52. FURTHER OBSERVATIONS *on the PRE-CAMBRIAN ROCKS of CAERNARVON.* By Prof. T. M'KENNY HUGHES, M.A., F.G.S. (Read May 14, 1879.)

[PLATE XXXVI.]

ON a former occasion (Quart. Journ. Geol. Soc. vol. xxxiv. p. 137) I offered a sketch of the Pre-Cambrian rocks which form the long ridge stretching from Bangor to Caernarvon. The classification I adopted was in descending order:—

- i. *The Volcanic series*, consisting of volcanic fragmentary ejectamenta, agglomerates, ash-beds, and slates, occurring near Bangor, and referred to as *Bangor beds*.
- ii. *The Felsitic series*, consisting chiefly of quartz felsites, and probably also of volcanic origin, occurring near Llanddeiniolen and Dinorwig, and now referred to as the *Dinorwig beds*.
- iii. *The Granitoid series*, occurring near Caernarvon, and referred to as the *Caernarvon beds*.

Endeavouring to correlate these groups with the divisions proposed by Dr. Hicks, I considered that the lowest group included less than the Dimetian, from which I proposed to cut off every thing above the brecciated bed below Bryngarn, on the left of the valley running down from St. David's to Porthclais. The upper group I divided into two. I do not know how far Dr. Hicks, in the modified classification recently offered to the British Association (Report, 1878, Trans. Sect. p. 536), adopts the above threefold classification. I considered that there was no unconformity visible between the groups, whether we accepted the brackets drawn by Dr. Hicks or those which I proposed.

Since this paper was first sent in much additional information has been brought forward by Professor Bonney, Dr. Hicks, and Mr. Houghton, in communications made to the Society, Feb. 5, 1879. A threefold division was adopted; but the authors disagreed entirely with the views I had expressed of the structure of the districts as regarded dips, strikes, faults, and the sequence of rocks, and affirmed the existence of a visible unconformity between the groups*.

I shall now describe the rocks of the district in ascending order.

I. *The Caernarvon Beds* (= Dimetian in part).

- ii. Upper Caernarvon = Crug Beds.
- i. Lower Caernarvon = Twt-Hill Beds.

I. i. *The Twt-Hill Beds.*

The coarse crystalline rock of Twt Hill is exposed over a small area on Twt Hill and in quarries along the north side of it. In a

* Having gone over the ground again with my friend Mr. Tawney, I am able to offer a fuller description of the district, and to bring forward much additional evidence on those points respecting which there has been a difference of opinion.

Fig. 1.—Section of Twt Hill, Caernarvon.

quarry in the first field on the N.E. of the hill, which we shall refer to as the Twt-Hill Field quarry, it is seen flanked on the S.E. by sandstone, grit, and conglomerate (see figs. 1 & 2). It is thrown back

Fig. 2.—Section N.E. of Twt Hill, Caernarvon.

by a small fault crossing the ridge N.E. of Twt Hill, with a downthrow on the E., so that it is found in the quarry by the highest new road above Yscuborwen with the same grit and conglomerate on its

Fig. 3.—Section in Quarry above Yscuborwen, Caernarvon.

S.E. flank (see fig. 3). This fault coincides with a greenstone dyke running S. 20° E. and seen in the quarry; and there is also seen in the same quarry another fault running up to the S. end of the dyke (fig. 4), nearly at right angles to it, and dropping the grit a little on the S.

The coarser variety of the Twt-Hill rock has been largely quarried behind Llysmeirion and Richmond Hill, and is again seen about half

Fig. 4.—Plan of Quarry above Yscuborwen, Caernarvon.

a mile E.S.E. of Llanfairisgaer, where it forms a rugged boss in a field N.W. of Bryn. This rock is a coarse crystalline aggregate of quartz and felspar, or, as Professor Ramsay has described it, is like a granite with no mica. In Anglesey a similar rock passes into a granitoid rock with mica. It is doubtful whether any specimen taken from the heart of this mass has exhibited clear evidence of a fragmental origin. There are many systems of divisional planes, and sometimes one set and sometimes another come into prominence from their regularity and persistency.

