# Chapter 6 The succession in the Mona Complex

## Introductory

Local successions can be made out in the several isolated regions and inliers of the Mona Complex, but these must all be brought into harmony before a general succession throughout the Complex can be established. Now the scheme of colours and symbols that has been adopted on the one-inch map for the various sub-divisions of the Complex has been applied throughout, the New Harbour Beds of Holyhead, for example, being coloured and lettered with the Amlwch Beds, the Church Bay Tuffs with the Skerries Grits, and so on. But, from the foregoing petrological description, it will already have appeared that the same colour and letter has been applied in several cases to formations that differ considerably in character; that the scheme, in fact, implies a number of correlations. These have, indeed, been incidentally alluded to in the petrological descriptions. Evidence for them will now be given.<ref>Attention is drawn to the fact that the validity of these correlations, while affecting, of course, the colour- and symbol-scheme, does not in any way affect the maps as such. The lines laid down upon them are completely independent of these correlations.</ref>

A general scheme of the succession will, then, be put forward, with brief accounts of the sections upon which it is founded.

## Correlations within the Complex

Such fossils as have been found in the Mona Complex, though of great interest, cannot yet be utilised for purposes of correlation; and correlations of unfossiliferous rocks may, even when they are comparatively undisturbed, be vitiated by change of facies. Where disturbance is great, and metamorphism has set in, the risk is still greater; and, therefore, the correlations which will now be set forth are put forward with reserve. The geographical extent of the exposed portions of the Complex, however, is not large, hardly affording space for change of facies so great as to prevent recognition. And, what is much more important, though moderate changes of facies must be admitted, yet the greater subdivisions of the Complex contain members with persisting characters, by whose presence the identity of the changing members can be recognised.

***Holyhead Quartzite and South Stack Series*** — The quartzite of Rhoscolyn has the same characters as that of Holyhead, and stands in the same relation to the South Stack Series. The South Stack Series itself undergoes no change of consequence all over Holy Isle, and is easily recognisable, the only local variation being that the beds adjacent to the Quartzite are less massive at Rhoscolyn than they are above the South Stack. In the Coeden Beds, identified with this series, there is a change of facies, but it is not great. The grits are rather thinner, usually darker, and weather cream-colour instead of white; but there is a great deal of a peculiar fine bluish-green grit, which is very prevalent (E9313) [SH 231 821]–(E9314) [SH 217 798] in the South Stack Series. Like that series, they are free from volcanic bands. Certainly they cannot be identified with the Skerries Grits, which, only half-a-mile away, are coarse, massive, and ashy, so that specimens can be distinguished at a glance. In short, they resemble the South Stack Series more nearly than any other group in the Complex, with differences easily explicable by a slight change of facies, so that the decision rests with the stratigraphy, and will be considered below.

***The New Harbour Group*** — The Amlwch Beds differ from the New Harbour Beds of Holy Isle chiefly in the sharp individualisation of their thin grits, which are also rather coarser. But there are persisting beds common to the two. The spilitic lavas of the Amlwch Beds are of precisely the same type as those of the New Harbour Beds, and the associated jaspery phyllites and pale bedded jaspers are indistinguishable in the two series. Thus three members of marked character pass on unchanged, and it is therefore inferred that the Amlwch Beds are a northern facies of the New Harbour Group. In confirmation of thisit is to be noted that the Lynas alternating beds of the north correspond in character to the Soldier's Point beds of Holy Isle and the west, the latter becoming still more like them at the Garnlier, while the Bodelwyn beds of the north approach the character of the fine Celyn beds of Holy Isle. Further, that it is in the Soldier's Point and Lynas beds that the spilitic lavas and jaspers occur in the two regions respectively. And finally, that the relative positions of the sub-groups are as follows:

| | | |
|---|---|---|
| South Stack Series (Llwyn Beds) | | Coeden Beds |
| {Celyn Beds | Pelitic | Bodelwyn Beds} |
| {Soldier's Point Beds | Psammitic (with lavas and jaspers) | Lynas Beds} |
| Church Bay Tuffs | | Skerries Grits |

thus confirming the correlation in a remarkable manner, and showing that the change of facies is less than at first sight appears. This correlation is of great importance, as, once established, it adds weight to the evidence for all the other identifications of groups in the Northern Region.

***The Skerries Group*** — The Skerries Grits resemble the Church Bay Tuffs, with part of which they are correlated, in that their matrix is a pyroclastic porcellanous epidosite of the same nature as that which often makes up the body of the latter; in which, when grits occur (as on the Rhos-y-cryman coast) they are of thorough Skerries type. An extraordinary massiveness, with occasional impersistent bedding, is a marked character of both. Most important, however, is the fact that both of them contain fragments of the same peculiar felsitic and granitoid micropegmatites, which are developed on such a great scale at The Skerries, indicating that both drew their materials from the same supply. It is therefore inferred that the Sherries Grits are a northern, gritty facies of part of the Church Bay Tuffs; and, as their quartz (see p. 59) is largely pyroclastic, the difference is less than appears at first sight. In the Trwyn Bychan band, Church Bay types act as a matrix to the part of the Skerries Grits with which they alternate. Reasons have already (p. 62) been given for referring the Tyfry Grits to the Skerries Group, in which case they must be regarded as an eastern facies of the Church Bay Tuffs. The pyroclastic nature of some of the hornfels of the Coedana granite has already been dwelt upon; and the field-aspect of the crypto-crystalline variety often recalls that of the Church Bay Tuffs. Thin short basic bands occur in both (see pp. 94, 284, 334). Where least altered, the porcellanous epidosite of those tuffs is constantly suggested, and there is the same rare and impersistent bedding. The hornfels as a whole cannot possibly represent any of the well-stratified members of the Complex, and so the massive Church Bay Tuff is the only member which it can represent, a conclusion confirmed by its relations to the rocks of Bodafon.

