Chapter 27 The tectonics of the Carboniferous rocks

Types of structure

After the deposition of the Red Measures, another period of earth-movement set in, during which the Carboniferous rocks were thrown into broad and gently inclined curves, broken by many normal faults, one of which is of great magnitude; faulting being indeed much more conspicuous than curvature. Save in the Penmon Area, the dominant strike is north-easterly.

Two systems of faulting may be distinguished. In one of them the trend is steadily north-east and south-west, its members often being conspicuous upon the maps from acting as boundaries for many miles. It may be called the External System. The other is a reticular system which develops for the most part in the interior of the Carboniferous areas, and may be termed the Internal System.<ref>There is also a system that has a north-west and south-east trend, for which there is reason to suspect a later date altogether. It will be discussed in Chapter 28.</ref>

The internal system

In the Principal and Penmon Areas this is highly developed, but in that of the Straitside is hardly discernible, if indeed it exist at all. Its faults (with one or two exceptions) tend either to approach a meridian or a parallel of latitude. Sometimes the one series, sometimes the other, seems to be the later, from which we may infer that movement along the two directions was alternate, and that the internal system as a whole is all of essentially the same age. But no member of it is ever known to cross a boundary-fault, so that we may look upon the external as later than the internal system. Few of the internal faults have displacements of as much as 100 feet. The Huslan fault, however, which is pene-latitudinal, is about 250 feet, while the Llangefni, Careg-onen, and Dinas Valley faults, which are pene-meridional, are about 170, 200, and 300 feet in throw respectively. In the Principal Area both sub-systems are well developed, some 25 faults being known in the tract between the Cefni and the eastern sea. In the Penmon Area latitudinal faults are very rare, but of the pene-meridional 30 may be counted in the three and a half miles between Careg-onen and the Lighthouse.

Now it is a remarkable circumstance that of this array, probably some 60 faults in all, anyone walking round outside the bold boundary-escarpments of the limestone at a distance of a quarter of a mile, would hardly be aware. No matter what their trend or what their magnitude in the interior, these faults (with the sole exception of that at Llangefni) fail, in spite of the moderate dips, to produce any conspicuous displacement of the escarpment. Imper-sistence, in fact, characterises the whole system, even the large ones dying out with surprising rapidity. But the point of chief significance is that the direction of waning is towards the margins of the synclinal areas. And it may also be noted that the pene-meridional faults of Penmon become rapidly more frequent as we approach the Puffin Channel, where the direction of dip sweeps round through some 60° or 65°.

All the features of this system, therefore, seem to point to the view that it is essentially a phenomenon of accommodation to differential subsidence, the faults waxing in magnitude with the sinking of the beds into the deeper parts of the synclinal depressions.

The external system

The members of this, comparatively few in number, are all of considerable, one of great, magnitude, that one being the Berw fault (or rather plexus) presently to be considered. The Lligwy, Braint, and Dulas faults have displacements of not less than 250, 350, and 400 feet respectively, while the Gelliniog fault which bounds the Red Measures may also be as large as these. Just outside the Island are the Port Dinorwic fault, and those which run through the city of Bangor.

They differ from those of the internal system, first in that, while those are rarely large, these are never small, but much more significantly in their persistence. The lesser external may be smaller than the greater internal faults, but while the latter wane rapidly, these persist for many miles, which is a diagnostic character in a few cases where there isno great

divergence of trend. They are for the most part nearly straight, and, except the Lligwy fault, approximately parallel. Hardly any sections are known across them. How many of those which do not enter Carboniferous areas may belong to the same system has been discussed on p. 556.

The Dinorwic, Dulas, and Berw faults have the curious effect of nearly abolishing the south-eastern limbs of the three major synclines, leaving us, throughout the Island, hardly anything but the north-western limbs. Not even the Penmon Area can be regarded as such a limb, for it has a persistent north-north-west strike, and is to be regarded as a portion of the short end' of the long oval anticline whose denuded core separates the Principal from the Straitside syncline, or rather as part of the end of a submarine syncline lying, *en echelon,* between the strikes of those. A portion of its south-eastern limb, however, may be recognised in the northerly dips of Puffin Island.