In the quarries on the N. side of Twt Hill the most bed-like planes turn over to the N., or a little W. of N., as if dragged down to the fault which brings on the Carboniferous rocks. In the N. corner of the Twt-Hill Field quarry (fig. 5) there is a band of decomposing grey felspathic rock, full of more or less regularly developed doubly terminated quartz crystals, similar to those found by Mr. Tawney in the rocks of St. David's; and in this a band, from two to eighteen inches thick, of hard close-textured siliceous rock, which thickens rapidly to the east, with an inclination of about 30° N.N.E. It is somewhat interrupted along joints, so as to suggest that it may not represent original bedding, but may be due to a kind of indigenous vein-structure. On the other hand, this interruption of the continuity of the mass at a joint is not at all conclusive against its being a bed of sedimentary origin with any one who has observed the irregular and interrupted manner in which the grits and quartzites of Anglesey are thrust in among the crumpled schists with which they are associated.

Fig. 5.—*North-east end of Field Quarry, Twt Hill, Caernarvon.*
S.W. N.E.

On the two bosses which occur N. and N.E. of Twt Hill there is a brownish or yellowish-pink felsite, generally showing a platy structure. This should be distinguished from the Twt-Hill rock. In the large quarries on the N.W., facing the Straits, there is an altered grit. If the more obvious divisional planes represent bedding, these dip in a northerly direction, and are the highest beds there seen; they would necessarily be thrown back out of sight by the fault seen in the roadside quarry, fig. 3.

Close to the great fault which brings on the Carboniferous rocks near Tycoch there is a crystalline grey felspathic rock, much crushed and traversed by slickensides, the surfaces of some of which are glossy, black, and anthracitic-looking. This rock probably belongs to some part of the Caernarvon series.

I. ii. *Crug Beds.*

On the S.E. side of the ridge we find strong proof that a group of beds, somewhat similar to the Twt-Hill rock in essential characters, but finer, alternates with felsite-like rocks or passes into them; and though nothing like dip can be made out in them, the strike, as followed along the ridge (see map, Pl. XXXVI.), from about half a mile N.E. of Pengwraich to the brow of the hill above Dinorwig station, shows that they run nearly with the trend of the hill, with perhaps a little more north in them, and generally somewhat dragged over towards the fault along the Carboniferous beds.

On the boss N.W. of Pengwraich we find on the N.W. side crystalline beds, like the finer portions of the Twt-Hill group; and on the S.E. side of the same boss a felsite-like rock. A precisely similar boss occurs close to Crug, with a coarser rock on the N.W. and a felsite-like rock on the S.E. In the road between the two places rock of the coarser variety is exposed.

In the field N.W. of Bryn finer and coarser varieties of the same kind of rock are exposed in bosses projecting through the soil, while immediately over the wall on the N.W. the coarse granitoid rock of Twt Hill is seen. A grey crystalline felspathic rock much seamed by quartz veins forms the most prominent point in this field on the N.E. of the house.

Still further on to the N.E. in the same line, in the lower part of the little valley which runs down from below Tynymaes to about half a mile E.N.E. of Plas Llanfair, there are alternations of beds of finer and coarser crystalline rock, which must be referred to this group. One pink bed we find again, almost identical in character,

in the same strike on the brow of the hill above the station at Port Dinorwig. Here it occurs between grey felspathic rocks; and these can hardly be distinguished from parts of the great mass of felsites which occupy almost all the high ground above Port Dinorwig, and, repeated by faults, stretch away to Llanddeiniolen on the S.E. and Brithdir and Beulah Chapel on the N.E.

