38. *On the RELATIONS of some of the OLDER FRAGMENTAL ROCKS in NORTH-WESTERN CAERNARVONSHIRE.* By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., F.G.S.,¹ and Miss CATHERINE A. RAISIN, B.Sc. (Read June 20th, 1894.)

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1. GENERAL CONSIDERATIONS.

IN a recent paper published in the Quarterly Journal of the Geological Society,² a new and revolutionary hypothesis is put forward as to the age and position of certain well-known conglomerates and associated beds in North-western Caernarvonshire. The new explanation presents at once some difficulties, but these have been increased in number and gravity by a fresh study of the district. We selected those portions of it examined by Mr. Blake, in which the more critical sections occur, and tested with the microscope the questions raised by work in the field. The one or the other author was already in possession of a fair number of slides from the district in dispute, and nearly fifty additional specimens have been expressly prepared for the present paper.

According to the new hypothesis, the strata previously mapped and described from near Llyn Padarn and from neighbouring districts can be distinguished into two groups separated by a strongly marked unconformity. While the one part is held by Mr. Blake to be of early Cambrian age, the other is 'post-Llanberis.' A question at once suggests itself, namely, to what epoch (from the Menevian onwards) do these so-called 'post-Llanberis' sediments belong, and where in adjacent districts may we find beds that can be correlated with them? Of this problem Mr. Blake has not succeeded in offering a solution, but he evidently perceives that it is one which claims consideration.

The new hypothesis, however, would involve two consequences of far-reaching import. The unconformity is described as being marked by nearly horizontal beds overlying earlier strata approximately vertical in position. Such an unconformity would be the record of

¹ The larger share of the work in this paper has been done by Miss Raisin. She has visited all the sections, often more than once. There are some which I have not examined, and others which I have not seen since the date of my former paper. It is only just that I should make this clear.—T. G. B.

² 'On the Felsites and Conglomerates between Bethesda and Llanllyfni, North Wales,' Quart. Journ. Geol. Soc. vol. xlix. (1893) pp. 441-465.

tremendous disturbances. The uplifting and denudation of the earlier strata, previous to a renewal of deposition, are changes which we should expect to find associated with a period of mountain-making. This can be no local phenomenon¹: its record must extend over a wide area. Yet nowhere in the surrounding districts do we find evidence of such a break throughout the whole of the Cambrian and Ordovician periods—unless we concede that Mr. Blake has established the existence of one, farther north, immediately before the beginning of the Arenig epoch. Of even this hypothesis, however, he declines to avail himself here,² so that a second great break must be introduced. Yet, so far as we know, there is no certain evidence of the existence of either. Only when we arrive at the commencement of the Upper Llandovery age have geologists agreed in recognizing one comparable with this in importance. This difficulty is dismissed in a few inconclusive sentences. Yet it is one which no detailed observation, no withdrawal of any small part of the evidence can possibly meet. It is general, and must be dealt with before the hypothesis can have any solid foundation.

The other difficulty, which is not even considered, is partly connected with the preceding one. It is the necessity of twice uncovering the felsite³ in order to obtain from it a great amount of material to help so largely in forming the two series of strata, the one before, the other after; the tremendous break we have mentioned.⁴ So complete was the exposure of the felsite in what he takes for the second period that Mr. Blake describes this 'post-Llanberis' conglomerate as shading into the 'reconstructed' felsite.⁵ But the denudation cut even deeper, since the so-called later conglomerate includes granitoid and quartzite-pebbles, which must have been obtained from early pre-Cambrian rocks. Yet, curiously enough, the 'Llanberis' strata, though they have been so completely planed down, have not contributed any large amount of fragments. Only exceptionally do we find these or slaty pebbles of any kind, as, for example, at Moel Tryfaen. The detailed evidence, then, ought to be

¹ Mr. Blake says it has to be decided whether 'this unconformity is any more than a local one' (*op. cit.* p. 463). But surely, were it local, this would require such exceptional and extraordinary conditions as to be practically impossible.

² *Ibid.* p. 465. The unconformity which has been claimed in some previous papers, as separating the Cambrian from the pre-Cambrian, would not of course help Mr. Blake; and this presents no serious physical difficulties.

³ We refer to the well-known mass which is shown in the Geological Survey map as near Llyn Padarn, and as extending for a considerable distance from Bethesda to the S.W.