***The Gwna Group*** — The identification of the Gwna Bed's in the several districts, in spite of the disruption and deformation they have undergone, presents but little difficulty. The autoclastic mélange and green-schist have essentially the same characters all the way from Garth Ferry to Carmel Head and from Llanddwyn to the Corwas Inlier. In the Gynfor district there is but little volcanic matter, but as that is plentiful at Carmel Head and Wylfa there is no real northern facies. Now it is true that sediments like those of the Amlwch Beds could furnish a mélange and green-schist which might be confused with those of the Gwna Beds, so that reliance on the characters of these rocks alone might lead to erroneous correlations. The Gwna Beds, however, contain a quartzite, a limestone, a graphitic phyllite, and nodular jaspers which are peculiar to themselves, with spilitic lavas and tuffs that are unlike the spilitic lavas of the Amlwch series. Of the special members, only the jaspery phyllites could be confused; and the associated jaspers are quite unlike in the two cases. All or some of these characteristic members are found in every one of the Gwna districts, and it is they that sustain the correlation. All of them are present in the Middle Region, and the quartzite is never absent anywhere. In the Corwas Inlier it and the green-schist are the only members. In the Aethwy Region the lavas and jaspers are finely developed. At Gynfor they are on a very sma 11 scale, but the quartzite, limestone, and black phyllite attain their maximum. The Bodafon quartzite is assigned to this horizon, because (apart from its staining) it has all the usual characters of the Gwna quartzite, and differs widely from that of Holyhead, the only other quartzite of the Island, whose associates are totally absent at Bodafon, while the Bodafon Moor beds are certainly of Gwna type. Although there is no northern Gwna facies, there are western and eastern facies, parted by a line, or group of lines (which are not laid down on the maps), running up Gwna Vale, and thence east of Mynydd Bodafon to Llaneilian. In the western facies the limestones are grey, with graphitic phyllites, the quartzite rather thick, and the spilitic lavas very thin. In the eastern facies the graphitic phyllite is absent, and many of the limestones are manganous and full of spilitic lapilli; while the lavas are vastly thicker, appearing on two horizons (the Engan and the Llanddwyn spilites), with one of which there are spilitic tuffs. The alternating grits and phyllite (now largely autoclastic mélange) also thicken enormously. Thus: the western facies is dominantly sedimentary and relatively thin as a whole; the eastern facies contains a great volcanic development and is very thick. No transitional facies appear even along the partino. line. That line is also the parting between the Church Bay Tuffs and Tyfry Beds, which are southern and eastern facies of the Skerries Group.

***The Fyllyn Group***, in anything like its original condition, is known only at the Fydlyn,Inlier. No other facies has as yet been detected, though there is reason to suspect (see p. 233) that it thickens greatly in a south-easterly direction.

***The Penmynydd Zone of Metamorphism*** — Evidence as to the horizon of the recognisable parts of the Peiimynydd Zone has already been given in considering the origin of its rocks. The sedimentary component is undoubtedly the Gwna Group. A suggestion *was* thrown out on p. 127 that the felsitic element (always largely, sometimes wholly, sodic) might represent the Fydlyn rocks. Good evidence for that suggestion will presently appear.

***The Gneisses*** — With regard to the mutual relations of the gneisses, there need be no hesitation in regarding those of all the several inliers as essentially one and the same formation or metamorphic zone. The same albite-granites, and the same albite- oligoclase-biotite-gneisses, with the type-mineral sillimanite, are common to them all.

The Coedana granite, with its porphyritic orthoclase and hornfels-alteration, is regarded as distinct—a later intrusion from a potassic magma.

## Order of succession

Evidence as to the order of succession of the greater clastic subdivisions of the Complex is to be found in its western tracts to the south of the Carmel Head thrust-plane, untroubled by any change of facies. But the link between the Skerries and New Harbour Groups is much better exposed in the Northern Region, so that if the correlations just now made have been correctly made, the chain of evidence is complete. In which direction that succession should be read, which, that is to say, is its true order chronologically, will be considered further on.

The key to the succession is in Holy Isle.

***Holyhead Quartzite and South Stack Series*** — By the road along the south side of Holyhead Mountain, on each side of the word Reservoirs', felspathic massive grits with seams of mica-schist of the same type as those of the great cliffs that look down upon the South Stack, rise from below the Holyhead Quartzite and graduate up into it. On the high moor to the east of the Stack two small outliers of white quartzite rest, infolded, upon the South Stack Series (Figure 28). At and west of Ynys Wellt point the South Stack Series graduates imperceptibly into the quartzite. On the cliffs of Rhoscolyn (Folding-Plate 2) the quartzite is seen six times to rest upon or be folded into the South Stack Series, the junction being conformable to the bedding of that series. At Rhoscolyn Head the change is so gradual that the line drawn is really arbitrary. In the chasm 200 yards to the south-east of the Head the junction (rather sharper) is clearly seen on the face of a great cliff. The South Stack Series and the Holyhead Quartzite are therefore adjacent members of the succession.

***South Stack Series and New Harbour Beds*** — The South Stack Series (and always its Llwyn member) is also seen, at a number of places, in relation to the Green-mica-schists, and the junction is clearly exposed at three sections near Stryd; at the large 'H' to the west-south-west (Cae-allt-wen. crag of six-inch map); by the dyke on the Porth Dafarch road; at and east of Bodwradd; by the Lifeboat Station, Rhoscolyn; in Borth Wen; and at three sections on the curve thence to Pentre-iago. At all these sections there is a rapid but unbroken change from the one type of sedimentation to the other. Further, at all of them (except the northern Stryd section, which is not quite deep enough—see p. 266), and at some ten places more, where, without actual exposure of the junction, the two series are seen close together, a little albitic basic band (Figure 29), (Figure 30), 31), usually from six to twelve inches thick, is found. It is not at the junction, but about a yard within the Green-mica-schists, graduating into them, and is unaouoteuty a basic tuff. At Borth Wen, Rhoscolyn, it thickens out to several yards, and assumes the characters of the spilitic lavas of the group, but thins rapidly to six inches when followed round the curve. At more than twenty places, therefore. a thin snilitic tuff is found within the Green-mica-schists, always about a yard from the junction with the South Stack Series. That junction, consequently, must be regarded as a true horizon.

But if the South Stack Series be adjacent to_the quartzite on the one hand, and to the New Harbour Beds on the other, they must lie between those two, which they can actually be seen to do between Rhoscolyn Hill and the Lifeboat Station, so that the succession in Holy Isle is:

Holyhead Quartzite

South Stack Series

New Harbour Group

***New Harbour and Skerries Groups***. At Porth-y-defaid the New Harbour Beds are succeeded by the main mass of the Church Bay Tuffs: but there is evidently a rupture, for Gwna Beds are brought against the same line inland, and a (later) dislocation is actually visible on the low foreshore. Yet on the north side of this there is a 50-foot band of green-mica-schist, finer than that to the south, but, like it, containing thin seams of jaspery phyllite. It would appear, therefore, that the dislocation is dying out seawards and that the margin of the New Harbour Beds just escapes upon its further side. This band is highly epidotic, and graduates in clear exposures into the Church Bay Tuffs, which also contain thin purple seams for a few yards more. At their northern end close to Yr-ogo-goch (though the New Harbour Beds do not appear) the tuffs contain many thin bands of pale bedded jaspers and green grits like those found at the margin of the New Harbour Group. Bands of the tuff, somewhat metamorphosed but easy of recognition, alternate with the New Harbour Beds (there also containing purple phyllites) at Brwynog. A few yards east of Llanddeusant Church a massive epidositic tuff of Church Bay type appears among, and graduates into, the Green-mica-schists; and a very fine one with wriggling vcinlets like those of Llanrhyddlad behaves in the same way on the coast at Penial. Whether these be nips of the main tuffs is not known, but even if not, they show that explosions of the same kind were taking place during the deposition of that part of the New Harbour Group. At the Garn, typical Church Bey Tuff, highly sheared, succeeds the Green-mica-schist all across the inlier (Folding-Plate 9). The actual junction is not laid bare by any one section, and as the change, where it occurs, is a little more rapid than would be expected at a passage, there may be a small rupture. Only a small one, however, for the approach to the change is quite gradual, both rocks passing into a fine crypto-crystalline platy schist of intermediate character. In the New Harbour Beds, a few yards from the line, is a band resembling the tuff, also a thin basic schist with bedded pale jaspers; and similar jasper occurs also in the tuffs for a few yards close by, thus indicating a natural junction. None of these sections, taken by itself, furnishes a demonstration, but taken together they leave no serious doubt that the New Harbour Beds are adjacent to the Church Bay Tuffs.

Passing to the Northern Region, it will be found that the relations between the Amlwch Beds and Skerries Grits are absolutely clear. On the rugged western cliffs of Bull Bay thin hard bands begin to appear in the southern part of the massive Skerries Grits, and increase in numbers until there is a perfectly gradual passage by change of material, into the Amlwch Beds. Indeed, the position chosen for the boundary is arbitrary, and intermediate types are found all along the line to the westward, inland. Thin jaspery phyllites, which occur in the gritty tuffs to the north of the junction, also knit the groups. At the east end of the Middle Mouse a massive purple-green pebbly tuff, intermediate between the Tyfry and the Skerries types, graduates by alternations into flaggy Amlwch Beds. A similar tuff appears among the Amlwch Beds, and displays the same relations, at Porth-y-gwartheg.

Along the southern side of the main outcrop of the Skerries Grits, especially at the 'a' of 'Llanfechell', at Bwlch, and at Pen-yr-orsedd, the Amlwch Beds alternate with them for a few yards. But the finest section of all is where the same line runs out to sea at Llanrhwydrys Church. It should be visited at low water. Just beyond a small fault and a dyke is a cliff at whose foot the Amlwch Beds, typical thin hard grits with phyllites, dip under massive ashy Skerries Grits with little acid fragments. In the cliff itself thin fine beds occur among the coarse massive ones, both being impersistent, and the junctions being sometimes irregular and quite unsheared. There is a clear passage from the Amlwch to the Skerries Group. Indirect evidence of the stratigraphical unity of the two groups is found at Amlwch, on the cliffs 300 yards east of the end of the path that comes from the Coastguard Station, where the flaggy Amlwch Beds themselves are pebbly. Their junction with the Skerries Grits of the East Mouse cannot be many yards away beneath the sea. But the pebble contents of the Amlwch Beds are the same as that found upon the Mouse; indicating that, for some time, they were drawing their materials from the same source. If, then, the Amlwch Beds be rightly correlated with the Green-mica-schists of Holyhead, no doubt can remain that the Skerries Group and the New Harbour Group are adjacent members of the succession. On the western cliffs of Bull Bay the Skerries Grits are seen to lie between the Amlwch Beds and the Church Bay Tuffs.

***Skerries and Gwna Groups*** — That the Gwna Beds adjoin the Skerries Group is clear on both sides of the Carmel Head thrust-plane. At Brwynog, Rhyd-wyn and Gareg-Iwyd to the south, and at Mynachdy, Caerau, and Llyn Llygeirian to

the north of it, epidositic ashy matter of Church Bay and Skerries type is inextricably involved with Gwna Green-schist. At the south end of Porth Swtan the junction is exposed. The foreshore west of the '73' level is composed of typical Church Bay Tuff, in which are small fragments of a pink felsite. At the foot of the cliff close by, where the roadway comes down to the beach, the body of the rock is identical with the decomposed parts of the tuff and, like it, homogeneous, with fresh portions that are good epidosites. In this material the first Gwna quartzites appear, above them foliation sets in, with broken banding, and the whole passes rapidly into decomposing Gwna mélange with many small quartzites, but still ashy between them in places. On the headland south of Porth-yr-hwch (Folding-Plate 10) a clear passage is again seen from one group to the other. A few thin short bands of hard fine siliceous grit appear in the tuff, then these increase in number, and in a few yards the rock becomes a typical Gwna mélange, in which, a little distance to the south, are quartzites, limestones arid spilites. Inland, on the same line, a passage of the same kind is to be seen in the ravine a little west of Pant-yr-eglwys alluvium. All along that line and along the lines of junction to the north-west and north of Llanrhyddlad Church intermediate types are met with, and the boundaries laid down upon the maps are more or less arbitrary. At the Garn Inlier (Folding-Plate 9) the Church Bay Tuffs are succeeded by Gwna mélange, and the junction is well exposed on the escarpment a little way below the summit. Just as at Porth-yr-hwch, fine siliceous grits begin to appear in the previously homogeneous tuff. These grow more numerous; and, the heterogeneous mass at once breaking up under the shearing stresses, we pass in a few yards into Gwna mélange, in which lenticular quartzites then appear. Its matrix is still ashy even at the crest of the escarpment. The same junction is well seen at Hell's Mouth, both on the reefs at the beach and in a rocky chasm a few yards east of them. There is a vertical shear-plane in the chasm, but it is not the boundary, for it lies within the Gwna Beds. In the green tuff, here unusually schistose, a few small autoclasts of pale Gwna grit begin to appear, and then increase in numbers across a width varying from two or three feet to several yards, until the rock has become a typical autoclastic mélange chiefly composed of grit, with here and there a calcareous phacoid. But, though the grits are pale grey, the schistose matrix of the mélange is at first green and full of the fine reconstructed pyroclastic matter of the tuffs, like the usual Gwna mélange further south. There is therefore a passage, as at the other sections.

Such are the best sections across this junction. They leave no doubt that the Gwna lies next to the Skerries Group in the succession, graduating into it. Gwna mélange (pp. 354–6) appears within the Tyfry Beds in the Pentraeth Inliers, and their shear-cleavage is one with the foliation of that mélange, while purple beds like those common in them are incorporated into Gwna Green-schist at Bryn-gwallen. On the shore of the Aethwy Region to the northeast of Garth Ferry (p. 359) the Gwna grits contain fragments of keratophyres like those in the Tyfry grits, and of albite-quartz-felsites and albitic hypabyssal rocks like those of The Skerries. In the Dingle at Llangefni the grits of the mélange contain deformed pebbles an inch and a half in length which are identical with the hypabyssal albitic boulders of The Skerries, demonstrating that the Gwna Beds were then drawing their materials from the same source as did the Skerries conglomerates.

