 6 feet thick. This outcrop is that of a large lenticle, faulted against other beds all round. In the old quarry near the house the beds have been worked out into the faults, which brought them against *Didymograptus-bifidus* Beds on the north and against Bala rocks on the east and south. Some of the beds are highly fossiliferous, bands of limestone being entirely composed of *Orthis*. *Asaphus tyrannus* occurs here, but perhaps, not quite so abundantly as at Lower Court. *Trinucleus* occurs in crowds, in the tump of crushed limestone by the side of the lane.

Farther west the nearest exposure is at Waundwrgi, 2 miles west of Whitland, in Messrs. Marr & Roberts's ground.

(2) North of the Anticline.—Very different from rocks of the same age on the south, the *Asaphus-tyrannus* Beds on the north are singularly devoid of calcareous matter. They here consist of ash and ashy shales, compact in places, and generally abounding in fossils. They lie immediately upon *Didymograptus-Murchisoni* Beds, and the conditions under which they were deposited were so uncongenial to graptolite-life that *D. Murchisoni*, so abundant in the beds below, disappeared abruptly, not to reappear again. Not a single specimen has been discovered, either in the ashes or in the beds above them. Trilobites, however, are fairly abundant in the ash-bands and in the shales, and are associated—in the higher beds—with graptolites of biserial type.

As these beds invariably follow *Didymograptus-Murchisoni* striped flags, their outcrops will not be followed here in detail. Only such exposures will be dealt with as afford the most convenient opportunity for the study of the beds.

At Pant-yr-hendref Quarry, a short distance south of Mydrim, the *Asaphus-tyrannus* Ash is quarried for road-metal and building purposes; and this is the place where it is best developed in the whole district. In the fresh condition, some of the layers are fine-grained, even flinty, and dark blue in colour. They weather into various shades of brown, cream-colour, and even white, but they generally retain their hardness. The upper beds are somewhat sandy and flaggy, yielding a few graptolites. The following fossils occur here :—

Diplograptus foliaceus, Murch.
Climacograptus sp.
Asaphus tyrannus, Murch.
Ogygia Buchii, Brongn.
Acidaspis sp.
Trinucleus Lloydii, Murch.

Trinucleus favius, Salt.
Orthis vespertilio, Sow.
Lingula granulata, Phill.
Lingula sp.
Orthoceras; etc.

Eastwards the beds are not seen in Melin-ricket Quarry, but they form a tump in the field 40 yards to the north. They are exposed in the Llysonnen Quarry opposite, and contain fair numbers

of trilobites. They are also seen in Pantglâs Quarry, in the Dewi-fawr Valley. As they are followed westward they become modified in character, being still ashy, but much less compact, so that at Llanboidy they have become soft, easily-dressed stone. They have been quarried for building at Hafod and Pengaerfach, and are well exposed in an old quarry in a garden at Maesgwynne. At Pensarn, west of that locality, they have been extensively quarried, supplying building-stone for the country round. They are very fossiliferous here, yielding *Asaphus tyrannus*, Murch., *Ogygia Buchii*, Brongn., *Homalonotus*, *Trinucleus*, and graptolites, etc. They have also been quarried in the wood south of Frowen. At Llanboidy and westward they are immediately overlain by black shales crowded with *Diplograptus*, associated with trilobites—chiefly *Trinucleus Lloydii*, Murch., *Tr. favus*, Salt., *Ogygia Buchii*, Brongn., also a few specimens of *Orthis*, and large numbers of *Lingula granulata*, Phill.

In the quarry north of Canerw, already referred to, these beds have been brought up against higher beds by a thrust from the north. In a quarry north of Trehir (at Cefn-trehir) the ash is quarried for road-metal; but its relation to other beds here is far from clear, owing to some obscure faulting in the immediate vicinity.

Along the northernmost outcrop there are no quarries, and the presence of the beds, as well as their character, has to be inferred from road- and ditch-exposures. From what evidence there is, it is premised that the ash thins out and the shales become less ashy and more argillaceous as they pass northward. The Llanglydwen-Lane section, north of the bridge, proves this, as no hard beds occur there at all, though the section is otherwise complete and typical.

(e) Llandeilo Group: *Dicranograptus*-Beds.

These rocks occupy a considerable portion of the area, both north and south of the anticline. Exposures are numerous, and usually the beds are highly fossiliferous. A very noticeable feature in the character of the beds is, that they contain much iron-pyrites. This is so abundant in some localities, that springs issuing from the black shales assume the appearance and character of those found in the vicinity of coal- and iron-mines.

(1) South of the Anticline.—The passage upwards from the *Asaphus-tyrannus* Beds is nowhere to be observed on the south of the anticline, but the *Dicranograptus*-Beds themselves are seen passing up in several localities.

The beds are well exposed in the neighbourhood of St. Clear's, and a good section is seen immediately north of the bridge across the Tave, and in close proximity to the east-and-west fault mentioned above (p. 614). The shales are here intensely black and somewhat

ashy, with a fair abundance of fossils. Here, presumably, Prof. Lapworth collected graptolites which he identified as follows:—

<i>Dicranograptus formosus</i> , Hopk.		<i>Climacograptus cælatus</i> , Lapw.
<i>Dicellograptus sextans</i> , Hall.		<i>Climacograptus pereccavatus</i> , Lapw.
<i>Diplograptus foliaceus</i> , Murch.		

The following additional fossils have been obtained from a well close by:—

<i>Dendrograptus</i> sp.		<i>Corynoides curtus</i> , Lapw.
<i>Climacograptus tubuliferus</i> , Lapw.		<i>Orthis argentea</i> , His.

East of the Gynin, the beds are seen near the old lime-kiln at Llandeilo-aber-cowyn, where *Orthis argentea*, His., occurs. The beds here are easily recognizable, although graptolites are very rare. Their passage upwards is also seen in a very good and continuous section.

Black shales of the same description have been dug from a well at Foxhole, are seen in a ditch east of Division Park, and from abundant debris are known to be present in the small hill or ridge north of that fault, but are here evidently faulted against higher beds.

The dips north and south of the Cywyn, near where it falls into the Tave, indicate an anticlinal fold of some extent. The fold itself, however, has been worn away, and its place is now occupied by the Cywyn Valley. Conditions pointing to the same fact are also seen on the west of the Tave.

Black shales are exposed in a small pit in the Corporation ground south of Morfa-bach. Their occurrence here is accounted for by the Cywyn antiline, but there is some faulting in the vicinity.