⁴ Although the so-called earlier 'Llanberis Beds' generally are finer-grained, they can be clearly proved to be at places mainly composed of material derived from the quartz-felsite. As examples we may mention beds in some of the 'banded slates' synclinal east of Llyn Padarn, and the 'more felsitic material . . . almost . . . pure felsitic ash,' described by Mr. Blake south of the second conglomerate (*op. cit.* p. 445).

⁵ *Ibid.* p. 447. Thus, apart from other objections, Mr. Blake's hypothesis of several successive felsites (*e. g.* Moel Goronwy) and their denudation will not lessen the difficulty referred to above, since here (and at other places) the 'post-Cambrian' conglomerate is supposed to be deposited on one of the earlier felsites.

of the strongest and clearest nature, if it is to establish the supposed unconformity. This evidence, in all places but one, is indirect; we will consider that instance first, and then pass on to the other cases.

II. EVIDENCE FROM MOEL TRYFAEN.

This locality is the one which seems at first sight most to support Mr. Blake's hypothesis. As we were unable to spare the time for any thorough re-investigation of the adit,¹ we have considered how far the surface-exposures, taken in conjunction with Mr. Blake's description of the tunnel,² necessitate the acceptance of his hypothesis. The general succession crossed on the western slope above and north of the Bryngwyn incline (that described as 'the southern slopes') is claimed as representing the tunnel-section, but it is not very clear how the author accounts for the absence from the tunnel of the conglomerate of the tramway-cutting.³ This is at a lower level and strikes towards the adit, which, it is admitted, commences in felsite.

The main difficulty, however, is the apparent absence of the summit-conglomerate from the tunnel. Certainly nothing in the detailed section given by Mr. Blake can fully represent the extensive outcrop on the top of the hill. Assuming the accuracy of his observations of the tunnel, there seems on our theory no other explanation possible than that this conglomerate is faulted out; and the broad outcrop at the summit might be due partly to such disturbance. This seems suggested by the changed dip found in the associated green grits.⁴

The chief arguments drawn by Mr. Blake from the surface exposures are, that the dip is nearly horizontal, and that the northern slopes are covered by conglomerate and grit. Special reference is made to two lines of crags in this direction. It is said that the upper "most distinctly show a low dip of not more than 5° to the east" (*op. cit.* p. 462). We took the dip on several blocks and surfaces, of which four at least were clearly shown varying from 15° to 25° generally to S. of E. or S.E.⁵; while in the grit of the summit-

¹ Each of us on separate occasions has been through it, but not with good lights.

² That difference of opinion is possible would appear from the fact that a specimen which one of us collected at a hundred paces from the mouth or northern end of the adit, that is, somewhere in '29, light crystalline felsite,' is an unquestionable felsitic grit.

³ Prof. Bonney in 1878 collected a specimen from the spoil-bank at the N.W. mouth of the adit which closely resembles this conglomerate, and noted 'Cambrian conglomerate' as one of the four varieties of rock lying about. In 1880 he passed through the adit (but only with a bull's-eye lantern) and found 'Cambrian conglomerate' following after the felsite with (?) some felsitic grit. This is probably identical with the rock mentioned by Mr. Blake in a note (*op. cit.* p. 460).

⁴ These do occur, although Mr. Blake says (*op. cit.* p. 462):—'nor can we find any green grit on the summit.'

⁵ These, in some cases, are the dips shown on exposed surfaces, and so may be less than the true angle.

crag the dip is distinctly as much as 40° to a westerly or south-westerly point (approximately W.S.W.).

It is then said that "the lower crags are of conglomerate like that of the summit." The rock clearly is a conglomerate, one of those largely made up of material from the quartz-felsite, with pebbles also of quartzite and occasionally of granitoid rock, while the large slate-fragments of the mass at the top of the hill are wanting. Thus it seems to us that lithologically this conglomerate does not resemble that of the summit; it more probably represents a band at a different level, like that of the tramway-cutting. The argument implied in the words "all is covered by conglomerate and grit" is less strong than it seems, because no small part consists of unbroken sward. So far as any inference is justifiable from the latter fact, it would be that there probably is a softer rock, such as slate, in this part of the hill.

