Chapter 13 The Ordovician rocks

Introduction

Next to those of the Mona Complex, rocks of Ordovician age are the most extensive in the Island. They are distributed in one large and 26 minor districts or small outliers, all of which are of the nature of more or less broken synclinal infolds. These may be grouped as follows, beginning at the Strait:

The Menai Fragments

The Llangoed Area

The Strips along the Berw Faults

The Llangwyllog Area

The Principal Area

The Carmel Head Areas

Mynydd Eilian

The Northern Wedges

An exposure on the mainland shore between the Bridges is so important that it will be described in this volume. That which is here called the Principal' Area is the large tract which occupies so much of the central and north-western portions of the Island, in the midst of which is the alluvial tract of Cors y Bol. It is not merely the largest area; it is also that in which the zonal succession is by far the most complete. The next two tracts are really its wings, and barely separable from it. The eighth is a group of nine small wedge-shaped tracts along the northern coast, which differ in many respects from all the others. On parts of the Llangoed, Llangwyllog, 'and Principal Areas there is heavy drift, but not for long together, and the harder grits are well exposed. On Mynydd-y-garn and Mynydd Eilian the rocks rise above the 500-foot contour.

All the main divisions of the system are represented; and the zonal succession is nearly — may possibly be quite — complete.

In Chapter 9 it has been shown that the Ordovician rests upon the Mona Complex with an unconformity of the first magnitude. In Chapter 12 it is also shown to be unconformable both to the Baron Hill and to the Careg-onen rocks, and its unconformable relations to the Cambrian are set forth in the same chapter. Its deposition must therefore have been preceded by a prolonged period of severe erosion, during which the Cambrian and later Pre-Cambrian formations of the Island were swept away, the Mona Complex laid bare, and then cut into far down into its crystalline depths.

Petrology

Owing to the absence of the volcanic rocks that are developed on so great a scale in the adjacent mountain-land, the Ordovician rocks of Anglesey are, lithologically, somewhat uniform by comparison, the greater part of most of the districts being composed of shales. The other rocks that enter into the succession are conglomerates and pebbly grits, with finer grits, and some limestones, cherts, and oolitic ironstones. There is generally a cleavage, but it is not often strong, and is sometimes absent altogether. It will be described in Chapter 18.

The conglomerates and grits

These are extremely variable in composition, owing to the rapid changes of the local members of the Mona Complex, from which they are, very obviously, derived. They have, however, a characteristic aspect of their own, being tough and greywacke-like between the pebbles, as are so many grits of Ordovician age in Britain. They vary in colour from grey to green, and have a tendency to rusty weathering. On the northern coast there is a, purple conglomerate, whose colour is due, to secondary haematite, which has penetrated pebbles as well as matrix.

The Conglomerates — Most of the constituent pebbles have been enumerated on p. 244. Every durable member, indeed, of the Mona Complex is represented, except the Holyhead Quartzite and the South Stack Series, which were evidently either buried or excluded by a westerly drift at the time of deposition. Venous quartz is a less important constituent than in most conglomerates; and no materials but such as might have come from the Mona Complex have been seen. So local in origin is their pebble-content that the district whence a specimen has been taken can often be inferred.<ref>This is the reason of the comparative scarcity of venous quartz. For in the southeast, where the Mona Complex is extremely rich in quartz-augen, the basement beds of the Ordovician are but grits, which are rarely pebbly. Also, in the tracts between Llanerchymedd and the eastern sea, where the proportion of augen-quartz pebbles is greater than elsewhere, the conglomerates are thinning rapidly. So the system was never given an opportunity to gather any great quantity of augen-quartz.</ref> It is noteworthy that nearly all the pebbles are schistose, unaltered Gwna spilite even being quite rare; from which it is evident that the upper tectonic horizons of the Complex, which must have been undeformed, had been destroyed by older waste and its schistose parts laid bare, before the commencement of Ordovician denudation.. (See pp. 253–4, 401).

The conglomerates are often coarse, pebbles of two or three inches in length being quite common; and in two places there are 'giant-conglomerates' or boulder-beds. (Plate 27). In the sea-cliffs north of Ogo Gynfor there may be seen blocks of quartzite of great size, but in positions where it is difficult to measure them. In the midst of the dunes west of Trewan Sands Crossing are conglomerates full of boulders of quartzose schist, New Harbour mica-schist, granite, gneiss, and hornblende-gneiss. Some of the boulders of granite are three feet, and those of gneiss four feet in length. The pebbles of quartzite and granite are well rounded, those of the foliated rocks tend to be sub-angular, while, near Bod-Deiniol, some beds about two feet thick are almost composed of thin pebbles of green-mica-schist, flat or wavy, and six (one of them 15) inches in diameter. They are sharp-edged, and irregular in outline. Lying on the bare dip slopes, they give a curious appearance to the conglomerate, rather like that of certain Mesozoic rocks that are full of large shells of *Ostrea* or *Exogyra.* Here and there, especially in the valley at Bodynolwyn-groes, the conglomerates contain 'galls' of dark shale, indicating some contemporaneous erosion. Bedding is usually well marked, even the boulder-beds being parted, at short intervals, by massive beds of grit. About Llyn Traffwll, however, the bedding is apt to be obscure.

The ordinary Grits are usually dark or greenish grey, but in several districts there is a very light, almost white, variety, usually rather coarse. Generally the texture is hard and greywacke-like, a character due to presence in the matrix of chioritic matter, derived doubtless from the Mona Complex. Their felspar is almost wholly albite, of the types abundant in the Complex. The greywackes are for the most part coarse, and disposed in thick, massive, though seldom irregular beds. On two horizons, however, there are what may be called 'alternating groups', which consist of rapid alternations of dark shales and thin, even-bedded, grits; the grits being fine, with numerous parallel but short films of shale. An unusual type, rather prevalent about Ceidio, is a gritty black mudstone, in which many of the sandy grains are felspar, often subangular. At Bryn-celyn, Llangoed, there is a Beculiar variety of this, crowded with felspars, which are chiefly albite-oligoclase, with a possible range to andesine, about a tenth of an inch in length. They are unrolled and angular, many with re-entrant angles, one being noticed with no less than four re-entrant angles. Fragments with such forms are apt to be produced by the explosion of lavas. If these originated in that manner, they are the only contemporaneous volcanic material in the Ordovician of Anglesey, and must have been wind-borne from the south.

In spite of local variations, all these conglomerates and grits have certain characters in common, due chiefly to the greywacke-like state of the matrix, and it is not usually difficult to recognise a specimen as from Ordovician rocks.

Shales

Nearly all of these are black or dark-grey, save one group that is of a dull-green or grey-green colour. There are a number of subtypes, but as these are intimately connected with the graptolitic zones, their description, as well as that of the green shales, will be postponed to p. 413.

Limestones

Calcareous knots are to be found here and there in the conglomerates, but only at Porth Padrig (Mynachdy) can anything be described as a true limestone, and even these are quite of small extent. They are clean grey rocks, rather crystalline, and showing many small organic bodies on the weathered surface.

Cherts

These are found in the zone of *Nemagraptus gracilis,* but only on the northern coast. They consist of alternations of shale and cherty grit, with hard bands, an inch or so thick, of clean black chert that breaks quite smooth and conchoidally. This (E10516) [SH 408 946] consists of true crypto-crystalline silica with minute angular clastic quartz and a little calcite, and is crowded with sponge-spicules. Of these Dr. G. J. Hinde remarks: 'The greater number are transverse sections of simple rod-like spicules; in a few cases longitudinal sections can be faintly distinguished, but none complete. These spicules appear to be cylindrical or fusiform (no remains of hexactinellid spicules can be seen), and they are not characteristic of any special group of sponges or of any geological horizon'. (Fig 200).

Oolitic ironstone

This is now known at fifteen places, viz. Bryn-celyn and Plâs-yn-llangoed (Llangoed), Llanddona, Llangwyllog, Llandyfrydog Mill, Gwredog (Llanerchymedd), Pwll-goch-isaf, Pen-bol, Fferam-uchaf and South Lane (Llanba,bo), Ucheldre-uchaf (Llanifiewyn), Gorlan-goch (Mynydd-y-Garn), the Bay and Pen-terfyn (Cemaes), and Porth Wen Bay. Those of the northern coast are grey siderite-rocks, feebly oolitic. Those of Llanbabo are ferrified grits with angular quartz and a few doubly terminated quartz-prisms, also feebly oolitic. The rest are heavy black oolites (Plate 28), Fig. 1 with grains rather less than one millimetre in diameter, oval rather than spherical; though that of Llangoed is locally a true pisolite, with grains more than half an inch across. These grains are composed of a pale green mineral, often darkened by concentric shells of ruddy ferric oxide, and sometimes have a quartz grain at the centre. Some show a dark cross in polarised light. The matrix may be partly mudstone or siderite, but in the most perfect, such as the Llangoed rock, is the same green mineral, with a few grains of angular quartz. All the ironstones tend to graduate into heavy black shales or fine angular grits. The green mineral resembles the glauconite of the Kentish Hythe Beds in having a low birefringence and a high refractive index not far from 1,600, but is paler, and largely made up of scales that give a tolerably definite straight extinction. As quartz and calcite are always present, it follows from the composition of the rock that this mineral must be a ferrous-aluminium-magnesium silicate free from alkalies, and with a low percentage of silica.

Of the following analyses, Nos. I. and II. were kindly furnished by Messrs. E. J. Morris and W. E. Williams, B.Sc., and No. III. (which was made in 1870) by Mr. Thomas Prichard of Llwydiarth Esgob. It will be seen that there is considerable variation.

	I.	I.	II.	II.	III.	IV.
	Var.A	Var.B	Var.A	Var.B	—	—
SiO_2	26.20	32.00	41.80	37.50	17.30	—
TiO_2	10	—	.05	—	—	—
Al_2O_3	15.71	15.12	16.18	9.17	11.00	—
Fe_2O_3	3.70		4.28	—	48.08	26.99
FeO	28.45	35.35	24.28	29.90	5.47	—
FeS_2	1.39	1.5	5.6	1.5	—	—
MnO	1.67	trace	1.86	trace	2.52	—
CaO	6.50	2.60	1.00	1.25	1.62	—
MgO	1.36	4.25	0.43	9.50	1.11	—
H_2O hygro	7.90		8.44	—	2.20	—
H_2O combine		9.20		—	8.54	—
CO_2	3.00		nil	6.66	—	—

P_2O_5	3.93	1.53	112	0.81	1.16	—
SO_3	—	—	—	—	0.28	—
Total	99.91	100.20	100.00	94.94	99.58	—
Fe	—	27.50	—	—	37.92	18.89

I Black oolitic ironstone, Bryn-celyn, Llangoed; south side of road at '216'. (E9795) [SH 602 796]. Anal. (A) Herbert Greenwood, Assay Office, Liverpool; (B) Pattison and Stead, Middlesbrough.

II Black oolitic ironstone, 275 yards north-west of Gorlan-goch, Mynydd y Garn. (E10352) [SH 318 897], (E11079) [SH 319 897]. Anal. not stated.

Two varieties in each case. But the specimens analysed are not those that have been sliced, and have not been seen by me.

III Dark oolitic ironstone. Llandyfrydog Mill. (Melin Esgob of six-inch map). Anal. not stated.

IV Brown gritty ironstone. Corner in lane, 700 yards south-south-west of Llanbabo Church. (E10338) [SH 378 862]. Anal. J. O. Hughes. Iron calculated as Fe_2O_3, but state of combination not determined.

The Zonal succession

The Stratigraphical succession is as follows:

	Zone	**Lithology of deposits**
Hartfell	Dicellokraptus anceps?	Barren green shales, conjecturally referred to these zones.
	Dicellokraptus complanatus?	
	Pleurograptus linearis	Not found.
	Dicranograptus clingani	Dark banded shale.
	Climacograptus wilsoni	Dark shale.
	Climacograptus peltifer	Do.
Glenkiln	Nemagraptus gracilis	Sooty-black mudstones and shales (underlain on the northern coast by nodular limestones, ironstone, cherty shales, and grits with conglomerate, purple at the base.
	Glyptograptus teretiusculus	Dark shale with some beds of grit.
Llanvirn	Didymograptus murchisoni	Oolitic ironstone usually near top. Black micaceous shale with thin sandy seams, and felspar-grits at Llangoed.
	Didymograptus bifidus	Blue-black micaceous shale with thin courses of grit.
Arenig	Didymograptus hirundo	Blue-black micaceous shale with thin courses of grit.
	Didymograptus extensus	Blue-black micaceous shale with thin courses of grit.
	Didymograptus extensus	Basal conglomerate and grit.

The zones are, in the text of this volume, grouped as in the above column. This grouping differs from that adopted in the Monograph on British Graptolites published by the Palmontographical Society merely in the adoption of the term 'Llanvirn' for the zones with graptolites of 'tuning-fork' type. In recent publications on South Wales, the Bala beds are extended so as to include the Dicranograptus Shales, and therefore the zone of *Nemagraptus gracilis.* In the present work, the Scottish terms 'Glenkiln' and Hartfell' will be employed instead of 'Llandeilo' and 'Bala'<ref>They are not, however, to be considered as necessarily synonymous with those terms.</ref>. Not only are the zones for those divisions clearly defined, but the Scottish Glenkiln and Hartfell facies (lithological as well as faunal) are undoubtedly present in Anglesey. It may be possible ere long to consider the graptolitic zones of Western Europe in connexion with the conditions of deposit of the several areas. Till that is done, it would be premature to impose any one grouping of the zones upon the European region as a whole.

Palaeontology

The faunas of the several zones are as follows<ref>The local fossil-lists will be found in Chapter 14. The Ordovician fossil-lists are founded on a series of some 1,300 specimens, about three-fourths of which were collected by Messrs. Macconochie and Muir, and the remainder by the author, with some that were obtained by Mr. J. O. Hughes. In addition to this series, the fossils collected by Dr. Callaway, Dr. Matley, and some other authors, and quoted in their papers, have been incorporated in the lists (some having been re-named). All the graptolites have been named by Miss Elles, the trilobites by Mr. Lake, the brachiopods by Dr. Matley, the phyllocarids by Dr. Peach, and a few other organisms by Dr. Ivor Thomas.</ref>:

Zone Of Didymograptus extensus

Dictyonema sp.

Dendrograptus sp.

Didymograptus deflexus *E.&W.*

Didymograptus extensus (*Hall*)

Didymograptus gibberulus *Nich*.

Didymograptus nicholsoni *Lapw*.

Didymograptus nitidus (*Hall*)

Didymograptus uniformis *E.&W.*

Tetragraptus amii *Lapw*.

Tetragraptus headi (*Hall*)

Tetragraptus serra *Brongn*.

Caryocaris wrighti *Salter*

Leptaena rhomboidalis (*Wilck.*)

Lingulella sp.

Orthis alata *J. de C. Sow.*

Orthis proava *Salter*

Orthis testudinaria *Dalm*.

Orthis vespertilio *J. de C. Sow.*

Parastrophia aemula *(Dav.)*

Rafinesquina llandeiloensis (*Dav*.)

Hyolithid

Aeglina binodosa *Salter*

Ampyx donatus (*Ang*.)

Asaphus sp.

Calymene parvifrons *Salter*

Calymene tristani *Brongn*.

