

Ph.D. 1940.

The Geology of the Prescelly Hills and Adjoining
Areas in North Pembrokeshire and Carmarthenshire.

by

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This thesis describes the geology of an area, over 85 square miles in extent, of Ordovician rocks. All the ground has been mapped on 6-inch scale maps, whilst mapping on the one-inch scale has been pursued westwards to correlate this with the Hayscastle Trefgarn Area (Thomas & Cox.).

The ground has been described under three sub-titles:-

1. "Prescelly Area",
2. "Imbricate Area",
3. "Western Carmarthenshire Area".

Thrusts, tending to the N.W., traverse the country, and all the evidence available points to their having, at least, been initiated in pre-Bala times.

The distribution of the rocks in the "Prescelly Area" is governed by the Revern and Crug-yr-hwch anticlines, and the complementary Brynberian Syncline. Prominent developments of volcanic rocks occur near the base and at the top of the Lower Llanvirn succession.

The "Imbricate Area" is complicated structurally and stratigraphically by the aggregation of thrust planes along this 'belt' of country. Within this narrow area two distinct facies of the Arenig, Llanvirn, and Llandeilo rocks are brought into juxtaposition by south-eastwardly thrusting.

"Western Carmarthenshire Area" is essentially the faulted and folded northern limb of the "St. Clears Anticline" (D.C. Evans, 1906). The rocks in this Area have an east-to-west strike, and a relatively simple structure.

2.

Sill-like intrusions of 'spotted', and quartz-dolerites, keratophyres, a bostonite, and sheared granophyre, are prominent rock-types in the "Prescelly", and "Imbricate" areas. Intrusive rocks are unknown in the "Western Carmarthenshire Area".

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The "Prescelly Area"

and the

Adjoining Areas

in North Pembrokeshire

The Geology of the Prescelly Hills
and the
Adjoining Areas in North Pembrokeshire
and Carmarthenshire.

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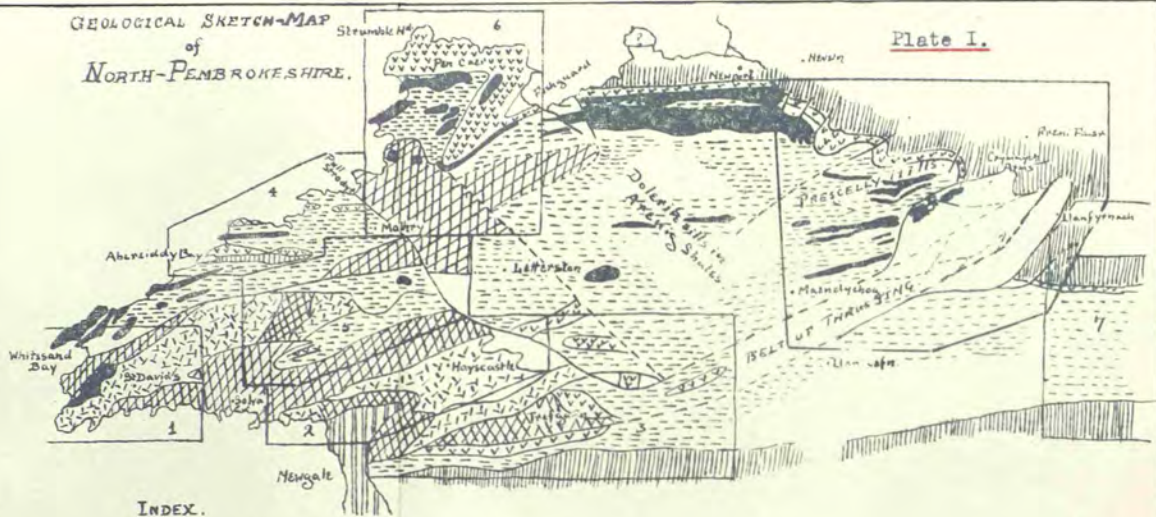
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GEOLOGICAL SKETCH-MAP
of
NORTH-PEMBROKE SHIRE.

Plate I.



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| | Coal Measures. | |
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Introduction

The area described in this thesis is situated around the Eastern boundaries of North Pembrokeshire, and includes adjoining tracts of Carmarthenshire. Extending over an area of 108 square miles, it is represented on the Ordnance Survey 6-inch Sheets, Pembrokeshire VI, N.E., S.W.; VII, S.W., S.E.; XI, N.W., N.E., S.W., S.E.; XII, N.W., N.E., S.W., S.E.; XVIII, N.W., N.E., S.W., S.E.; XIX, N.W., S.W.

Included within the confines of this area is the major portion of the Prescelly Hills, extending in an E.N.E. direction from Foel Cwm Cerwyn to the western-most limit marked as Foel Trigarn - a distance of 4½ miles. Beyond this the detailed mapping on the 6-inch scale was continued in order to incorporate the areas included by Freni Fawr, Freni Fach, Crugiau Dwy, Foel Tyrch, Carn Wen and Rhyd Wylim. The Afon Nevern forms a convenient boundary in the north for descriptive purposes, although investigations were continued northwards beyond this in order to verify the validity of the geology and structures of the area here described. The southern boundary is marked by a line drawn roughly eastwards from Rhyd Wylim to a little beyond, and south of Llanglydwen, whilst the western boundary is taken as a line drawn roughly north and south....

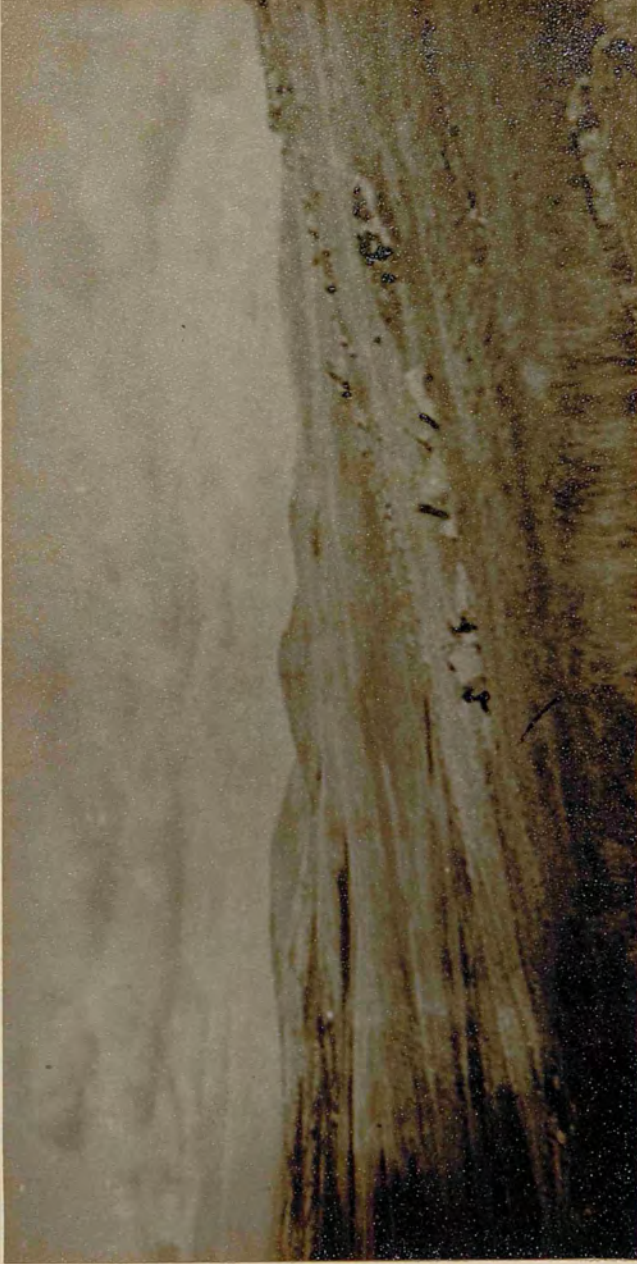


Plate 2

View of the Prescelly Hills looking eastwards from Tafarn-y-bwlch.
Scree of doleritic material in the foreground. Foel Trigarn and Freni
Fawr dominate the scenery in the background.

and south through a point a little to the east of Maenclychog.

Plate 1 shows the position of this area relative to those ~~areas~~ already described in North Pembrokeshire by other workers. To the south-east it adjoins the area described by Mr. D.C. Evans (Plate 1, 7) in 1906. To the west there remains an area separating the ground here described, from that ^{investigated} ~~described~~ by Thomas and Cox (Plate 1, 3) in 1924. So the ^{Prescelly Hills district} ~~area~~ resolves itself into the key-stone position upon which the interpretation of the geology of the remaining undescribed ^{portion} ~~area~~ of north Pembrokeshire will largely depend.

Amid the planated and somewhat featureless topography of the greater portion of Pembrokeshire, the Prescelly Hills and the country around, form striking features. Their barren nature, graceful outline, and somewhat abrupt emergence from the low plateau, tend to exaggerate the actual elevation of the hills. The greater portion of this area lies well above the 500-foot contour line, and large tracts of uncontoured land, above the 1000-foot contour line, extend all along the Prescelly range and the highest portions of the surrounding hills. Such areas received special attention during this work, and the ground was carefully outlined by ^{form-lime contours on} ~~sketching~~ the 6-inch scale maps before the geology was represented on them.

Adding....



Plate 3

View looking southwards from Craig Talfynydd (dolerite) across the drift-covered area of Gors Fawr. Foel Tyrch (capped by dolerite and flanked on each side by the Lower and Upper Tyrch slates, shales and ashes).

Adding a wild and rugged beauty to the flanks and summits of the hills are rocky "carns" of dolerite, keratophyre, soda-trachyte and rhyolite. They form interesting scenic features to which great importance was attached by the 'ancients' as they form natural defences and were consequently the sites of Celtic camps and the scene of Druidical rites - remains of which are still to be seen. Chief among these is the amazing cromlech at Pentre Ifan.

The planated tracts to the north and south of the Prescelly Hills are traversed by deep, striking, V-shaped valleys which are the result, in most cases, of a super-imposed drainage. The rivers traverse the area without paying a great deal of regard to the variance of lithological and structural elements of the district. However, certain of the streams, such as the upper reaches of the Eastern Cleddau, and notably the Afon Taf, have denuded valleys along important structural lines of weakness.

Marshy, drift-filled areas are prominent on both sides of the Prescelly Range. To the north a great tract of marsh-land stretches from below Tafarn-y-bwlch eastwards along the base of the range, and finally banks up, and around, the north-western flanks of Foel Trigarn (Plate 2). To the south of the Prescelly Range drift deposits extend as tongue-like areas converging to form the broad tract of

marsh-land....

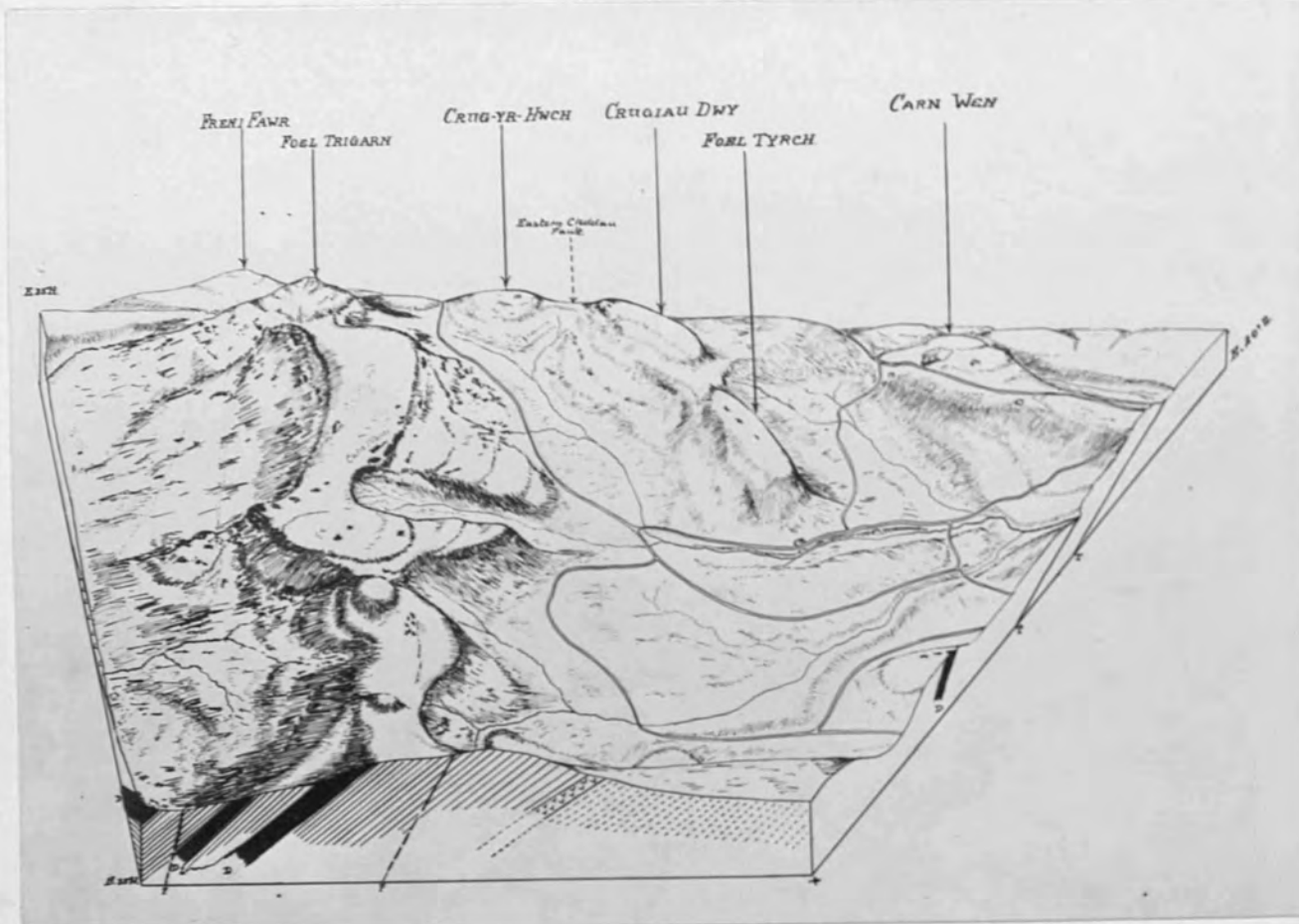


Plate 4

Black diagram indicating the topography of the Prescelly Hills and the adjoining areas.

marsh-land known as Gors Fawr, and Rhos Fach. One tongue extends along the broad valley occupied by the upper reaches of the Eastern Cleddau (Plate 3). Another tongue runs southwards along the course of the Afon Tewgyl. A well marked lateral moraine fringes the eastern limits of this latter tongue. Another tract of drift extends southwards from the prominent "cwm," known as Cwm Cerwyn, towards Gors Fawr.

Unlike the greater part of Pembrokeshire, the topography of the district does, to some extent, exemplify the geological structure and rock distribution.

The river valleys afford excellent exposures of rock, and together with the information derived from quarry-cuttings, and farm-house wells, the interpretation of the large areas of drift-covered country was rendered possible to a fair degree of accuracy.

The block diagram (Plate 4) indicates the distribution of the more important land forms in this area, and it has been incorporated into this thesis in order to bring out the vivid topography on the north with the ever diminishing intensity of the land-form towards the more southerly of the district.

The rocks exposed in this area are all of Ordovician age ranging upwards from the Tetragraptus Shales (Arenig) to Upper....

to Upper Bala. Numerous volcanic and hypabyssal rocks characterise the rock sequence and lend great petrographic interest to the area.

It is hoped that the structural elements identified in this area will throw some light upon the future explanation of the anomalies which exist at the moment in the classification of the Ordovician rocks of Wales.

2. Previous Literature

Despite its prominence as a topographic unit in Pembrokeshire, this area has received but little attention from geologists in the past. Many scattered references have been made to the Prescelly Hills in earlier publications but little detailed geological mapping has been pursued.

The first reference to the geology of this area is of great historic import as it dates back to 1595. The reference is incorporated in a treatise compiled by George Owen of Henlys, who made a very comprehensive survey of South Wales. This work was not published until over a century later, and was finally incorporated into the writings of Richard Fenton (1811).[⌘] George Owen described how in a little brook (Afon Whitehook) descending from

[⌘] See list of references.

the Prescelly Hills there was a rock ... "coale blacke in Colour, and Soft: and his propertie is to colour upon anythinge that it is rubbed on, a blewe colour but which is more strange it serveth to marke sheepe for countrie people." He further stated that ... "the Countrie people call it Nod Glas or blewe markinge stone."

George Owen also indicated that slate-quarrying was a prominent industry of the North Pembrokehire area during, and before, his days.

It remained until the publication of Murchison's "Silurian System," in 1839, before any further reference was made to this district. Murchison observed that "in the principal range of slaty rocks constituting the Precelly Mountains, where the greatest quantity of the best slate is obtained, there are occasional coincidences of cleavage lines and laminae of deposit." He further records that ... "the trap-rocks ... consist of greenstone of several varieties, passing into porphyritic greenstone and porphyry with much compacted felspar rock ('corneen'). Murchison also records a visit made to this area by Sedgewick.

In 1845 the Geological Survey, under the direction of Sir H.T. de la Beche, published a one-inch geological map of North Pembrokehire, but there was no accompanying memoir. This map was later revised by Aveline in 1875 (Sheet 40, O.S.). The whole of the area, hereafter described, was coloured

7

coloured on Aveline's map as slates and shales with associated ashes and felspar traps of Lingula Flag and Llandeilo age. Prominent intrusions of 'greenstone' were also recorded on the map.

In 1897 Dr. J. Parkinson contributed a very valuable collection of notes on the petrographic character of the volcanic rocks of the Prescelly Hills. In the main he confined his attention to outcrops on Foel Trigarn, Carn Alw, and still further to the west in the direction of Rosebush. However, as Dr. Elsdon pointed out, "Dr. Parkinson was unable to establish quite definitely the age of the Prescelly lava-flows, which may date from Arenig times" (1908, p. 273). In addition to this reference, Dr. Elsdon has drawn a very accurate comparison between the lava-flows of Fishguard and those of the Prescelly Hills area. He further classified the diabase intrusions of these two areas into one group, which he termed the "Llanwnda Type."

In 1906, Mr. D.C. Evans published a paper on the "Ordovician Rocks of Western Carmarthenshire," an area which adjoins, and is partly incorporated by, the southeastern boundary of the ^{ground} ~~area~~ hereafter described. Reference was made by Prof. O.T. Jones (1912) to the age of the slate group developed to the east of Crymmych Arms.

Prof. Jones....

Prof. Jones referred these beds to a low horizon in the Dicranograptus Shales (L. Bala).

In the Geological Survey Memoir on the "Country Around Haverfordwest" (1914), reference was made to the widespread distribution of the "spotted" diabase as glacial erratics, which find their origin in the ... "sheet-like masses of the Prescelly Mountains." In 1920 further attention was drawn to this peculiar rock-type by Thomas, when he correlated this dolerite with the so-called 'blue-stones' of Stonehenge, and cited the Prescelly hills as the source of this material. However, in 1922 Mr. G.M. Part endeavoured to cast some doubts upon the exact petrographic affinities of the Stonehenge and Prescelly rock-types.

The larger portion of Mr. Part's publication is an elaboration of the petrology of the volcanic rocks of the Prescelly Hills. He records several new rock-types for the area such as the soda-trachytes of the Rosebush area and the keratophyre of Foel Trigarn.

The Geology of the Prescelly Hills, sensu stricto, was described by the Author in 1937, when its structure and age of the rocks were determined. This work is deposited in thesis form in the Library of the University of Wales. Since that date the work has been considerably extended, and a fuller description of the Fishguard - Newport (Volcanic Group, and the succeeding beds to the north) have been appended

been appended to previous description of the Prescelly Hills area. Further, an extensive tract of ground has been now mapped, and hereafter described, which throws a great deal more light upon the geology of the Prescelly Hills and its neighbouring areas in North Pembrokeshire.

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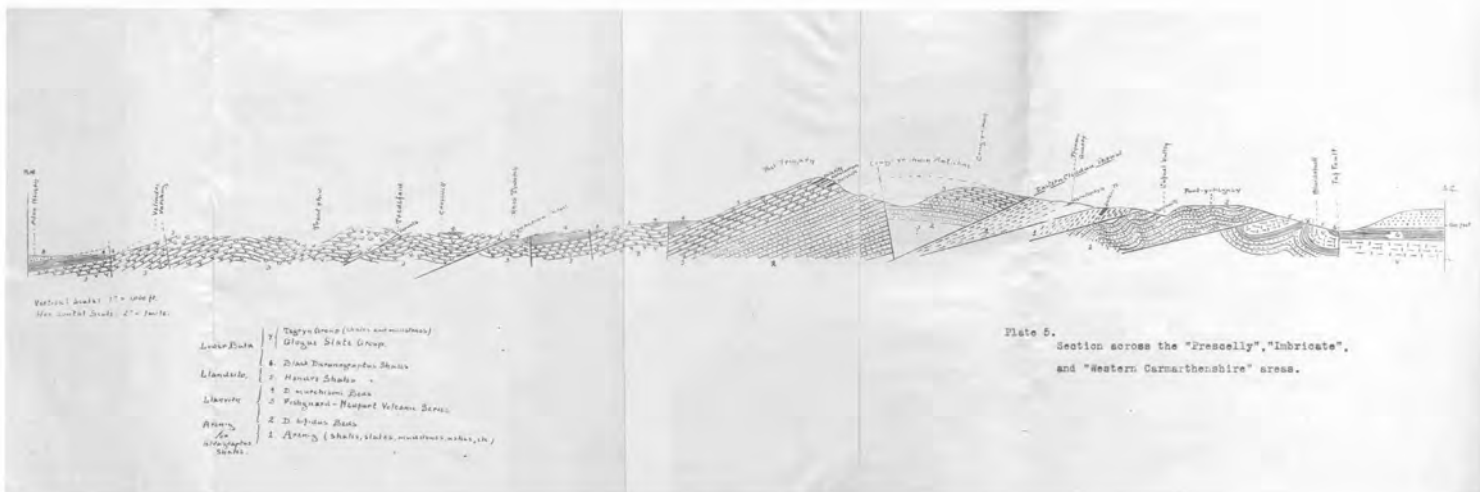


Plate 5.
Section across the "Prescelly", "Imbricate",
and "Western Carmarthenshire" areas.

3. General Structure

It will be seen from the accompanying map that the rocks generally possess a caledonoid strike, typical of most of North Pembrokeshire and Central Wales as a whole. On the southern and south-eastern portions of the area here described there exists an east to west element of strike. The existence of these two divergent lines of strike immediately resolve the area into two structural units, separated from each other by the trace of the "Taf ^{Fault} ~~Thrust~~". To the south and south-east of this line the rocks are disposed upon what may broadly be described as the northern limb of the St. Clears Anticline (Evans, 1906, p.647). Its simplicity of structure has been slightly obscured by the development of subsidiary folds and transverse- and strike-faulting (See Plate 5).

To the north of the Taf Thrust Line the remaining area again resolves itself into two structural units. Between the Taf ^{Fault} ~~Thrust~~ and the Eastern Cleddau ^{Thrust} ~~Fault~~ is an area of intense disturbance. Here the rocks are displayed as an imbricate pattern caused by the thrusting of the country to the north southwards towards the relatively 'stable block' to the south-east.

North of the Eastern Cleddau ^{Thrust} ~~Fault~~ (the ground mainly occupied by the Prescelly Hills), the geological structure is again

is again comparatively simple. The disposition of the outcrop of the rocks is controlled by the Brynberian Syncline and the Prescelly Anticline, both folds possessing an element of pitch some 5° to 10° to the east-north-east.

Not only is the area divisible into three units on structural grounds, but also upon variance in the lithology of the rocks. The rocks are all of Ordovician Age, but the facies in the northernmost area differs markedly from that of the southernmost area, while ^{portions of} both stratigraphical successions are represented in the intervening area. Therefore, it is here submitted that a description of this portion of N. Pembrokeshire is best recorded as three distinct areas, which can only be connected on structural grounds. The petrographic detail connected with the rocks occurring in each unit has been included as appendices to the description of each area. Each separate area will be hereafter described under the following titles:-

- A. The "Prescelly" Area.
- B. The "Imbricate" Area.
- C. The "Western Carmarthenshire" Area.