Thus it does not appear that we can prove the conglomerates on the hill to form a single great mass, or that this is approximately horizontal as implied by Mr. Blake¹: hence we are still not satisfied "that the conglomerate lies unconformably on, and is independent of, the underlying members of the Cambrian Series" (*op. cit.* p. 463).

III. WEST OF LLYN PADARN.

In the district west of Llyn Padarn we will discuss first that part of the railway-section where the evidence can be best brought to a test examination. This is towards the inlet of the lake at the north of the cutting. It is stated as an argument here that 'Purple Slate' (*op. cit.* fig. 6, *b*; fig. 7, no. 11) occurs in contact with the felsite with no conglomerate between.² The section of the supposed junction is undoubtedly very difficult. We agree with Mr. Blake that both the slate and the felsite-like rock are broken, but after careful microscopic study of both varieties we have come in other respects to rather different conclusions. The purple rock certainly appears to be a variety of slate. The light-coloured one in junction-specimens is almost wholly composed of felsitic material, and might be a crushed condition of the quartz-felsite, but the relation of the two is more like that of sediments, and the darker sometimes contains bands of an intermediate character. Thus the mass is most probably an interbanded dark mud and felsitic grit,

¹ There seems in addition one negative argument which should be considered. If the thick massive conglomerate unconformably overlies Cambrian strata, nearly horizontally or with a low dip to the east, then it would be a curious coincidence that it should have been cleanly removed from over all the purple slates. So far as we know, no representative of it has ever been noticed, although extensive quarries are worked almost continuously along the east of the hill. The conglomerate-and-grit has so successfully resisted denudation at one part that it forms the thick crags of the summit, while less than 100 yards away the same resistant strata have been entirely removed.

We have to thank the owner, Mr. Menzies, for kindly giving us some interesting details relating to the slates worked in the quarries and to the associated grits.

² *Ibid.* p. 451.

subsequently very much compressed and wrinkled.¹ The latter fact, which seems quite clear in the three slices examined, appears contrary to Mr. Blake's view of the rocks.

The 'Purple Slate' is said by Mr. Blake to occur in mass along the lower levels only (*ibid.* p. 450).² The rock is partly purple and is slaty, but we fail to see any evidence which would correlate it with the purple slate of the quarries, as seems intended by Mr. Blake in his use of the term. Lithologically even, one of the most characteristic structures in the 'post-Llanberis' strata—the interbanding of fine grit and purple slate—is certainly indicated in one part of the mass. It is followed in the railway-cutting by the beds of the synclinal, which are taken as 'post-Llanberis' (see our fig. 1, 7 *b*, 7 *c*, 7 *d*, 7 *e*, and 6, 7, 6, in map, fig. 4, p. 594), and the dip of the 'Purple Slate' (fig. 1, 7 *a*) is similar in direction to that in the northern arm of the synclinal (about 70° S.E. by E.). The southern arm, however, gives still more distinct evidence. Mr. Blake describes and draws the conglomerate, *g*, as mounting "over the back of a dyke of greenstone" (*op. cit.* p. 450, fig. 6). We find below this conglomerate a purple slaty rock or banded and cleaved argillite, indistinguishable in hand-specimens from that claimed as 'Cambrian' on the north (see our fig. 1, 7 *b*, 7 *a*). Bands similar in character also occur in the 'post-Llanberis' synclinal. Thus the supposed 'Cambrian' beds dip (at the north) with the 'unconformable' strata above, can be matched with bands intercalated among them, and appear to be reproduced to the south, turning up in that arm of the synclinal, exactly as we should expect if there were no unconformity.

The other argument used here is the distribution of the conglomerate. It is said to occur at the spots marked *a*, *c*, *g*, *m* (*op. cit.* p. 451, fig. 6), extending over different beds of the earlier series. The southern mass *m* cannot give much help. Mr. Blake, we suppose, faults it down,—we think it more probable that the rock is faulted up. The conglomerate *a*, however, is supposed to pass over to that marked *c* in the synclinal (see 3 and 7 *b* in our fig. 1, and 3 and 6 in map, p. 594). Of these Mr. Blake says "there can hardly be a doubt . . . that [they] are parts of the same mass" (*loc. cit.*). But lithologically they appear somewhat distinct, both in hand-specimens and on microscopic examination. The conglomerate *c* has a less squeezed look than the conglomerate *a*, is more purple, and contains clearly fragments of rocks of more basic or intermediate composition, which seem practically absent from the latter. Further, the thickness of *c* is probably less than 20 feet, while that of *a* must be much greater. We believe that it is a distinct layer at a higher horizon, and it is

¹ Undoubtedly a mass of felsite occurs just beyond; but, as the slate is conspicuously wrinkled, its dip can hardly be parallel to the surface of the igneous rock.

