Chapter 22 The Carboniferous System and the Carboniferous Limestone

The Carboniferous Series as a whole

Measured by extent alone, Carboniferous rocks come third in importance among the formations of Anglesey, for they occupy almost as much of its surface as the Ordovician beds; and their physical relationships are of unusual interest. Of the continuous sheet which once overspread nearly the whole, if not the whole, of the Island area, three fragments only of any considerable size, with nine small outliers, now remain; and it will be noticed that all of them lie within the. eastern and south-eastern half of the Island. Of these, the one which; occupying some five miles of the eastern coast, and, gradually narrowing, runs all through to Malldraeth Sands, may be referred to, both on account of its size and fulness of development, as the 'Principal Area'. It is bounded on the southeast by the great rupture that is called in this work the Berw fault.<ref>The nature and magnitude of the Berw fault (or rather faults) will be described and discussed in Chapter 27, but must be assumed in this and in Chapters 23, 24, 25, and 26.</ref>

Next in extent is what may be called the 'Straitside Area', extending from near the main line of railway to the western end of the Menai Strait; and thirdly, the small but interesting 'Penmon Area', in which is included Puffin Island.

The lower member of the system is well exposed, especially on the coasts and bold inland escarpments of the Principal and Penmon Areas. At Bwrdd Arthur the limestonerises to a height of 530 feet.

The succession is as follows:

	Red Measures	Red Sandstone and marl.
Upper	Coal Measures	Sandstone, shale, coal, and ironstone.
	Millstone Grit	Massive sandstone.
	Zone of Posidonomya	Chert and thin limestone.
Lower	Zone of Dibunophyllum (D1, D2, D3)	Limestone with many sandstones and thin shales.
	Lligwy Sandstone.	Conglomerate and sandstone.

The three upper divisions will be dealt with in Chapters 24–26, 35. The base of the system rests with complete unconformity upon all the older rocks, even upon the Old Red Sandstone; though its relations to that are not, upon the maps, as conspicuously unconformable as its relations to the Ordovician and the Mona Complex.

Carboniferous Limestone Series

Introductory

The Carboniferous Limestone of Anglesey was laid down within a zone of rapidly varying conditions of deposit, so that it presents different features in each of the three areas, even in different parts of the same area, and is never the same for very long together. Nevertheless, there are general facies common to all the districts; so that it will be possible to describe the series as a whole independently of local developments.

Petrology

The rocks represented are limestone, chert, shale, and sandstone with conglomerate. It is a true 'limestone series', for by far the greater part is really limestone; mechanical sediment, however, appearing on a number of different horizons, and. in beds of considerable thickness. Shales, though of constant occurrence, are always thin.

Sandstones

Normal sandstones — The most prevalent type is coarse, thick-bedded, usually false-bedded, and seldom without a few pebbles. It varies a good deal in hardness, but is generally rather loose and crumbly under the hammer. Externally it weathers almost white, but is surprisingly brown and ferruginous when broken, the iron salts washing away too rapidly to develop a russet weathered crust. The matrix has not the green tint of the Ordovician greywackes. It often contains little aggregates of a soft white powdery substance that when teased out under the microscope is found to be crystalline kaolinite in minute hexagonal plates. For a fuller study of this mineral see page 660.

The fine sandstones differ markedly from even the finer parts of the normal type, being hard and often somewhat quartzitic, and though weathering rustily have clean blue-grey cores. Generally they are thin-bedded and flaggy.

Black sandstones are found in a few places. The tint appears to be due to a dense hydro-carbon rather than to uncombined carbon.

Calc-sandstone — Many of the sandstones are calcareous, and by increase of calcite may graduate into gritty or pebbly limestone, and thence into clean limestone with a few scattered grains of clastic quartz.

Conglomerates

Four types can be recognised, which must have accumulated under different conditions respectively; namely, the Basement Conglomerates of the south-west, the Lligwy Bay Conglomerate, the Normal Conglomerates, and the Limestone-conglomerates.

The Basement Conglomerates of the South-West — These are confined to a quadrilateral delimited by lines joining the Menai Suspension Bridge, Llangefni, Bodorgan, and Aber Menai Point. The basement beds of the Carboniferous in this tract vary greatly in character, save that the matrix has the usual crumbly texture of the normal sandstones, though not their whiteness, and are often coarse, with boulders frequently six inches, and occasionally two feet in diameter. They are markedly local in origin, being derived from the immediately adjacent members of the Mona Complex. In this local character they are precisely like the basement conglomerates of the Ordovician, from which they differ in little more than in their lack of induration.

The Lligwy Bay Conglomerate — At Careg-ddafad, Lligwy Bay, lying below pebbly sandstone and conglomerate of the normal type and with the usual contents (see below), is a bed, whose base is not seen, crowded with water-worn boulders about six or eight inches, and some of them two feet in diameter ((Plate 35) and (Figure 291)). But these boulders are not from the Mona Complex.<ref>A few small pebbles of siliceous Gwna Green-schist and Penmynydd mica-schist can be found between them if sought for, but are rare.</ref> They are:

1. 1. Hard grey grits
2. 2. Black gritty shale
3. 3. Hard black mudstone
4. 4. Pyritised and silicified shale
5. 5. Pyritised and silicified grit
6. 6. Pyritised and silicified felsite
7. 7. Quartz-rock, streaky -or banded
8. 8. Dolerite of the Palaeozoic Intrusions
9. 9. Felsite of the Palaeozoic Intrusions

The most abundant are Nos. 1–5, next to them No. 7, while Nos. 6, 8, 9 are rare. Nos. 1–3 are Ordovician, of types common in the Principal Ordovician Area. Nos. 4–7 are Parys Mountain rocks, and have been already quoted as evidence in Chapter 19, p. 567. Those of No. 5 are hard siliceous grits, often quite coarse, highly pyrifised, and manifestly from the metasomatic tract of Parys Mountain. But no such rocks are-now to be found there. It is suggested that they may be the remains of higher beds of the Silurian Series, destroyed during the Carboniferous erosions. Nos. 8 and 9 are quoted in Chapter 16 (p. 510).

The normal conglomerates — The normal sandstones often pass rapidly into conglomerate, functioning then as matrix to it; and all the rest of the numerous conglomerates of the series, which appear on horizon after horizon from the basement upwards, are of this type. They are even lighter in tint than the normal sandstones, and have about the same degree of coherence. The pebbles, which do not often exceed three or four inches in diameter, are apt to be slightly irregular of surface; but here and there a type occurs in which oval ones, crowded closely together, are as smoothly rolled as sugar-plums, and give quite an unusual appearance to the rock. The great majority, perhaps 80 or 90 per cent., are composed of a venous quartz of the types common among the quartz-attgen of the Penmynydd Zone and the Gwna Green-schist (pp. 68–9, 111, 115, (Plate 8), (Plate 11)). Next to them comes Gwna quartzite, and then scarlet Gwna jasper, which is almost always present and is quite a feature of these rocks. Dark Ordovician grits are probably as frequent as the latter, but the jasper is of course much more conspicuous. Gwna Green-schist and Penmynydd mica-schist (though only their hard siliceous varieties) can generally be found if sought far. Any other materials than these are extremely rare. It will be observed that the Mona Complex is represented only by the most durable of all its members, a circumstance in which these rock-types differ totally from the Ordovician conglomerates, whose pebbles include almost every member of the Complex (see pp. 244, 404–5). The high percentage of augen-quartz is another feature in which they differ from the Ordovician, where it is, except in the thin conglomerates of the east, quite a rare pebble.

Further, both as to characters and pebble-contents, these rocks are singularly independent of locality and also of horizon; another contrast with the Ordovician conglomerates, which are markedly local in derivation, their contents changing rapidly as they sweep across from one member of the Mona Complex to, another. But no matter whence it comes, whether east or west, from a low horizon or a high, a conglomerate of this group displays, even in a hand-specimen, the same crustal bleaching, the same crumbly matrix, the same excess of augen-quartz pebbles, the same characteristic appearance clue to an occasional scarlet fragment of jasper catching the eye among the crowd of white ones. To say that a specimen is from some position in the Carboniferous Limestone is easy; to specify the position is impossible.

Limestone-conglomerates — An interesting feature of these deposits is the existence in them in many places of conglomerates (or, perhaps, rather, breccias) composed almost entirely of fragments of limestone (Plate 36). These are not of cataclastic origin, for they occur between quite unbroken beds, and also graduate into the ordinary conglomerates. In some of those a few lumps of limestone may be seen, the rest of the pebbles being of the usual kind. Then, a short distance along the outcrop,"the number of limestone-fragments may rapidly increase, until the rock has become a crowded mass of them, with only a few small pebbles of quartz here and there in the gritty matrix, which is generally ferruginous. The fragments are usually from one to six inches in diameter, but larger ones occur, and in the Lligwy Bay conglomerate there are great blocks of limestone four feet in length. That they are not ordinary pebbles derived from Pre-Carboniferous limestones is soon seen; for many contain crinoids and Other common Carboniferous fossils, besides which broken pieces of Carboniferous corals and brachiopoda (particularly *Productus* frequently occur as independent fragments. Sometimes the blocks can be identified as from the underlying bed of limestone. Sometimes the bits of limestone are oval and well rounded, but they are much more often sub-angular, or even quite irregular in shape, with re-entering curves, and even deep cavities that widen inwards (Figure 286) and are filled with the gritty matrix. There is reason to think that the limestone was comparatively soft at the time, for every now and then the blunt end of one fragment pushes into the side of its neighbour, fitting the cavity in which it lies (Figure 287). On the other hand, some of the blocks contain drusy cavities, and must have consolidated before being broken up, while the passages from solid limestone into breccia (see p. 612) also point to previous consolidation. Yet, again, the many loose fragments of fossils would seem to have been detached from an unconsolidated matrix. The subject requires further investigation.

Shale

Though rapidly alternating with some of the limestones, shale is but a subordinate member of the series. At Porth-y-forllwyd there is a bed six feet thick, but most of the shales are thin partings, dwindling to mere films as they bend over the nodular swellings of the limestones. Lithologically they call for little remark. Those in the sandstone are apt to be grey, and somewhat gritty; those between the limestones rather bituminous, and very black. They are crumbly and incoherent, quite unlike the micaceous, flaggy, elastic shales of the Ordovician and Silurian. Reddish marl is found in a few places.

Chert

Except in the higher beds, chert is also insignificant in quantity, occurring in the usual form of branching dark nodules; the dark tint being due to specks and clots of what is probably carbon with very likely some dense hydrocarbons and organic sulphides (*cf.* p. 605). At the summit of the series, however, there is a considerable development of tabular chert (Plate 40), most of which is light grey weathering to straw colour. Two out of the three that have been sliced Dr. Hinde finds to be genuine sponge cherts, simple rod-like spicules being the only ones visible. In another slide the organic remains are more miscellaneous, chiefly fragments of crinoids and polyzoa. In two he finds the foraminifer *Endothyra.* There is no difference between the organic contents of the dark and light varieties.

The limestones

Three principal types can be distinguished. They are:

1. ***Clean white limestone****,* crystalline-looking to the naked eye, massive and thick-bedded in habit.

2. ***Grey limestone****,* variable in texture, from crystalline to rather compact, usually but not always thick-bedded.

3. ***Black limestone****,* always fine and compact, rather heavy, always thin-bedded, and almost always interbedded with thin shales.

Type No. 2 is by far the most prevalent. Type 1 shows a mosaic of clean calcite, in which are numerous foraminifera, beautifully preserved, with other organic debris, the shell-walls of which are replaced by a much finer mosaic. Type 2 shows the same general characters, but with less of the clear mosaic, a good deal of rather turbid matter, and many specks of opaque minerals. Type 3 contains none of the clear, large-grained calcite, being composed throughout of a fine homogeneous mosaic, whose calcite elements are parted by films of brown semi-transparent flocculent material, which here and there forms larger aggregates, and is for the most part isotropic. Some crystals of pyrite are present. Organic fragments are rare.

Extreme examples of types 1 and 3, and an ordinary example of type 2, have been analysed, with the following results:

	I.	II.	III.
Residues insoluble in HCl	0.36	7.96	21.84
Al_2O_3+Fe_2O_3	0.18	0.60	0.37
CaO	55 40	50.51	41.59
MgO	Nil	0.60	1.11
CO_2	44.18	40.38	33.87
	100.12	100.05	98.78
Undetermined —		—	1.22
Percentage $CaCO_3$	98.93	90.19	74.26
Composition of insoluble residues:			
SiO_2	—	—	90.62
Al_2O_3+Fe_2O_3	—	—	9.12
	—		99.74

I. White Limestone, Benllech Cove, about 210 yards north of the house (E10336) [SH 522 827]. Anal. J. O. Hughes.

II. Grey Limestone, Penrhyn-y-gell (E10334) [SH 517 853]. Anal. J. O. Hughes.

III. Black Limestone, Benllech Sand, south of the 'B' (E10337) [SH 522 825]. Anal. J. O. Hughes.

Mr. Hughes writes: 'The strength of the HCl used was 20 per cent., and it was boiled (being the constant boiling solution). The "undetermined" portion of the black limestone consists of free carbon and some volatile sulphides. Lead acetate paper was blackened when held near the freshly-ground rock. An attempt at dry-distillation was partly successful. The powder, strongly heated, evolved fumes having an offensive odour resembling that of petroleum as well as H_2S, and were condensed to a pale yellow oil; only about three drops, however, could be collected, so that further examination was not possible'.

