Chapter 18 The tectonics of the Ordovician and Silurian rocks

Introductory

The older Palaeozoic rocks of Anglesey were powerfully affected by the great movements that set in all over the north-west of Europe at the close of Silurian time.<ref>Some of the phenomena that were used as evidence for the stratigraphy in Chapters 13, 14, 15, are used again here, but strictly in reference to the tectonics.</ref> Repeatedly folded, torn by numerous thrust and slide-planes, both on the small scale and on the large, the complexity of their tectonics is second only to that of the Mona Complex. Cleavage is general, though very variable in intensity; there are also shear structures, and some degree of mineral re-construction has taken place in connexion with them in certain districts.

Local phases of the movements repeat rather curiously the corresponding local phases of those by which the rocks of the Mona Complex are affected; and care is needed, where this is the case, to distinguish between them. But the evidence given in Chapter 9, on pp. 425–6, and elsewhere, is conclusive, and it should be clearly understood that the great earth-movements of the Mona Complex, with their accompanying anamorphism, were completely over before the lowest Ordovician rocks of the Island were deposited; that its crystalline schists were already then in the condition in which we now see them; and that any modifications induced in them by the Post-Silurian movements were of a catamorphic, not of an anamorphic nature.

Let us begin by considering the effects of those movements in the region of the Menai, tracing their variations across the Island until on the northern coast we lose sight of them beneath the sea.

Comparative tectonics of the several infolds

The Menai Strait to the Llangwyllog area

The Extensus shales of the Strait are remarkable for their undeformed condition. There is no cleavage, and the graptolites are as beautifully preserved as in the south of Scotland. This is due<ref>Harker, 'Bala Volcanic Series', pp. 114–116.</ref> to the protection afforded by the old Llyn Padarn ridge from the compression undergone by the rocks on its further side; and no lateral movement of importance is perceptible about the Strait, so that the impulse from the south-east seems to have been the only one operating for some distance out into Anglesey. The shale and ironstone of Llangoed, accordingly, are little if at all compressed. But there is a sign of opposition in the reversal of hade along part of the Garth Ferry fault (p. 432).

On crossing the great anticlinal core of the Aethwy Region, however, a cleavage appears. The Strips along the Berw Faults belong to an Ordovician major syncline that is let in between the Aethwy and Middle Regions of the Mona Complex. Its northeastern parts are compound, owing to the rise of the subsidiary faulted anticlines that bring up the Pentraeth Inliers. The cleavage is vertical, both along the south-eastern limb and in the strips that, nipped in between the inliers, cannot be far from the chief synclinal axis. The north-western limb of the major infold is buried under Carboniferous rocks. But the verticality of the cleavage, berth on the south-eastern limb and on the axis, points to a general tectonic symmetry, with south-easterly dips along the north-western limb. All the structures in this infold indicate an equilibrium of impulses. In the Llangwyllog Area, too (Figure 201), the symmetry of the folding and the verticality of the cleavage, again indicate a dynamic equilibrium.

The Principal Area and its wings

The structures are far better displayed in the Principal Area, but they are somewhat complex. Ignoring for a while the northwestern wing that runs out to Carmel Head, we have seen that the main body of the area has the form of a rudely elliptical syncline, for it broadens in the middle, narrowing towards either coast, where also the base begins to rise. The broad central portions are also seen to be the deepest, as it is in them that the infolds of the higher zones are found. But the dispositions of these infolds, and the repeated risings of the base, as well as sections like those of Rhosneigr shore (Figure 261), (Figure 262), (Figure 263), reveal that the major syncline is full of subsidiary folding, and that many of the subsidiary folds are of considerable amplitude. A persistent northerly dip shows also that this folding must, in common with the major syncline itself, be isoclinal (Folding-Plate 11).

There is an exception to this between Dulas Bay and Bachau, where the overfolding is reversed (Figure 205), (Figure 206), the base torn out, and the Mona Complex driven north-westward over the Ordovician shales on the Bodafon thrust-plane (Figure 156), (Figure 276), (Figure 278). Between the two impulses, there is, just where the thrust is dying out, an approach to a synclinorial structure. The Bodafon thrust-plane must be regarded as a final repetition, in the heart of Anglesey, of the impulse from the south-east that is so powerful on the mainland. Its effects die out westward, and at Foel Hill (Figure 204) are quickly overpowered by the advance-waves of that impulse from the north that is dominant over all the outer parts of Anglesey.

An obliquity is introduced along the western margin of the area by the form of the broad anticline whose denuded core is the Western Region of the Mona Complex. This, instead of being continued north-eastward towards Rhosgoch, pitches rapidly down where the River Maw crosses it. The Ordovician rocks are therefore thrown off on its northern side into another deep depression which meets the major syncline obliquely. This is the north-western wing, and the position of the infolds of the higher zones about Llanbabo, just where it opens out into the major syncline, shows that the floor sinks to an unusual depth where the branch depression meets it.

The folds, however, are seldom free from rupture. This is often visible in the small ones of the Rhosneigr wing, the tendency being for the anticlines to be overthrust on their southern sides. That the subsidiary folds inland are also ruptured is manifest from the disposition of the higher zones about Llanbabo (Figure 208), (Figure 211), and from the frequent absence of the basal conglomerate on one side or another of the inliers of the Mona Complex (Folding-Plate 11). Such, indeed, is the nature of the major syncline itself, along whose northern margin is the greatest rupture of all, the Carmel Head thrust-plane.

Ruptured Major Isoclines of the North- West and North-East — Between the parallels of latitude 53° 22■ and 53° 24■ the great Palaeozoic tract, though isoclinal from south to north, is approximately synclinal east and west, for both on its western and eastern wings the Mona Complex rises on a succession of large anticlines that pitch landwards from the coast. Rupture has, however, taken place along almost all their junctions., the planes being inclined for the most part at high angles to the north. The rising core of ancient rocks would seem to have torn itself away on its northern side from the Palaeozoic mantle, and thrust itself over that mantle southwards (Figure 214), (Figure 216), (Folding-Plate 10).<ref>The ruptures on the north limbs of the anticlines, however, may not all be of the same nature. Those of moderate inclination are probably thrusts at a lower angle than the dip. Those which approach 90° must be true downthrows. But these downthrows clearly belong to the period now being considered, being grouped in association with the thrust-planes, and differing from the normal faults of later date in being clean cuts with little or no brecciation. 'Lag-faults' complementary to thrust-planes do not seem to be known in the classic regions of the North-West Highlands and Southern Uplands of Scotlatd, and some of the leading authorities on those regions have grave doubts as to the existence of the structure. Those of doubtful character have therefore been referred to simply as 'slips' or slides'.</ref>

The curious winding boundary between Brwynog and the coast emerges at Yr-ogo-goch as a nearly vertical plane of slipping (Figure 203), but it is possible that planes of different characters truncate each other inland. Both the Garn and Gader Inliers are driven forward upon the powerful Garn and Hwch thrust-planes

(Folding-Plate 9), (Folding-Plate 10), which must have considerable overdrive in the horizontal dimension (p. 464). The dynamical effects of the Garn thrust are obvious (p. 463). The ruptures which bound the Nebo Inlier are Very singular, and can hardly be described in words. On the southern side (Figure 264), (Figure 265), subsequently to the development of the over-thrust the gneiss and shale must have been carded together' by a series of complex minor movements. This thrust-plane disappears westward, allowing the basal grit to rest upon the gneiss in a nook of the anticline at Nebo, but only for a short time, the grit being quickly overturned, and another (invisible) thrust-plane running thence to Trysglwyn. At the junction on the north side, the steep slip, and the low thrust-planes in the folded shales (Figure 266) are very remarkable. Similar thrust-planes, one of them horizontal (Figure 267), (Figure 268), are numerous in the shales on the sea-cliffs all the way to Porth-y-corwgl.

Immediately to the north of the Nebo anticline are the deepest infolds of all the Palaeozoic rocks of Anglesey, Silurian beds being taken in. There must also have been oscillation east and west, for while the Nebo anticline pitches westward at Trysglwyn, the Parys infold pitches eastward. 'Concerning the depth of the latter we have definite information. The 'Colonel's Shaft' was sunk in it to a depth of 300 feet below the floor of the West Pit (Figure 214).<ref>The vertical line in the East Pit in (Figure 214) shows the depth of the Colonel's Shaft in the West Pit. By reason of the pitch, the shaft would reach a lower horizon than does the vertical line in the figure.</ref> It did not reach the felsite, for its latest spoil-bank is composed of the Gregarius shales. The thickness of the felsite can hardly be less than 300 or 400 feet at that point; to which must be added the difference between the levels of the pit floor and of the summit of the hill, about 240 feet. So the depth of the infold to the base of the felsite, at this place, must be about 900 feet; and as it is pitching eastward, its depth at the eastern end can hardly be less than 1,300 feet. Some of its inner crumplings can be seen on the east wall of the West Pit. If the thickness of the Ordovician zones (see p. 423) be further added, and 100 feet allowed for the conglomerate (as at Fresh Water Bay), then the total depth of the infold from the base of the Tarannon Beds to the surface of the Mona Complex must be about 4,200 feet. It was, however, quite early (see p. 460) modified by a steep eastward over-thrust near the western end (Figure 212), and this again overridden by the Rhwnc thrust-plane (Figure 212), (Figure 213), which, moving in advance of the Carmel Head thrust-plane, has driven the upper portions of the infold in a south-westerly direction, carrying Silurian shales across the Nebo anticline at Trysglwyn (Figure 214).

The easterly pitch cannot have continued far. Instead, however, of gradually rising again, the infold is now cut off and over-ridden by the Corwas thrust-plane (nowhere seen in section), which must therefore be of considerable magnitude. Further on is another deep Ordovician infold, that of Mynydd Eilian, a double syncline whose maximum depression must be at the Rhosmynach outlier. Its details are obscure, but the arrangement must be somewhat as indicated in (Figure 216).

Such are the structures of the north-western and north-eastern Palaeozoic rocks of Anglesey. But the rarity of zone-fossils and the obliteration of the bedding make it impossible at present to obtain more than a very general picture. When further zonal information is obtained, it will be possible to follow the thrusts and undulations out into the surrounding Ordovician shales; but the Garn and other thrust-planes, though evidently of considerable magnitude, cannot as yet be traced far beyond the margins of the inliers. In any case, the whole of this system of disturbances disappears with the oncoming of the Carmel Head thrust-plane.

The Northern Wedges

Before, however, proceeding to a discussion of that master-line, it will be well to take a general view of the nature of those movements of which there is evidence along the northern coast. For the successive nips of Ordovician rocks are complementary to anticlines which closely resemble those just now described. Wherever well exposed, the broken Ordovician infolds are steeply overthrust on their northern, and either torn out or highly compressed upon their southern limbs. The infold near Mynachdy (Figure 94), (Figure 222), (Figure 224) is bounded on the north by the Mynachdy thrust-plane, but where the base rises at Porth Padrig it is almost unrecognisable from crushing (see p. 551). The same general principle is displayed very clearly in the great section at Ogof Uynfor (Figure 220), where the powerful overthrust on the north (with the minor thrusts. in advance of it) contrasts vividly with the planes of slipping on the southern side. The next infold is also slipped on the south and overthrust on the north. The outer side of the last infold of all has been destroyed by the sea, save where a very small strip of the Mona Complex on the cliffs of Torllwyn appears to be thrust on to the conglomerate. The southern side is for the most part unfaulted, but is intensely compressed (Figure 217). The prolongation of this infold east of Porth Wen is again (though at high angles) slipped and overthrust; but the great thrusts of Trwyn-bychan appear to be movements of the Mona Complex (pp. 314, 472).

The great slipped and thrust isoclines of Llanfairynghornwy and Llaneilian are evidently due to the general southward impulse which culminated in the Carmel Head thrust-plane. These northern infolds, being of the same nature, are probably heralds of a similar disruption. It is likely, therefore, that the islet of the Middle Mouse is the last visible survivor of a considerable tract of the Mona Complex, riding upon another powerful thrust-plane whose outcrop is concealed beneath the waters of the sea.

Summary

The tectonics of these rocks fall into two regions, in which the structures are of two distinct types. The dividing line runs across Anglesey from Llanfaelog to Mynydd Bodafon. To the south-east of this line the structures, with fewr excdptions, are symmetrical about vertical axes. To the north-west of it they are, with scarcely an exception, isoclinal, with a southward overdrive. The strike of some of the isoclines, however, is distorted about the large western anticline.

The Carmel Head Thrust-plane

We must now return to a consideration of this master-feature, called in this work, after its best exposure, the Carmel Head Thrust-plane'.

Evidence of rupture

That it really is a line of rupture can be seen from the following considerations: First: the structural and dynamical phenomena that are visible at its 10 exposures, and at Gwaen-ydog. Secondly: it is continuous from sea to sea, and all along the line there is a sharp contrast between the rocks on the two sides. Thirdly: the stratigraphical relations are not those of succession or of unconformity. In spite of the apparent upward succession', an outcrop of the zone of *Didyinograptus extensus* is interposed, at Llanbabo, between that of *Dicranograptus clingani* and the escarpment of the thrust-plane, close to which also are shales of Arenig type. Not only so; but a number of different horizons come up against the line, and that on either side. On the south: the basal conglomerates of the zone of *Did. extensus,* the *Did. bifidus* shales, those of the lowest zone of the Glenkiln, the green shales of Parys Mountain that are referred to the Upper Hartfell, and the New Harbour and Gwria Beds of the Mona Complex. On the north: the following members of the Mona Complex: The Gwna Green-schist, quartzite, limestone, and spilites, the Lynas and Bodelwyn divisions of the Amlwch Beds, with the spilites and jaspers of that group, the Skerries Group, and the Coeden Beds. The Nemagraptus beds and the Gneisses of Mynachdy only fail to reach the line by an interval of 200, and the Silurian shales of the Parys infold by an interval of 600 yards. Eighteen different zones in all are thus brought against or close to this line, and several of them are brought there more than once. Every Paleozoic dyke that reaches it, moreover (as may be seen on the one-inch map and in (Figure 269)), is cut off abruptly. It will also be noticed that the Gader, rydlyn, and Garn Inliers all strike at this line.

Its inclination

The plane being thus, it is manifest, one of disruption, what is the nature of that disruption? First: the curvature of the outcrop, quite unlike that of a normal fault, at once arrests attention. From Porth-y-corw gl to Carmel Head it is 14 miles in length. If, to this curve, a chord be drawn, joining up the two sea-sections, then the convexity, measured along a normal to this chord, is two and three-quarter miles at the Llanfliewyn bend; and the angles' subtended at the two ends are 20° and 32°. Next: the inclination of the plane can be measured at nine places. 'At Carmel Head it is 20°–25°, but as low as 15° in one place. At Porth-y-corwgl it has risen to 55° or 60°. But this high dip only begins to come on to the east of Rhosgoch, and for more than two-thirds of its course the average inclination is probably about 25°. For at the four little inliers (Folding-Plate 13) in the cliff south-east of Carmel Head it is at 45°, at Porth-yr-ebol 18°, on the northern slopes of Mynydd-y-garn about 20°, at Llanfairynghornwy Post-office 40° to 45°, at the roadside south of the church 45°, at the roadside east of Bod-hedd about 30°, after which it is evidently very low all along the Mynydd Mechell, and at the bend by the Gwaen-ydog road it is actually horizontal.

Such being the observed inclinations, the outcrop might be expected to be, not merely curved as a whole, but locally sinuous. This is, accordingly, perceptible with ease even on the one-inch map, and conspicuous on those of larger scale. On the north slopes of Mynydd-y-garn there are two small circular faults', one an inlier of the thrust-plane, exposing the over-ridden shale below, the other an outlier of the Gwna schists resting on shale. The outcrop itself is not exposed, and it is from these that the estimate of inclination has been made on that hill. For, in order that an inlier and an outlier may be possible, the dip of the plane cannot be much greater than the slope of the ground, which, calculated from the contours, is about 18° (Folding-Plate 9).

Along the south of the rugged Mynydd Mechell, the outcrop is at the foot of a sinuous escarpment, and its form will be realised better from (Figure 269) than from description. Standing in the deep bay' north-west of Gwaen-ydog, where (though the actual plane is not exposed) the feature is most pronounced, a clinometer held up to it shows that it is horizontal (Folding-Plate 11). Several small knobs of schist in this 'bay' must be outliers. An interesting result of the horizontality of the thrust-plane is that the numerous. Palaeozoic dykes (pp. 512, 525, 528) which traverse the Mynydd Mechell must be-indeed are almost visibly — *sans racine*, and cut off downwards at depths of 50 to 100 feet. Their original roots left behind, they have been (like so many of the Lewisian dykes of Scotland) carried forward along with the whole *nappe de récouvrement* in which they are enclosed. At Llyn Llygeirian the plane is thrown down to the east by a normal fault, and its outcrop shifted southwards for more than a quarter of a mile. A few small faults also shift it between this and Llanol, as well as at Porth-yr-ebol. The plane is, therefore, a true overthrust, and is of the same character as the major thrust-planes of the North-west Highlands.