² Again on p. 455, it is stated that 'nowhere are the felsite and Purple Slate, which are seen at the level of the railway (11, 12), to be found above.' The 'Purple Slate' is discussed in the next few sentences. But a felsite also occurs up the hill S.W. of Tan-y-pant Cottages. It is difficult on any theory to explain this outcrop, but it undoubtedly is shown in several well-marked bosses.

Fig. 1.—Diagrammatic Section along Railway, west side of Llyn Padarn (south of the inlet of the lake), showing the junction of the supposed 'Cambrian' and 'post-Llanberis Beds.

Note.—The bands of conglomerate in 7 e are rather more distinct in the cliff than is shown in the diagram. Two bands occur immediately S. E. of the lines FF in the northern arm of the synclinal, and one band N. of FF. (*Cf.* G. May, Geol. Mag. 1868, pl. vi.)

followed by two or three still thinner,—a sequence which commonly happens.

Thus we maintain the ‘opposite conclusion,’ to quote Mr. Blake’s own words,¹ and although we deny the identity of *b* with the Purple Slate, we do not ‘miss the synclinal,’ but make it more definite; and we fail to see any reason why *m* at least should not be faulted up.

Tracing the beds inland, the last-mentioned faults would account for the difference of the rocks exposed in the grounds opposite Glyn Padarn. Our observations there do not accord with Mr. Blake’s. We are told that we come to grits and conglomerates which are ‘corresponding rocks’² to those of the railway-section. The conglomerate *m* is the massive quartz-felsite conglomerate with quartzite-pebbles (3 in fig. 4, map, p. 594); but the conglomerates or pebbly bands (in the grounds) and the associated grits are, many of them, quartzose rocks containing quartz-pebbles and grains of blue quartz (11 in fig. 4, map, p. 594). This rock is similar, therefore, in many respects to the green grit with blue quartz associated with the Purple Slates³; and in these very masses layers of purple slate or argillite occur. Even the “large mass of purple slate lying horizontally on the top of finer conglomerate”⁴ seemed to us, if we correctly identify the place, to belong certainly to one of these bands. It is not, therefore, a fragment derived from any possible underlying rocks, and so no proof that the series is ‘post-Llanberis’ in age.

Mr. Blake says: “If we pass along an E.N.E. to W.S.W. line . . . we cross a definite succession.” It is not easy to recognize this definite succession. Compact grits are followed by a coarse green pebbly grit with bands of conglomerate and of argillite, but beyond the wall this runs on the west right up to the slate tips; the grey slate outcrop being nearer the quarry. It is further stated that this succession has “a gentle dip towards the E.N.E.” and that “we have here a series . . . nearly horizontal.” Some of the dips which we noticed are obscure, but three are clear:—to N.N.W., to N.W., and to N. of W. at 30°, 18°, and 30°; while one dip to S.E. at 32° appears to be due to a synclinal roll.

The description of a regular series takes no account of any faults, but one at least (probably two) can be traced across the neighbouring slate-quarry.⁵ The apparent interruption of this slate may be due to another line of fault roughly north-easterly, for, as we have stated, a fault is seen (or rather parallel faults) on the railway-section near the continuation of the line of junction.⁶

¹ *Op. cit.* p. 452.

² *Ibid.* p. 453.

³ A green grit, containing similarly blue, purple, and red quartz-grains, is characteristic of certain bands in the Harlech and Barmouth areas.

⁴ *Ibid.* p. 453.

⁵ This may be partly the cause of some variation in the dips and outcrops nearer the road.

⁶ These are shown in the section given by Mr. Maw (*Geol. Mag.* 1868, pl. vi. and p. 121), from which our drawing differs in some minor details. We have not, however, thought it necessary to give a separate diagram, as we believe that Mr. Maw’s drawing correctly represents the important points of the general succession, except in the matter of the unconformity.