- so arranged and described from north to south of the whole map. It has also been found convenient to denote the stratigraphical succession (with the exception of the Bala rocks) at the beginning of the separate descriptive tracts of each area.

The Prescelly

The "Prescelly Area"

The rocks exposed in the "Prescelly Area," arranged in stratigraphical order, are as follows:-

^{Upper} ? Lower Bala	{	d. Freni Fawr Group.
^{Lower} Upper Bala	{	c. Tegryn Group.
	{	b. Glogue Slate Group.
	{	a. Dicranograptus Shale Group.
Llandeilo	{	Hendre Shales.
U. Llanvirn	{	D. murchisoni Mudstones and Shales.
L. Llanvirn	{	d. Fishguard-Newport Volcanic Series.
	{	c. "Bifidus Shales."
	{	b. Syfynwy Volcanic Group.
	{	a. Thin bedded shales and slates.
Arenig	{	b. Pale grey and buff coloured mudstones.
	{	a. Blue-black shales and slates.

Apart from the interesting assemblage of volcanic rocks and intrusive dolerites and a keratophyre, the rocks of the "Prescelly Area" are, on the whole, difficult to deal with owing to the fact that exposures are poor. ~~and~~ ~~the monotony of shaly lithological types.~~

1. Arenig Series (or Tetragraptus Shale Series)

The Arenig rocks have not been identified on palaeontological grounds, but their age has been deduced from their field relationships with undoubted Lower Llanvirn (D. bifidus Zone) Beds. The junction between the Arenig and Lower Llanvirn is purely an arbitrary one devised upon lithological grounds to coincide as near as possible

possible to the division described by earlier workers in North Pembrokeshire (e.g. Thomas and Cox, 1924, p.523). This junction is taken with the development of ashy mudstones exposed at various points along the southern flanks of the Prescelly Hills.

(a) Few exposures of these blue-black shales exist in the Prescelly area, and what rock exposure is available constitutes a very high horizon in the Arenig, but probably below the Zone of *D. hirundo*. The prevalence of drift in the western end of the area renders description of these shales somewhat difficult, and no attempt is here made to give any account of their sporadic distribution. ^{of the outcrops.} Exposures of these thinly bedded, highly cleaved, blue black shales are best seen in the bed of Dwrđy Brook, particularly near Dwrđy Cottage, where an unsuccessful attempt has been made to work these beds as roofing slates. The cleavage is so intense at this point that the shale splits into long pencil-like flakes. This is due to the proximity of the Eastern Cleddau Thrust, one branch of which is well displayed in the quarry-face at Dwrđy Cottage. The slate has been milled down into 'rubble' and fine clay 10 feet in thickness and forms a very conspicuous feature marking the position of the thrust-plane in the quarry face. Here the so-called *Tetragraptus* shales are thrust over the beds of the Lower

blocky and pale-grey in colour weathering to a striking creamy-yellow colour. Beautiful, banded, iron-staining of the joint-faces is a marked feature of the rock. The mudstone sometimes tends to be hard and splintery and it has been used as 'ballast' material for the country roads in the near vicinity of the quarry. On weathering, the rock breaks down into a fine powder which binds into a compact mass in the roads, hence forming very good 'ballast' material.

To the east the mudstones are again exposed at intervals along the southern flanks of Cnwc Rhudd. Evidence of lateral variation in the mudstone group is afforded by a section in a deep gully high up on the hillside above Clyn-saethmaen Farm. Here the shales are interbedded with the blocky mudstones. The shales are sheared, and, owing to their high pyritic content, on weathering they convey the impression of rotten wood.

Eastwards of Cnwc Rhudd the ground along which the projected line of the junction should traverse is obscured by a heavy cover of drift - both glacial and rainwash.

2. Lower Llanvirn

The Lower Llanvirn Shales, tuffs, agglomerates and volcanic rocks closely resemble beds of similar age to the west

the west and north-west of the Prescelly Hills. In this area they have been subdivided into four main groups, purely upon lithological grounds.

- d. Fishguard - Newport Volcanic Series.
- c. "Bifidus Beds."
- b. Syfynwy Volcanic Group.
- a. Blue-black shales.

(a) Above the Arenig mudstones is a development of thinly bedded blue-black shales, with intercalations of thin bands of "siltstones." The whole is some 150 feet in thickness. Towards the top of this group, and directly below the base of the Syfynwy Volcanic Group, the beds contain considerable developments of pyroclastic material, excellent exposures of which occur near the old sheep pen, immediately south of Carn Afr; and also at the bottom of the steep encircling slopes of Cwm Cerwyn.

Exposures of the shale and mudstone components of the sequence are very restricted along the whole length of the southern flanks of the Prescelly Hills. Their line of strike is, however, easily and accurately determinable from the trace of the succeeding Syfynwy Volcanic Group in both an easterly and westerly direction from Cnwc Rhudd, the type locality.

Slate is sometimes developed in this group of shales. In Cwm Cerwyn serious attempts have been made to develop slate quarries. Here the cleavage is well developed and

in the

in the main cleavage and original bedding of the rock coincide. Reference to this slate is made by George Owen (1595). Murchison also noted particularly the coincidence of cleavage and bedding in this locality. Here the slates have been slightly indurated, but in no way bleached, by the intrusion of two thin dolerite sills. In certain thin bands the slate possesses a high cleavage value[ⓧ], but the position of the site and the scarcity of available material led to the termination of this venture. Slates ("Bifidus Beds") of the same colour, which have been extensively quarried in the Rosebush quarries, also contributed to the early abandonment of quarrying in Cwm Cerwyn.

Thinly bedded shales, belonging to this horizon, are exposed in the farmyard of Carn-meini uchaf, and in trial holes up on the hillside above the Farm. Further east an almost continuous exposure of these shales is exposed in the bed of a small stream which descends the hillside near Congl Farm. The exact junction of these beds with the overlying soda-trachytes of the Syfynwy Volcanic Group is unfortunately obscured. It seems evident^{to}, however,

[ⓧ] "Cleavage-value" is a term here employed to indicate the measure of the ability of the slate to cleave to a thickness suitable for use as roofing slates.

that there

that there is here a marked diminution in, if not complete absence of, the pyroclastic material in these uppermost members of the shale group.

It is convenient, at this point, to note that westwards from Cnwc Rhudd there is a steady increase in the amount of pyroclastic material developed in the upper part of this shale group, and it is more difficult to dissociate this group of shales from the Syfynwy Volcanic Group. In the striking section exposed at the Syfynwy Falls there is a ~~marked~~ development of fine-grained crystal tuffs ~~with~~ *and thin bands of* ~~interstitial developments of~~ soda-rhyolites. The lowest
 " " " " rhyolite and the beds above have been chosen as constituting the conventional base of the Syfynwy Volcanic Group.

(b) The Syfynwy Volcanic Group

Some 150 feet above the basal beds of the Lower Llanvirn occurs this distinctive development of volcanic rocks. It is named after the type - locality ~~exposed~~ along the banks of the River Syfynwy. In its extent westwards and eastwards of this locality it forms a very excellent, easily mappable line upon which the interpretation of the structure of the beds above and below can be assessed. In an area poor in exposure of rock it forms an important lithological line in the Lower Llanvirn beds.

Although

Although occupying an undoubtedly constant stratigraphical horizon, the Syfynwy Volcanic Group varies in lithology westwards and eastwards from the Syfynwy - Rosebush area. At the Syfyⁿwy Falls the rock consists of pale-blue to green-grey, fine-grained rhyolites and crystal tuffs which weather to a striking creamy-white colour, with usually a ~~striking outer~~ coating of soft grey or white powdery residue ~~on the surface~~. ~~Steel-grey and white, stripy weathering often exhibit beautiful ~~crystal~~ flow structures on the surface of the rhyolites.~~ The whole exposure is rendered even more striking by the development of rectangular joint planes, ~~of~~ which erosion by the river has taken advantage, and has resulted in the production of a very picturesque waterfall.

The upper limit of the volcanic group is very well exposed on the eastern flanks of Banc-ddu, a few hundred yards north of New Inn, where a small lenticle of volcanic rocks is thrust over "Bifidus Shales." The irregularities of the upper surface of the highest tuff are filled with shale material, and it seems evident, in some places along the exposure, that a small time-gap existed, probably marked by scouring of the more or less consolidated tuffs.

Eastwards the development of rhyolite diminishes and more basic material takes its place. Five hundred yards

S.E. of

S.E. of Pant-y-maenog Farm is a small exposure of pale green coloured soda-trachyte. The rock is hard, badly brecciated, and indurated by vein quartz. It is vesicular in parts - the vesicles being filled with chloritic mineral.

A similar rock type forms the prominent rocky exposure known as Carn Afr. Small exposures stud the outcrop as it strikes towards a point some 500 yards south of the summit of Foel Cwm Cerwyn. Here the outcrop is terminated by a fault.

Interstratified with the shales and slates of Cwm Cerwyn is a thin lava-flow some 10 feet in thickness. The rock is grey in colour and relatively coarse-grained. In hand-specimen it is strikingly like a grit, but under the microscope it is easily defined as a devitrified, chloritised lava - probably originally a ~~soda-trachyte~~ trachyte. There seems little doubt that this is an attenuated representative of the Syfynwy Volcanic Group. Its lateral distribution is very limited in the Cwm as it is quickly truncated on both sides by normal faults.

Eastwards, the Syfynwy Volcanic Group is next encountered emerging from the heavy-drift cover of the Tewgyll Valley. The volcanics make prominent carns, and, along with excellent features, it forms an easily mappable line along the southern flanks of the Prescelly Hills. The most prominent....

most prominent of the carns are those above Ty Cwta Farm,^{and at} Carn Bwdcyn, and Carn Sarn. The rock is very uniform along its line of exposure. It is blue-grey in colour when fresh, but more commonly tinted by various shades of green when only slightly weathered. Felspar phenocrysts stand out quite prominently on the ~~roughly~~ weathered surfaces of the rock, showing a marked trachytic orientation of the felspar laths. The rock is usually highly chloritised, the mineral often filling irregular cracks in the rock.

The best exposure of these soda-trachytes is situated in the quarry-cutting immediately below Carn Bwdcyn, where the rock has been quarried for road metal. The face of the quarry is strongly traversed by joints, the rock being traversed by irregular 'stringers' of vein quartz. The quartz is often deep blue-green in colour due to the occlusion of particles of the rock and of secondary chlorite. Large ovoid vesicles up to 12" in length are sometimes developed. They are always lined with a thin coating of quartz, filled with soft, earthy iron oxides - obviously the result of the oxidation of iron-pyrites. In one instance a vesicle was exposed filled with bright greenish yellow sandy material consisting of a mixture of euhedral crystals of quartz coated with sulphur. The residue of oxidised

iron

iron coated this vesicle to a thickness of $\frac{3}{4}$ " , but there was comparatively no iron staining traceable in the loose material in the cavity.

To the east of Carn Bwdcyn another fine exposure of soda-trachytes form Carn Sarn. To the east of Carn Sarn the succession is expanded, and the major portion of the soda-trachytes obliterated by an intrusion of dolerite into the trachytic lavas. Beyond this point the trachytes are truncated by a transverse faulting.

This irregular.....

~~.....~~

This irregular lateral development of pyroclastic material, and the variation in the petrographic nature of the constituent volcanic rocks which make up the Syfynwy Volcanic Group, is here submitted as being the reason why difficulty has been experienced in the past of correlating these rocks with the lower members of the Lower Llanvirn, instead of assuming, as was done, that they represented an horizon equivalent to that occupied by the Llanrian (or Fishguard - Newport Volcanics) Volcanics of N. Pembrokeshire (Part, 1922). It is here submitted that mapping on the 1-inch to one mile scale has shown that ~~there is no doubt that~~ the blue-black shales are the equivalent of Sealyham Shales, and the succeeding Syfynwy Volcanic Group is the stratigraphical representative of the Sealyham Keratophyres (Thomas & Cox 1924, p. 535).

c. The "Bifidus Beds"

Between the Syfynwy Volcanic Group and the Fishguard - Newport Volcanic Group exists a prominent development of shales, slates and associated ash-bands. In one instance these beds have yielded a fairly rich suite of fossils which included among them *D. bifidus* (Hall). On this palaeontological evidence the group has been given the title of "Bifidus Beds "

The "Bifidus Beds" extend over the greater part of the Prescelly Hills and westwards on to Banc-du and the high ground to the north, including such prominent features as Foel Eryr, Rhwyng-y-dwyfordd, Waun Mawn, and the country around Cerrig Meibion Owen. In all the group is over a 1000 feet in thickness - a precise definition of thickness is difficult to make owing to the irregular implacement of dolerite intrusions in the succession together with small scale faulting and overthrusting.

The shales and slates and associated bands of ash and agglomerates succeeding the Syfynwy Volcanic Group in the Greenaway district have been identified (Part G., 1922, p. 175) as being of Upper Llanvirn age on the grounds that one specimen of *D. murchisoni* had been found in the shales. The specimen was described as "being badly smeared by the cleavage." Examinations of this and other localities have

failed to yield any further palaeontological evidence to support this definition. This view was ^{further} supported by the fact that Mr. Part identified the Syfynwy Volcanic Group, as being the same as the Fishguard - Newport Volcanic Group. The detailed mapping of the area shows that the two sets of Volcanic rocks are separated by the "Bifidus Shales." It follows then that the shales of Greenaway and Banc-du are definitely of Lower Llanvirn age.

A fine development of the "Bifidus Beds" is exposed on the bare steep slopes of Cwm Cerwyn, particularly in the stream section in the N.E. corner of the Cwm, where the shales succeed agglomerate and tuff which constitute the upper limits of the Syfynwy Volcanic Group. Here, the shales are in no way affected by dolerite intrusions. Some 700 feet of these shales are exposed. They consist of well-bedded blue-black shales with intercalations of thin bands of blue-grey, fine grained ash, never greater than three inches in thickness.

Apart from the exposures in Cwm Cerwyn, which unfortunately yielded no fossil evidence, there are very few opportunities available for studying the rest of the succession of the "Bifidus Beds." Only in close proximity to dolerite intrusions, where the shales are bleached, and the fine grained ashes hardened to splintery adinoles, are the individual members of the succession usually exposed.

To the

To the north, and north-west, of Cwm Cerwyn there is a tendency for there to be a development of gritty bands in the succession. Around Tafarn-y-bwlch and Waun Mawn the beds are in the nature of flaggy shales. Still further north in a deep gully descending from the road to Ty-dwr-uchaf Farm, a number of bands of splintery, green tuffs, varying from a few inches to a few feet in thickness, are associated with flaggy, blue-black mudstones.

Eastwards from Cwm Cerwyn the "Bifidus Shale" Group is greatly affected by dolerite intrusions and exposures are rare. Between Carn Goediog and Carn Breseb the few exposures which are present on the hillside indicate that this portion of the succession is made up of a series of flinty adinoles, blue-black and highly pyritous shales, with intercalations of fine grained ash and slate-agglomerate.

Between Carn Meini and Carn Ungwr there are quite a number of exposures of the "Bifidus Shale Group," consisting of a series of spotted shales and silver-grey slates which are not unlike the Arenig slates of the Lower Tyrch Group (see description of the "Imbricate Area"). The slates are succeeded by a series of well-bedded, dark-grey, gritty shales which contain numerous fragments of albite-oligoclase feldspar phenocrysts. A locality situated some fifty yards due north of Carn Meini reveals an exposure of grey-weathering fossiliferous shales. The fossiliferous band is

no more....

no more than three feet in thickness, and along with specimens of a few trilobite fragments, and a few poorly preserved brachiopods, the following fossils have been collected.

Didymograptus bifidus (Hall)

Trinucleus ~~comp.~~^{cf.} Bucklandi (Barrande)

Trinucleus sp.

Orthis sp.

Orthis sp.

This exposure is of extreme importance as upon it has been based the identification of the shales, slates and associated pyroclastic rocks of the Prescelly Hills as belonging to the Lower Llanvirn. It is the first known fossiliferous horizon to be described on the Prescelly Hills. This undoubted occurrence of the zone-fossil *D. bifidus* (Hall) greatly reduced the difficulties of mapping in this area.

Towards the extreme east of the "Prescelly Area" there are very few exposures of these shales. On the northern flanks of the Prescelly Hills, upon which these shales would be expected to outcrop, they are covered with rainwash and glacial drift. Also, the succession here is greatly affected by the massing of dolerite intrusions, the main one being the "spotted dolerite" of Carn Meini, Carn Gyffrwy and Carn Ddafad-du.

Exposures of these shales are fairly plentiful near the base of the Fishguard - Newport Volcanics outcropping on the northern flanks of Foel Trigarn, but nowhere along the whole extent of the area has it been possible to obtain an exposure revealing the actual junction of the "Bifidus Beds" with the over-lying Fishguard - Newport Volcanic Group. However, all the near-by evidence points to a sharp division between the two groups of rocks. It seems that at most points along the extent of the Volcanic Group the era of vulcanicity was initiated by a sudden outpouring of rhyolitic lava at slightly varying intervals of time, and from a number of distinct centres of eruption.

d. The Fishguard - Newport Volcanic Series

The "Bifidus Beds" are succeeded by a development of volcanic rocks. Extending from the Fishguard - Strumble Head area (Cox, P.G.A., 1930, p. 274) the Volcanics strike through Dinas. Passing to the south of Velindre they bend sharply into the 'nose' of an anticline, and then swing eastwards again along the northern flanks of the Prescelly Hills as far as Foel Trigarn. Anticlinal folding, aided by faulting, swings the outcrop southwards from Foel Trigarn on to Crug-yr-Hwch, but its further extent is obliterated by the presence of the Eastern Cleddau Thrust.

At Fishguard....

At Fishguard Old Harbour, despite the fact that strike-faulting has reduced the thickness of the Volcanics, it is estimated that there are at least 700 feet of these rocks. Through the Dinas-Velindre area (not described here) the thickness of the Volcanics is greatly affected by intrusions of dolerite and keratophyre. However along the whole of its outcrop (), the Volcanics maintain a fairly constant thickness varying between 500 to 600 feet even at the most easterly point of outcrop, Crug-yr-Hwch.

Great lateral variation in lithological types over relatively short distances makes correlation of separated areas of outcrop very difficult to deal with. However on recognising the following broad subdivisions of the Volcanic Group, areas of outcrop separated by formidable areas of drift could be assigned to their relative positions in the volcanic sequence.

- c. Upper Rhyolite Group
- b. Pyroclastic Group
- a. Lower Rhyolite Group

The rhyolites near Gelli-Pant-cwm belong to the Upper Rhyolites, while those exposed in Ty Canol Woods and around Pentre Ifan Cromlech belong to the Lower Rhyolites.

The rhyolites are mainly fine grained, with occasional phenocrysts of lath-shaped feldspars. In the main they are non-vesicular...

non-vesicular (cf. rhyolite on Foel Trigarn p. 36), and while perlitic structures are not usually identifiable in hand specimens, microscopic examination reveals attempts at its formation (e.g. rhyolites at Sychpant). Oft-times beautiful examples of rhyolites showing ~~fine fluidal~~ flow structures are met with (e.g. Carn Alw rhyolites), and occasionally the rhyolites are spherulitic in texture. The ashes and tuffs associated with the Lower and Upper Rhyolites are usually fine grained, but occasionally coarse-grained varieties appear in the Pyroclastic section of the Volcanics. The coarser varieties, almost always contain large, fresh, phenocrysts of albite-oligoclase feldspars in a very fresh condition, and in the majority of cases they are brecciated also ^(Plate 14). Vitro-lithic tuffs are also ~~prominently~~ developed at various horizons (e.g. at the small quarry near the Bridge at Brynberian).

In the Nevern-Brynberian district it has been found impossible to subdivide the volcanic succession into the above-mentioned groups. However, rhyolites are developed near the base, as in the small roadstone quarry near Sychpant, and near the top of this succession of rather monotonous, blue-grey to green coloured fine-grained tuffs. They closely resemble the development of the Volcanics in the Brynberian to Crosswell section, which is described below.

The massive....

The massive cromlech known as Pentre Ifan is constructed of fine-grained agglomeratic tuffs, which were obtained from a nearby exposure, which probably marks the site of a very ancient quarry. Similar tuffs have also been used for the construction of walls, some of which are reputed to be very ancient.

An interesting occurrence of brecciated rhyolite is exposed in an old quarry near the roadside north-^{East}~~west~~ of Dyffryn Benglog. It is fifteen feet in thickness, but its contact with the underlying fine-grained tuffs is obscured by debris. Lithologically it is identical in composition with the occurrences of brecciated rhyolite in the Tredefaid Quarry and Carn Alw. Although it has been found impossible to map the outcrop of this rhyolite for any distance, its position in the volcanic succession suggests that it is the same one as that exposed in the Tredefaid Quarry about $1\frac{1}{2}$ miles to the south-east of Dyffryn Benglog.

Apart from the above points of interest, the volcanic rocks of the Nevern - Brynberian district are identical with those described below from the Brynberian-Crosswell section.

A complete succession of the Volcanic Group is exposed along the valley of the Afon Brynberian, which runs almost along the line of pitch of the Brynberian Syncline. Here the succession consists almost entirely of tuffs, with a single rhyolite near the base and one near the top of the succession

succession. The junction, with the underlying "Bifidus Beds" is not exposed.

Near Mountain Hall the fine-grained green-coloured tuffs are succeeded by a fine-grained soda-rhyolite, 15 feet in thickness. At the base of the rhyolite a zone of intermixture, some four feet in thickness, between rhyolite and tuff is clearly exposed. The rhyolite is succeeded by hard, quartz-veined, green, chloritised tuffs which are well-exposed near the bridge. These in turn are succeeded by a persistent band of light-buff weathering mudstones which, on careful mapping from Brynberian to a point some distance south of Crosswell, explained the enormous development of pyroclastic rock witnessed along the Brynberian Valley section. The mudstones are succeeded by well-bedded beautifully spotted vitro-lithic tuffs, interbedded with thick bands of hard, grey-green, indurated tuffs. The spotted tuffs present a striking patch-work colouration of greens, greys, browns, and speckled with white spots of felspathic ^{material}. The hard grey tuffs often contain large pockets of soft limonitic ~~material~~ often up to five feet in diameter. The walls of the pockets are almost invariably lined with iron-stained crystals of quartz.

Succeeding these highly-coloured tuffs the rest of the succession resolves itself into a somewhat monotonous series of fine-grained

of fine-grained blue-grey tuffs, which weather ~~strikingly~~ white, the weathered surfaces often showing striking bands of white and grey. One interruption to the monotony of this succession is afforded by the development of a ~~striking~~ band of vitro-lithic tuff in the small quarry on the eastern bank of the river near Pont-saith-gareg. The band is some 15 feet in thickness and consists of vitro-lithic tuff containing wisps and patches of dark, optically inert material set in a fine-grained glassy, light-coloured felsitic matrix. The agglomeratic affinities of this rock-type are best seen on the weathered faces of the rock exposure.

Despite the monotony of this pyroclastic succession to the north of Pont-saith-gareg there is a marked occurrence of soft bands within these hard tuffs. The softer bands are ^{indicated} ~~marked~~ by hollows, the rock in which is always concealed by rainwash, but it is here submitted that these hollows mark the exposure of softer fault-breccias. Small scale faulting (transverse to the direction of pitch), has produced this abnormal, apparent, development of pyroclastic material. The down-throw of these faults is along the direction of the pitch of the main Brynberian Syncline; i.e., towards the north-east.

However The

~~However~~, The monotony of rock-type is once more dispelled towards the top of the volcanic succession. In the Tredefaid Valley, a tributary valley of the Brynberian, small scale thrusting and faulting appear (~~small scale~~) and the rock types consist of blue-black gritty, felspathic ashes interbedded with fine-grained splintery, light-grey tuffs. Sections on the southern flanks of the valley and in the quarries show striking examples of current bedding in these pyroclastic rocks. Some of the ash-bands are intensely contorted.