The Berw Fault

By far the greatest member of the external system is that which has been already often alluded to in this work as the Berw Fault. Being one of the master-lines in the tectonics, not only of the Carboniferous but also of the Ordovician and the Mona Complex, it is well worthy of a special discussion.

Passing completely through the Island between Malldraeth and Red Wharf Bays, it throws the whole Carboniferous series of the Principal Area, including the Red Measures, against the Mona Complex and Ordovician rocks. For about half of its course it is a single fracture; but near Plâs Berw it forks (Figure 302), taking in the Esgeifiog strip of Carboniferous Limestone, and this double fault runs on as far as Plâs Penmynydd. Thence to Red Wharf Bay it becomes extremely complex, developing, indeed, into a plexus of dislocations which near Tyfry is more than a mile in width, and in which rocks of several ages are involved.

The magnitude of this great fault can be determined at three points of its course, Red Wharf Bay, Esgeifiog, and Plâs Berw. At Red Wharf Bay its north-western branch, bounding the Limestone, appears at first sight to throw in the whole of that series. Two deductions, however, must be made. The Lligwy Sandstone is totally absent at Careg-onen. The fault's end at the Bay is approximately five-eighths of the distance from Lligwy Bay to Careg-onen, so that proportion of the Lligwy Sandstone, 125 feet, must be assumed to have died out. Then the rise of the beds on the Red Wharf syncline brings the Brachiopod band of the upper part of D2 against the fault instead of the higher sub-zones of Dwlban, so that the whole of the Deb, D3, and P zones, a total of 350 feet, must also be deducted. This reduces the throw of the fault at this end to 825 feet.

At Esgeifiog, as the cherts between the branches of the fault belong to the highest beds, the thickness of the series in that strip must be fully that which exists at Lledwigan, 500 feet. But the position of the base on the upthrow side cannot be lower than the summit at Graig-fawr, which is 100 feet higher. Therefore the displacement of the eastern branch cannot be less than 600 feet. That of the western branch, which brings the Red Measures against the cherts, must be about 1,500 feet. Near Plâs Berw, where the fault is single, it throws the whole of the Carboniferous series, including the Red Measures, against Ordovician grits. But more precision is attainable here, for the little sandstone outlier of Twr gives the level of the base of the system on the upthrow side. Adding its height above the marsh to the other measurements, we obtain the throw of the great fault.

	Feet
Red Measures at Berw	300
Coal Measures.	1,100
Millstone Grit	400
Limestone Series at Llangristiolus	450
Height of base at Twr	165
	2,415

From this a little deduction should be made for a local drag-up of the beds close to the fault which appears for some yards at Holland Arms, so, in round numbers, the throw may be taken at 2,300 feet.

This great displacement is really a result of the south-westward pitch of the Red Wharf and Malldraeth syncline. There is little doubt that the rapid waning of the fault observable at Red Wharf is continued under the sea. For the Penmon syncline is beginning there to develop on the upthrow side, and at Fargen (pp. 611, 615) has already brought in the D3 sub-zone. It is quite likely, therefore, that, some five or six miles to the north-east of Pentraeth, the whole Berw-plexus has died out altogether.

There is now no good exposure of the disturbances produced at the fault; but Henslow (in his plate 17), figures a section in sharply contorted limestone and shale at Ceint, reproduced here in (Figure 305). The strike of the bands in the Pentraeth inliers of the Mona Complex evinces a tendency to sweep round a little towards the faults, as if there had been some horizontal movement in opposite directions, to the north-east on the northern and to the south-west on the southern side.