Its inclination seems to have been determined by the tectonics of the over-ridden rocks. Where it is riding over low-dipping isoclines of moderate amplitude it is at a low angle, but where it is meeting with the deep, steep, and hard-packed infolds of Parys and Llaneilian, the resistance causes it to rise up much more steeply, while its angle is moderate in the north-west, where the underlying tectonics are of intermediate character. From which it would further appear that the high dip of the east was of the nature of a local deflection, and that the direction of the impulse itself was at a low angle.

On Mynydd-y-garn and on the eastern hills, where the Ordovician shales are cleaved and toughened, it outcrops upon a dip-slope, but from Llanffiewyn to Rhosgoch, where the shales are uncleaved, and the hard Coeden Beds are the rocks brought forward, it gives rise to a most pronounced escarpment, about 50 feet in height and very rugged, overlooking the smooth country of the Ordovician shales.

Its dynamical effects

The thrust-plane is admirably exposed at Carmel Head, in a narrow cove about 300 yards to the west of the north point of the headland. On the six-inch map reproduced in Folding-Plate 13 it is easily identified as the inlet west of Porth-y-wig. The cliff on the northern side of this cove (see (Plate 31), which is the Frontispiece to Vol. 2; and also (Figure 270)) is about 40 feet in height. For about 10 feet from the beach it is composed of the dark slaty shales (E9511) [SH 294 930] with undulating cleavage; then there is a gently sloping shelf, a yard or two in width, above which is a vertical and partly overhanging wall of greenish Amlwch mica-schist (E9512) [SH 294 930], see p. 295 finely but thoroughly crystalline and folded in rapid isoclines<ref>This folding may be seenin an unpublished photograph (No. A1446).</ref>. whose axes meet the shelf at angles of 40° or more. The sloping shelf is the bare sole of the great overthrust, and along it, at the foot of the upper cliff, the plane itself can be inspected, inch by inch, for nearly 30 yards. For a good part of the way it is a clean, sharp cut, into which the blade of a knife can be inserted. That is also the nature of the junction at the little inliers (see p. 465) and at Porth-yr-ebol; also, so far as can be made out, at Llanfairynghornwy Post Office and Church, but at Porth-y-corwgl the junction is obscured by bush. Here and there, however, along the shelf at Carmel Head, a little 'milled' material appears in the fissure, and near the seaward end, there is a foot thick of pale green mylonite (E9513) [SH 294 930], in the midst of which little strips of the quartz-seams of the mica-schist are dragged along. Slick ensides upon the sole indicate that the direction of movement was about south 10° east at this place. The shale below is traversed by minor thrusts, bending its cleavage-planes and pushing them over, and dragging out its seams of venous quartz; minor thrusts also diverging upwards from the main thrust-plane into the mica-schist, along which its foliation, its quartz-seams, and its isoclinal overfolds, are cut and pushed over in the same way: At the great plane itself, the folds of the mica-schist and indeed all the structures of both rocks are powerfully deformed and sheared, in a way that will be better conveyed to the mind by (Figure 271) than by description.

The section leaves no doubt that the development of the great overthrust was later than the foliation of the mica-schists, later than their over-folding, later even than the cleavage<ref>The thrusting phase of the movements was (see below) subsequent to the compressing phase that produced the cleavage.</ref> and the quartz-seams of the shales.

At Llanfairynghornwy Church (Figure 272) Gwna Green-schist is thrust on to an isoclinal anticline of Ordovician grit and slaty shale. At Bod-hedd quarry Gwna mélange has been thrust on to shaly and pebbly grit containing true derived fragments of schists like some of those at Mynydd-y-Garn and Rhydwyn. The rocks are decomposed, and the position of the main thrust is not clear, but enough can still be seen to show that strips of the Gwna rocks have been driven on to the Ordovician beds again and again, and are now incorporated with them.

At Gwaen-ydog a quite different type of structure was produced. The floor of the western bay' shown in (Figure 269) is a bare sole. In the ravine below are the shales with pebbly bands, relatively undisturbed, that are described on p. 457. On the south-western end of the bay are some thin outliers of tolerably solid schist. This, as we trace it downwards, the shaly group as we trace it upwards, begin to break down, and between them, on the escarpment of the platform, is an extraordinary breccia, composed of fragments of the two, and of all sorts and sizes. The yielding shales furnish a kind of matrix, with a rude parallel structure dipping northwards at low angles, suddenly interrupted, however, by blocks of schist, one of which (Plate 32), a foot high and three or four inches thick, stands up in it vertically. One or two masses of schist in the breccia are several yards in length, and one of them retains its ancient folding; while similar great masses of the shaly rocks retain their bedding, marked out by thin hard seams of mudstone. Masses of the schist can be watched in the act of breaking down, and traced on into jumbled breccia among which are strips of broken shale. The whole is complicated by the fact that the pebbly bands interbedded with the shales were in many cases original epiclastic breccia full of derived fragments of schists, usually of small size. Crushing up, these have been rammed in between the larger cataclastic fragments. Yet along some of the crush-lines of the latter are seams of fine breccia that can hardly be distinguished from the old epiclastic breccia .; and in many places there is broken material which might be assigned to either mode of origin. Thus, the structures found along the Cannel Head thrust-plane may be said to link the phenomena of the North-West Highlands with those of the Isle of Man.

Why, however, did brecciation take the place of mylonisation and shearing at this particular portion of the line? An explanation is to be found in the local relationships of two great tectonic horizons. Examination of the fragments in the breccia, and also of the solid schist of the south-western outliers, reveals that these are not composed of the massive Coeden Beds that form the main escarpment, but of the lenticular chloritic Gwna Green-schist. A little distance to the west, at Llanfflewyn, a narrow strip of that formation is shown upon the one-inch map, and a reference to Chapters 8, 10 (and Folding-Plate 5) will recall that this is a dwindled portion of the Llanfairynghornwy Belt, a long *lambeau* that underlies another great overthrust, which has been called the Caerau thrust-plane. The platform in the 'bay' of Gwaen-ydog is therefore a sole, partly of the Carmel Head, partly of the Caerau thrust-plane, upon which the Coeden beds, already inverted, were driven over on to the Gwna Beds. The two planes are approaching each other eastwards, and at this bay' they have almost come together. So the dwindling plate of Gwna Beds between them had become very thin, and at this place was only a few yards in thickness. The Gwna Beds, owing to their heterogeneous character and their lenticular structure, were lacking in cohesion; and when reduced to so thin a plate, they refused even to mylonise, but, with the steady masses pressing on above them, broke up tumultuously as they were driven forward.

Magnitude of the Carmel Head Thrust-plane

Is it possible, in conclusion, to obtain any measurement of the extent of the over-drive of this great disruption? The methods that were made use of in the North-West Highlands are not in this case available, and therefore no exact estimate is possible. Certain other methods, however, are available, and as the results they give are concordant, confidence may be reposed in them. We have seen that the plane as a whole is inclined at a low angle, and that the normal to the chord is nearly three miles long. The minimum over-drive, therefore, may be taken at about three miles. But neither at Gwaen-y dog nor at Carmel Head is there any sign whatever of a waning of the dynamical effects. Comparing those at Carmel Head with the effects produced at Highland thrust-planes, they are considerably less than those at the Moine, but certainly not less, probably rather more powerful than those at the Kinlochewe thrust-plane, the minimum over-drive of which is three miles.<ref>This measurement is from the main outcrop to the Meall a' Ghiubhais outlier. See 'Geology North-West Highlands', p. 547.</ref> But the Carmel Head rocks do not lend themselves easily to the production of mylonite. This, added to the normal of the chord, gives an estimate of six miles at Crwaen-ydog.

Approaching the question from a different direction, we have seen that, when once the thrust is over-passed, all the five Ordovician zones below that of *Aremagraptus gracilis* have disappeared by overlap. What is the rate of overlap? The lowest of the zones, that of *Didymograptas extensus,* well developed on the Menai Strait, is still present at Llanbabo (and evidently also at Gwaen-ydog, see p. 457), more than 14 miles from the Strait; so that, as far as the thrust-outcrop, the overlap is imperceptible. That it suddenly steepened so rapidly that all these zones were overlapped in three miles and a half (the distance of the *Nem. gracilis* zone at Cemaes) is most unlikely. That they were overlapped in the course of 200 yards (the distance of the *Nem. gracilis* zone at Mynachdy) is manifestly impossible! Let us, to be on the safe side, suppose that the *Did. extensus* shale is just on the point of being overlapped at the thrust-plane; and also that the total thickness of the five zones is only three times<ref>According to the measurements given on p. 423, the multiple would be four times. Yet the estimates for three of the five zones are minima, and are undoubtedly too small</ref> its thickness. Thus, if the overlap went on at the same rate, the base would reach the zone of *Nem. gracilis* 42 miles to the north of the outcrop of the thrust-plane. Again, however, to be on the safe side, let some of these data be yielded up, let indeed no less than half be yielded up, and let us suppose that the rate of overlap was doubled. Even then, the base would not reach the Nemagraptus zone for more than 20 miles. As the land now is, it reaches it in 32 miles at Cemaes, and in 200 yards at Mynachdy. From this very moderate estimate of the rate of overlap, then, the extent of over-drive on the Carmel Head thrust-plane must be placed at about 20 miles.

Closely connected with the question are certain peculiarities in the behaviour of the zone of *Nemagraptus gracilis.* This, the only Ordovician zone that is found on both sides of the thrust-plane, displays different facies on the different sides. At its base in the north, it develops 180 feet of purple and 300 feet of pale conglomerate, both often very coarse, of which there is no trace whatever in the south, not even at Llanbabo, which is only 42 miles away. The ironstone is found in both districts, but with different characters (see p. 406), and as in the south its horizon is usually rather lower, it is not a strictly zonal deposit. The coralline limestones are known only in the north. More important is the fact that the spiculiferous cherts and cherty shales, which are 150 feet thick in Gynfor, are totally absent in the south. The only beds that pass on unchanged are the sooty shales, and as they are found even in Scotland (see pp. 413, 454), no less could be expected.

The faunal changes are perhaps still more significant. Throughout Anglesey, the Nemagraptus zone has yielded, in all, 58 species. Of these, 30 have been obtained only in the north, 11 only in the south, leaving no more than 17 that are common to both north and south. And of these 17, 16 are graptolites, the seventeenth being the Scottish brachiopod *Paterula balcletchiensis* (Day.), which is found as low as the Bifidus zone. More: of the same 17, 10 are fossils of the persistent sooty shales, which are therefore the beds that maintain the greater part of the community between the two facies. Had those 'beds been, by any accident, cut out in the north, only 7 out of 58 species of the zone would have been found to cross the thrust-plane. And yet the present distance between the two faunas is only four miles and a half. Palontology and lithology thus unite with stratigraphy to indicate that differing facies of the Nemagraptus zone, which were originally many miles apart, have been brought close together on this thrust-plane.

Yet one more method is available. Three of the members of the Mona Complex, namely, the flaggy Amlwch Beds, the massive ashy Skerries Grits, and the thick-bedded Coeden schists, are not found below the thrust. In the Ordovician, conglomerates and pebbly grits occur at intervals all along the line, a short distance from or actually in contact with the thrust-plane. The pebbles in these conglomerates (often large) are, so far as has been seen, such as form portions of the floor on the south side of the thrust, and such only. They include the Gneisses and their granites, the Church Bay Tuffs, the Gwna Green-schists, with the limestones, and most abundantly of all, the white quartzites of that group. Not a single pebble has been found of the three types that are confined to the north side of the thrust-plane. Yet, with the country as it now is, all these have extensive outcrops quite close by, and are very durable material, and the drift of pebbles (see p. 464) was from north and north-east. Had they been, as they now would be, accessible to the denuding agencies of that region, they must have furnished a large proportion of the pebbles.<ref>As they actually have to the glacial deposits of that very tract, the direction of whose transport happens to be locally the same as that of the pebbles of Ordovician time.</ref> Their total absence (even if present, they must be extremely rare) is a singular and striking circumstance, and it points to the following conclusion. In Ordovician times these rocks were *out of reach*—too far away to the north for their pebbles to be drifted into latitude 53° 24■ 30■, the latitude of these conglomerates. They must, indeed, have been miles away; and they have been brought into the latitude in which they now are by a gigantic over-drive.

Four independent lines of investigation therefore converge to the conclusion that the over-drive along this thrust-plane was on a very great scale indeed.

Nowhere, of course, can these measurements be made perceptible to the eye. Nevertheless, there is a view-point from which it is possible to realise visually something of the magnitude of the great thrust. Standing on the eastern horn of

Gwaen-ydog 'bay'; and looking, first, to right and left at the long sinuous escarpment of the rugged crystalline schists that so palpably ride upon the Ordovician shales, and then turning to gaze over the wide undulating country that extends northwards to the sea, one can envisage in the most vivid manner the whole Northern Region of the Mona Complex as a gigantic *nappe de récouvrement,* 30 square miles in visible extent. Here, more than at any other spot, can one form a living mental picture of what is implied in the measurements of the Carmel Head thrust-plane.

Petrological effects

The effects of these movements upon the rocks themselves must now be considered. They are of three principal kinds — cleavage of the normal type, shearing (with foliation), and disruption. Their intensity varies greatly, but the degree of deformation that is generally present may be described as moderate, the tracts in which it is either absent or powerful being of limited extent.

Cleavage

In the Ordovician shales the cleavage is, for the most part, feeble. It is feeblest and often absent altogether in the broad central part of the Principal Area, particularly in the parts that are opposite the opening to the north-western wing. Though strong enough to destroy the tendency to split along the bedding, it is but a mechanical rearrangement of the particles, and is not comparable for a moment with that of the great slate-zone of the mainland, in which there has been a good deal of mineral reconstruction. The slaty shales easily shatter under the hammer, and are also apt to be much oxidised along the cleavage-planes, having neither the elasticity nor the chemical stability of the Penrhyn slates. The decree of deformation they have undergone is indicated by the fact that, while their little grains of quartz may be optically uninjured, delicate graptolites have been considerably distorted. In the Rhosneigr syncline the cleavage (Figure 261), (Figure 263), (Figure 273), (Figure 274) is much stronger; and in the deep infolds of Mynydd Eilian, Parys Mountain, and those about Carmel Head the shales have become lustrous phyllites, with abundance of secondary mica. Some of these rocks are quite comparable to the less altered members of the Mona Complex, and in some greenish gritty phyllites about Bryn-y-mor, Llaneilian, the resemblance is made still closer by the development of a good deal of chlorite.

Cleavage has been proportionally developed in the grits and conglomerates, some of which, indeed, are more deformed and reconstructed than any of the shales. In the massively bedded conglomerates of the Tywyn Trewan cleavage is often the only structure to be seen. With what rapidity it may develop is remarkably seen along the Garn Inlier. At the eastern end of the conglomerate, near Castell, there is hardly any cleavage at all, but at the summit escarpment hardly half a mile away, it has become so powerful as to obscure the true position of the base. It happens that the underlying member of the Mona Complex is the Gwna mélange; full of lenticular autoclasts of grit, the foliation dipping north, and the rock not much reconstructed. These very autoclasts have furnished the pebbles to the conglomerate, so that, when intensely compressed, it simulates the older rock. There is, indeed, no sharp line to be found, and a provisional one only has been drawn, at a zone where the horny texture of the ancient matrix disappears, and the fragments, now blunter and less lenticular, include schistose Gwni rocks as well, as Gneiss and Church Bay Tuff. The most deformed and altered of all the Ordovician sedimentary rocks is the purple conglomerate of the northern coast, especially on Torllwyn and at Graig Wen (Figure 217), the cleavage, however, being omitted in that figure). The overlying greenish-grey conglomerate is itself strongly cleaved, junctions with the interbedded grits being shredded out, but this increases as the base is approached, and the purple conglomerate (particularly its fine interbedded muds) is often sheared almost beyond all recognition. The most interesting section is where the compressed and ruptured anticline appears in Porth Wen Bay. Here, not only is the ordinary cleavage greatly intensified, but there is a second series of shear-planes at a lower inclination, which drive the original cleavage into sigmoidal curves, and, curving themselves, run into it at acute angles. The combined effect is to stretch the pebbles, and tail them out into acutely-ending phacoids, imparting to the rock as a whole somewhat of the aspect of an augen-gneiss. The matrix has become a lustrous phyllite (E10514) [SH 408 940], and the fine white mica that has been developed exceeds that in many rocks that are usually described as schists.