Ogygia selwyni *Salter*

The beds with *Tetragraptus headi* occur far below shales that contain the Extensus fauna (see pp. 442, 445). The trilobites are found lower still, and may be taken as characteristic of the zone, excepting *Aeglina binodosa.* Of the discovery of *Calymene tristani,* made in the year 1906, Mr. Lake wrote at the time: The occurrence of this species in Anglesey is of exceptional interest. It is a French and Spanish form, and hitherto has only been found in Britain in the Budleigh Salterton pebbles and in the Gorran Haven Beds'. It will be observed that *Orthis proava* is found on the lowest horizons yet known in the Island. For a discussion of the nomenclature of this fossil see the article by Dr. Matley quoted in the Bibliography (1911). It is the. form long known in Anglesey fossil-lists as *O. carausii*or *O. calligramma*. The unusual richness of the zone in trilobites and brachiopods is due to the development of fossiliferous grit along the base.

Zone of Didymograptus hirundo

Favosites fibrosus (*Goldf.*)

Palaeocyclus sp.

Petraia sp.

Dictyonema sp.

Didymograptus hirundo *Salter*

Didymograptus nitidus (*Hall*)

Diplograptus (Glyptogr.) dentatus (*Brongn.*)

Orthis proava *Salter*

Aeglina binodosa *Salter*

Trinucleus gibbsi *Salter*

Zone of Didymograptus bifidus

Azygograptus sp.

Climacograptus scharenbergi *Lapw.*

Cryptograptus antennarius (*Hall*)

Dendrograptus sp.

Dicellograptus moffatensis (*Carr.*)

Dichograptus sp.

Didymograptus affinis *Nich.*

Didymograptus artus *E.&W.*

Didymograptus acutidens *E.&W.*

Didymograptus bifidus (*Hall*)

Didymograptus deflexus *E.&W.*

Didymograptus geminus (*His.*)

Didymograptus gracilis *Törnq*.

Didymograptus hirundo *Salter*

Didymograptus nanus *Lapw.*

Didymograptus nicholsoni *Lapw*.

Didymograptus patulus (*Hall*)

Didymograptus stabilis *E.&W.*

Diplograptus (Glyptogr.) appendiculatus *Elles*

Diplograptus (Orthogr.) calcaratus *Lapw.,* var. priscus *E.&W.*

Diplograptus (Amplexogr.) confertus *Lapw.*

Diplograptus (Glyptogr.) dentatus (*Brongn.*)

Glossograptus acanthus *E.&W*.

Glossograptus armatus *Nich.*

Lasiograptus mucronatus (*Brongn.*), var. inutilis *Hall*

Phyllograptus angustifolius *Hall*

Phyllograptus *cf.* typus *Hall*

Signagraptus?

Trichograptus sp.

Acrotreta sp.

Lingula brevis *Poril.*

Orthis proava *Salter*

Paterula balcletchiensis (*Day.*)

Aeglina major *Salt.*

Placoparia sp.

Trinucleus sp.

Caryocaris sp.

Zone of Didymograptus murchisoni

Cryptograptus tricornis (*Carr.*)

Didymograptus amplus *E.&W.*

Didymograptus euodus *Lapw.*

Didymograptus geminus (*His.*)

Didymograptus murchisoni (*Beck*)

Diplograptus (Orthogr.) calcaratus *Lapw.*

Diplograptus (Amplexogr.) coelatus *Lapw.*

Diplograptus (Glyptogr.) dentatus (*Brongn.*)

Diplograptus (Glyptogr.) teretiusculus (*His.*)

Acrotreta nicholsoni *Dav*.

Lingula granulata *Phill.*

Orthis proava *Salter*

Orthis testudinaria *Dalm.*

Paterula balcletchiensis (*Day.*)

Aeglina sp.

Placoparia sp.

Trinucleus gibbsi *Salter*

Zone of Glyptograptus teretiusculus

Climacograptus antiquus *Lapw.*

Climacograptus scharenbergi *Lapw.*

Cryptograptus tricornis (*Carr.*), *var.* schäferi *Lapw.*

Didymograptus indentus (*Hall*)

Diplograptus (Amplexogr.) perexcavatus *Lapw.*

Diplograptus (Glyptogr.) teretiusculus (*His.*)

Diplograptus (Mesogr.) foliaceus (*March.*)

Lingula sp. nov.

Paterula balcletchiensis (*Day.*)

Caryocaris sp.

Zone of Nemagraptus gracilis

Those forms which have only been found in the northern and southern districts respectively are marked N. and S.

Sponge-spicules, N.

Favosites fibrosus (*Goldf.*), N.

Monticulipora sp., N.

Prasopora grayae *Nich. & R. Eth., jun.,* N.

Solenopora compacta *Bill., N.*

Callograptus sp., N.

Climacograptus antiquus *Lapw.*

Climacograptus bicornis (*Hall*)

Climacograptus brevis E.&W.

Climacograptus scharenbergi *Lapw.*

Cryptograptus tricornis (*Carr.*)

Cryptograptus tricornis *var.*

Cryptograptus schäferi *Lapw.,* S.

Dendrograptus sp., N.

Desmograptus sp., N.

Dicellograptus divaricatus S.

Dicellograptus intortus *Lapw.*

Dicellograptus patulosus *Lapw.*

Dicellograptussextans (*Hall*)

Dicellograptus var. exilis *E.&.W.,* S.

Dicranograptus brevicaulis *E. cf; W.,* S.

Dicranograptus nicholsoni *Hopk.*

Dicranograptus ramosus (*Hall*)

Dicranograptus rectus

Didymograptus superstes *Lapw.*

Diplograptus (Orthogr.) calcaratus *Lapw.,* S.

Diplograptus (Orthogr.) calcaratus *Lapw.,* S., *var.* acutus *E.&W., S.*

Diplograptus (Mesogr.) multi-dens E.&W.*, var.* compactus *E.&W., S.*

Diplograptus (Glyptogr.) teretiusculus (*His.*)

Diplograptus (Glyptogr.) teretiusculus (*His.*)*, var.* euglyphus *Lapw.*

Glossograptus armatus *Nich.,* S.

Lasiograptus mucronatus (*Hall*)*, var.* bimucronatus (*Nich.*)

Nemagraptus explanatus (Lapw.), var. pertenuis *Lapw.,* S.

Nemagraptus gracilis

Petalograptus? phylloides *E.&W.*, N.

Ptilograptus sp., N.

Acrotreta sp., N.

Leptaena rhomboidalis (*Witch.*), N.

Lingula brevis *Portl., N.*

Lingula ovata *McCoy,* N.

Lingula tenuigranulata *McCoy,* N.

Lingula ap. nov., S.

Orbiculoidea elongata (*Portl.*), S.

Orbiculoidea perrugata (*McCoy*), *N.*

Orthis confinis *Salter, N.*

Orthis proava *Salter, N.*

Orthis testudinaria *Dalm., N.*

Orthis vespertilio *J. de C. Sow.,* N.

Paterula balcletchiensis (*Day.*)

Rafinesquina sp., N.

Rhynchonella sp., N.

Siphonotreta sp., N.

cf. Ctenodonta, N.

Strophomena imbrex *Day.,* N.

Maclurea logani *Salter,* N.

Maclurea matutina *Hall,* N.

Calymene sp., N.

Chasmops sp., N.

Illaenus caecus *Holm., N.*

As in the case of the Extensus zone, the richness of this in forms other than graptolites is due to the development of fossiliferous grits upon a local base. The forms of the higher sub-zone of *Climacograptus peltifer,* though recognised in the Island, can hardly be separated from that of *Nemagraptus gracilis.* The corals are from the limestone of Porth Padrig, Mynachdy. It will be seen that there are important differences between the northern and southern faunas of the zone. They are discussed in Chapter 18.

Zone of Climacograptus wilsoni

Climacograptus wilsoni *Lapw.*

Zone of Dicranograptus clingani

Climacograptus bicornis (*Hall*)

Climacograptus caudatus *Lapw.*

Climacograptus minimus (*Carr.*)

Climacograptus scharenbergi *Lapw.*

Dicellograptus morrisi *Hopk.*

Dicranograptus ramosus *Hall*

Diplograptus (Orthogr.) calcaratus *Lapw., var.* basilicus *E.&W.*

Diplograptus (Orthogr.) truncatus (*Lapw.*)

Diplograptus (Orthogr.) vulgatus *E.&W.*

Leptograptus sp.

Lingula sp. nov.

The graptolite fauna,:therefore, includes 25 genera and 82 species and sub-species.<ref>Including that of the Silurian rocks, the total graptolite fauna of Anglesey comprises 28 genera and 123 species and sub-species.</ref> The persistence of the brachiopods, particularly of *Orthis proava,* which is found all the way from the zone of *Didymograptus extensus* to that of *Nemagraptus gracilis,* is in strong contrast to the zonal restriction of the graptolites and trilobites.

Upper Hartfell Beds

With the zone of *Dicran. clingani* the faunal succession of the Ordovician comes to an end, so far as is' at present known, in Anglesey, Miss Elles remarks that on the adjacent mainland, at Conway, the graptolitic fauna comes to an end at that same horizon, a change in the lithology also setting in. At Conway, though the upper parts of the pale mudstones that succeed have yielded many trilobites, the lower parts are barren. In Scotland, the *Dicran. clingani* shales are succeeded by a few feet of black shale of the zone of *Pleurograptus linearis,* and those by pale greenish mudstones with one or two 'thin seams of shale. These are the 'Barren Mudstones', but their shale-seams have yielded graptolites of the zones of *Dicellograptus complanatus* and *Dicell. anceps.*

Now, on the northern slopes of Parys Mountain, rising, so far as can be made out, from beneath the lowest zone of the Llandovery, are certain barren green shales of a type that has not been seen on any other horizon of the Ordovician succession in the Island; and Mr. Macconochie considered that, allowing for the effects of cleavage, they bore a decided resemblance to the 'Scottish Barren Mudstones'. In this view Dr. Horne, who visited the ground, is inclined to concur. Dr. Peach, to whom he showed a specimen, thought 'it might well pass for a type between the normal zone in the Moffat area, and the Lowther shales which represent that zone in the Leadhills region'. They are certainly in the position where the upper part of the Hartfell series might be expected to rise. The same green shales are found again on Mynydd Eilian, lying some way above beds that are just at the passage from the Glenkiln to the Hartfell series. True green shales are not found at Conway, but the trilobite mudstones of that district have dull green tracts and films, and might easily, by deformation, have been converted into rocks like some dull-green beds at the base and top of the Parys northern shales. Yet their trilobites could hardly have been so totally obliterated. Parys Mountain is about 100 miles from the Moffat area of Scotland, and Conway is 23 miles away in a direction at right angles to the Parys-Moffat line. The Lower Hartfell shales of Anglesey are of the same type as those of Moffat. The Parys green shale resembles, admittedly, the Scottish Barren Mudstones. It is possible that a change in the conditions of sedimentation may have taken place four times as rapidly in an east-south-east as in a north-north-east direction, so that, the correlation here suggested is not as improbable as at first appears. More than this it does not seem possible to say until Upper Hartfell fossils are obtained in Anglesey.

Zonal types of shale

In the course of the fossil-collecting, Messrs. Macconochie and Muir found that certain slight lithological differences between the shales of the different graptolitic zones were very constant, so much so that after a while they were often able to assign specimens of shale to their correct horizons by these characters alone. They drew up a series of notes on the subject (summarised below), aided by which the author re-examined a number of the best sections in the field. The differences are subtle, but of the six leading types it may be possible to convey some idea.

Arenig and Lower Llanvirn. In all three zones the prevalent shale is 'blue-black' and not very fine. It is plentifully spangled with small flakes of mica, which lie at considerable angles to the bedding, thus imparting a peculiar unevenness to the lustre, and also preventing the shale from being very fissile. The shale of Rhosneigr contains iron soluble in HNO_3, as well as an appreciable amount soluble in dilute hot HC1, and sulphides (doubtless pyrite). (J. O. Hughes.)

Zone of Didymograptus murchisoni. These are somewhat smoother, and rather darker, 'black, slabby, some layers being slightly calcareous'. (A. Macconochie.)

Zone of Glyptograptus teretiusculus. These are of lighter tint, and still more flaggy.

Zone of Nemagraptus gracilis. These are different from all the others, being dead-black or sooty, 'soiling the finger' a little on fresh fracture, and very 'rusty' down the joints. They are also far less fissile, and sometimes might be described as mudstones. The cherty shales of the north are paler, and somewhat sandy.

The Lower Hartfell shales are not so dark, and do not soil the fingers, but are blacker and smoother than those of the Arenig. They weather to an orange tint.

The Barren Shales of Parys Mountain and Mynydd Eilian are rather fine and smooth, pale, and differing from all the rest in having a distinctly greenish tinge. The colour is due to chlorite (apparently pennine), with some delessite, partly disseminated in thin flakes that lie along the cleavage, but occurring also as veinlets, in which they develop crowds of imperfect spherulites. These chlorites are of relatively recent date, for the veinlets cut the cleavage, though usually at a low angle.

Thin gritty seams are found on all the horizons, so there is nowhere any great thickness of pure pelitic sediment.

The Oolitic Ironstone, where it has yielded fossils, is on or near the zone of *Glyptograptus teretiusculus,* and is, elsewhere, just below the sooty, but above the cherty shales of the zone of *Nemagraptus gracilis*. At Llangoed it seems to lie near to that of *Didymograptus murchisoni.*

The graptolite sub-faunas of Anglesey

By Miss G. L. Elles, Sc.D.

The graptolitic facies of the Lower Palaeozoic rocks is well represented in Anglesey, and is closely comparable with that found upon the mainland of North Wales, though in some cases the lithological type of the rocks containing it is somewhat different. Both in Anglesey and on the mainland this facies ceases in the Ordovician with the zone of *Dicranograptus clingani,* and is resumed again after an interval, in Lower Llandovery times with the characteristic fauna of the *Mesograilus modestus* flags.

The following zones appear to be represented:

Silurian	Llandovery	Zone of *Monograptus sedgwicki*
		Zone of *Monograptus convolutus*
		Zone of *Monograptus gregarius*
		Zone of *Mesograptus modestus*
Ordovician	Hartfell	Zone of *Dicranograptus clingani*
		Zone of *Climacograptus wilsoni*
	Glenkiln	Zone of *Climacograptus peltifer*
		Zone of *Nemagraptus gracilis*
		Zone of *Glyptograptus teretiusculus*
	Llanvirn	Zone of *Didymograptus murchisoni*
		Zone of *Didymograptus bifidus*
	Arenig	Zone of *Didymograptus hirundo*
		Zone of *Didymograptus extensus*

In the zone of *Did. extensus* the fauna consists, at Bodynolwyn and Chwaen-hen, merely of the zone fossil and a *Didymograptus* allied to *Did. deflexus E.&W.* which is known to occur in the zone on the mainland of North Wales where the fauna is richer. Beds to the south-east of Treiorwerth contain abundant fragments of a large Dichograptid, which is probably *Tetragraptus headi* (Hall). Near Llanerchymedd is one of the bands with Dendrograptids that are characteristic of certain horizons in the zone, and *Did. gibberulus* Nich. has been found at Llangoed.