It will be seen from a study of the map that there are anomalies in the behaviour of the faults of the Berw plexus, the gravest being at Plâs Penmynydd; from which it appears that the Ordovician rocks must have been already broken and brought against the Mona Complex in Pre-Carboniferous times, and that the Post-Carboniferous fractures took place along an ancient zone of weakness. Tyfry and Gwna rocks lying on the Bodorgan Fold had been brought down among Penmynydd schists, and a wedge of these driven up through them during the later movements of the Complex. Then Ordovician rocks, which had been laid down uncon-formably thereon, and afterwards folded, were let down into that Complex in long wedges by the Post-Silurian movements. On a composite floor so produced the Carboniferous deposits were laid down unconformably. Then they in their turn were let down on the Berw faults into and below that floor, broken anticlines driving it up through them, letting them down in synclines into the crests of ancient anticlines, and thus reversing in places the direction of movement upon pre-existing planes. To trace out the history in detail is difficult, perhaps impossible. But there can be little doubt that the existing arrangement is the net result of repeated movement and repeated denudation.

Relations and age of the movements

North-easterly strikes are not common in the Carboniferous rocks of England and Wales, and even these of Anglesey are probably not the exception that they seem to be at first sight, for there is good reason to suppose that they have nothing to do with movements of the true 'Caledonian' type. Reference to any general map will suggest that they are merely a part of the great Carboniferous curve that sweeps round the whole skirts of North Wales from Oswestry to Carnarvon, the north-easterly trend being locally accentuated by superimposition (see above) of Post-Carboniferous upon older faults which were truly 'Caledonian'.

We have seen that the internal fault-system is to be regarded as the older of the two. There are, unfortunately, no Mesozoic rocks by which to check the age of the external system. But from its relation to the whole Carboniferous curve of North Wales, together with the great magnitude of the Berw, and the overthrust (see below) along the Dinorwic fault, it may reasonably be assigned, in the main, to the same period as the powerful disturbances by which Carboniferous rocks were so extensively affected in Pre-Mesozoic times. The Berw plexus, however, we have seen to have been a re-juvenescence of a very ancient zone of recurrent movement, initiated as far back even as the time of the Mona Complex, and along such a zone there is unlikely to have been complete quiescence during the Post-Triassic disturbances. But there is reason to believe (see Chapter 28) that there was no recurrence of any consequence upon it in Tertiary time.

Comparison with the tectonics of the older systems

In the Carboniferous rocks of. Anglesey there is a total absence of the isoclinal, shearing, or thrusting structures that recurred so persistently in all the older periods. Only one Post-Carboniferous overthrust is known in the district, and it is just outside the Island area, being that which (p. 674) drives the Limestone over the Red Measure conglomerate of Llanfair-is-gaer. There are no signs of lateral compression, and slaty, cleavage is 'unknown, connected with which, doubtless, are the gentle dips of the Carboniferous rocks, compared with the deep and steep infolds of the Ordovician rocks, even where they also are symmetrical about vertical axes. Folding that may be described as contortion is only

known (Figure 305) close to the Berw fault.

Yet just as between the Ordovician and the Mona Complex (pp. 5.58–9) there are some curious correspondences. Both at the Strait and Dulas a Carboniferous depression is evidently superimposed upon one of Ordovician age, but the Ordovician in the one case and the Carboniferous in the other are too scantily preserved for a comparison. The Malldraeth and Red Wharf syncline of the Carboniferous partly coincides with an old Ordovician infold whose north-western limb (p. 418) is buried under it. But the southeastern limb of the older infold was developed, that of the later one is almost abolished; and the axes of the two fail to coincide. Moreover, the north-western limb of the later infold extends all the way to Lligwy, sweeping across not only the north-western limb of the older one, but across the deep Ordovician infolds of Llangwyllog, which strike obliquely (pp. 439, 556) at it, and with which no Carboniferous infold coincides. The coincidences between the Pre-and Post-Carboniferous faults in the Berw plexus we have found to be in some cases actually reversals. Thus once more, although there are tectonical correspondences, they turn out on scrutiny (save in the peculiar Berw cases) to be but simulations.