Comparison of these analyses shows that the white limestone is almost pure calcite; that the grey limestone contains rather more than might be expected of muddy matter; that the black limestone contains a large quantity of finely divided silica and argillaceous matter, and that its blackness is due to fine carbon, in which are held certain volatile organic sulphides. With the exceptions now about to be described, all the limestones will be found to belong either to one of these three principal types or to gradations between them.

Purple-red limestones occur in a few places, and it is noteworthy that these (as well as red sandstones) are nearly all in the Straitside Area, which there is reason for supposing to have been covered unconformably by red beds.

Gritty limestones are not uncommon, and a few scattered grains of quartz can sometimes be found in the midst of an ordinary clean limestone. Some grains of quartz interlock with the calcite, as if enlarged *in situ.*

Oolites are less developed than in some other Carboniferous districts, those which do occur being. very clean rocks, usually full of foraminifera and other organic fragments. An unusual variety that looks like an Oolite externally occurs at Maes-hir-gad, Llanidan. The granules, however: consist of large single crystals of calcite, rudely oval, interlocking with the mosaic of the matrix. One of them shows organic structures, as if the rock were a foraminiferal limestone altered in a rather exceptional manner.

Mottled limestones are developed on quite a large scale, particularly in the Principal and Penmon Areas. They are not merely rubbly or irregularly jointed rocks, but consist of a matrix of rather light colour, in which are irregular bodies, an inch or two across, of finer, darker matter, making up perhaps a little less than half the rock. Along the fine cracks that weathering develops at their junctions are brown films, perhaps of dolomite. In the fresh rock, under the microscope (E9990) [SH 482 804], the junctions are tolerably sharp, but the difference between the materials less conspicuous. The dark is on the whole more free from dusky- matter, but the light contains perhaps more organisms, most of which are foraminifera.<ref>This is transcribed from notes written in 1902. It is evident that these 'mottled limestones' are of the same nature as the 'pseudo-breccias' of Gower, which have been studied by Mr. E. E. L. Dixon (*Quart. Journ. Geol. Soc.,* 1911, p. 507). it is remarkable that both are foraminiferal; and that in both cases, as well as in the North-West of England (E. J. Garwood, *Quart. Journ. Geol. Soc.,* 1912, p. 477), the zone in which they are found is that of *Dibunophyllum.*</ref>

Dolomite

Local dolomitisation is not uncommon, but no dolomite-horizons have been recognised. The carbonate of the corals is often brown, and at Penrhyn-y-gell large groups of coral have acted as centres from which dolomitisation has proceeded outwards for some inches, so that the coral is surrounded by a magnesian zone with, generally, a rather well-defined margin, the surrounding rock remaining grey. Finally, at Seiriol and Penmon there are great beds of massive dark brown dolomite. The magnesian are generally more crystalline than the adjacent ordinary limestones, being often beautiful saccharoid rocks with geodes containing still larger crystals. Some quartz is moulded on the carbonates. Four of these dolomites have been analysed by Mr. J. O. Hughes.

	I	II	III	IV
Residues insoluble in HCl	0.21	1.12	1.25	0.87
Al_2O_3 (+Fe_2O_3 in II, III, IV)	0.66	17.11	1.95	2.05
CaO	30.31	29.77	32.16	30.12
MgO	16.20	9.98	18.38	20.85
CO_2	45.72	42.25	46.01	46.46
Fe_2O_3	1.39	—	—	—

FeO	5 61	—	—	—
	100.10	100.23	99.75	100.35
Percentage $CaCO_3$	54.12	53.16	57.43	53.79
Percentage $MgCO_3$	34.02	20.84	38.38	43.61
Percentage $FeCO_3$	9.03	—	—	—

I. Margin of coral, Penrhyn-y-gell (E10335) [SH 517 853].

II. Block in Lligwy Bay Conglomerate, Careg-ddafad (E10332) [SH 499 871].

III. Seiriol, north-west of Llangoed (E6061) [SH 634 805].

IV. Cliff east of Penmon Church.

These should be compared with the normal grey limestone given in column II of the analyses on p. 605, especially that from the margin of a coral, as it is from the same bed as (E10334) [SH 517 853]. It will be seen that the insoluble residues are low in each case, but that iron and aluminium are higher, sometimes much higher. In No. I it appears as if most of this iron combines with magnesium to replace calcium in the carbonate, which agrees with the fact that under the microscope visibly ferruginous matter is confined to films between the crystals. The proportion of magnesium to calcium in the rock of Penmon Cliff is very nearly that of pure dolomite, which is $CaCO_3$ = 54.35, $MgCO_3$ = 45.65.

There is some evidence as to the dates of the dolomitisation. The large Penmon dolomite seems to be bounded by what are regarded (see Chapter 27) as early faults, and although certain breccia-fissures are dolomitised it is by no means certain that they are due to faulting. In the Lligwy Bay and other limestone-conglomerates, many of the blocks that are clearly epiclastic are highly magnesian, while other blocks in the same conglomerate are grey limestones of quite different character. These magnesian blocks sometimes contain drusy cavities with bitter-spar, and must therefore be derived from a bed that had first consolidated and then become dolomitised before it was broken up; and as the erosion is clearly contemporaneous (pp. 603, 612), so must be the dolomitisation. The moulding of quartz upon the carbonates also indicates an early date. Yet, in other cases, the matrix of the conglomerate is itself magnesian. We have seen, also, that the corals are frequently altered in advance of the matrix, a phenomenon which is regarded by Mr. Dixon as one of subsequent alteration.

It therefore appears that some at any rate of the dolomitisation was practically contemporaneous, but that it was followed, perhaps not long after, by renewals of the process.

In none of these rocks is there the least trace of cleavage, or of any internal dynamical rearrangement whatever, in which circumstance they contrast strongly with all the systems upon which they repose, including the Old Red Sandstone.

Palaeontology

The limestones are rich in fossils at almost all horizons, and corals are decidedly more numerous than brachiopods, an exception, however, being the giganteid *Producti,* which are abundant. Crinoids are somewhat subordinate, thoroughly crinoidal limestones not occurring very frequently. Trilobites, as usual, are rare. In some of the clean and massive rocks minute organisms are extremely abundant, most of them being foraminifera. Some of the coral-beds are remarkable. At Morcyn, for example, their dip-slopes on the foreshore are almost composed of beautiful radiating groups of *Lithostrotion* as much as a yard in diameter, with which the simple corals are also mixed in great profusion, and similar beds are to be seen at other places (Plate 37). In the sandstones hardly anything is found but fragments of plants, not now determinable.

The zones and sub-zones

The whole of the Limestone belongs to the Upper or Visean division<ref>The fossil lists in this chapter and in Chapter 23 are founded on 2,230 specimens, of which 1,364 were collected by Mr. Muir (assisted in the Principal Area by Mr. J. O. Hughes), the remainder by the present writer. Those from the coast of the Principal Area were examined by Dr. Vaughan.

some gasteropods by Mrs. Longstaff, some trilobites by Dr. Woodward, and some ostracods by Prof. Rupert Jones. All the specimens were afterwards named individually by Dr. Ivor Thomas.</ref>, the *Dibunophyllum* Zone alone being recognised, though that is very strongly developed. The question as to whether the *Seminula* Zone can exist in the Island is discussed on pp. 616, 653.

The sub-zones D1, D2, D3 are all present. Explicitly D3 beds with *Cyathaxonia* are known only at the Fargen Hill outlier, where their top is not reached. But Dr. Vaughan recognises, not only D2a=maximum of *Lonsdaleia floriformis,*<ref>Dr. Ivor Thomas writes that he is inclined to regard a delimitation into narrow sub-zones with some degree of scepticism, drawing attention to the important part played by facies in this formation. Limestones hundreds or even thousands of feet in thickness', he remarks, may be homotaxial with much thinner ones in areas not far apart, the fauna, moreover, changing considerably with the change of facies; so that correlation nay be difficult'.</ref>*"* but also D2b=maximum of '*Lonsdaleia duplicata*'; and Dr. Ivor Thomas characterises the assemblages at a number of localities (at which *Lonsdaleia duplicata* is apt, moreover, to be unusually abundant), as 'D2 or higher', or 'D2 or D3', remarking that though the forms actually found at any one of these can hardly be placed more definitely,. 'D3 may yet be present, since many D2 forms range up into it'. Now the top of the beds characterised as 'D2b', 'D2 or higher', 'D2 or D3', is visible. As it is approached they become cherty, and quickly pass up into a well-defined series of tabular cherts, upon which reposes the Millstone Grit. The stratigraphy, therefore, seems to cast the balance in favour of the beds in question being assigned to D3.

With regard to the horizon of the cherts themselves, the evidence at present is as follows. The Millstone Grit. (see Chapter 24) is assigned to the Bullion Mine horizon of the Coal Measures. The cherts have not as yet yielded, *in situ,* any zonal fossils, but only *Endothyra,* with ill-preserved polyzoa, crinoids, and brachiopods. A cherty series, however, which is known to exist in force only a short distance away (see Chapters 30, 33) has yielded among other forms *Posidoniella laevis* (Brown) and *Posidonomya membranacea* McCoy. The presence of *P. laevis* might be held to link the cherts with the Millstone Grit, but there is a suspicion (p. 619) of slight unconformity at the base of that sandstone; whereas their brachiopods, polyzoa, crinoids, and foraminifera link them to the Dibunophyllum limestones? with whose upper cherty beds they alternate. Pending the discovery in them of definitely zonal forms *in situ,* the charts may be assigned, and with considerable confidence, to the zone of *Posidonomya,* which is, in any case, well-developed in the immediate vicinity.

The following are the faunas of the several sub-zones<ref>The local fossil-lists will be found in Chapter 23.</ref>:

Lower Dibunophyllum Zone (D1)

Alveolites septosus (*Flem.*) [abundant]

Aulopora sp.

Carcinophyllum sp. [θ of Vaughan] (V)<ref>'V' signifies that the identification is on Dr. Vaughan's authority.</ref>

Cyathophyllum murchisoni (*Edw. & Haime*)[abundant]

Dibunophyllum sp. [θ of Vaughan] (V)

Koninckophyllum sp. [θ of Vaughan] (V)

Lithostrotion affine? *Edw. d Haime*

Lithostrotion *cf.* martini *Edw. & Haime*

Syringopora geniculata *Goldf.*

Syringopora reticulata? *Goldf.*

Fenestella sp.

Fistulipora sp.

Rhabdomeson sp.

Stenopora?

Crinoidal columnals

Palaeechinid

Athyris expansa (*Phill.*)

Athyris planisulcata (*Phill.*)

Chonetes *cf.* buchiana *de Kon.*

Chonetes *cf* hardrensis (*Phill.*)

Chonetespapilionacea (*Phill.*)

Daviesiella aff. comoides (*J. de C. Sow.*)(V)

Daviesiella llangollensis (*Dav.*)

Dielasma canaliferum *de Kon.*

Leptaena *cf.* distorta *J. de C. Sow.*

Cf. Martinia ovaliglabra *Vaughan*

Productus edelburgensis *Phill.*

Productus giganteus (*Mart.*) [D1 form; abundant]

Productus *cf.* hemisphaericus *J. Sow.*

Productusmargaritaceus? *Phill.*

Productus *cf.* ovalis *Phill.*

Productus *cf.* productus (*Mart.*)

Productus sp. [of '*giganteus*' group]

Productus sp. [of '*semireticulatus*' group]

Productus sp. [of '*striates*' group]

Cf. Pugnax pleurodon (*Phill.*) [Davidson's interpretation]

Pustula punctata? (*Mart.*)

Cf. Reticularia lineata (*Mart.*)

Rhynchonella t *cf.* lacta *de Kon.*

Rhipidomella michelini (*L'Eveille*)

Cf. Schellwienella crenistria (*Phill.*)

Seminula ambigua (*J. de C. Sow.*)

Spirifer sp.

Spiriferina octoplicata (*J. de C. Sow.*)

? Amusium concentricurn *Hind*

Conocardium sp.

Cf. Leiopteria laminosa (*Phill.*)

Bellerophon sp.

Murchisonia kendalensis Mc*Coy*

Naticopsis sp.

Phanerotinus sp.

? Straparollus dionysi *de Monti*

Phillipsia eichwaldi? (*Fisch. de Wald.*)

Upper Dibunophylliim Zone (D2).

The forms found in the beds indicated by Dr. Vaughan and Dr. Ivor Thomas as 'D2b','D2 or higher', 'D2 or D3', are marked with an asterisk.

Endothyra bowmanni *Phill.*

Textularia sp.