The zone of *Did. hirundo* is represented near Llanerchymedd by beds containing both *Did. hirundo* Salt. and *Did. nitidus* (Hall). The fauna of these Arenig Beds agrees sufficiently well with that of the beds found on the mainland on the shores of the Menai Strait, the River Seiont, and in the Lleyn Peninsula (Nant-y-gadwen)<ref>*Geol. Mag.,* 1904, p. 199.</ref>, for there to be no doubt as to their horizon, though as a whole the mainland fauna is a far richer one; this is, however, probably accounted for by the nature of the exposures. The Llanvirn zones have a far more extensive distribution both on the Island and mainland, though the latter have not as yet been mapped in detail.

Beds with a somewhat mixed fauna which must belong approximately to the junction of the Arenig and Llanvirn occur near Fferam-uchaf and again south-west of Llandyfrydog Church; and beds with a peculiar fauna at present unknown elsewhere in North Wales<ref>Dr. Matley kindly permits us to add that, since this was written, he obtained the same fauna at Aberdnron in the Lleyn and submitted the graptolites to Miss Elles. He hopes before long to publish his results.</ref> have been discovered in the old 'Chapel' shaft at the west end of Parys Mountain; the peculiar feature of these beds is the occurrence of numerous *Phyllograpti* (chiefly *Phyll. angustifolius* Hall); other forms, however, such as *Did. acutidens* E.&W. and *Glypt. dentatus* (Brongn.) are found, which belong to the zone of *Did. bifidus* elsewhere, and it is probable both from the position of the beds, and the nature of the fauna, that these beds belong to the lowest portion of the zone of *Did. bifidus* or to beds immediately underlying that zone. The best exposures of the zone of *Did. bifidus* are those round about Llanerchymedd, where an absolutely typical faunal assemblage is found, viz..:

Didymograptus bifidus (*Hall*)

Didymograptus artus *E.&W.*

Didymograptus nanus *Lapw*.

Didymograptus cf. nicholsoni *Lapw*.

Didymograptus acutidens E.&W.

Glossograptus acanthus E.&W.

Glyptograptus dentatus (*Brongn*.)

Amplexograptus confertus (Lapw.)

Beds belonging to a precisely similar horizon have been found on the coast of Dulas Bay, at Ucheldref-uchaf, Llanrhyddlad, and at Rhosneigr; the upper portion of the zone is seen at Caergwrli near, Llanbabo, where the beds contain in addition both *Did.* cf. *patulus* (Hall), and *Did. stabilis E.&W.*, and a similar horizon seems to be indicated at one of the trial shafts at the west end of Parys Mountain, where *Dicellograptus moffatensis* (Carr.) comes in as an important fossil.

The passage beds *below* and *above* the zone of *Did. bifidus* have not as yet been detected upon the mainland<ref>But see preceding footnote.</ref>, but as both the lower and higher zones are also graptolitic there is little reason to doubt their existence: it would seem that they merely require to be worked out. The succeeding zone of *Did. murchisoni* is also well seen in the Island, and in a boring at Llangoed yields beautifully preserved graptolites. The beds belonging to this zone as seen at Bryn-celyn, Llangoed, contain an assemblage of forms typical of this horizon wherever it occurs in the British Isles. They have yielded the usual abundance of the zone fossil itself *Did. murchisoni* (Beck) associated with the common variety *geminus* (His.) and the somewhat less common species *Did. amplus* E.&W.; very similar in character is the fauna found near Llanbabo Church and at Dulas Bay, though at this latter locality *Did. murchisoni* alone predominates, as it does also at both the Llanbabo localities, and at Llangoed.

The succeeding Glenkiln beds are not well known upon the mainland of North Wales as yet, though shales belonging to this horizon are sometimes intercalated in the great Ordovician volcanic series, as at. Conway (*Quart. Journ. Geol. Soc.*, lxv, p. 176), but in many places it is likely that they are represented by volcanic rocks. The beds intervene between the welt-known zones of *Did. murchisoni* and *Nem. gracilis,* and in Central Wales are commonly rich in Diplograptidae, of which *Glypt. teretiusculus* (His.) is, as a rule, the most abundant and characteristic form; they may therefore be referred to the zone of *Glypt. teretiusculus.* These lower beds are found at Gorlan-goch near Mynydd-y-garn. The typical assemblage appears to be:

Glyptograptus teretiusculus (*His.*)

Hallograptus mucronatus (*Hall*)

Cryptograptus tricornis, (Carr.) *var.* schäferi *Lapw.*

Amplexograptus perexcavatus (*Lapw.*)

Didymograptus indentus (*Hall*)

The higher horizon, the zone of *Nem. gracilis,* with its rich and varied fauna has long been known from the cliff south of Llanbadrig Church. where the assemblage is as follows:

Nemagraptus gracilis (*Hall*) (rare)

Dicellograptus sextans (*Hall*)

Dicellograptus intortus *Lapw.*

Climacograptus schärenbergi *Lapw.*

Climacograptus antiquus *Lapw.*

Climacograptus bicornis (*Hall*)

Glyptograptus euglyphus (*Lapw.*)

Hallograptus bimucronatus (*Hall*)

The comparative rarity of *Nem,. gracilis,* absence of *Did. superstes,* and abundant Diplograptidae seem to indicate that these beds are fairly high up in the zone, and a more characteristic fauna of the zone as a whole is to be found at the Lane south-south-west of Llanbabo Church, where the following graptolites are found in some abundance:

Nemagraptus gracilis (*Hall*)

Didymograptus superstes *Lapw.*

Dicellograptus sextans (*Hall*)

Dicranograptus nicholsoni *Hopk.*

Glyptograptus euglyphus (*Lapw.*)

Climacograptus scharenbergi *Lapw.*

Climacograptus antiquus *Lapw.*

Climacograptus bicornis (*Hall*)

Cryptograptus tricornis (*Carr.*)

Orthograptus calcaratus (*Lapw.*), var. acutus *E.&W.*

A very similar fauna occurs at Fferarn-uchaf, Llanbabo, and there can be little doubt that the beds there seen are of the same age, as are also those in the cliff south of Llanbadrig Church.

Somewhat higher beds containing *Dicran. rectus* (Hopk.) are seen in the cliffs at Careg-onen, and an horizon, which must be approximately that of the zone of *Cl. peltifer,* is represented by the beds seen between Bryn-goleu and Capel-côch Windmill and on the shore at Porth-y-gwichiaid. Beds on the mainland corresponding in a general way to the two higher Glenkiln zones of Anglesey are found at Tyddyndicwm, near Tremadoc, and have been recently described by Fearnsides (*Quart. Journ. Geol. Soc., vol.* lxvi, p. 170), and the lowest beds of the Cadnant shales, seen in Conway railway cutting, are probably comparable with the highest zone (*Quart. Journ. Geol. Soc.,* lxv, p. 180).

In Anglesey, as on the mainland, only the Lower Hartfell is graptolitic; the beds near Llanbabo Church, with their peculiar forms resembling *Cl. wilsoni* Lapw., probably represent the basal zone of *Cl. wilsoni,* and there can be no doubt that the rocks just south of Llanbabo Church have yielded a fauna typical of the zone of *Dicran. clingani,* and far richer than that as yet described from the mainland. These beds have yielded —

Dicellograptus morrisi *Hopk.*

Orthograptus calcaratus (*Lapw.*), basilicus (*E.&W.*)

Climacograptus caudatus *Lapw.*

Climacograptus minimus (*Carr.*)

Climacograptus bicornis (*Hall*)

This locality is the only one known where these beds are now to he seen in the Island, though both upper and lower horizons are represented in the higher beds of the Cadnant shales of the Conway district, and are well exposed in the railway cutting near Conway Station.

All the Llandovery zones would appear (see Chapter 15) to be represented in the shales of Parys Mountain, though it is only by close scrutiny of the fauna that this becomes apparent. With the exception of those mentioned at the end of this paragraph, all the fossils have been obtained from the spoil-banks of certain shafts and tunnels. Such forms, however, as *Dimorphograptus, Cl. medius Törnq*., M. *typhus* Lapw., *Mesogr. modestus* Lapw. seem to indicate the Modestus flags of the Conway district and other areas, while *M. revolutus* Kurck, *M. jaculum* Lapw., *M. gregarius* Lapw., *Mesogr. magnus* (H. Lapw.), *Glypt. sinuatus* (Nich.), and *Petalogr. minor* Elles, seem to indicate the horizon of the zone of *M. gregarius,* also known at Conway with a similar fauna. The zone of *M. convolutus* has been detected by Mr. Griffith J. Williams, yielding *M. convolutus* (His.), *M. limatulus* Törnq., *M. regularis* Törnq., *M. involutus* Lapw., *M. leptotheca* Lapw., *M. clingani* (Carr.), *Cephalogr. cometa* (Gein.) and other forms (Williams, *Geol. Mag.,* 1907, p. 149); and the highest zone of *M. sedgwicki* has also been detected and has yielded *M. sedgwicki* (Portl.), *M. tennis* (Portl.), *Glypt. serratus,* var. *barbatus* E.&W., and *Cl. scalaris* (His.), a perfectly typical assemblage. Both these zones show a richer fauna than beds of the corresponding horizon on the mainland, at least so far as the Conway district is concerned. There is some indication of the presence of slightly higher beds, but the fossils are poorly preserved, and the evidence at present is not very conclusive.

General view of the Ordovician rocks <ref>The local fossil-lists will be found in Chapter 14; most of the sections in that chapter and in (Folding-Plate 9), (Folding-Plate 10), (Folding-Plate 11).</ref>

1 The Menai Fragments

These, though small, are of great zonal importance. The base, with a massive grit, rises at Garth Ferry. Between the Bridges (though on the mainland shore), shale of the zone of *Did. extensus* emerges from beneath Carboniferous rocks. The fauna, which includes two species of *Tetragraptus,* is the fullest that has been found in that zone in North Wales. The contents of the glacial drifts also shows' that the zones of *Did. hirundo* and *Did. bifidus* must outcrop along the floor of the Strait in a northeasterly direction.

2. The Llangoed area

The base is not seen along the western margin, and is cut out also at Careg-onen on the coast (Figure 194), but appears at the little outlier of Landdona, where the basal grit is absent. On the eastern side of the district the Ordovician rocks pass, with a strong unconformity, beneath the Carboniferous Limestone. The zones of *Did. extensus, Did. murchisoni, Glypt. teretiusculus,* and *Nem. gracilis* can be recognised. That of *Did. murchisoni* is finely developed, and so is the pisolitic ironstone. Higher zones are evidently coming ore to the east, but exposures are too scattered for the structure to be made out.

3. The strips along the Berw Faults

The base appears to emerge at Bwlch-gwyn, and further southwest, massive greywackes ((Figure 302), Chapter 24) rise from below shale of Arenig type. The only zonerecognised is that of *Did. hirundo,* but there is room beneath it for that of *Did. extensus.* Most of the long strip is composed of shale of Arenig type, feebly cleaved. Those at Pentraeth and

Llanddona are known almost entirely from the evidence of drift and features. In the latter, the zone of *Nem. gracilis* appears to be developed.

The strips that rest against the Aethwy Region of the Mona Complex are evidently part of the south-eastern limb of a major syncline whose north-western limb is buried under the Carboniferous rocks. The others must be ruptured subsidiary infolds taken in between the Pentraeth Inliers.

4. The Llangwyllog area

This tract (Figure 201) is bounded almost entirely by faults that are oblique to the axes of the folds, but the base, with a white grit, emerges for short distances on the western side. The zones recognised are those of *Did. bifidus, Nem. gracilis,* and *Cl. peltifer,* those below being cut out by faulting, and as almost the whole area consists of shales, only parts of which have been searched with care, the intermediate zones will doubtless be found. There are four infolds of the zone of *Nem. gracilis,* from beneath one of which the oolitic ironstone rises. In the most northerly inf old the Peltifer shales are found. Bedding is obscure, but from a persistent, though feeble, vertical cleavage, it appears that the axes of the folds are at high angles.

5. The Principal Area

The whole of the complete succession given on page 408 is found in this area. The structure (Folding-Plate 11) is that of a great oval and isoclinal syncline whose major axis ranges north-east and southwest. But it is distorted by junction with a narrower one whose axis is nearly at right angles, the wing, that is, which runs out to Carmel Head (p. 420). The base of the system emerges along the greater part of the south-eastern and western margins, but the northern boundary is one of the most powerful overthrusts known in Southern Britain, which will be called the Carmel Head Thrust-plane.<ref>Evidence as to the reality, the nature, and the magnitude of this thrust will be found in Chapter 18, but must be anticipated in this and the succeeding chapter.</ref> The major syncline is full of innumerable isoclinal undulations, 18 of which are of sufficient amplitude to bring up the underlying floor: and conversely, there are at least 10 infolds (Figure 207), (Figure 208), (Figure 209), (Figure 210), (Figure 211), of amplitude great enough to bring in the higher zones, those above that of *Didymograptus bifidus.* That of Parys Mountain (Figure 207), (Figure 208), (Figure 209), (Figure 210), (Figure 211), (Figure 212), (Figure 213), (Figure 214), brings in even Silurian beds. A remarkable feature is the enormous development of the basement conglomerate towards the south-west. From about 350 feet near Llanerchymedd, it increases until in the Tywyn Trewan it cannot be less than 2,500 feet and is probably 3,000 feet in thickness, and the whole of this great psephitic deposit is on or below the zone of *Didymograptus extensus.* In the south-westerrr wing that zone only is known. In the tracts about Llanerchymedd, where the base keeps on emerging, the zone of *Did. hirundo* comes in, but still no higher one. To the north and east of this are wide tracts of the zone of *Didymograptus bifidus.* They are surmounted by Murchisoni shales in the broad tract between the Nebo and Deri anticlines, and about Rhosgoch. Glenkiln shales, with the oolitic ironstone, and with *Nemagraptus gracilis,* are taken in along tracts on either side of Cors y Bol (which is an obscure anticline), and at Llandyfrydog Mill. The *Nemagraptus* beds are beautifully seen at the three infolds of Llanbabo (Figure 207), (Figure 208), (Figure 209), (Figure 210), (Figure 211), where the zonal succession is displayed in an unusually small space. Their proximity to the Western margin must be due to a rupture close to the base, and the infolds must be very deep and steep, as the Extensus beds rise again immediately to their north. In two of the infolds of Llanbabo the Lower Hartfell zones of *Cl. wilsoni* and *Dicran. clingani* are also taken in. The barren green shales referred to the Upper Hartfell appear on the northern slopes of Parys Mountain, on a limb of the deepest of all the infolds, that which takes in the Silurian beds. Instead, however, of a steady pitch thither from the infolds of Llanbabo, shales with *Phyllograptus* intervene, appearing just to the west of the Parys escarpments. This anomaly can only be explained by rupture of the Parys infold along thrusts in advance of the Carmel Head Thrust-plane. Here also the termination of the Principal Area is complicated by the uprise of the large Nebo and Corwas anticlines, which compel the Carmel Head Thrust-plane to leave the Principal for the Mynydd Eilian Area. The major syncline thus contains five deep depressions — that of Tywyn Trewan containing the great conglomerate, one about Llandyfrydog Mill, one on either side of Cors y Bol, and one at Parys Mountain. Between them rise the group of small anticlines about Llanerchymedd, and a large one at the Deri, with shallower ones in Cors y Bol and to the north of Llanbabo. Cleavage is feeble or absent across the broad middle of the syncline.