Disruption

Signs of this may be detected almost everywhere. Its initiation can be very clearly seen on the Rhosneigr shore (Figure 273)–(Figure 274): a further stage (figured by Dr. Matley) at Porth-newydd, Mynachdy; and a still further one at the old slate quarries of Llaneilian, where the black phyllites contain isolated phacoids of grit like those of the old Gwna Beds. Autoclastic rocks on the large scale are, however, developed only at Gwaen-ydog (as already described on p. 546), at Porth Padrig (Mynachdy), and Fresh Water Bay.

At Porth Padrig, for a width of 60 yards to the south of the regular Glenkiln beds described on pp. 477–8, is an extraordinary mélange of black shale, grit, limestone, quartzite, Gwna Green-schist, and schistose tuff, beyond which on the Pad rig slip (Figure 224), rocks of the Mona Complex rise *en masse.* The shale and some of the limestone are certainly Ordovician; the quartzite, green-schist, and tuff are as certainly part of the Mona Complex, to which a portion of the limestone and some of the grits also seem to belong. One of the quartzites is a lenticular mass ten feet long and six feet thick, and yet it rests upon a band of shale. But it is not easy to convey in words any clear picture of this perplexing section. Its explanation seems to be as follows. The Ordovician rocks here have been caught in a thrust and slipped infold. Before the effort to produce a slide on the south was finally successful, the rising floor began to be driven up (Figure 222), at a number of places, into the overlying Ordovician beds, for short distances. Had that floor been homogeneous, a succession of regular thrusts would have resulted. But it happened, at this place, to be composed of the already auto-clastic mélange of the Gwna Group, with lenticular quartzites and limestones- in a matrix of ashy green-schist and schistose tuff. These, under the new strain, broke up once more along their ancient thrust-planes, once more isolating their harder masses, which were driven bodily up into the Ordovician sediments above. But those sediments themselves, by a singular coincidence, contained, not only conglomerates full of epiclastic fragments derived from the Mona Complex, but masses of limestone rudely lenticular in their original deposition-forms. These lent themselves readily to the production of new limestone phacoids, which were carded in-and-in with the old lenticular Gwna limestones, these being driven up among them from below, both sets gliding over one another along strips of old Gwna Green-schist and of Ordovician shale, superimposing mélange upon mélange, and producing a wellnigh inextricable confusion.

The autoclastic rocks of Freshwater Bay are well exposed upon the cliffs between Porth-y-corwgl and the old slate quarries, and again on their eastern side for about 230 yards. The rocks, before disruption, were a series of dark shales with bands of hard whitish grit often several feet in thickness. The grits have been cut into short lengths, which have not only been sheared into phacoids but also dressed into pseudo-boulders that are tolerably well rounded. Great interest is, however, added to the sections by the presence of many pebbles and boulders of quartzite, limestone, green grit, Gwna Green-schist, gneiss, and granite, some of which, especially the quartzites, are thoroughly rolled, and as much as a foot in length. These are clearly epiclastic, but if any doubt remained it would be dispelled by the existence of phacoids, and even rounded pseudo-boulders, of Ordovician grit full of epiclastic pebbles of quartzite and other members of the Mona Complex. Autoclastic and epiclastic boulders are therefore present side by side in this curious mélange, which has been produced by the destruction of a true conglomerate that lay at the base of the Arenig Beds, and the epiclastic boulders that now lie in fine shale have in all probability been wrenched out of their original beds of grit and driven some distance in among the shales, so that they may now be described as being at one and the same time epiclasts and autoclasts.

In each of these three cases, we may note that special facilities were provided for the production of autoclastic mélange, by the operation of local dynamical conditions upon amenable types of rock.

The effects upon the dykes and sills

These have already been alluded to when discussing the age of the rocks in Chapter 16, and local details added in Chapter 17. But reference was made to the present chapter for a discussion of the petrological modifications as such. The effects may be classed under the following heads: mineral degradation; brecciation; the production of isolated mylonitic lines or shear-planes; pervasive shearing with survival of igneous texture; foliation but with catamorphic minerals; mineral anamorphism.

Few if any of the intrusions have escaped from the first of these. No basic rock is known to be untouched by it. The igneous texture is unaffected, but the pyroxenes are more or less chloritised, the felspars, though usually to a less extent, micacised or calcified. Through rocks in this condition small faults may pass (Figure 253) (Figure 254), and occasionally there is brecciation, a good example being that shown in (Figure 233) and (Plate 30).

In the next stage, undulating shear-lines, along which the displacement was quite small (Figure 252), but the pressure considerable, begin to appear. Many of these are mere films, but along others a seam of sheared material is developed, which may be an eighth of an inch in thickness. In these the rock has completely broken down, and the seam has the typical flaser structure of a mylonite.

Usually these mylonites. are several feet apart or even rarer. But in part of the great dyke of Gaerwen ((Figure 306) and p. 513) and other cases, a crowd of them, only an inch or half an inch apart, constitute a pervasive shearing, though between them the igneous texture still survives. In the dykes immediately above the Carmel Head thrust-plane several may be seen in a single microscopic slide. At this stage the pyroxenes are usually completely chloritised, the felspars micacised. The needles of apatite resist molecularly, but are broken into short lengths and these portions driven off sideways.

Finally, in parts of the dolerite at the Barclodiad-y-gawres, the basalt of Mynydd y Wylfa (Figure 139), and the picrite of Mynydd Eilian, igneous texture has disappeared, and the rocks have become true fissile chloritic schists, with fine flaser structure. On Mynydd Eilian it is the once compact selvage of the hornblende-picrite that has become foliated, and the resulting schist is composed almost entirely of felted chlorite, with little granules of iron-ores. As a rule, the basic intrusions have yielded much more to the deforming stresses than have the acid ones. One of the sills of the Eilian coast has, however, become schistose throughout, though not excessively, its peculiar mosaic being just recognisable in a few places between the more fissile folia; and ahigh degree of deformation has been induced on the north limb of the Parys Mountain felsite.

The dip and strike of the new planes has interesting variations. In the northern sills, whose own dip and strike is an earlier product of the same movements, this dip is for the most part northward, and is rudely parallel to the major axis of the sill. The dykes, however, with their pre-existing north-west trend and vertical position, presented their direction of greatest resistance almost directly to the line of application of the shearing stress. Moreover, enclosed for the most part in already compressed rocks of the Mona Complex, they could not often be wrenched far out of place. Only in rare cases, therefore, are they traversed, as in the broad Rhoscolyn dyke, by regular shear-zones at a high angle to their trend. Generally the distribution of the new planes is evidently a resultant, determined by the trend of the dyke and by the strike which the compressing or shearing force was endeavouring to impose upon the district. In some cases this took the form of simple differential movement along the margin of the dyke, but more often it is combined with curving vertical shears, which where they run out and join that along the margin, produce a maximum of deformation. The chlorite-schist of the dyke at the Barclodiad-y-gawres is produced at the junction of such a pair of shears. In a great number of cases, among which are the dykes immediately above the Carmel Head thrust-plane, the resultant is much more complex, and the dyke is traversed in all directions by a network of mylonitic seams. Finally (p. 511, 532), the new planes have been in their turn folded, but this is very rare.

Minerals of anamorphic evolution have also been developed, though usually on a small scale. In the schistose parts of the Parys Mountain felsite the felspar has been replaced by fine secondary mica, which is also present, though only along limited zones, in the Eilian sills above referred to. The chlorite of the fissile schists is probably of dual origin. Where it is a direct product of the break-down of pyroxenes 'under shearing stresses, it is catamorphic. But where it is a foliated reconstruction of the materials of early chloritisation (p. 498) it is to be regarded as a chlorite of anamorphic evolution. Further, thin sections of the basic intrusions reveal the fact that even in rocks that have the external aspect of ordinary massive dolerites, and in which abundance of perfect augite still remains, a higher stage of reconstruction has begun. Some of the augite was first chloritised in the usual way, but this chlorite is now pierced in all directions by little needles of pale green actinolite. Similar needles have developed in the chloritic tracts of the large picrite sill of Mynydd Eilian.,In a further stage, the augite has begun to be converted marginally, but without any destruction of its crystal outlines, into paramorphic hornblende. This is the 'third hornblende' of the large dykes of Holy Isle, and the 'fourth hornblende' of the hornblende-picrites mentioned on pp. 487, 491.

The most advanced stage of all is seen in the Mynydd Mechell and on The Skerries. A dyke about 200 yards east of the little Llyn Bwch, and therefore half a mile from the escarpment of the Carmel Head thrust-plane (E10394) [SH 363 894]

<ref>It is probable, from the strike of the thrust at Carmel Head, that The Skerries are about the same distance from its outcrop.</ref> has become a perfect ophitic epidiorite'. The felspar, partly fresh and retaining its original albite-twinning, partly kaolinised and micacised, penetrates plates of a mineral which extinguishes simultaneously over large areas, precisely like ordinary ophitic augite; but the whole of this mineral is now green hornblende, well crystallised, and full of little granules of epidote that lie along the cleavage planes. Besides these there are also green tracts representing the amphibolised chlorite of the less altered dykes, but in which little chlorite now remains, for they are composed of a mesh-work of actinolite, less acicular and slender, however, than that of the earlier stages of the reconstruction. The peculiar character of this dyke is perceptible to the unaided eye, and its larger hornblendes can be distinguished under the hand-lens.

These ophitic epidiorites are not schistose. Indeed, not a single true basic reconstruction-schist of this period has been found in the Island. In the basic intrusions, anamorphism and deformation have been mutually exclusive, the minerals of the schistose parts being minerals of catamorphic dissolution, such as chlorite and calcite; while it is in the undeformed parts that we find the minerals of true anamorphic evolution. From which it would appear that where, as was frequently the case among the dykes, the energy of the stresses was unable to find relief in molar, it found expression in molecular movement, and chemical activity resulted. This is interestingly exemplified in the dykes just mentioned. Immediately above the Carmel Head thrust-plane, they are mylonised, but 100 feet or so above it, they are undeformed and their augites are amphibolised. At this tectonic horizon, they were, in the Mynydd Mechell and on The Skerries, enclosed in the Coeden Beds and in the Skerries Grits, some of the toughest and most unyielding rocks in the whole Island, which, refusing to break up<ref>A contribution to the general stability would be made by the fact that, as movement along the Carmel Head thrust-plane was about south 10° east, it would not be at 90° but only at some 60° to the strike of the dykes.</ref>, were carried forward *en masse.* Protected by this encasement, the dykes travelled with the whole moving *nappe de récouvrement;* differential movement was excluded, and so the only readjustments possible for them were chemical.

Chronology of the movements

The cleavage dips in the same direction as the axes of the isoclines, and is clearly related to the folding. North of latitude 53° 22■, however, the traces of its planes are seldom straight, but are apt, even in fine and homogeneous shales, to be somewhat wavy and quivering', as if disturbed by lateral pressure at a later period. At Porth-y-gwichiaid and other places the cleavage is ruptured along many minor thrust-planes, between which it is curved sigmoidally in a way that indicates an impulse from the north (Figure 267). On the north cliffs of the little bay one of these thrust-planes (Figure 268) is horizontal. On Mynydd Eilian the shale splits into pencils', owing to a second cleavage that traverses the ordinary one and is at a lower angle. A second cleavage is developed also in the district about Carmel Head, and its nature can be studied on the rocky headland north of Porth-y-dyfn. Here the ordinary cleavage is folded quite sharply (quartz-seams developing- along the folds, which have an easterly pitch), and driven southward along the planes of the second cleavage, which traverse it at intervals of one inch or less. They are at low angles, horizontal in places, and are coated with films of minute secondary mica, so that the rock is now a true phyllite. The second cleavage is thus, in reality, a minimum' thrusting, of the same nature as the minor thrusts of Porth-y-gwichiaid, and of Carmel Head itself immediately below the thrust-plane. The lenticular structure of the purple conglomerate at Porth Wen is also due to the disruption of a first cleavage by a shearing that is in reality a minor thrusting. Closely related to lenticular shearing, moreover, are the autoclastic rocks described on. pp. 551–2. Those of Fresh Water Bay may be referred to the same impulse as that which induced the second cleavage in the adjacent shales of Mynydd Eilian; while those of Gwaen-ydog are a product of the Carmel Head overthrust. Finally, it is to be noted that all these structures are found in the immediate vicinity of either the great thrusts of Llanfairynghornwy and Llaneilian, or those of the Northern Wedges, or of the Carmel Head thrust-plane itself.

We see, therefore, that there is a considerable variety of tectonic phenomena that can all be shown to be later than the cleavage; and that can be shown, further, to be due to the same impulse as that which brought about the thrusting. And we have already seen (see pp. 545, 465) that the Carmel Head and other great thrust-planes are undoubtedly also later than the cleavage.

It is thus apparent that there were two successive stages or phases of these movements, and that they were dynamically distinct. The first was related to the folding, was compressive, and induced the cleavage. The second was disruptive, producing flexure, shearing, autoclasts, a second cleavage, and minor thrusting, and culminated in the production of the great overthrusts.

Normal faulting

The folds and thrust-planes we have been discussing are cut by a series of normal faults which differ from even the steepest of the slips and slides in that they are in no way complementary to thrust-planes. Where they are laid bare they are always found to brecciate, and they are clearly the products of totally different dynamical conditions. Some of them, indeed, may even be Post-Carboniferous. But we know from two independent sources that there was Post-Ordovician faulting of considerable importance which was nevertheless Pre-Carboniferous. At the close of Chapter 27 it will be shown that some members of the Berw plexus are superimposed upon Pre-Carboniferous ruptures. And it is patent upon the maps that the faults which bound the Llangwyllog Area, though (p. 438) later than the folding, are antecedent to the deposition of the Old Red Sandstone, which gives us a second *terminus ad quod.* Further, we shall see in Chapter 33 that Carboniferous rocks must closely skirt the northern coast; yet not even the powerful Hell's Mouth fault brings in any Carboniferous outlier on its downthrow side. The normal faults which haunt the Ordovician tracts will therefore be treated, at any rate provisionally, as Pre-Carboniferous.

There is a series running from north-east to south-west, and another running north and south or north-west and south-east.

The principal examples of the first series are those of the Berw and Llangwyllog plexi and the singular Hell's Mouth fault. These are not necessarily strike-faults, for those of Llangwyllog have an obliquity to the axes of the infolds ranging from 5° to 20°, while the Hell's Mouth fault is nearly at right angles to the local strike of the Northern Wedges. The latter produces quite four feet of breccia, but its throw is difficult to estimate, for its behaviour (pp. 219, 474) is anomalous, evidently owing to its being an ancient rupture upon which movement recurred in Palaeozoic times.

Most important of the other series are the Coedana fault which cuts out the basal conglomerate on one side of the bay south of Llanerchymedd, the Garn fault, and those which cut the Carmel Head thrust-plane. The throw of the first is probably about 300 feet. Estimates of the displacement along the Garn fault are not easy to obtain, as it acted on already thrust and folded zones, but a mean of those obtainable at Bonw and the ironstone indicate a throw of about 1,000 feet. Those which cut the Carmel Head thrust-plane are interesting, as they recall the manner in which the thrust-planes of the North-West Highlands are displaced by the dip-faults of that region. Seven are known, but most of them are quite small, the largest being the Geirian. fault at Llanfflewyn, which has a vertical throw of about 100 feet.

About Llangwyllog, the longitudinal faults appear to be cut by some north-and-south ones, from which it would appear as though that series were the later of the two. If so, we obtain a much closer *terminus ad quod,* for two of such faults are filled by ore-deposits at Parys Mountain which, as we shall find in Chapter 19, cannot be much later than the thrusting stage. But if the faulting under consideration followed so quickly on the thrusting, we can hardly doubt that it was, however unlike, a true dynamic sequel thereto. It is reasonable to suppose that such great displacements in the horizontal dimension would bring about serious redistributions of load upon the earth-crust, and that these would necessitate readjustments in the vertical dimension. To such an episode, therefore (*cf.* Appendix 9), these faults may, with tolerable confidence, be ascribed.