Alveolites septosus (*Flem.*)*

Aulophyllum *cf.* pachyrendothecum *Thoms. & Nich.**

Campophyllum sp. nov.*

Carcinophyllum sp.*

Cyathophyllum murchisoni (*Edw. & Haime*)*

Cyathophyllum regium *Phill.**

Densiphyllid

Dibunophyllum matlockense *Sibly**

Dibunophyllum muirheadi *Nich. Thoms.**

Dibunophyllum sp. [θ of Vaughan]

Dibunophyllumsp. [*cf.* ψ of Vaughan]*

Diphyphyllum lateseptatum *McCoy* (broad and narrow forms)*

Lithostrotion affine (*Flem.*)*

Lithostrotion irregulare (*Phill*.)*

Lithostrotion junceum (*Flem.*)*

Lithostrotion martini *Edw. & Haime*

Lithostrotion mccoyanum *Edw. & Haime**

Lithostrotion portlocki (Bronn)*

Lonsdaleia duplicata (*Mart.*)*

Lonsdaleia floriformis (*Flem*.)*

Lophophyllum sp.*

Syringopora geniculata *Phill.**

Syringopora ramulosa *Goldf.**

Syringopora reticulata *Goldf.**

Zaphrentis enniskilleni *Edw. & Haime**

Fenestella sp.

Fistulipora?

Crinoidal columnals

Archaeocidaris sp.

Athyris expansa (*Phill.*)*

Athyris planisulcata (*Phill.*)

Athyrisroissyi (*L'Eveillé*)*

Brachythyris planicosta *McCoy*

Chonetes buchiana *de Ken**

Chonetes hardrensis (*Phill.*)*

Chonetes papilionacea (*Phill.*)*

Chonetes sp. [= *C. compressa* Sibly, *non* Waag.]

Daviesiella comoides (*J. Sow.*)*

Daviesiella llangollensis (*Dav.*)

Dielasma attenuatum (*Mart.*)

Dielasma hastatum (*J. de C. Sow.*)

Dielasma sacculum (*Mart.*)

Dielasma gillingense (Dav.)*

Leptaena analoga (*Phill.*)

Martinia ovaliglabra *Vaughan**

Martinia ovalis? (*Phill.*)

Orthotetid [new]

Productus aculeatus (*Mart.*)*

Productus auritus (*Phill.*)

Productus concinnus *J. Sow.*

Productus *cf.* corrugatus *McCoy**

Productus Productus crassus (*Mart.*)

Productus giganteus (*Mart.*)

Productus *cf.* hemisphaericus *J. Sow.**

Productus latissimus *J. Sow.**

Productus longispinus *J. Sow.**

Productus *cf.* productus (*Mart.*)*

Productus pugilis *Phill.** semireticulatus (*Mart.*)*

Productus sp. ['giganteid' var.]*

Productus sp. ['*longispinus*' group]

Productus sp. [*cf.* '*striatus*' group]

Productus sp. [*cf.* '*undulatus*' group]*

Pugnak pleurodon (*Phill.*)

Pustula *cf.* elegans (*McCoy*)*

Pustula punctata (*Mart.*)*

Pustula cf. carringtoniana (*Dav.*.)'

Reticularia lineata (*Mart.*)*

Rhipidomella michelini (*L'Eveille*)*

Rhynconellid

Serninula ambigua (*J. de C. Sow.*)

Schizophoria resupinata (*Mart.*)*

Spirifer bisulcatus *J. de C. Sow.**

Syringothyris laminosa(McCoy)

Phillipsia eichwaldi (*Fisch. de Wald.*)

Leperditia inflata (*McCoy*)

Leperditia acuta (*McCoy*)

Amusium concentricum *Hind*

Bellerophon sp. [apparently new]

Cytherella? inflata (*Münst.*)

Euomphalus sp.

Macrochilina?

Microdoma?

Mourlonia?

Murchisonia conula (*de Kon.*),

Murchisonia *var.* convexa *J. Donald*

Naticopsis plicistria (*Phill.*)

Naticopsis ampliata (*Phill.*)

Straparollus planorbiformis *de Kon.**

Discetoceras?*

Megalichthys sp.

Upper Dibunophyllum Zone (D3)

Alveolites septosus (*Flem.*)

Alveolites septosus (*Flem.*) var.

Campophyllum?

Cyathaxonia sp.

Cyathophyllum regium? *Phill.*

Cyathophyllum sp.

Dibunophyllum sp.

Lithostrotion irregulare (Phill.)

Lonsdaleia floriformis (*Flem.*)

Syringopora geniculata? (*Phill.*) [narrow form]

Syringopora sp.

Dielasma?

Productus sp. ['giganteid' type]

Productus sp.

This list is from Fargen Hill alone, and does not' include the 'D2a', 'D2 or higher', or 'D2 or D3' beds, even where those lie immediately below the charts.

Posidonomya Zone (P)

The fossils were not obtained *in situ,* and the list will be found in Chapter 30 ('Extra-Insular Erratics'.)

Characters of the fauna

By Dr. Ivor Thomas

The fauna as a whole appears to be more closely related to that of the Midland area than of the South-Western district. Though many forms such as *Cyathophyllum regium* Phill., *Cyath,ophyllurn murchisoni* (Edw. and Haime), *Lithostrotion irregulars* (Phill.), *Lithostrotion junceum* (Flem.) &c., among the corals, and *Reticularia lineata* (Mart.), *Chonetes papilionacea* (Phill.), *Productus elegans* McCoy, *Rhipidomella michelini* (Leveille) and others among the brachiopods, are common to the three districts, some of the species found in Anglesey are of the Midland type and, so far as evidence is at present forthcoming, are absent from the South-Western province. Among these are *Dibunophyllum matlockense* Sibly, *Campophyllum* sp. nov., and *Chonetes* sp. The new *Campophyllum* has received the MS. name *C. derbiense* from Dr. Vaughan; it has not yet been described, as far as I can ascertain. The species of *Chonetes* was fully diagnosed and figured by Dr. Sibly<ref>Sibly, T. F., The Faunal Succession in the Carboniferous Limestone (Upper Avonian) of the Midland Area (North Derbyshire and North Staffordshire)'. *Quart. Bourn. Geol. Soc., vol.* lxiv, 1908, London, pp. 34–82.</ref> as *Chonetes compressa* sp. nov., but as this specific name is preoccupied<ref>Waagen, W., *Mem. Geol. Surv. of India, Palaeont. Indica,* Ser. xiii, 'Salt Range Fossils'; 'Productus-Limestone Fossils'; iv. (fast. 3), 'Brachiopoda', 1884, Calcutta, p. 630.</ref> it naturally falls into abeyance. Since the form is well characterised I propose that it be known henceforth as *Chonetes siblyi* nom. nov.

Among other distinctive features of the Anglesey fauna compared with that of the South-Western district is the absence, as far as the material examined is concerned, of true *Productus hemisphaericus* J. Sow. Instead of the typical *hemisphaericus* we find a new species which is distinguished, among other features, from Sowerby's form by being more coarsely costate, more rounded and higher in the venter, while the main flanks are steeper and the umbonal region typically more incurved. It is referred to in my determinations as *Productus* cf. *hemisphaericus* J. Sow.

Contemporaneous erosion and disturbance

That erosion took place rather often, and on a considerable scale, during the deposition of the Carboniferous Limestone, is shown by a number of different phenomena, and some others, perplexing when taken singly, can in their turn be explained by means of it.

1. Limestone-conglomerates

These are in themselves a proof of such erosion, and little need be added to the description on p. 603. At certain places, as at Lligwy Bay, the stages of their formation can be studied. A massive limestone, at first normal, begins to be traversed by irregular cracks, and rapidly brecciates. Then a few foreign pebbles appear, the calcareous blocks become isolated, and the rock passes into a true limestone-conglomerate. The cracking suggests drying and shrinkage, and yet, as already shown, some of the blocks do not appear to have been hard.

2. Erosive junctions

A little to the south of Borth-wen, Benllech, is a narrow creek about 20 feet deep, one side of which is limestone with a few thin sandstones, the other pebbly sandstone. Yet, in the cave at the creek's head it can be seen that there is no fault. The relations are as in (Figure 288). Clear erosive junctions are seen at a conglomerate a few yards to the south (Plate 36). At a crag on the south shore of Llyn Cadarn, 350 yards west-south-west of the 'c', a few feet of limestone-conglomerate lie between limestones. The junction is very irregular, with 'steps' up of as much as a foot, and also projections of the floor up into the conglomerate.

3. Behaviour of the sandstones on the large scale

A glance at the map shows that the sandstones vary in thickness with great rapidity, often dying out quite suddenly where there is no reason to suppose any fault exists. The resulting outcrops are very complex and anomalous, especially in the Vale of Cadarn, and sometimes it is possible to show that the sandstones are changing their horizon. One of them in the Vale of Caban can be shown from the dips and contours to have risen across the limestones at least 50 feet in 566 yards as it is traced to the south-east.

4. Sandstone pipes

At Moelfre Point and Island, at Porth-yr-aber, at Huslan Cliff, at Trwyn-dwlban, and Dwlban Old Quarry, localities which are on horizons ranging from just above D1 to a few feet below P, limestones (usually massive and crystalline) are pierced from above by numbers of pipes that are filled with fine white sandstone. In nearly all cases these pipes proceed from one of the beds of sandstone. Except where they descend into the pipes, such sandstones rest. conformably upon the piped limestone and are conformably overlain by the next member of the series, sometimes a shale, but usually another limestone (Figure 289).

The most striking exposure is that at Trwyn-dwlban, where the piped limestone dipping south-south-east at about 4° to 5° forms the foreshore, and several of the plugs have been left standing, each in its circular pit, some four or five feet above the level of the surrounding rock (Plate 38), looking rather like gigantic fossil corals, or the 'Paramoudras' of the chalk, while others, torn out by the sea, lie prostrate in all directions.<ref>Since the early winter of 1907 more of these have, unfortunately, been thrown down by the sea.</ref> These pipes vary considerably in size. Some at Moelfre Point are only about five inches wide and 'the same deep. Those at Trwyn-dwlban are about six feet in diameter at the top, and can be traced to a depth of about five or six feet. But at Dwlban Old Quarry, about 230 yards to the south, there is a pipe no less than 12 feet in depth, whose bottom is not visible (Plate 39). The material of these plugs is hard and somewhat 'gannister'-like, and very fine save for a few groups of little pebbles. They are bedded, the bedding being parallel to that of the series as a whole. Sometimes the beds within the pipes have a gentle downward bend, but there is not the least sign of collapse in the beds above, indeed at Trwyn-dwlban the upper surface of the sandstone is domed upwards a little over each pipe's mouth. None but the usual marine fossils have been found. The Dwlban sandstone contains what appear to be annelid castings, and that of Porth-yr-aber a few brachiopods, while the Dwlban shale (Figure 289) yielded a shell, poorly preserved, which Mr. E. T. Newton believed to be *Spirifera ovalis.* The late Mr. Bennie kindly examined the same shale for small organisms, but none were found.

The floors or 'bowls' of the pipes, which can be seen on Moelfre Island and at Porth-yr-aber, are clean and smooth (Figure 290). Sometimes there are a few small cracks, but these do not communicate with any underlying sandstone, neither is there any disturbance of the beds below. It is evident that the pipes have been filled in from above.

5. Local discordances

At a bay of the cliff on Puffin Island, north of the Old Telegraph Station, a massive, jointed limestone, slightly dolomitic-looking, dipping at 10° rests upon thin-bedded limestone with shale, dipping in the same direction at 15° to 20°. The beds both above and below this unconformity can be traced past the buildings on to the escarpment face of the Island, but no discordance has been observed at any other section. There is a similar unconformity between two limestones, a light massive one being again the upper, at a crag facing north on the hill above Penrhyn, east of Traeth Bychan, about 330 yards south of the point's end. But the discordance is here even more local, dying off in a few yards. The difference of dip is 4° or 5°.

6. Local disturbances

Here and there in the sandstones, especially in the neighbourhood of limestone-conglomerate, the less resistant beds, such as the shales, have been buckled up into little anticlines that affect them only, over and under which the other beds pass undisturbed. One of these is well seen at Borth-wen south cliff (Plate 36). But the most remarkable of the local disturbances is at Careg-ddafad, Lligwy Bay. The great conglomerate described on p. 602 and some thin finer beds dip at low angles, not exceeding 5°, and the limestone of the south-east cliffs of the Bay at 9°; but in a belt between these about 20 to 30 yards in width (shown at the left end of (Figure 291)), the dip suddenly rises to very high angles. The rocks of this belt are massive but rather 'rubbly' limestones with a little shale, and a limestone-conglomerate with a red sandy matrix in which are boulders up to four feet in length. Of this great disturbance, however, no effects appear along the strike inland, and even at the coast it does not seem to be bounded by any faults. Within it, although beds abut upon each other in places, no faults can be traced on from these abutments. The limestones are brecciated close to the conglomerate, and also invaded by rude lines of brecciation.