6. Mynydd-y-Garn to Carmel Head

This tract, really a wing of the Principal Area, consists of several deep infolds (Folding-Plate 10), between which the Mona Complex rises, but bounded for the most part by slips and overthrusts, the whole being cut off to the north-east by the Carmel Head thrust-plane. The base emerges, however, upon the Garn Inlier (Folding-Plate 9), where a massive conglomerate, full of pebbles of the Mona Complex, rests upon and oversteps three zones of that Complex. Very few fossils have been obtained, but extensiform graptolites are present in shales that are some distance above the conglomerate, so that there is no reason to assign the base to any higher horizon than that of the zone of *Did. extensus,* which it occupies only four miles away to the south-east. No fossils of any kind have been found beyond the Garn, but the existence of interrupted borders of conglomerate along the margins of the Mona Complex, shows that the base keeps on rising, and that zones higher than that of *Did. bifidus* are not likely to be found in these infolds of barren shales, which are, indeed, of persistently Arenig type. Just at the beginning of the district, however, an infold of the zone of *Glypt. teretiusculus,* with the ironstone, has been preserved by being let down against the Garn fault. The effects of earth-movement are very great. Cleavage (doubtless the cause of their barrenness) becomes more and more powerful in the shales, until at Carmel Head a second cleavage is developed. At the summit of the Garn it obscures the junction of the Gwna mélange with the conglomerate. The schists of the Garn Inlier are driven southward over the Arenig shales along a powerful thrust (Folding-Plate 9), that may be called the Garn Thrust-plane.

7. Mynydd Eilian

This district, nearly but not quite isolated at the narrow nip of Pensarn, must be regarded as a pair of deep synclinal infolds (Figure 216) parted by an anticline that rises round the end of the Corwas Inlier of the Mona Complex. It lies between the Carmel Head thrust-plane and the great Gwichiaid slip, and alt its boundaries are planes of rupture. The zones that have been identified are:one high in the Arenig or low in the Llanvirn (probably that of *Did. bifidus*), that of *Glypt. teretiusculus,* and one on the junction of the Glenkiln and Hartfell group. Some little way above these, there is grey-green shale of the type that is conjecturally correlated with the Barren Mudstones of Scotland. Shale of Arenig type appears in places, especially towards the south. A coarse conglomerate rises between ruptures at Porth-y-corwgl and Fresh Water Bay, and as Arenig Beds are present, this is doubtless on the same horizon as the basement conglomerates five miles away, no such deposit being known on any of the higher zones except upon the northern coast. But at a small outlier near Llys Dulas the basal grit is absent. Bedding is rarely to be seen, cleavage powerful and sometimes double, and the whole district is full of minor thrusts.

8. The Northern Wedges

These are a series of much-ruptured infolds along the northern coast, in Gynfor, Pant-y-gaseg, and Mynachdy (Figure 217), (Figure 218), (Figure 219), (Figure 220), (Figure 221), (Figure 222), (Figure 223), (Figure 224), Black shales and ironstone with a rich fauna of the upper part of the zone of *Nemagraptus gracilis* rest upon spiculiferous cherts and cherty shales with a fauna of the base of that zone, and these upon pale and purple conglomerates. The conglomerates rest upon, and contain pebbles of the Mona Complex, often with an apparent conformity, but with a strong discordance at Ogo Gynfor (Plate 29), (Figure 220), (Figure 221),. Here therefore, the base of the Ordovician system is little, if at all, below the zone of *Nem. gracilis.* The zone displays remarkable differences of facies, both lithological and faunal, from those of its developments in all the other parts of the Island. In particular, the cherts, the cherty shales, and the purple conglomerate, are known only in these wedges. The faunal differences will be apparent on reference to the list given on pp. 410–11. These differences of facies are reviewed and discussed in Chapter 18.

The Northern Overlap

From the foregoing sketches it will have been seen that, as we proceed northwards from the Strait, the zone of *Did. extensus,* with its basement conglomerate below, can be recognised as far as the edge of the Northern Region of the Mona Complex — (the line that we have called the Carmel Head thrust-plane); and that wherever the zone has not been definitely proven, either there is room for it, or it is cut out by faulting. The detailed evidence will be found in Chapter 14, but we may briefly summarise it here. The zone is well developed along the Menai Strait, and can be traced round the

Llangoed Area to Llanddona. In the strips along the Berw faults there is abundance of room for it below shales with *Did. hirundo.* In the Llangwyllog Area the shales that rest upon the basal grit are cut out by faulting. On Mynydd Eilian the Lower Llanvirn is unaccompanied by conglomerate, which appears only by itself on thrust and slipped anticlines where the Arenig shales are cut out. At Mynydd-y-garn there is plenty of room for the Extensus and Hirundo zones below shales which have yielded extensiform graptolites. In the Principal Area, the Extensus zone, with basal conglomerate below, is still well developed at Llanbabo, less than a mile from the Carmel Head thrust-plane; while at Gwaen-ydog, just at the thrust, where pebbly grits are rising, the shales are still of the 'Extensus' type.

Between the Menai Strait and the Northern Region of the Mona Complex, therefore, theie is no sign of overlap, the base of the Ordovician system remaining in the zone of *Did. extensus.*

Along the northern coast, where the Ordovician reappears beyond the Northern Region of the Complex, a basement conglomerate is again found resting upon that Complex (Plate 29), (Figure 220), (Figure 220),(Figure 220), but the shales that rest on this conglomerate are no longer those of the Extensus zone. They are little, if at all, below the zone of *Nem. gracilis.* All the five lower zones of the system have therefore been overlapped.

Between Gwaen-ydog and Cemaes this elimination of the five lower zones is effected in three miles and a half. At Mynachdy it is effected in 200 yards! This overlap, and especially the astonishing suddenness with which it appears to come on, is of the first importance in all the older geology of Anglesey. Its significance (which we have already been obliged to assume in Chapters 7, 8 and elsewhere) will be discussed in Chapter 18.

Thickness of the series

In Anglesey itself it is not possible, owing to the folding, to obtain measurements of thickness for all the zones. But minimum estimates may be obtained by aid of the adjacent portions of the mainland, in which the same general conditions of sedimentation prevailed.<ref>Evidence for the Anglesey measurements wilt be found in Chapter 14. Those at Conway have been made from the published figures by Miss Elles. At Carnarvon, the boundaries of the zones were transferred from her drawing to a six-inch map, on which dips were recorded at short intervals. *Quart. Journ. Geol. Soc.,* 1909, p. 177; *Geol. Mag.,* 1904, p. 201.</ref> Let us consider the zones in order downward. At Conway the Bala mudstones attain to about 430 feet, and the green shales of Parys Mountain are likely to be a good deal thicker. <ref>The local fossil-lists will be found in Chapter 14; most of the sections in that chapter and in (Folding-Plate 9), (Folding-Plate 10), (Folding-Plate 11).</ref> The beds between the base of the zone of *Cl. wilsoni* and that of *Cl. peltifer* appear to measure at Conway about 500 feet. On the north coast of Anglesey, where the top of the zone of *Nem. gracilis* is not reached, it is about 200 feet, excluding the conglomerates. The zones of *Nem. gracilis* and *Cl. peltifer,* therefore, may safely be taken to be not less than 500 feet. In the Llangoed boring the zone of *Glypt. teretiusculus,* its top not seen, was passed through for 90; and that of *Did. murchisoni,* its bottom not reached, for 110 feet. The dip was very low, so that the thicknesses of the zones cannot have been less than these depths, and may be considerably more. The best section across the three lower zones is along the river at Carnarvon. There is but little disturbance in the shales, and measurements from dip are not likely to be exaggerated. Moreover, the top of the Bifidus, and the base of the Extensus zones are not seen. About 600 feet of Bifidus, 690 feet of Hirundo, and 500 feet of Extensus shales crop out in this river.

But the 500 feet of the Extensus shales are no measure of the duration of that episode. In the Tywyn Trewan the Arenig conglomerate gives the astonishing measurement, where it is dipping north-east, of 3,000 feet (p. 440). Measurements near Treior worth p. 442) where it is dipping north-west, give, from the base at the Ty-hen Inlier, 2,600 feet; and (assuming a corresponding emergence, or nearly so, of the base along the strike) at Ffynnon-y-inab 2,700 feet. As north-easterly and north-westerly dips agree in yielding these high figures, the great thickness indicated would not seem to be an illusion due to repetition. The average of these measurements is 2,766 feet. If 266 feet be deducted as a precaution, then the conglomerate in this district may be taken at 2,500 feet.

The results may be tabulated thus, the second column being modified according to the lesser estimate of the conglomerate that has been suggested above:

Feet

Hartfell — Trilobite mudstones of Conway	430	
Hartfell Zone of Dicran. clingani	30	
Hartfell Zone of Cl. wilsoni	120	
Glenkiln Zone of Nem. gracilis, &c.	500	
Glenkiln Zone of Glypt. teretiusculus	90	
Llanvirn Zone of Did. murchisoni	110	
Llanvirn Zone of Did. bifidus	600	
Arenig Zone of Did. hirundo	690	
Arenig Zone of Did. extensus	500	
Total of the fine deposits	3,070	3,070
Arenig Basement Conglomerate	3,000	2,500
Total Ordovician	6,070	5,570

These figures, however, must not all be regarded as estimates for Anglesey itself. They must be taken as the nearest approximations at present possible to the thicknesses prevalent in the region of which Anglesey forms a part.

The composition of the Sub-Ordovician floor

The Sub-Ordovician floor, wherever visible, is composed (save at the eight little outliers described in Chapter 12) of the rocks of the Mona Complex. The evidence of unconformity (which is conclusive), with the transgressions of the base from horizon to horizon of the Complex, have been given on pp. 243–4. But the distribution of those members with reference to the Ordovician base has interesting bearings upon the relations of the system to the older systems, and of those to one another. Also, as the un-conformity is usually less conspicuous in the field than might have been expected from its great magnitude, it will be useful to bring together the sections at which the base is actually exposed, giving in each case the graptolitic zone, and the member of the Complex upon which it can be seen to rest. Local details of both subjects will be found in Chapter 14.

Taking first the zone of *Didymograptus extensus,* we find it laid bare at Garth Ferry and at Llanddona, resting upon Gwna Green-schist; and again at Penmynydd, resting upon Penmynydd mica-schist. At Bwlch-gwyn it rests against an old quartz-felsite (see p. 398) intrusive in that schist; the schist being in both these cases ascribed to the horizon of the Fydlyn Beds. At the Bodwrog outlier it still rests upon Penmynydd rocks, but in this case of Gwna horizon. At Bodenog it reposes upon the Coedana granite, at Bachau upon the hornfels aureole of that intrusion. At Bryn-gwallen its floor is of gneiss. At the three exposures on the Foel Inlier, that floor is of mica-schist and quartz-schist ascribed to the Gwna Beds; at the Deri Inlier,-of schistose hornfels. At the Nebo Inlier it is of gneiss.

In the Northern Wedges: the base of the zone of *Nemagraptus gracilis* is seen to rest, along Pant-y-gaseg ridge, sometimes on the Gwna grits and phyllites, sometimes on the Gwna quartzite. At Graig-wen, Hell's Mouth, and Llanlliana Head, upon the quartzite. At Ogo Gynfor, where there are three exposures, the floor is composed of thin Gwna quartzites with phyllitic partings.

Thus the base of the system is laid bare in 21 sections. At Ogo Gynfor (Plate 29), (Figure 220), (Figure 221), the Ordovician and the Mona Complex dip in opposite directions, and the discordance is conspicuous, but unfortunately this fine crag is not easy of access. At the Nebo Inlier there is considerable angular divergence, but the section is very shallow. At most of the other sections the two systems happen to dip in the same general direction, and the discordance of dip rarely exceeds 10° or 20°. Thus, an unconformity of the first magnitude is rendered inconspicuous in the field by a series of tectonical coincidences.

We have already seen that the Sub-Ordovician floor is a complicated mosaic, made up of a number of different members of the Mona Complex. But it is possible to proceed a little further, and to form an estimate of the proportions in which the several members enter into that mosaic.

The Mona Complex and the Ordovician come together, upon the surface, along a total of about 130 miles of boundary. Of this line, some 17 miles are powerful rupture. Along the remaining 113 miles, either the base is unruptured, or the ruptures are not too great to cut out the lower zones, leaving us able, by one means or another, to ascertain upon what members of the Complex the base is resting. Now, out of these 113 miles, there are 100 along which it is resting upon either the Gneisses, the Fydlyn Beds, the Gwna Beds, or upon Penmynydd-Zone schists representing one or other of the two latter. Along 13 miles it must be resting on either the Church Bay Tuffs or the New Harbour Beds (though never upon the Skerries Grits). As to the Holyhead Quartzite and the South Stack Series, not only does it never rest upon either of them, but they never even come near to it.<ref>Nor has a single pebble of them been found in an Ordovician conglomerate. This, however, might be due to the westerly drift.</ref> That is to say, that along 87/100 of its outcrop, the Ordovician base rests upon the older members of the Complex. More than this; from the Mona tectonics and from the contents of Ordovician conglomerates (see Chapters 8 and 14) it has been possible to ascertain the nature of nearly the whole of the floor that is concealed beneath the Ordovician deposits, except in the eastern parts of the Llangoed Area, which is of no great extent. There is no doubt that some nine-tenths or ten-elevenths of it must be composed of the same four older divisions of the Complex.

Thus we see that all but an insignificant proportion of the Sub-Ordovician floor is composed of those members that lie below either one or both of the stratigraphical breaks within the Complex, while the Holyhead Quartzite and the South Stack Series do not enter into its composition at all. The reason for this will be seen by referring to pages 235–6, and (Figure 100), (Figure 101). It is that, owing to the effect of the pitch upon the tectonic horizons and primary thrust-planes, those two members are unable to emerge except in the extreme west, but are buried, eastwards, beneath a vast mass of more ancient rocks. As these tectonics are all Pre-Ordovician, and as the base of the Ordovician is itself rising westward at more than double the angle of the pitch in the underlying rocks, there can be little doubt that the said two members of the Complex were completely buried, throughout the whole extent of Anglesey, in Ordovician times, and were inaccessible to Ordovician denudation.

Now, had the Holyhead Quartzite and the South Stack Series belonged to the Olenellus zone, we should have expected the composition of the Sub-Ordovician floor to have been the precise reverse of this. We should have expected the Cambrian (however attenuated by Ordovician erosion) to have skirted the outcrops of the Ordovician, parting them from the remainder of the Complex. Such is the disposition of that system on the mainland, where it skirts the Ordovician base' for many miles. Such is the disposition even of the little fragments of the Baron Hill and Careg-onen rocks. Moreover, that Cambrian rocks should, in Ordovician times, have been buried beneath vast Pre-Cambrian masses (large parts of which are far less metamorphosed than themselves) is quite incredible. But, though the reader was referred by a footnote on p. 253, to the present discussion, it seems really superfluous to add anything to the evidences as to the stratigraphical unity of the Bedded Succession, and as to the Pre-Cambrian age of the whole Complex (as a tectonic unit) that are given in Chapters 6–9.