A thin, but striking, development of brecciated rhyolite, identical with ^{that} ~~the brecciated rhyolite~~ of Carn Alw (Lower Rhyolite Group), is exposed in the extreme western corner of the Tredefaid Valley. This is succeeded by a series of massive, fine-grained, dark-blue ashes, which grade upwards into a series of coarsely bedded ashy-shales, which form the highest beds of the Fishguard - Newport Volcanic Series in the Crosswell district.

Nowhere

Nowhere is the great inconstancy of rock-type so vividly displayed as between the Bryn-berian-Crosswell district and Carn Alw, some two miles apart. Carn Alw is composed of a striking development of rhyolites belonging to the Lower Rhyolite Group. Here the rhyolites are exposed on the southern limb of a synclinal structure, and consist of spherulitic, brecciated, and fluidal types. These rocks have received attention in the past (Parkinson, 1887). The great variety of rock-textures displayed by the rhyolite mass is due to the fact that the carn exposes a series of contemporaneous lava-flows within which juvenile reactions and movements have played a great part. Sometimes the rock is composed of incipient growths of spherulites; sometimes the spherulites are completely developed (see Plate 17, p. 60); sometimes the rhyolites are strikingly brecciated; and, in not a few cases, beautiful fluidal structures are developed in the rock, and these are vividly displayed on the freshly fractured surfaces of the rock.

The brecciated lava-flow, which mainly outcrops on the more northerly flanks of the Carn, is a striking rock-type. In hand specimen it reveals close similarity to an agglomerate, with its light-coloured felsitic rock

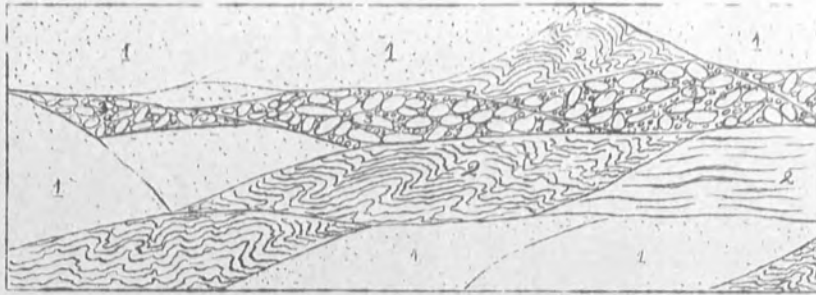
fragments...

fragments set in a dark, almost bottle-green matrix. Closer examination shows that certain portions of the brecciated rock is made up of an intimate association of spherulitic, and fluidal rhyolite (see Plate 10a).

The fluidal rhyolites are mainly developed on the extreme northern flanks of the Carn, and particularly fine examples are to be seen as large boulders in the scree-material (~~scree~~). The scree-material which extends northwards from the Carn mainly consists of steel-blue, fine-grained tuffs, dark-grey coarse-grained, feldspathic crystal tuffs, and slate-agglomerates. The presence of these rock-types suggests that the succession of the Volcanics in the Carn Alw district is similar to the Foel Trigarn rocks.

Exposure of the lowest members of the Volcanics on the northern slopes of Foel Trigarn is relatively poor, but the evidence deduced from the scree material suggests ~~quite~~ strong similarities with the Carn Alw rhyolites. The fine grained rhyolites, and the fluidal rhyolites are at least present, but no trace has been found of the spherulitic and brecciated rock-types which are so prominent on Carn Alw.

Succeeding the Lower Rhyolites on Foel Trigarn are a series of white-weathering 'porcellanous-tuffs,' ^{and} vesicular
ashes...



- 1. Fine-grained rhyolite.
- 2. Rhyolite showing flow structures.
- 3. Spherulitic rhyolite.

Plate IOa.

Diagram illustrating the brecciated
rhyolite of Carn Alw.

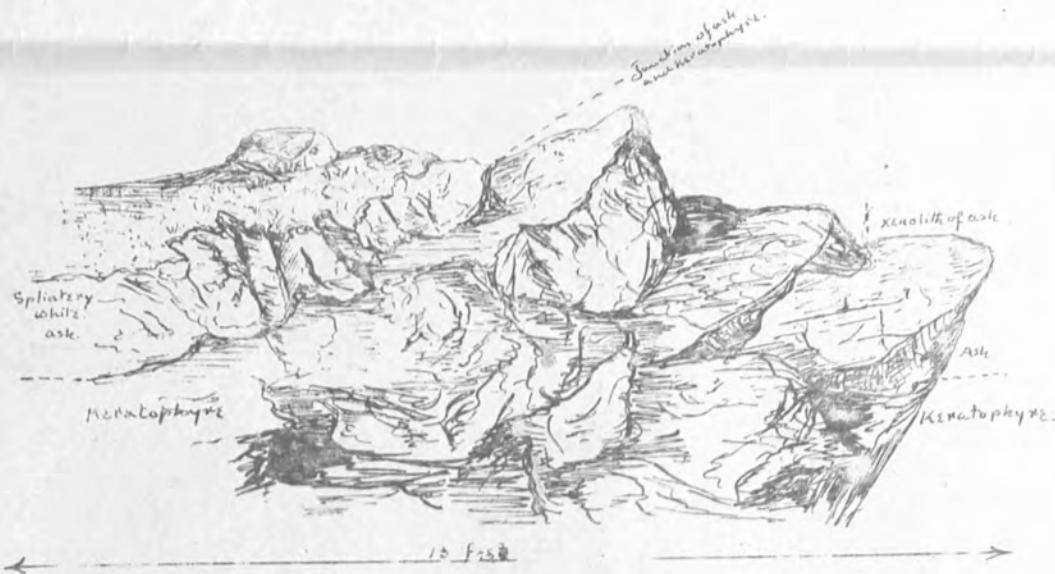


Plate IOb.

View of the intrusive keratophyre
of Foel Trigarn.

which are
ashes, succeeded by a band of coarse-grained slaty-ash beds, some fifteen feet in thickness. Above these slaty beds are a series of extremely hard, glassy, indurated felsitic tuffs, into which has been intruded a prominent intrusion of keratophyre. (Plate 10b)

Alternating with the foregoing rock-types are thin beds of feldspathic ashes containing large phenocrysts of albite-oligoclase feldspar. When fresh the rock is steel-blue in colour, spotted with the pale-coloured feldspar phenocrysts. When weathered, the rock breaks down into a dirty-brown coloured sponge-like mass.

The coarse-grained vesicular rhyolite, which is taken (for descriptive purposes) as the base of the Upper Rhyolites on Foel Trigarn, outcrops near the summit of the hill on the north side. This material, along with the dolerite, has been used in the construction of the outer defences of the old British Camp which lends historic fame to Foel Trigarn. The vesicular rhyolite is succeeded by a set of steel-blue coloured, fine-grained ~~fluidal~~ exhibiting flow-structures. rhyolites. These are best exposed in the quarry above Parc-yr-wrach Farm. Above these rhyolites are a series of fine- and coarse-grained crystal tuffs, and agglomerates. The volcanic succession is terminated with the development of slate-agglomerates. These latter rock-types consist

of wisps...



Plate 11

Microphotograph of slate agglomerate showing wisps of slate (some marked X) set in a fine-grained ashy matrix. Holohedral crystals of pyrites (marked Y) are also shown. Locality: Quarry near Ffynnon-wen.

of wisps, and fragments, up to 2.5 cms. in length, of blue-black slate set in a strikingly light-coloured felspathic matrix (see Plate 11). Holohedral crystals of pyrites are usually well developed in these rocks, where they are best exposed at such places as in the bed of the Afon Whitehook, and in the small quarries near the farm Ffynnon-wen and Felin-uchaf.

The agglomerates and coarse-grained tuffs exposed above Maes-y-garn Farm, on the eastern flanks of Crug-yr-hwch, compare very closely with uppermost members of the Volcanics on Foel Trigarn, and this similarity is borne out by the field relationships of these rocks with the overlying Upper Llanvirn beds.

Boulders of rhyolite, crystal tuff, and coarse-grained agglomerates on the western slopes of Crug-yr-Hwch, together with the few exposures that are available, show that there is no appreciable diminution in the thickness of the Fishguard-Newport Volcanic Series at this point. The complete disappearance of the Volcanic Series between Crug-yr-hwch and Crugiau Dwy is, therefore, all the more striking. The marked absence of any great eastward reduction in the thickness of the Volcanics all along the line of strike suggests that they possessed a much more widespread distribution to the south and east

than...

than is now indicated in this portion of N. Pembrokeshire. Their complete absence to the south and east is explained by the fact that the probable continuation of the Volcanics has been obliterated by south-westwardly thrusting along the line of the Eastern Cleddau Thrust.

The Fishguard - Newport Volcanics ^{has} proved to be a very useful datum line in the mapping of the "Prescelly Area" and the country away to the north and north-west as far as Fishguard, Strumble Head and Pen Caer.

3. Upper Llanvirn

Succeeding the Fishguard - Newport Volcanic Series in the "Prescelly Area" as a rapid transition are a series of dense black, highly pyritous mudstones and shales, which are often fossiliferous. Amongst the faunal assemblage of these beds is the Upper Llanvirn Zone fossil, *Didymograptus murchisoni* (Beck). There are occasional instances of overlap of these mudstones on to varying rock-types of the Upper Rhyolite Group of the Volcanics, but owing to the marked lateral change in lithology of the Volcanics as a whole, it is difficult to postulate a definite stratigraphical break in the succession.

Eastwards there is a very gradual variation in the

mudstones...

mudstones and shales to blue-black thinly bedded fissile slates. This lateral variation takes place between Nevern and Crosswell. It is a gradual change from the somewhat gritty, blue-black and grey-blue unfossiliferous shales which characterise the Dinas to Nevern outcrop (west of the area here described) to the distinctive, fossiliferous, dense, black mudstones and shales of the main portion of the "Prescelly Area" (██████████).

Historically these Upper Llanvirn beds are of great interest since they were recorded by George Owen as early as 1595, when the name "Nod Glas" was assigned to them. Unfortunately they cannot be given this title here as the term has been previously used for a similar lithological horizon in the Bala rocks (Zones of *Dicranograptus clingani* and *Pleurograptus linearis*) of the Dinas Mawddwy - Corris district (Pugh, 1928).

On the steep bank of the Nevern, below Pen-cnwc-bach Farm, the junction of these mudstones with the Volcanics is clearly exposed. As in all other exposures of this junction, it consists of a definite, but rapid, transition from the truly pyroclastic, to the truly sedimentary material. A thin conglomerate, six inches in thickness, containing rounded fragments of tuffs, is taken as the arbitrary junction. The steep face of the bank affords a
fine...

fine section in these mudstones and shales. Although not very fossiliferous, the following fossils have been identified from this locality.

D. murchisoni, var. *geminus* (His.)

Climacograptus sp.

Trinucleus cf. *murchisoni* (Salt.)

Lingula sp.

? *Monobolina*. sp.

From Pen-cnwc-bach the U. Llanvirn beds strike southwards towards Pont Gynon, where, owing to their sooty-black colour, they were once mistaken for coal seams, and consequently worked as such.

Fine exposures of these mudstones, with their junction with the Volcanics below clearly exposed, extend along the small valley running southwards from Mirianog-west Farm to Rhos Tywarch Farm. Here the beds are badly faulted and crushed and contain large pockets of iron pyrites.

Another fine exposures of these beds occurs in the bed of the Afon Whitehook, where their junction with the Volcanics is clearly displayed immediately south of Felin Uchaf Farm. The harder mudstone bands in particular are very fossiliferous, but the fossils are usually pyritised and poorly preserved. Along with the following fossils,

fragments...

fragments of trilobites of the *Ogygia* type and graptolites of the *Climacograptus* genus occur.

Didymograptus sp. ? *murchisoni* (Beck.)

Climacograptus sp.

Siphonotreta sp.

Lingula sp.

The most accessible, and the best fossil locality in these beds in the "Prescelly Area" occurs in a small roadside quarry eighty yards up the hill from Blaen-y-cwm farm, on the northern slopes of Crug-yr-hwch. A thin band in these heavily jointed mudstones situated in the extreme S.W. corner of the quarry proved to be very fossiliferous whilst the rest of the mudstones are relatively barren. The following assemblage has been obtained.

Didymograptus murchisoni (Beck.)

D. comp. ^{cf.} *suecicus* Tullberg (viz. Plate 12).

Climacograptus sp.

Trinucleus sp.

Ogygia sp.

Obolus ^{cf.} ~~comp.~~ *Davidsoni* (Salter)

Lingula sp.

The occurrence of *Lingula* and the graptolite, *D. comp. suecicus*, are the most abundant of the fossils preserved. The latter type is of interest, and appears to be a new species of *Didymograptus* not unlike *D. suecicus* Tullberg. Its interest lies chiefly in the preservation
of the...

Plate 12.

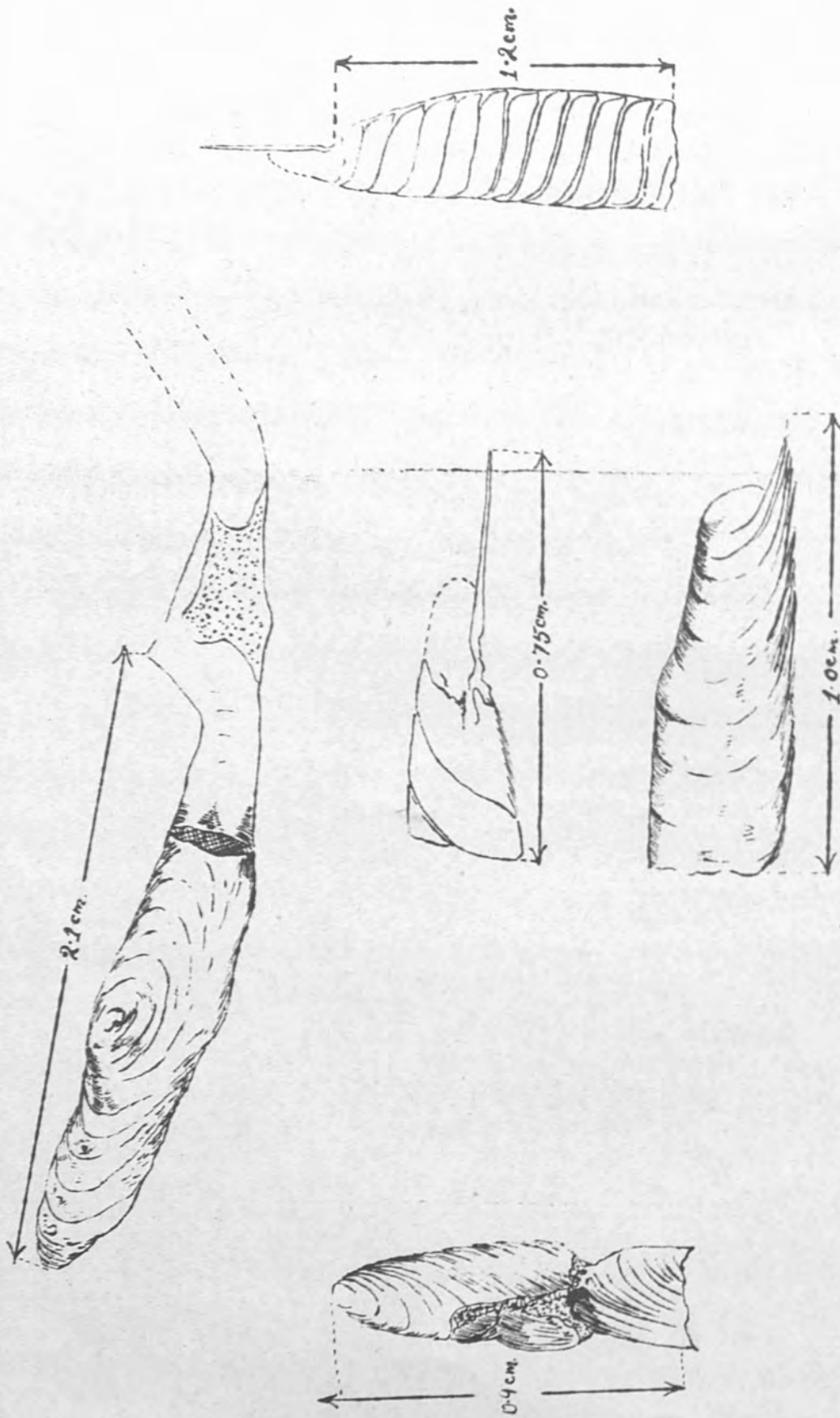


Plate 12.

of the spine-like prolongation of the distal end of the stipe (Plate 12).

The U. Llanvirn mudstones swing southwards around the eastern flanks of Crug-yr-hwch and their outcrop is then terminated by the trace of the Eastern Cleddau Thrust. Similar fossiliferous mudstones are characteristic of the U. Llanvirn beds of the "Imbricate Area," but they differ quite markedly from those in the "Western Carmarthenshire Area."

Llandeilo (Hendre Shales)

The Hendre Shales can only be distinguished as a lithological group in a very limited portion of the "Prescelly Area." (). From Nevern to a point about one mile west-north-west of Crymmych Arms, Llandeilo rocks may be represented in the series of coarse-grained, blue-grey, fissile, highly cleaved shales which succeed the Upper Llanvirn beds. The striking resemblance of these shales to the beds characteristic of the Glogue Slate Group (Lower Bala) suggests that westwards of Crymmych Arms the Llandeilo rocks have been cut out by the unconformable spread of the Glogue Slate Group and the succeeding Tegryn Group.

Typical...

Typical Hendre Shales have been traced, as an ever widening 'belt', ~~extending~~ from a point just east of the Afon Whitehook south-eastwards, and eventually southwards as they swing around the 'nose' of the Crug-yr-Hwch Anticline on the eastern slopes of Crug-yr-Hwch. These beds are identical ⁱⁿ ~~with the~~ lithology ^{of} ~~attributed to these~~ ~~Hendre Shales~~ of Carmarthenshire (Evans, D.C., 1906; and Geol. Sur. Mem. of Carmarthenshire). They consist of characteristically brown-weathering fossiliferous mudstones and shales, which are always easily differentiated from the succeeding Black Dicranograptus Shales on lithological grounds alone. The basal development of coarse, to fine-grained, felspathic described as the Asaphus Ash (Evans, D.C., 1906); or coarse felspathic grits known as ^{the} Fairfach Grits (Geol. Sur. Mem. Carmarthenshire) are absent in this area. Hence no sharp division is mappable between the Upper Llanvirn beds and the Hendre Shales (Llandeilo). However, the available evidence points strongly to the conclusion that a rapid transitional phase probably exists between the two formations.

A somewhat thin development of brown-weathering mudstones succeeds the dense-black mudstones of the Upper Llanvirn in the Afon Whitehook section. These are followed by typical shales of the Glogue Slate Group, and no Black...

no "Black Dicranograptus Shales" are represented here. It is possible that these brown weathering mudstones may be the attenuated representatives of the Hendre Shales (Llandeilo) in this section. However, taking into account the badly weathered condition of the material and the absence of any recognisable Llandeilo fossils in these beds, it is thought advisable here to include these mudstones with Upper Llanvirn beds.

Good exposures of Hendre Shales occur in the stream section below Blaen-y-cwm Farm. Here they consist of typical brown-weathering, blue-black, graptolitiforous shales, and blocky mudstones, all highly cleaved, ~~and~~ jointed and badly weathered. Fossil remains are plentiful, but apart from fragments of *Trinucleus fimbriatus* and *Climacograptus* sp., the material is too poorly preserved for precise identification.

Another good exposure of these shales occurs in the farmyard at ~~Pant-y-gwrdwn~~. Here, again, the fossils are poorly preserved.

The mapping of the Hendre Shales outcrop has been made possible, in spite of the small number of exposures by the fact that a well marked, grade-away feature is usually developed and the shales produce a characteristic brown, light loamy soil. Augering ^{the soil} has helped

tremendously...

tremendously in this case. The uppermost limit of the characteristic soil along with the presence of fragments of Hendre Shale produced very good lones along the eastern flanks of Crug-yr-Hwch in spite of the almost complete absence of exposure along this portion of the outcrop.

5. Lower Bala

The beds referable to the Lower Bala are, apart from the relatively thin development of Dicranograptus Shales, relatively unfossiliferous, and they have been subdivided into lithological groups, as follows:-

? Upper Bala	}	d. Freni Fawr Group	- Blue, cleaved mudstones and shales, with a prominent development of quartzite and grit at the base. Over 600 feet.
		c. Tegryn Group	- Gritty shales with grit bands. 500 feet
Lower Bala	}	b. Glogue Slate Group	- Blue-black slates and cleaved mudstones. 400 feet
		a. Dicranograptus Shale Group	- Black shales with Dicranograptids. Zone of Mesogr. multidentens. Up to 250 feet.

(a) Dicranograptus...

(a) Dicranograptus Shale Group

The distribution of the Dicranograptus Shales in the "Prescelly Area" is similar to that described for the Hendre Shales (Llandeilo). They consist of dense-black, stripey-weathering shales, which, although often highly pyritous, never weather to the brown colour, which is characteristic of the Hendre Shales. This property has proved to be of immense value in the mapping of the field relations of these two groups of shale material.

The Dicranograptus Shales are well exposed on the steep northern banks of the Blaen-y-cwm tributary valley of the Afon Nevern. The beds are fairly fossiliferous at this point, but the graptolites are usually too poorly preserved, even in the unweathered shales, for precise identification. However, *Mesograptus multidentis*, Elles & Wood, is usually fairly well preserved, and identifiable, in these shales.

Another fine section in these Shales extends along the railway line at, and south of, Crymmych Arms Station. Here the shales are thinly bedded, and fissile, stripey-weathering, and black in colour. Stringers and disseminated developments of pyrites often abound in these beds. Here again graptolites are plentiful, but poorly preserved...

preserved. *Mesograptus multidentis*, Elles & Wood, and *Climacograptus implicatus*, Hopk., have been identified from this section. The best specimens of *Mesograptus* were obtained from the shales immediately below the Glogue Slate Group. Above the Zone of *Mesograptus multidentis* occurs a series, 16 feet in thickness, of gritty, pale-grey shales interbedded with black shales typical of the lithology of the *Dicranograptus* Shale Group. These black shales are devoid of fossil remains. Thus between the Glogue Slate Group and the *Dicranograptus* Shale Group the Zones of *Orthograptus vulgaris*, *Dicranograptus clengani*, and *Orthograptus truncatus*, are missing, or are represented by the 16 feet of passage beds. This nonsequence is more marked westwards of Crymmych Arms, as near the bottom of the Blaen-y-cwm valley the Black *Dicranograptus* Shales rapidly diminish in thickness and are finally overlapped entirely by the Glogue Slate Group above. At a point $\frac{1}{2}$ mile down the valley, the Glogue Slate Group **finally** rests upon the Hendre Shales (Llandeilo) and the Black *Dicranograptus* Shales are entirely absent in the area between this portion of the NeVERN valley and NeVERN. It is interesting to note at this point that the *Dicranograptus* Shales are well exposed in the Fishguard district - particularly at the Brickyard.

(b) Glogue...

(b) Glogue Slate Group

In the Crymmych Arms district the black Dicranograptus Shales are succeeded through what appears to be a rapid transition of black shales with thin bands of light-grey, gritty shales and mudstones, ~~by~~ to a series of highly cleaved slates. These slates are some 500 feet in thickness and they have been quarried quite extensively and used liberally in this area as roofing slate and flagstones. They are well exposed in the numerous quarries which extend northwards from the large quarries at Glogue, and extend as a huge spread of slatey shale from Crymmych Arms to Newport, overlapping the Dicranograptus Shales and Llandeilo Rock and overstepping eventually on the Newport Area on to the Murchisoni Shales.

The typical slate of this group is blue-grey to blue-black in colour developing striking dark blue-black spots, possessing an irregular-ovoid outline, often up to 2 cms. in length. In many ways they resemble quite closely the Ceiswyn Beds of the Corris - Aberllefenni area (Pugh, Q.J.G.S., 1923, p.508) in lithology, and also approximates to some extent to the stratigraphical horizon of the Ceiswyn Beds.

Westwards...