Discussion of the phenomena

The varied phenomena described above are evidently not due to ordinary earth-movements. Dr. Strahan, who examined the sections from Lligwy Bay to Borthwen with the writer in 1911, suggested that these and kindred disturbances that occur in the neighbourhood of limestone-conglomerates were probably due to the foundering of beds into cavities produced by the contemporaneous erosion of which there is such abundant evidence, and this is almost certainly the true explanation. Most likely something of the same kind is the explanation of the local unconformities between limestones just described above. Yet it is not easy to believe that a sea-floor upon which such thick masses of clean limestone were accumulating was so constantly within the reach of wave or current action. An ingenious suggestion of Prof. W. H. Hobbs may possibly serve to relieve this difficulty, though not free from difficulties of its own. In letters to the present writer in 1906–7 concerning the sandstone-pipes, he compared them (adding that similar pipes are now known in Arkansas) to the sand funn'els produced c, by the derangement of ground-water by earthquakes, such as those of the Calabrian earthquake of 1783, described long ago by Lyell, and of the Carolina earthquake of 1886, and certainly they have a close resemblance to these. Prof. Hobbs, and also the Comte de Montessus de Ballore, have adopted this theory in publications to which reference will be found in the Bibliography. The chief difficulty attaching to this view is that the pipes were certainly filled with sand from above: but the Comte d. Ballore (in a letter to the present writer) sees no difficulty in this, provided that they could have been drilled out by water from below, and we have seen that there are cracks in the bottoms of some at least of those whose floors can be examined. Certainly shocks to a sea-floor might be expected to break up some of its half-consolidated deposits, and also, setting the bottom-water in motion, wash out irregular channels and fill them with debris, besides causing disturbances and founderings like those of Lligwy Bay.

The Seminula Zone — In conclusion, some light may perhaps be shed upon the question of possible beds of the Seminula zone. The Lligwy Bay conglomerate is full of great blocks of limestone, and yet no limestone can be seen beneath it. The limestone of these blocks, moreover, is not all of the same type. Some thickness of beds appears therefore to have been broken up, as has been found to be the case<ref>The Country Around Carmarthen', *Mem. Geol. Surv.,* p. 81.</ref> at the Pendine conglomerate in South Wales. No zonal fossils have been found in the Lligwy blocks, but it is not at all unlikely that they are portions of a lower zone than any that exists within the Island area; so that the lower (though *only* the lower, see pp. 617–8) parts of the Lligwy Sandstone may be expected to belong to the Seminula zone.

General view of the Carboniferous Limestone<ref>The local fossil-lists will be found in Chapter 23; the sections in Chapters 23, 24, and in Folding-Plate 12.</ref>

Principal Area

The country between the Cefni and the Eastern Sea (Folding-Plate 12).

Lowest of all the Carboniferous rocks of the Island is an important bed that may be called the Lligwy Sandstone. It is followed immediately by the limestones of the D1 sub-zone, upon which rests, on the coast (Figure 293), the Helaeth sandstone, 20 feet in thickness. Now, following the outcrops past Aberstrecht, it appears that the base of this bed cannot be far from that of the great Lligwy escarpment, which runs under Lligwy house and past Cae-rhos-lligwy. Just below that escarpment a definitely DI assemblage of fossils (p. 637) has been obtained, and a little above it, a definitely D2 assemblage, no forms of lower horizon appearing again. The foot of the escarpment, therefore, and the base of the Helaeth sandstone, have been taken as the upper limit of the D1 sub-zone; which; on the coast, includes about 200 feet of limestone. In the rest Of the area nearly all the assemblages that are zonally definite belong to D2 (D2a of Vaughan), and those that are less definite are consistent with them, from which it is evident that the greater part of the country between the Cefni and the eastern coast is on that horizon. There are large beds of pebbly sandstone, which, especially about Cadarn and Caban vales, are of considerable thickness. They seem to be on five separate horizons, but their relations are anomalous and irregular. Three places in the interior, and those at Red Wharf, have yielded the higher fauna called 'D2 or higher', 'D2b', or 'D2 or D3', while at Red Wharf these beds are followed by the bedded cherts ascribed to the Posidonomya zone. The stratigraphy, therefore, points to a considerable portion of the south-eastern margin, as well as some elevated plateaux further west, belonging to the D3 sub-zone.<ref>See the remarks by Dr. Ivor Thomas, and discussion, on p. 608.</ref>

Along the western margin, from Lligwy to Llangefni, a curving range of bold escarpments overlooks a marshy valley floored by the Lligwy Sandstone.. This escarpment, though a geographical unit, is geologically somewhat complex and anomalous. At the roadside by Lligwy woods, where the faunas are well defined, the base of the D2 sub-zone is about 50 feet above the Lligwy Sandstone, but, a little beyond the Llanerchymedd road, has come to rest directly on that sandstone. At this place, therefore, the whole of the 200 feet of limestone that compose the D1 sub-zone on the coast has disappeared.<ref>The thinning of the D1 limestones can be seen on the one-inch map, and also by comparing (Figure 293) with (Figure 277) and (Figure 296).</ref> Not only so, but we find that, though the dip is not north-easterly but south-easterly, the top. of the Lligwy Sandstone, which was at sea-level in Lligwy Bay, is now at 230 feet above sea-level; a rise which coincides, within a few feet, with the thickness of the D1 limestones that have disappeared. The Lligwy Sandstone is therefore climbing to higher and higher horizons. Nevertheless, its thickness has dwindled by at least 100 feet, so that its base must be rising still more rapidly. There must therefore be a true basal overlap; combined with a change, on each successive horizon, from a calcareous to a psammitic facies.

The relation thus demonstrated is actually visible to the eye. Crossing the vale of Lligwy towards Mynydd Bodafon, and looking back at the escarpment, bed after bed of limestone can be seen to come bending round from the interior of the plateau and take its place at the brow of the scarp, the bed that had formed the brow now passing along the scarp-face just below. Moreover, knowing the position of the top of the D1 sub-zone at the foot of the escarpment, that horizon can be followed by the eye through the woods of Lligwy, and along the curving slopes below Hen Capel Lligwy, as far as the farm-buildings of Aber-strecht. The position of the top of the Lligwy Sandstone being also known, the eye can take in at a sweep almost the whole extent of the sub-zone, and watch it thickening sea-wards from its vanishing-point by the Llanerchyinedd road, to where it has attained to nearly 200 feet at Aber-strecht. The first sub-zone, thus overlapped, never reappears, and the same relations continue to the south-west, bed after bed of the second sub-zone lapping on to the Lligwy Sandstone, which has itself nearly disappeared by the time that it is cut off at the Llangefni fault. Close to Llangefni, the overlap is again perceptible to the eye, for the quartzite inlier of the Old Windmill rises into the Pencraig Sandstone, which is high up in the second sub-zone.

As far as Red Wharf and Talwrn the dip is persistently to the south-east at low angles, with a number of small faults. Two faults, those of Dinas Valley and Huslan (Figure 294), are of importance, as in Dr. Vaughan's opinion, they each repeat the D2a fauna that is well developed about Morcyn, in which case they must be downthrows to the west and north of some 300 and 250 feet respectively. No fault of any magnitude, however, breaks the western escarpment, from which it would appear that the general effect is gently synclinal, the faults tending to neutralise each other, or die out. The fault of Dwlban gap is also of importance, as it ushers in the high limestones and bedded cherts (Figure 295) of Red Wharf. Thence to the Berw boundary fault are north-westerly dips (Folding Plate 12), and the limestones of the Bay and of Pontraeth contain a brachiopod fauna with latissimoid Producti that recalls the highest beds of the Straitside Area. The Red Wharf syncline is on the strike of the Coalfield. But the rise of the Coal Measures on the pitch, combined with the development here of part of the south-eastern limb, has prevented the Upper Carboniferous Series from appearing on the eastern coast. The base of the *Posidonomya* cherts, however, is just reached on the summit of the Castell-mawr outlier (Figure 295) (Plate 40) in the deepest portion of the curve.

From the Cefni to Bodorgan (Figure 302).

The D2 sub-zone can be traced as far as Ffrwd-onen, but it is quickly followed at Llangristiolus by higher beds, probably D3, and these by cherts like those of Red Wharf. The overlap is proceeding rapidly. Concealed beneath the alluvium of the upper Cefni, and passing through the eastern part of Llangefni town, is a fault with a downthrow to the east of about 170 feet. Its displacement appears, indeed, to be much greater, but is exaggerated by overlap. Beyond the Llangefni fault the Pencraig Sandstone, rapidly dwindling, reappears, but is now at the base, the Llanddyfnan limestones having disappeared all but a patch in a small outlier. Passing on to Llangristiolus, the magnitude of the overlap is shown by the fact that the 'D2b' or (more probably) D3 limestones are now only some 220 feet, and the cherts about 300 feet above the base. Therefore the sandstones which appear at intervals below the limestones must be at successively higher horizons westwards. At the railway (Figure 298) the limestone is 140 to 150 feet thick, and it dies out altogether before the sea is reached, the Millstone Grit resting directly upon the Mona Complex at Bodorgan. The cherts have not been seen in the railway cutting, or indeed beyond Felin-bach, suggesting that there may be some degree of erosion at. the base of the Millstone Grit.<ref>Since this was written, Messrs. Dixey and Sibly have suggested a similar relation in South Wales. (*Proc. Geol. Soc.,* April 5, 1917.)</ref> Good zonal forms have not been obtained beyond Ffrwd-onen, but it is evident that the limestones of Trefdraeth must be in the D3 sub-zone. Along much of the tract the Mona Complex overlooks the Carboniferous rocks in a straight fault-like feature some 50 feet in height. But the sections on the railway and at the Henblâs water show that this must be really a Pre-Carboniferous margin, determined by the structures in the Mona Complex.

Esgeifiog Strip

Caught between branches of the Berw faults (Figure 302), a narrow strip of the Limestone Series ranges for three miles and a half from Dyffryn to Plâs Berw. No good zonal fossils have been found. Near Phis Penmynydd is a shallow syncline, and then the beds roll over southward, striking obliquely across the axis of the strip. At Rhyd-yr-arian ravine a cherty series appears, and continues, dipping to the north-west, all the rest of the way. This resembles in every particular the cherts that overlie the limestones at Bryn-y-gors across the marsh, and at Red Wharf, and may be assigned to the zone of *Posidonomya.* It is likely, therefore, that nothing lower than the D3 sub-zone rises to the surface in this strip; and as the overlap is already far advanced in the Llangefni country, not much more than a mile away, it is improbable that any great thickness of the D2 sub-zone underlies it.

The Straitside area

This (Figure 299) is bounded, except about Plus Llanfair, entirely by the Braint fault, but the existence of little outliers of sandstone just outside shows that the throw must be moderate, At the base is a thick pebbly sandstone with soft purple marls not known elsewhere in the Island, which may be called the Fanogle Sandstone. No D1 fossils have been found, and that sub-zone is evidently overlapped, unless it be represented by the sandy group. Limestones with the D2 fauna rest immediately upon the Fanogle Sandstone, and occupy the greater part of the area, being well exposed in the crest ridge of Bryn Siencyn, with their fauna clearly developed. South of Phis Newydd the higher beds come on, earthy limestones rich in corals, upon which rests the purple Edwen oolite, followed by the purple Edwen Sandstone, and that by the *Lonsdaleia*-limestones of Moel-y-don. As cherts appear on the opposite shore, the D3 sub-zone must lie beneath the waters of the Strait, unless it is represented in part by the Moel-y-don limestones. The dips are steadily to the south-east, and the Fanogle Sandstone appears to rest against an old slope of the Mona Complex near Plâs Llanfair (Figure 300). Sandstones are found at intervals throughout. They, and many of the limestones, have a purplish red colour, probably a staining from the Red Measures, which in this district lay directly on the limestone. From the crest-ridge to the Strait the country is a dip-slope, broken by minor, impersistent escarpments. The base of the higher zones ranges along that of the Carnedd Sandstone to Porthamel Hall, whence, slightly shifted southwards, it must run out again to the shore of the Strait somewhere below Llanidan.

The Penmon area

In spite of the advantages of more than five miles of sea-cliff, of bare plateaux, and a bold escarpment, this district (Figure 194), (Figure 301) is the least easy to interpret, partly because of faulting, but also because of the obliquity both of the coast and of the escarpment to the strike. The usual lithological types all occur (light and massive limestones being conspicuous on the high plateaux), but at Penmon cliff and Seiriol are the largest and most massive dolomites in the Carboniferous of Anglesey. In one important respect this area differs from the other two—there is no basement Sandstone or conglomerate; the lowest beds being the limestones of Careg-onen cliff, which rests with a striking unconformity upon Ordovician shales ((Figure 194) and (Plate 26)B).

The district may be summarily described as the southern segment of a synclinal basin, complicated by an overlap towards the southeast.

The D1 sub-zone, which cannot be less than 300 feet thick at Careg-onen, is reduced to not much more than 100 at Bwrdd Arthur and the Marian-dyrys. It appears to be bounded by a fault running from north-west to south-east through Fargen-wen, and D2 beds are brought down against it. These now lie at the base, and continue along the escarpment as far as the great curve near Llangoed, after which their place is taken by the higher members of the sub-zone, which at Penmon have overlapped on to the base, and of which the eastern extremity of Anglesey as well as Puffin Island appear to be composed. There is thus an overlap here as well as in the Principal Area, but it is in an easterly direction.

Most of the middle of the district is occupied by ordinary D2 beds; but in a triangular tract that is bounded by the Fargen-wen and Seiriol faults these are surmounted by the higher members of that sub-zone, upon which again rest the Cyathaxonia Limestones of the Fargen Hill outlier. At the Fedw-fawr, however, these D3 limestones are absent, and their place appears to be taken by the Fedw sandstone, in which there is abundant evidence of contemporaneous erosion. In the Eastern Promontory the same function appears to be performed by the Parc sandstone. The cherts have not been seen, so the top of the D3 sub-zone does not seem to be reached anywhere.