We are therefore to picture the Sub-Ordovician floor as composed, for more than nine-tenths of its area, of the Gneisses, the Fydlyn Beds, the Gwna Beds, and the Penmynydd Zone. Some narrow bands of Tyfry Beds must have entered into it about the Malldraeth, and a small tract of New Harbour Beds and Church Bay Tuffs emerged upon it in the West. The space occupied by the Baron Hill and Careg-onen rocks was negligible. No Cambrian has been discovered in the Island, even as pebbles in the conglomerates. If that system form a part of the Sub-Ordovician floor at all, it must be in the heart of the concealed areas, and even there only to a trifling extent. The Gneisses must have occupied more than one-sixth of the surface, for not only do they underlie most of the Principal Ordovician Area, but there is reason (see p. 464) to suspect that considerable tracts of them are over-ridden by the Carmel Head thrust-plane.

With regard to the tectonic horizons present in the floor, we have seen that the higher ones must have been swept away by the Cambrian erosion, and it now appears. that both limbs of the Rhoscolyn and one of the Holyhead Recumbent Fold must have been buried. So the Ordovician rocks must repose almost entirely upon the Nappes of Holyhead and Bodorgan. We have also to remember that the Mona Complex had not, in Ordovician times, been re-folded, or driven together by the Carmel Head and other powerful thrust-planes, which have added greatly to its already great inherent complication.

Combining all these circumstances, we can discern that the Sub-Ordovician floor differed from the present surface of the Mona Complex first in that it contained much more extensive tracts of the Gneisses; and secondly in that it had not been super-complicated by the Paleozoic movements; also that it included fewer stratigraphical horizons, while the tectonic horizons were reduced to little more than two. Altogether, it was geologically a good deal simpler than the surface that we see to-day.

Physiography

The conglomerate at the base of the Arenig Beds varies remarkably in thickness. Particulars will be found in Chapter 14, but the following is a summary of the measurements obtained:

	Feet
Tywyn Trewan	3,000
Treiorwerth	2,700
Bod-Deiniol	1,000
Bron-heulog<ref>Calculated on the assumption that the rate of thinning from the Tywyn Trewan to Bed-Deiniol continues as far as this, of which there is little doubt.</ref>, Llanfaetblu	400
Prys-owen, Llanerchymedd	350
Berw	320
Mynydd-y-garn	250
Llangwyllog Area	180
Deri Inlier	160
Foel	90
Nebo	30
Garth Ferry	20
Coast of the Nebo hiller	0
Pen-yr-allt, Llanddona <ref>The conglomerate seems also to be absent at the Dragon, Penmynydd, but the section needs to be re-examined, in case a rupture has been overlooked.</ref>	0

The conglomerate usually becomes finer as it thins, being no more than a massive grit at Nebo and Garth Ferry, whereas in the Tywyn Trewan it contains the 'giant' boulder-beds with blocks four feet in diatheter. It must have been laid down upon an uneven surface, and a study of its variations will throw some light upon the features of that surface.

Now, everywhere to the south of the Carmel Head thrust-plane the conglomerate is overlain by the shales of the zone of *Didymograptus extensus,* with which it has not been found to interdigitate to any serious extent, so that the base of those shales may be taken as a datum-plane, from which the depths of the ancient hollows filled with conglomerate can be estimated. If, then, we take the difference between the thicknesses found at any two points, and divide it by the number of miles of distance between those points, we shall obtain the average inclination, in feet per mile, of the ancient surface. The following table of rates of thinning and of rise of slope gives the first results:-

Tywyn Trewan to Bôd-Deiniol	N.N.E.	285 feet per mile
Tywyn Trewan Prys-owen	N.E.	371 feet per mile
Tywyn Trewan Llangwyllog	E.	400 feet per mile
Tywyn Trewan Berw	E.S.E.	260 feet per mile
Llaufaethlu to Mynydd-y-garn	N.W.	60 feet per mile
Prys-owen to Coast of Nebo lnlier	N.E.	43 feet per mile
Llangwyllog to Llanddona.	E.	20 feet per mile
Berw to Garth Ferry	E.N.E.	43 feet per mile
Berw to Llanddona	N.E.	36 feet per mile
Garth Ferry to Llanddona	N.	8 feet per mile

But these figures cannot all be made use of as they stand. In the cases where the measurement is across the strike the horizontal distance has been materially reduced by the Post-Silurian folding and thrusting. From sections such as (Folding-Plate 11), (Figure 201), and others, it would seem that the present distances are to the Ordovician distances as about 1 to 1.75 or 1.5. In the distance from Llanfaethlu to Mynydd-y-garn we have to allow for the over-drive along the Garn thrust-plane, which there is reason to think is as much as a mile or two. In such cases, therefore, the inclinations obtained have been too steep. Making the reductions indicated, we obtain the following results for the slopes as they were at the dawn of Ordovician time:

Llanfaethlu to the Tywyn Trewan, a fall of 285 ft. per mile
Prys-owen to the Tywyn Trewan, a fall of 371 ft. per mile
Llangwyllog to the Tywyn Trewan, a fall of 266 ft. per mile
Berw to the Tywyn Trewan, a fall of 180 ft. per mile
Mynydd-y-garn to Llanfaethlu, a fall of 40 ft. per mile
Coast of Nebo Ifilier to Prys-owen, a fall of 35 ft. per mile
Llanddona to Llangwyllog, a fall of 15 ft. per mile
Garth Ferry to Berw, a fall of 35 ft. per mile
Llanddona to Berw<ref>If (see p. 435) the conglomerate be absent at Penmynydd, then there would be no fall thither from Llanddona, and the fall from Penmynydd to Berw would steepen to 80.</ref>, a fall of 32 ft. per mile
Llanddona to Garth Ferry, a fall of 6 ft. per mile

The first fact that emerges is that (except the trifling one from Llanddona to Garth Ferry) all the slopes converge towards the Tywyn Trewan. The next is, that if we draw a curve through Llanfaethlu, Llanbabo, Llanerchymedd, Llangwyllog, and Berw; then, on the convex, outer, side of this curve, all the slopes are gentle; but that at the curve, they suddenly steepen<ref>It may be useful to note that the ancient slope from Llanerchymedd to the Tywyn Trewan must have been very nearly the same, both as to distance and angle, as that from the summit of the mountain called Elidyr-fawr to the pier at Garth Ferry.</ref> towards its concave, inner side, which contains the Tywyn Trewan.

This curve, therefore, would appear to mark out the brow of a vast Pre-Ordovician hollow, some 3,000 feet in depth, which may be conveniently referred to as the Trewan Cirque. The parts of it that are now accessible spread out (once more allowing for the folding) to a width of about 16 miles from north-west to southeast and ran for about ten miles eastwards into the land, so that it was somewhat cirque-like. To its north, east, and south we seem to discern a lofty, gently-sloping plateau, draining into the Trewan cirque, which itself drained westwards into the sea. Bounding the cirque was a curving mountain-rampart. In the course of the surveying it was noticed that the pebbles in the western conglomerates had a drift from east or north. This fact now finds an interesting explanation in the Arenig drainage of that region. And it is in the bottom of the ancient cirque that we find the gigantic boulder-beds.

When we obtain our first glimpse of this great valley, the sea was already creeping in, for the Arenig trilobites and brachiopods are found in its very lowest deposits. Somewhat afterwards, during a brief quiet interval, fragments of *Tetragraptus* from the sea outside were floated in. But by degrees, as the land went down, the great cirque was completely filled with its wastage, until all became submerged, and the shales with *Didymograptus extensus* were laid down both over the site of the buried valley and upon what had once been the surface of the high plateau.

The physiography thus revealed throws light on the relation between the Ordovician and the Cambrian systems. Had the overlap been a conformable one, Cambrian deposits might have been expected in such a place as this, but not even in the depths of the Trewan cirque is there the least sign of any but an Arenig fauna. Nor is there any sign of the Careg-onen rocks. Indeed, on the contrary, it is remarkable that the only district where they are known is about Llanddona, where the Arenig conglomerate has thinned out altogether, indicating that they were caught in sharp infolds which, not plunging very deeply, were destroyed where Arenig erosion was severe, and preserved only on the high land of that tune.

It is of importance to note, not only that the whole of the conglomerate is of Arenig age, but that the period of the submergence and infilling of this old physiography saw no appreciable faunal change, whereas that of the deposition of only some 500 feet of the overlying shale saw the change to the Hirundo fauna. The chronological value of the Exfensus zone must therefore be very great.

The disappearance of the basal conglomerate indicates that, with the submergence of the ancient high plat eau, land had passed out of sight all over the area. Nor does it ever come into sight again in the country to the south of the Carmel Head thrust-plane, where the sedimentation remains persistently thalassic for the rest of the Ordovician period. To the north of that line, however, land suddenly reappears, but on the horizon of the Glenkiln beds, all the five lower zones having been overlapped. It will be seen in Chapter 18 that there has undoubtedly been great crustal shortening, and that the land of that 'time must have been much farther away than at first sight appears. Probably it had been lying in that direction throughout Ordovician time, but beyond the area that is now accessible to us, the sea creeping gradually over it. Where we do catch a far northern glimpse; it is but a passing one, of a shallow land-locked hollow some two miles in length, soon filled in (as was the much older and much greater Trewan cirque) with conglomerate, and then over-swept by the steadily encroaching sea.

The relations of the Ordovician of Anglesey to that of the adjacent Mountain-land are as yet but imperfectly understood. But we now know that it is (above the quite exceptional and local conglomerate of the Trewan cirque) comparatively thin, thoroughly thalassic, and almost free from volcanic material, whereas that of the mountain-land is vastly thicker, is full of psammitic sediment, and contains enormous volcanic accumulations. The contrast is marked, but its physiographical interpretation cannot be attained until the graptolitic zones have been traced all along the mountain-land and linked up with those of the thalassic tracts of Anglesey.

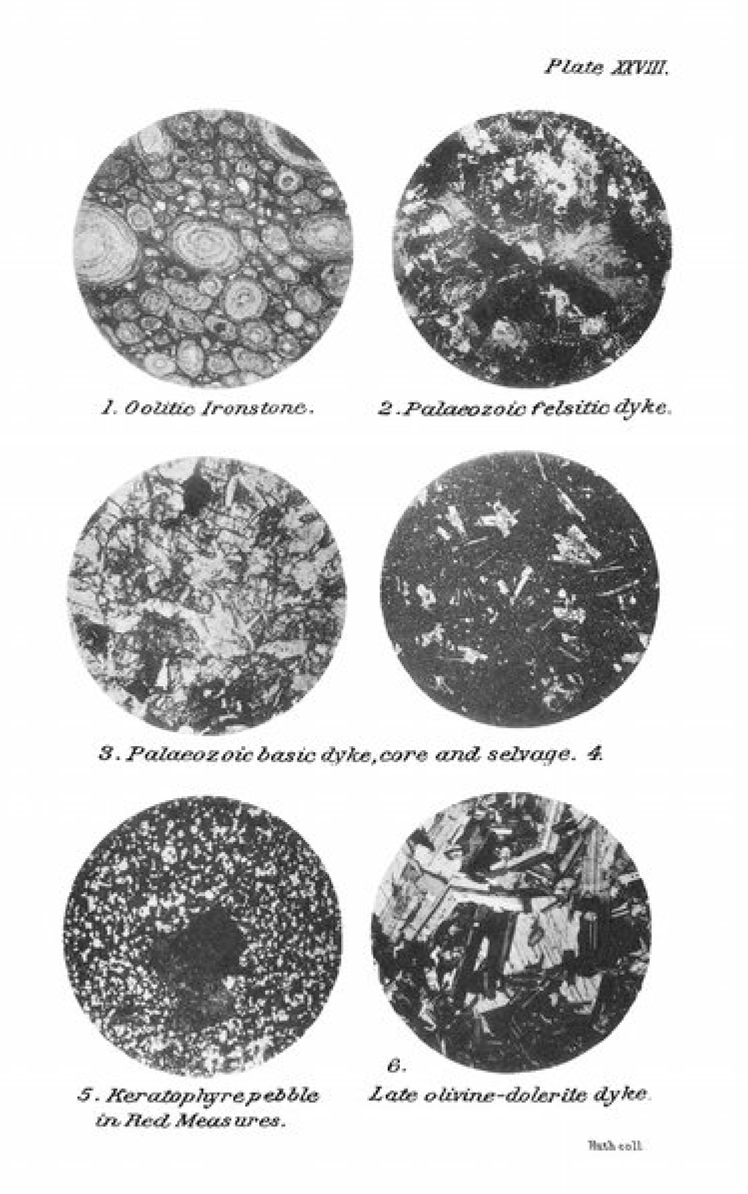
Conclusion

Reviewing the Ordovician rocks of Anglesey as a whole, it will first be remarked that the zonal succession is complete from the horizon of *Didyntograptas extensus* to that of *Dicranograptus clingani,* and that the remainder of the system appears to be represented by barren green shales. The horizons are defined by well-marked graptolite and trilobite faunas, accompanied by somewhat persistent types of brachiopoda.

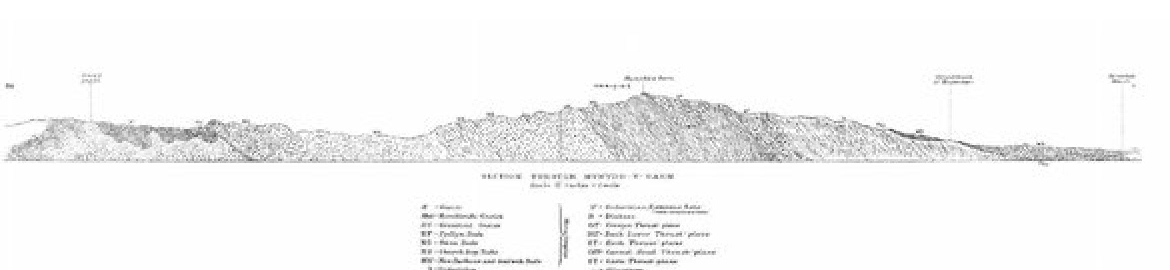
No sign of an overlap is found until the northern coast is reached, but in that district all the zones below the Upper Glenkiln have, almost suddenly, disappeared. Except in some small parts of the Llangoed Area the Sub-Ordovician floor seems to have consisted entirely of the ancient rocks of the Mona Complex. At the dawn of the Arenig period that old surface appears to have been a plateau some 3,000 feet in height, with great valleys cut down to sea-level. These were filled in and the plateau submerged, the sea creeping very slowly northward and eastward. With the submergence of the plateau, the region became, in contrast to the Ordovician of the present mountain land of Wales, thalassic, with attenuated sedimentation and freedom from vulcanicity.

The Ordovician rocks, as we now see them, are disposed in a series of synclinal infolds, between which the Mona Complex keeps on rising. The major synclines are multiplex, being full of innumerable minor folds, and repeatedly ruptured, their boundaries being in some cases thrust-planes of great magnitude. This folding was accompanied by the,production of a cleavage, not often, however, of much intensity.