Date of the movements as a whole

In Anglesey itself, the latest beds involved are the Llandovery and Tarannon shales of Parys Mountain; while at the base of the Old Red Sandstone (p. 556 and Chapter 20), a *terminus ad quod,* absolute, is imposed. On the Mainland, however, there seems to be no break of any importance between the Tarannon and the Ludlow Beds: none, certainly, during which disturbances such as these can have taken place; but the Silurian series as a whole is vigorously folded. The great movements described in this chapter may therefore be referred to the close of Silurian time.

Comparison with the tectonics of the Mona Complex

Movements on so great a scale as this series and those of the Mona Complex having been superimposed upon each other, it will be instructive to compare the tectonics of the two.

We find, first, that structures on the minor, major and maximum scales recur, but that the minimum foldhig is almost absent in the Palaeozoic series. Folding is very rarely rapid enough for one to obtain hand-specimens that show it, whereas in the rocks of the Mona Complex such can easily be had. Of the maximum structures there is but one Post-Silurian example, the Carmel Head thrust-plane, which, indeed, is typically recumbent and on a scale quite comparable with the recumbent structures of the Mona Complex. Owing, however, to the total abolition by it of the middle limb of its ideal fold, there is a complete absence in the Palaeozoic succession of those widespread inversions which are general in the Mona Complex.

Isoclinal and symmetrical folding are both found in the Palozoic series, the isoclinal perhaps predominating; but the a-clinal and polyclinal types are unknown. Thrust-planes frequently develop upon the isoclines, whether on the minor or the major scale. In one place we shall find an approach to a Palaeozoic synclinorium, but of vastly less intensity than the great Mona synclinorium of Aethwy.

There is an important difference in the chronology of the two kinetic series. In the Mona Complex, the major and minor folds that are known to us are secondary and ternary, the recumbent folds and thrust-planes being powerfully folded' by 'them. In the Palaeozoic series, the major and minor are older than the maximum structures, the Carmel Head thrust-plane being an approximately plane superficies, unaffected by any later flexures.

Comparing the petrological effects, we find that the micaceous anamorphism developed along the cleavage of the Palaeozoic sediments is usually quite feeble, and that in the rare cases where a true crystalline schist has been produced, the grade never exceeds the lowest stages of the Gwna Green-schist. The same is the case with the Palaeozoic intrusions, fine sericitic and chloritic schists being the highest stages of Palaeozoic foliation; though unfoliated ophitic epidiorites represent a higher anamorphic state. Only in one or two cases have Post-Silurian cleavage or foliation-planes been folded. In general, it may be said that, while the Palaeozoic anamorphic maximum exceeds the anamorphic minimum of the Mona Complex, the Palaeozoic anamorphic average cannot for a moment compare with the average produced by the older kinetic series. True autoclastic mélange, also, which in the Mona Complex occupies nearly 50 square miles, has been found at three places only among the Palaeozoic rocks, with an aggregate area of a few hundred square yards, special facilities for its production existing in each case. Thus, autoclastic mélange, regional in the Mona Complex, is in the Palaeozoic rocks merely local.

At the beginning of this chapter it was remarked that local phases of the tectonics of the older are simulated by those of the later series.<ref>It is believed that the two have been disentangled in all cases of any considerable importance, with one exception. The age of the Caerau, the Wig, and other large thrust-planes of the Northern Region, has not yet been determined with certainty (see pp. 216–19). It is not unlikely, indeed, that the very great overdrive on the Carmel Head thrust-plane was facilitated by the tough crystalline schists first giving way along a pre-existing rupture that lay at but an acute angle to the direction of stress. The energy thus economised would be able to carry the *nappe de récouvrement* much farther than would otherwise have been the case.</ref> Let us rapidly trace the two systems<ref>It will be remembered that we shall be comparing primary Ordovician with secondary Mona structures (p. 182).</ref> across the Island.

At the North-Western Inliers, both the Mona Complex and the Ordovician are disposed in deep ruptured isoclines overdriven from the north. But at Fydlyn the Ordovician infold is taken in over the roof of one of the older anticlines, while the ancient Gader infold is now the core of an Ordovician anticline.

The most striking coincidence of the tectonics is that between the Northern Region of the Mona Complex and the Principal Ordovician Area, both of which are thrown into southward facing isoclines for many miles. The Ordovician isoclines, however, are autochthonous; those of the Mona Complex are *sans racine,* and have left their roots behind a long distance to the north. The Ordovician isoclines, in addition, roll on southwards past the flanks of the Western Region of the Complex, whose structures face them.

Coincidence recurs on the confines of the Middle Region, where the Dulas-Esgob Ordovician syncline is cradled within a syncline of the Mona Complex.. Both are symmetrical about a vertical axis, and both are composite of many subsidiary isoclines. But whereas the isoclines of the older system face outwards from their axis, those of the Ordovician face inwards towards theirs, with an approach to a synclinorial structure.

There is another coincidence at the Llangwyllog Ordovician syncline, which is superimposed upon the Bodwrog syncline of the Mona Complex. But while the Ordovician axis is vertical, the Bodwrog syncline is overdriven a little to the north-west; and the subsidiary infolds also fail to coincide.

Along both flanks of Aethwy, the rocks of the Complex as well as the Ordovician dip on the one side towards the Malldraeth, on the other towards the Strait. But whereas the Ordovician dips are those of a truly symmetrical anticline, the dips in the Complex belong, on the Malldraeth side, to the western limb of the Aethwy main anticline, which is isoclinal; on the Menai side, to the eastern limb of the Llanddona synclinorium.<ref>Here, as at Llangwyllog, the utmost causal connexion that can be admitted is that where the Palaeozoic stresses were of themselves producing symmetry, the pre-existing structures of the Complex offered facilities for its production.</ref> Not only so, but the axis of that synclinorium, passing obliquely across the Aethwy Region (Figure 98), strikes at the Ordovician with a discordance of about 78°.

Thus: every one of these remarkable coincidences turns out on scrutiny to be a simulation. Confirmation, accordingly, emerges from an independent source for the conclusions already reached in Chapter 9. The structures of the Mona Complex (however disrupted by later movements) are its own, and are in no case a birth of Paliuozoic time.

But there are signs of repetition. For one cannot but think that the repeated isoclines and thrusts of the north are products of an impulse which, sated only for a while by its effects upon the Mona Complex, gradually accumulated again, and broke out afresh in Post-Silurian time. Indeed, it does not seem to have been totally sated even then, but (as we shall see in Chapter 20) to have required a third outbreak before it became finally exhausted.

General view of the movements

Let us endeavour, in conclusion; to obtain a comprehensive view of these phenomena. At the close of Silurian time, the region under consideration was caught, as it were, between two, great opposing movements of the earth-crust. One was the northward impulse proceeding from the Snowdonian syncline, the other was the southward impulse that culminated in the Carmel Head thrust-plane. In the intervening region, during at any rate the earlier stages of the process, the horizontal components of the two impulses neutralised each other, and a series of parallel symmetrical folds with vertical axes was produced. Later on, the northward impulse pushed out farther, and the advance undulations of both impulses can be traced to the neighbourhood of Llanerchymedd, where the isoclines about the Foel inlier face the Bodafon thrust-plane. The impulses, however, did not face each other directly. One was southward, the other north-westward. Their advance infolds were therefore oblique to each other, which resulted in the rise of a broad anticline, whose core is the Western Region of the Mona Complex, about which the chief synclinal area divides. Two tracts were relieved from compression, one in the broad central parts of the Principal Area, the other along the Strait, under the lee of the 'Llyn Padarn Ridge'. That ridge' must have been in the main of a tectonic nature, due to the enormous depth and steepness of the Snowdonian depression. Against the Pre-Cambrian floor, thrown almost into a vertical position, the older Palaeozoic rocks were intensely compressed, but the pressure was resisted, at any rate at the tectonic horizon of the great slate-zone. Had the northward impulse prevailed, the whole region would have been thrown into a gigantic synclinorium, 20 miles or more in width. The success of the resistance has limited the production of synclinorial structure to the narrow Dulas-Esgob tract. The first effect of the great southward impulse was to produce a series of shallow isoclines in the Cors y Bol district, and of deep and steep isoclines in latitude 53° 23■ to 53° 24■, in which there was again great compression, resulting in a slaty cleavage, and in deformation of the igneous material. The impulse recurring, the cleavage itself became flexured and ruptured, minor thrusts appeared, and great over-thrusts developed upon the major isoclines. Finally, the southward impulse became irresistible, the whole northern region tore away, and was driven forward for some 20 miles upon the Carmel Head thrust-plane.

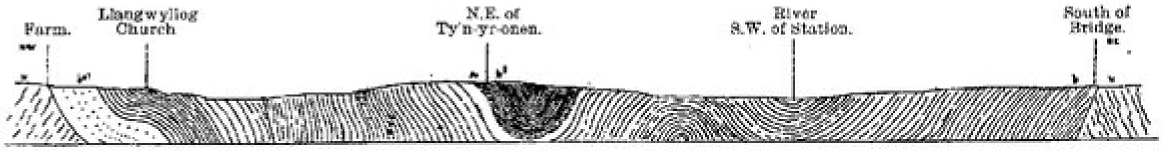


FIG. 201.—SECTION ACROSS THE ORDOVICIAN ROCKS OF LLANGWYLLOG.
Scale—8 inches = 1 mile.
M = Penmynydd (Mona) Schists. b = Ordovician (undifferentiated).
be = Extensus Zone (with basal grit). Fe = Oolitic Ironstone. bx = Gracilis Zone.

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

FIG. 261.

(Figure 261) Folding, thrusting, and cleavage on the foreshore at Rhosneigr. Amplitudes about one foot.

FIG. 262.

(Figure 262) Folding, thrusting, and cleavage on the foreshore at Rhosneigr. Amplitudes about one foot.

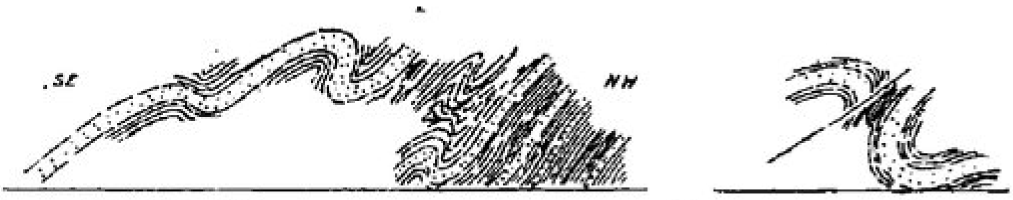
FIG. 263.

(Figure 263) Folding, thrusting, and cleavage on the foreshore at Rhosneigr. Amplitudes about one foot.

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

FIGS. 205, 206.—NORTH-WESTWARD FACING ISOCLINES IN ARENIG BEDS BELOW THE BODAFON THRUST-PLANE.

(Figure 205) North-westward facing isoclines in Arenig Beds below the Bodafon Thrust-plane. Height six feet and two feet. Bend in stream mile east of Llwydiarth Esgob.



FIGS. 205, 206.—NORTH-WESTWARD FACING ISOCLINES IN ARENIG BEDS BELOW THE BODAFON THRUST-PLANE.

(Figure 206) North-westward facing isoclines in Arenig Beds below the Bodafon Thrust-plane. Height six feet and two feet. Bend in stream mile east of Llwydiarth Esgob.

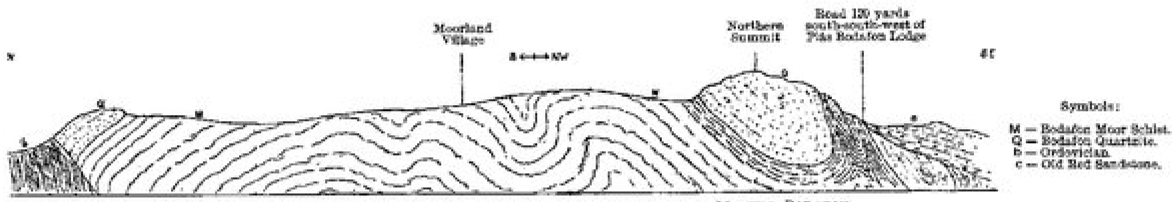


FIG. 156.—SECTION ACROSS BODAFON MOOR AND THE NORTHERN SUMMIT OF MYNYDD BODAFON.

(Figure 156) Section across Bodafon Moor and the northern .summit of Mynydd Bodafon. Scale: Eight inches = one mile. Symbols: M = Bodafon Moor Schist. Q = Bodafon Quartzite. b= Ordovician Shale. c = Old Red Sandstone.

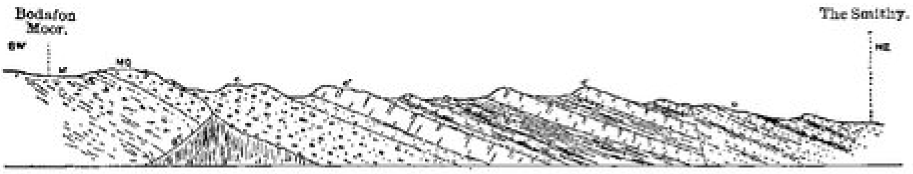


Fig. 276.—SECTION FROM THE NORTH END OF BODAFON MOOR, THROUGH THE OLD RED SERIES, TO THE SMITHY.
Scale: eight inches = one mile.

Symbols used in Figs. 275, 276, 277, 278.

M = Bodafon Moor Schists } Mona
MQ = Bodafon Quartzite } Complex.
b = Ordovician.

c = Old Red Sandstone Series.
c' = " " Cornstones.
d = Lligwy Sandstone (Carboniferous).

d2' = D1 Subzone of Carboniferous Limestone.
d2" = D2 " " "
BT = Bodafon Thrust plane.

(Figure 276) Section from the north end of Bodafon Moor, through the Old Red Series, to the Smithy. Scale: eight 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.

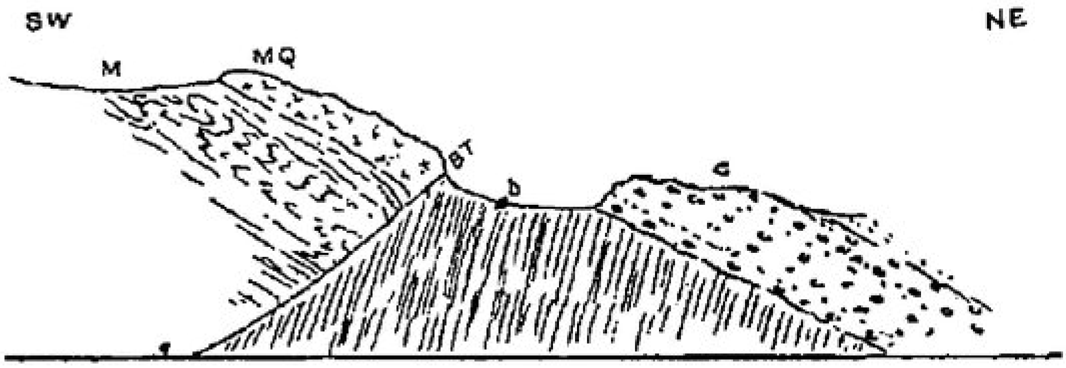


FIG. 278.—SECTION PARALLEL TO PART OF FIG. 276, ALONG A LINE 266 YARDS FURTHER TO THE WEST-NORTH-WEST.

(Figure 278) section parallel to part of (Figure 276), along a line 266 yards further to the west-north-west. Scale: 8 inches = 1 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.

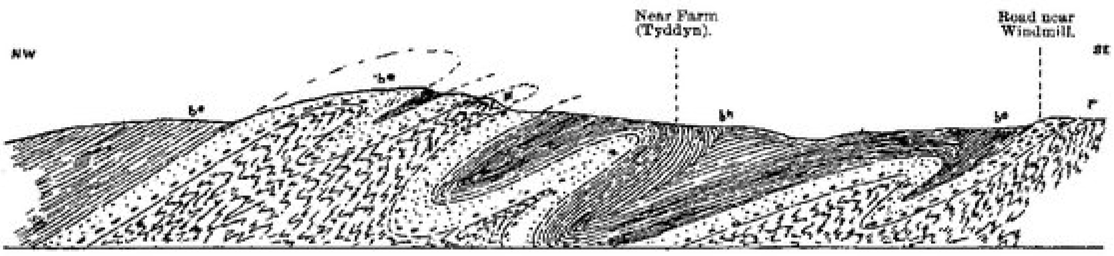


FIG. 204.—SECTION ACROSS FOEL HILL, LLANERCHYMEDD.
Scale—12 inches = one mile.
M = Mica-schist, u = Hornfels } Mona Complex. b^h = Zone of *Did. hirundo.* b^e = Zone of *Did. extensus* (with basal conglomerate).