Westwards of the Crymmych Arms district the Glogue Slates lose their characteristic ability to cleave into commercial slates owing partly to the fact that they are crumpled and heavily brecciated and partly because they grade quite rapidly into the grey-blue greywacke type which characterises the Lower Bala succession between Nevern and the Pembrokeshire coast. It has proved unprofitable for the moment to attempt to map these beds westwards owing to the difficulty of obtaining a satisfactory lithological horizon for use as a datum line.

Towards the top of the Glogue Slates lenticular bands of vari-coloured grit are developed on the S.E. and N.E. flanks of Freni Fawr. North-westwards towards the coast they develop into thick mappable bands. These thin bands of grit are taken as the base of the Tegryn Group which succeeds the Glogue Slate Group.

(c) Tegryn Group

(d) Freni Fawr Group

These two groups are described later in the description of the rocks of the "Western Carmarthenshire Area."

6. Intrusive

6. Intrusive Rocks

Intrusions of dolerite are numerous in the Prescelly Area. In isolated cases keratophyres are found as intrusive bodies in North Pembrokeshire, but in the Prescelly Area only one keratophyric intrusion has been identified.

(a) Dolerites

Apart from one important type the dolerites of the Prescelly Area are much the same as those described in other parts of North Pembrokeshire (Cox and others, 1931), and in particular resemble those of the Fishguard Area described by Dr. Elsdon as the "Llanwnda Type."

They include fine- to coarse-grained or gabbroid quartz-dolerites, all of which have been subjected to a secondary chloritisation and partial albitization. They are exposed as Carns, which are usually dotted along the summits of the higher ground. In the main they bear a strong relationship to the geological structure of this Area. Large dolerite intrusions accumulate in the cores of anticlines (as in the Nevern district) and tend to die out towards the compact axial regions of the synclines, as displayed by the dolerites of Cerrig Meibion Owen, in the Brynberian district. Furthermore, they form
excellent...



Plate 13a

Dolerite from Carn Meini, Prescelly Hills, showing the white feldspathic patches, identical with those occurring in the dolerite masses of Stonehenge (see Plate 13b). Slightly reduced.



Plate 13b

Black spotted dolerite from Stonehenge (Thomas 1922, Plate XXI).

excellent, mappable lines in the otherwise poorly exposed "Bifidus Shales," particularly on the Prescelly Hills.

The dolerite exposed on Carn Goediog, parts of Cerrig Marchogion, Carn Arthur, Carn Breseb, Carn Meini, and Carn Gyffrwy is a particularly striking rock type. It has achieved, and afforded the Prescelly Area, some prominence by the fact that it has been identified as the "spotted dolerite" which constitutes the "bluestones" of Stonehenge (Thomas, 1922). The late Dr. Thomas described the rock as "a bluish-green, even-textured diabase that is characterised by an abundance of irregular felspar crystals (albite-oligoclase) that appear in hand specimen as pinkish or white spots ranging from the size of a pea to that of a hazel-nut." Sometimes the spots are widely spaced but generally they are clustered together with the interspaces rarely exceeding 2 cms.

Along with the fact that "such spotted diabases are, as far as Great Britain is concerned practically restricted to Pembrokeshire" (Thomas, 1922), it is equally striking that within the confines of Pembrokeshire the actual distribution of the spotted diabases is limited to the six carns enumerated above. However, boulders, in the form of erratics, of this characteristic rock-type are widespread in the south of Pembrokeshire and

Carmarthenshire...

Carmarthenshire (Geol. Survey Memos. of Carmarthen and Haverfordwest).

The dolerite intrusion is of Ordovician age. It is significant, also, that in no instance is there any record of dolerites intrusive into beds newer in age than those of the Llandeilo in this area. Even though it may be conceived that they are sill-like offshoots of a deep-seated intrusion, it seems unlikely that they would be restricted to those beds below the lower-most horizons of the Llandeilo if the date of intrusion was very much later than Llandeilo times. Further the dolerite is intimately connected with the folding and faulting of the area, and whether or not the intrusions occurred synchronous with the tectonic developments, it is in no way greatly removed from this date. Thus the interesting corollary presents itself, that the folding and faulting is also of Ordovician date in its inception. This is supported by the fact that none of the dolerites penetrate the Bala beds, which rest unconformably upon those of U. Llanvirn and Llandeilo age. It is here suggested, that these dolerites were intruded during Llandeilian times.

(b) Keratophyre

(b) Keratophyre

An intrusion of keratophyre (12 feet in thickness) penetrates and indurates the ashy-shales and tuffs of the Fishguard - Newport Volcanics outcropping at the summit of Foel Trigarn. The keratophyre was first identified by Mr. G.M. Part (Geol. Mag. 1922) and it is the only example of such an intrusion in the "Prescelly Area."

In hand specimen the keratophyre is grey-green in colour when fresh, but often acquires a deep greenish hue on weathering. It is generally even-grained and non-porphyrific. At one point along the limited extent of the exposure a large irregularly ovoid accidental-xenolith of crystal-tuff, derived from overlying tuffs, is exposed within the intrusion, on the most easterly point of its exposure (Plate 10b).

Petrography

The "Prescelly Area," contains a fairly wide diversity of rock types. These were fully described in the M.Sc. thesis (1938) which is deposited in the Library of the University of Wales. The following account is abstracted from this work.

(a) The...

(a) The Syfynwy Volcanic Group

The Volcanic Group is composed of soda-rhyolites, soda-trachytes, ~~and andesitic rock types~~. Associated with these are varying amounts of blue-grey, splintery, fine-grained crystal-tuffs.

The soda-rhyolites of the Syfynwy - Greenaway district are often conspicuously porphyritic consisting of phenocrysts of feldspar, lying in a felsitic matrix. The ground mass consists of granular quartz, small laths of feldspar with interstitial chlorite. The small feldspar laths often exhibit a marked fluxional arrangement, even when the fluxional structure is not very pronounced in the ground-mass, there is usually a distinct parallelism of the smaller phenocrysts. The chlorite occurs as scaly or fibrous aggregates and irregular patches and is secondary. There is no definite evidence as to the identity of the original ferro-magnesian constituent. In one example from Greenaway, the outline of ^{the} pale, yellowish chlorite pseudomorphs is strikingly like hornblende. All the feldspars have been albitised - small patches of calcite occur in the albitic phenocrysts. Another rock from Greenaway contains abundant phenocrysts of soda-orthoclase and albite, together with scattered, irregular patches of chlorite...

chlorite set in a groundmass varying in texture from micro-, to crypto-crystalline. The original groundmass was probably glassy, as the chlorite often picks out beautiful perlitic structures.

The ~~and~~ trachytic rock-types of the Cnwc - Carn Afr district are usually not so fresh as the more massive rhyolites of the Syfynwy - Greenaway district.

The pale-green, fine-grained, splintery trachyte exposed 500 yards N.W. of Eithbed fach contains phenocrysts of soda-orthoclase and albite usually up to 0.7 mm. in length, associated in groups simulating a "glomeroporphyritic" structure. Epidote, occasionally pseudomorphing a pyroxene, and some interstitial quartz are also present. The trachytic groundmass consists of minute laths of felspar, showing fluxional arrangement, with interstitial chlorite, and a variable quantity of epidote and sphene.

At Carn Afr the trachytes are decomposed. They contain much epidote, chlorite and secondary silica. As a rule, they are highly vesicular, the vesicles being filled with chlorite. There is often an outer layer of small imperfect spherules of quartz within these vesicles.

Eastwards from the Cwm Cerwyn district, soda-trachytes, remarkable uniform in character, extend along the southern

flanks...

flanks of the Prescelly Hills. They contain laths of albite-oligoclase feldspar (~~parallel extinction angles vary from 13° to 18°~~), set in a fine-grained, 'felted' feldspathic and chloritic matrix. The whole approximates to a pilotaxitic texture. The trachytic structure in the majority of cases is indefinite, but in some types it is well developed. The original ferro-magnesian minerals are entirely decomposed, but their former presence is indicated by the large amounts of platy, and fibrous, growths of secondary chlorite. Subordinate amounts of apatite, and calcite are also distributed throughout these rock-types.

(b) The Fishguard - Newport Volcanic Series

The lava flows of the Lower Rhyolite Group are associated with considerable developments of vari-textured ashes and crystal-tuffs. Fine-grained, vesicular, highly chloritised felsites predominate in the extreme west, particularly in the vicinity of Pentre Ifan. Further to the south-east vitro-lithic, fine-grained tuffs, brilliantly mottled in green, brown, blue and white (depending on the degree of weathering) are well developed between Brynberian and Pont Saeson. Associated with these are fine-grained, highly...



Plate 14

Microphotograph of felspathic ash showing 'rounded' and brecciated phenocryst of albite-oligoclase, set in a fine-grained felspathic matrix charged with dark 'dusty' material. Locality: Near Pant-saith-gareg.

highly silicified felsitic tuffs, and a prominent band of slate agglomerate. The matrix of these rock types is often difficult to determine owing to the large amounts of optically inert, 'dusty,' material present. A feature of interest in certain of the ashes is the presence of large phenocrysts of albite-oligoclase felspar which are rounded and usually brecciated (see Plate 14). In some specimens small fragments of pumiceous material are present and in others patches of clear calcite are prominent (see Plate 15).

Spherulitic rhyolites are developed at a number of points, and seem to be characteristic of the Lower Rhyolite Group. These are particularly well exposed at Carn Alw. All grades of spherulitic growth ranging from the flattened spherulites, which in the main may be regarded as incipient spherulitic growths (see Plate 16), to the perfectly formed spherulites (the 'axiolites' of Dr. Parkinson, Q.J.G.S. 1897) shown in Plate 17. The individual spherulite usually possesses a 'core' of felsitic material, and sometimes incomplete concentric zones are present (see Plate 17). These probably mark pauses or interruptions during the growth of the spherulite. The spherulitic rhyolites are intimately associated with the
rhyolitic...

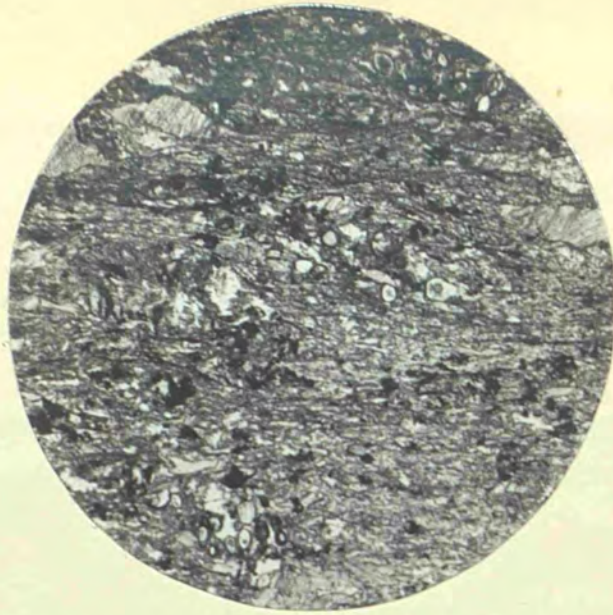


Plate 15

Microphotograph of volcanic ash showing a schistose-like structure, and containing small pieces of pumaceous lava, and patches of clear calcite. X 30 diameters.

Locality: Foel Trigarn.

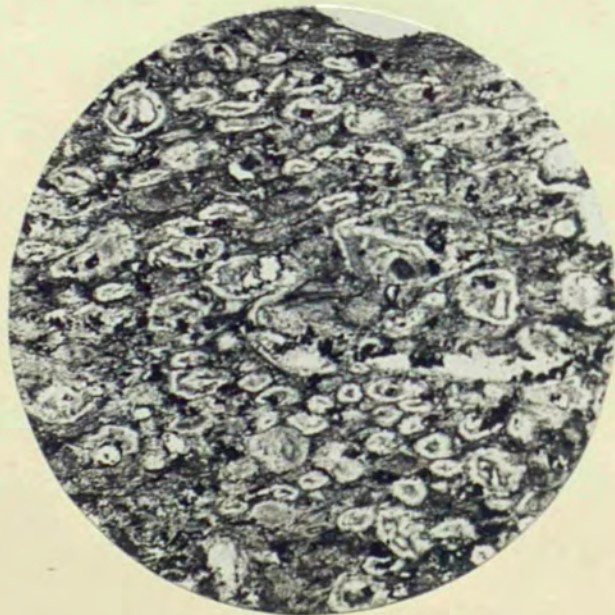


Plate 16

Microphotograph of spherulitic rhyolite with flattened spherulites. X 26 diameters. Locality:

Carn Alw.

rhyolitic types at Carn Alw. Certain of the specimens from Carn Alw consist of intermixtures of spherulitic and flow-banded rhyolites, with the striking brecciated types (see Plate 10a).

The brecciated rhyolites have been adequately described by Dr. J. Parkinson (1897). They have probably resulted from the action of juvenile movements whilst the lava was only partially consolidated. In the main, the angular fragments consist of fine-grained rhyolites, but often ^{showing} beautiful ~~fluidal rhyolites~~ ^{flow-structures} and spherulitic rhyolites are mixed up in this brecciated mass.

Rhyolites showing beautiful flow structures are well developed in the Lower Rhyolite Group (see Plate 20). In some cases, small accidental xenoliths of slate, caught up by the lava-flow, are prominent in these rhyolites. One specimen (Plate 19) shows a flow-banded, micro-felsitic rhyolite, within which feldspar (albite oligoclase) phenocrysts have been rotated and partially corroded, along with the occlusion of a fragment of slate. The slate xenolith contains remarkably fresh phenocrysts of feldspar (andesine-labradorite). The junction of xenolith with the rhyolite takes the form of a highly chloritised zone from which offshoots of green chlorite (slightly pleochroic, polarisation colours are deep blues) penetrate the ground-mass



Plate 17

Spherulitic rhyolite. X 30 diameters. Locality:
Carn Alw.

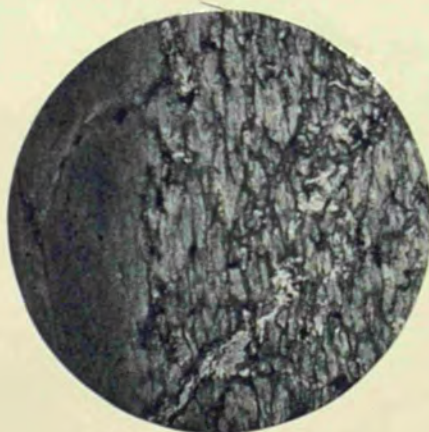


Plate 18

Microphotograph showing the junction of the spheru-
litic rhyolite with the fluidal rhyolite. X 26 diameters.
Locality: Carn Alw.

mass of the rhyolite. It is here suggested that the secondary chlorite, which forms such a prominent constituent of these rhyolites, has been mainly formed as the result of the decomposition of assimilated sediments.

(c) The Intrusive Rocks

Among the intrusive rocks of the "Prescelly Area" the most interesting petrographic varieties are the "spotted dolerites" of Carn Meini and its immediate neighbourhood and the intrusive keratophyre of Foel Trigarn.

1. The "Spotted-dolerite"

This distinctive rock type received but little attention from Dr. Parkinson (1897), but following its identification as the analogue of the Stonehenge "blue-stones" by the late Dr. H.H. Thomas (1922), it has attracted a great deal of attention, mainly from archaeologists.

The pink and white spots are prominent on the weathered surface of the dolerite. Although the spots present a definite outline in hand specimen (Plate 13a and b), under the microscope they are never found sharply differentiated from the rest of the crystalline structure

of the...

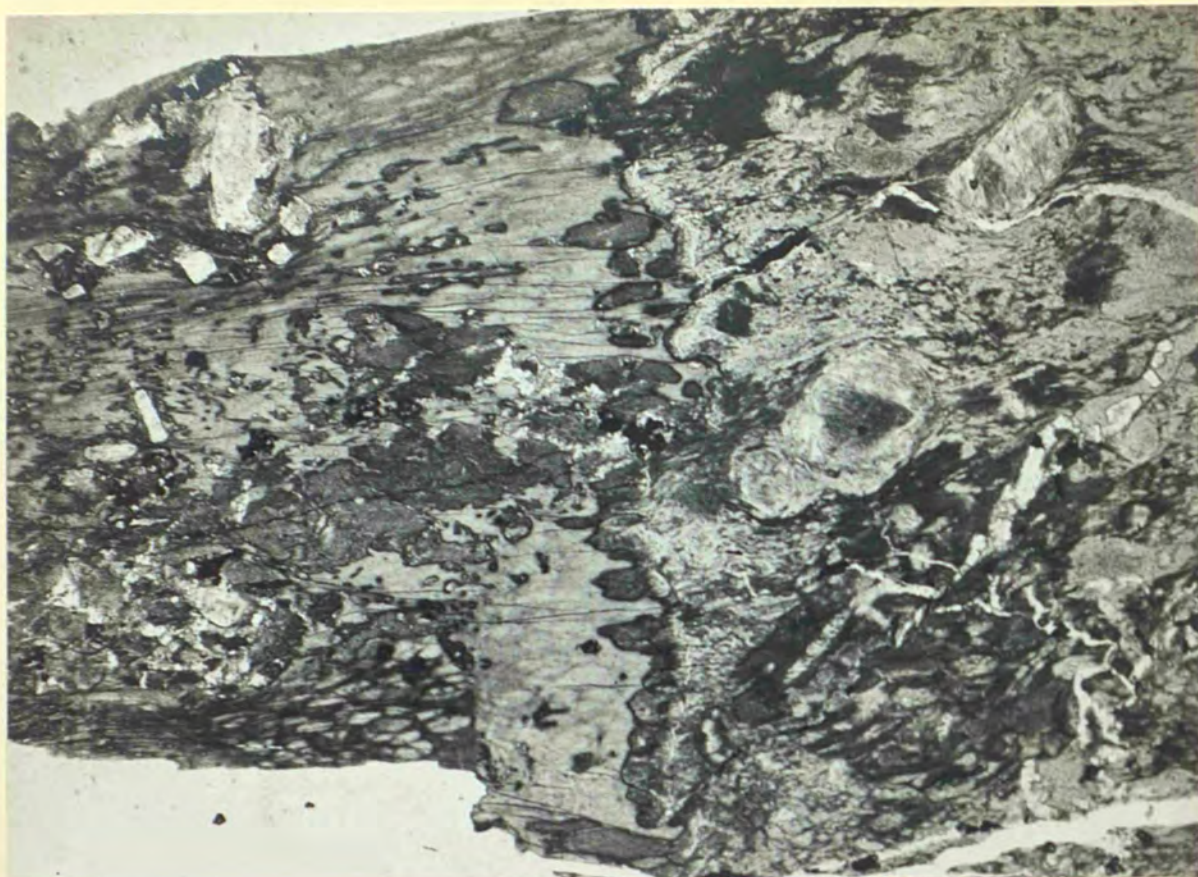


Plate 19

Microphotograph of fluidal rhyolite; contains accidental xenolith of slate. The chloritised junction is well marked between the slate and the rhyolitic material. X 10 diameters. Locality: Carn Alw.



Plate 20

Fluidal rhyolite.
After Dr. J. Parkinson
(1897). Locality:
Carn Alw.

of the rock (Plate 21). These 'spots' consist of imperfectly developed crystal-aggregates of albite-oligo-clase felspar which in the majority of cases are now completely saussuritised. They probably represent ~~massive~~ centres of crystallisation around which there were molecular concentrations of sodium, calcium and aluminium silicates. The remaining portions of the rock are frequently gabbroid in texture. Epidote and prehnite are often prominent constituents of the rock.

2. Keratophyre of Foel Trigarn

This grey-green coloured rock consists of laths of albite arranged in sub-trachytic manner in a fine-grained, highly chloritised groundmass which is charged with felspar microlites. Secondary chlorite is developed as plate-like and fibrous growths, whilst calcite and granular sphene are present in subordinate quartzites.

Its intrusive nature is apparent from the occlusion of vitric tuff (see Plate 10b), the rock which now lies above the keratophyre. In some respects it resembles the "variolitic keratophyre" of Abereiddy Bay (Cox, 1915), but it differs in the absence of the clustering of the felspar microlites in the groundmass.

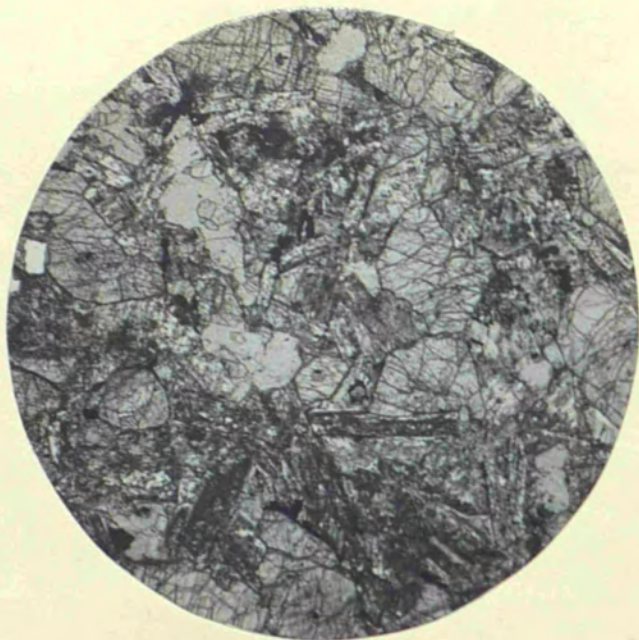


Plate 21

Microphotograph of "spotted dolerite." After
Dr. H.H. Thomas (1922). X 15 diameters. Locality:
Carn Meini.

B. The "Imbricate Area"

The section here defined as the "Imbricate Area" consists of a strip of country, roughly 2 to 3 miles in width, running in a S.W. to N.E. direction. Its margins are delineated by the trace of the Eastern Cleddau Thrust on the north and the Taf Fault and associated thrusts on the south. The title "Imbricate Area" has been assigned to this section of the country in preference to any geographical one, since it expresses its geological constitution. It is an area made up of 'fragments' of Arenig, Llanvirn, and Llandeilo rocks which resemble rocks of similar ages to the north and south of it. In short, within the confines of this narrow belt, two widely spaced facies along with the intermediate facies of rock, existing within the Ordovician 'geosyncline' at approximately the same time, have been brought into juxtaposition by south-westwardly thrusting.

As far as is possible, with such divergent rock-types of the same age, the following stratigraphical sequence has been designed for the "Imbricate Area." It is built up of both palaeontological and lithological horizons.

? Upper Bala...

? Upper Bala	...	Freni Fawr Group
Lower Bala	...	<ul style="list-style-type: none"> c. Tegryn Group b. Glogue Slate Group a. Black Dicranograptus Shale Group (Zone of Mesogr. multicens)
Llandeilo	...	Hendre Shales
Llanvirn	...	<ul style="list-style-type: none"> b. D. murchisoni Shales "Murchisoni Ash" a. D. bifidus Shales
Arenig	...	<ul style="list-style-type: none"> c. D. hirundo Mudstone Group b. Tyrch Group <ul style="list-style-type: none"> Upper Tyrch Sub-group Lower Tyrch Sub-group a. "Sheared Shale" Group

1. ARENIG.

The Arenig rocks have been largely subdivided into lithological groups, in order to render their description a little more orderly than would otherwise be possible.

a. Sheared Shale Group

Sheared Shales occur at various horizons in the Arenig rocks, but the lowermost beds of the Arenig visible in the Imbricate Area constitute such a striking lithological group of sheared shales that it is found convenient to consider them under this title. The beds constituting the Sheared Shale Group consist of thinly bedded, blue-black to blue-grey shales, badly sheared and smashed and heavily veined with quartz.

The best exposures of these beds are visible along the railway line between Maenclychog and Llanycefn. Repeated small-scale thrusting has resulted in a widespread distribution of these sheared shales along this section, even though the maximum amount of individual beds involved may only constitute a very small thickness of the apparent thickness exposed.

Between the little cottage, Yr Allt, and the railway tunnel, there is progressive increase in the intensity of the shearing which has affected these beds. At the northern entrance to the tunnel the shearing is so intense that nearly

that nearly all semblance of original bedding has been obliterated. The original bedding can sometimes be detected by the presence of thin beds of gritty-mudstones which are usually pale-grey in colour and never more than 3 inches in thickness. Inside the tunnel is a striking section showing gritty-mudstones and shales strikingly contorted and sheared.