II. *Dinorwig Beds* (=Felsitic series).

The next series consists chiefly of great masses of grey quartz felsite. No distinct bedding can be made out in any section; but the strike can be inferred, in the lower part of the series, from the manner in which the rock occurs with reference to the boundary of the underlying formation, and more clearly by following certain beds of marked character in the middle and upper part. It is seen with a subordinate purple bed near Tanyperti, on the S. of which it is overlapped by a set of grits very similar to some of those which flank the Twt-Hill beds at Caernarvon (see map, Pl. XXXVI.). It projects at intervals all along the ridge to near Brithdir, and then can be followed on the other side of the Bangor road to the fault N.E. as far as Beulah Chapel.

A fault runs S.W. and N.E. under Careg goch W. of Llanddeiniolen, dropping the grits on the N.W.; and passing between Cefn and Tanyrwyllfa, crosses the valley near the dyke under Tynycoed, repeats a great part of the felsitic series by bringing them up again on the S.E., and so runs into the Bangor-road fault N. of Brithdir.

This repeated mass of felsites is overlapped near Llanddeiniolen by grits and conglomerates, which can be traced at intervals to the Bangor road N.E. of Brithdir (see map and fig. 6).

On the mass S. of Brithdir a purple bed is seen near Garth; and this seems to be developed to the N.E. into the Brithdir rock, which is a red quartziferous felspar porphyry. To the S.W. of this, running parallel to it, is a mass of purple brecciated rock seen in the ravine near Y Ganol, and running by Cae Cerig to the E. of Brithdir till it is lost under the overlapping grits and conglomerates.

A similar sequence of beds can be made out in the mass on the W. of the Careg-goch fault. A purplish bed of quartz felsite is seen trending N.E. near Tanypërthi; and at Pantyfallenfach a purple brecciform felspar porphyry can be traced for some distance with a similar strike. These are probably equivalents of the Brithdir porphyry and Brithdir breccia respectively, thrown back by the Careg-goch fault (see section, fig. 6).

III. Bangor Beds (= Volcanic series).

The ground N.E. and E. of Brithdir is much disturbed, and I have not worked out the details; but the sequence is clear further to the N.E., and by reference to it the leading features of the rest of that district can be made out. The volcanic beds are well exposed

Fig. 7.—Section from Menai Bridge to Bryniau Bangor.

on Bryniau Bangor, from the W. shaft of the tunnel to near the path above the station, and are seen, as already elsewhere described, to consist of hornstones, fine green banded slates, and agglomerates, including fragments of rock precisely similar to the beds among which the agglomerates occur. They contain also small faults and contorted broken-up beds, lying between others apparently undisturbed. From such indications we may infer that we have here a volcanic series, consisting chiefly, in this part, of fragmentary ejectamenta. Following the bands across their edges in descending order, we come to purplish somewhat felsitic-looking rocks; and it is not improbable that we have here traces of small later lava-streams, of which the earlier greater flows are preserved in the underlying Dinorwig beds.

If the Brithdir and Pantyfallen brecciated rocks are lava-flows, owing their brecciform appearance to half-molten fragments in the lava, they would have to be bracketed with the Dinorwig beds; and this ejection, with imperfect fusion, would seem to indicate the commencement of the conditions under which the Bangor beds were accumulated, in which the fragments appear to have been thrown out unmelted, forming great masses of agglomerate and ash.

We must therefore consider the lowest of the Bangor beds visible in that area to be the coarse brecciated conglomerate seen near Careg Hwfa, immediately S.E. of the purple grits. This conglomerate is very conspicuous with its large pebbles of green felspathic rock weathering milk-white. The dip of the volcanic beds is very clear, averaging about 55° S.E.; and as we follow them along their strike to the N.E. we find them disappearing under the Cambrian conglomerates and grits, which can be traced lapping round the end of the hill from near Minford to below the Mount.

So it will be seen, first, that all the older groups run parallel to one another between Caernarvon and Bangor, the strike nearly coinciding with the trend of the hills, with a little more north in it, and dragged down towards the great faults here and there.

Secondly, that a connected though variable series, consisting of grits and conglomerates, flanks them on the S.E., and folds round the north-eastern end of the several masses into which the range is cut up by valleys, overlapping in turn each of the four groups into which the older rocks have been divided, and changing their character somewhat according to the rocks on which they rest and from which they were principally derived. These grits and conglomerates I refer to the base of the Cambrian, and I now propose to trace them more in detail.