Passage-beds, intermediate in character between Skerries and Gwna type, are well seen about Nant-newydd, Llangefni. At Llangristiolus, 160 yards east of the late dyke and 60 yards north of the footpath to Llan-fawr, is a craglet escarpment that shows bedding well. At its foot are ashy grits with green partings, in which are purple seams just as in the undoubted Tyfry Beds a few yards to the south. At its brow the grits become siliceous and thinner, and at once break down into lenticular mélange with small quartzites. There is a clear passage from the Tyfry to the Gwna Beds by thinning of the beds and by decrease of pyroclastic matter. The same is the case in the railway cuttings at Bodorgan and on the coast near Twyn-y-parc. On the craggy brow south of Porth-ro there is a passage from Tyfry to Gwna phyllite. The Tyfry Beds, therefore, stand in the same relation to the Gwna Beds as do the Skerries Beds with which they are correlated.

At Mynydd Bodafon the massive hornfels graduates into the beds (themselves converted into hornfels) that 'underlie' the Bodafon quartzite. Here also, then, The Skerries and Gwna Groups adjoin and alternate with each other; thus confirming, moreover, the identifications of the hornfels and the Bodafon quartzite with members of those groups.

***Gwna and Fydlyn Groups*** — At Fydlyn the gritty felsitic tuffs alternate for a few yards with Gwna Beds (Figure 32), and are twice seen to graduate into the Gwna mélange between there and Trwyn Crewyn. The Fydlyn rocks are therefore closely linked with the Gwna Group. As they are not seen at the junction with the Church Bay Tuffs they must lie on that side of the group which is remote from the Skerries Beds.

***The Coeden Beds*** — The position of the Coeden Beds may now be considered with advantage. It has been shown that they are more nearly related lithologically to the Llwyn part of the South Stack Series than to any other member of the Complex, and that they cannot be identified with the Skerries Grits. Along their northern margin they adjoin the Amlwch Beds, and are knit with them by a zone of rapid alternation, so that they undoubtedly succeed the Amlwch Beds in the direction away from the Skerries Grits. That, further south, is precisely the position of the South Stack Series relatively to the New Harbour Beds and Church Bay Tuffs. Those two groups, however, are identified with the Amlwch Beds and Skerries Grits. The Coeden beds, therefore, may be with confidence regarded as a facies of the South Stack Series.

Correlating, then, the Northern Region with the remainder of the Complex, we have

The Bedded Succession

| ***South*** | ***North*** |
|---|---|
| Holyhead Quartzite | |
| South Stack Series | Coeden Beds |
| New Harbour Beds | Amlwch Beds |
| Church Bay Tuffs | {Skerries Grits<br>{Church Bay Tuffs |
| Gwna Beds | Gwna Beds |
| Fydlyn Group | |

It will be seen that the correlations made on lithological grounds are sustained in every case by the positions of the beds in the respective orders of succession. The foregoing members constitute that portion of the Complex which will be referred to as The Bedded Succession'.

***The Pennignydd Zone*** is not, indeed, a stratigraphical horizon. But we have seen (pp. 122–6) that its rocks are partly a crystalline condition of the Gwna Beds, partly altered felsite and felsitic tuff. These acid volcanic rocks, therefore, adjoined the Gwna Beds in the succession, but no such rocks are found at the junctions with the Skerries Group, or in that group itself. No facies of that group found in the Middle or Aethwy Regions could have yielded such a product as the Penmynydd acid mica-schists of those regions. The Fydlyn rocks, however, could; and we have seen that they adjoin, and that their felsitic tuffs graduate into, the Gwna sediments on their other side. The felsitic parts of the Peninyny-dd schists may, therefore, be correlated with the Fydlyn rocks.

***Position of the Gneisses*** — The position of the Gneisses remains to be considered, but our knowledge is unsatisfactory, for there are no sections displaying their original relations to any rocks of known horizons. The Nebo Inlier and those about Llanerchymedd and Bryngwran are completely isolated by Ordovician rocks. But they all lie on one great curving zone of strike, and as the small inliers are manifestly one with the great gneiss of the Middle Region, it is clear that a continuous floor of gneiss must range beneath the Ordovician rocks all through the central parts of Anglesey. The gneiss of the Gader Inlier is faulted, on the cliffs, against Gwna mélange full of lenticular grits in a slightly anamorphic matrix. The rocks are in totally different crystalline conditions, and a passage is impossible. At Mynachdy, north of the 'h' and below the drive, Gwna phyllite and quartzite are seen only about nine inches from gneiss, but there is no change in the Gwna rocks, and the junction must be a rupture. The gneiss of the Middle Region is isolated from the remainder of the Complex by the great Coedana granite. At Gwyndy it is seen very close to two of the hornfelses of that granite (which are believed to be modifications of the Church Bay Tuffs), but the change of type is abrupt and the junctions not exposed. On the Holyhead road, between Caerglaw and the ninth mile-post, gneiss and mica-hornfels strike at one another, and a passage is suggested. But again the rocks of the nearest exposures are contrasted, on the north being thorough gneiss, on the south being thorough hornfels; and as the hornfels is a little crushed in the crag that overlooks the road, there is doubtless a fault running east and west, as is indicated by the features. At Holland Arms, on the edge of the high wood, south of the 're' of 'Pentre', there is a 30-yard band of coarse micaceous gneiss along the edge of the basic ones. Just outside the wood, close to the gneiss, is a hard siliceous rock with large micas which appears to be an unusual modification of the Penmynydd schists, but it is poorly exposed and the junctions are not seen. All the known junctions are therefore either faulted, thrust, or hopelessly obscure. It is to be noted, however, that wherever gneisses appear the adjacent member of the Complex in their immediate neighbourhood is either the Gwna Beds, the Gwna-ward portions of the Sherries Group (of which the hornfels appears to be a modification), or the Penmynydd schists; never any member of

the Holyhead Group. Whatever their true relations, then, they may with confidence be placed at the Gwna-ward end of the succession. And as the Fydlyn and Gwna rocks are interbedded at their junction, the Gneisses must be placed at the extreme end beyond the Fydlyn Group.

### Tabular statements of the succession

The successions in the several regions and inliers are therefore as follows. And the general succession in the Complex may be taken to be as in the table given on p. 164.

**Local successions**

**Holy Isle**

Holyhead Quartzite

South Stack Series

New Harbour Beds

**Western Region**

New Harbour Beds

Church Bay Tuffs

Gwna Beds (W.)

**Fydlyn Inlier**

Church Bay Tuffs

Gwna Beds (W.)