Immediately south of Woolston Farm are several exposures of black shales, some of which can be traced to the St. Clear's-Bridge Fault. The beds also occur in the high bank of the Tave, near Llysywig, but are not very fossiliferous. There are moreover several other small exposures in the neighbourhood, which are useful to point out the path of the fault.

The beds are well and typically exposed, both in quarry- and road-sections, south of Mylet. Here they are abundantly fossiliferous, and are seen passing up into arenaceous deposits—rotten limestone—full of fossils. The black shales have yielded the following fossils:—

<i>Dicranograptus rectus</i> , Hopk.		<i>Climacograptus minimus</i> , Elles.
<i>Dicellograptus Morrisii</i> , Hopk.		<i>Callograptus</i> (two species);
<i>Climacograptus tubuliferus</i> , Lapw.		etc.

Some other good exposures are seen near Moelden. Here the beds show signs of shearing and other disturbances. The black shales pass up somewhat abruptly into rotten limestone, most of which seems to have been pinched out, and a little to the east disappears altogether.

From this point to near Llanddowror there is a small synclinal fold enclosing rotten Bala Limestone. Parallel to this, on the

Fig. 6.—Section east of Llanddowror, on the scale of 6 inches to the mile.
(Marked on the map, Pl. XLVI, as 'Section I.')

Fig. 7.—Section west of Llanddowror, on the scale of 6 inches to the mile.
(Marked on the map, Pl. XLVI, as 'Section II.')

south of it, is an east-and-west fault, which brings the *Dicranograptus*-Beds against Upper Bala rocks. The structure is made tolerably clear by several useful exposures at and near Maeslan and along the Penygraig lane, where the fold and fault are seen in section.

The black shales are much exposed at Llanddowror, particularly near the Rectory,¹ along the old road, and up the Maeslan lane. The character of the rock is fairly constant, and fossils are moderately plentiful. The section at the Rectory has yielded:—

Diplograptus foliaceus, Murch.
Climacograptus tubuliferus, Lapw.
Climacograptus pereccavatus, Lapw.
Glossograptus sp.
Dicellograptus sp.

Dicranograptus Clingani.
Corynoides curtus, Lapw.
Holopella sp.
Orthoceras.
Discina; etc.

From Llanddowror Bridge, some distance up towards Pentrehowell, there is a very instructive exposure. Here can be seen the gradual upward passage of the black shales to the Bala-Limestone stage above. The shales become increasingly arenaceous: thin bands with crinoid-ossicles, etc. become frequent; *Orthis* and other brachiopods, as well as cephalopods, make their appearance. The lower limestone-bands have lost their lime, and have assumed the character of a light greyish-buff sandstone; but on the brow of the hill the rock is still strongly calcareous.

The lane leading to Faynor discloses a small section in the black shales coming out under the Bala Limestone of Llanddowror Quarry. They are here faulted against Upper Bala Beds. (See fig. 7, p. 628.)

Another strip of *Dicranograptus*-Shales extends from near Talfan Lodge to Cwmcaedu, and is faulted against Upper Bala both on the north and on the south. (Near Talfan are seen traces of mining operations in these beds—presumably another endeavour to find coal.)

In the dingle south-west of Faynor, the black shales are let out by one of the numerous faults which traverse this locality, but the outcrop is of very limited extent.

(2) North of the Anticline.—From Pant-yr-hendref Quarry to a point 100 yards north of Mydrim, there is almost a continuous road-section across the *Dicranograptus*-Beds. For convenience in the field, these beds are divided into three subgroups, according to their lithological characters:—

- α —Black shales, weathering into various shades of buff and yellow;
- β —Black shales, with lenticular limestone-bands;
- γ —Black slaty shales which crumble on weathering, but do not bleach.

This subdivision will also, to some extent, hold good palæontologically, inasmuch as the assemblage of fossils varies concurrently with the lithological changes. In the buff-yellow beds graptolites,

¹ A short distance east of the Rectory a level has been driven into these shales in search of coal.

trilobites, and brachiopods occur in fair numbers. The calcareous beds contain a few trilobites at the base, but graptolites are very abundant throughout, even in the compact limestone. The slaty black shales contain graptolites in profusion, and little else.

(a) From Melin-ricket to Penlan there is only one definite area occupied by the buff-yellow beds. The upward passage from the *Asaphus-tyrannus* Beds can be well seen at Llysonnen Quarry, in the road-section north of Peny-bigwrn, Lan Quarries, Pant-yr-hendref Quarry, and the road-section south of Oernant-uchaf. Fossils occur at all these localities, the following being the most abundant :—

Diplograptus foliaceus, Murch.
Climacograptus sp.
Dicellograptus sextans, Hall.
Dicranograptus ramosus, Hall.
Dicranograptus cf. *rectus*, Hopk.
Ogygia Buchii, Brongn.
Trinucleus favus, Salt.

Orthis calligramma, Dalm.
Orthis testudinaria, Dalm.
Orthis elegantula, Dalm.
Lingula cf. *granulata*, Phill.
Lingula attenuata, Sow.
Siphonotreta micula, McCoy.

South-east of Castell-gorfod these beds are faulted against *Didymograptus-bifidus* Beds on the south. Near Castell Quarry, however, the *Asaphus*-Ash and the *Didymograptus-Murchisoni* Flags are brought against them by the same fault; but a little farther west they are again thrown against *D.-bifidus* Beds.

Near Penlan, the main area is split into two by a thrust from the north (already referred to), and in the Fenni Valley, near Melin-nant-yr-eglwys, the beds are almost entirely cut out by a number of faults. At Nant-yr-eglwys they are very much broken up by the faults, which have similarly affected other beds, already described.

From Blaensarngoch westward, as far as the neighbourhood of Llanboidy, the *Dicranograptus*-Beds occupy a well-defined area, and are faulted against *Didymograptus-bifidus* Beds both on the north and on the south. They are well seen in the low ground west of Clyngwynne—around Waunfawr and Waunfach. On the road near Ddol, and in Parsonage Farmyard, they are full of fossils of the usual type; they are also well exposed and fossiliferous at Wern-oleu-fach and Wern-oleu-fawr.