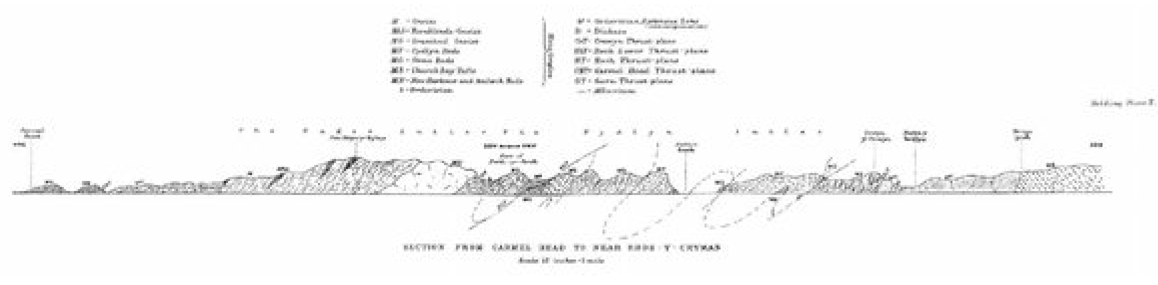
(Plate 27) Granitoid boulder from the Mona Complex in Arenig basement conglomerate. Tywyn Trewan.



(Plate 28) Microphotographs of rocks later than the Mona Complex. 1. Oolitic Ironstone. 2. Palaeozoic Felsite Dyke. 3, 4. Palaeozoic Basic Dyke. 5. Keratophyre Pebble in Red Measures. 6. Late Olivine-Dolerite Dyke. See Appendix 3.



(Folding-Plate 9) Section through Mynydd-y-garn. Scale 12 inches = 1 mile.



(Folding-Plate 10) Section from Carmel Head to near Rhos-y-Cryman. Scale 12 inches = 1 mile.

(Folding-Plate 11) Section across the Principal Ordovician Area from Llanol to Prys-Owen. Scale 8 inches = 1 mile.

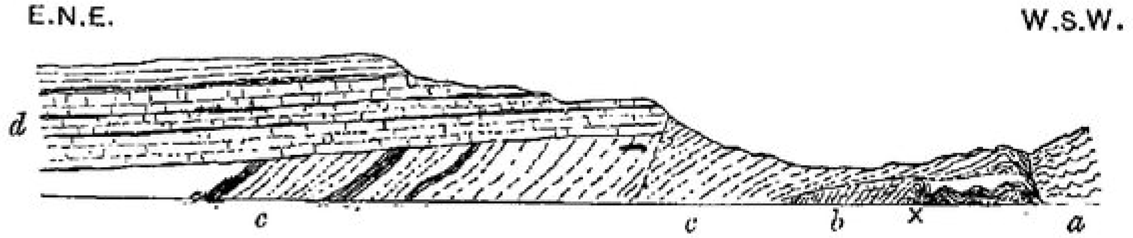


FIG. 194.—SECTION ALONG THE CLIFFS AT CAREG-ONEN.

Scale: One inch = 440 feet.

(Figure 194) Section along the cliffs at Careg-onen. Scale: one inch = 440 feet. Gwna Green-schist (a); Careg-onen Beds (b); Ordovician Shales (c); Carboniferous Limestone (d).

FIG. 302.—SECTION ACROSS THE ANGLESEY COALFIELD FROM LLEDWIGAN TO BERW.

Scale—Eight inches = one mile.

M = Penmynydd schists, MS = Tyfry beds } Mona Complex. b = Arenig grits. d_2 = Carboniferous Limestone. dp = Posidonomya cherts. d^4 = Millstone Grit. d^5 = Coal Measures. 1, 2, 3, 4, 5, 6, 7 = Coal Seams. d^6 = Red Measures.

(Figure 302) section across the Anglesey coalfield from Lledwigan to Berw. Scale eight inches = one mile. M = Penmynydd Schists, Mona Complex MS = Tyfry Beds Mona Complex d2■ = Carboniferous Limestone. dp = Posidonomya Cherts. d4 = Millstone Grit d5 = Coal Measures. 1, 2, 3, 4, 5, 6, 7 = Coal Seams. d6 = Red Measures.

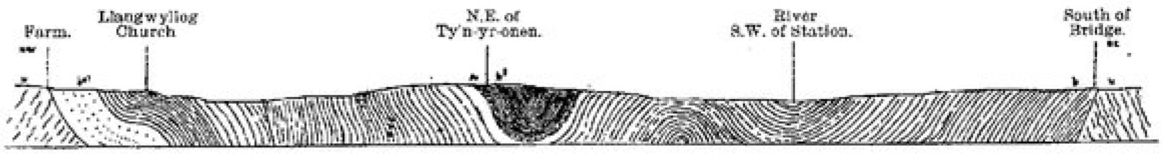


FIG. 201.—SECTION ACROSS THE ORDOVICIAN ROCKS OF LLANGWYLLOG.

Scale—8 inches = 1 mile.

M = Penmynydd (Mona) Schists. b = Ordovician (undifferentiated). be = Extensus Zone (with basal grit). Fe = Oolitic Ironstone. bg = Gracilis Zone.

(Figure 201) Section across the Ordovician rocks of Llangwyllog. Scale 8 inches = 1 mile. M = Penmynydd (Mona) Schists. b = Ordovician (Undifferentiated) be = Extensus Zone (With basal grit) Fe = Oolitic Ironstone. Bg = Gracilis Zone.

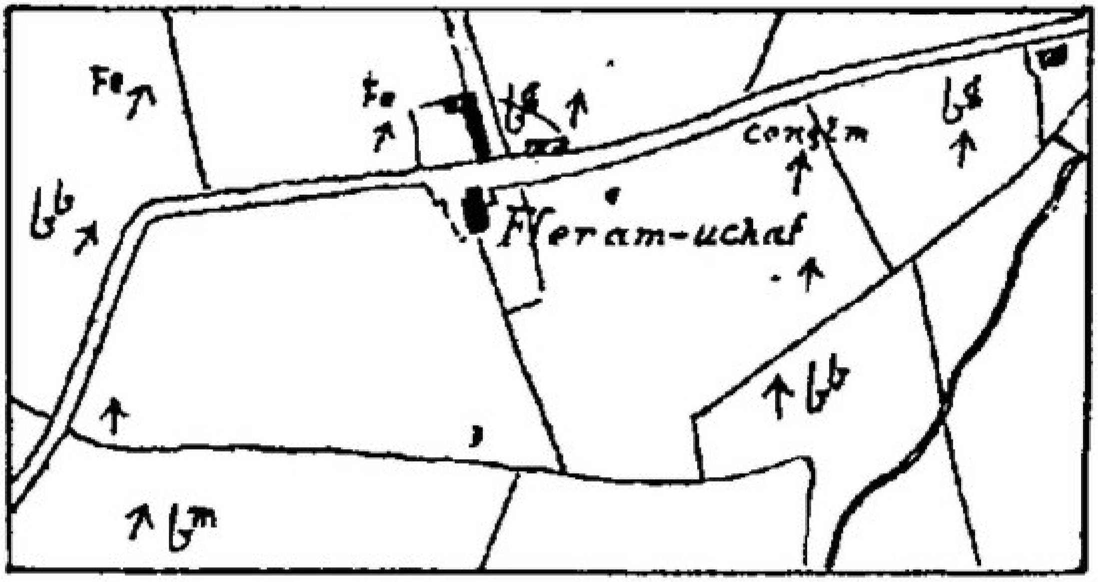


FIG. 207.—THE FFERAM INFOLD.

(Figure 207) The Fferam Infold. Six inches = one mile. Symbols as in (Figure 208) [MG = Gwna (Mona) Schists. Be = Zone Of Did. extensus (with basal conglomerate) Bb = Zone of Did. bifidus. bm = Zone of Did. murchisoni. Fe = Oolitic Ironstone. Bg = Zone Of Nem. gracilis.]

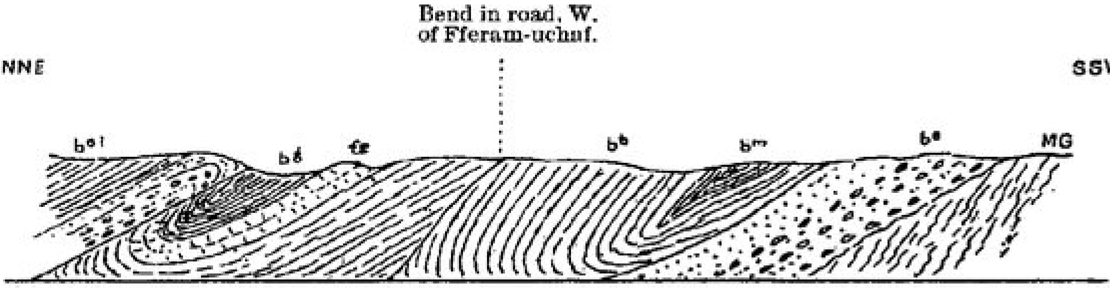


FIG. 208.—SECTION ACROSS THE FFERAM INFOLD, LLANBABO.

Scale—12 inches = one mile.

MG = Gwna (Mona) Schists. be = Zone of *Did. extensus* (with basal conglomerate).
bb = Zone of *Did. bifidus.* bm = Zone of *Did. murchisoni.* Fe = Oolitic Ironstone.
bg = Zone of *Nem. gracilis.*

(Figure 208) Section across the Fferam Infold, Llanbabo. Scale-12 inches = one mile. MG = Gwna (Mona) Schists. Be = Zone Of Did. extensus (with basal conglomerate) Bb = Zone of Did. bifidus. bm = Zone of Did. murchisoni. Fe = Oolitic Ironstone. Bg = Zone Of Nem. gracilis.

FIG. 209.—IRONSTONE AND GRACILIS SHALES AT THE LANE INFOLD.

(Figure 209).-Ironstone and Gracilis Shales at the Lane Infold.

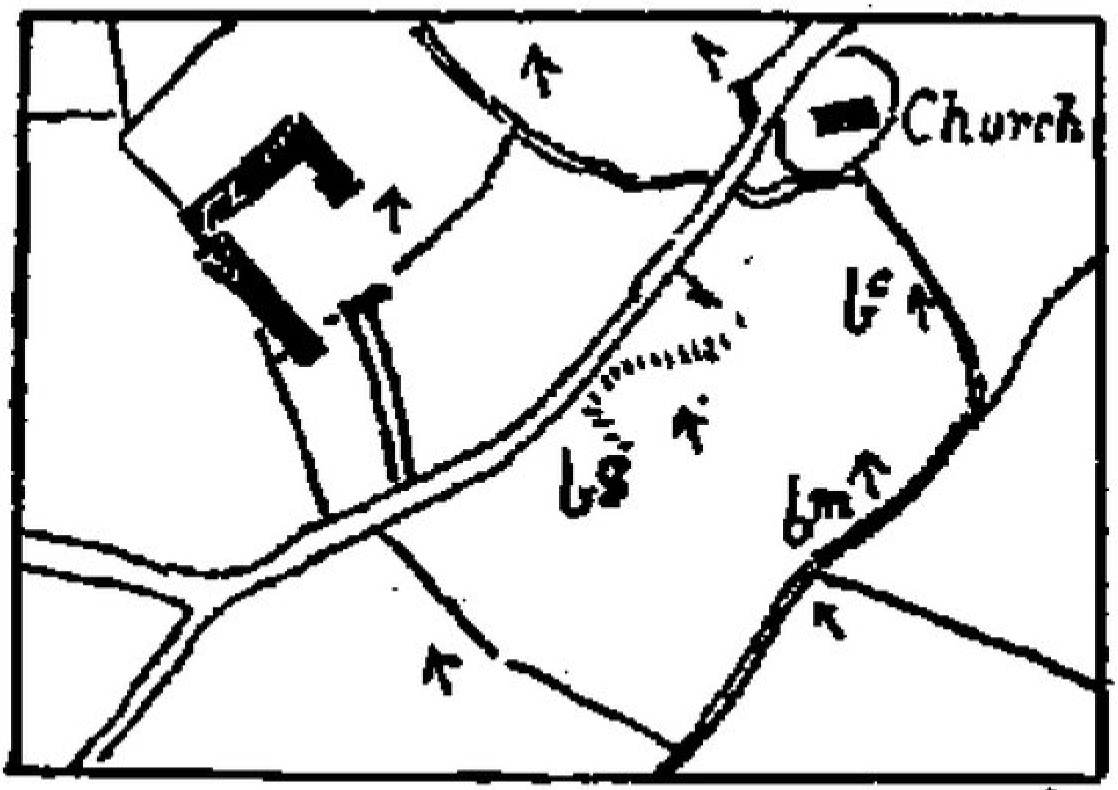


FIG. 210.—THE CHURCH INFOLD.

(Figure 210) The Church Infold. Six inches = 1 mile. Symbols as in (Figure 211) [Be = Zone of did. extensus (with conglomerate) bb = zone of Did. hirtindo. bb = Zone of Did. bifidus. bm = zone of Did. murchisoni. Bt = Zone of Glypt. teretiusculus. bg = Zone of Nem. gracilis. be = Zone of Dicran. clingani.]

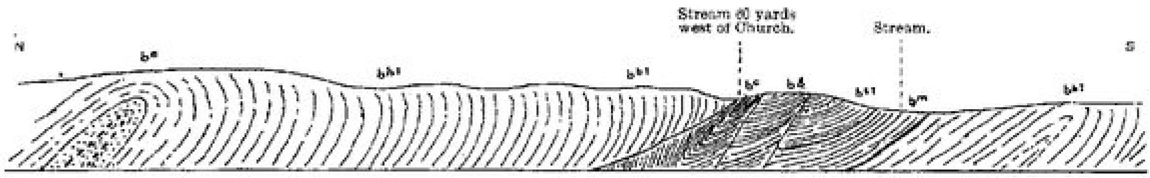


FIG. 211. SECTION ACROSS THE CHURCH INFOLD, LLANBABO.
Scale—12 inches = 1 mile.
b^e = Zone of *Did. extensus* (with conglomerate). b^h = Zone of *Did. hirundo.* b^b = Zone of *Did. bifidus.* b^m = Zone of *Did. murchisoni.* b^t = Zone of *Glypt. teretiusculus.* b^g = Zone of *Nem. gracilis.* b^c = Zone of *Dicran. clingani.*

(Figure 211) Section across the Church Infold, Llanbabo. Scale-12 inches = 1 mile. Be = Zone of did. extensus (with conglomerate) bb = zone of Did. hirtindo. bb = Zone of Did. bifidus. bm = zone of Did. murchisoni. Bt = Zone of Glypt. teretiusculus. bg = Zone of Nem. gracilis. be = Zone of Dicran. clingani.

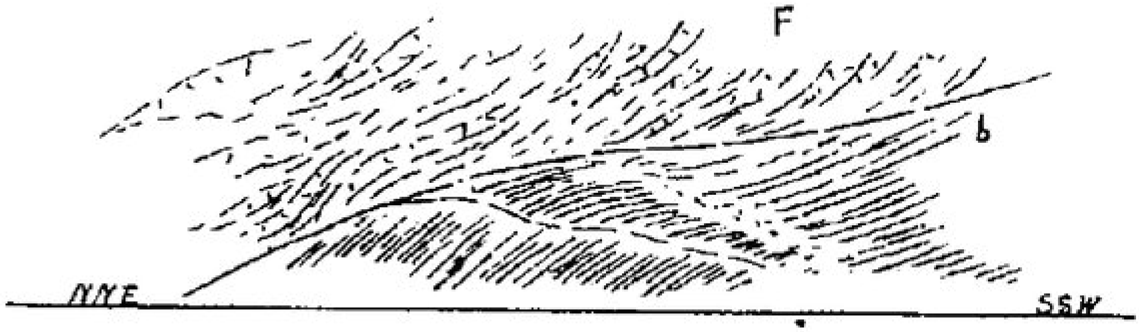


FIG. 212.—THE RHWNC THRUST-PLANE AT RHWNC.