Cambrian.

We find them well developed on the shore S.W. of Garth Point, where there is the following section:—

Fig. 8.—Section seen along Shore of Menai Straits between Garth Point and Gored Gith, Bangor.

Sandy mudstones with subordinate purple beds are seen here and there in road-cuttings and elsewhere on the hill above, and the conglomerate can be traced obliquely up the hill-side. It crops out below Menai View, runs across from that to near Friddodd, and is exposed in a large quarry near Plas Lodwig. It is seen, well scored by glacial striæ, in the road that leads from Friddodd towards Belmont. Probably one of the faults seen on the shore near Gored Gith cuts it off on the S.W., and it is thrown forward by

the Bangor-road faults into the city, where it appears again below the Mount, from which it can be traced at intervals across the end of the hill by the E. shaft of the tunnel, and S. and S.W. to Nant Gwtherin.

The area of two square miles lying S.W. of Bangor is a difficult bit of mapping, from the number of faults and dykes, and the partial metamorphosis accompanying them; but the beds can be pretty well identified. I think the district could be satisfactorily worked out, especially if we had six-inch maps.

Felsites occupy the whole area between the Carboniferous fault and the Trawscanol fault as far N.E. as Penychwynfa. Cambrian grits cross the road near Beulah Chapel, and are seen in the small road-cutting in the field opposite the entrance to Belmont. Here also there is a greenstone dyke exposed, and on the E. side of it, close to the gate, the conglomerate occurs. To the E. pale mudstones are seen along the road from the George Hotel to Bangor, and near the four road ends by the "f" of Gosphwysfa. E. of this the conglomerates are repeated as described above, being seen almost uninterruptedly running from Gored Gith to Plas Lodwig. On the S.E. side of the Trawscanol fault Cambrian grit crops out along the top of the ridge by Bryn Adda, and then we have the interruption of a dyke running along the lane from S. of Maesmawr to the lower Bangor road.

A short distance S.W. of this, by the "dd" of Tafarnnewydd, a red grit and fine conglomerate, like the Careg-Hwfa beds, come to the surface, and are quarried in places.

Along the roadside by Tyddyndu sandstones and mudstones are seen traversed by a dyke which comes behind Coedty. These beds dip at a high angle (50° and 60°) to the N.E., and must be cut off from the felsites of Cilmelyn by the Trawscanol fault.

There are some hornstones and baked-looking banded slates on the rugged hill near the "w" of Tafarnnewydd, which at first sight I should be inclined to throw in with the Bangor group; but I have not worked out that bit, and there are beds very like them caught in along the dykes S.E. of the conglomerate of Tymawr near Llanddeiniolen, and these may either be Cambrian, altered by the Coedty dyke, or be older rocks faulted in.

The actual base of the conglomerate and grit I have not seen in this part of the district. Fig. 8 shows the section near Garth Point, and fig. 9 those made out on either side of Bryniau Bangor.

The conglomerate is less conspicuous, and the coarse grit more so, as we trace the series to the S.W. The conglomerate consists of large pebbles, almost all of which are fragments of felsite with a few of quartzite. The grit is generally a tolerably pure siliceous rock with but little feldspathic matter. The conglomerate is generally weathered to a considerable depth. It is much decomposed to the bottom of all ordinary quarries; but some fragments brought up the shaft, probably from the same bed deep down, are of tough purplish rock, containing pebbles of felsite similar to those in the more weathered conglomerate.