In the immediate vicinity of Llanboidy they have been cut up by faulting, and at Pengaerfach the outcrop is split into two by a ridge of older beds. One outcrop follows that of the *Asaphus-tyrannus* Beds in the direction of Maesgwyn-isaf, where, like the older beds, they are cut off by a fault. The other outcrop occupies the low ground between Wern-oleu-fawr and Frowen, stretching from Pensarn Quarry on the south to Canerw Quarry on the north. West of Frowen the beds run out on the ridge, as the older beds—*Didymograptus-Murchisoni* Flags and *Asaphus-tyrannus* Ash—were said to do.

Following the northern outcrop of the *Asaphus-tyrannus* Ash is another belt of buff-yellow *Dicranograptus*-Beds, traceable from Nant-yr-eglwys Mill past Maencoch, Llain, Trebleiddiau, and

Dyffryn. At Wern-y-berni they are thrown northwards by some obscure faulting, and are well seen at Sarnau, Cwrtau-mawr, and Cwrtau-bach. The cut-up character of the ground west of Cwrtau-bach and round Llwyn-llwyd and Lan affords abundant exposures, but it is often very difficult to trace the relation between the various beds. The road near Tycoed and Waungron affords a continuous exposure, but fossils are obscured by cleavage. South of Abertigan the beds run out in a manner similar to that observed west of Frowen. On the north the beds are faulted against *Didymograptus-Murchisoni* Flags.

Another belt of these beds follows the Llanglydwen-Abertigan outcrop of *Asaphus*-Beds, and, like them, is cut off by a fault near Fron-isaf.

(β) Calcareous bands.—It is suspected that there is a calcareous development of the buff-yellow weathering mudstones at more than one horizon; but it is quite clear that the most persistent of them is very local. Whether this is due to conditions of sedimentation, or to subsequent weathering and decalcification, has not been made out.

At the village of Mydrim there is a considerable thickness of calcareous beds, some lenticular bands being fairly-compact blue-black limestone. A good section of the beds is seen under the graveyard, and fossils are abundant: some bands are crowded with graptolites of types hitherto unknown elsewhere in South Wales. The following have been identified:—

<i>Leptograptus validus</i> , Lapw.	<i>Diplograptus</i> cf. <i>foliaceus</i> , Murch.
<i>Leptograptus grandis</i> , Lapw.	<i>Didymograptus superstes</i> , Lapw.
<i>Leptograptus latus</i> , Elles & Wood.	<i>Climacograptus</i> sp.
<i>Dicellograptus</i> cf. <i>sextans</i> , Hall.	<i>Glossograptus</i> (?) <i>Hincksii</i> , Hopk.
<i>Dicranograptus brevicaulis</i> , Elles & Wood.	<i>Dictyograptus</i> sp.
<i>Dicranograptus</i> cf. <i>Nicholsoni</i> , Hopk.	<i>Trinucleus favius</i> , Salt.
<i>Dicranograptus rectus</i> , Hopk.	<i>Trinucleus</i> sp.
<i>Dicranograptus</i> , sp. (new).	<i>Orthis testudinaria</i> , Dalm.; etc.

Eastward, these beds are only traceable for a short distance, but westward they are more persistent.

A well has recently been sunk at Oernant-uchaf, cutting through most of these beds, and the material brought up has yielded fossils of the above description and, in addition, two or three poor specimens of *Nemagraptus gracilis*, Hall.

At Castell-gorford the beds have been quarried for lime-burning; but it does not appear that the experiment was attended with much success.

The beds occur at Penlan, but the limestone is very thin. It does not come to the surface at all between here and Llain, where an occasional slab occurs among the black shales. The same beds are seen in a deep ditch immediately west of Trebleiddiau; but they are exceedingly rotten, yielding only an occasional slab of compact

limestone. Fossils also occur, but it is very difficult to secure a good specimen, owing to the extreme friability of the rock.

At Dyffryn, a quarter of a mile to the north, however, the beds are much stronger, and have yielded limestone for lime-burning, a portion of the old kiln being still in evidence. The section exposed in this old quarry is very instructive, as showing the true relation of the limestones to the beds above and below. The several alternations of calcareous bands with buff-yellow mudstones and shales prove conclusively that the limestones belong to the beds below, rather than to the slaty black beds above.

West of this section the limestones are traceable up the dingle towards Sarnau, but they completely disappear before that point is reached.

(γ) The black slaty beds.—These form a belt of varying width along the northern margin of the ground. They are highly cleaved and intensely black, except that in some localities they contain a good deal of what appear at first sight to be mica-flakes. On closer examination, however, the regular triangular form of these tiny bodies points to their organic origin, and it is suggested that they are graptolite 'embryos,' or what afterwards became siculæ.

Although the beds are, as a rule, highly fossiliferous, they have yielded little besides graptolites, and these, owing to cleavage, very much distorted. Iron-pyrites is also very abundant. There are abundant exposures all along their outcrop, and quarries have been opened in them at frequent intervals—occasionally for building-material, but much oftener for drain-rubble.

They enter the district at Rhyd-aber-wern near Melin-ricket, and are frequently seen up the dingle in the direction of Bwlch, Sarnau, Penrheol, and Mydrim, at all of which places they are exposed in quarries and otherwise. They are well seen on Llangarthgynin Hill, near Trip Bridge, and along the road leading to Caerlleon Farm. They are affected by much faulting north of Penlan, and their junction with the brown-grey mudstones above has been thrown northwards from near Trip Bridge to a point some distance north of Melin-dol-goediog.

They are much in evidence again at Melin-nant-yr-eglwys, where they are considerably cut up by faults. Fossils are very abundant, but distorted, in Melin-nant-yr-eglwys Quarry. The following occur:—

<i>Dicranograptus rectus</i> , Hopk.		<i>Climacograptus</i> cf. <i>tubuliferus</i> , Lapw.
<i>Dicranograptus Nicholsoni</i> (?) Hopk.		<i>Climacograptus</i> sp.
<i>Diplograptus foliaceus</i> , Murch.		<i>Glossograptus</i> sp.

The black beds frequently come to the surface on both sides of the Fenni, as far as Llechglawdd, near which place they are abundantly exposed, but pass up into higher beds—the brown-grey mudstones—in the immediate neighbourhood.

At Cwm-felin-mynach they are so much cleaved that both bedding and fossils are obliterated. From Cwm-felin they are traceable up

the dingle south of Waun-rhyddod and Bronysgawen, past Sarnau, to Glanrhyd, south of Eglwys-Fair-a-Churig, where they have yielded fossils of the Melin-nant-yr-eglwys type.