Throughout the district there is a persistent low dip to east-northeast, which is exchanged on Puffin Island for one of about 10° to the north. The synclinal accommodation is therefore obtained in great measure by faults, of which no fewer than 12 cross the area in the half-mile between Trwyn-dinmor and the Lighthouse. Few of them produce any appreciable effect upon the escarpment, so that it would seem as if they were all connected with the curious oblique fall of the beds into the synclinal trough that is now hidden, from our eyes beneath the sea.

Thicknesses, overlap, and unconformity

Thicknesses

The maximum thickness is not easy to determine, as it is not certain at what point en the eastern coast repetition of parts of D2a begins. For example, the north shore of Traeth Bychan appears to be determined by a fault, yet it is by no means certain that the beds at Penrhyn-y-gell are at the summit of the D2a sub-zone. Assuming, however, that they are, then we obtain for the Principal Area:

	Feet
Cherts of P., at Esgeifiog, not less than	100
D2b and D3, from Trwyn-dwlban to Castell-mawr	250

D2a, from the base of the Helaeth Sandstone to Penrhyn-y-gell	520
D1, to the bottom of the Helaeth Sandstone	230
Lligwy Sandstone (base not seen) 300, or at least	200
Total	1,300
At Lledwigan, Llangefni, the total thickness is about	500
At the main line of railway, the total thickness is about	150
At Bodorgan	0

In the Straitside Area, along the shore section:

D2b and (?) D3 thence to Moel-y-don Ferry.	350
D2, from this sandstone to south side of the dyke	250
Fanogle sandstone, about	300
D1 (apparently missing)	0
Total	900

A measurement across the whole Straitside Area, the base, however, being faulted, so that we do not obtain a total thickness, gives

Gwydryn to Moel-y-don	640

In the Penman Area, owing to the faults and overlaps, it is not easy to obtain satisfactory measurements, especially of the middle sub-zone. But a minimum can be arrived at by combining the D1 beds that are seen in Careg-onen cliff, and the Deb to D3 beds of Puffin Island, with a cross measurement of D2 from the foot of the escarpment near Llangoed Church to the coast, a tract free from faults of any large size, which gives:

	Feet
D2b and D3, Puffin Island (top not seen)	150
D2a, Llangoed Church to northern coast	450
D1 of Careg-onen cliff	300
Total	900

If we combine the maximum thicknesses of the sub-zones in the several areas, adding at least 100 feet (and the throw of the Lligwy fault at the sea is probably much more than that) for the lower part of the Lligwy Sandstone, we obtain for the whole of the Limestone Series at its thickest a total of some 1,600 feet.

Overlap

From the foregoing figures, and from the stratigraphical sketches given on pp. 616–21, it will have been seen that overlap is a most important principle in the development of this system throughout the Island. The greatest of the overlaps is that which can be traced from Lligwy to Bodorgan, a distance of 13 miles. We have seen how the Lligwy Sandstone gradually mounts to. higher and higher horizons, finally disappearing at Llangefni; and how the D sub-zone is overlapped near Graig-fryn. We now can trace the Limestone Series dwindling from 1,300 feet at Lligwy to 500 feet at Llangefni, 150 feet at the main line of railway, and finally to nothing at the Bodorgan woods, the Millstone Grit coining, as will be seen in Chapter 24, to repose directly upon the Mona Complex at Bodorgan. The whole of the Limestone Series has thus been overlapped in the course of 13 miles, a rate of 100 feet per mile. At the Straitside Area there is also an overlap, for the D1 sub-zone is missing. Overlap is again pronounced in the Penmon Area, for the whole of the D1, and at least the lower part of the D2 sub-zones, disappear between Careg-onen and Penmon, the overlap in this case being in an easterly direction. Moreover, the Lligwy Sandstone is missing at Careg-onen, so the eastward overlap has already begun, and must prevail almost all the way from Lligwy to Penmon. Finally, there is indirect evidence (see Chapter 33) that all round the north-western and western confines of Anglesey the Posidonomya cherts lay directly upon the Ordovician and the Mona Complex, and that the Dibunophyllum limestones were never deposited at all upon those parts of the Island. There must therefore have been overlap from Lligwy to the east-south-east, south, south-west, west, and north-west; from

Careg-onen to the east, south, and south-west; and from Fanogle to the west-south-west and west.

Unconformity

That the Carboniferous Limestone rests upon the Mona Complex and the Ordovician with an unconformity of the first magnitude is obvious from the maps, and the discordance is visible at Bodorgan and at Careg-onen (Figure 194), (Figure 298). Its relation to the Old Red Sandstone might be supposed to be merely that of overlap, like that of the several members of the series upon one another; but the evidence given in Chapters 20 and 21 leaves no doubt that unconformity prevails in this case as well. The break between the formation and all its predecessors is therefore complete in this district. There is also (p. 619) a suspicion of unconformity at the base of the Millstone Grit.

Composition of the sub-Carboniferous floor

Interesting light is thrown upon this by a comparative study of the conglomerates, combined with the stratigraphy.

The Old Red Sandstone (see Chapter 20) can have covered but little of the surface of that time, and the Carboniferous rocks passed quickly across it on to the older formations. From Lligwy to Llangefni, however, they rest upon it. From Llangdni to Bodorgan they rest upon the Mona Complex, as they do along the opposite side of the Malldraeth, and also in the Straitside Area, though just across the Strait they rest upon Arenig shale, as they must in the Malldraeth syncline itself. In the Penmon Area, and at the Dulas outlier, the floor is wholly of Ordovician rocks. But on the Pre-Carboniferous land as a whole the Mona Complex must have been much more extensively buried than it is in the Anglesey of to-day.

We have seen (p. 602) that the nature of the basement conglomerates of what we have termed the south-western quadrilateral indicates direct derivation from the Mona Complex, and here, accordingly, we find that the Carboniferous base reposes directly thereupon, and that the Complex was exposed.

The peculiarities of what we have called the normal conglomerates indicate, therefore, some difference in the conditions of erosion. These peculiarities, and the contrasts with the Ordovician conglomerates (which we know to have been derived directly from the Complex) have been described on pp. 602–3; but a brief recapitulation of them in tabular form may conduce to lucidity.

Ordovician Conglomerates

1. Nearly all Mona Complex represented
2. Nearly all Mona Complex represented
3. Augen-quartz quite subordinate
4. Matrix green with chlorite
5. Contents dependent on locality

Carboniferous normal conglomerates

1. Only-Penmynydd and Gwna rocks represented
2. Only durable members of those divisions represented
3. Augen-quartz dominant
4. Matrix pale brown or colourless
5. Contents independent of locality

For the source of the Penmynydd and Gwna pebbles we need only look to those parts of the Middle and Aethwy Regions that have just been shown to have been bare in Carboniferous times. If, however, the rest of the Complex had then been as open to the sky as it is to-day, why should not the Carboniferous conglomerates, especially the northern ones, be full of the gneisses, granites, hornfelses, and other crystalline rocks that crowd those of the Ordovician? Their absence is not to be explained by direction of transport, for we shall see that the drift of pebbles, instead of being away from, was actually towards the positions of the present Carboniferous areas. One case is peculiarly instructive. Boulders of the rocks of Parys Mountain, as we have seen (pp. 567, 602), found their way to Lligwy. In the course of their journey they had to pass across the Nebo Inlier of the Mona Complex. Yet not a single fragment of the Nebo Gneisses has been found in the Lligwy Bay conglomerate! There is no escape from the conclusion that, in Carboniferous times, the greater part of the Mona Complex lay buried beneath a cover of Ordovician rocks.

In the light of this revelation, let us examine the other four contrasts given in the Table. The southern parts of the Complex lay bare. Yet (item 2 of Table) even of their rocks, only the most durable survive as pebbles. They must therefore be erratics, the less durable having succumbed to the wear and tear of travel — travel, as we may now discern, on to and across wide tracts of the now dwindled Ordovician shield.

Next: the striking contrast between the proportion of augen-quartz in the two systems (item 3 of Table) becomes intelligible. The Carboniferous conglomerates we have seen to have been fed from the Aethwy and eastern Middle Regions, tracts in which augen-quartz is extraordinarily plentiful. And, as it was the most durable of all their pebbles, natural selection, during the journey across the margins of the Ordovician shield, would eliminate even some of the other four durable materials, until it attained to the high percentage that we now see. Its journey, however, was rarely long enough to smooth off every irregularity of surface.

The differences of colour (item 4 of Table), too, receive their explanation. The pervading tint of the Mona Complex is due (see pp. 148–9) to chlorites, which would be the first of all its minerals to succumb to the hardships of a journey.

With regard to the fifth item: it is not difficult to see that the contents of the Ordovician conglomerates, being derived directly from the Mona Complex, would vary with its rapid local variations.

Those of the Carboniferous, on the contrary, came from tracts composed only of Penmynydd and Gwna, with some narrow strips of Tyfry rocks. Moreover , the erratic pebbles would mingle on the journey, and the mixed shingle would be of constant composition.

Finally, with the elimination of all but the five durable members, those alone, and in proportions determined by their several dura-bilities, would be supplied to all the normal conglomerates, irrespective of locality.

It may be asked, what has become of the Ordovician material itself. A few pebbles of the grits are usually to be found, but they are seldom numerous. Now, the only extensive outcrops of these grits are in the western parts of the Island, and the Ordovician grits, hard though they be, are full of chlorite and clastic albite, and would be chemically unstable under the severe weathering to which they would be exposed in so long a journey. Towards the east, by far the greater part of the Ordovician series consists of shale, which could do little but contribute to the frequent black shales of the Carboniferous. Ordovician pebbles, therefore, are not to be expected in large quantity. Positive evidence, however, on the point is afforded by the contents of the oldest of the Carboniferous conglomerates, the often-referred to boulder-bed of Lligwy Bay ((Figure 291) and (Plate 35)), which is a basement deposit. Its boulders are wholly of Lower Palaeozoic rocks, the most abundant being Ordovician grits.

The whole of the evidence of the conglomerates, whether negative or positive, thus converges to the conclusion that most of the surface presented to Carboniferous erosion was composed, save for the limited tract of Old Red Sandstone, of Ordovician and Silurian rocks, the Mona Complex appearing only on the open cores of the old anticlines, then far less deeply denuded than they are to-day.

Can we arrive at any idea of the number and extent of those exposures? To the north of the latitude of Llangefni we know of none. The only open cores of which there is any positive evidence are those already indicated, in the south-west. - From the nature of the pebbles, it is likely that the Middle Region of the Complex was open to the south of a line drawn through Llangefni, Druid Farm, and Porth Trecastell. From the absence of gneissic pebbles it is questionable whether the Aethwy Region was bare any farther north than the Holyhead main road. The Mona Complex, however, was not bare throughout the whole even of the south-western tracts. The outlier of Trefdraeth (p. 399), now so small, was doubtless larger in Carboniferous times; and in any case, we know that between Red Wharf and Malldraeth Bays, the Carboniferous rocks repose upon the Ordovician of a major syncline (p. 418), which is nearly buried by them.

To sum up: the Sub-Carboniferous floor was composed for the most part of Ordovician and Silurian rocks, traversed by intrusions and locally metasomatised. Towards the east these were interrupted by the long tract of Old Red Sandstone; and in the south-west the Mona Complex was laid bare upon the open cores of two large anticlines.

Physiography

Such being the composition of the Pre-Carboniferous land, is it possible to arrive at any ideas in regard to its featuring Some light is thrown on this subject by the thicknesses and distribution of the sub-zones, if we employ the method already made use of (pp. 427–30), in our attempt at an investigation of the Ordovician physiography. Let us once more take the difference between the thicknesses found at any two points, and divide it by the number of miles between those points, obtaining thus the average inclination, in feet per mile, of the ancient surface.

The total thicknesses are as follows, in round numbers:

	Feet
Lligwy Bay	1300
Careg-onen	900
Fanogle	900
Lledwigan, Llangefni	500
Bodorgan Tunnels	150
Bodorgan Coast	0

Thus we obtain the following gradients:

Llangefni to Lligwy Bay	NNE	100 feet per mile
Bodorgan Coast to Lligwy Bay	NE	100 feet per mile
Bodorgan Coast to Llangefni	NE	84 feet per mile
Bodorgan Coast to Fanogle	ENE	100 feet per mile

In Chapter 33 we shall see that there is evidence that, on the present Sea-floor from Bull Bay to Holyhead Bay, the cherts of the Posidonomya zone are present, the underlying beds being overlapped. If the cherts are of the same thickness as in the Principal Area, we have

Holyhead Bay to Lligwy Bay	E	100 feet per mile
Bull Bay to Lligwy Bay	SE	200 feet per mile
Bodorgan Coast to Holyhead Bay	NW	10 feet per mile

In the Penmon Area, D1 + D2a are overlapped in three and a half miles, which gives

Penmon to Careg-onen	W	200 feet per mile

The sub-zones D1 + D2a have the same combined thickness in the Principal and Penmon Areas, but the Lligwy Sandstone (at least 200 feet) is missing at Careg-onen, and has been overlapped, giving approximately

Careg-onen to Lligwy Bay	WNW	32 feet per mile

At the dawn, then, of the Dibunophyllum episode of the Carboniferous period, an eastern sea was just beginning to encroach upon a slowly subsiding land, wide uplands rising to the south-west, west, and north-west. Land also rose in the direction of Penmon, which may have been connected with the western uplands.<ref>Further light 'will be shed upon the extent of the Penmon rising when the fossil sub-zones of the Orme have been worked-out.</ref> These uplands rose, it would seem, about Bodorgan, to some 1,300 feet above the sea, but extensive tracts that were but little lower swept all yound the west and north of what is now Anglesey. Eastward and north-eastward from Bodorgan, and eastward from Holyhead, they sloped with remarkable uniformity<ref>At Llangefni, howeier (pp. 618, 640), the uniform slope was suddenly interrupted by an ancient quartzite hill 100 feet in height. Between Trefdraeth and Llangristiolus, a 50-foot crag ran for some three miles along the side of the hollow.</ref> at about 100 feet per mile.<ref>Nearly the same gradient, that is, as from Ogwen Lake to the sea at Port Penrhyn, Bangor.</ref> The westward slope from Penmon was steeper, but does not seem to have been maintained. South-eastward from about Bull Bay the gradient of the upland steepened to some 200 feet per mile. Towards Bodorgan, the south-westward rise drops from 100 to 84 feet per mile, as if we were approaching, not a ridge, but a broad and flattening plateau.