(Figure 204) section across Foel Hill, Llanerchymedd. Scale-12 inches = one mile. M Mica-schist and u = Hornfels, Mona Complex. bh = Zone of Did. hirundo. be = Zone of Did. extensus (with basal conglomerate)

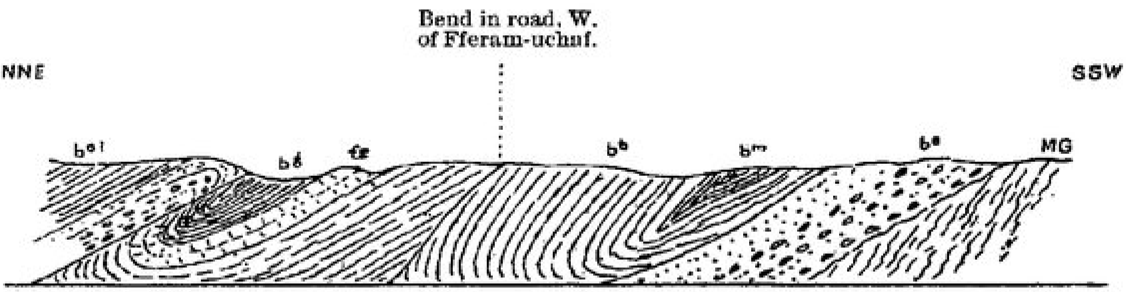
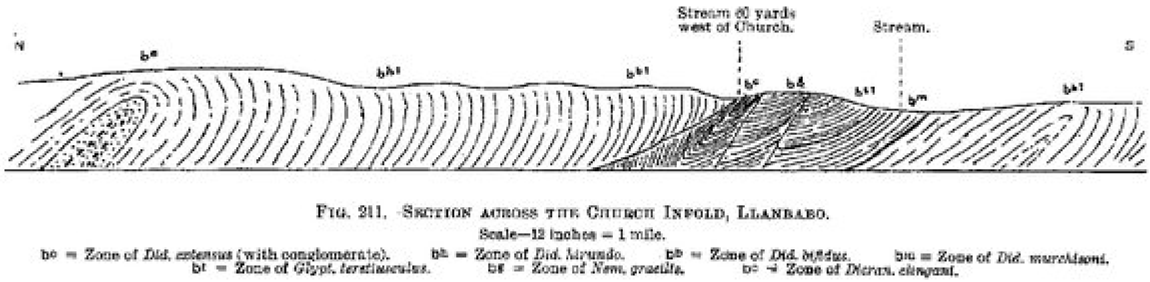
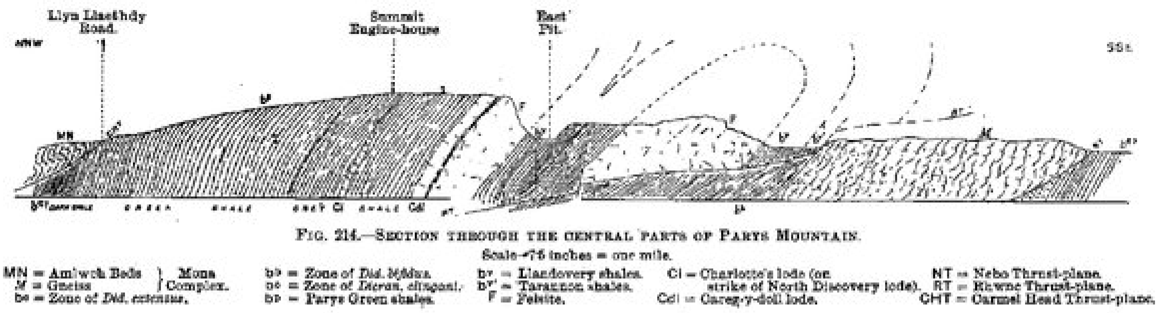


FIG. 208.—SECTION ACROSS THE FFERAM INFOLD, LLANBABO.
Scale—12 inches = one mile.
MG = Gwna (Mona) Schists. b^e = Zone of *Did. extensus* (with basal conglomerate).
b^b = Zone of *Did. bifidus.* b^m = Zone of *Did. murchisoni.* Fe = Oolitic Ironstone.
b^g = Zone of *Nem. gracilis.*

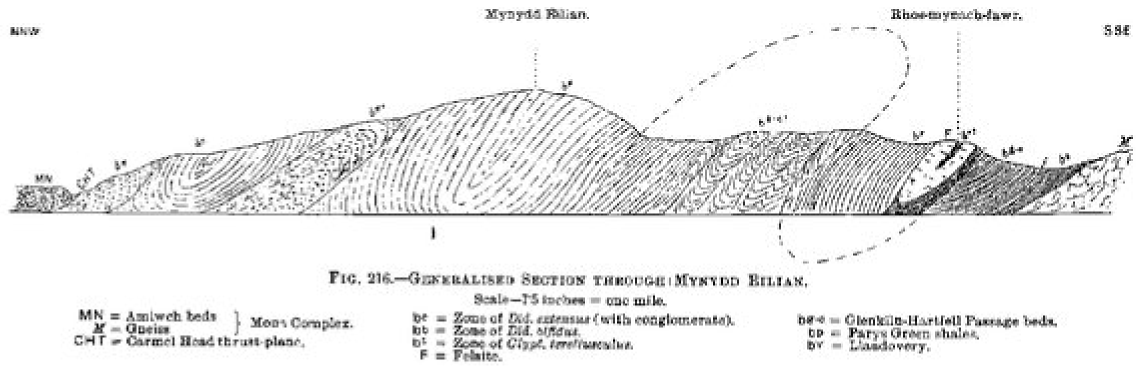
(Figure 208) Section across the Fferam Infold, Llanbabo. Scale-12 inches = one mile. MG = Gwna (Mona) Schists. Be = Zone Of Did. extensus (with basal conglomerate) Bb = Zone of Did. bifidus. bm = Zone of Did. murchisoni. Fe = Oolitic Ironstone. Bg = Zone Of Nem. gracilis.



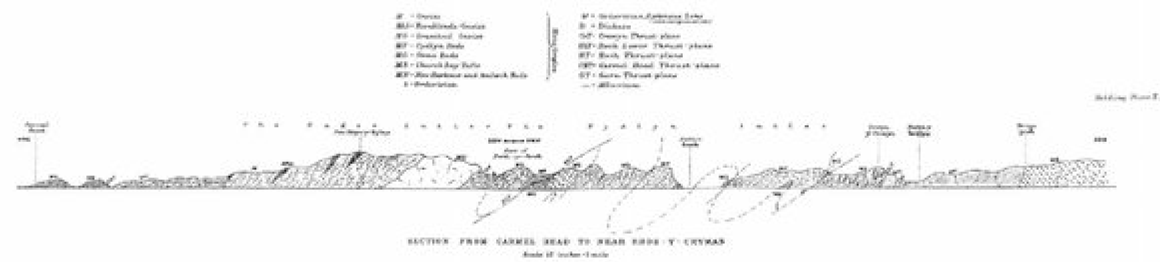
(Figure 211) Section across the Church Infold, Llanbabo. Scale-12 inches = 1 mile. Be = Zone of did. extensus (with conglomerate) bb = zone of Did. hirtindo. bb = Zone of Did. bifidus. bm = zone of Did. murchisoni. Bt = Zone of Glypt. teretiusculus. bg = Zone of Nem. gracilis. be = Zone of Dicran. clingani.



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



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



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

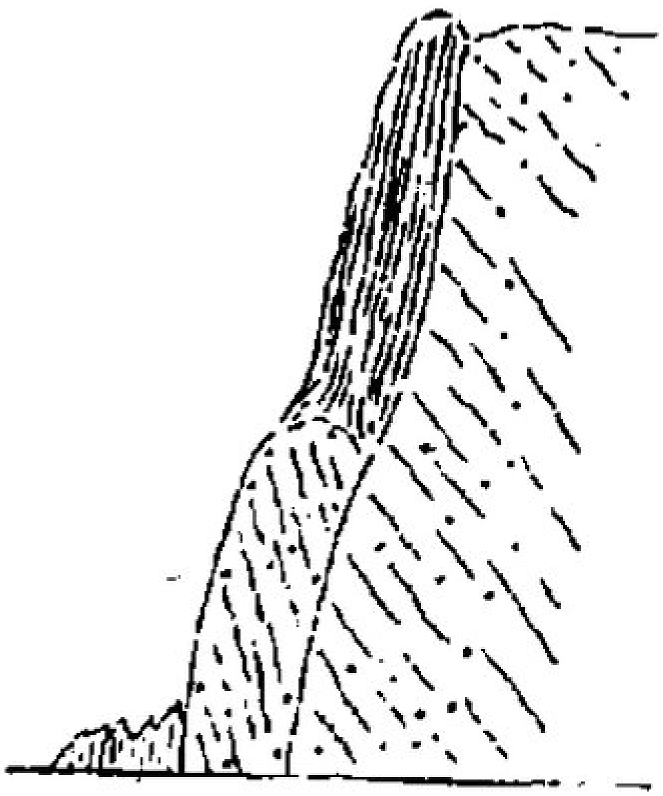


FIG. 203.

THE RUPTURE AT YR-OGO-GOCH.

(Figure 203) The rupture at Yr-ogo-goch. Height about 100 feet.

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

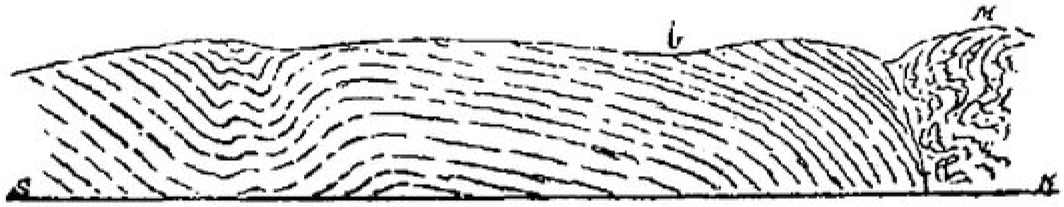


FIG. 264.—THE NEBO THRUST-PLANE ON THE COAST.

M = Gneiss. b = Bifidus Shales.

Height: about 20 feet.

(Figure 264) The Nebo Thrust-plane on the coast. M = gneiss. b bifidus shales. Height: about 20 feet.

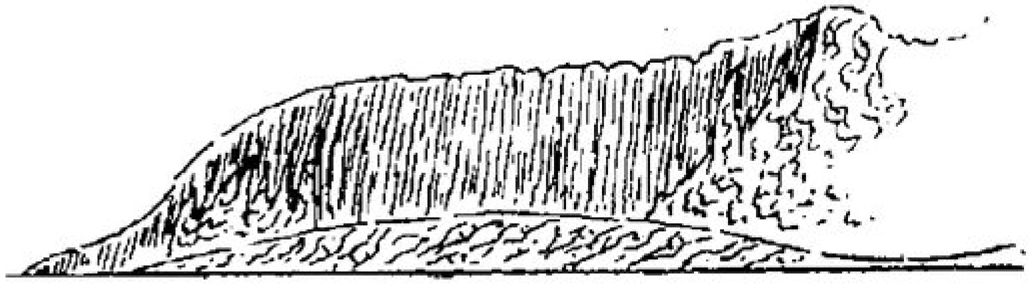


FIG. 265.—DETAIL OF FIG. 264.

(Figure 265) Detail of (Figure 264) Height: about one foot.

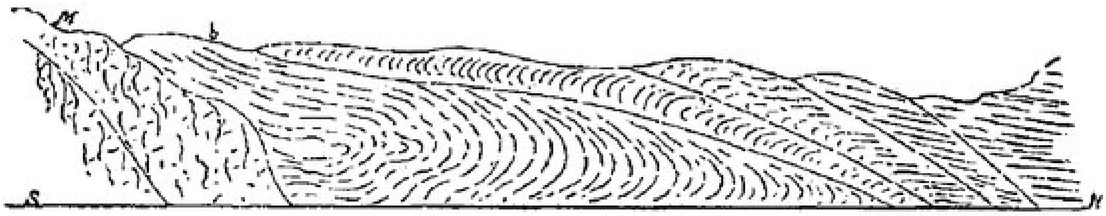


FIG. 266.—THE GWICHIAID SLIDE AT THE SEA-CLIFF, WITH THRUST-PLANES IN FOLDED SHALES.

Height: about 30 feet.

M = Gneiss. b = Llanvirn Shales.

(Figure 266) The Gwichiaid Slide at the sea-cliff, with thrust-planes in folded shales. Height: about 30 feet. X= gneiss. b Llanvirn shales.

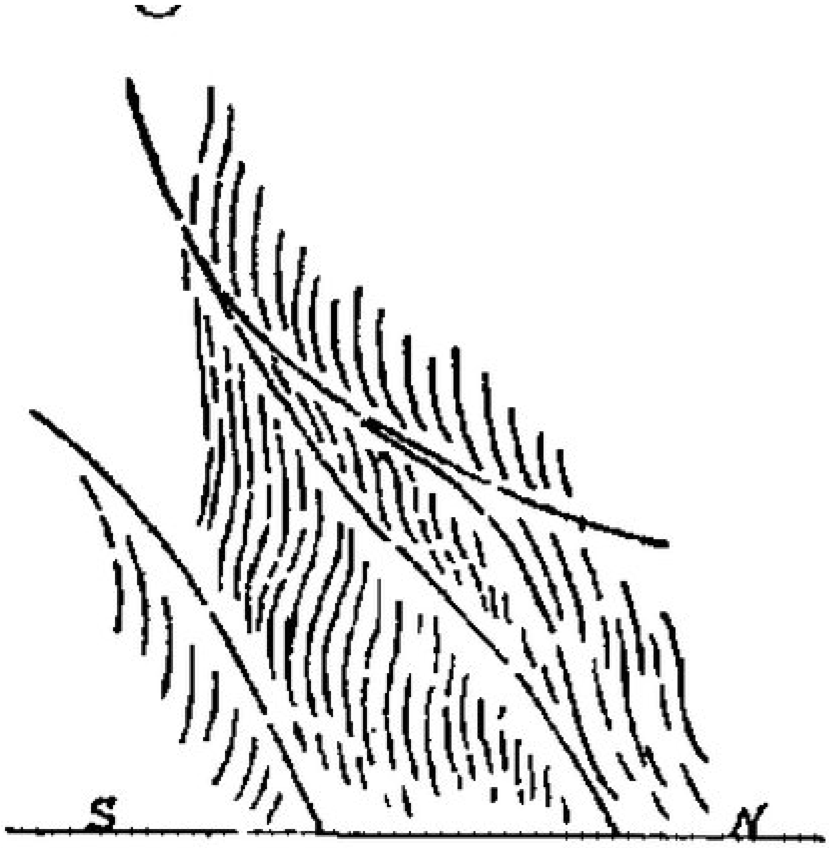


FIG. 267.

MINOR THRUSTS IN SHALE. PORTH Y GWICHIAID BEACH.

(Figure 267) Minor thrusts in shale. Porth y gwichiaid beach. Height about 10 feet.

FIG. 268.

HORIZONTAL THRUST IN SHALE. NORTH CLIFF OF PORTH Y GWICHIAID.

(Figure 268) Horizontal thrust in shale. North cliff of Porth y gwichiaid. Height: about 10 feet.

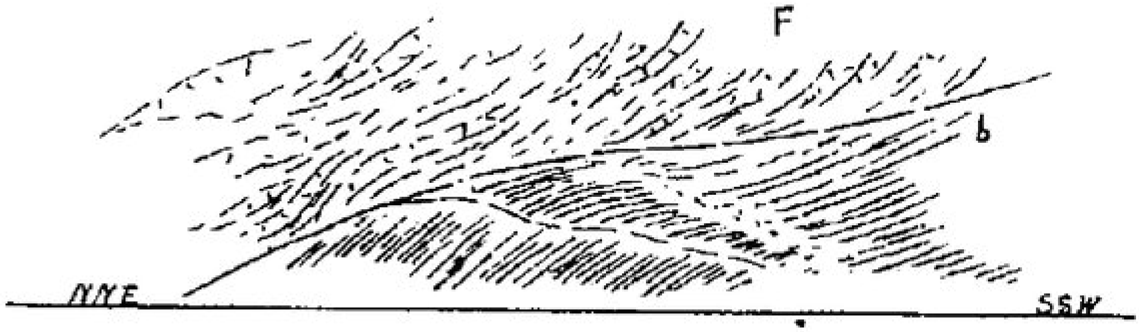


FIG. 212.—THE RHWNC THRUST-PLANE AT RHWNC.