South of Fron-isaf the outcrop is shifted for some distance northward by a fault. From here the black beds follow the lower beds normally, and are typically exposed near Sylvania Factory, where they have yielded *Orthis argentea*, His.

A short distance south of Llanglydwen Station a 'lenticle' of these beds has been faulted in among *Didymograptus-bifidus* Beds. They can be well seen near the signal-post, where they have yielded a few distorted graptolites and *Orthis argentea*, His. They are also very pyritous here, as elsewhere.

(3) Conclusions.—The occurrence of *Orthis argentea* in these shales tends to show that they cannot be of Llandeilo age.

The late Thomas Roberts reported the occurrence of *O. argentea* at Dyffryn-pwdrn north of Llanboidy and elsewhere, where the succession is practically the same as at Mydrim. Mr. Roberts presumably found his specimens in the black slaty beds, which are the equivalents of the beds at Fron-isaf and Llanglydwen.

The graptolitic fauna of a considerable portion of these beds is, in the opinion of Miss Elles, more characteristic of Llandeilo than of Bala-Caradoc age; but further search for fossils, and a closer examination of both beds and fossil-forms, will probably bring forth evidence showing that the upper portion is of Bala-Caradoc age. Until that is done the matter must remain unsettled.

(f) Bala-Caradoc Rocks.

Bala-Caradoc rocks of Pembrokeshire type are well developed in the district, and are readily divisible into the four groups enumerated by Dr. J. E. Marr & the late Thomas Roberts in their paper on the Haverfordwest district,¹ namely :—

- (α) Robeston-Wathen Limestone.—Limestones and calcareous shales.
- (β) Sholeshook Beds.—Arenaceous limestones.
- (γ) Redhill Beds.—Blue-grey mudstones and shales, with some thin sandstone-bands.
- (δ) Slade Beds.—Blue-grey mudstones and shales, with limestone-bands.

(1) South of the Anticline.

(α) Robeston-Wathen Beds.—These beds are typically exposed immediately north of Llandeilo-aber-cowyn, where the *Dicranograptus*-Shales are seen passing up. Some of the limestone-beds are very compact and break sharply under the hammer, but weather into dust. An unusual feature observed here is the occurrence of lines of pebbles in some of the beds. The compact limestone is fairly fossiliferous, but better specimens can be collected from the calcareous shale-partings. (For fossils see the appended list, pp. 634-35.)

¹ Quart. Journ. Geol. Soc. vol. xli (1885) p. 476.

LIST OF BALA-LIMESTONE FOSSILS. (ROBESTON-WATHEN AND SHOLESHOOK LIMESTONES.)

NAMES OF SPECIES.	a.		& β.		α ² & β.	β.		
	Foxhole.	Bronhaul.	Llandello-aber-Cowyn.	Clôg-y-frân Farnyard.	Moelden.	Llanddowror.	Clôg-y-frân Wood.	Trefanty.
								Faynor.
<i>Nidulites favus</i> , Salt.	...	...	...	...	...	×	×	×
<i>Callograptus</i> sp.	...	...	...	...	...	×	×	×
<i>Heliolites interstinctus</i> , Wahl.	...	...	...	...	×	×	×	×
<i>Heliolites megastoma</i> , M'Coy	...	...	...	...	...	×	×	×
<i>Heliolites inordinatus</i> , Lonsd.	×	×	×	×	...	×	×	×
<i>Favosites fibrosa</i> , Goldf.	×	...	×	...	...	×	×	×
<i>Favosites gothlandica</i> , Foug.	...	...	×	...	...	×	×	×
<i>Monticulipora lens</i> , M'Coy	...	...	×	...	...	×	×	×
<i>Monticulipora favulosa</i> , Phill.	...	...	×	...	...	×	×	×
<i>Halysites catenularia</i> , Linn.	×	×	×	×	...	×	×	×
<i>Sphaeronites stelluliferus</i> , Eichw.	...	...	×	...	...	×	×	×
<i>Syringophyllum organum</i> , Linn.	×	...	×	...	...	×	×	×
<i>Petraia rugosa</i> , Phill.	×	×	×	×	...	×	×	×
<i>Petraia equisulcata</i> , M'Coy	×	...	...	...	...	×	×	×
<i>Petraia elongata</i> , Phill.	×	...	...	...	...	×	×	×
<i>Cyathophyllum articulatum</i> , Wahl.	×	...	×	...	...	×	×	×
<i>Omphyma turbinata</i> , Foug.	×	...	...	×	...	×	×	×
<i>Echinosphearites balticus</i> , Eichw.	...	...	...	×	...	×	×	×
<i>Glyptocrinus basalis</i> , M'Coy	...	...	...	×	...	×	×	×
<i>Serpulites dispar</i> , Salt.	...	...	...	...	...	×	×	×
<i>Cornulites serpularius</i> , Schloth.	...	...	...	...	...	×	×	×
<i>Tentaculites anglicus</i> , Salt.	...	...	...	...	...	×	×	×
<i>Fenestella subantiqua</i> , D'Orb.	...	...	...	...	...	×	×	×
<i>Glaucanome disticha</i> , Goldf.	...	...	...	...	...	×	×	×
<i>Ptilodictya dichotoma</i> , Portl.	...	...	...	...	...	×	×	×
<i>Ptilodictya costellata</i> , M'Coy	...	...	...	...	...	×	×	×
<i>Beyrichia</i> sp.	...	...	...	...	...	×	×	×
<i>Agnostus trinodus</i> , Salt.	...	×	...	...	...	×	×	×
<i>Illænus Bowmanii</i> , Salt.	×	...	×	×	×	×	×	×
<i>Calymene Blumenbachii</i> , Brongn.	...	...	...	...	...	×	×	×
<i>Calymene brevicapitata</i> , Portl.	...	...	...	...	...	×	×	×
<i>Calymene duplicata</i> , Murch.	...	...	...	...	...	×	×	×
<i>Encrinurus punctatus</i> , Brunn	...	...	...	...	×	×	×	×
<i>Encrinurus sexcostatus</i> , Salt.	×	...	×	...	...	×	×	×
<i>Staurocephalus globiceps</i> , Portl.	...	...	...	...	...	×	×	×
<i>Cybele verrucosa</i> , Dahn.	...	...	...	...	...	×	×	×
<i>Cybele rugosa</i> , Portl.	...	...	...	...	...	×	×	×
<i>Cybele Loveni</i> , Linnrs.	...	...	...	...	...	×	×	×
<i>Sphaerexochus boops</i> , Salt.	...	...	...	...	...	×	×	×
<i>Lichas lacatus</i> , M'Coy	×	...	×	×	×	×	×	×
<i>Cheirurus bimucronatus</i> , Murch.	...	...	...	...	...	×	×	×
<i>Cheirurus octolobatus</i> , M'Coy	×	...	...	...	...	×	×	×
<i>Cheirurus juvenis</i> , Salt.	...	...	...	...	...	×	×	×
<i>Trinucleus seticornis</i> , Eaton	...	...	...	...	...	×	×	×
<i>Trinucleus</i> , var. <i>Bucklandi</i> , Barr.	...	...	...	...	...	×	×	×
<i>Trinucleus concentricus</i> , Eaton	...	...	...	...	...	×	×	×
<i>Trinucleus fimbriatus</i> , Murch.	×	...	×	...	...	×	×	×