Mr. Blake speaks of it there as a 'slight fault,' but it is so only on his own hypothesis; to argue from that statement is reasoning in a circle. This 'slight fault' is supposed to account for the grit and conglomerate being carried down to the railway-level; while at the higher ground they are "all but actually *seen* to overlie [the Purple Slates] unconformably" (*op. cit.* p. 454).

We have discussed the grounds for this view, drawn from the lithological succession and the dip. The remaining argument, as given by Mr. Blake, is: "if I understand rightly the section given by Mr. Maw . . . it runs beneath these very grits and conglomerates." But, apart from the fact that that section represents conglomerate under purple slate, there is a serious misunderstanding, for the adit described begins about 80 yards away from these grits, since it extends from the second to the third Glynrhonwy Quarry.¹

Passing to the north-west, we cannot agree that the conglomerate can be traced 'step by step from 13 by 14, etc., to 19' (*op. cit.* p. 455). It can be traced from 13 nearly to the streamlet which comes down (past Tan-y-pant) to the corner of the inlet of the lake, but—as we believe—not beyond (3 in our map, p. 594). The conglomerates south of the streamlet appear to represent the—probably thinner and higher—bands of the railway-section (6, etc., in map, p. 594). Along the boundary next the felsite, we are told that the conglomerate behaves as an unconformable deposit. The variation may be due partly to faulting, partly to the occurrence of inter-changeable deposits of grit and coarser material, much as the local sandy and pebbly beaches of the present day. But the important outcrop is the 'knob of hard Purple Slate' intervening between felsite and conglomerate. The few such knobs as we saw appear to be part of the purple banded series occurring on the hill,² and do not separate the felsite from the conglomerate. At the place (21)³ marked by Mr. Blake as proving the existence of 'Cambrian' slate, we find the outcrops⁴ next the felsite to be, firstly a cleaved, rather coarse grit somewhat resembling a 'rain-spot' breccia, then a purple quartz-felsite grit with pebbles, a purple banded grit and argillite, greenstone, then purple grit, after which the quartz-felsite conglomerate reappears (see map, p. 594).

Then we turn to the 'associated rocks' and the evidence of their lamination. Mr. Blake says that "almost wherever seen these laminae, etc., are horizontal . . . a circumstance which first excited my

¹ We have to thank W. Roberts, Esq., the manager of the Glynrhonwy Slate Quarries, for very kindly giving us this and some other information in answer to our enquiries. He mentioned also, what seemed to us a point of some interest, that the goodness of the slate appeared to depend on the occurrence of an adjoining mass of grit ('granite' of the quarrymen).

² Included in Mr. Blake's map in the symbol 'Post-Llanberis conglomerates and grit,' fig. 7; also fig. 2. This inclusion of things so different as coarse conglomerate and banded slaty and gritty rocks under one symbol makes Mr. Blake's maps difficult to follow, and likely to mislead an observer unfamiliar with the ground.

³ *Op. cit.* p. 452, fig. 7.

⁴ At the parts measured by scale on the map.

suspicious that they were not what they had been taken for.”¹ In an area extending for about $\frac{1}{4}$ mile “above the road from the Glyn Peris Hotel to the commencement of the felsite,” passing Tan-y-pant, some roughly horizontal outcrops occur,² but fourteen dips more or less trustworthy were measured, out of which not one was horizontal, very few were gentle dips, the average was from 30° to 35° or 40° , and two at least indicated high angles of 50° and 70° .³

We have not worked over all the details farther up the hill, but until some distinction is drawn between different grits and conglomerates no inference from isolated outcrops can be trusted. Certainly the specimens at one part from near Cefn Du quarries, lithologically, are similar to the quartz-grits which are found among the workable slates, and are very different from the great quartz-felsite conglomerate. If slate-holes were found on different sides of this grit,⁴ this would be no more than might have been anticipated.