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

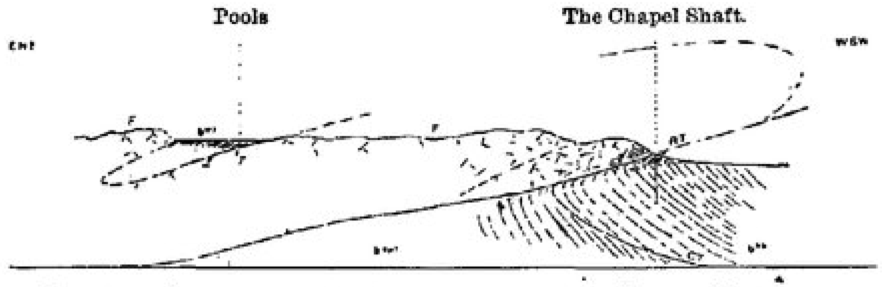


FIG. 213.—SECTION THROUGH THE WEST END OF PARYS MOUNTAIN.
Scale—eight inches = one mile.
bhb = *Phyllograptus* and adjacent Shales. bcp = Hartfell Shales. bv = Llandovery Shales.
F = Felsite. CT = Chapel Thrust-plane. RT = Rhwnc Thrust-plane.

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

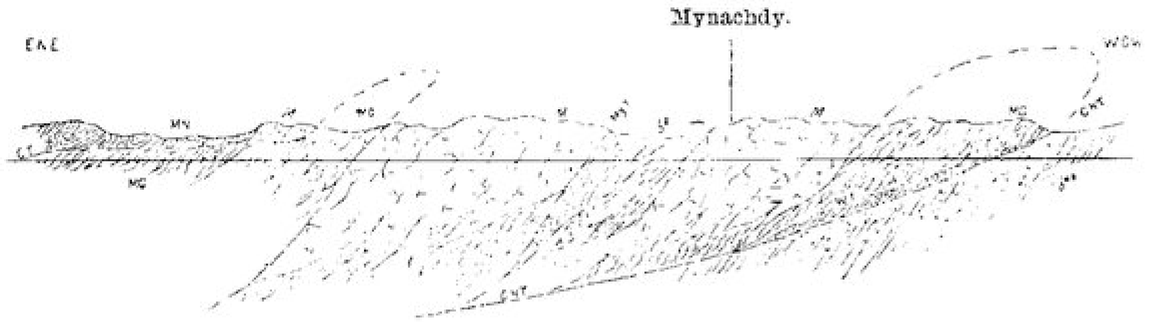


FIG. 94. SECTION AT MYNACHDY.

(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.

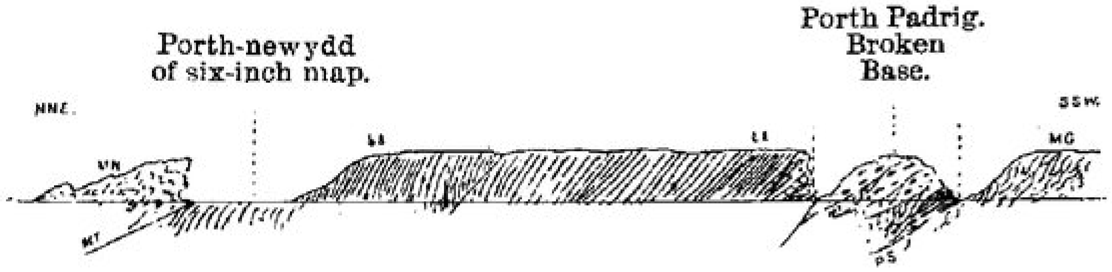


FIG. 222.—SECTION THROUGH THE ORDOVICIAN INFOLD OF MYNACHDY.
Scale—eight inches = one mile.
MN = Amlwch beds. MG = Gwna beds.
bg = Glenkiln shales, with limestone and conglomerate.
MT = Mynachdy thrust-plane. PS = Padrig slide.

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

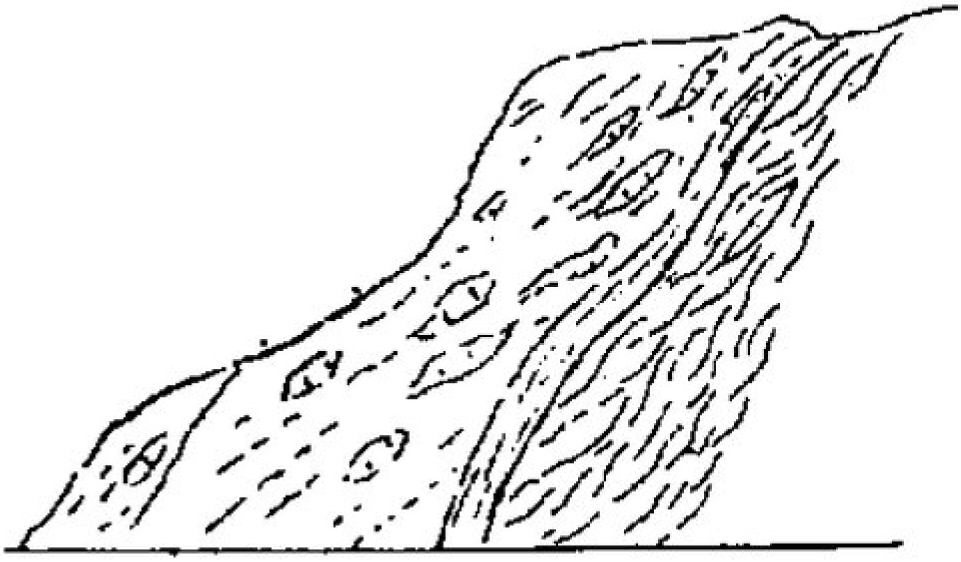


FIG. 224.
THE PORTH PADRIG SLIDE.

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

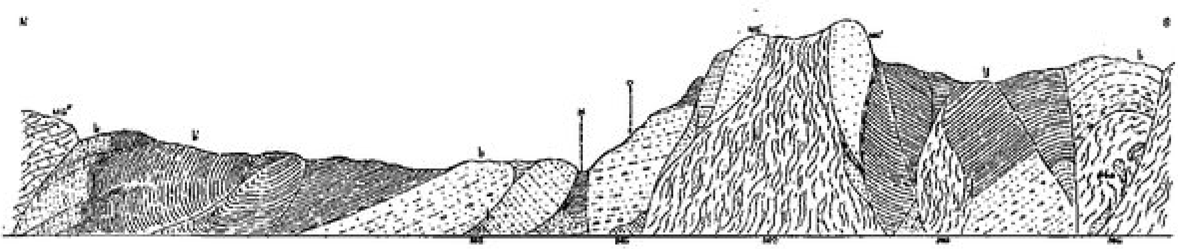


FIG. 220.—CLIFF SECTION AT OGOF GYNFOR.
Drawn from a boat, and brought to one plane. Scale about 65 feet = one inch.
MG = Gwna mélange. MG′ = Gwna quartzite. MG″ = Gwna limestone. b = Glenkiln conglomerate. b′ = Cherty shales.
Graptolites [Af. 3507–22] obtained from base of shales below X. Unconformable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

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

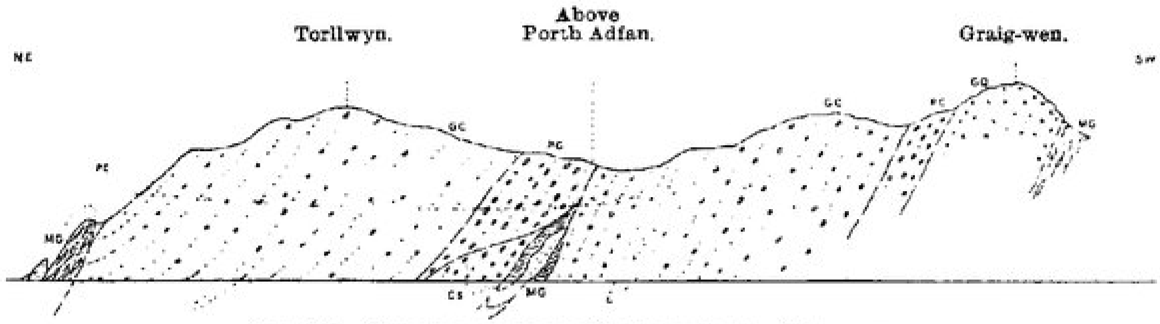


FIG. 217.—SECTION THROUGH TORLLWYN AND GRAIG-WEN.

Scale—16 inches = one mile.

MG = Gwna grit and phyllite
GQ = Gwna quartzite
} Mona Complex.

CS = Cherty shales
GC = Grey conglomerate
PC = Purple conglomerate
} Glenkiln.

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

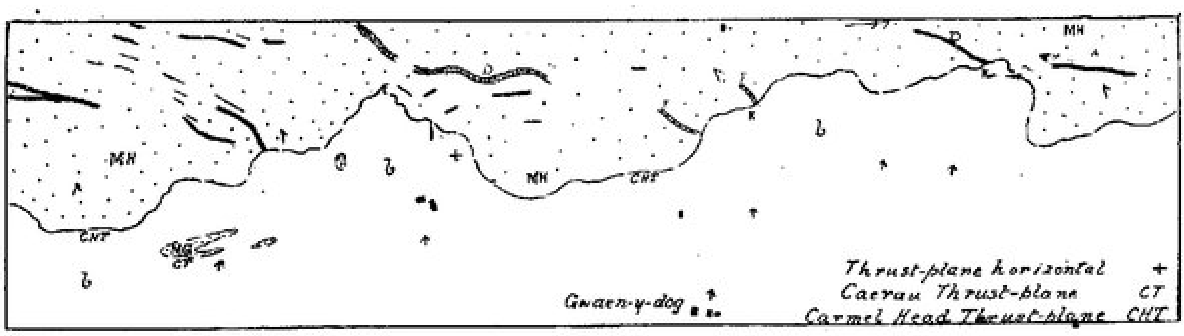
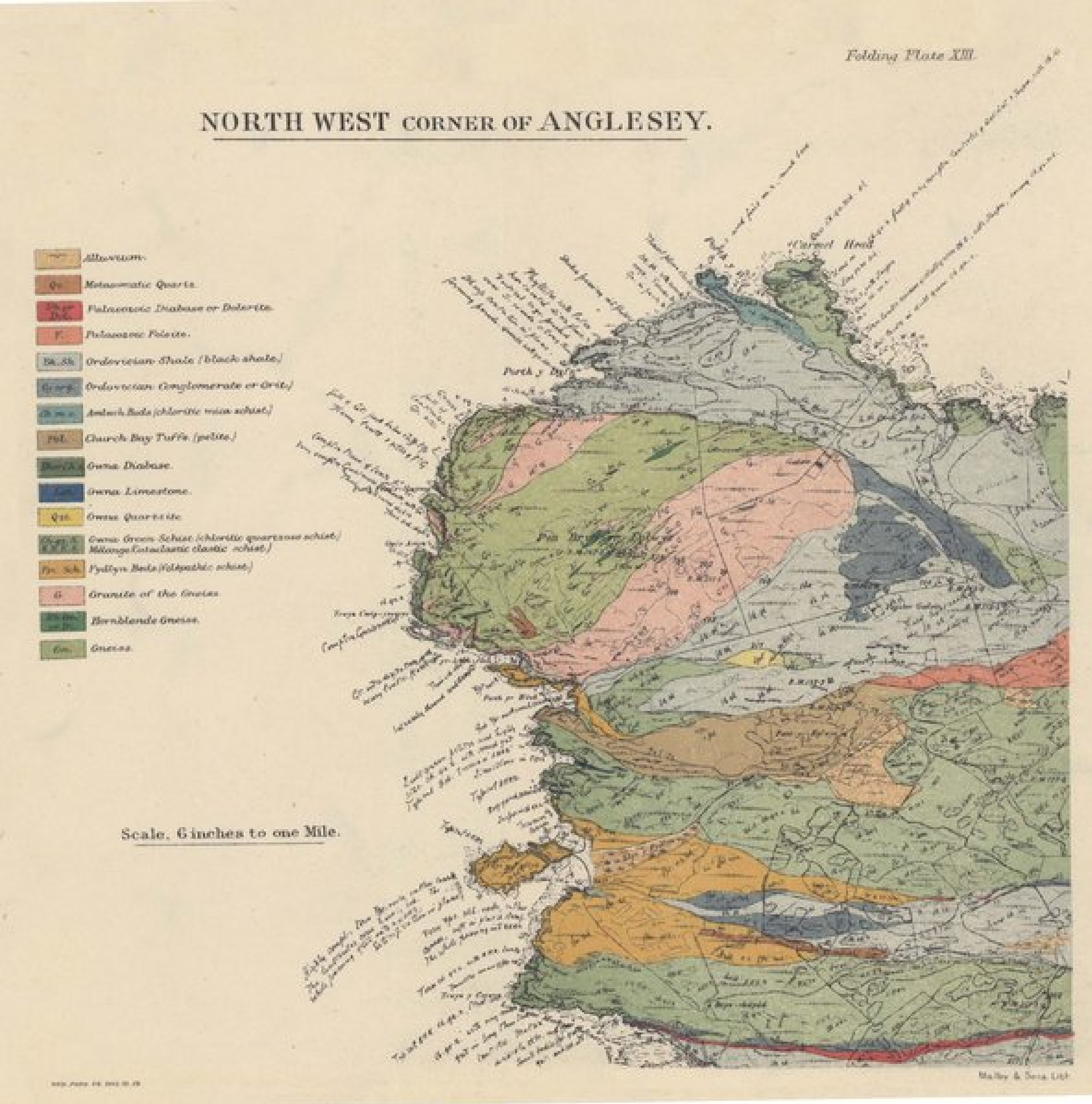


FIG. 269.—OUTCROP OF THE CARMEL HEAD THRUST-PLANE AT GWAEN-YDOG.

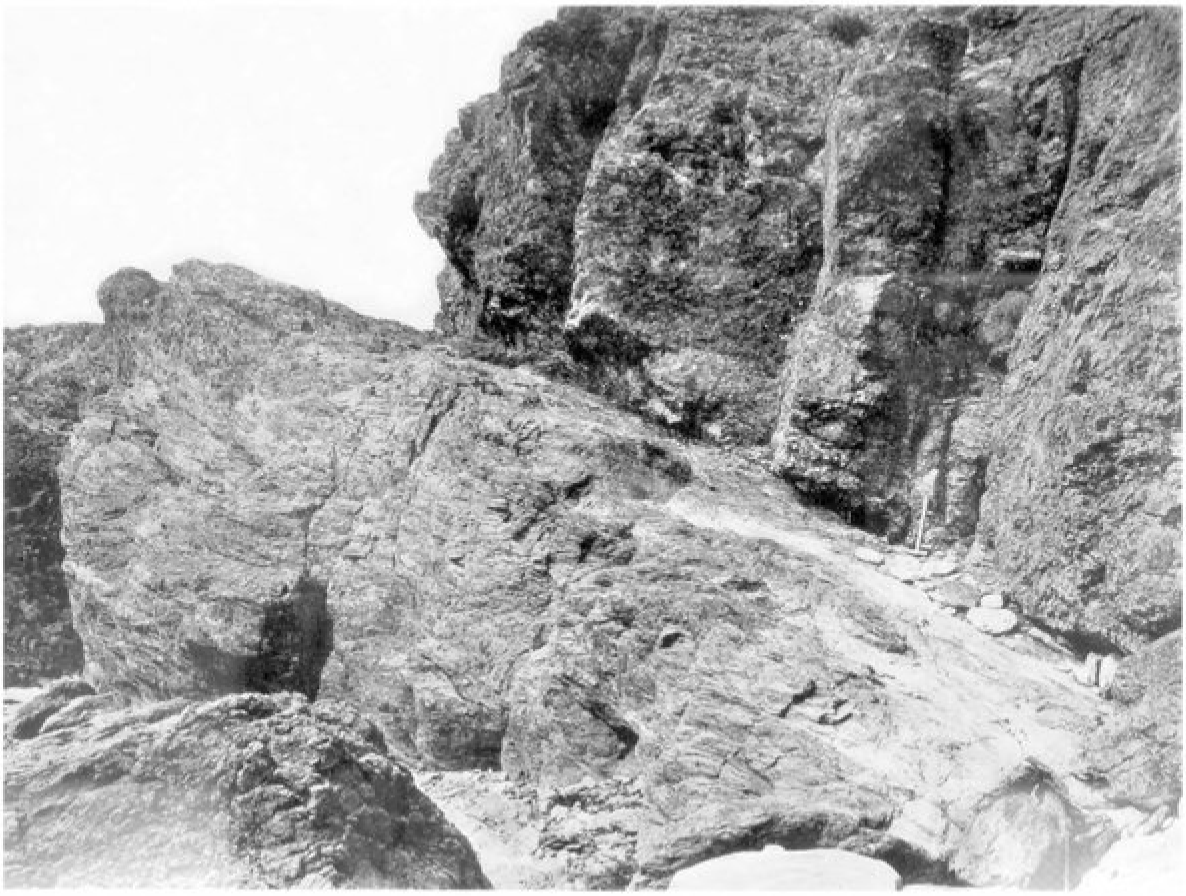
From the six-inch maps.