LIST OF FOSSILS (*continued*).

NAMES OF SPECIES.	a.		a & β.		a? & β.	β.			
	Foxhole.	Bronhaul.	Llandeilo- aber-Cowyn.	Clôg-y-frân Faynyard.	Moelden.	Llanddowror.	Clôg-y-frân Wood.	Trefanty.	Faynor.
<i>Phacops apiculatus</i> , Salt.....	..	..	..	..	..	×			
<i>Phacops truncato-caudatus</i> , Portl.	..	..	..	..	..	×		×	
<i>Phacops macroura</i> , Sjögren	..	..	..	..	..	×			
<i>Phacops Brongniarti</i> , Portl.	..	..	..	..	..	×			
<i>Asaphus Poucisi</i> , Murch.	×	..	..	..	..	×	..	×	
<i>Ampyx tumidus</i> , Forbes.....	..	..	..	..	..	×	×	×	
<i>Ampyx rostratus</i> , Sars	..	..	..	..	..	×	×	×	
<i>Remopleurides</i> sp.	..	..	..	..	..	×	..	×	
<i>Acidaspis Brightii</i> , Murch.	..	..	..	..	..	×			
<i>Homalonotus bisulcatus</i>	×	×	..	..	..	×	×	×	
<i>Homalonotus rudis</i> , Salt.	..	..	..	..	..	×	×	×	
<i>Orthis calligramma</i> , Dalm.	×	×	×	×	×	×	×	×	×
<i>Orthis Actoniae</i> , Sow.	..	..	..	..	..	×	..	×	×
<i>Orthis flabellulum</i> , Sow.	..	..	..	..	..	×	..	×	×
<i>Orthis porcata</i> , M'Coy	..	..	..	..	×	×	..	×	
<i>Orthis bifurcata</i> , Schloth.	×	..	..	..	×	×	..	×	
<i>Orthis elegantula</i> , Dalm.	..	..	..	..	..	×	..	×	
<i>Orthis testudinaria</i> , Dalm.	×	..	×	×	..	×	..	×	
<i>Orthis vespertilio</i> , Sow.	..	..	..	..	..	×	..	×	
<i>Orthis striatula</i> , Emmons	..	..	..	..	..	×	..	×	×
<i>Leptæna sericea</i> , Sow.	..	×	..	..	..	×	×		
<i>Leptæna transversalis</i> , Wahl.	..	..	..	..	..	×	..		
<i>Leptæna tenuicincta</i> , M'Coy	..	..	..	..	..	×	..	×	×
<i>Leptæna quinquecostata</i> , M'Coy ..	..	..	..	..	..	×	..		
<i>Strophomena rhomboidalis</i> , Wilck.	×	×	×	×	×	×	..	×	×
<i>Strophomena grandis</i> , Sow.	×	..	×	..	..	×			
<i>Lingula attenuata</i> , Sow.	×	×	×	..	..	×			
<i>Discina perrugata</i> , M'Coy	..	..	..	..	..	×			
<i>Siphonotreta micula</i> , M'Coy	..	..	..	..	..	×	×	×	
<i>Holopæa concinna</i> , M'Coy	..	..	..	..	..	×	×		
<i>Holopæa conica</i> , Sow.	×	..	..	..	..	×			
<i>Holopella</i> cf. <i>tenuicincta</i> , M'Coy...	..	..	..	..	..	×			
<i>Turbo rupestris</i> , Eichwald	..	..	..	..	..	×			
<i>Murchisonia</i> sp.	..	..	..	..	..	×			
<i>Lituites cornu-arietis</i> , Sow.	..	..	..	..	..	×	×	×	
<i>Lituites anguiformis</i> , Salt.	..	..	..	..	..	×	×	×	
<i>Cyrtoceras sonax</i> , Salt.	..	..	..	..	..	×	×	×	
<i>Orthoceras vagans</i> , Salt.	..	..	..	..	..	×	..	×	
<i>Phragmoceras nautileum</i> , Sow.	..	..	..	..	..	×			
<i>Ecculiomphalus Bucklandi</i> , Portl.	..	..	×	..	..	×	×		
<i>Bellerophon bilobatus</i> , Sow.	..	..	..	..	..	×	×		

At Foxhole, north of the Cywyn Valley, another good exposure occurs, where some quarrying operations have been carried on within recent years. The character of the beds is very similar to that of those exposed in the lower portion of the section at Llandeilo-
Cawyn, and the fossil-assemblage presents the same facies.

Reference has already been made to the dips at these two localities, and to the structure that they suggest (p. 627).

West of the River Tave the same beds are seen in a quarry near Bronhaul. This, probably, is Phillips's 'Upper Moor' fossil-locality. Fossils are fairly abundant and typical.

The narrow belt of folded-in beds of this age between Moelden and Llanddowror does not yield any fresh samples of the rock, and the weathered material is slightly different from that furnished by these beds elsewhere.

The beds are not typically exposed at Llanddowror. They are undoubtedly represented there, but not well developed.

At Clôg-y-frân, however, beds of Llandeilo-aber-Cowyn type are well seen in the farmyard, where they are faulted against *Didymograptus-bifidus* Beds and *Asaphus-tyrannus* Limestones (see p. 599). The beds are exposed, in a very rotten condition, near the pond; but fresh samples may be obtained from the lane in the field close by, and in the yard near the stables. They dip northwards at about 45°. Along the bottom of the yard higher beds, with abundance of typical fossils, are seen dipping under them. This is another indication of the overfold referred to above (p. 614).