Southwards, fine sections of these beds are exposed in the railway cutting as far as Dol Fach, and the whole is characterised by the typical shearing and impregnation of quartz veins, and, despite their complexity of structure, they present a somewhat monotonous aspect.

Southwards from Dol Fach, the shales are persistently blue-grey in colour, very thinly bedded, highly cleaved and undoubtedly identical in lithology with the *Didymograptus bifidus* Shales (L. Llanvirn) of North Pembrokeshire and Carmarthenshire. They are separated from the shales to the north of Dol Fach by a thick smash represented by a mixture of vein-quartz and fragments of shales which are highly sheared and in the main typical of the lithology of the Sheared Shale Group. It is here submitted that, despite the absence of fossil evidence, it seems highly probable that the Sheared Shale Group does not represent an upward continuation of the beds below them, south of Dol Fach. Although the shales to the south of Dol Fach are sheared

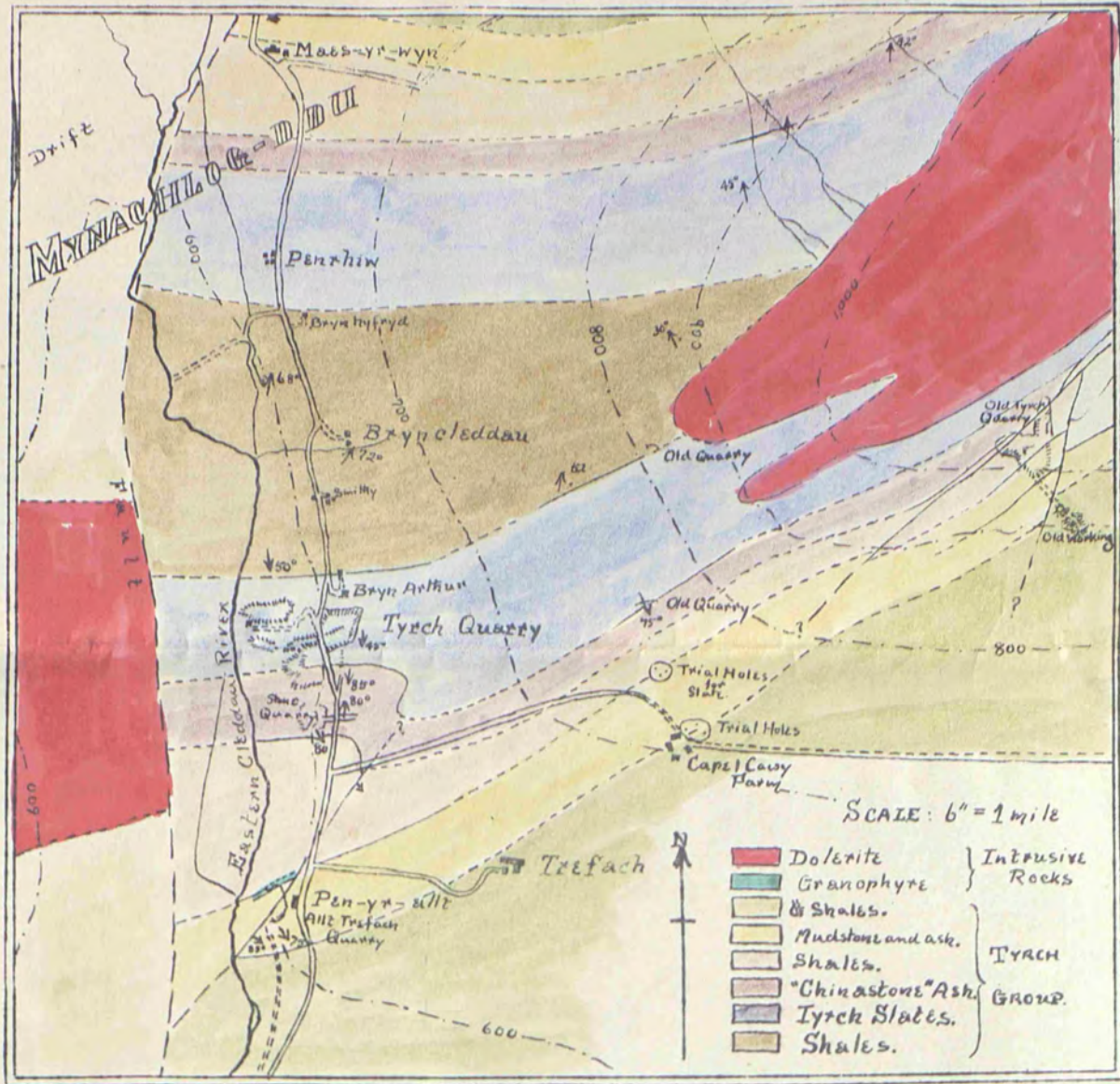


Plate 21.

Six-inch map of the Tyrch district,
 showing the sub-division of the
 Tyrch Group (Arenig).

are sheared comparable in intensity to those of the Sheared Shale Group, the shearing is probably the direct result of southerly drag caused by the over-riding beds from the north-west.

Eastwards, similar developments of the Sheared Shale Group, over-riding the normal L. Llanvirn shales are exposed in excellent sections along the steep valley slopes of the Eastern Cleddau in the Clyn Gwyn district. Still further to the east the Sheared Shale Group is not represented, but newer beds of the Arenig rest successively upon the Lower Llanvirn Shales, which in lithology are typical of the country to the south of the Imbricate Area.

b. Tyrch Group

The Tyrch Group has been subdivided into two main sub-groups - the Lower and Upper Tyrch Sub-groups. It has been found useful in the field to recognise these lithological sub-groups, as by means of ~~their~~^{this}, isolated sections of shales, slate or ash could^{then} be placed fairly accurately into their correct stratigraphical positions. In some cases the various components of each sub-group can be clearly indicated on ~~maps~~^{maps} (as on the slopes of Foel Tyrch, Plate 21), but in general it has only been found possible to map the broad line of sub-division between these two sub-groups.

b. Lower

b. Lower Tyrch Sub-Group

The Lower Tyrch Group contains slates which constitute the most important economic commodity in the area. These slates were quarried as early as the thirteenth century, when the slate was produced from Gilfach Quarry, which is today the largest of the productive slate quarries in North Pembrokeshire. In the "Description of Pembrookshire" (George Owen, 1595) it is stated that there was a considerable trade in slate from this area during the sixteenth century. George Owen makes interesting comments on the fact that the quarrymen "cleave the same to what thinnes they think best, and so the self same stone and the quarry serveth to beginne and end the house." During the nineteenth century old quarries were reopened and many new ventures embarked upon, but today only three of these are still producing slate.

The lithological succession within the L. Tyrch^{Sub-}Group is capable of a threefold subdivision.

- | | | | |
|------------------------|---|--|------------------|
| Lower Tyrch Sub-Group. | } | 3. Tyrch Slates - Grey-green, and silver-grey, spotted slates with thin bands of chinastone ash. | 100 to 120 feet. |
| | | 2. Putty-coloured slates with thick bands of hard greenish-yellow mudstone. | 50 to 100 feet. |
| | | 1. Blue-grey, thin-bedded gritty shales. | over 400 feet. |

Sometimes these sub-divisions are capable of being mapped^{over} short distances, but owing to the isolation of the individual

the individual areas of outcrop of the Lower Tyrch Group within the Imbricate Area, these subdivisions do not warrant separate titles.

(1). The blue-grey gritty shales are often cleaved but never to such an extent that they can be used as roofing slates. Outcrops of these beds are few, the best exposures occurring immediately north of Tyrch Quarry, where they are disposed in the core of the Tyrch Anticline.

It should here be pointed out that these blue-grey shales probably represent in part the uppermost beds of the Sheared Shale Group. An upward transition of the sheared-shale type to the ordinary unsheared gritty shales is exposed between Yr Allt cottage and Maenclychog Station.

(2). The putty-coloured slates have been worked for roofing-slates in two localities, one marked by the Old quarry behind Gilfach Farm and a little to the south in the Quarry near Llwyn-yr-ebol Farm. In each case they have been found unprofitable to work owing to the fact that they crumble on weathering and possess a very low 'cleavage-value'. However, this slate has an attractive colour, which, when blended with the filming of iron oxides, which so often coats the cleavage surfaces of these slates, produces a very striking "rustic slate".

Interbedded with these slates are bands of hard, well jointed mudstones up to five feet in thickness. In texture they present

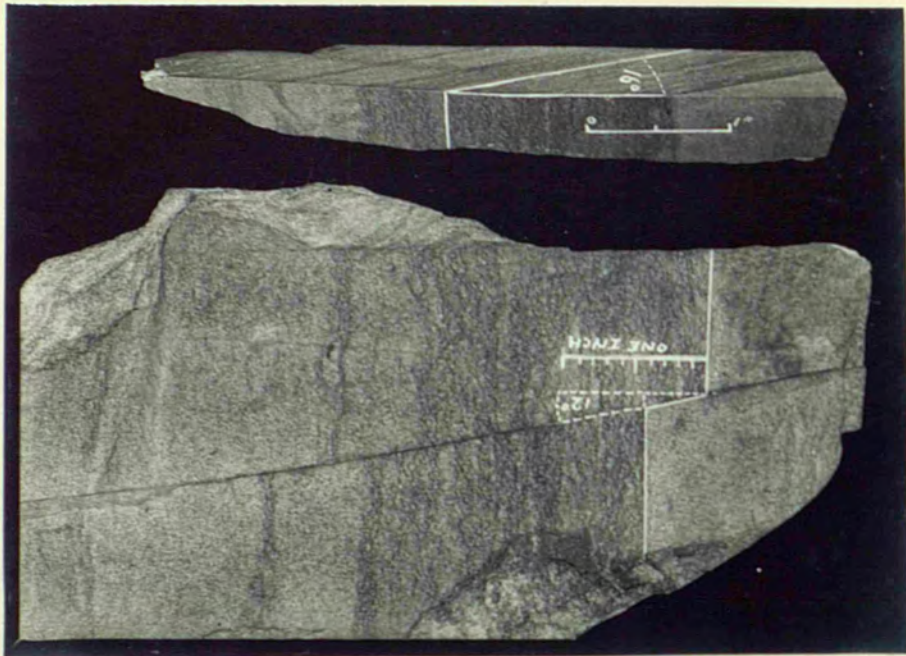


Plate 22

The relationship of the original bedding to the cleavage planes, and small-scale faulting in the "Tyrch Slates." Locality: Tyrch Quarry.

they present certain features not unlike the ashes of the Crugiau Dwy Group.

(3). Tyrch Slates.- These grey-green and silver-grey spotted slates constitute an important and interesting development of sediments. They are usually associated with dolerite intrusions and on first sight would be classified as aureoles of bleached slates around the sills and lacolith-like masses. The detailed mapping of the Tyrch Slates has shown that, in the cases where there is no thermal metamorphism, the slate is still pale-grey, and grey green, and it is undoubtedly the primary colour of the slates. They are composed of large amounts of finely divided felspathic material (of the order of 200-mesh) held in^a quartzose matrix. This material has either been derived from the denudation of some pre-existing volcanic tuff, or has been formed from well sorted volcanic dust. The latter suggestion is supported by the fact that within the slate succession intensely hard beds, up to six inches in thickness, of banded chinastone ash exist. (Also, in the westernmost parts of this area (e.g. Temple Druid Quarry) these grey-green slates are interbedded with blue-black spotted shales).

The metamorphism has not, apart from the production of spotting, given rise to any marked assemblages of metamorphic minerals. Small flakes of biotite are present,

but not

but not plentiful whilst the chloritisation of the slates is probably the major metamorphosing effect produced by the dolerite intrusions. However, it is very noticeable that the degree of induration which causes the complete disappearance of cleavage in the slate, is more marked on the "upper-side" than on the "under-side" of the sills. This property has proven of great use in the interpretation in the field of the dip of the dolerite intrusions relative to the slates.

The "cleavage-value" is not particularly high in these slates, the major slaty-cleavage planes varying from 0.5 mm. to 1.5 mm. apart. However, the beautiful colour compensates for this deficiency and provides a reasonable market value for these slates.

The cleavage planes are usually parallel to the original bedding of these beds, but in not a few cases it diverges from this position (Plate 22) making angles varying up to 80° with the original bedding planes. In some cases small-scale faulting is beautifully picked out by the darker bands in the original bedding. In other cases where there has been movement along the cleavage faces, the surface of the cleaved slate presents a series of roughly parallel ridges, which are not unlike ordinary ripple-markings in appearance. This is known as "ripple-cleavage" by the quarrymen.

At Tyrch



Plate 23

Photograph of Gilfach Quarry showing the slate working. Dolerite is exposed on the extreme right face of the quarry.

At Tyrch Quarry the slates dip at an angle of 35° beneath the Crugiau Dwy Ash Group (see Plate 21). The cleavage planes are mainly at an angle of 16° to the planes of original bedding (Plate 22) but still dipping in the same direction. The major cleavage faces of the slate are often of the magnitude of 1.5 mm. apart, but one 'vein', 8 feet in thickness produces slate of a relatively high cleavage-value, with the cleavage planes varying from 0.3 mm. to 0.5 mm. apart.

Although no actual contact with the dolerite is experienced as yet in Tyrch Quarry it seems evident that as quarrying progresses eastwards into the side of Foel Tyrch, the dolerite is being rapidly approached. There is a steady increase in the induration of the actual slate, and a gradual loss of the cleavability of the slate.

Gilfach Quarry provides a very clear and interesting exposure of the grey-green and silver-grey slates disposed between two sills of dolerite (see Plates 23, 24, 25).

The slate

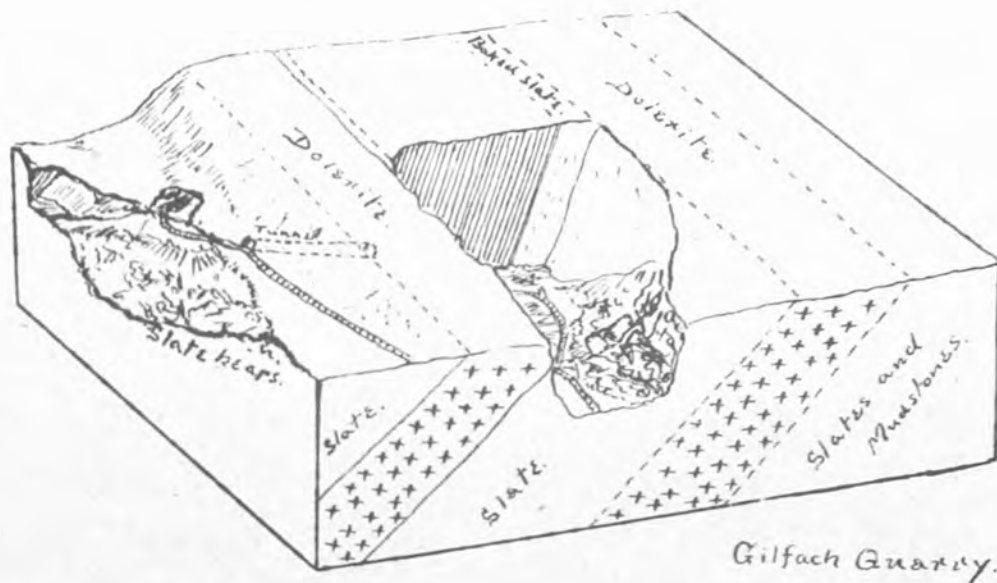


Plate 24

Block diagram illustrating the structure of Gilfach Quarry.

The slate usually possesses a very high 'cleavage-value.' In the Gilfach quarry the joint-planes are not closely spaced, as in the majority of the other quarries, and slates up to 3 feet x 1 ft. 6 ins. can be extracted.

On the eastern face of the quarry (Plate 23) the dolerite has been stripped clean of all slaty material, and a zone of complete induration, 6 feet in width is visible (Plate 25). With presence of a small fault, which produces 8 feet of 'smash', which ^{is} pierced by strong stringers of vein quartz, the slate has been entirely ruined, and this eastern section of the quarry has now been abandoned.

The dolerite sill on the west face of the quarry has been pierced by a tunnel. The tunnel section clearly exhibits the marked difference in the width of complete

induration

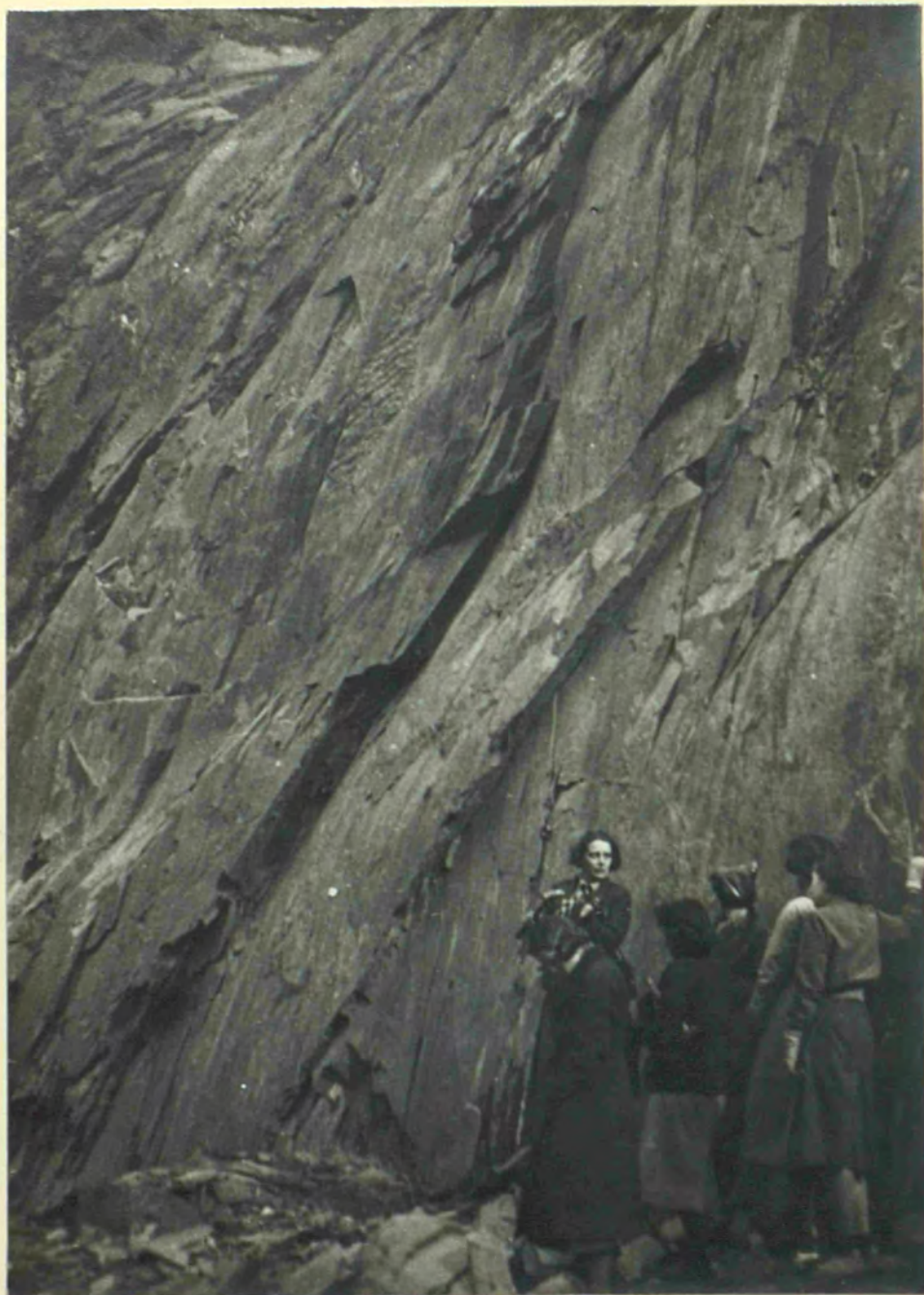


Plate 25

Photograph showing the junction between the
dolerite and slate on the "east-face" of Gilfach Quarry.

induration on the 'upper-side' and 'under-side' of the dolerite sill, which dips to the W.N.W. at 87° . On the 'upper-side' the undurated zone is upwards to 8 feet in thickness, whilst on the 'under-side' it is never greater than 1 ft., as good slate is extracted to within this distance of the dolerite. The dolerite is highly decomposed into a clayey, ferruginous mass. Extensive quarrying in the Llandilo district has exposed very good sections in these Tyrch Slates. At Llandilo Quarry the slate possesses the typical grey-green, and silver-grey colour, and includes large nodular masses of decomposed pyrites mixed with strings of asbestos, and 'mangled' slate material. Here the slate has been metamorphosed by a dolerite sill, which is exposed along the north face of the quarry. Small scale faulting and the presence of a number of 'posts' (the quarrymen's term for hard pillars of slate rock traversing the beds at right angles to the cleavage planes, and to the strike of the cleavage lines).

A small disused quarry near Temple Druid reveals an interesting exposure of the Tyrch Slates. The typical grey-green, and spotted silver-grey Tyrch Slates are interbedded with blue-grey spotted slates possessing a silvery sheen on the cleavage planes. Both the grey-green and the blue-grey rock-types have been undoubtedly subjected to a similar degree of thermal metamorphism by

the nearby

the nearby dolerite sill. In the first case the maximum metamorphism produces grey-green ~~actinolites~~^{actinolites}, while the latter rock-types are metamorphosed into chiasmolite slates. It is here evident that the original composition of these two types of interbedded sediment was quite different from one another. This explains the fact that to the west of this area the Tyrch Slates, as such, are not represented in the Arenig succession. There seems no doubt that they grade laterally into the normal blue-black shales typical of the Tetragraptus Shales described by the earlier workers in Pembrokeshire. The Tyrch slates consisted entirely of fine felspathic dust, which was deposited in a particularly biologically sterile portion of the Arenig Sea, - as is indicated by the complete absence of fossils from these beds. Large volumes of heterogeneous muds would not have affected graptolitiferous life. This is shown by the fact that westwards, from the area here described, fossils are found in the Arenig Shales (Tetragraptus Shales). Their absence from the Tyrch Slates is here suggested to be due to the large volumes of felspathic dust (probably due to volcanic action) which infected the sea in this easternmost portion of the area.

c. Upper Tyrch Sub-Group

Succeeding the Lower Tyrch Group is a series of chinastone ashes, ashy shales, coarse grained ashes and mudstones

mudstones, and blue-grey thinly bedded shales with interbedded ash and mudstones. These rocks have been grouped together under the title of the Upper Tyrch Group and are classified as follows.

Upper Tyrch Group	{	4. Shale Division.	over 500 ft.
		3. Coarse Ash and Mudstone Division.	100 feet
		2. Ashy-shale Division.	150 feet.
		1. Chinastone Ash Division.	20 to 100 ft.

The components of the Upper Tyrch Sub-Group are best exposed on the northern, western and southern flanks of Foel Tyrch (Plate 21). Elsewhere only one or more of the divisions are exposed, and it is usually impossible to outline them on a map. However, the recognition of these divisions of the Upper Tyrch Sub-group has provided the clue to the interpretation of a very difficult section of the "Imbricate Area."

(1). The beds of Chinastone Ash division are well exposed in natural sections and in the small Stone Quarry immediately south of the Tyrch Slate Quarry. They are here seen to follow the Tyrch Slates very sharply, but there is no evidence of a structural break between the two groups.

The Chinastone Ash division is made up of grey-blue mottled ash containing fragmentary laths of plagioclase felspar, succeeded by hard splintery green ash interbedded with prominent bands of pale-grey to white chinastone ashes, which are

which are often beautifully banded. These bands of china-stone ash vary up to 10 feet in thickness.

The ashes in the Stone Quarry have been indurated by a sill of dolerite, which is probably a small tongue-like off-shoot of the main dolerite mass of Foel Tyrch. Only the 'nose' of this dolerite is visible in the quarry-face of the Stone Quarry.