Fydlyn Beds

**Gader Inlier**

Gwna Beds Gneiss

**Garn Inlier**

New Harbour Beds

Church Bay Tuffs

Gwna Beds (W.)

**Corwas Inlier**

New Harbour Beds

(Church Bay Tuffs?)

Gwna Beds

**Northern Region**

Coeden Beds Amlwch Beds Skerries Grits Church Bay Tuffs

Gwna Beds (W.) Gneiss

**Deri Inlier**

Penmynydd Zone (Gwna)

**Nebo And Llanerchymedd, &c., Inliers**

Gneiss

**Middle Region**

Tyfry Beds

Gwna Beds (E.)

Penmynydd Zone (Gwna W.)

Penmynydd Zone (Fydlyn)

Gneiss

**Pentraeth Inliers**

Tyfry Beds

Gwna Beds (E.)

Penmynydd Zone (Fydlyn)

**Aethwy Region**

Tyfry Beds

Gwna Beds (E.)

Penmynydd Zone (Fydlyn)

Gneiss

No reason has been given, so far, for placing the Holyhead Quartzite towards the top, and the Fydlyn Group towards the bottom of the table. The reasons will be given on pp. 165–6. The reasons for placing the Plutonic Intrusions above the Bedded Succession will be found on p. 167. The Penmynydd Zone has been included in the table because of its great importance in the Complex. But it is included, not as a stratigraphic but as a metamorphic zone, and the reason for placing it at the top will be found on p. 167.

**The general succession**

| Group Name | Southern Facies | Northern Facies | Western Facies | Eastern Facies |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Penmynydd Zone of Metamorphism | Correlated in part with Fydlyn and Gwna Groups | | | | Mica schist, quartz-schist, limestone. graphite-schist, hornblende-schist, glaucophane-schist. |
| Plutonic Intrusions | — | — | — | — | Coedana granite, diorite, serpentine-suite. |
| Holyhead Quartzite (Holyhead Group) | — | — | - — | — | Massive quartzite. |
| South Stack Series (Holyhead Group) | South Stack Series 2. Stack Moor Beds Llwyn Beds | 1. Coeden Beds | — | — | Massive schistose grits with partings of mica-schist. Thin-bedded ditto, ditto. Thin tuff-schist. Fissile green-mica-schist. Gritty green-mica-schist. with bedded jasper, jaspery phyllite, and spilitic lava. |
| New Harbour Group (Holyhead Group) | New Harbour Beds 2. Celyn Beds 1. Soldier's Point Beds | Amlwch Beds 2. Bodelwyn Beds 1. Lynas Beds | — | — | Massive tuffs, and ashy grits and conglomerates. Bedded ashy grits in east. |
| Skerries Group | Church Bay Tuffs | Sherries Grits Church Bay Tuffs | — | Tyfry Beds | Alternating grit and phyl]ite, autoclastic mélange, and green-schist. |
| Gwna Group | — | — | Gwna Beds Attenuated and chiefly sedimentary. | Gwna Beds Thick and with much volcanic matter. Black phyllite absent. | Quartzite, limestone, graphitic phyllite, jasper, jasperry phyllite. Spilitic lava, tuff, and albite-diabase, often passing into chlorite-epidote-schists. |
| Fydlyn Group | — | — | — | — | Acid lavas and tuffs with thin sediments. All schis tose. |
| The Gneisses | — | — | — | — | Basic and acid gneiss with granitoid matter. |

## Chronological order of the succession

There seems no doubt that this is the real succession in the Complex. But nothing in the succession itself, or in the field-relations of its members; affords any evidence as to its true chronological order, except the circumstance that the

Gneisses, its most deep-seated member, are found at the Fydlyn-ward end, which suggests that in that direction the lower and older beds may be at least expected. The state of alteration of the clastic members proves nothing, for, although the Gwna Beds usually display a low grade of alteration and the Holyhead Group a high one, yet in the Penmynydd Zone the Gwna Beds are as highly crystalline as anything at Holyhead.

There is, however, one piece of evidence that is of great weight, if, indeed, it be not conclusive. As well as their boulders of unknown igneous rocks, the conglomerates on The Skerries have yielded some pebbles of white quartzite and scarlet jasper. The quartzite is fine, unfoliated, and not of Holyhead but of thorough Gwna type. The jasper is unmistakable; it is the type known only in the spilitic lavas and limestones of the Gwna Group. Smaller fragments of the same quartzite and jasper are also found here and there in the Skerries Grits upon the mainland of Anglesey. There can be no doubt, therefore, that the Skerries Grits are later than the Gwna Beds. But, if any member of a given succession can be shown to be later than any other member, that carries with it the chronological order of the whole of that succession. The Fydlyn rocks, then, will be taken to be the lowest, the Holyhead Quartzite the highest member of the sedimentary and volcanic series of the Complex; the Gneisses the lowest member of the whole Complex.

There is confirmatory evidence. Fragments of quartzite of Gwna type are found in the Church Bay Tuffs, the Amlwch Beds, and the Green-mica-schists of Holyhead; and small fragments of scarlet jasper in the South Stack Series and the Holyhead Quartzite. No fragments indicating a contrary succession are known.

It will be well to tabulate the composite (and a few simple) fragments that have been found in the Complex altogether.<ref>These fragments may be seen in the following (among other) slides and specimens:

In Holyhead Quartzite, (E10128) [SH 218 825].

In South Stack Series, (E10131) [SH 217 805], (E10135) [SH 224 806], (E10137) [SH 229 834], (E10570) [SH 203 823].

In New Harbour Beds, (E10150) [SH 235 830], (E10156) [SH 249 834].

In Amlwch Beds, uncut specimens.

In Church Bay Tuffs, (E10370) [SH 298 898], and specimens.

In Trwyn Bychan Tuffs, (E10513) [SH 408 940], (E11251) [SH 393 949].

In Skerries Grits on Main Island, (E10384) [SH 306 929], and specimens.

In East and Middle Mouse, (E9319) [SH 383 959] (E9320) [SH 383 959] (E9321) [SH 383 959] (E9322) [SH 383 959] (E9323) [SH 383 959] (E9324) [SH 383 959], (E10511) [SH 382 959], and specimens.

The Skerries, E. (E10579) [SH 268 948], (E10580) [SH 268 948], (E10581) [SH 268 948], (E10582) [SH 269 951], (E10583) [SH 270 951], (E10584) [SH 266 947], (E10585) [SH 266 947], (E10586) [SH 266 947], (E10587) [SH 265 948], (E10588) [SH 266 947], (E10589) [SH 265 948], (E10590) [SH 266 947], (E10591) [SH 269 950], (E10592) [SH 268 948], (E10593) [SH 268 948], (E10594) [SH 268 947], (E10595) [SH 268 948],, and specimens.