Beds of the same age and of similar character are exposed behind the old cottage at Cwm-caedu. Here they are seen to succeed the black shales, and they pass up to the next stage in the vicinity. Fossils are not abundant, but the few that do occur are of the characteristic type.

(β) Shoeshook Beds.—These differ somewhat from those just described, in being much more arenaceous, and generally coarser in texture. On weathering, they produce sandstone of fair quality, but the material is often nothing better than loose sand. Fossils are, as a rule, very abundant.

The upper part of the section at Llandeilo-aber-Cowyn doubtless exposes beds of this age, but they are not so sandy.

At Foxhole, however, the succession is well seen. I availed myself of an opportunity to examine a continuous section from the Foxhole exposure to the old quarries on the brow of the hill near Trefanty, where the arenaceous beds have been much quarried in years gone by. Under ordinary circumstances, the relation of the two groups can be clearly made out here. These old quarries have yielded many fossils: big slabs have been seen which were covered with *Trinucleus seticornis*, *His.* and tails of *Cybele verrucosa*, *Dalm.*

These beds are well developed and extensively quarried at Llanddowror, 2 miles west of St. Clear's. They crop out along the brow of the ridge running in a north-westerly direction from the quarry—through the Gelli Wood, narrowing the valley of the Tave near Clôg-y-frân Bridge, and rising in a bold bluff on the north of the gorge—where they have been more or less extensively quarried. They cross the Tave a short distance south-west of Clôg-y-frân, a small exposure in the meadow indicating their strike, but they appear to be cut off by a fault at no great distance.

The beds are much exposed at Faynor, both in quarries and otherwise. They come out in the watercourse leading from the yard, past the well to the bottom of the dingle, where they are slightly disturbed by a fault which cuts them off a little to the south of this point.

About half way up the hill in the direction of Penlan Farm, they are again seen in a small quarry where they are nearly horizontal; but in the lane immediately to the north they dip northwards at a low angle. The upper beds are seen at Penlan, where they pass up into the next stage, the beds of which are here nearly horizontal.

A small patch is exposed at Parcau, about half a mile to the west. Here the beds dip gently south-westward, and pass up into the next stage immediately west of the yard.

(γ) Redhill Beds.—The arenaceous limestones are seen passing up into this stage near Clóg-y-frân Bridge. The calcareous matter gradually disappears, forming, at last, merely small lenticular masses of sandy limestone in blue-grey shaly mudstones. The lenticles are generally full of fossils, but the mudstones themselves are very barren. These mudstones on weathering assume the characteristic olive-green colour. Fossils are usually rare all through them, except in isolated patches: that is, there are no continuous fossiliferous bands.

Rocks of this age are abundantly exposed in the south of the anticline, and are readily distinguishable from those below; but to fix their exact upward limit is not an easy matter, if at all possible.

At Parc-y-graig, north of Foxhole, a small section of these beds is seen in the bank of the Tave, but fossils are very rare here. Only a few specimens of *Orthis* and crinoid-fragments occur. Abundant débris is seen on the hill south of Pant-dwfn, under conditions which assist in locating the fault that brings the beds against *Dicranograptus*-Shales (p. 629).

On the west of the Tave the beds are exposed near Morfa-bach in two small quarries. In the smaller and lower quarry the beds are of the usual type, and fossils are rare. A few stray specimens of *Leptæna sericea*, Sow. and fragments of *Favosites* occur. This section is fairly high up in the series. In the upper quarry are bands of weathered limestone, containing crinoid-fragments. There is a small thrust from the north shown in section here, and it is suggested that the calcareous beds belong to a higher stage.

In the yard at Lower Cresswell is a small exposure, which has yielded a good number of fossils, including:—

Favosites fibrosa, Goldf.
Ptilodictya dichotoma, Portl.
Hemicosmites rugatus, Forbes.
Ilænus Bowmani, Salt.
Trinucleus concentricus, Eaton.
Trinucleus cf. *seticornis*, Eaton.
Homalonotus sp.

Calymene sp.
Orthis calligramma, Dalm.
Orthis biloba (?) Linn.
Orthis elegantula, Dalm.
Orthis testudinaria, Dalm.
Leptæna sericea, Sow.
Orthoceras gracile, Portl.; etc.

The beds are also frequently exposed near Moor, Tadil, and Maesygrove. In the watercourse between the latter place and Moelden, the beds are traceable to within a short distance of the *Dicranograptus*-Shales, indicating pretty nearly the locality of the fault. The beds are also well seen at Maeslan and in the Pen-y-graig and Cwmdwr lane, dipping northwards at both places, and broken by faults seen in section in the lane.

Near Talfan Cottages is a small quarry on the roadside, where the beds are somewhat coarser in grain and dipping northwards. They are faulted against lower beds on the north and south, in the immediate vicinity. *Favosites fibrosa*, Goldf.; *Phacops* cf. *macroura*, Sjögren; *Trinucleus concentricus*, Eaton; *Orthis calligramma*, Dalm., etc. occur here.

The lane leading to Talfan affords a continuous exposure, but fossils are very rare. Here the beds are faulted on the south against *Dicranograptus*-Beds, and on the north, a short distance from the farmyard, against Sholeshook Limestone (β).

There are several exposures near Felin-ban. The one on the road leading to Cnycau shows the beds in contact with the Old Red Sandstone, and dipping southwards at a high angle. It is probable that a small thickness of beds of the next stage is present here. The character of the rock and the fossils suggest as much.

A quarter of a mile up the road the Llandowror limestone comes out with a low southerly dip. This is seemingly a portion of the Llandeilo-aber-Cowyn anticlinal fold. The ground is, however, much cut up by faults about here.

At the entrance to Penlan the beds are almost horizontal. An exposure of 200 yards or more along the road in the direction of Cnycau shows the gradual steepening of the dip, but fossils are very rare.

West of Parcau the beds are frequently exposed. Sections are seen in the lane leading to Pont Parcau. The few fossils that do occur are of the usual type.

Exposures are abundant near Penlan, Faynor, and Pentrehowel, and in the woods near Teiau-bach. The road-exposure west of Pentrehowel has yielded

Favosites fibrosa, Goldf.
Ptilodictya dichotoma, Portl.
Trinucleus concentricus, Eaton.
Ilænus sp.
Orthis calligramma, Dalm.