At Klondike Quarry, on the southern flanks of Foel Tyrch, two bands of chinastone ash, 3 feet and 5 feet thick, separated by 2 feet of shale, outcrop near the top of the quarry-face. Succeeding these ashes are a few feet of green slate, but it seems evident from the striking similarity between these chinastone ashes and those in the Stone Quarry, together with the field relationships, that the bands of ash in the Klondike Quarry belong to the Chinastone Ash division. Here is probable evidence that eastwards the Chinastone Ash division varies laterally into a group of beds composed mainly of shale. However, in such an area as the "Imbricate Area", where each stratigraphical succession is dislocated from its neighbour by faults and thrusts, ^{this} ~~the~~ apparent rapidity of change from chinastone ash into normal slaty-shales is not unusual. The absence of the probably originally existent gradual interphase between ash and shale has been obscured by thrusting.

Due north

Due north of Gilfach Slate Quarry, the Tyrch slates are followed by mottled ashes, somewhat similar to those exposed in the Stone Quarry section. Exposures are poor in this part and further correlation is impossible, but their presence is of use since it delineates the upper limit of the Tyrch Slates.

Near Carn Wen dolerite quarry, an old quarry exposes chinastone ashes resting sharply upon grey-green Tyrch Slates. Here the ashes are beautifully banded, and oft-times very vesicular, the vesicles filled with iron pyrites.

(2). The Ashy-shale division is difficult to describe owing to the fact that as a sub-division of the Upper Tyrch Sub-group, its presence is only justified in the Foel Tyrch district. Even within the encompass of this small area there is a change of facies from ashy-shales to good, well-cleaved slates possessing no pyroclastic affinities.

The ashy-shales are best exposed in the section southwards from Tyrch Slate Quarry (Plate 14). Here they consist of some 150 feet of blue-grey, coarse-grained ashy shales interbedded with hard pale-green chinastone ash.

On the southern flanks of Foel Tyrch, the Ashy-shale division is represented by a series of blue-grey to green slates. They have here been quarried as roofing slates. Owing to local difficulties caused by strike-faulting, together with the approximation to a small tongue-like

off-shoot.....

off-shoot of the Foel Tyrch dolerite mass, it has been found impossible to work this slate as a paying proposition. The slate here has a fairly high cleavage-value, and the value of the slate is further enhanced by the fact that the cleavage faces of the slate are usually covered with a coating of iron oxides which lends to the slate a very fine multicoloured, and pleasing 'rustic' effect in reds and browns. Undoubtedly, if it had not been for the local structural difficulties experienced in quarrying at this point, the quarry would have yielded the best 'rustic-slates' in Pembrokeshire.

(3). Coarse Ash and Mudstone Division. This Sub-Group is again best exposed in the Foel Tyrch district. It consists of bands of coarse-grained, dark-grey, speckled with white, felspathic ashes, interbedded with hard blocky, olive-green, ashy-mudstones.

The coarse ashes and mudstones are best exposed in the section southwards from Tyrch Slate Quarry (Plate 21), and in particular in the quarry near Pen-yr-allt Cottages. Here the ashes have been indurated by an intrusion of a granophyric rock-type, the precise identification of which has been rendered impossible by the badly weathered nature of the exposure. The indurated ashes and mudstones have been extensively quarried at this point for use as ballast material ..

material in road construction in the neighbourhood.

A somewhat similar exposure of these beds occurs in a recent trial-excavation $\frac{1}{2}$ mile south-west of Carn Wen. The trial cutting has been made with a view to quarrying the rock for road-metal as the mudstones and ash at this point have been intensely indurated by an intrusive dolerite sill.

The mudstones and ash of this division are now being extensively quarried to the east of Foel Tyrch, near Ffynnon Farm. The mudstones vary from the hard, green-coloured type to a soft, sandy, pale-green mudstone. There is an absence of the coarse, grey, speckled ash in this locality, but its lateral variant is probably the intensely hard, splintery, pale-grey-green ash which outcrops in the small quarry on the other side of the road from the present productive quarry.

As at the Pen-yr-allt quarry, there is an intrusion of a more acid nature than is normal for the Area appearing in the south corner of Ffynnon Quarry. Here, instead of being granophyric, it is a true keratophyre containing occlusions of mudstone.

(4). The Shale Division consists of blue-grey to blue-black shales with interbedded blue-grey mudstones, and greenish-grey splintery ashes. It is quite impossible to give even an approximate estimate of the thickness of this division owing to the presence of faulting, folding and 'packing' of sediment, together with duplication of the beds

the beds by small-scale thrusts. However, it can be said that they are at least over 500 feet thick.

The best exposures of these beds exist along the south-eastern bank of the Eastern Cleddau River between Pont Glandy and the confluence of the Eastern Cleddau with the Afon Wern.

Attempts have been made at working the slaty members of the succession as roofing slates near Llandilo Cross and a little further to the west at Dwrdy. In both localities the slates are blue-black in colour, breaking with a splintery fracture, and traversed by a lattice-work of joint planes. The slates are also traversed by a set of cross-cleavages at right angles to the major cleavage planes of the slate. This, together with the presence of jointing, has tended to reduce the size of the slate extracted and has so led to the failure of the projects.

It is not always easy to distinguish this Shale Division from the Ashy-Shale Division. The Ashy Shale Division is, however, made up of coarser deposits than the Shale-Division, and they contain a relatively high percentage of felspathic material in the form of fragmentary laths of plagioclase feldspars. Apart from the relatively thin bands of felspathic ashes, the Shale Sub-Group is distinctly deficient in felspathic material in the form of broken plagioclase phenocrysts.

d. *Didymograptus*

d. Didymograptus hirundo Mudstone Group

81

Two relatively small areas of mudstones, which have yielded trilobites and graptolites characteristic of the Zone of *Didymograptus hirundo*, outcrop within the confines of the Imbricate Area. They have been structurally dissociated from each other by thrusting.

The first area is situated south of Carn Wen (see Plate 34 map). Here the Mudstones succeed the Shale Sub-Group (Upper Tyrch Group), but the actual junction is not exposed. The extent of the *D. hirundo* Mudstone Group is delineated by the traces of thrusts, and the disposition of the beds is controlled by a 'ruckled' anticlinal fold.

Exposures are poor, but in the main the *D. hirundo* Mudstone Group is apparently made up of blue-grey to pale-buff mudstones with partings of grey-green shales. A small trial-pit on the main road from Glandy Cross to Crymmych Arms, and about 1 mile south of Carn Wen, exposes grey-blue mudstones with thin partings of sandy shale, all of which weather to a light buff colour. No fossils were recorded from this locality.

In a small quarry, 80 yards south of the main road, and a little south-west of the above locality, blue-grey to grey-green compact mudstones are exposed. The beds are strongly jointed, and often extremely hard, breaking with a somewhat splintery fracture. In the past, they have been

have been quarried for use as 'ballast' material in road construction in the neighbourhood. The rock is difficult to extract from the quarry face at present, but when a suitable exposure of the bedding planes is made, the mudstones are found to be fairly fossiliferous. The following fossils have been obtained from this locality:-

Didymograptus hirundo Salt.

Aeglina binodosa Salt.

Calymene cambrensis Salt.

Ogygia cf. *selwyni* Salt.

? *Caryocaris* sp.

Orthoceras sp.

Monobolina sp.

The second district, occupied mainly by the *D. hirundo* Mudstone Group, consists of a lenticular area, bounded by thrusts, situated N.N.E. of Carn Wen, in the neighbourhood of Pentre Galar. Here the beds are disposed in sharp anticlines and synclines, all pitching to the N.E. at varying angles from 5° to 15°.

Here the beds consist of vari-coloured mudstones with vesicular green-grey to light buff, brown-weathering ashy mudstones with clayey partings. These latter beds are best exposed in the small roadside quarry S.S.W. of Pentre Galar. The beds are not very fossiliferous, but one thin band of pale-grey mudstone has yielded the following fossils.

Didymograptus

Didymograptus nitidus Hall.

Didymograptus hirundo Salt.

Trigonograptus ensiformis Hall.

Caryocaris sp.

Lingula sp.

Another small quarry on the northern side of the Pentre Galar - Hermon road, about 150 yards from Pentre Galar affords a similar exposure of mudstones, but no fossils were recorded from this locality.

2. Llanvirn Series

Two facies of the Llanvirn are distinguishable in the Imbricate Area, and it renders the description of the distribution of their outcrops difficult. It has not been possible, with the scanty evidence available, to correlate accurately the individual successions of these two facies, but the broad correlations which are hereafter described serve to show their probable relationships one to the other.

The two zones common to the Llanvirn have been identified and the Llanvirn series has been sub-divided into the Upper and Lower Llanvirn Series.

Lower Llanvirn (zone of *D. bifidus* Hall)

Two facies of the Lower Llanvirn are distinguishable in the country N.E. of Carn Wen. Although originally
fairly....

fairly widely separate in the area of deposition during Lower Llanvirn times, they have now been brought together by south-westwardly thrusting. The following table indicates the relative positions of the two groups of rock in the stratigraphical sequence.

Carn Wen District

Pant-y-begney District

4.	Soft, grey, pale-weathering ashy-mudstones and flagstones	4.	Mudstone Group	Hard blue-black mudstones with bands of shale. 200 ft.
3.	?	3.	Ash-Shale Group	Blue-black, thinly bedded shales and prominent bands of splintery green and grey ashes 60 ft.
2.	? Absent	2.	Pant-y-begney Group	Grey gritty mudstones with beds of hard quartzose siltstones 100 ft.
1.	?	1.	Shale Group	Blue-black shales with thin bands of splintery ash and agglomerates

In the Carn Wen District, the Lower Llanvirn beds are best exposed in the quarries near Burrows Farm, on the southern slopes of Carn Wen, and in the small quarry on the south side of the road which runs from Burrows north-eastwards along the south-eastern flanks of Carn Wen.

In the quarries near Burrows Farm, the beds consist of light-grey to grey-green ashy-mudstones, often deeply ironstained

ironstained along the joint faces. Some of the bands are steel-grey in colour and intensely hard and possessing a splintery fracture. The mudstones here are fairly fossiliferous but the fossils are usually difficult to extract and are usually badly crushed and distorted. The following have been identified from this locality.

Calymene cf. *cambrensis* Salt.

Illaenus sp.

Ogygia sp.

Trinucleus sp.

The rock has here been quite extensively quarried for use as road 'ballast' material, and for the construction of walls.

The small disused quarry north-east of Burrows Farm, near the roadside, affords an exposure of flaggy, pale-grey to blue-grey mudstones with sandy partings. These beds proved to be very fossiliferous and the following specimens were obtained.

Didymograptus bifidus Hall

Didymograptus protobifidus Elles & Wood

Aeglina caliginosa Salt.

Aeglina sp.

? *Barrandia* sp.

Ogygia cf. *buchi* Brongn.

Trinucleus

Trinucleus gibbsi Salt.

Lingula sp.

Othoceras sp.

The position of these mudstones in the Lower Llanvirn succession is not certain. The presence, however, of *Didymograpti* bearing strong affinities with *D. murchisoni* suggests that they undoubtedly occupy an horizon somewhere near the top of the Lower Llanvirn Series. It is upon fact alone that they have been correlated with the Mudstone Group of the Lower Llanvirn beds of the Pant-y-begney District.

In the Pant-y-begney District, the Lower Llanvirn is represented by a great development of blue-black mudstones and shales with accumulations of pyroclast-material at certain horizons.

In the neighbourhood of Cae'r Aeron Farm, these mudstones are overthrust on to the 'papery' shales of the Upper Llanvirn. Here the susceptible shale components of the sequence are badly sheared and crushed. Poorly preserved specimens of *D. bifidus* were obtained from exposure of these beds in the stream about 500 yards W.N.W. of the Farm.

Obscure *Didymograpti* were also present in the hard flaggy blue-black mudstones exposed in the stream near Tre Howel Farm.

The type

The type section for these beds is exposed in the deep, V-shaped valley of the Afon Gafael (Plate 26). Fossils are rare in these beds but occasional specimens of *D. bifidus* and other obscure graptolic remains have been obtained from various points along this section.

The beds are packed into a series of isoclinal folds, inclined to the south-east, and the succession is expanded by repetition caused by small-scale faulting and thrusting which are too small to show on a suitable geological map. The section has been rendered more intelligible by subdividing the succession into the four groups mentioned above. These groups are purely arbitrary ones and it is impossible to map them as individual bands over great distances.

(1) The Shale Group is exposed along the more northerly extent of the section, and consists of blue-black shales with thin beds of splintery blue-green ash, never more than three feet in thickness. The lowest available members of the succession are best exposed on the steep banks of the Afon Gafael, a short distance south-east of Ffwdwn Farm. Here the succession exposed is as follows:-

6. Blue-black..

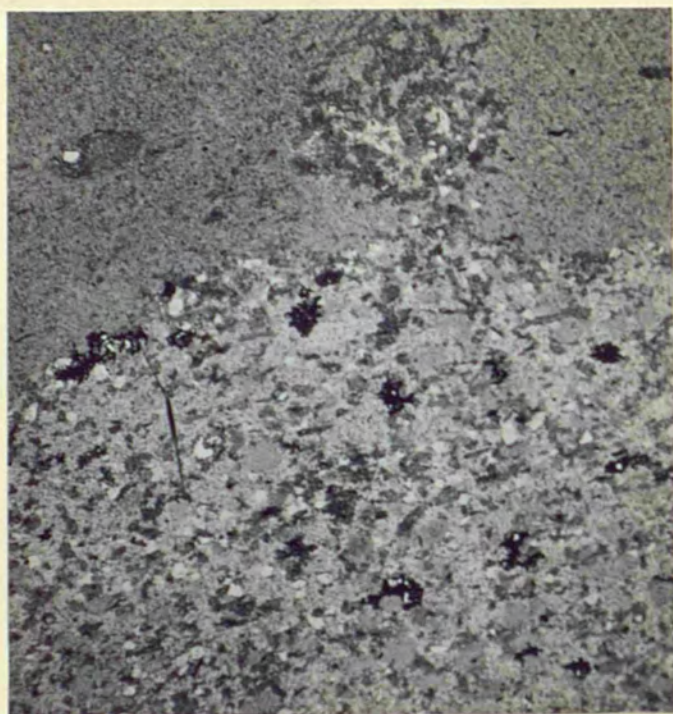


Plate 27

Microphotograph showing "wisps" of coarse quartzose mudstones, caught up by current action in the finer grained mudstone deposits above.

6. Blue-black, thinly bedded, pyritous shales.
5. Coarse-grained, well-bedded mottled grey-white feldspathic ash, containing prominent laths of Plagioclase feldspars.
25 feet
4. Cleaved, blue-black, splintery shales
3 feet
3. Steel-blue coloured, fine-grained splintery ash, breaking with a good conchoidal fracture.
5 feet
2. Well-bedded grey-green ashes, heavily veined with quartz, often agglomeratic and containing angular fragments of blue-black shale.
10 feet.
1. Coarse and fine-grained, strongly jointed ashes with partings of shale.
over 15 feet

Southwards the blue-black shales are the predominating members of the Shale Group succession. Intrusions of bostonite are exposed on the western bank of the valley and, as far as the evidence goes, it seems that there are only two actual intrusive bodies, which have their outcrop repeated many times within the Shale Group succession as far south as Allt-y-graig. (~~Plate 23~~).

(2) The Pant-y-begney Group is not well exposed in the Afon Gafael Valley owing to accumulations of rainwash and valley gravels. Higher up on the hillside, blue-grey, gritty, well-bedded, mudstones and blue-black shales are exposed in small quarry cuttings and trial holes. It seems probable from the relationship of the gritty mudstones and the shales



Plate 227

Microphotograph showing lateral movement in the Pant-y-begney
midstones.

the shales that the beds were shallow water deposits. One fact is certain from the specimens examined microscopically and that is that the deposits were subjected to water currents, as is indicated by the specimen shown in Plate ~~25~~²⁶. These beds have also been subjected to pressure and lateral movement along the bedding planes, which have produced incipient faulting and contortion within the bed (Plate ~~27~~²⁸).

(3) These beds consist of cleaved, blue-grey shales with thin bands of mudstones and splintery ash. They outcrop at intervals along the banks and in the river bed of the Afon Gafael, where they are interfolded with the Mudstone Group above.

(4) The Mudstone Group has been so defined as to include the succession which occurs at the top of the Lower Llanvirn series. The Group is made up of a preponderance of mudstone material with partings of shale. The rocks are always blue-black in colour and constitute a lithology which is completely different from all other known developments of the Lower Llanvirn beds in the "Prescelly Area," and the "Western Carmarthenshire Area."

Upper Llanvirn (Zone of *Didymograptus murchisoni* Beck).

The Upper Llanvirn beds consist almost entirely of thinly bedded blue-black shales with occasional developments of gritty

of gritty mudstones. Exposures are few but wherever they are exposed they are always very fossiliferous.

It seems that the Upper Llanvirn Series begins with a development of ash, but as exposures are limited in number this is by no means a certainty. The so-called Murchisoni Ash is best exposed at Pont-y-Gafael, where it is seen to succeed the Mudstone group of the Lower Llanvirn quite sharply, but there is no sign of any structural discordance between them.

Here the Murchisoni Ash is grey-blue in colour, and very coarse-grained. Large laths of plagioclase feldspars are prominently displayed on the weathered surfaces of the rock. However, in Pont-y-Gafael the ash has been indurated and mylonised by thrust movements, and has been transformed into a blue-grey white-speckled fine-grained splintery rock type, which, if it were not for the fact that its association with the normal type of Murchisoni Ash was not clearly exposed, would be difficult to correlate with the unaltered rock type.

The shales which succeed the Murchisoni Ash are usually blue-grey, thinly bedded; almost 'papery'-shales. Mudstones are sometimes developed near the top of the succession. They have certain characters in common with the Upper Llanvirn shales of the Western Carmarthenshire Area, but they are easily distinguishable from these by the absence

absence of striping and the development of a large number of beds of dense, blue-black mudstones, which so characterises the Upper Llanvirn beds of Carmarthenshire.

Thinly bedded, fossiliferous shales are well exposed in the small brook near Cae'r Aeron. Here the graptolites are badly preserved but two undoubted specimens of *Didymograptus murchisoni* Beck, and one specimen of *Climacograptus coelatus* Lapw. have been identified from this locality.

The 'fragment' of Upper Llanvirn shales which succeeds the Murchisoni Ash in the Pont-y-Gafael section has yielded no recognisable fossils apart from *Siphontreta micula* M'Coy.

Along the banks of the small brook descending from Pant-y-begney to Blaiddbwl Farm, a complete, but very condensed, succession of Upper Llanvirn beds is exposed. Here some 50 feet of blue-black shales with grey mudstones near the top, succeed the coarse, speckled, brown-weathering Murchisoni Ash. The top of the succession is marked by a thin bed of conglomerate, 18 inches in thickness, which marks the base of the Hendre Shales (Llandeilo). Certain of the mudstone and shale beds are crowded with *Didymograptids* of which both *D. murchisoni* Beck and *D. murchisoni* var. *geminus* have been identified.

As in most other areas of Llanvirn rocks it seems highly improbable that the *D. murchisoni* Zone is of constant thickness.

Llandeilo (Hendre Shales)

The succession of Hendre Shales in the "Imbricate Area" is very similar to that described in the "Prescelly Area" and the "Western Carmarthenshire Area". One minor point of difference between the Hendre Shales of the "Imbricate Area" and those of the other areas here described, is that the basal members of these Series consist of dense black mudstones not unlike the Upper Llanvirn beds of the "Prescelly Area".

The type locality for these mudstones is situated in the small valley leading down to Blaiddbwll. Here the base of the mudstones is marked by a thin development of shaley conglomerate, which contains rounded fragments of coarse felspathic ash, and splintery shales, - undoubtedly all of Llanvirn age.

These mudstones are dense black in colour - even possessing a sooty appearance. On weathering they bleach to a striking pale-cream colour, and in its final stages of weathering breaks down to a soft clayey soil - a point which is of great importance in mapping the field-relationships of these beds. Fossils are abundant, but usually difficult to extract. The following have been identified from this locality.

Trinucleus fimbriatus Murch.

Trinucleus aff. favus Salt.

Trinucleus lloydii Murch.

Asaphus

Asaphus tyrannus Murch.

Ogygia buckii Brogn.

Beyrichia sp.

Elsewhere exposures of these mudstones are few and fossil evidence scanty, owing to the east with which these beds break down on weathering.

Alternations of blocky mudstones and shales, all of which weather to the typical brown colour attributable to the Hendre Shales group characterise the Llandeilo succession above the basal development of mudstones. Large spreads of these shales and mudstones extend over the north-eastern extent of the "Imbricate Area", particularly between Llanfyrnach and Hermon.

At Glandwr the Hendre Shales are overlain by an overthrust mass of Upper Llanvirn mudstones and felspathic ash. The Hendre Shales at this point have yielded numerous specimens of *Trinucleus lloydii* Murch., and *T. fimbriatus* Murch., together with some poorly preserved *Climacograptids* and *Diplograptids* (probably *Diplogr. foliaceus* Murch.)

Lower Bala

The Lower Bala of the "Imbricate Area" has been classified in the same way as the Lower Bala rocks of the "Prescelly Area".

(a) Black Dicranograptus Shale Group.- No sharp line of division is mappable between the Hendre Shales and the

and the Black Dicranograptus Shales. In Carmarthenshire these two developments of shale are separated by either a development of characteristic blocky calcareous mudstones or lenticular bands of limestone (Mydroni Limestone, Evans, D.C., 1906).

Paying close attention to disposition of the exposures and taking into account the outstanding fact that the Hendre Shales always weather to their peculiar brown colour and produce a soil of characteristic colour a reasonably good line has been elucidated for the Llandeilo-Lower Bala junction. The Black Dicranograptus Shales are black in colour, and often pyritous, but they do not weather to the light brown colour of the Hendre Shales. The Group is usually intensely cleaved and well jointed, and when split along the cleavage planes they are always coated with small flakes which possess a silvery sheen. It has been suggested that these flakes might be "graptolite embryos", or which eventually gave rise to the production of graptolite siculae (Evans, D.C., 1906, p. 632). However, there seems very little doubt that these flakes are the result of the 'shredding' of the shale material as it is split along the cleavage planes. Only when such shreds contain fragments of graptolites is there any indication of organic structure in them.

Intense cleavage has, on the whole, ruined the preservation

preservation of the graptolites and only in a limited number of cases has it been possible to identify any of them with any certainty.

Good exposures of the Black Dicranograptus Shale Group occur near Nant-y-gafr Farm. Two small quarries at this point show exposures of Hendre Shales in one, and Black Dicranograptus Shales in the other. Unfortunately, the actual junction is obscured by debris, and rainwash, but here again there appears to have been no structural break between the two sequences, and the junction probably takes the form of a rapid transition from one type to the other.

Further along the lane leading N.N.E. from Nant-y-gafr Farm, at a point near the railway line which is marked "House" on the accompanying map, is a very fossiliferous exposure of the Black Dicranograptus Shales. Here the shales are highly cleaved, but certain of the beds have produced faces on the shale which are crowded with graptolites, so much so that it has affected their preservation. However, the following graptolites have been identified from this point.

Mesograptus aff. Multidens Elles & Wood

Dicellograptus sp.

Orthograptus sp.

Along the Hermon-Glogue road good exposures of Hendre Shales and Black Dicranograptus Shales occur along the roadside. On the hillside, just before entering the
village

village of Glogue, these shales have yielded the following graptolites at various points. This faunal suite has been included together as it has been found impossible to really sub-divide the zone of *Amplexograptus arctus*, from the zone of *Mesograptus multidentis*, but both zones are undoubtedly developed between the top of the Hendre Shales and the basal members of the Glogue Slate Group.

Amplexograptus arctus Elles & Wood

Dicranograptus brevicaulis Elles & Wood

Dicranograptus aff. *rectus* Hopk.

Diplograptus ^{cf.} ~~comp.~~ *foliaceus* Murch.

Climacograptus ^{cf.} ~~comp.~~ *tubuliferous* Lapw.

Mesograptus multidentis Elles & Wood

Dicellograptus sp.

Orthograptus sp.