In Tyfry Grits, (E9839) [SH 517 767], (E10009) [SH 435 743], (E10074) [SH 405 719], (E10116) [SH 389 633], (E10117) [SH 388 632], (E10118) [SH 388 632], (E10119) [SH 388 632], (E10198) [SH 453 745], (E10199) [SH 453 745], (E10200) [SH 456 749],, (E11250) [SH 503 767].

In Gwna Grits, (E10105) [SH 385 623], (E11038) [SH 387 952], (E11196) [SH 585 744], (E11249) [SH 455 762].

In Gwna Quartzite, (E9801) [SH 559 764], (E9954) [SH 466 759], (E10196) [SH 457 758].</ref> The following members of the succession have yielded the fragments that are enumerated in the right-hand column:

| | |
|---|---|
| Holyhead Quartzite | Jasper, granoblastic rocks, mica-schist, Gwna quartzite (?) |

| | |
|---|---|
| South Stack Series | Jasper, Gwna quartzite, schistose grit, hypa-byssal albite-rocks, granoblastic rocks, mica-schist, blue quartz, tourmaline-mica-schist, granite, gneiss. |
| New Harbour Beds | Gwna quartzite, granite. |
| Amiawch Beds | Gwna quartzite, green grit, pegmatitic felsite. |
| Church Bay Tuffs and Skerries Grits | Pegmatitic felsite, pegmatitic albite-granite, Gwna quartzite, Gwna jasper, green grit, purple grit and mudstone, keratophyre and spilite, schistose grit, granoblastic rocks with mica, mica-schist. *Fragments within these pebbles* — Spilite and keratophyre, granoblastic rocks, mica-schist. |
| Tyfry Grits | Albite-trachyte, keratophyre, spilite, quartz-felsite, tourmaline-mica-schist, gneiss (?). |
| Gwna Grits | Keratophyre, albite-quartz-felsite, hypa-byssal albite-rocks, micropegmatite, granite, schistose grit, quartz-schist, mica-schist. |
| Gwna Quartzite | Spilite, granoblastic rocks with mica, mica-schist, tourmaline |

The green grits and the purple grits and mudstones may be from the Gwna Beds, and the keratophyres and albite-trachytes are doubtless from unexposed parts of the Gwna spilite-magma. The pebbles of the Skerries Grits (unless detached and brought into those beds by volcanic explosions) imply some degree of unconformity between the Skerries and the Gwna Groups. South of the Carmel Head thrust-plane the two groups appear too closely knit for this to be admissible. It is true that the Tyfry Beds appear to rest, sometimes on the spilite-limestone group, sometimes on other Gwna sediments, but there is too much disturbance in those regions for unconformity to be affirmed with confidence. In the Northern Region a break (masked by deformation) is admissible, but it is probably quite a local one, such as may easily occur in volcanic districts. Not a single fragment that can be recognised as from the Gwna, rocks displays the slightest foliation or deformation of its own. All the evidence, whether of pebbles or of junction-sections, indicates that, at the time when the Skerries Beds began to be laid down, the Gwna rocks had not been affected by any regional metamorphism. Incidentally, the pebbles reveal the interesting fact that the Gwna sands and cherts must have been quartzitised and jasperised at a very early period, long before that of the regional metamorphism of the Complex.

Turning to the other pebbles, the great igneous boulders of The Skerries indicate that acid hypabyssal rocks were then undergoing erosion, and from the size of the boulders it is clear that they were exposed to waste at some place very near The Skerries. The less deep-seated of them had been exposed somewhat earlier, small fragments of such being found in Gwna grits. They must be of great antiquity: but they cannot be *in, situ* anywhere in Anglesey, and their source remains unknown. The Skerries conglomerates, coarse though they be, represent only a local platform of erosion; and, of the Gwna sediments, even the coarsest are but grits. The true base of the whole clastic series of the Complex must therefore be lower down, and it still' eludes us.

### Chronology of the plutonic intrusions

***The Coedana Granite*** is injected into the Gwna rocks and Skerries Group, the Serpentine-suite into the New Harbour Beds. But it has been further shown that the thermal alteration induced had in each case been preceded by some degree of deformation, and in the case of the Coedana granite by folding, though the intrusive rocks themselves underwent afterwards both deformation and anamorphic reconstruction. The plutonic intrusions can therefore be assigned to an interval or intervals in the great earth-movements of the Complex. Some light will be thrown (see pp. 208, 211, 277) on the dates of these intervals by the tectonic relations of the intrusions.

As the ***Serpentine-suite*** have suffered more deformation than the Coedana granite, their foliation being locally folded and their tremolite-schists highly anamorphic, it is reasonable to suppose that they are somewhat older. The Plutonic sequence would thus be: Peridotite, Pyroxenite, Gabbro, Granite.

***The Penmynydd Zone of Metamorphism***, we have seen to be later than the intrusion of the Coedana granite.

## The Relations of the Gneisses to the Bedded Succession

A question that still remains over is that of the true relations of the Gneisses. It appears, from the evidence that has just been given, that they must, as far as mere position is concerned, be placed below the Fydlyn and Gwna rocks, and thus at the bottom of the whole succession. Is their metamorphism, however, the same as that which has affected all the rest of the rocks of the Complex; or are they portions of an ancient gneissic floor, whose metamorphism was produced before the deposition of any of the members of that succession? A conclusive answer cannot as yet be given to this question, but some evidence is available, and that on both sides will now be set forth.

Their proximity to the Coedana granite in the Middle Region certainly suggests that they are genetically connected with it, and that their metamorphism is, like that of the Penmynydd Zone, a part of the regional metamorphism of the whole Complex. We have seen, however, that the felspars of the two rocks are different, and that the granitoid element of the gneiss cannot be the Coedana granite. And as the Coedana hornfels is a far less deep-seated product than the gneiss, the two cannot have been produced in the same thermal zone. The diorite of Llangaffo cutting (see p. 99) appears to have been an intrusion into Fydlyn or Gwna rocks now converted into Penmynydd mica-schist, but it is very doubtful whether it can be identified with the basic portions of the gneiss. No boulders of the Gneisses have as yet been found in the Skerries conglomerates, nor have any that are undoubtedly from them been found in any member of the succession.