Orthis flabellulum, Sow.
Orthis biforata, Schloth.
Leptæna sericea, Sow.
Cyrtoceras sp.

The beds occur also at Clôg-y-frân, where they are much disturbed by folding and faulting. Along the lane to the south the dip continually varies, and a little fold is seen in section in a small exposure in the field at the bend in the road. A few yards to the south-west the beds are faulted against the arenaceous limestones, having been thrown down quite 100 feet. Fossils collected in this locality include:—

Favosites fibrosa, Goldf.
Hemicosmites rugatus, Forbes.
Hemicosmites oblongus, Pander.
Petraia sp.
 Crinoid-fragments.
Calymene cf. *Blumenbachii*, Brongn.
Phacops cf. *Brongniarti*, Portl.
Homalonotus bisulcatus, Salt.

Orthis calligramma, Dalm.
Orthis elegantula, Dalm.
Orthis testudinaria, Dalm.
Orthis bifurcata, Schloth.
Leptæna sericea, Sow.
Leptæna tenuicincta, M'Coy.
Eccutiomphalus Bucklandi, Portl.;
 etc.

(δ) Slade Beds.—These beds are well represented in the area, but the line separating them from those of the stage below cannot be drawn with any degree of confidence, the upward passage being very gradual and devoid of any definite dividing-break. The mudstones and shales are undistinguishable from those of the Redhill Series, but the bands of limestone (usually weathered) which occur in them, and the typical assemblage of fossils in the higher part, are the only indications available that the higher stage has been reached.

It is very probable that beds of this age occur near Heol-down, and Lower Cresswell, and also on Maesgwrda Hill, but there is no satisfactory exposure. There is, however, a good little section in an old quarry west of Cwmdwr, near Llanddowror, where some bands of calciferous shales and mudstones are exposed. The rock is much crushed, and dips south-westwards. Some bands are crowded with *Favosites fibrosa*, Goldf. and *Phyllopora Hisingeri*, M'Coy. Other fossils occurring here are:—

Crinoid-fragments.
Tentaculites anglicus, Salt.
Ilænus sp.
Calymene Blumenbachii, Brongn.
Trinucleus seticornis, Eaton.

Glauconome disticha, Goldf.
Strophomena rhomboidalis, Wilck.
Leptæna sericea, Sow.
Orthis elegantula, Dalm.; etc.

There are several good exposures near Redgate; one in the wood to the north shows one of the bands of limestone, which is very rotten here, but crowded with fossils.

The same beds come out on the main road, at the first rise to the west. These sections have yielded crowds of *Favosites fibrosa*, Goldf. and *Phyllopora Hisingeri*, M'Coy: *Trinucleus seticornis* is also very common. Other fossils collected here are:—

Glyptocrinus basalis, M'Coy.
Tentaculites anglicus, Salt.
Calymene Blumenbachii, Brongn.
Ilænus Murchisoni, Salt.
Ilænus Boumanni, Salt.
Trinucleus concentricus, Eaton.
Glauconome disticha, Goldf.

Strophomena rhomboidalis, Wilck.
 (abundant).
Leptæna sericea, Sow.
Leptæna quinquecostata, M'Coy.
Orthis calligramma, Dalm.
Orthis testudinaria, Dalm.
Orthis porcata, M'Coy.
Orthis elegantula, Dalm.

The same bands are again exposed near Pant-y-iar, where fossils of the usual type are fairly abundant.

At Cnycau there is a roadside section showing some very fossiliferous mudstones and bands of rotten shelly limestones.

The former contain crowds of *Leptaena sericea*, Sow.: and the latter are almost entirely composed of *Orthis*, chiefly *O. testudinaria*, Dalm.

These bands come out on the western side of Cwm-pâl and in the wooded ground near Dol-dderwydd. One band in particular, composed of crowds of *Orthis*, is seen in the Old Pale lane, where it reaches the top of the hill: this is probably the same as the Cnycau *Orthis*-limestone. The fossils collected from it are:—

Orthis testudinaria, Dalm.
Orthis biforata, Schloth.
Orthis calligramma, Dalm.

Orthis elegantula, Dalm.
Leptaena quinqucostata, M'Coy.

Forest Tunnel has been excavated in beds of this age, and here some of the limestone-bands are unweathered and full of fossils. The dip here is almost vertical, and the beds are faulted against *Didymograptus-bifidus* Beds on the north and against striped Lower Llandovery (?) Flags on the south. The beds are traceable for about 200 yards westward, on both sides of the Tave, and then they disappear entirely, being cut off by a fault. The fossils include:—

Favosites fibrosa, Goldf.
Phyllopora Hisingeri, M'Coy.
Petraia sp.
Tentaculites anglicus, Salt.
Calymene Blumenbachii, Brongn.
Illænus sp.
Trinucleus seticornis, Eaton.

Trinucleus concentricus, Eaton.
Strophomena rhomboidalis, Wilck.
(very abundant).
Strophomena corrugatella, Dav.
Leptaena sericea, Sow.
Orthis biforata, Schloth.
Orthis testudinaria, Dalm.; etc.

A slice of these beds has been faulted down among *Didymograptus-bifidus* Beds at Forest: they are exposed at Forest Farmyard, and at intervals between that place and a point south of Pant-y-gwynyn. The fossils (which abound) are of the Tunnel type.

(2) North of the Anticline.

The black slaty *Dicranograptus*-Shales are succeeded, north of the anticline, by brown-grey mudstones, grits, and sandstones, in all of which fossils are extremely rare—a few specimens of *Orthis* being all that has been discovered in them. They possess no character in common with the beds that succeed the *Dicranograptus*-Beds on the south. They are somewhat like beds of the Redhill stage, but much more like the Great Pale beds which will be dealt with below. Their age must remain therefore an open question, till further work has been done among them and more fossils discovered.

(g) Lower Llandovery (?) Rocks.

The last series (δ) of beds pass up into conglomerates, grits, and sandstones, with blue-grey mudstone partings. The conglomerates are seen *in situ* at Pant-y-mwswm, and are here about 8 feet thick. These are succeeded by grits and grey sandstones, well exposed at Greystones. There are very few localities where these beds can be seen in place, but their outcrop can be readily traced by means of abundant loose blocks and debris. This strikes a more or

less irregular curve along the eastern brow of 'Pale Mountain,' between Greystones and Dol-dderwydd, where the beds are cut off by a fault.