It is not, however, found to be so much decomposed as we follow it towards Caernarvon. In the quarry at Hendrewen, where

Fig. 9.—Section from road near Glan Adda, $\frac{1}{4}$ mile S.W. of Bangor Station, due E. across Bryniau. (Length of Section 1 mile.)

it is seen to be dropped by a small fault against the Bangor beds to the N.W. flank of the Bryniau ridge, it consists of a very tough grit and irregular conglomerate, the conglomerate in places being very coarse; one pebble was over a foot in longest diameter. It is here traversed by a dyke, near which it is slightly altered. These beds can be followed, dipping in a N. and N.W. direction, to near Tairffynnon, W. of which place the Bangor beds crop out below them. They can be traced along the N. side of the valley towards Perfeddgoed, and crossing the valley, which probably coincides with faulted ground, we can trace similar purplish conglomerate and grit up the road to Wern, and here and there E. of Brithdir, across the road N.E. of Cae Cerig, and beyond the rough land of Rhosfawr. We find bosses of grey coarse grit on one side and of felsite on the other over the hill to Fachell. There we have a fine series of sections, from which the E.N.E. part of fig. 6 has been drawn. The grits associated with the conglomerate are sometimes purplish where the conglomerate is purple, as near the Poorhouse on the Bangor road, but sometimes grey or yellowish, even when the conglomerate is purple. Generally the grits underlying the conglomerate are grey and yellow, as near Wern and Fachell.

About a quarter of a mile N.E. of Fachell, in a large quarry by the road opposite Tymawr, the conglomerate is well seen. Its general colour is purple, and on closer examination it is seen to be composed of pebbles of great variety, from a grey or salmon-pink quartz felsite to a bright porphyry, in which red crystals of feldspar shine in a black matrix. This conglomerate is followed by the usual Cambrian grits, sandstones, and mudstones, which are found a little further on much troubled by a great greenstone dyke.

A fault which causes the smashed rock seen along the road by Fachell throws back the Cambrian to the W. of Llanddeiniolen. S. of this fault, near the church, black and grey banded flaggy shales occur, like those seen in a similar position E. of Bryniau

Bangor; and W. of these, grits and purplish sandy shales crop out in the road and quarry near the Rectory. These are probably all above the conglomerate.

Coarse grits, like those near Fachell, occur along the S.E. flank of the hill for about three quarters of a mile near Careg goch, and are quarried here and there. They dip at about 30° to 40° S.S.E. and E.S.E. I take these to be the base of the Cambrian, here irregularly and unconformably lying upon the felsites, and thrown back from the grits of Fachell by the same fault which repeats the Brithdir beds at Pantyfallen and Tanypertthi.

Two miles further to the S.W. we find the grits and conglomerates flanking the Caernarvon beds on the S.E. sides of the ridge. They are first exposed in a small disused quarry, in a field on the top of the hill between Yscuborwen and Tygwyn, where they are seen dipping 45° to 48° S.S.E. and S. 30° E. (fig. 10). The conglomerate

Fig. 10.—Section in Quarry on top of hill between Yscuborwen and Tygwyn, Caernarvon.

N.W.

S.E.

*a*². Tough sandstone and grit.

*a*¹. Grit and conglomerate, with quartz, quartzite, lydian stone, jasper, mica-schist, &c.

consists chiefly of white quartz, among which pebbles of blood-red jasper are conspicuous, and less commonly fragments of mica-schists three or four inches in longer diameter. The conglomerates pass under tough grey grits and sandstone, which crop out under the hedge all along the opposite side of the quarry, as shown in fig. 10, which is drawn not quite at right angles to the strike, and therefore shows a somewhat lower angle than true dip.

Less than half a mile S.W. of this a quarry is being worked close to the road recently constructed towards the top of the hill, near some new villas. In this a somewhat similar but finer conglomerate is seen faulted against the Twt-Hill rock, and passing with a dip of about 15° under very tough grey grit weathering yellowish (figs. 3 and 4). The dyke fault, with a downthrow on the N.E., now throws the grits and conglomerates forward to the S.; and they are next seen in the quarry illustrated by fig. 2, resting on the Twt-Hill rock at an angle of about 65° , and dipping under grits and somewhat flaggy sandstones seen in the S. corner of the quarry. The conglomerate has been cut back to the Twt-Hill rock, leaving patches adhering in places, owing partly to the irregularity of the base, and giving the appearance of alternations of Twt-Hill rock and conglomerate, dipping a little to the E. or W. of S. The true

dip is seen, however, at the S.W. end of the quarry, and the long face of rock fronting the S.E. is very nearly the bedding-plane.