IV. EAST OF LLYN PADARN: INLAND SECTIONS.

Along the eastern boundary of the series of conglomerates, etc., Mr. Blake’s map is misleading, even according to his own description. As he says, the conglomerate *i* resembles *a*, yet he marks it by a different symbol (*op. cit.* p. 447, fig. 2). It is with this conglomerate, *i* (3, near the Boat-house, in our map, p. 594), that we have to correlate various outcrops north of Mr. Blake’s 18, west of the felsite on which 24 is marked, while the so-called ‘Banded Slates’ (*g-h*, *op. cit.* fig. 2, ‘Cambrian’) are many of them lithologically indistinguishable from—and can be traced along to—the banded gritty series of the east of Y Bigl marked as ‘post-Llanberis’ (see our map, 5, 6, 7, p. 594).

A further argument is based on the stratigraphy of Moel Goronwy (Moel Gronw). Mr. Blake states that the felsite of this hill differs from that of Clegyr in being more compact.⁵ We think it would be an improvement to substitute ‘less’ for ‘more,’ but the difference is trifling and the former rock agrees in its general character⁶ with the ordinary felstones of the neighbourhood, displaying a fluxional

¹ *Op. supra cit.* p. 455. It is impossible, we find, to be sure of the exact outcrops indicated by the numbers on Mr. Blake’s maps; but the area examined here extended beyond ‘18, 16, 10,’ the points to which he especially referred.

² At some spots small synclinals or anticlinals seem indicated.

³ Other dips not so well exposed were measured, and many more were noticed. Some variation in the dips doubtless is due to the intrusive greenstone. The whole hill very possibly is underlain by a large mass, which may occur like a laccolite, and certain of the strata are baked and changed to porcellanite. Some knobs of hard purple slate occur, which evidently are parts of the banded series altered in this way. The general dip in the part towards the felsite is to a north-westerly point, but south of the Tan-y-pant streamlet the direction is changed.

⁴ *Op. cit.* p. 455.

⁵ *Ibid.* p. 450.

⁶ One slide of the rock includes many small crystals of secondary minerals, some being white mica, others probably a carbonate. But similar minerals occur in the main mass of the felsite.

structure equal to that of Cwm-y-glo, and enclosing lumps of a compacter and redder felstone,¹ as the principal mass does near Bettws Garmon. Although the massive conglomerate of the western is wanting on the eastern margin of the igneous rock of Moel Goronwy, yet the felsitic grits with occasional seams of quartz-felsite pebbles² indicate a similarity of material (4 in our map, p. 594). But the existence here of a fault seems highly probable from the nearness of the outcrop of purple slates, from the absence of the main mass of the conglomerate, and from the variation found along a continuous line down to the lake. On the railway Mr. Blake states that there is possibly a fault, but makes no allowance for its continuance at Moel Goronwy.

Tracing next the outcrops along the western boundary of the conglomerates, etc., the most important argument is the sudden change at the north of the quartzite-conglomerate (11, 12), which, if the map given by Mr. Blake were accurate, could be explained only by more than one fault. But instead of the rocks east of the line 25 to 11 in his map being rightly represented by the same symbol as the great quartzite-conglomerate, they require a different sign, and the difference between the rocks east and north of 11—that is, between ‘post-Llanberis’ and ‘Cambrian’—does not exist. The same purple and grey-weathered, finely laminated and banded grit and argillite (which we should describe as of Y Bigl type) occurs, followed to the eastward in each case by green banded slaty rocks and grits, like those on the summit of Y Bigl. If the fault which Mr. Blake marks on the railway (*op. cit.* p. 445, fig. 1, between *a* and *x*) is continued inland,³ it would account first for the conglomerate, then for the felsite, coming into close association with the banded gritty or slaty rocks (see F² in our map, p. 594, south of Tyddyn Du, 3, 1, and 7).

Between the two boundary-lines the rocks of the slate-railway section strike towards the slopes of Y Bigl. On this hill several examples are noticed, and two are drawn representing grits overlying Pale Slates (*op. cit.* pp. 448, 449, figs. 3, 4). We were not satisfied as to this interpretation for the one which we visited, but as the horizon of these beds is part of the point in dispute, the sections would only supply an argument for an unconformity to an observer who already is convinced. We are also told of the difference between all these rocks of Y Bigl and those of the railway syncline. As we shall show, the latter include some banded grits and conglomerate, such as occur over the higher slopes. It is, however, true that here on the hill the pale banded slates of the railway do not seem to extend over a wider area, as should happen in a section of a syncline,

¹ Sir A. Geikie has called attention to both these characteristics, *Quart. Journ. Geol. Soc.* vol. xlvii. (1891), *Pres. Addr. Proc.* p. 94.