Recapitulation

The steep, rapid, and often isoclinal folding of the older systems is now no longer to be seen. The Carboniferous rocks are disposed in broad and gentle synclines of the normal type, one of which attains, however, an amplitude of more than. 2,000 feet. The subsidences are effected in great measure by an internal system of accommodation-faults, while the south-eastern limbs of the infolds are almost entirely abolished by a system of large external boundary-faults. One of these, called the Berw fault, has a maximum displacement of 2,300 feet, and branches into a plexus of ruptures that is more than a mile in width.

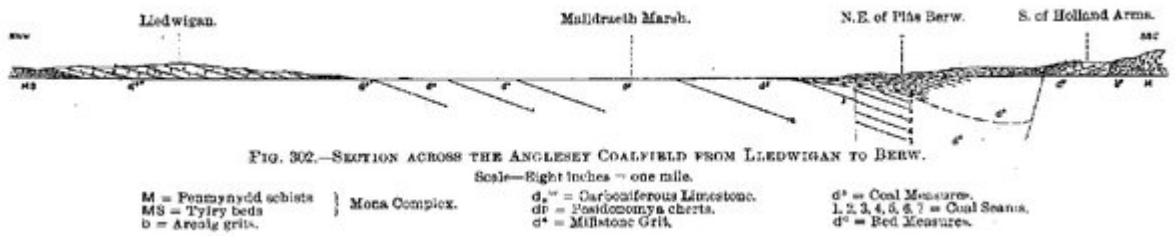

FIG. 302.—SECTION ACROSS THE ANGLESEY COALFIELD FROM LLEDWIGAN TO BERW.
Scale—Eight inches = one mile.

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

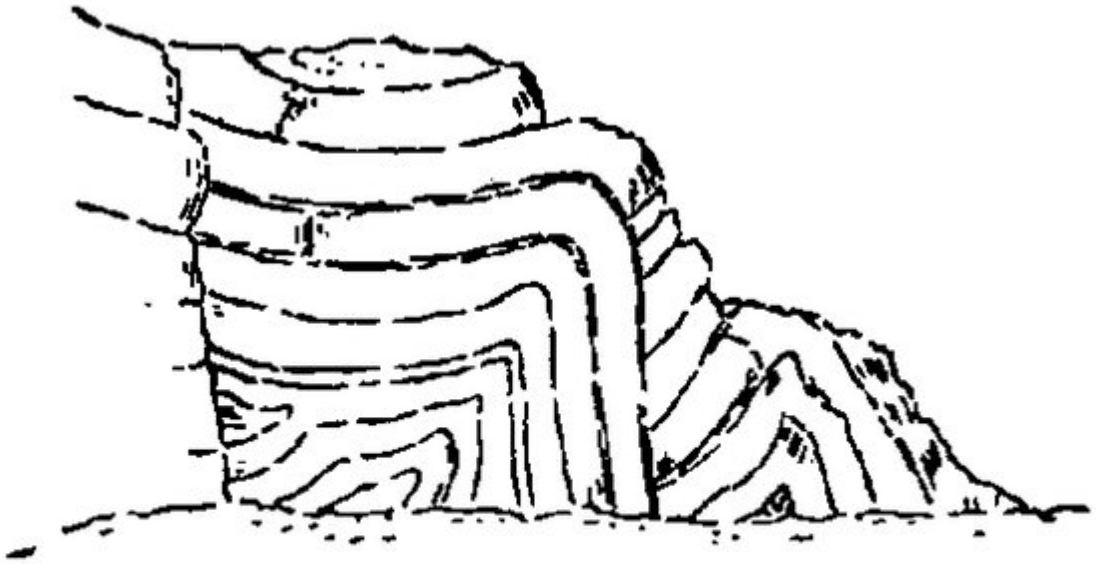

FIG. 305.

FOLDING AT THE BERW FAULT, CEINT.

(Figure 305) Folding at the Berw Fault, Ceint. (after Henslow.)