MH = Coeden Beds.
F = Felsite Dykes.
MG = Gwna Beds.
D = Dolerite Dykes.
b = Arenig Beds.
K = Crushed Dykes.

(Figure 269) Outcrop of the Carmel Head Thrust-plane at Gwaen-ydog. From the six-inch maps. MH = Coeden beds. MG = Gwna Beds. b = Arenig Beds. F = Felsite Dykes. D = Dolerite Dykes. K = Crushed Dykes.



(Folding-Plate 13) The North-West corner of Anglesey. Reproduction of manuscript six-inch map.



(Plate 31) The Carmel Head thrust-plane at Carmel Head. Frontispiece to Vol 2.

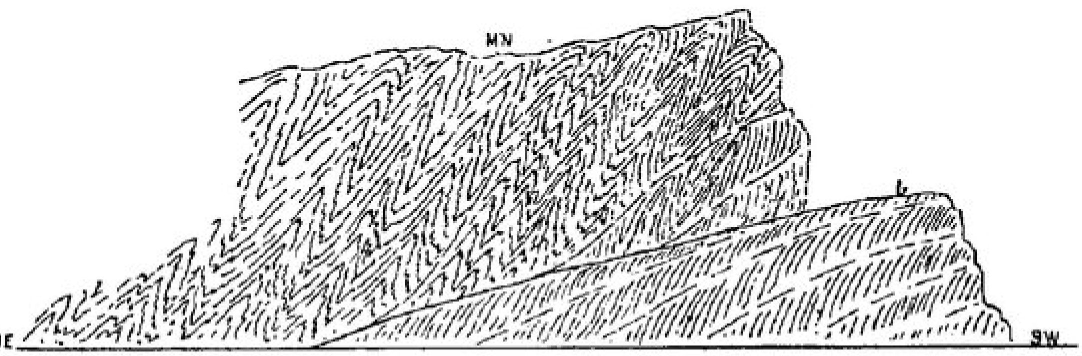


FIG. 270.—THE CARMEL HEAD THRUST-PLANE AT CARMEL HEAD.
MN = Amlwch Beds. b = Cleaved Ordovician Shale.

(Figure 270) The Carmel Head Thrust-plane at Carmel Head. MN = Amlwch Beds. b = Cleaved Ordovician Shale.

FIG. 271.

MINOR THRUSTS AT THE CARMEL HEAD THRUST-PLANE, CARMEL HEAD.

Depth: about one foot.

CHT = The Main Thrust.

(Figure 271) Minor thrusts at the Carmel Head Thrust-plane, Carmel Head. Depth: about one foot. ChT = The Main Thrust.

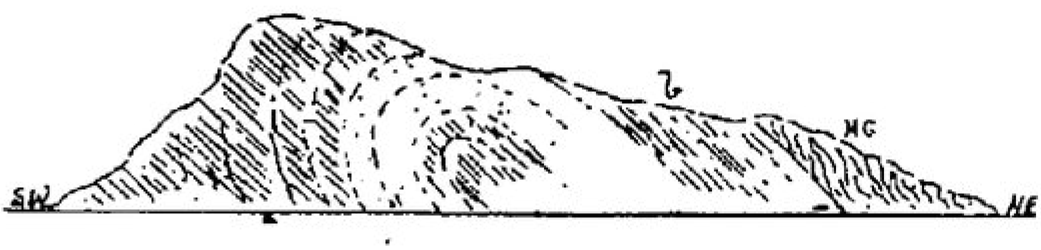


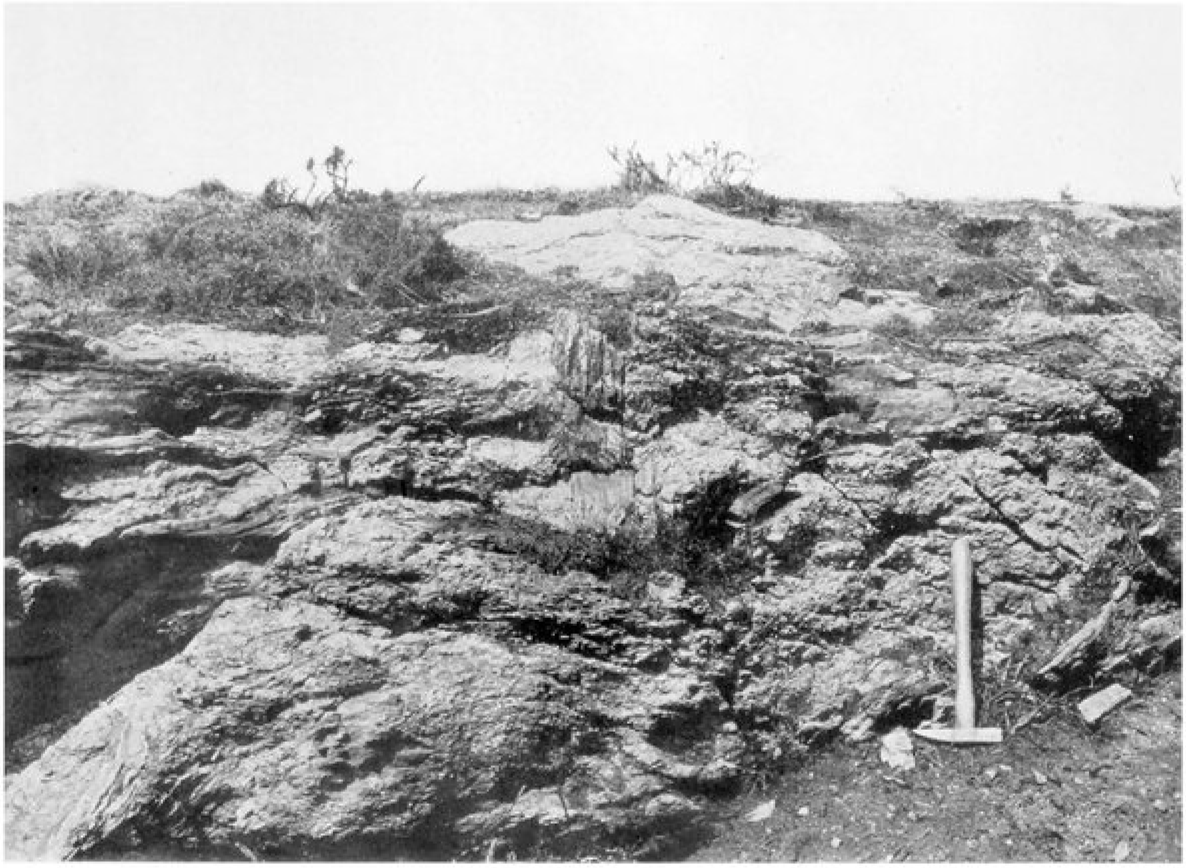
FIG. 272.

THE CARMEL HEAD THRUST-PLANE, 147 yards south-west of LLANFAIRYNGHORNWY CHURCH.

Height: about eight feet.

MG = Gwna Beds. b = Ordovician Beds.

(Figure 272) The Carmel Head Thrust-plane, 147 yards south-west of Llanfairynghornwy Church. Height: about eight feet. MG = Gwna Beds. b = Ordovician Beds.



(Plate 32) Brecciation at the Carmel Head thrust-plane. Gwaen-ydog.

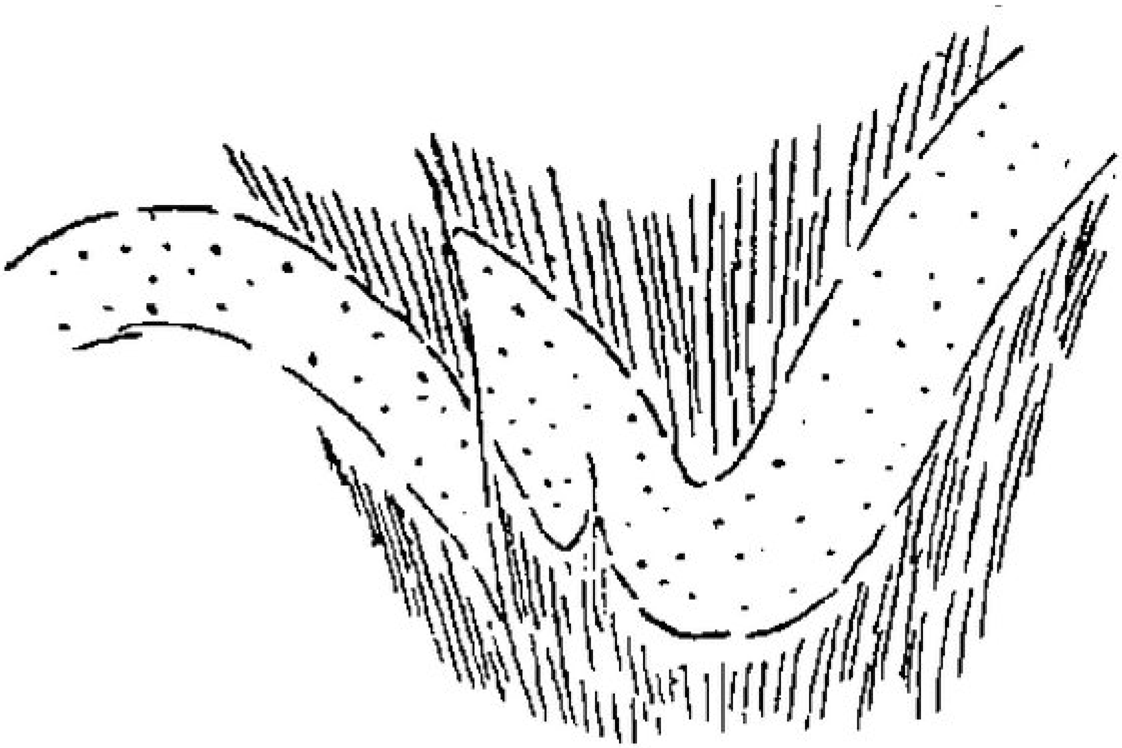


FIG. 273.

FOLDING AND CLEAVAGE IN ARENIG SHALE WITH GRITS FROM 3 TO 12 INCHES THICK.

Foreshore at Rhosneigr.

(Figure 273) Folding and cleavage in Arenig Shale with Grits from 3 to 12 inches thick. Foreshore at Rhosneigr.

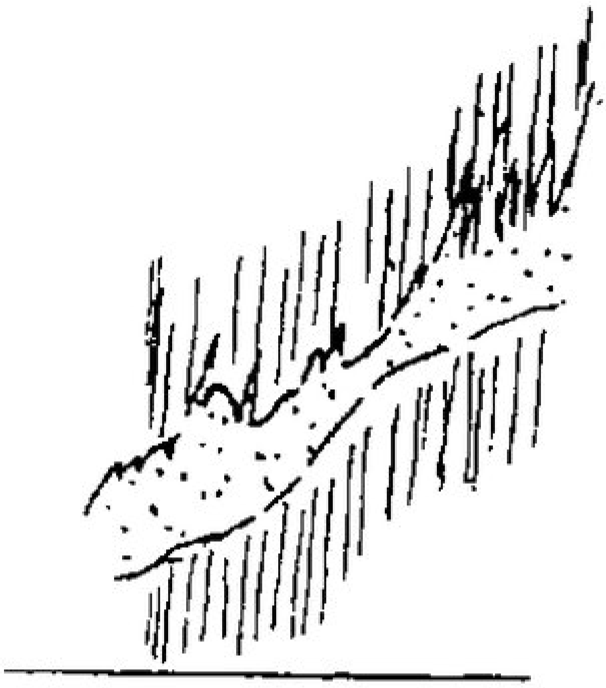


FIG. 274.

SHREDDING OF ARENIG BEDS ALONG CLEAVAGE.

Rhosneigr Shore.

(Figure 274) Shredding of Arenig Beds along cleavage. Rhosneigr Shore.

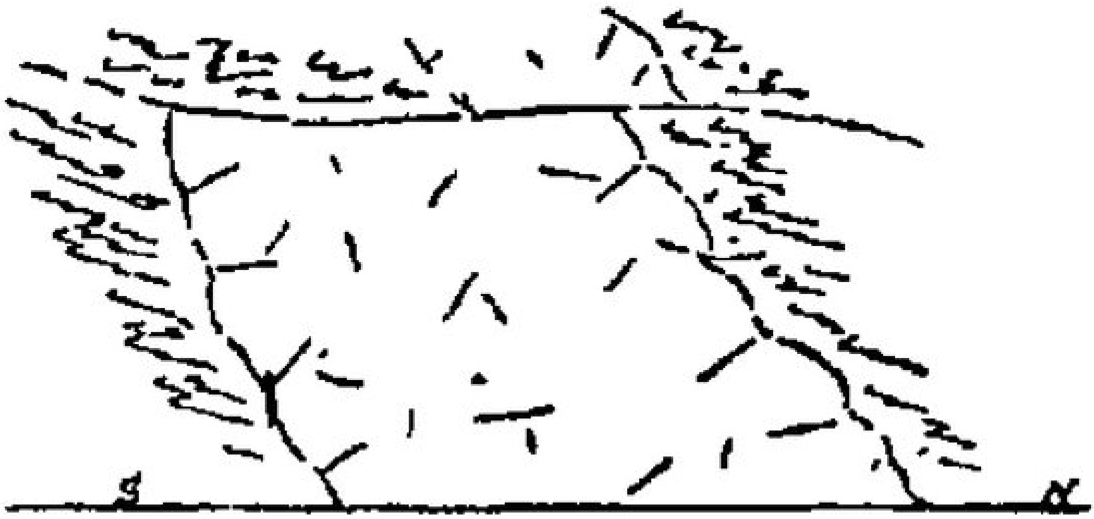


FIG. 253.

THRUST IN DYKE AT PANT-HOWEL.

(Figure 253) Thrust in dyke at Pant-howel. Height about 20 feet.

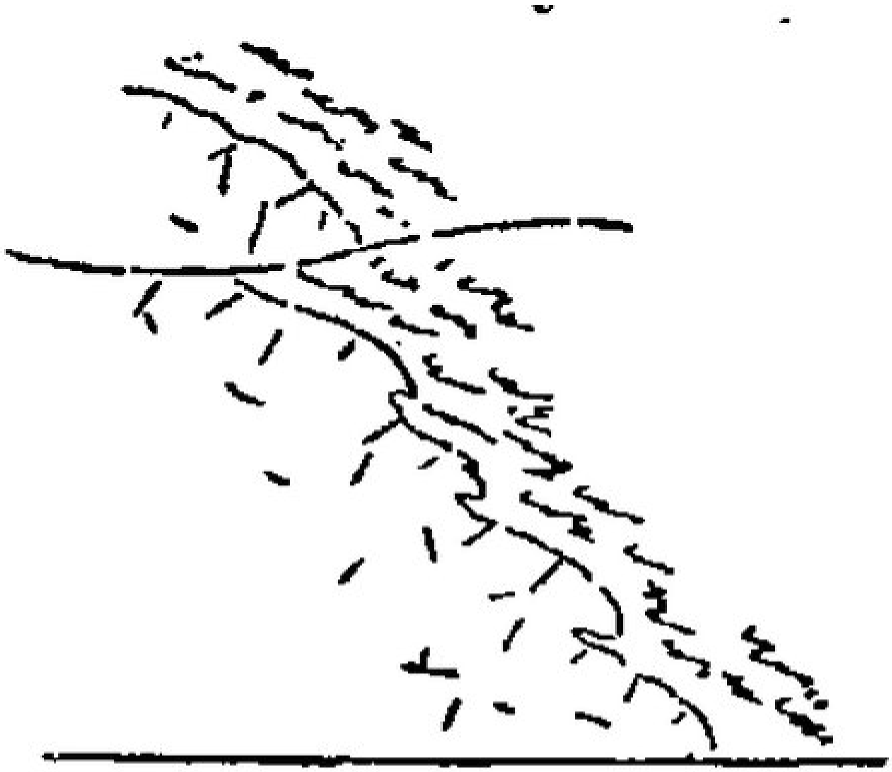


FIG. 254.