Members of the series are seen near Forest Tunnel and in the wooded ground north of Great Pale. A thin band of mudstones cropping out in the wood has yielded some fragments of fossils including *Orthis*, *Atrypa* (?), and trilobites (*Acidaspis Brightii*? and *Trinucleus*?).

The grits have been quarried in Pale Wood and at Penygraig. West of the latter place they are either faulted out, or overlapped by the Old Red Sandstone; but they are well exposed again in Middleway Dingle and in Penyback Quarries, south of Whitland. In the quarries the beds are vertical, and exhibit beautiful samples of ripple-marks, which give a clue as to the conditions under which they were laid down. Fossils are extremely rare in these beds—so much so, that with the exception of the specimens found in Pale Wood, only one or two poor unidentifiable fragments have been discovered.

Whether these beds are of true Lower Llandovery age has not been definitely settled; but it is quite clear that they are younger than the Bala rocks of this region, and older than the Old Red Sandstone, under which they are seen to pass at several points.

IV. CONCLUDING REMARKS.

It is deemed unnecessary to take up any space for correlation, for most of the beds agree closely with the beds of other Welsh areas, which have been carefully and fully worked out by various authors.

The *Tetragraptus*-Beds are, in most respects, in complete agreement with those beds at St. David's, the fauna at Blaencediw being identical with that found at Whitesand Bay (Miss Elles).

The *Didymograptus-bifidus* and *D.-Murchisoni* Beds of this region are, lithologically, very similar to those beds as exposed at Llanvirn and Abereiddy, and the two faunas are practically identical.

The *Asaphus-tyrannus* Beds, although varying much in lithological character, agree palæontologically with beds of that age in the typical areas of Llandeilo and Pembrokeshire.

The *Dicranograptus*-Beds are like those of Pembrokeshire in some respects, but there is one feature that calls for special remark. Miss Elles says that *Leptograptus*-Beds were not known to occur in South Wales till they were discovered at Mydrim. These beds, she says, are on the same horizon as the Rorrington Flags of Shropshire.

The three lower members of the Bala-Caradoc Series of this area are so like the Robeston-Wathen, the Sholeshook Limestones, and the Redhill Beds of Messrs. Marr & Roberts, that they could hardly be mistaken by anyone that had seen those beds in Pembrokeshire. There is, however, a slight lithological difference between the fourth member (δ) and the Slade Beds of Haver-

fordwest. Yet their relative position, general character, and fossil-contents render their identification fairly certain.

The beds to which a Lower Llandovery age has been assigned, being singularly barren, are like beds of that age elsewhere in their very barrenness. I feel convinced that their proper place has been allotted to them, but cannot satisfactorily express the reasons that form the basis of this conviction.

Some work on the belt of ground that lies to the north of the area now described will, it is believed, throw much light on this matter.

In conclusion, I desire to state that when this work was in its earlier stages I received much valuable advice from the late Dr. Henry Hicks, F.R.S. I also desire to express my indebtedness to Miss G. L. Elles, D.Sc., who very kindly examined and identified some of my graptolites, and made valuable suggestions as to the age of the rocks from which the graptolites had been collected.

It is right that I should also express my obligations to those landowners and landholders who very kindly and readily granted me permission to go over their land, and otherwise helped me with the work; also to many farmers and others who rendered me assistance with pick and spade, and in collecting a large number of fossils.

EXPLANATION OF PLATE XLVI.

Map of the Ordovician rocks of Western Caermarthenshire, on the scale of 1 inch to the mile.

DISCUSSION.

The CHAIRMAN (Mr. A. STRAHAN) considered that this paper showed evidence of long and careful work in the field. Almost unassisted, the Author had succeeded in identifying the zones and unravelling the structure of a most complicated bit of Ordovician ground. When the officers of the Geological Survey entered the region in 1903, he not only placed all his knowledge at their disposal, but continued his work in close association with them—to their great mutual advantage. Pressure, however, had been put upon him to bring his results before the Geological Society of London, and thus get full credit for his own researches.

The ground which the Author had examined was partly the same as that described in a paper compiled by Dr. Marr from notes left by the late Mr. Thomas Roberts, and published in the Quarterly Journal in 1893. Roberts's work, so far as it went, was excellent, but he had made no more than a commencement of his investigation of the district when he died.

Mr. T. C. CANTRILL thought that one of the most important points in the paper was the identification of *Nemagraptus gracilis* in the limestone which, at Mydrim, separates the brown-weathering *Dicranograptus*-Shales below, from the black *Dicranograptus*-Shales

above. This discovery by the Author appeared definitely to prove the presence in South Wales of beds of Glenkiln age, and suggested the possibility of the shales overlying the limestone being referable to the Hartfell Group. The Author's record of *Dicranograptus Clingani* from these beds tended to confirm that supposition.

The Author placed the Robeston-Wathen Limestone below that of Sholehook, and regarded them as calcareous developments of the *Dicranograptus*-Shales and Redhill Beds respectively; and this was in agreement with the view expressed by Marr & Roberts in their paper on the Haverfordwest district.

Miss G. L. ELLES remarked, on the great skill shown by the Author in the working-out of a complicated area. He had submitted some of his graptolites to her, and the evidence afforded by them merely confirmed the results arrived at by him on independent grounds.

With regard to the question as to how much of the *Dicranograptus*-Shales should be regarded as of Bala (Hartfell) age, she was inclined to think that a considerable portion of them contained a fauna more allied to that of the Llandeilo (Glenkiln). There appeared to have been some confusion between *Dicranograptus rectus*, a characteristic and common Glenkiln form, and *Dicranograptus Clingani*, an equally-characteristic but far less common Hartfell species; hence beds containing a typical Glenkiln fauna seemed in some cases to have been relegated to too high an horizon.

Mr. H. H. THOMAS, in reply, thanked the Fellows on behalf of the Author for their kind reception of the paper; he agreed with Mr. Cantrill and previous speakers on the great importance of the Author's work in so complicated a district. The Author fully realized the great value of Thomas Roberts's work, which had been of considerable assistance to him. The Author had submitted to the speaker specimens of the igneous rocks from Llanboidy and Dolwilym, which are both ophitic diabase. The Llanboidy rock is very much decomposed; but the Dolwilym rock is much fresher, and is characterized by the presence of pseudomorphs after a rhombic pyroxene, a mineral not very common in the Pembroke-shire minor dykes. It is likely that these masses belong to the same intrusion, but this is impossible of proof, except from a study of the field-relations.