On the other hand, a fragment of a coarse muscovite-biotite-gneiss (E10135) [SH 224 806] has been found in the South Stack Series; another, less certain in character (E10200) [SH 456 749] in the Tyfry grits; large plates of white mica like that of the fragment in (E10135) [SH 224 806] are not uncommon in the coarser grits of the Complex, while small granitoid pebbles are occasionally seen, and, felspars of granitoid aspect are abundant. The position of the Gneisses below the whole known sedimentary series points, it would seem, to their being an ancient floor. In the Middle and Aethwy Regions, their strike is often north-westerly, as if it were a survival of the effects of movements older than those which (there striking persistently north-east) have incorporated them into the Complex. Moreover, in spite of their lepidoblastic seams, they are seldom sharply folded, as though they were parts of a massive ancient floor that was already comparatively rigid. Their position in the Middle Region is not easy to account for on either hypothesis, and is probably due to an ancient folded thrust-plane, bringing them against the Church Bay Tuffs (see pp. 221, 184), which has been obliterated by the great flood of the Coedana granite. It is noteworthy that, whereas the crystalline condition of the members of the Bedded Succession varies considerably from place to place, that of the Gneisses is always the same. Wherever they appear, whatever the state of the adjacent rocks, the Gneisses are always, and right up to the junctions, the same coarsely and plutonically crystalline products that have been described on pp. 128–143. Their crystallisation appears, therefore, to be independent 'of that of the Bedded Succession, appears to be their own, and consequently anterior to the deposition of that succession. The strongest evidence yet known as to their age and relations is derived from certain places (pp. 177, 216) (Figure 94) where the succession is known to be inverted, and where they are found adjacent to the Gwna Beds, overlying them in secondary synclinal nips. Now, at such places, the Gwna Beds are strongly autoclastic and very slightly re-crystallised, but there is a steady progressive metamorphism as we pass from them to the tectonically lower and lower members of the (inverted) succession. The Gwna Beds, that is to say, though just at the lower margin of the zone of fracture, are slightly anamorphic. Yet the gneiss that overlies them is texturally as highly crystalline as it is anywhere. But it is heavily crushed and its coarsely crystalline structures broken down. Though now almost in the same zone of the earth-crust, the Gwna Beds are slightly anamorphic, the Gneisses are wholly and severely cata-morphic. It follows that the deep-seated crystalline characters of the Gneisses, their characters, that is to say, as gneisses, must be older than the deposition of the Gwna Beds, and, consequently, older than that of the Fydlyn Beds. There must therefore be an unconformity of the first magnitude between the Gneisses and the remainder of the Complek. But this unconformable junction has never been found. Within the limits of Anglesey, at any rate, it is probably cut out everywhere by thrusting. When the structures of the Complex come to be considered, it will be seen that along such thrust-planes (pp. 204, 209) foliation has developed, masking their nature as disruptions, and that they have been also folded. The balance of evidence, therefore, is in favour of regarding these gneisses as parts of an ancient floor. But the preceding argument, though strong, is indirect, and is not a demonstration.

## The Ancient Floor

That the Bedded Succession of the Mona Complex rests unconformably upon a yet more ancient foliated complex, whose foliation was complete, not only before the Mona metamorphism but before the deposition of the sediments now involved in that, is, however, certain. From the fragments contained in the Complex here and there, we get, even if the visible Gneisses form no part of that old floor, some dim light as to its nature, and see that it included schistose grits, mica-granulites, mica-schists, and tourmaline-mica-schists, with granitoid and also gneissose rocks.

**Note** — In this chapter, attention has been focussed upon the succession of the *main* divisions of the Complex. The relative positions of the *sub-divisions* have been, in several places, implied; but full evidence would have involved detail that might have rendered this chapter too intricate. Where -she positions of sub-divisions are known they have been placed in that order in the table on p. 164. The evidence will be found in chapters 8 and 10, particularly in chapter 10, and on pp. 383–5. In the latter place more precise particulars will also be given with regard to the stratigraphical horizons on which the Penmynydd metamorphism is known to develop.

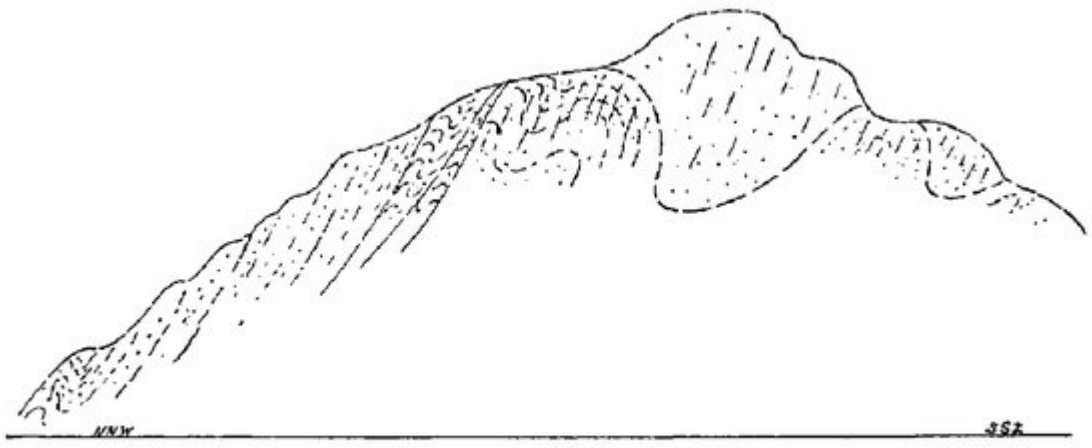
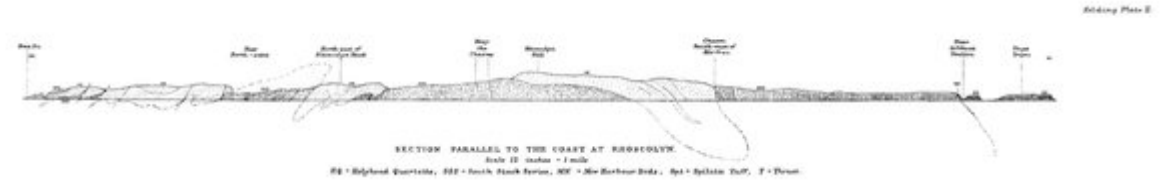



FIG. 28.—INFOLDED OUTLIER OF HOLYHEAD QUARTZITE ON THE SOUTH STACK MOOR.

*(Figure 28) Infolded outlier of Holyhead Quartzite on the South Stack Moor. At the 500 foot contour. Height of section, 60 feet.*



*(Folding-Plate 2) Section parallel to the coast at Rhoscolyn. Scale 12 inches = 1 mile. HQ = Holyhead Quartzite, SSS A South, Stack Series, MN = New Harbour Beds , Sp.t Spilitic Tuff, T Thrust.*

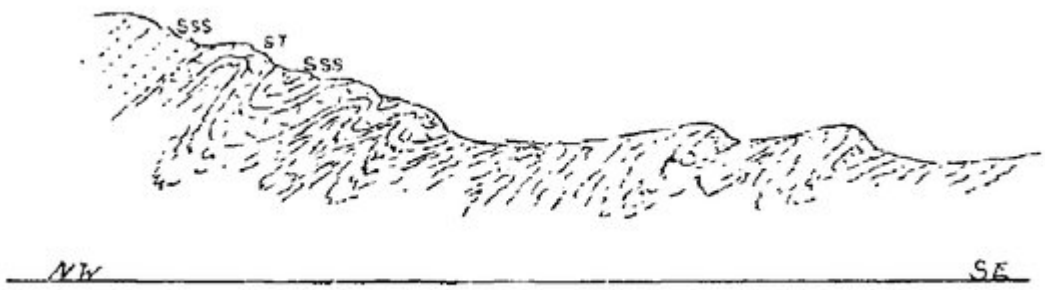



FIG. 29.—SPILITIC TUFF AND PASSAGE BEDS.