(Figure 212) The Rhwnc Thrust-plane at Rhwnc. Height about 10 feet. F = Sheared felsite. b = Arenig shales.

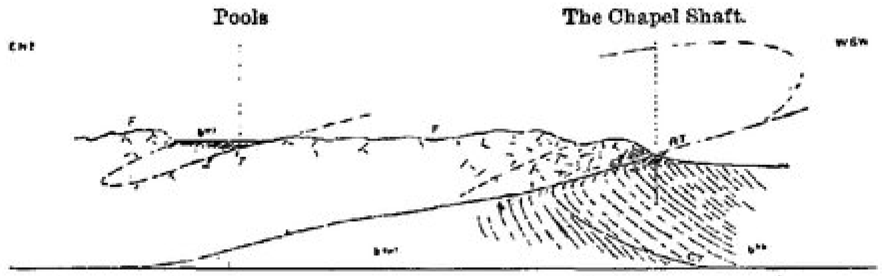


FIG. 213.—SECTION THROUGH THE WEST END OF PARYS MOUNTAIN.
Scale—eight inches = one mile.
bhb = *Phyllograptus* and adjacent Shales. bcp = Hartfell Shales. bv = Llandovery Shales.
F = Felsite. CT = Chapel Thrust-plane. RT = Rhwnc Thrust-plane.

(Figure 213) Section through the west end of Parys Mountain. Scale eight inches = one mile. bhb = Phyllograptus and adjacent Shales. bcp = Hartfell Shales. bv = Llandovery Shales F = Felsite. CT = Chapel Thrust-plane. RT = Rhwnc Thrust-plane.

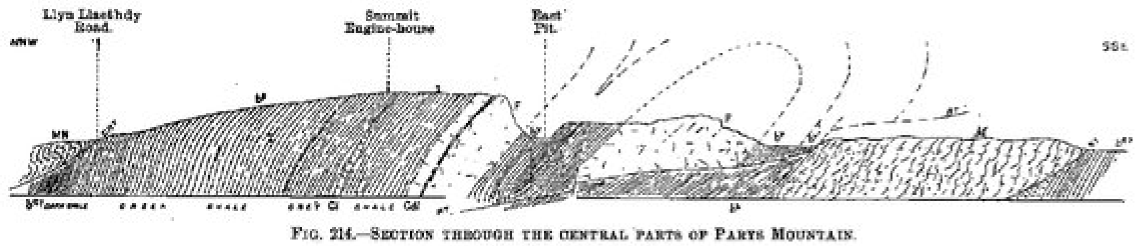


FIG. 214.—SECTION THROUGH THE CENTRAL PARTS OF PARYS MOUNTAIN.
Scale—7·5 inches = one mile.
MN = Amlwch Beds } Mona Complex. M = Gneiss. be = Zone of *Did. extensus*. bb = Zone of *Did. bifidus*. bc = Zone of *Dicran. clingani*. bp = Parys Green shales. bv = Llandovery shales. bv' = Tarannon shales. F = Felsite. Cl = Charlotte's lode (on strike of North Discovery lode). Cdl = Careg-y-doll lode. NT = Nebo Thrust-plane. RT = Rhwnc Thrust-plane. CHT = Carmel Head Thrust-plane.

(Figure 214) Section through the central parts of Parys Mountain. Scale 7.5 inches = one mile. MN = Amlwch Beds, Mona Complex, M=Gneiss, Mona Complex Be = Zone of Did. extensus. bb = Zone of Did. bifidus. bc = Zone of Dicran. clingani.. bp = Parys Green shales. bv = Llandovery Shales. bv■ = Tarannon shales. F = Felsite. Cl = Charlotte's Lode (on strike of north discovery lode) Cdl = Careg-y-doll lode. NT = Nebo Thrust-plane. RT = Rhwnc Thrust-plane. CHT = Carmel Head Thrust-plane.

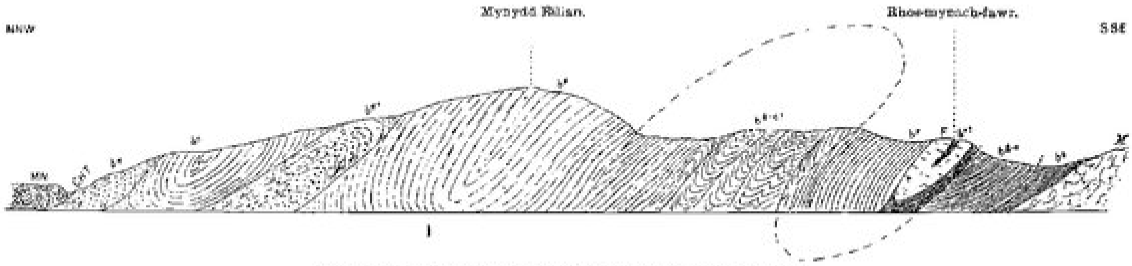


Fig. 216.—Generalised Section through Mynydd Eilian.

Scale—7·5 inches = one mile.

MN = Amlwch beds, M = Gneiss } Mona Complex. CHT = Carmel Head thrust-plane. be = Zone of Did. extensus (with conglomerate). bb = Zone of Did. bifidus. bt = Zone of Glypt. teretiusculus. F = Felsite. bg-c = Glenkiln-Hartfell Passage beds. bp = Parys Green shales. bv = Llandovery.

(Figure 216) Generalised section through Mynydd Eilian. Scale-7 5 inches = one mile. MN = Amlwch Beds, Mona Complex. M =Gneiss, Mona Complex. CHT = Carmel Head Thrust-plane. be = Zone of Did. extensus (with conglomerate) Bb = Zone of Did. bifidus. bt = Zone of Glypt. teretiusculus. F = Felsite, bg-c = Glenkiln-Hartfell Passage beds. bp = part's green shales. by = Llandovery.

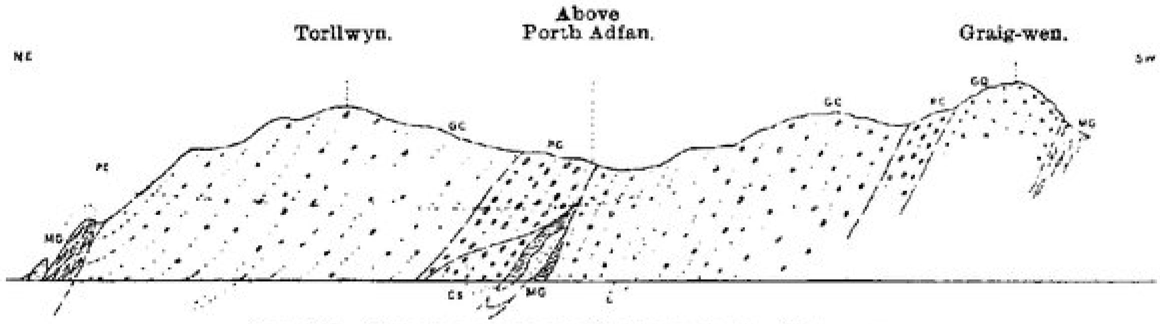


Fig. 217.—Section through Torllwyn and Graig-wen.

Scale—16 inches = one mile.

MG = Gwna grit and phyllite, GQ = Gwna quartzite } Mona Complex. CS = Cherty shales, GC = Grey conglomerate, PC = Purple conglomerate } Glenkiln.

(Figure 217) Section through Torllwyn and Graig-wen. Scale-16 inches = one mile. MG = Gwna grit and phyllite, Mona Complex. GQ Gwna quartzite, Mona Complex. CS = Cherty Shales. Glenkiln. GC = Grey conglomerate, Glenkiln. PC =Purple conglomerate, Glenkiln.

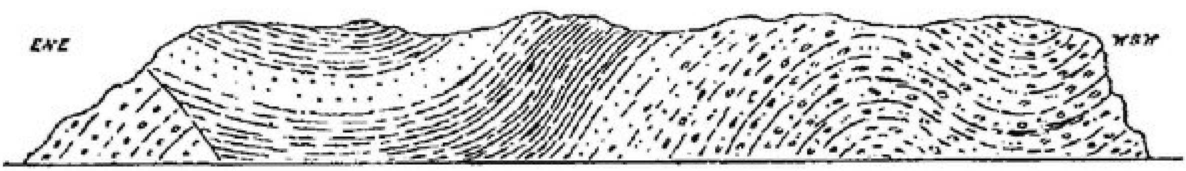


Fig. 218.—North-west Cliff of Llanlliana Head.

(Figure 218) North-west cliff of Llanlliana Head. Sketched from a boat. Height about 100 feet. Glenkiln conglomerate and cherty shales.

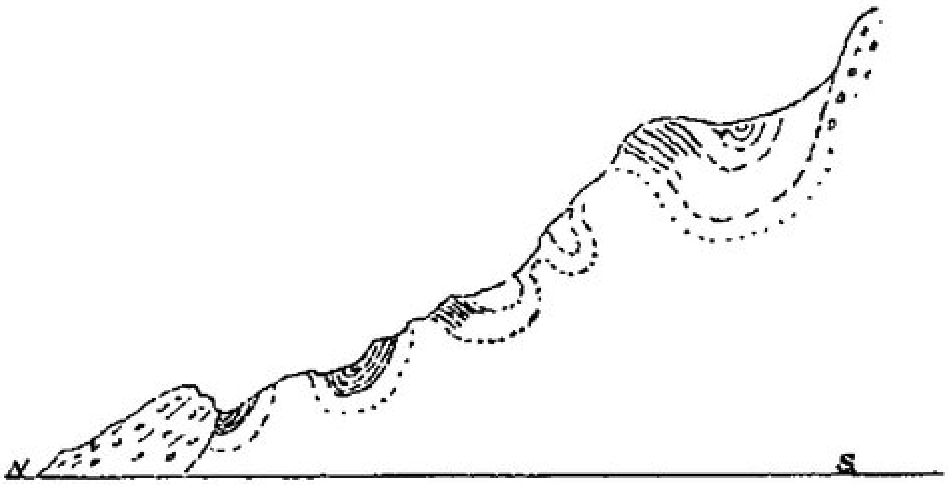


FIG. 219.—BLUFF ABOUT 200 FEET HIGH.

(Figure 219) Bluff about 200 feet high. About 200 yards east of Glochog. Glenkiln conglomerate and cherty shales.

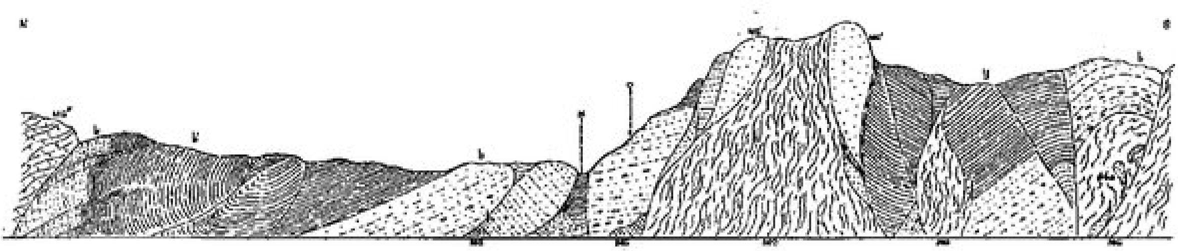


FIG. 220.—CLIFF SECTION AT OGOF GYNFOR.
Drawn from a boat, and brought to one plane. Scale about 65 feet = one inch.
MG = Gwna mélange. MG′ = Gwna quartzite. MG″ = Gwna limestone. b = Glenkiln conglomerate. b′ = Cherty shales.
Graptolites [Af. 3507–22] obtained from base of shales below X. Unconformable base (see Plate XXIX and Fig. 221) well seen at cliff's foot below O.

(Figure 220) Cliff section at Ogof Gynfor. Drawn from a boat, and brought to one plane. Scale about 65 feet = one inch. MG = Gwna mélange. MG■ = Gwna quartzite. Mg■ = Gwna limestone. b = Glenkiln conglomerate. b■ = cherty shales. Graptolites [a.f. 3507-22] obtained from base of shales below X. Unconformable base (see (Plate 29) and (Figure 221)) well seen at cliff's foot below O.

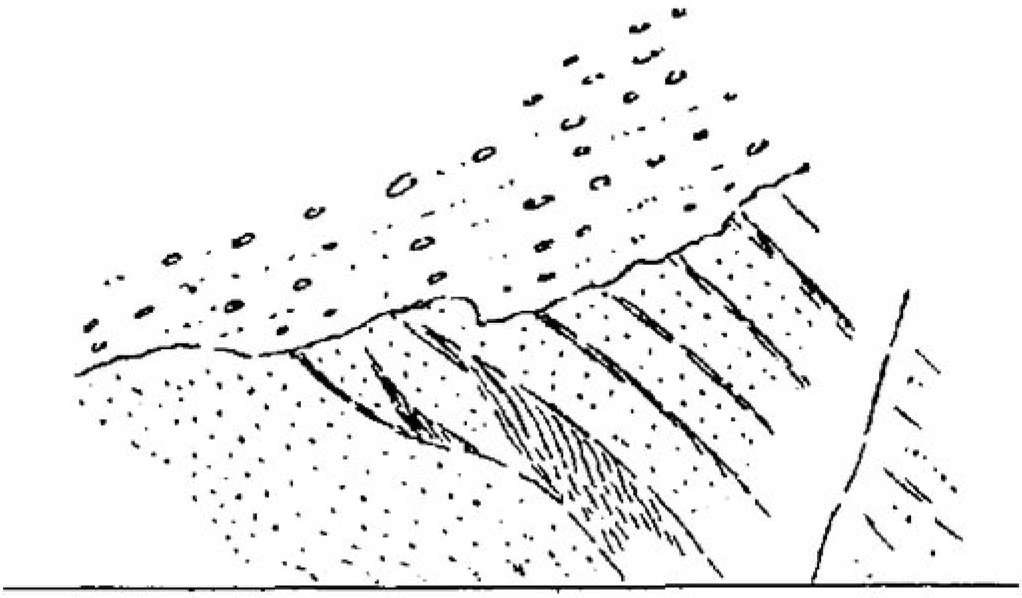


FIG. 221.—THE UNCONFORMABLE JUNCTION OF PLATE XXIX.

(Figure 221) The unconformable junction of (Plate 29).

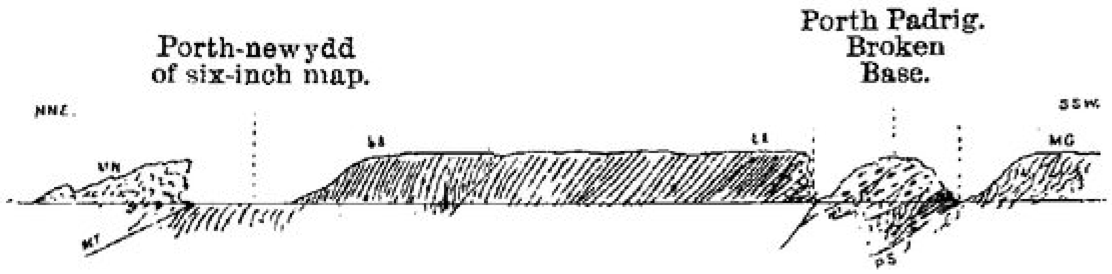


FIG. 222.—SECTION THROUGH THE ORDOVICIAN INFOLD OF MYNACHDY.