A FEW INCHES OF THE NORTHERN MARGIN SHOWN IN FIG. 253.

(Figure 254) A few inches of the northern margin shown in (Figure 253).

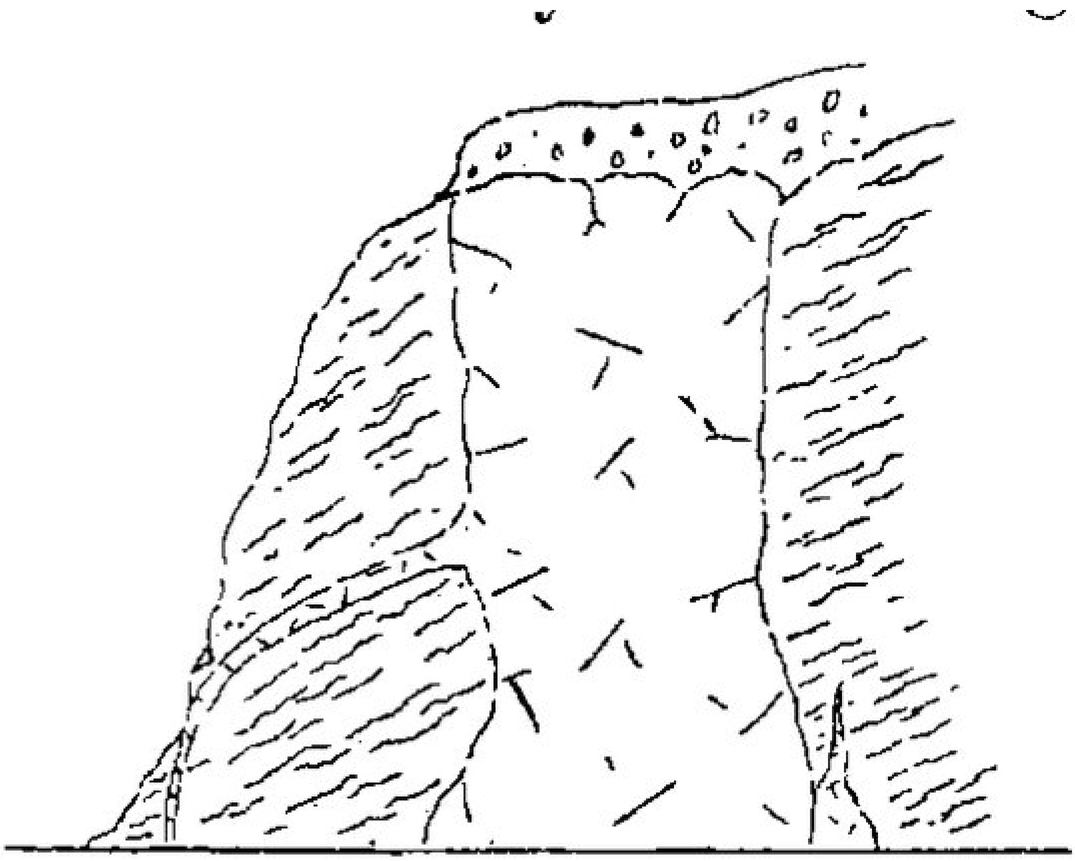
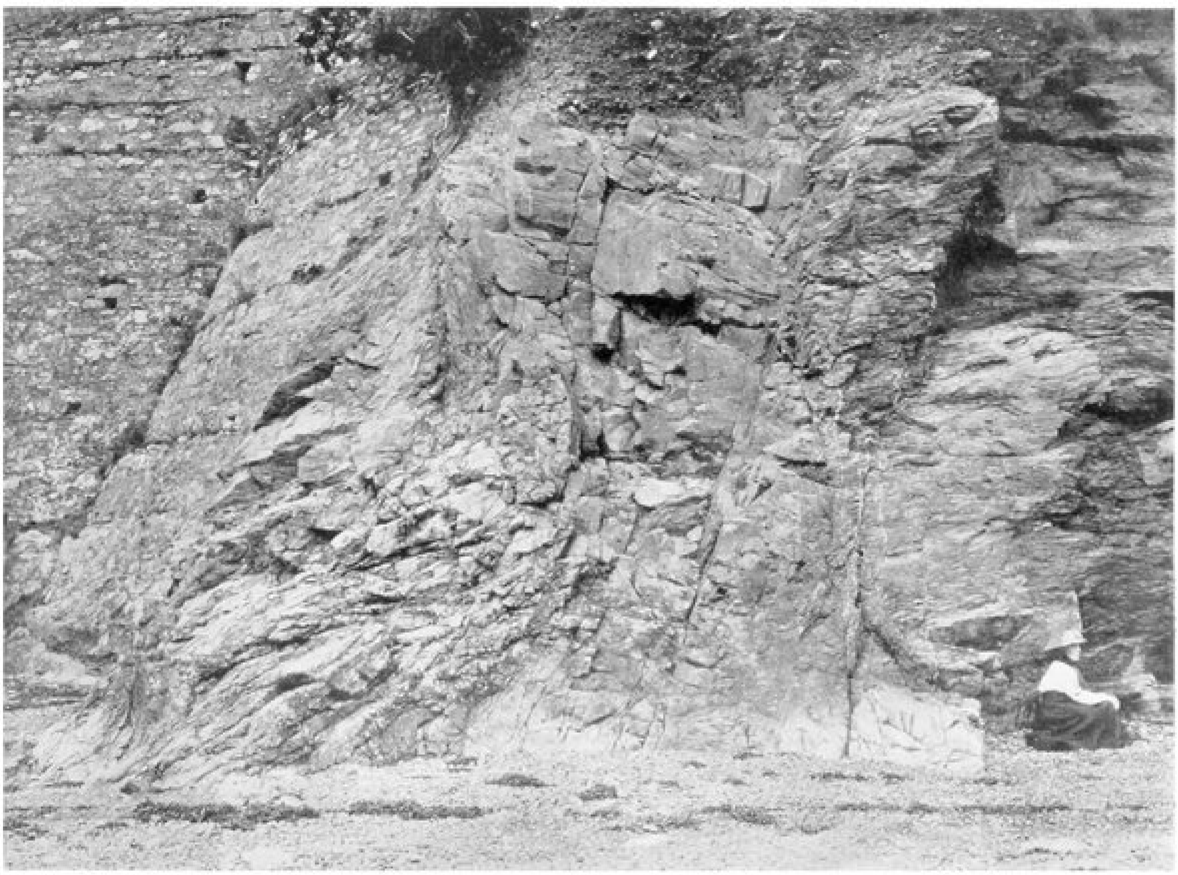


FIG. 233.

13-FOOT DYKE OF PLATE XXX.

(Figure 233) 13-foot dyke of (Plate 30).



(Plate 30) Paleozoic dolerite dyke on the Menai shore.

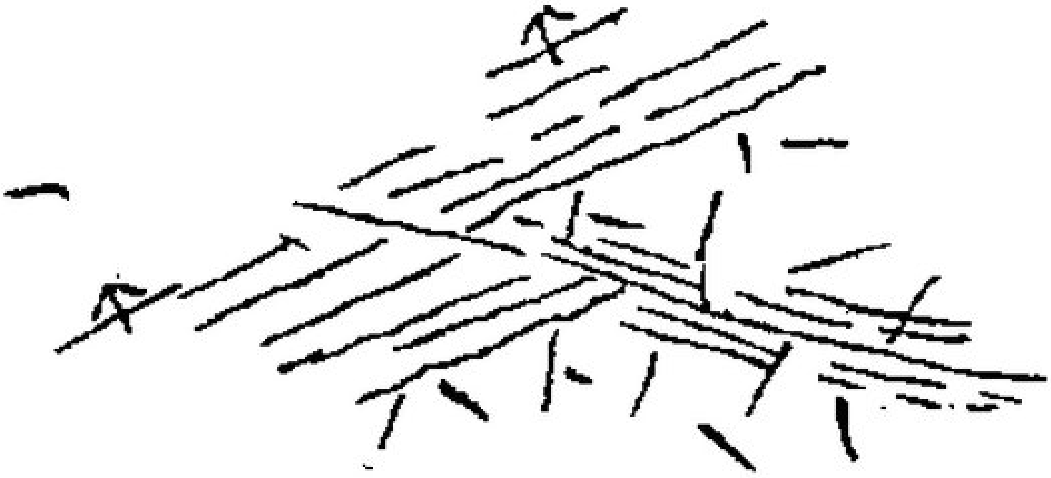


FIG. 252.

SHIFT OF MARGIN OF BASIC SILL, OGO-FAWR.

(Figure 252) Shift of margin of basic sill, Ogo-fawr.

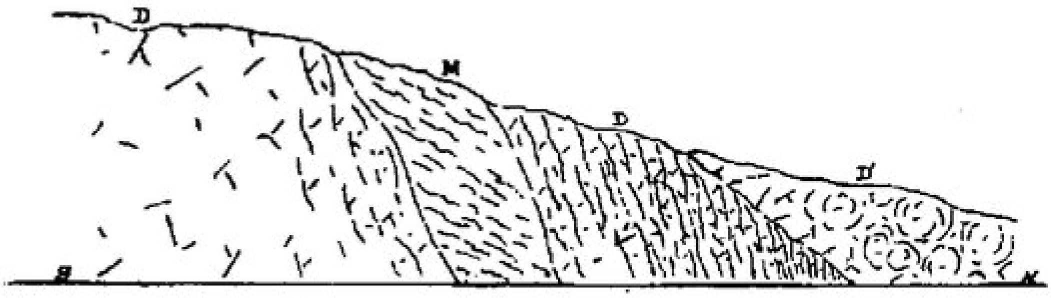


FIG. 306.—JUNCTION OF A PALÆOZOIC AND A LATER DYKE NEAR GAERWEN.

Scale: One inch = about 15 feet.

M = Penmynydd Mica-schist. D = Palæozoic Dyke.
D′ = Later Dyke.

(Figure 306) Junction of a Palaeozoic and a later dyke near Gaerwen. Scale: one inch = about 15 feet. M = Penmynydd mica-schist. D = Palaeozoic dyke. D■= later dyke.

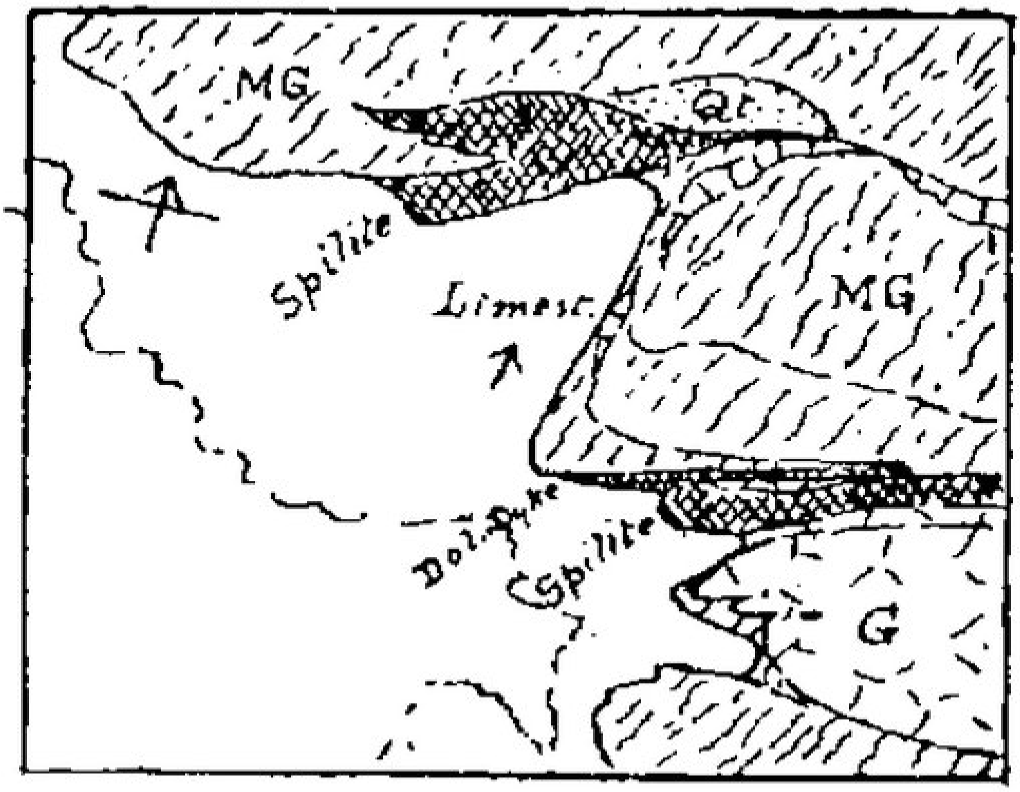


Fig. 139.

North-west Cliffs of Mynydd Wylfa.

(Figure 139) North-west cliffs of Mynydd Wylfa. From the 1100-1 or 1:2500 map. MG=Gwna Mélange. Qt=Gwna Quartzite. G=Granite.

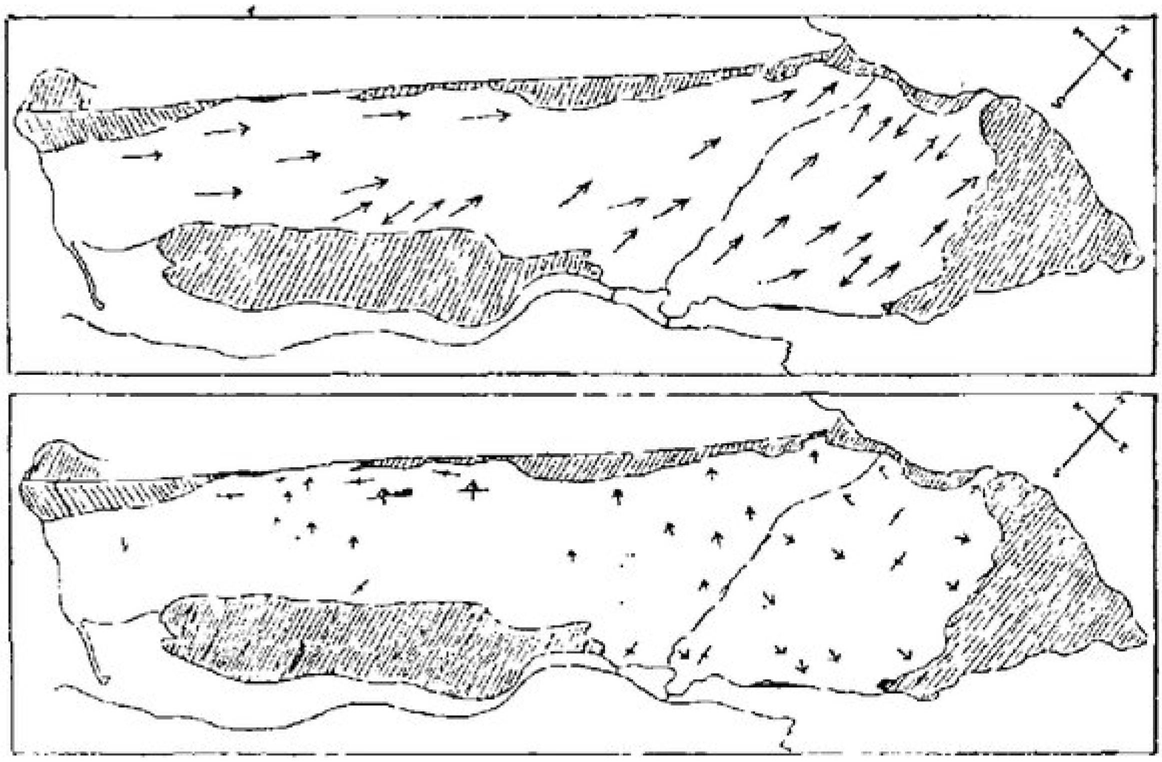


FIG. 98.—STRIKE, DIP, OVERFOLDING, AND PITCH IN THE AETHWY REGION.

(Figure 98) Strike, dip, overfolding, and pitch in the Aethwy region. Scale: Six miles = one inch. Broken line junction of Penmynydd Schist and Gwna Green-schist. Long-tailed arrows = Pitch.