The conglomerate is much like that seen in the quarry shown in fig. 10, except that almost all the pebbles are white quartz. It is exceedingly tough. The finer portions are much like the upper conglomerate seen at Garth Point (see fig. 8, *a*³), and also resemble some of the conglomerate in the Hendrewen quarry (see fig. 9).

The overlying beds consist of a grey grit and micaceous purple flaggy sandstone. This is much weathered, and it is not clear how far the colour may be due to weathering.

The conglomerate is again seen on the S.E. of Twt Hill in front of the new church. The dip was not clear, but it appeared to be S.E. (fig. 1).

Thus we find the conglomerate and grit, which must all be referred to the base of the Cambrian, flanking the Pre-Cambrian rocks all the way from Twt Hill, Caernarvon, to Garth Point, Bangor, dropped in and repeated by faults here and there, and lapping round the ends of all the principal masses of which the range is made up.

The character of the beds varies according to the rocks on which they rest, and from which they were principally derived. Near Caernarvon the conglomerate contains chiefly quartz; near Llanddeiniolen it is composed of pebbles of felsitic rocks in a fine matrix, also like felsitic rock. Near Bangor, though the pebbles seem to be chiefly derived from felsitic rocks, the matrix, especially those portions which are furthest from the felsitic rocks, is often a grit, and generally is much more open and porous, probably being largely derived from the elastic volcanic series; and this accounts for that portion of the conglomerate being most decomposed.

DESCRIPTION OF PLATE XXXVI.

Map of the district between Bangor and Caernarvon.

DISCUSSION.

Dr. Hicks remarked that the points of difference between himself and the author of this paper were now very small, as it was quite clear that the author had abandoned the theory in which he attributed an igneous origin to the Dimetian (Twt-Hill) series; and he hailed the appearance of this memoir also as showing that Prof. Hughes was gradually coming round to his views, and accepting his threefold division of the Pre-Cambrian rocks.

Mr. TAWNEY stated that the specimen alluded to by Dr. Hicks as from a mineral vein was from a bed in the quarry near Twt Hill (admitted by every one who had been there to be a conglomerate); the only question was as to its age. Concerning this, two fairly divergent opinions were before us, viz. one recorded by Prof. Bonney, that it was a bed in the metamorphic Twt series; the other by Prof. Hughes, that it was lying unconformably against the

Twt-Hill series, and was of Cambrian age; the speaker inclined at present to the latter view.

Prof. BONNEY observed that he had not committed himself to more than two series, and that the views which he had stated in his paper had been founded not only on field-work but also on the microscope. With regard to the minor points in Prof. Hughes's paper, he thought there was no doubt evidence of fragmental structure in rock from the heart of the Twt-Hill mass; he did not think that colour was of much importance in the classification of felsite; and he thought that the district N.E. and E. of Brithdir, which Prof. Hughes said he had not worked out, was the most important part. He thought that evidence, both in the field and with the microscope, showed the beds of the Tairffynon district to be very different from the true Cambrian conglomerate; and that the grit from Fachell to Beulah Chapel was altogether different from that at Careg goch—the former being a felsite-grit, little altered, the latter a quartzite. Lastly, he maintained that the conglomerates in the grit near Twt Hill were totally different from the Cambrian conglomerate, were much more highly altered, were in true sequence with the beds below, and, so far, older than the Cambrian conglomerate.

Prof. HUGHES pointed out that Dr. Hicks had mistaken his views. In reply to Prof. Bonney he stated that he thought that the importance of working out a true sequence among the beds was so great as to warrant him in carefully studying that and the effect of faults. He had not neglected the microscopic characters of the rocks, and slices of all the more doubtful or important rocks were on the table; but his chief reliance had been placed on the behaviour of the great masses in the field.

SKETCH MAP of the DISTRICT BETWEEN BANGOR & CAERNARVON.

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