Scale—eight inches = one mile.

MN = Amlwch beds. MG = Gwna beds.
bg = Glenkiln shales, with limestone and conglomerate.
MT = Mynachdy thrust-plane. PS = Padrig slide.

(Figure 222) Section through the Ordovician Infold of Mynachdy. Scale eight inches = one mile. MN = Amlwch Beds. MG = Gwna Beds. bg = Glenkiln shales, with limestone and conglomerate. MT = Mynachdy Thrust-plane. PS = Padrig slide.

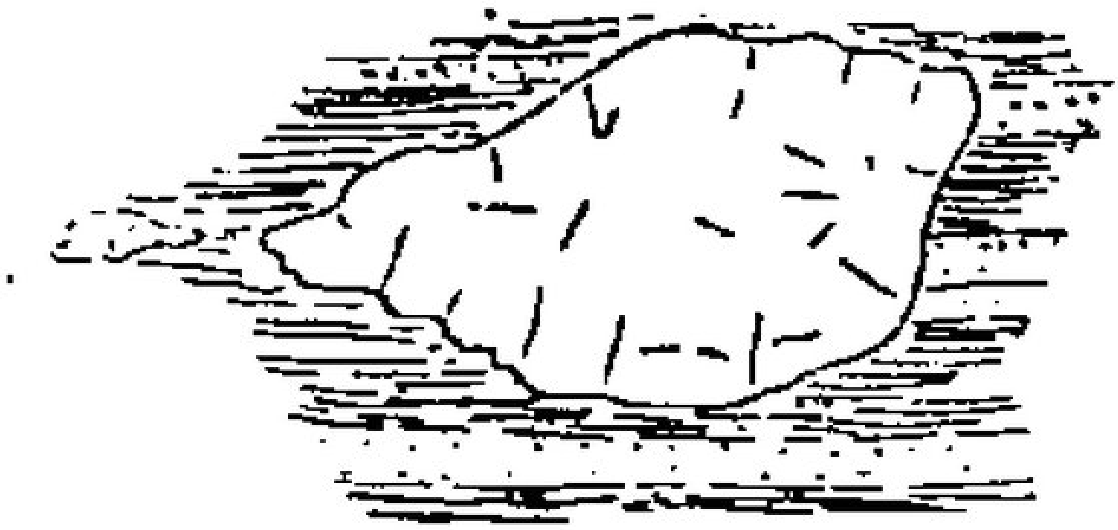


FIG. 223.
SIX-FOOT LIMESTONE LUMP IN GRACILIS BEDS.

(Figure 223) Six-foot limestone lump in gracilis beds. North cliff of Porth Padrig.

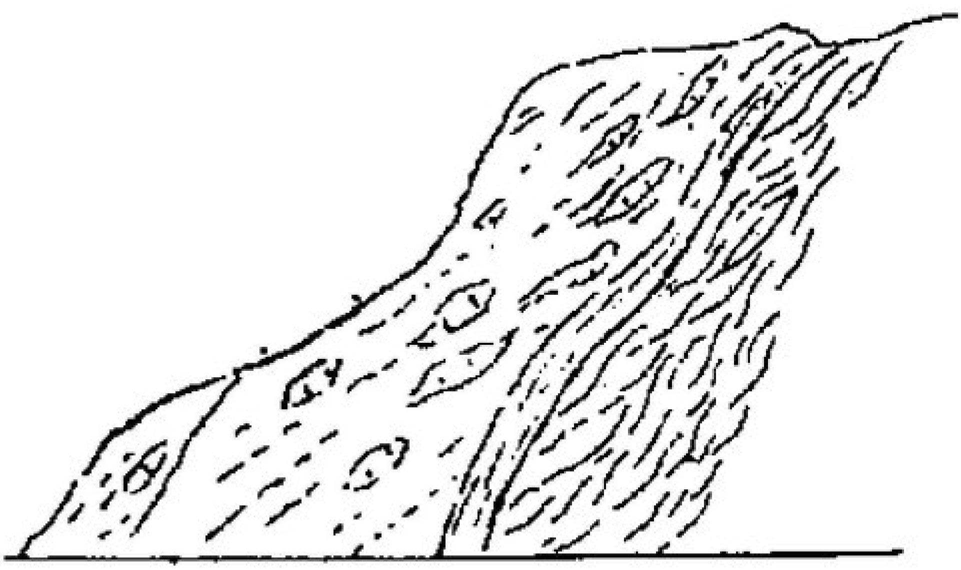
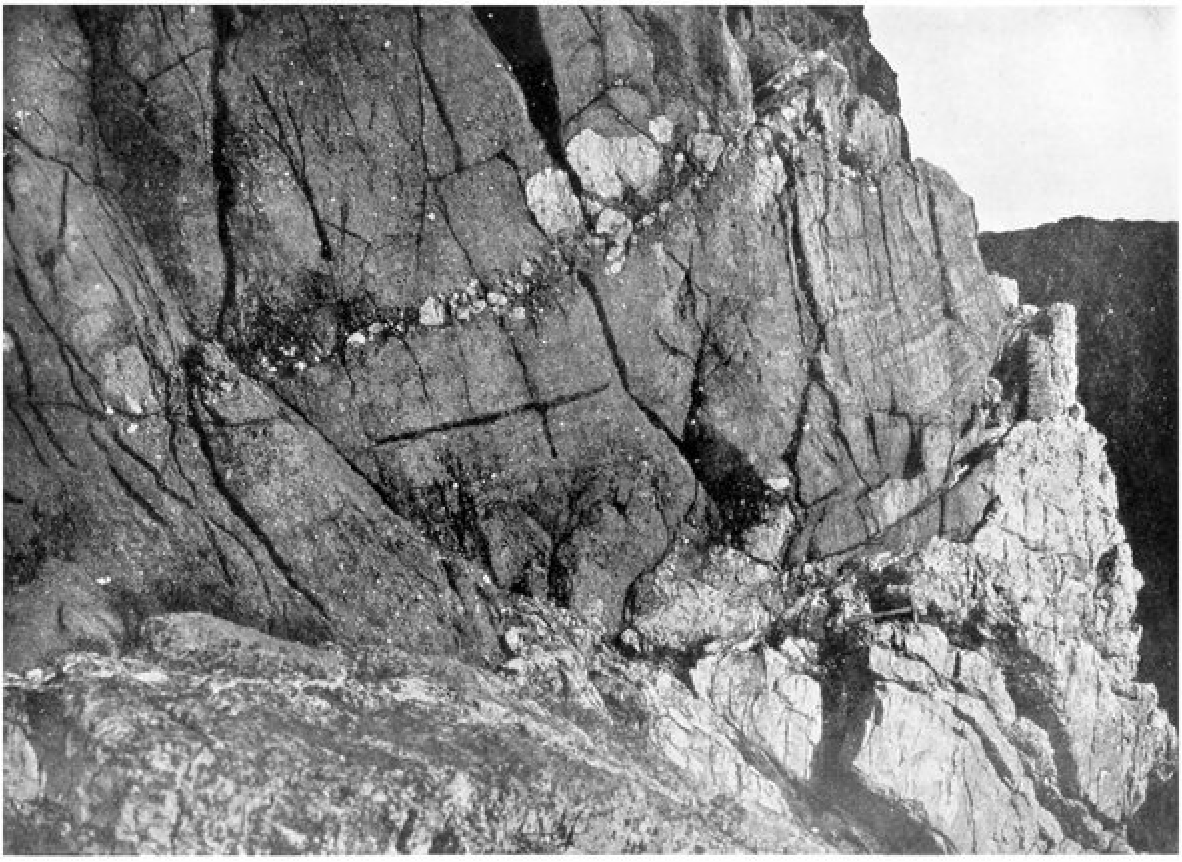


FIG. 224.
THE PORTH PADRIG SLIDE.

(Figure 224) The Porth Padrig slide. Height about 30 feet.



(Plate 29) Glenkiln conglomerate resting unconformably upon the Mona Complex. Ogo Gynfor.

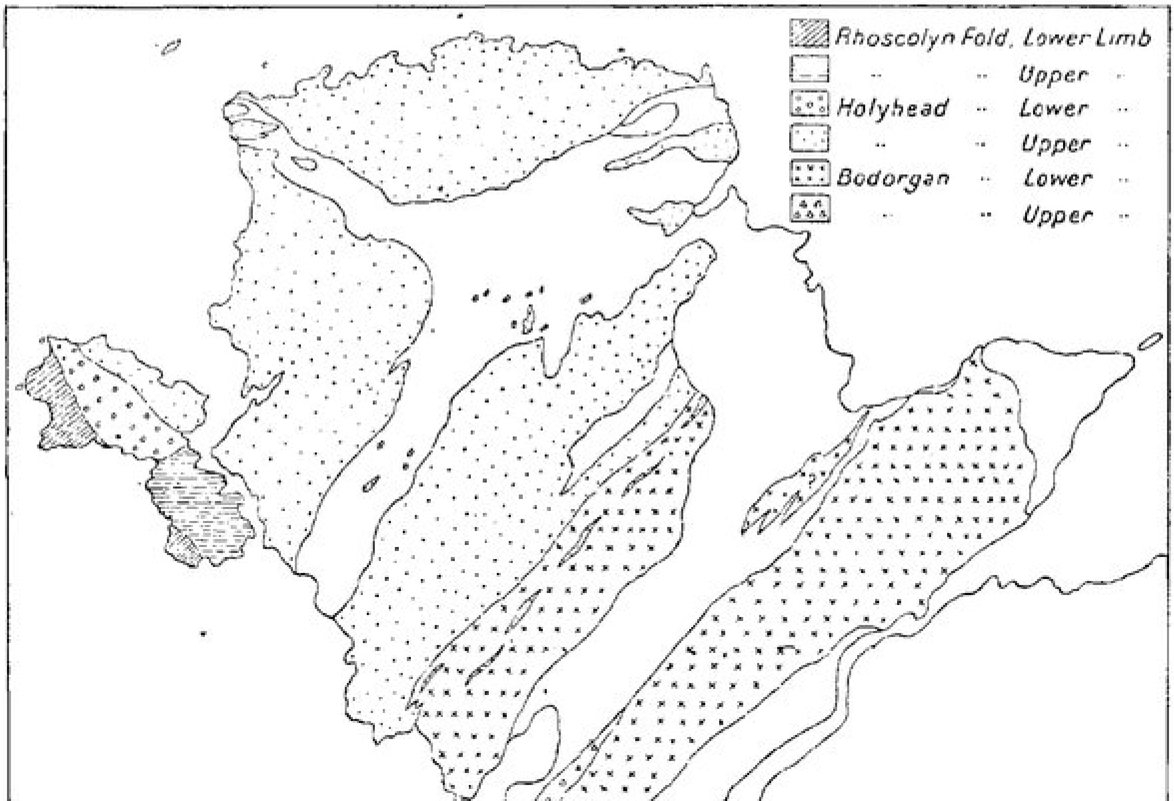
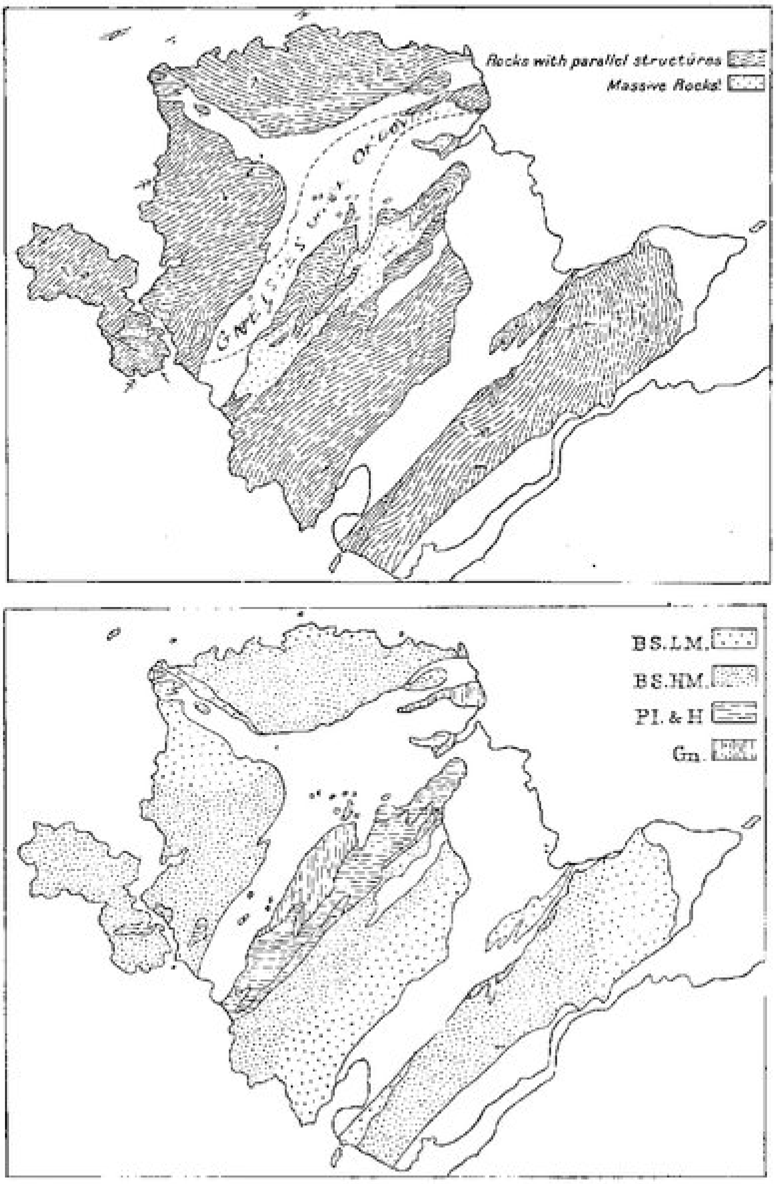


FIG. 100.—CHART SHOWING THE DISTRIBUTION OF THE TECTONIC HORIZONS OF THE MONA COMPLEX.
Scale: 1 inch = 6 miles.

(Figure 100) Chart showing the distribution of the tectonic horizons of the Mona Complex. Scale: 1 inch = 6 miles.



(Figure 101) a. Chart showing the general directions of strike and other structures in the Mona Complex. Scale: 1 inch = 6 miles. 101B Chart showing the distribution of the metamorphism in the Mona Complex. Scale: 1 inch = 6 miles. BS. LM. = Bedded Succession, Low Metamorphism. BS. HM. = Bedded Succession. High Metamorphism. PI. & H. = Plutonic Intrusions and Hornfels. Gn. Gneisses. Note: To bring out the waxings and wanings. delicate gradations of stipple would be required that could not he applied to a small-scale chart. The chart here given ignores all gradation, and minor complications, but shows at a glance the general distribution of the metamorphism.