*(Figure 29) Spilitic Tuff and Passage Beds. Crag at small farm (Cae-allt-wen) north of 'H' of 'Holy.' Scale, 24 inches = one mile. SSS = South Stack Series. ST = Spilitic Tuff.*

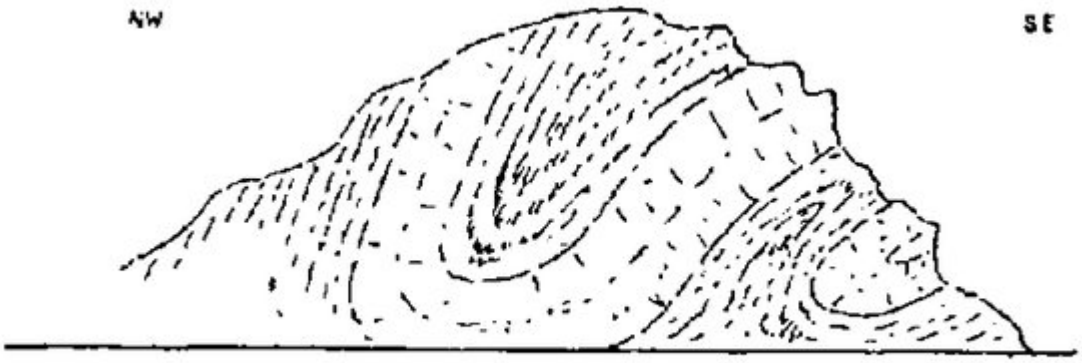
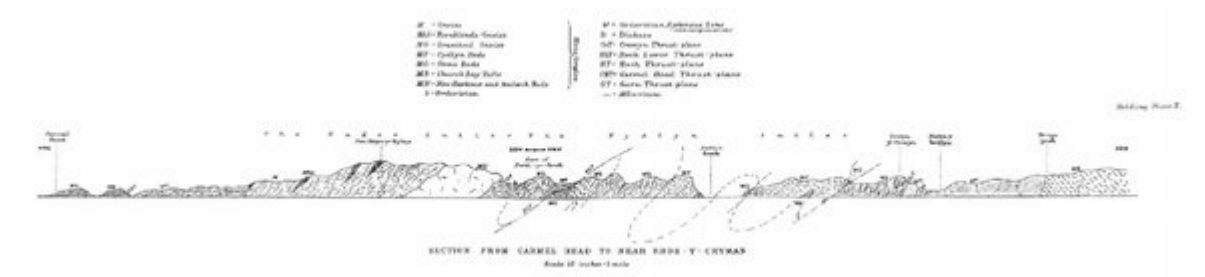



FIG. 30.

*(Figure 30) Spilitic Tuff and Passage Beds, Bodwradd. 500 yards north of west of Bodwradd. (LIwyn Beds taken in on pitch immediately to north-east.) Height, about 20 feet.*

*(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.*

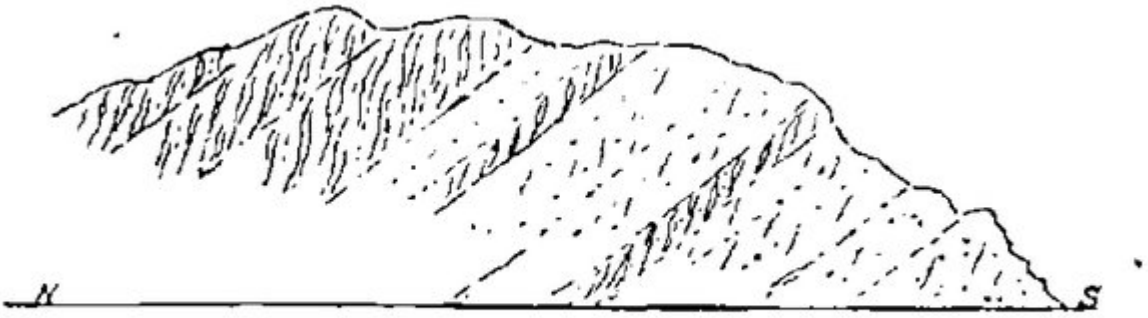



FIG. 32.

*(Figure 32) Passage from Fydlyn to Gwna Beds. About 10 feet high. Brow of Fydlyn Cliff.*

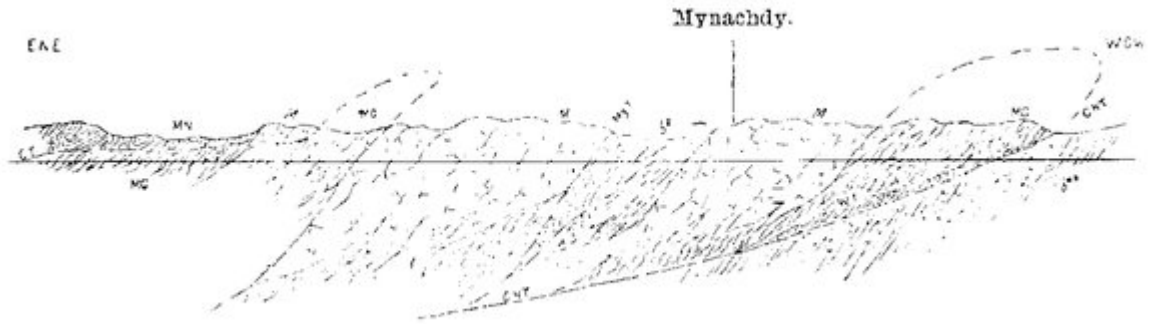



FIG. 94. SECTION AT MYNACHDY.

*(Figure 94) Section at Mynachdy. Scale: Nine inches = one mile. MN = Amlwch Beds. MG = Gwna Beds. M = Gneiss. beb = Lower Ordovician Beds. be = Glenkiln Beds. CT = Caerau Thrust-plane. MyT Mynachdy Thrust-plane. WT = Wig Thrust-plane. CHT = Carmel Head Thrust-plane.*