Now, if we reconsider all the data, we shall see that, with the exception of the eastward slope towards Fanogle, all the slopes converge towards Lligwy. Lligwy, therefore, marks out the bottom of a broad hollow<ref>The position of the Lligwy hollow would seem to have been determined by the original limits of the Old Red Sandstone, which would yield more easily to erosion than would the old rocks.</ref>, draining eastwards, open to the eastern sea, with slopes for the most part of about 100 feet per mile, except to the north-west, where they seem to have been twice as steep. Into the Lligwy hollow the Lligwy Sandstone steadily thickens and coarsens, and into it were carried fragments of the vegetation of the western uplands. In its bottom is the boulder-bed of Lligwy Bay, with blocks three feet in diameter<ref>By a curious repetition of conditions, the Lligwy hollow and the Lligwy Bay conglomerate stand in much the same relation to the Carboniferous physiography as do the Trewan cirque and the Trewan boulder-beds to that of early Ordovician time, though the Lligwy hollow is nothing like as deep or as steep as the Trewan cirque. But, still more strangely, the repetition is a reversal, for the slope of the Lligwy hollow is in precisely the opposite direction to that of the Trewan cirque.</ref>, and it may be noted that this tumultuous accumulation is just at the foot of the 200-foot gradient. An interesting side-light is thus thrown upon the preservation of the Parys boulders mentioned on pp. 567, 602. Pyritised rocks could hardly have survived the weathering incidental to a prolonged or a slow journey. They would have oxidised and broken up. Their journey, however, was only four miles, and with a gradient double that of the torrential Ogwen of the present day, it would certainly have been performed in quite a short time.

As the land slowly subsided, the eastern sea crept gradually into the Lligwy hollow; and doubtless the numerous abnormalities, such. as the irregular sandstones with limestone ltiinps, the local founderings and unconformities, and the sandstone pipes, are. due to somewhat spasmodic variations in the subsidence, combined with varying circumstances of the erosion of the western uplands, bringing about local contemporaneous erosion in ways which we can as yet understand but imperfectly.

In spite of the long-continued subsidence, large tracts of the western uplands remained (see Chapter 33) above the sea, their elevation reduced (in the parts accessible to us) to 100 or 200 feet, throughout the life-time of the Dibunophyllum fauna. With the advent of the Posidonomya fauna<ref>In this attempt at a picture of the Carboniferous physiography, the reader is asked to remember that our knowledge of the Posidonomya zone in Anglesey, and of its relations to the Millstone Grit, are as yet but imperfect.</ref>, the sea began to creep round and encroach from the north as well as from the east, but even at the close of that faunal episode, a little land (see Chapter 24) seems to have survived in the country about Bodorgan.

Conclusion

The Carboniferous Limestone Series of Anglesey consists of massive grey and white limestones with some groups of dark thin-bedded limestone and shale. Pebbly sandstone and conglomerate are present along most of the base, and at several horizons higher up. Contemporaneous erosion took place many times during the deposition of the series. Nearly the whole formation belongs to the Dibunophyllum zone, the sub-zones D1, D2, and D3 being all present: but the Seminula zone may possibly be represented in the lowest of the basal conglomerates, while some cherts at the top belong in all probability to that of *Posidonomya.* The thickness where most fully developed is about 1,300 feet, but the whole formation has disappeared. by overlap before the western coast is reached. The system rests unconformably upon all older formations, and was deposited upon an old subsiding land chiefly composed of Ordovician rocks with inliers of the Mona Complex, and a long though narrow tract of Old Red Sandstcule. The depositional area seems to have been a broad hollow, opening to the north-east, but closed to north-west, west, and south-west, and partly at any rate to the east as well.

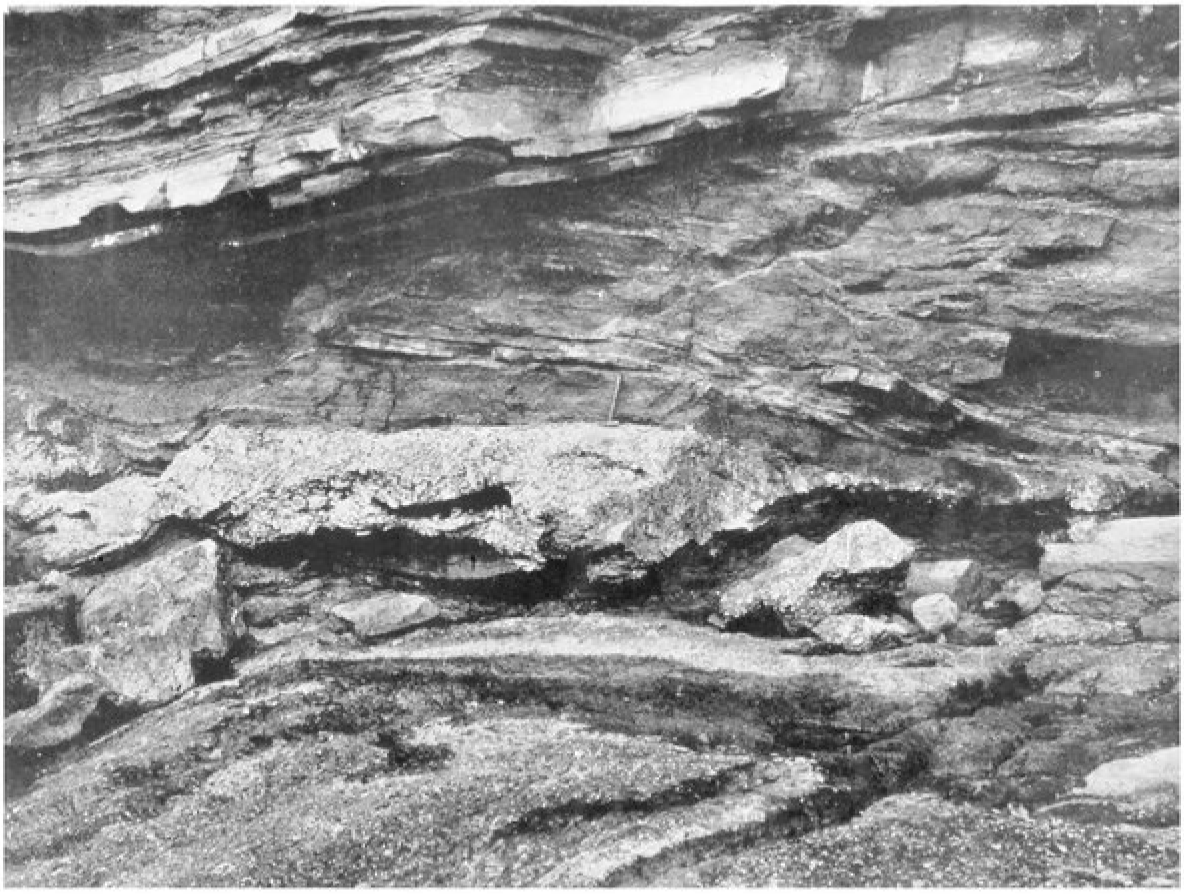
(Plate 35) The-Lligwy Bay Conglomerate. Careg-ddafad.

FIG. 291.—SECTION THROUGH THE CONTEMPORANEOUS DISTURBANCE AND THE LLIGWY BAY CONGLOMERATE, CAREG-DDAFAD.

(Figure 291) Section through the contemporaneous disturbance and the Lligwy Bay conglomerate, Careg-ddafad. Scale: one inch = 75 feet.

(Plate 8) Siliceous Gwna Green-schist with venous quartz-augen. Ynys Gaint, Menai Strait.

(Plate 11) Folded Penmynydd Mica-schist with quartz-augen. Graig-fawr, Holland Arms.



(Plate 36) Limestone conglomerate between false-bedded Sandstones. Borth-wen, Benllech.

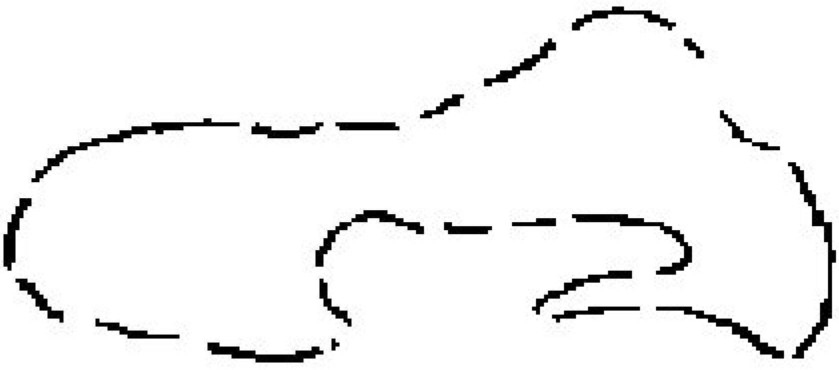
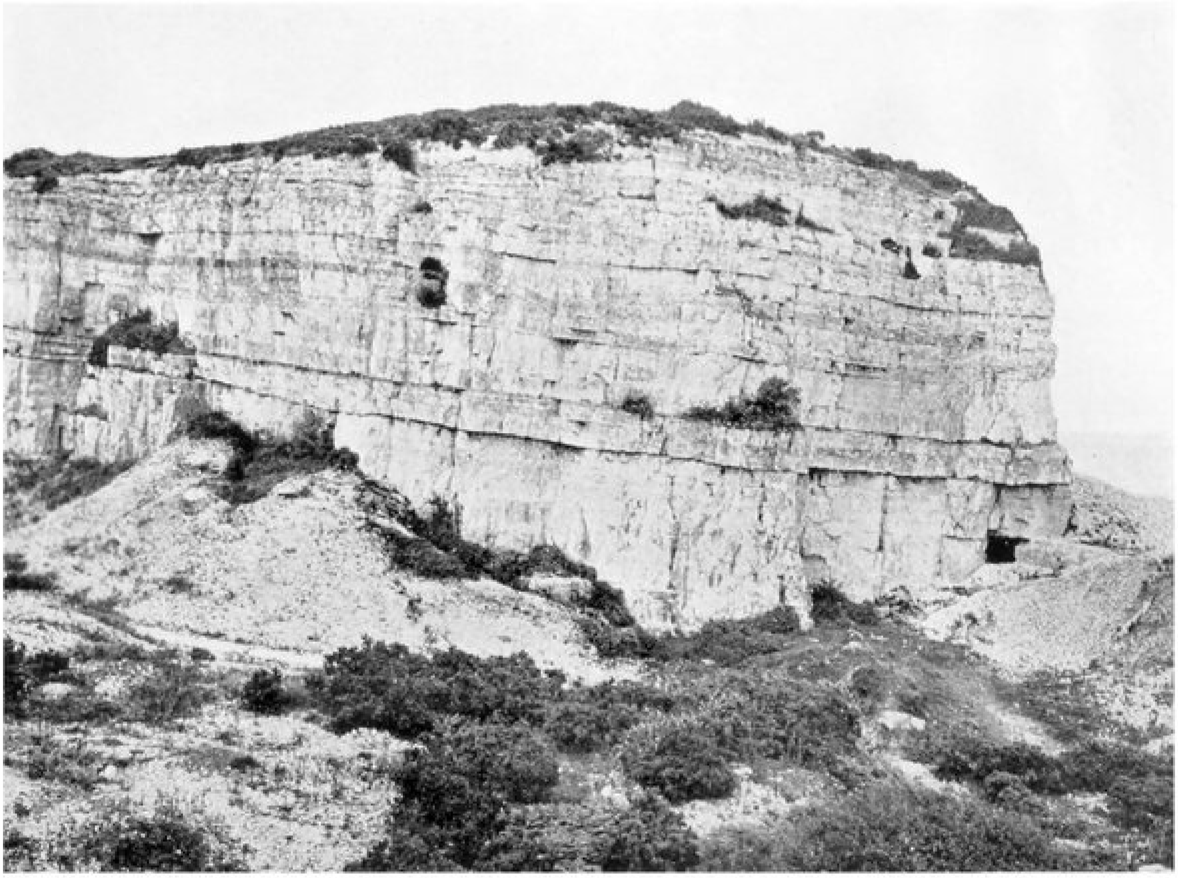


FIG. 286.