Exposures are few in the Taf valley, in the immediate vicinity of Glogue village, but a small exposure in the brook descending from the north-western extremity of Glogue Slate Quarries, reveals a series of black graptoliferous shales succeeded by thin bands of gritty, brown-weathering mudstones (not unlike the mudstones of Hendre Shales). The graptolites are too badly preserved for any form of identification beyond the fact that they are *Climacograptids*, *Orthograptids*, and one possible *Mesograptus* sp. The actual junction with the Glogue Slates is unfortunately obscured by rainwash, but it seems

evident

evident that here the highest zone of the Black Dicranograptus Shale Group is the zone of *Mesograptus multidentis*.

The Glogue Slate Group, the Tegryn Group and the Freni Fawr Group are best described along with the description of the "Western Carmarthenshire Area."

Intrusive Rocks

Intrusive dolerites, granophyric-felsite, bostonite and keratophyre are represented in the "Imbricate Area." Of these the dolerites are very widespread, whilst the others occur as isolated exposures.

(a) Dolerites.- As in the "Prescelly Area" the dolerites occur as sills and laccolithic masses, and are exposed either as rocky 'carns', large spreads of huge boulders, or in slate- and roadstone-quarries. These dolerites can be grouped along with those of the rest of N. Pembrokehire ("Llanwnda Type" of Dr. Elsdon, 1905), as they include fine, medium and coarse-grained quartz-enstatite-dolerites. The "spotted dolerite" of the Prescelly Area is absent in this Area.

The broad mass of medium-grained dolerite of the Gors Fawr district splits into two long 'fingers' when traced westwards towards Maenclychog. Here the dolerite is intrusive into beds of the Lower Tyrch Group (Arenig). The southern branch of the Gors Fawr dolerite is exposed as a prominent

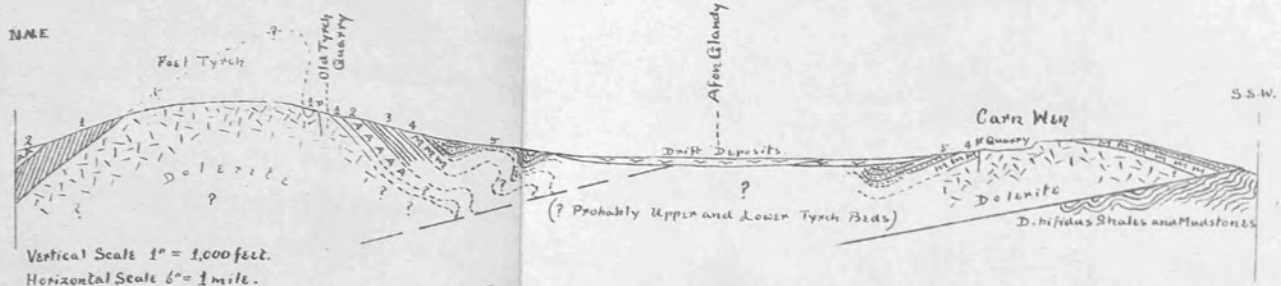
as a prominent cairn behind the Castle Hotel, Maenclychog. Here the dolerite is blue-green in colour, fine-grained and intensely hard. When hit with a hammer it produces a metallic sound, hence the name Maenclychog (The ringing stone).

To the south of Gors Fawr two dolerite sills, one of which is exposed in the bed of the Afon Wern, the other at Mynachlogddu Church, unite a little to the west and extends westwards as a single sill. As such it is exposed near the small slate quarry at Llyn; on the north face of the Llandilo Quarry; on the south side of the quarry near Temple Druid; and finally in the railway cutting near the bridge, a quarter of a mile south-east of Maenclychog Station.

A small intrusion of coarse-grained, decomposed dolerite is exposed near Cwm Isaf Factory. When fresh it is blue-green in colour, but is usually ironstained to a deep brown colour. It is usually so soft that it has been extensively used for making stone troughs which have been excavated from blocks of this dolerite. It is known locally as "Careg Nadd" (The sculptor's stone).

The dolerite sills exposed in Gilfach quarry have been previously mentioned (p. 72). The sill exposed on the north-west face of the quarry is almost completely decomposed into a soft ochreous mass, but occasionally blue-grey, coarse-grained cores of comparatively fresh

dolerite



Vertical Scale 1" = 1,000 feet.
 Horizontal Scale 6" = 1 mile.

- | | | | |
|--------|---|-------|-------------------------------------|
| Arenig | } | Tyrch | 5. Shales |
| | | Group | 4. Ashy mudstones. |
| | | | 3. Shales. |
| | | | 2. "Chinastone" ashes and mudstones |
| | | | 1. "Tyrch Slates". |

Plate 28.

Section from Foel Tyrch to Carn Wen.

dolerite are present in section exposed in the quarry tunnel which pierces this dolerite at right angle to its strike. The sill on the south-east face is a hard fine-grained blue-grey dolerite. Both these sills can be traced westwards for a distance of more than $1\frac{1}{2}$ miles. The 'north-face dolerite' of Gilfach Quarry is exposed in the small quarry nr. Llangolman Farm as a hard, fine-grained quartz-dolerite sill which fingers out in the quarry section into two blunt-nosed subsidiary sills.

Interesting masses of intrusive dolerite occur at Foel Tyrch, Crugiau Dwy, and Carn Wen. At all three localities the dolerite is represented as laccolith-like masses which fill the cores anticlinal folds (see Plate 28).

The dolerite of Foel Tyrch is generally blue-green in colour, fine-grained and well jointed. Coarse-grained varieties are also represented in this mass. Crugiau Dwy, which is the faulted continuation of the Foel Tyrch dolerite mass, consists in the main of coarse-grained gabbroid dolerite, in which large felspar phenocrysts are often abundant.

Small tongue-like offshoots form the main parent mass on both Foel Tyrch and Crugiau Dwy. The presence of the decomposed termination of one of these offshoots appears in the face of the small stone quarry near Tyrch Quarry. If this is a horizontal offshoot the difference in the level between it (O.D. 600 feet), and the highest

exposure

exposure of dolerite on Foel Tyrch (O.D. 1157.5 feet), suggests a thickness of at least 500 feet for Foel Tyrch dolerite mass.

At Carn Wen a dome-shaped mass of dolerite is exposed in the extensive workings of the roadstone quarry. It is partly capped on the summit and around the sides by a thick 'cover' of indurated mudstones, spotted shales, and splintery felspathic ashes. The dolerite is blue-grey in colour, medium-grained and intensely hard. The dolerite mass is traversed by two sets of joint planes, one set dipping at 70° to the N.30 E., and the other at somewhat similar angles in the opposite direction. These two sets of joint planes produce a lattice-work effect on the centre of the quarry face. Were it not for the presence of these joint planes, quarrying at such a locality would be an economic failure.

Large "rafts" of very hard, fine-grained, dull-grey, splintery hornfelsed sediment are of common occurrence in the dolerite. These "rafts" have undoubtedly been derived from the collapse of portions of the "roof" during the intrusion of the doleritic magma.

Another small laccolithic mass of dolerite extends north-north-eastwards from a point near Carn Wen. This dolerite is medium-grained and identical in lithology with the Carn Wen dolerite, with which it probably has a subterranean connection. A small

A small dolerite sill extends in a N.E. to S.W. direction from a point immediately south of Ffynnon Farm. The dolerite is medium-grained, dark-green in colour, and is exposed as a series of rocky carns along the restricted limit of its exposure.

The dolerites of the "Imbricate Area" are intrusive into Arenig rocks only. The absence of dolerite intrusions from the Llanvirn rocks suggests that the beds of this age, which in the "Prescelly Area" and the remainder of North Pembrokeshire are noted for the accumulations of intrusive dolerites, were outside the area affected by intrusions. Thrusting has now brought these widely separated areas of sedimentation close together.

The dolerites are invariably intruded along lines of weakness, and particularly into the 'cores' of anticlines. This dates the intrusions as either synchronous with, or immediately after the folding of the rocks. Since folding and faulting were initiated, at least, in pre-Bala times, and since the dolerites have been affected by these pre-Bala faults and thrusts, the dolerites, it is here submitted, are of pre-Bala age.

(b) Granophyric-felsite of Allt Trefach. - A small exposure of partially decomposed granophyric felsite, intruded into splintery, mottled mudstones (Upper Tyrch Group, p. 78), occurs in the extreme N.W. corner of Allt T^ŷrfach Quarry. The actual junction of the granophyric-felsite

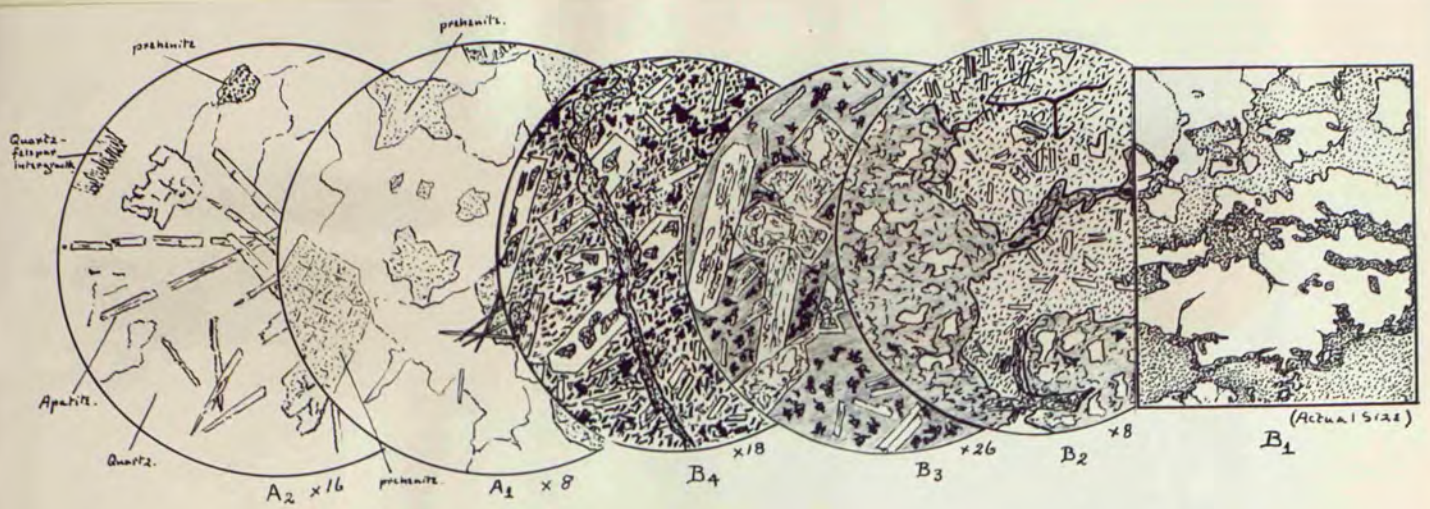


Plate 29.

A₁ and A₂ ; Microdrawings of the granophyric felsite of Allt-trefach Quarry.

B₁, B₂, B₃, B₄ ; Microdrawings of the keratophyre of Ffynnon Quarry.

felsite with the mudstones is hidden by falls of debris from the overburden.

The rock is medium-grained, and of a mottled white and grey colour. On the weathered surfaces it breaks down to a fine, grey-speckled, white powder - the result of kaolinisation of the feldspars.

No other exposure of granophyric rock is present in this area, so its mode of occurrence, and probable extent, is obscure. Rocks of such an acid composition are not common as intrusives in the Ordovician rocks of N. Pembrokeshire.

(c) Keratophyre of Ffynnon Quarry.- A single exposure of intrusive keratophyre appears at the southern end of the workings at Ffynnon Quarry. Unfortunately, quarrying operations at this stage are confined to the extraction of the indurated mudstones and feldspathic ash, which are present at this point (Upper Tyrch Group, p. 79). The keratophyre exposed is probably the margin of a larger body of intrusive rock which is nowhere exposed.

The keratophyre in hand specimen consists of irregular white patches set in a dark-grey groundmass of indurated mudstone (Plate 29, B₁). It is impossible to give further details of this rock-type until such time as more of it is exposed by quarrying. This is the only occurrence of intrusive keratophyre in the "Imbricate Area."

(d) Bostonite



Plate 30

Microphotograph of coarse-grained quartz-enstatite gabbro, showing spindle-shaped crystals of apatite, traversing large phenocrysts of albite-oligoclase and oligoclase-andesine feldspars; and acicular aggregates of prehnite. Locality: Crugiau Dwy.

(d) Bostonite of the Afon Gafael Valley.- The exposures of this bostonite intrusion are indicated on the map (Plate 34). The rock is coarse- to medium-grained, blue-grey in colour, weathering to a thin white crust, which is characteristic of all sodic of this neighbourhood. Felspar phenocrysts are usually best displayed on the partially weathered surface of the rock.

The intrusion varies from 8 to 10 feet in thickness, its outcrop being repeated several times by small-scale normal faults, downthrowing to the south. The beds into which the bostonite has been intruded consist of fine-grained, dull-grey mudstones, which break with a conchoidal fracture. The chilled margin of the bostonite varies up to 1'6" in width.

In spite of the fact that these beds cannot be traced over any distance from their locality, it seems evident that they must possess a very restricted distribution.

Petrography

(a) Dolerites.- The dolerites call for no special petrographic description. They consist of medium- to coarse-grained quartz-enstatite-dolerites usually showing ophitic structure. Similar dolerites have been previously described from the St. David's area of N. Pembrokeshire (Cox, P.G.A., 1930, and Elsdon, Q.J.G.S. 1906, p. 579).

Certain



Plate 31

Keratophyre intrusive into fine-grained sandstone.

Locality: Plynnon Quarry.

Certain specimens (Plate 30) are best described as quartz-enstatite gabbros.

(b) Granophyric-felsite.- Remnants of granophyric quartz-felspar intergrowths are recognisable in thin sections of this rock, but decomposition in the form of albitisation and chloritisation tend to obscure microscopic structures. The felspar phenocrysts are albitised to albite-oligoclase (approx. $Ab_{70}.An_{30}$) feldspars with a low birefringence ($N_g-N_p: 1.5440-1.5350$), and extinction angles ranging from 16° to 21° to the twinning plane 010. Interstitial quartz contains long needles and hexagonal crystals of apatite, as is often graphically intergrown with secondary zoisite (Plate 29, A₂). This quartz-zoisite intergrowth is probably what remains of the original graphic textures. The zoisite is a prominent secondary constituent of the rock (polarisation colours, deep blue and violet), and is present as either granular masses, prismatic in shape, or as small flakes. It has probably been derived from the decomposition of the original calcic feldspars.

(c) Keratophyre.- The keratophyric portions of the rock possess a trachytic to pilotaxitic texture, and is made up of phenocrysts of albite-oligoclase, in a ground-mass composed of microlites of felspar (presumably albite-oligoclase) and isotropic chloritic (Plate 29, B₂, B₃, B₄; and Plate 31). The felspar phenocrysts range from 0.3 mm. to 1.5 mm.



Plate 32

Microphotograph (crossed marls) of bostonite, showing the divergent trachytoid arrangement of the felspar phenocrysts, and the isotropic chloritic groundmass. Locality: Afon Gafael Valley.

to 1.5 mm. in length.

Chloritisation has destroyed all traces of original ferromagnesian minerals. Subsequent movements have resulted in the brecciation of the felspar phenocrysts (Plate 29, B₄), and thin veins of clear quartz traverse the keratophytic fragments of the rock.

Similar keratophyres, intrusive into mudstones have been recorded from Abercastle (Cox, P.G.A. 1920, p. 267), and it stated that the brecciation of the keratophyre is "due to the presence of more or less abundant argillaceous material."

(d) Bostonite.- In thin section this rock consists entirely of felspar phenocrysts and isotropic chlorite, with a decided predominance of the former over the latter (Felspar 62%, Isotropic Chlorite 30.6%; using Shand's Recording Micrometer). The felspars consist of albite-oligoclase (Ng-Np. 1.5450-1.5401; ext. angles on 010 face to 001 cleavage planes range from 14° to 18°), arranged in a divergent trachytoid manner (Plate 32). The isotropic chlorite is probably a form related to rupidolite (R.I. $\beta^1 = 1.6170$).

They closely resemble the bostonites described from Skomer Island (Thomas, Q.J.G.S., 1911, p. 175).

The "Western

The "Western Carmarthenshire Area"

The work connected with the mapping of the ground immediately east of the Taf Valley, and incidentally the trace of the Taf Fault, and south of the major thrust lines is essentially a continuation of the work initiated by Mr. D.C. Evans (Evans 1906). The Llanglydwen district constitutes the extreme north-western corner of the map published by Mr. D.C. Evans. This particular section has been checked in detail, and certain parts revised on the strength of exposures which were not available at the time of the latter publication. This work has also extended the mapping southwards from Llanglydwen to incorporate the prominent feature known as Freni Fawr.

The rocks of the "Western Carmarthenshire Area" have been classified as follows:-

- | | |
|-----------------|--|
| 4. ? Upper Bala | Freni Fawr Group. |
| 3. Lower Bala | { Tegryn Group
Glogue Slate Group
Black Dicranograptus Shale Group |
| 2. Llandeilo | { Hendre Shales
Asaphus Ash |
| 1. Llanvirn | { D. murchisoni Beds
D. bifidus Beds |

1. Llanvirn

Both the Zone of *Didymograptus bifidus*, and the Zone of *Didymograptus murchisoni* have been identified in the Llanglydwen district. Lithologically the zones are very distinctive

distinctive, and are separated by a development of fine-grained felspathic ash - the Murchisoni Ash.

(a) Lower Llanvirn (Zone of *Didymograptus bifidus*).-

The *D. bifidus* beds of the Llanglydwen district consist of blue-grey shales interbedded with thin bands of flinty mudstones, and splintery felspathic ashes. The shales weather in irregular patches of light-brown and fawn, and when viewed edge-wise they possess a streaky appearance. They are also highly cleaved, and small-scale shear-zones are often prominently displayed in the exposures of these beds. Strong cleavage and shearing of the shales probably accounts for the rarity of fossils in these beds.

The best exposures of the *D. bifidus* Beds are situated on the steep slopes of the Afon Taf valley in the neighbourhood of, and south of Llanglydwen, particularly in the two small tributary valleys of the Taf known as Allt Coenant. However, no fossils have been obtained from the latter locality. Following the succession northwards from Allt Coenant towards Llanlydwen a triangular block of *Dicranograptus* shales have

been let

been let on to the section northwards from the Signal Box. At this latter point the faulted junction with the D. bifidus shales is clearly exposed, and some five feet of shale "smash" separates the two formations. The "smash" is composed of milled up fragments of shales belonging to both formations, the whole being injected with vein-quartz and highly pyritised. Traces of chalcopyrite are also present at this point. Many trial holes have been made in search of lead, iron, and cupriferous minerals along this section of the valley.

Fine exposures of the D. bifidus beds are exposed along the roadside leading up the hillside from Llanglydwen to Rose Hill house, and beyond this point in a southerly direction. Numerous thin developments of pale-yellow weathering, steel-blue, splintery ash are developed in this section. The ash bands are never more than sixteen inches in thickness and are usually about three inches thick.

One of the

One of the most accessible exposures of *D. bifidus* shales occurs along the road leading from the bridge at Llanglydwen westwards towards Porth-y-rhyd. One specimen of *D. bifidus* Hall was obtained from the shales near the bridge. Here the shales are faulted against excellent exposures of the Murchisoni Ash and the *D. murchisoni* beds.

An interesting exposure of *D. bifidus* beds is exposed eastwards along the valley leading up from Tigan. Here the *D. bifidus* shales yielded a few specimens of *D. bifidus* Hall, and they are exposed on the north banks of the valley. To the south they are faulted against the *Asaphus* Ash and Hendre Shales (Llandeilo), and these latter rocks strike due north and south, whilst the *D. bifidus* shales strike almost due east and west. Another interesting feature of this locality is that the *D. bifidus* shales are succeeded, without any apparent signs of a break, by the *Asaphus* Ash and then by the Hendre Shales. Here, the
D. murchisoni

D. murchisoni mudstones, although developed on the western sides of the Taf Valley at Llanglydwen, are absent in the "Tigan Valley." This is not unusual, as in many places further east in Carmarthenshire a similar state of things exists.

Numerous specimens of *D. bifidus* Hall were obtained from the poorly exposed roadside section on the steep hill leading from Pengawsai to Llys Ifor. Thin bands of ash are also a feature of this succession of the *D. bifidus* beds.

Westwards of the Llanglydwen district the *D. bifidus* beds are not very well exposed. However, there seems little doubt, from the exposures available, that these beds persist along this east-west line of strike into the district around Clyn-gwyn. At this point they are definitely overlain by the Arenig (Lower Tyrch Sub-group) rocks of the "Imbricate Area" which have been thrust south-eastwards over this ground occupied by the *D. bifidus* shales. The relationship of the *D. bifidus* shales to the Sheared Shale Group has been discussed in the description of the "Imbricate Area" (p. 64).

(b) Upper Llanvirn (Zone of *Didymograptus murchisoni*).-

The *D. murchisoni* beds can usually be sub-divided into a basal member, the Murchisoni Ash, and an upper member composed of dense-black mudstones which weather to a light shade of fawn. The uppermost beds of the mudstone and
shale

shale group are usually markedly striped on the weathered surfaces - a property which clearly distinguishes them from the Hendre Shales (Llandeilo).

The Murchisoni Ash forms a useful junction bed between the *D. murchisoni* shales above and the *D. bifidus* shales below.

The Murchisoni Ash is not developed in the district immediately east of Llanglydwen. This fact raises the question of whether the Murchisoni Ash is the stratigraphical equivalent of the Asaphus Ash, which still further east is linked with the Ffairfach Grit (Geol. Surv. Mem., Carmarthen). If all three beds are the same, then obviously the Asaphus Ash and the Ffairfach Grit cannot be linked, as the basal member, with the Llandeilo Beds (Hendre Shales or Llandeilo Limestone). However, one striking fact remains that wherever the ash is succeeded by a development of *D. murchisoni* shales the ash does not, so far as the evidence goes, contain fossils. No section in the St. Clears area (Evans, D.C., 1906) clearly demonstrates a full succession, such as the following:-

Llandeilo	{ 5. Hendre Shales
	{ 4. Asaphus Ash
Upper Llanvirn	{ 3. <i>D. murchisoni</i> Shales
	{ 2. Murchisoni Ash
Lower Llanvirn	1. <i>D. bifidus</i> Shales.

Until fossil evidence from the Murchisoni Ash throws light upon this problem it still remains unsettled. Here it is taken, for descriptive purposes, that the Murchisoni Ash

Ash and the Asaphus Ash are two distinct developments of pyroclastic material, although the view is here favoured that they are both identical.

An excellent exposure of the Murchisoni Ash, in the small quarry at Aber Taf cottage, is succeeded by the dense black fossiliferous mudstones and shales of the zone of *D. murchisoni*. Only the zone fossil, which is plentiful in these beds, along with *Didymograptus murchisoni* var. *geminus*. His. have so far been found in these beds. The Murchisoni Ash is some 25 feet in thickness, is steel-blue in colour when fresh and breaks with a sub-conchoidal fracture. It weathers to a pale fawn colour, and easily breaks down in its final stages to a fine cream-coloured powder. It is highly pyritous in parts, sometimes these accumulations of iron pyrites are represented by ovoid masses of resultant ochreous material. It is further interesting to note that this so-called Murchisoni Ash is indicated on the Geological Survey maps (Sheet 40, O.S.) as a bed of limestone. This is due to the fact that the ash contains calcareous lumps, and attempts have been made in the past to burn this material for lime. A lime-kiln, the remains of which are still visible, was set up for this purpose. This exposure at Aber Taf cottage was also examined for its supposed cupriferous content, and a trial hole, reputed to be many yards long, was made into it. However, neither

neither of the two ventures succeeded, and there is certainly not even the slightest trace of copper pyrites to be seen here now.

The south face of the Aber Taf quarry is traversed by the Taf Fault, and the ash has been severely slickensided, and the beds fractured and mylonised to a width of six feet. The Murchisoni Ash is here faulted against the *D. bifidus* Shales.

The Murchisoni Ash forms a prominent feature westwards to the quarry at Pengawsai. Here the ash is strongly jointed, and heavily impregnated with vein quartz. Here the ash is quarried for use as road metal.