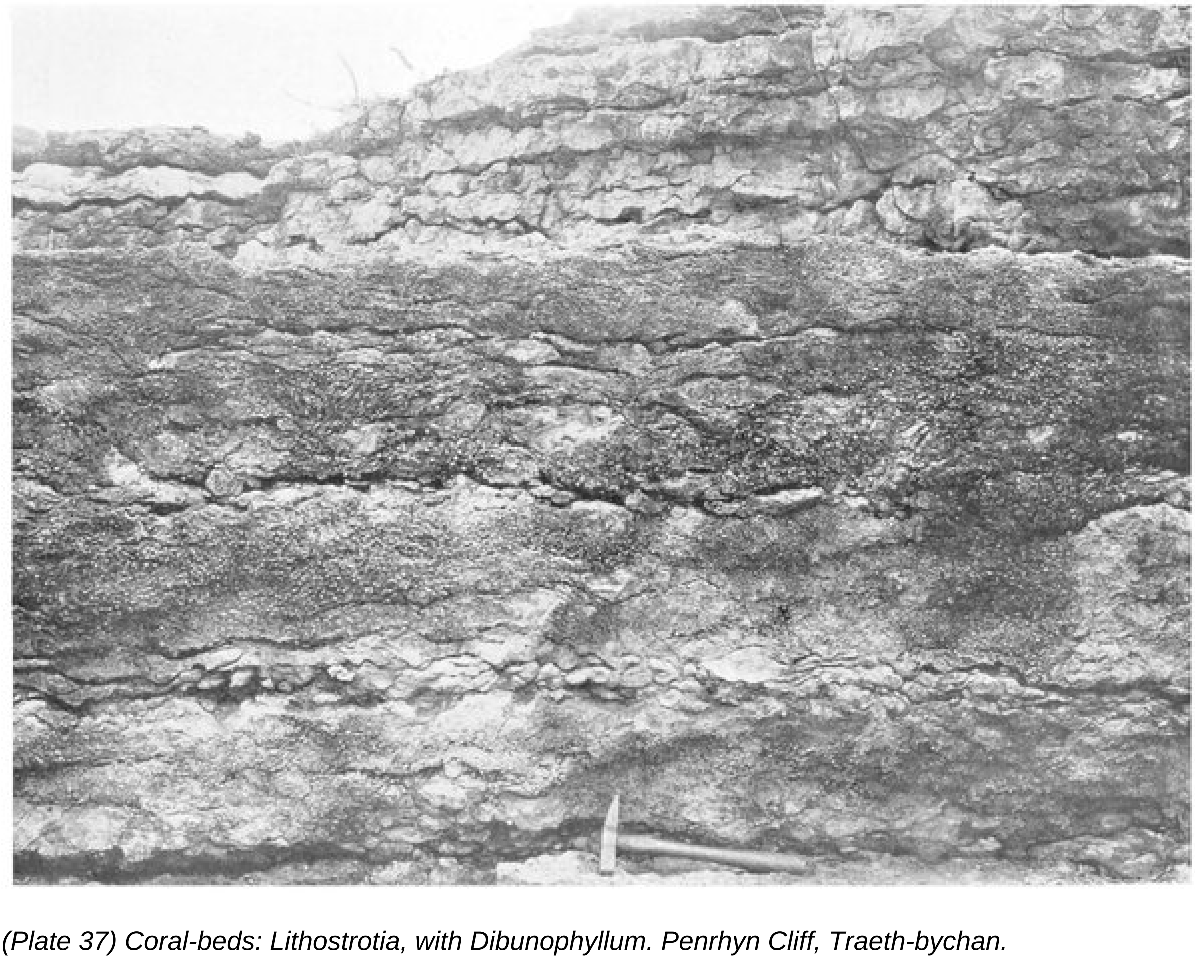
(Figure 286) Lumps in Limestone conglomerates.

FIG. 287.

(Figure 287) Lumps in Limestone conglomerates.



(Plate 40) Outlier of bedded cherts resting upon Carboniferous Limestone. Castell-mawr, Red Wharf Bay.



(Plate 37) Coral-beds: Lithostrotia, with Dibunophyllum. Penrhyn Cliff, Traeth-bychan.

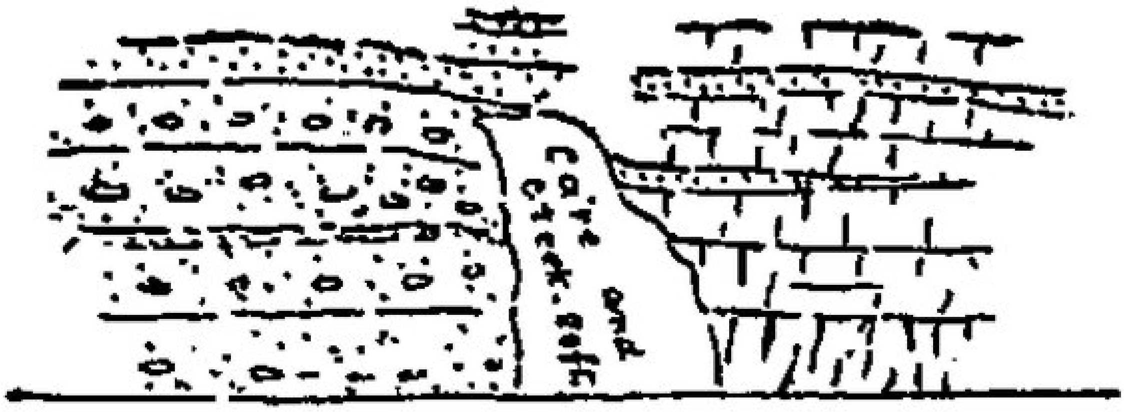


FIG. 288.

ANOMALOUS JUNCTION AT BORTH-WEN, BENLLECH.

(Figure 288) Anomalous junction at Borth-wen, Benllech.

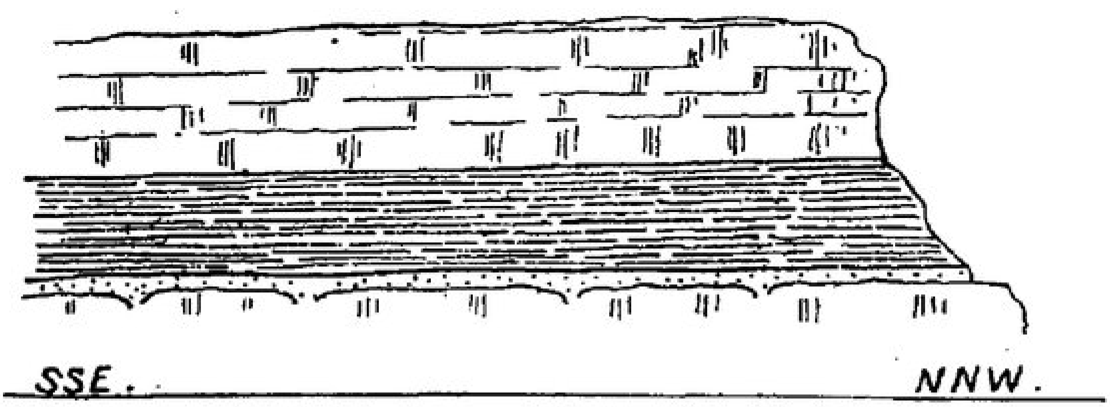
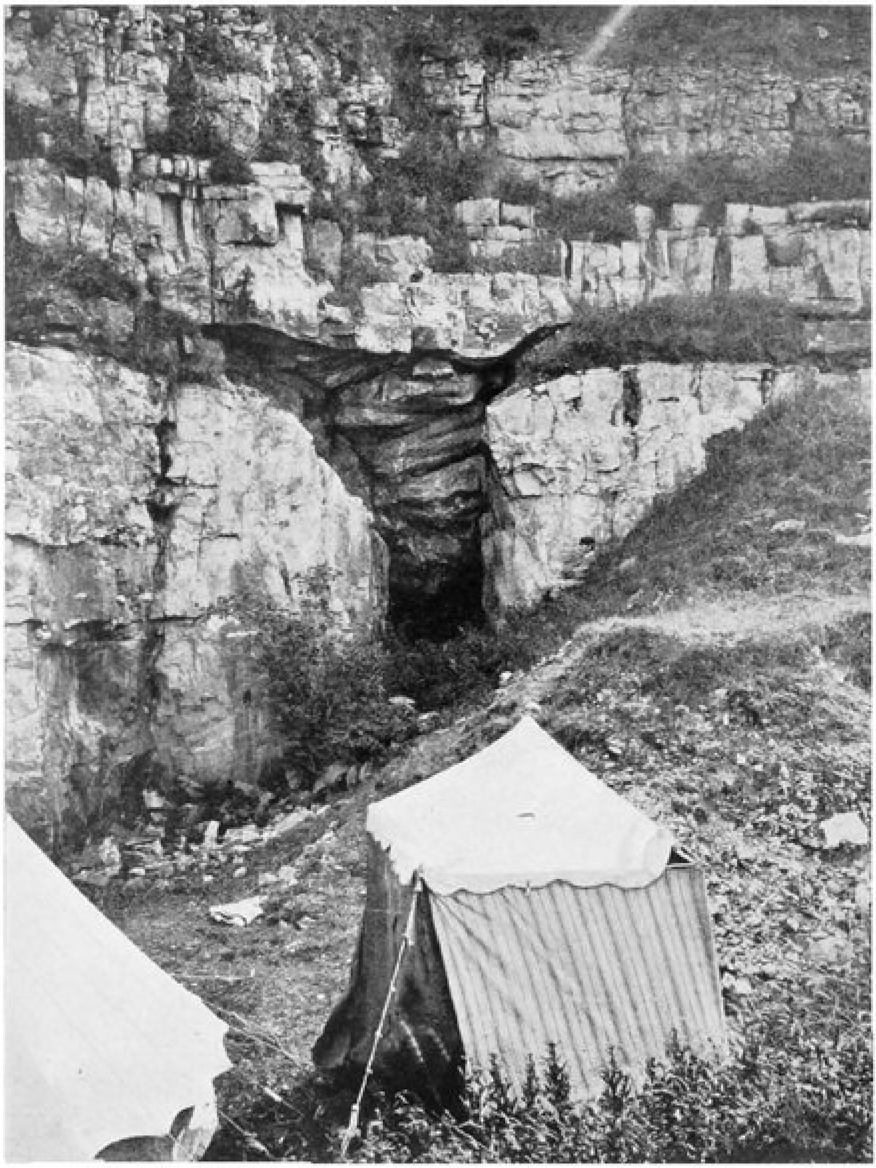


FIG. 289.—THE SUCCESSION AT TRWYN-DWLBAN.

(Figure 289) The succession at Trwyn-dwlban. (piped limestone, pipe-sandstone, shale, upper limestone.)

(Plate 38) Sandstone-pipe in Carboniferous Limestone. Foreshore, Trwyn-dwlban.

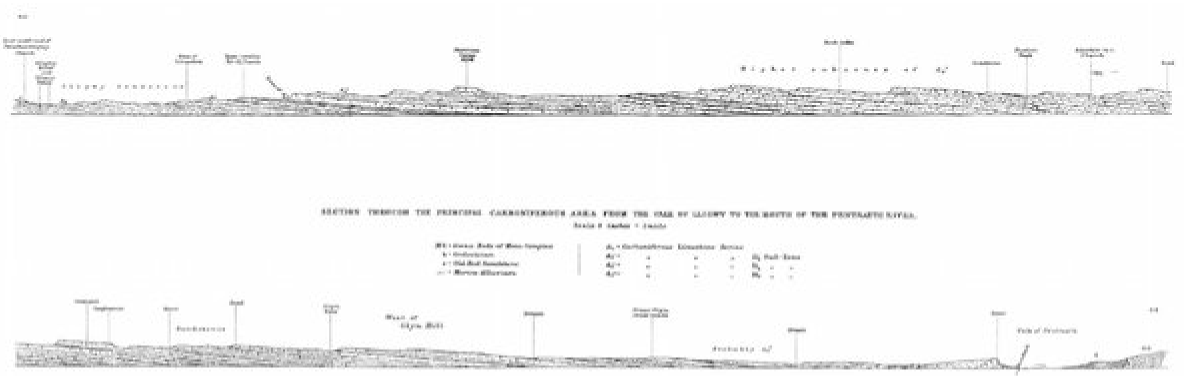


(Plate 39) Large sandstone pipe. Cliff between Castell-mawr and Trwyn-dwlban.

FIG. 290.

FLOOR OF SANDSTONE PIPE AT PORTH-YR-ABER.

(Figure 290) Floor of sandstone pipe at Porth-yr-aber.



(Folding-Plate 12) Section through the Principal Carboniferous area from the Vale of Lligwy to the mouth of the Pentraeth River. Scale 8 inches = 1 mile.