Further west the outcrop of the ash is difficult to trace. It outcrops in the pit for the mill wheel, at Maes-y-felin, and it strikes south-westwards towards Porth-y-rhyd. From this point it has been found impossible to trace its outcrop, and so, as is indicated by the appended map, its outcrop, along with that of the *D. murchisoni* shales is merged into the *D. bifidus* shales.

The *D. murchisoni* shales are poorly exposed, and apart from the occurrence at Aber Taf, only one other good fossil locality is exposed westwards from the Taf Valley. This occurs in a small disused quarry on the roadside leading to Castellgarw Farm. Here the

D. murchisoni

D. *murchisoni* beds are represented by thinly bedded black shales, which highly cleaved and weather to a deep red-brown or rusty colour. Both D. *murchisoni* Beck, and D. *murchisoni* var. *geminus* His. were recorded from this locality.

A lenticular area of D. *murchisoni* shales occurs between Hebron and Glandwr. Exposures are poor, and the shales are usually strongly cleaved and fossils are rare. A good fossil locality exists in the stream section below Cae'r Aeron Farm, and the following fossils were obtained.

Didymograptus murchisoni Beck.

D. *murchisoni* var. *geminus* His.

Glyptograptus aff. *dentatus* Brogn.

2. Llandeilo

2. Llandeilo

(a) Asaphus Ash.— The so-called Asaphus Ash has been included with the Llandeilo (or Hendre Shales). Although not persistent it is well exposed along the northern banks of the "Tigan Valley." Although not so fossiliferous as the type localities further east (Evans, D.C., 1906) a few specimens of *Asaphus tyrannus* Murch., and fragments of *Ogygia* sp. were obtained. In lithology the Asaphus Ash consists of a group, some 40 feet in thickness, of well bedded, coarse-grained, agglomeratic, felspathic, ash.

Another exposure of the Asaphus Ash strikes south-south-eastwards from the "Tigan Valley." Similar fossils were obtained from this exposure.

The Asaphus Ash has been used extensively in Carmarthenshire as a building stone, but no such use has been made of this beautiful building stone in the Llanglydwen district.

(b) Hendre Shales.— The Hendre shales have only a limited distribution in the Llanglydwen district. Lithologically, they are identical with the Hendre shales of the Imbricate area. It is here felt that no further comment regarding them is required at this point.

3. Lower Bala

As in the "Prescelly Area" and the "Imbricate Area" the Lower Bala rocks have been classified as follows:-

- ? U. Bala { d. Freni Fawr Group over 800 feet
- { c. Tegryn Group 300 "
- La Bala { b. Glogue Slate Group 200 "
- Bala { a. Black Dicranograptus Shale Group 150 to 300 feet

(a) Black Dicranograptus Shale Group. - The Black Dicranograptus Shales are identical in lithology with those of the "Imbricate" and "Prescelly" areas. The exposure of these shales is mainly confined to the Llanglydwen district. Here again the actual junction of these beds with the underlying Hendre Shales is nowhere exposed. However, in the small quarry near Trefach, the passage from typical Black Dicranograptus Shales through a series, 12 feet in thickness, of pale-grey, gritty mudstones with black shale partings, into the normal spotted slates typical of the Glogue Slate Group, is clearly exposed. Unfortunately, fossil evidence is poor at this locality, and no specific identification of the genera of graptolites present has been possible.

A small lenticule of Black Dicranograptus shales is exposed at a point on the east bank of the Afon Taf, opposite Blaiddbwl Farm. Here the shales are strongly jointed

jointed and highly cleaved. A small fault traverses the beds, and fine developments of holohedral crystals of iron pyrites are developed along the fault "smash."

Black Dicranograptus Shales are well developed along the railway line on the east side of the Afon Taf, between Llanfyrnach and Glogue. The beds are strongly jointed and highly cleaved, and they have been severely affected by the presence of the Taf Fault. Graptolites, although plentiful, are too poorly preserved for precise identification.

Lead has been mined from the Black Dicranograptus Shales at Llanfyrnach. Evidence available on the refuse tips suggests that the lead was entirely confined to these shales, as no specimens of Hendre Shales are visible in the debris. Graptolites are fairly well preserved in these shales, and the following have been identified.

Amplexograptus arctus Elles & Wood.

Dicranograptus brevicaulis Elles & Wood.

Dicranograptus aff. *rectus* Hopk.

Mesograptus multidentis Elles & Wood.

Dicellograptus sp.

Lead was extensively mined at this point as is indicated by the following figures of output.

Lead Ore

Date	Lead Ore (Tons)	Lead (Metallic Content) Tons	Total Silver Content (ozs.)
1859	96	65	390
1860	186	158	1,108
1861	43	29	263
1862	340	255	1,790
1863	250	170	850
1864	351	263	2,368
1865	322	235	2,066
1866	308	252	2,268
1867	282	211	2,175
1868	294	221	2,860
1869	360	270	4,050
1870	342	257	3,847
1871	219	157	1,872
1872	130	98	490
1873	150	105	1,341
1874	113	98	588
1875	80	58	669
1876	15	11	66
1877	8	6	36
1878	610	463	3,235
1879	1,065	789	6,334
1880	1,278	1,137	4,692
1881	1,695	1,241	9,575
1882	1,119	760	7,735
1883	831	628	4,541
1884	1,117	846	8,275
1885	1,439	959	9,776
1886	1,113	845	5,354
1887	656	498	3,156
1888	555	422	2,670
1889	120	91	458
1890	10	8	48
1891	Ceased work		

The lead

The lead is associated with calcite as its chief gangue mineral, but chalcopyrite and pyrites are also present in samples from the refuse tips. It is of interest to note that the silver content of this galena averages about 6 ozs. per ton. Mine plans are apparently non-existent, but it seems fairly certain that the lead is associated with thrust-planes. However, apart from a few stringers in the shales in the immediate vicinity of Llanfyrnach, no traces of any large ore body have been detected elsewhere in N. Pembrokeshire and north-west Carmarthenshire.

The junction between the Black Dicranograptus Shales and the overlying Glogue Slate Group is well exposed at various points between Llanfyrnach and Glogue. The junction takes the form of a series of transitional beds of blue-grey gritty mudstones and shales interbedded with dense black, stripy-weathering shales, the whole being usually about 8 feet in thickness. Careful mapping of this junction has shown that despite the fact that the Black Dicranograptus Shales dip at angles up to 60° beneath the Glogue Slates, the junction line maintains a close parallelism to the contours, and the Glogue Slates themselves rarely dip at angles exceeding 20° . This suggests that there is a structural discontinuity between the Black Dicranograptus Shales and the Glogue Slates.

(b) Glogue

(b) Glogue Slate Group

The Glogue Slate Group consists of about 200 feet of blue-grey, somewhat gritty highly cleaved shales, characterised by the development of dense black spots of irregular ovoid outline ranging up to 2.5 mm. in length. Their widespread distribution is due to the low angle of dip and the development of small scale folds, and not to any appreciable increase in thickness as traced from south to north and finally west-north-westwards.

The Glogue Slates (or 'blue-grey mudstones' of D.C. Evans, 1906) succeed the Black Dicranograptus Shales of the Eglwys-fair-a-churig district. The outcrop is then shifted northwards by a fault, and at Trefach the junction between the two groups is clearly exposed. Glogue Slates have been extensively quarried north of Pen-celli for use as roofing slates in the past. The inaccessible nature of the sites was partly the reason why these quarries were eventually abandoned.

Northwards from Pen-celli the Glogue Slates form the high ground on the eastern side of the Taf Valley.

At Glogue, extensive quarrying operations have produced a working face of 150 feet in height. The slate possesses a fairly high "cleavage value," but owing to the difficulty of working such a high quarry face, and the

rather

rather dull colour of the slates, this extensive working is now rapidly falling into ruin.

The Glogue Slates outcrop extends north-westwards along the upper reaches of the Afon Taf, but never does it cross the actual valley, neither is its outcrop affected to any undoubted degree by the powerful thrusts and faults of the "Imbricate Area." All these structures end suddenly against the Dicranograptus Shales - Glogue Slates boundary.

Slates and mudstones inseparable from the Glogue Slate Group and the succeeding Tegryn Group extend, as a broad belt to the north of the Prescelly Hills, in a westerly direction towards the coast at, and north of, Newport.

(c) Tegryn Group

The Tegryn Group consists of some 300 feet of blue-grey and purple mudstones, flagstones and shales. The Group is an arbitrary one which has been designed to separate the productive development slate (Glogue Slate Group) from the non-productive beds (Tegryn Group). This line of sub-division is capable of being mapped within reasonable limits along the western and north-western flanks of Freni Fawr, a distance of over three miles north-westwards from Tegryn. Beyond this the line has not been mapped.

Quarrying has been carried out on a small scale in various portions of the Tegryn Group. Flagstones have been quarried from a small quarry on the north side of Tegryn Village. Blocky mudstones have been quarried for use as "ballast" material for the roads in the neighbourhood of Cwm-gorllwyn. An attempt has been made at quarrying the shales as roofing slates, near Rhydwen.

No fossils have been found in these beds even though the lithology of the beds seems favourable for fossils.

? Upper Bala (Freni Fawr Group)

On the southern slopes of Freni Fawr the Tegryn Group is succeeded by about 150 feet of coarse grits, quartzites and thin beds of fossiliferous sandstone, with a thin development of conglomerate at the base. These in turn are succeeded by over 150 feet of splintery, blue-grey, gritty shales, followed by alternations of blocky, blue-grey stripey-weathering mudstones and thinly bedded blue-black shales.

The mapping of these beds has only been pursued in the immediate vicinity of Freni Fawr. At this stage it was considered advisable to elucidate the stratigraphical succession on Freni Fawr itself, as this would form the basis of future work on the northward extension of fieldwork which will complete...

will complete the succession to the base of the Silurian in the district around Newcastle Emlym.

The sandy mudstones are exposed immediately south of the tumulus (O.D. 1297 feet), and at this point they proved fairly fossiliferous. The following fossils have been identified from these beds:

Orthis (*Dalmanella*) *comp. testudinaria*

Leptaena rhomboidalis

Phyllopora *cf. hisingeri*

Halysites *sp.*

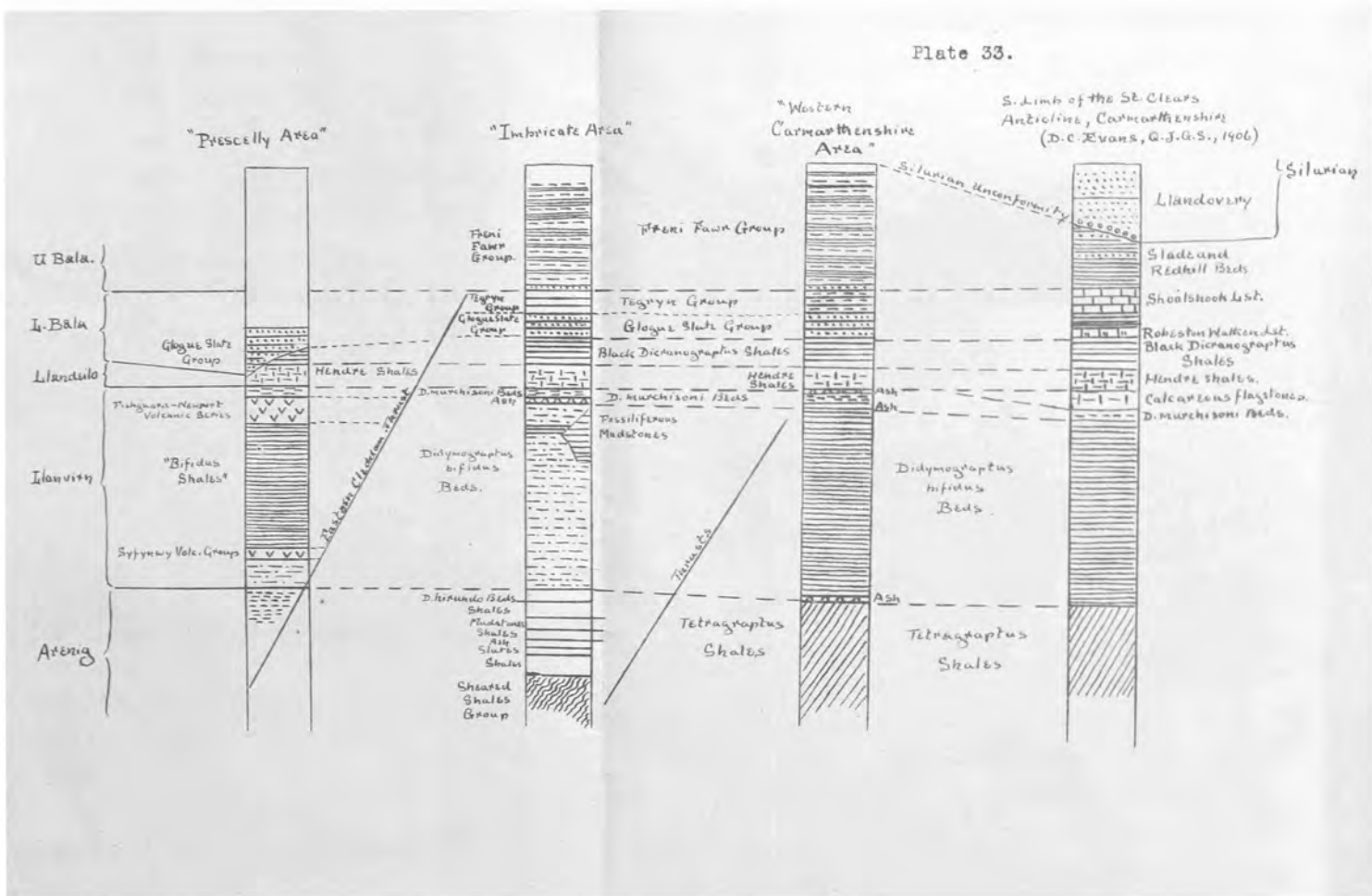
This faunal assemblage provides strong evidence for correlating these beds with the Slade and Redhill Beds (Evans, D.C., 1906), which are undoubtedly of Upper Bala age.

Correlation

The three areas here described have been correlated in tabular form in Plate 33, and their connection with the more standardised succession on the southern limb of the St. Clears Anticline (Evans, D.C., 1906) has been indicated.

The stratigraphical succession in the "Prescelly Area" is identical with that of the country between Fishguard and Newport, and the Ordovician succession of Aberiddy Bay (Cox, Q.J.G.S., 1915, p. 273) and in the neighbourhood of Sealyham and Wolf's Castle (Thomas & Cox, Q.J.G.S., 1924, p. 520). Mapping on the scale of 1 inch to one mile in the district

Plate 33.



district between Maenclychog and Ambleston has left no doubt as to the correlation of the Sealyham Keratophyres (Thomas & Cox, Q.J.G.S., 1924, p. 535) with the Syfynwy Volcanic Group.

The stratigraphical succession of the "Imbricate Area" bears resemblances to both the rocks of the "Prescelly Area" and those of the "Western Carmarthenshire Area." Striking dissimilarities exist between the Arenig and Lower Llanvirn rocks of the "Imbricate Area," and rocks of similar age to the north-west and south-east. The Tyrch Slates (Arenig) are not represented as such in any other development of Arenig rocks in North Pembrokeshire. The *D. bifidus* mudstones and shales are unlike the L. Llanvirn shales of the "Prescelly" and "Western Carmarthenshire" areas. This diversity of rock-type is due to the fact that the "Imbricate Area" is made up of sections of two widely separated successions within the area of sedimentation, which have been brought into juxtaposition with each other and with the intervening development of sediment, by south-eastwardly thrusting. Attempts have been made to diagrammatise these conditions in Plates 7 and 33.

The "Western Carmarthenshire Area" can be closely correlated with the succession on the southern limb of the St. Clears Anticline, even though there are striking changes in lithology between the two successions.

Tectonics

Tectonics

The structure of the Prescelly Hills, and the adjoining areas in North Pembrokeshire, is governed by the presence of powerful south-easterly thrusts.

The disposition of the rocks in the "Prescelly Area" is controlled by the presence of the Nevern Anticline, the Brynberian Syncline, and the Crug-yr-hwch Anticline. The axes of these folds extend, and pitch, from the west-south-west to the east-north-east. Small flexures are often developed within these large folds (e.g. Pen-cnwc-bach anticline within the Brynberian Syncline).

The Fishguard - Newport Volcanics are usually folded into broad anticlines or synclines, but the succeeding shales and mudstones of the Upper Llanvirn and Llandeilo are thrown into a series of tightly packed folds, and are often traversed by faults which have no apparent effect on the more resistant component - the Volcanics.

Thrusts, possessing an east-north-east to west-south-west trend such as those which are characteristic of the "Imbricate Area, " are not well developed in the "Prescelly Area."

The Brynberian Thrust, which thrusts "Bifidus Beds over the Fishguard - Newport Volcanics, has no appreciable effect upon the Glogue Slate Group to the north-east. South westwards the Brynberian Thrust undoubtedly increases in magnitude

magnitude, but large areas of drift and rainwash obscure many points along this line into the Greenaway district, where the Syfynwy Volcanic Group is thrust over "Bifidus Beds." The Brynberian Thrust probably swings westwards from Greenaway into the district south of Letterston, but the details of the intervening ground are still unknown.

Small transverse faults are prominent in the "Prescelly Area." It seems probable that a certain amount of lateral movement has taken place along these lines, particularly in the neighbourhood of Foel Trigarn.

The great mass of thrusts and tear-faults between the trace of the Eastern Cleddau Thrust, and the Taf Fault to the south, is the north-eastern continuation of the Trefgarn - Spittal Group of thrusts (Plate 1).

The Eastern Cleddau Thrust accounts for the disappearance of the Fishguard - Newport Volcanics in the country to the south-east of Crug-yr-hwch. Between Crug-yr-hwch and Crugiau-Dwy the "Bifidus Beds," the Fishguard - Newport Volcanics, and the Hendre Shales are thrust over Upper Tyrch shales and ashes (Arenig). North-eastwards the Thrust is concealed beneath a heavy cover of drift, but it emerges in the vicinity of Hermon where the Hendre Shales are thrust over the Pant-y-begney beds (L. Llanvirn). To a certain extent this thrust affects the Black Dicranograptus Shales
(Lower

(Lower Bala) but how much of this is due to post-Bala movements is uncertain. Most certainly the Eastern Cleddau Thrust has no effect upon the Glogue Slate Group (L. Bala) of the Glogue district.

The great mass of so-called "Sheared Shales" in the Rhyd Wylim district is due to this south-easterly thrusting. Here the oldest members of the Arenig visible in the area are thrust over L. Llanvirn (D. bifidus Beds) Shales. An extension of this thrust line along the northern slopes of the small valley between Glandy Cross and Hebron shows U. Tyrch and L. Tyrch beds (Arenig) thrust over the D. murchisoni beds (U. Llanvirn), Hendre Shales, and Black Dicranograptus Shales. At Glandwr the D. bifidus mudstones are thrust over Hendre Shales, as is shown on the section at Pont-y-gafael, and north-eastwards along the steep slopes of Pant-y-begney.

The dominant east-west strike of the "Western Carmarthenshire Area" forms a striking contrast to the caledenoid directions of the "Imbricate" and "Prescelly" areas. In the neighbourhood of Llanglydwen the beds have been subjected to intense faulting which is probably due, partly to the increasing intensity of the Taf Fault as traced south-westwards, and partly to the effects produced by the thrusting expressed by the "Imbricate Area."

The northward....

The northward extent of the Glogue Slate Group is characterised by the absence of any such intense structures. Small-scale folding and strike-faulting are the chief structural features of this expanse of rock. Cleavage is developed throughout the group, but rarely does it reach the high grade experienced in the Arenig (Tyrch Slates) rocks of the "Imbricate Area" and the Llanvirn ("Bifidus Beds" of Cwm Cerwyn) of the "Prescelly Area."

It seems evident that the major portions of the thrusts, folds and faults were developed during pre-Bala times. That such movements continued in Bala times is evident from the fact that the Black Dicranograptus Shales were affected by them. However, with the appearance of the Glogue Slate Group (L. Bala) all such movement had ceased, as is shown by the fact that the Glogue Slate Group spreads over the older rocks unconformably and conceals the prolongation of the structures they possessed.

The correlation of this portion of North Pembrokeshire with other areas to the west (Plate 2) leads one to postulate a similar pre-Bala date for the inception (at least) of such powerful elements as the Pwll Strodyr Fault (Cox, Q.J.G.S., 1915), and the Ford - Spittal thrusts (Thomas & Cox, Q.J.G.S., 1924). These pre-Bala movements were probably the forerunners of the main caledonian earth-movements. The effects of such pre-Bala movements have been greatly influenced, and probably

probably accentuated by these later movements, whilst the American movements, which have had such a pronounced effect upon the structure of South Pembrokeshire, must, conceivably, have produced torsional movements within the pre-existing structures in North Pembrokeshire.

Pre-Bala movements have recently been described in a paper (not yet published) given to the Geological Society recently by Dr. Mitchell. He describes structures in the Borrowdale Volcanics which are completely concealed by the unconformable cover of the Coniston Limestone (L. Bala).

In the Abbey Cwm-hir district (Roberts, 1929) there is undoubted evidence of pre-Silurian earth-movements:

These three widely separated areas show quite clearly that movements assigned under the title of "caledonian" did not take place during one set interval of time. The caledonian system of mountain-building had its date of inception in pre-Bala times and then developed in stages; each period of movement followed by a period of comparative rest during which erosion and sedimentation progressed. In a number of cases erosion of pre-existing Ordovician rocks must undoubtedly have occurred during such periods. Upper Bala conglomerates exposed in the cliff sections of Ceibwr Bay, 2 miles south-west of Cardigan, contain pebbles of dolerite and splintery tuffs similar to those described from the Fishgaurd - Newport Volcanic Series.

Conclusions....

Conclusions

(a) The rocks of the Prescelly Hills and its adjoining areas are wholly of Ordovician age.

(b) The Arenig, Llanvirn, and Llandeilo rocks have been subjected to intense pre-Bala movements, the effects of which have been modified by later earth movements.

(c) The structure of this portion of North Pembrokeshire has provided the key to the solution of the structure of the whole of North Pembrokeshire. North Pembrokeshire resolves itself into a series of nappes which override the country to the south-east. Each nappe is separated by tear faults (e.g. Pwll Strodyr Fault). Finally, the major portion of this thrusting was effected during pre-Bala times.

In conclusion I wish to record my indebtedness to Dr. L. Hawkes for his encouragement throughout this work, and for his invaluable assistance in the petrographic determinations of the igneous rocks of this area. To Professor A.H. Cox, University College, Cardiff, I would like to acknowledge my indebtedness for the interest he has taken in this work, and for bringing his vast knowledge of the Ordovician rocks of Wales to bear upon the field-relationships of these rocks.

I wish

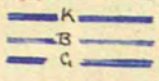
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Plate 34.

KEY.

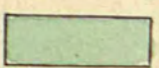


Dolerite.



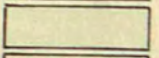
K Metaophyre
B Basalts
G Granophyre-felsite.

Intrusive Rocks.

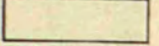


Frehi Fawr Group.

} ?U. Bala.

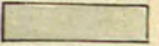


Tegryn Group.

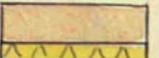


Glogue Slate Group.

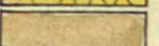
L. Bala.



Black Dicranograptus Shale Group.



Brendre shales and mudstones. } Llandeilo

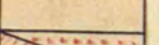


Asaphus Ash



Didymograptus murchisoni beds.

} Llanvirn.



Shales } D. bifidus beds.
Mudstones }

Blue Black Shales ? lowest Llanvirn



D. hirundo mudstones.

light yellow

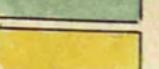


Shales and mudstones.

} Arenig.



Upper Tyrch Group.



Lower Tyrch Group.



"Sheared Shales" Group.



Fishguard-Newport Volcanic Series.



Syfynwy Volcanic Group.

} Volcanic Rocks.

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^{to University of London for the grants.}

THE GEOLOGY OF THE PRESCELLY HILLS AND ADJOINING AREAS IN NORTH PEMBROKSHIRE AND CARMARTHENSHIRE.

BY
WILLIAM DAVID EVANS, F.R.S.