FIG. 293.—GENERALISED SECTION FROM LLIGWY BAY THROUGH MOELFRE POINT.
Scale—Eight inches = one mile.
LBC = Lligwy Bay conglomerate. RCL = Royal Charter limestone. HS = Helaeth sandstone. ML = Moelfre limestone.

(Figure 293) Generalised section from Lligwy Bay through Morlfre Point. Scale eight inches = one mile. LBC = Lligwy Bay conglomerate. RCL = Royal Charter limestone. HS = Helaeth sandstone. ML = Moelfre limestone.

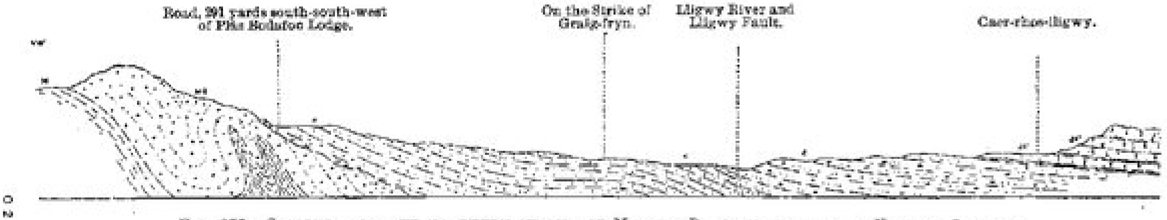


FIG. 277.—SECTION FROM THE NORTHERN SUMMIT OF MYNYDD BODAFON, ACROSS THE VALE OF LLIGWY.
Scale: 7·5 inches = one mile.
Symbols used in Figs. 275, 276, 277, 278.

M = Bodafon Moor Schists, MQ = Bodafon Quartzite } Mona Complex. b = Ordovician.
c = Old Red Sandstone Series. c′ = " " Cornstones. d = Lligwy Sandstone (Carboniferous).
d_2' = D_1 Subzone of Carboniferous Limestone. d_2'' = D_2 " " ". BT = Bodafon Thrust plane.

(Figure 277) Section from the northern summit of Mynydd Bodafon, across the Vale of Lligwy. Scale: 7.5 inches = one mile. Symbols used M = Bodafon Moor Schists, Mona Complex, Mq = Bodafon Quartzite, Mona Complex. b = Ordovician. c = Old Red Sandstone Series. c = cornstones d = Lligwy Sandstone d2■ = D1 Subzone of Carboniferous Limestone. d2■ D2 Subzone of Carboniferous Limestone. BT = Bodafon Thrust-plane.

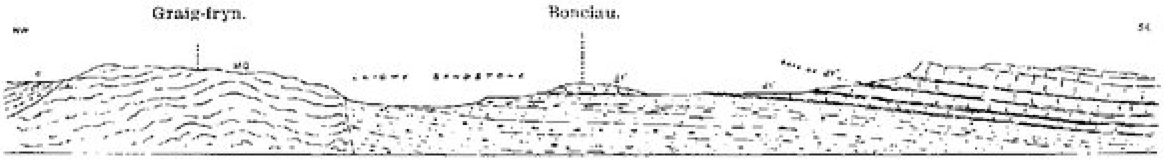


FIG. 296.—SECTION ACROSS THE GRAIG-FRYN INLIER AND THE VALE OF LLIGWY.
Scale—Eight inches = one mile.
MQ = Bodafon quartzite. C = Old Red Sandstone. d'_2, d''_2 = D_1 and D_2 sub-zones of Carboniferous Limestone

(Figure 296) Section across the Graig-fryn inlier and the vale of Lligwy. Scale eight inches = one mile. MQ = Bodafon Quartzite. C = Old Red Sandstone. d■2, d■2 = D1 and D2 sub-zones of Carboniferous Limestone

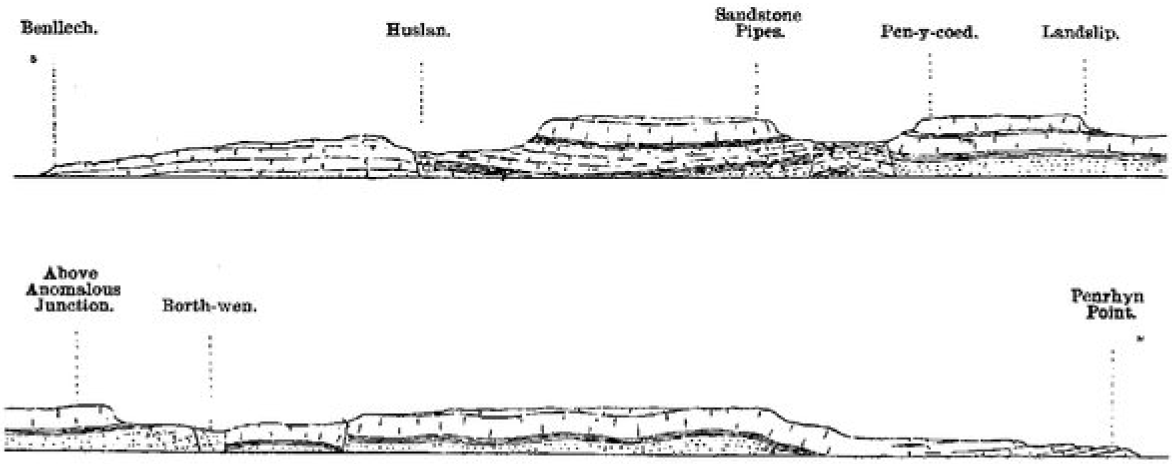


FIG. 294.—SECTION ALONG THE COAST FROM PENRHYN TO BENLLECH.

(Figure 294) Section along the coast from Penrhyn to Benllech. Scale nine inches = one mile.

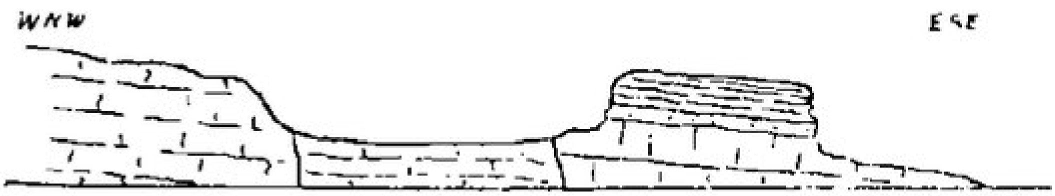


FIG. 295.
CASTELL-MAWR, RED WHARF BAY.

(Figure 295) Castell-mawr, Red Wharf Bay. Scale nine inches = one mile.

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.

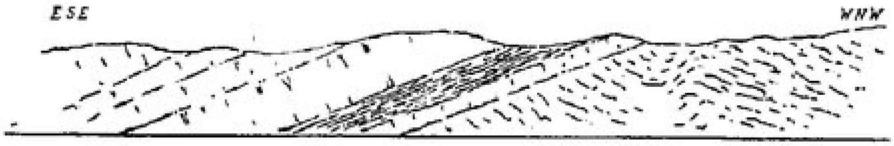


FIG. 298.—THE CARBONIFEROUS LIMESTONE RESTING ON THE MONA COMPLEX.

(Figure 298) The Carboniferous Limestone resting on the Mona Complex. Railway cutting, Bodorgan.

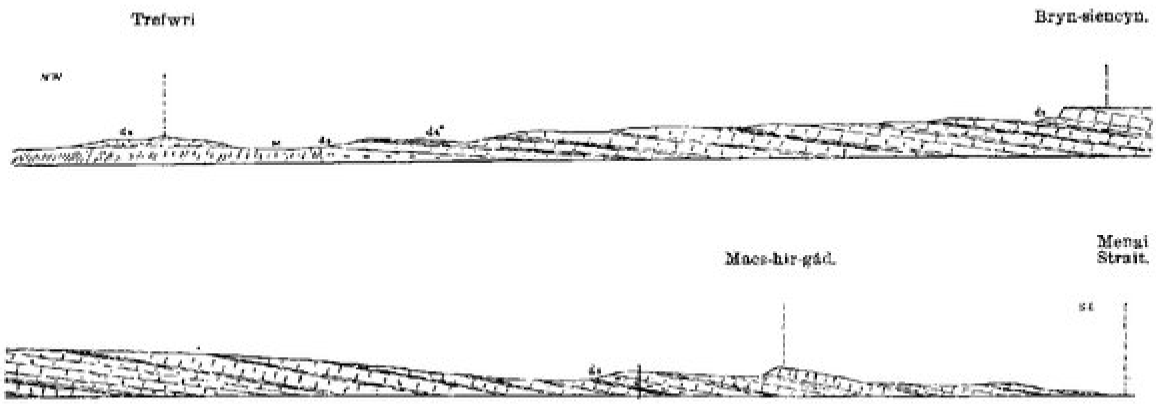


FIG. 299.—SECTION THROUGH THE STRAIT-SIDE CARBONIFEROUS AREA, FROM THE TREFWRI OUTLIER TO THE MENAI STRAIT.
Scale—Eight inches = one mile.
M = Mona Complex. ds = Carboniferous Sandstone. d_2 = Carboniferous Limestone.

(Figure 299) Section through the Strait-side Carboniferous area, from the Trefwri outlier to the Menai Strait. Scale eight inches = one mile. M = Mona Complex. ds = Carboniferous Sandstone. d2■ = Carboniferous Limestone.

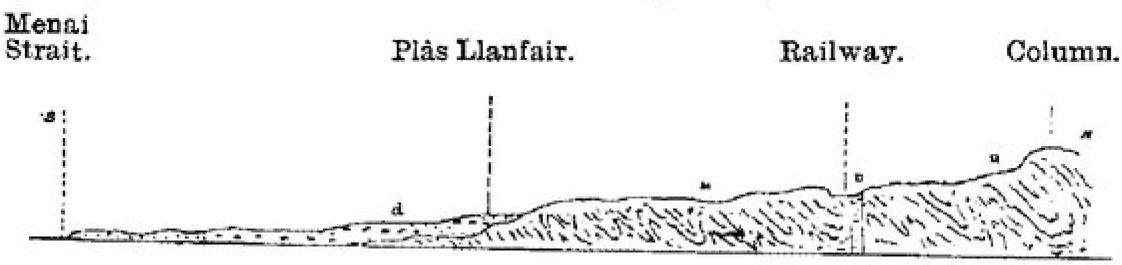


FIG. 300.—CARBONIFEROUS BASE AT PLAS LLANFAIR.

(Figure 300) Carboniferous base at Plâs Llanfair. Scale eight inches = one mile.

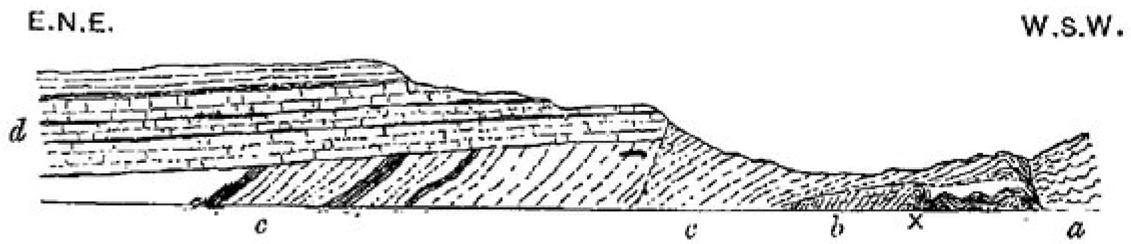


FIG. 194.—SECTION ALONG THE CLIFFS AT CAREG-ONEN.

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).

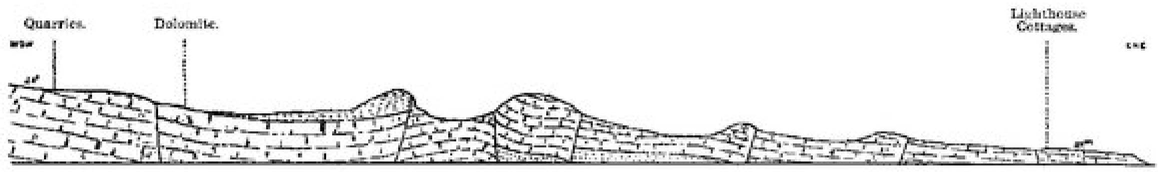


FIG. 301.—SECTION ALONG THE COAST FROM THE PENMON QUARRIES TO THE EAST POINT OF ANGLESEY.

Scale—16 inches = one mile.

d_2', d_2'' = D_2, D_3 sub-zones of Carboniferous Limestone.

(Figure 301) Section along the coast from the Penmon Quarries to the east point of Anglesey. Scale-16 inches = one mile. d2■,d2■ = D2, D3, sub-zones of Carboniferous Limestone.

The Skerries. From near Carmel Head.

[Face page [illegible]

[Face page [illegible]

Careg-onen Cliffs.
Mona Complex, Careg-onen Beds, Ordovician Shales, and Carboniferous Limestone.
Height seen = about 330 feet.

(Plate 26) The Skerries. From near Carmel Head. 26a Careg-onen Cliffs. Mona Complex, Careg-onen Beds, Ordovician Shales, and Carboniferous Limestone [Note.—The crags in the foreground are composed of the Careg-onen Beds, ex where to 1¾ to 2 and one eigth inches from right hand edge of view) the sharp anticline of G Green-schist (Figure 194), (Figure 195) rises from under them.].