² These apparently are the ‘curious breccias derived from the felsite,’ to account for which, on his hypothesis, Mr. Blake has to suppose the Moel Goronwy felsite a later eruption, *op. passim cit.* p. 450.

³ The fault which has been suggested by one of us as occurring between the felsite and the conglomerate was not supposed to be great, and might have died out in a short distance from the lake.

made by gradually rising ground. But if the axis of this syncline sloped to the south-west at an angle of about 12° ,¹ the lower strata of grit, etc., would spread over a broader tract. Is, however, the pale slate completely absent from the summit of the hill? It seems to us that it does occur (probably over a limited area), and that although the rocks show varietal differences, there is no strongly marked lithological distinction.²

Mr. Blake's hypothesis moreover only seems to substitute another and rather greater difficulty. If the Moel Goronwy felsite overlies in succession the Banded Slates, what has become of the syncline which admittedly has extended from the railway for nearly $\frac{1}{2}$ mile to Y Bigl, and then has died out in less than 300 yards? Or, if the syncline is continued, then the Moel Goronwy felsite must be separated from the Banded Slates by a fault. Then what has become of this fault at the railway? (Compare fig. 5, p. 597, *postea*.)

The strata of Y Bigl also are said to be horizontal, and this, if true, would be strongly against the view that they belong to the railway succession.³ The same position is exhibited in Mr. Blake's fig. 5 (*op. cit.* p. 449).⁴ As no dips are given on the map (away from the lake), we were unable to verify the particular observations on which the statement was founded, but the amount of the dip was measured at some twenty places⁵ lying within Mr. Blake's 'post-Llanberis' area on Y Bigl. Of these observations, in one the crumpled laminæ maintain a roughly horizontal direction,⁶ in all others the dips were not less than 35° , and in more than half they were as much as 50° or higher.⁷ And these are the beds whose horizontal position proves the unconformity!

V. EAST OF LLYN PADARN: ALLEGED UNCONFORMITY ON THE SLATE RAILWAY.

In the previous instances the evidence is indirect, but at one spot we are told that the hypothesis can be brought to a direct test.

¹ A greater slope than this is indicated at Yr Allt Wen in the Survey Memoir, fig. 64, p. 181.

² Specimens have been examined under the microscope and they show a certain amount of family likeness, particularly in the coarser bands. In each, but especially in two specimens from the syncline of the railway, several rather angular fragments of the dark rock (described *infra*, p. 598) occur, which generally are abundant in Mr. Blake's 'post-Llanberis' group.

³ An argument in support of this view may be drawn from the strike which can be traced in certain distinguishable layers as roughly to north-eastward; that is, agreeing in direction with the outcrops indicated in the railway section.

⁴ This section is difficult to understand, unless we are to suppose that a fault, throwing down the 'post-Llanberis' conglomerate at the N.W. end, ran opportunely along the nearly vertical junction of the felsite and the banded slates. But even so, the latter must have rested on the former and have been afterwards curiously twisted up just on the southern side of the fault.

⁵ These were the clearest exposures. The dips were noticed at many other outcrops.

⁶ At a place which we believe may be on the line of the anticlinal from the lake.

⁷ Here also, as at Moel Tryfaen, these measurements are sometimes less than the true dips. See p. 580.

To this must be the final appeal. Mr. Blake maintains that by the side of the slate-railway east of Llyn Padarn, his 'post-Llanberis' conglomerate can be seen unconformably overlying the beds which are admittedly Cambrian. This is at the spot originally described by one of us¹ as the second of the three masses of conglomerate (numbered 3, 6, and 3, in our fig. 2, p. 590, and in our map, p. 594). It is a thinner mass, as was then noticed, and it also differs somewhat lithologically from the first and the third, so that, from these reasons, and from careful tracing of the dip in the associated beds, we now incline to think this second conglomerate may be a different and slightly higher band.

In the original diagrammatic section along the railway given in the description referred to above, the synclinal and the anticlinal were shown. At the latter part Mr. Blake introduces a fault, and we (though partly for different reasons) think that one probably is present; but we do not agree with him in thinking that "there is no anticlinal" (*op. cit.* p. 446). We still adhere to the original diagram, but should shift the position of the anticlinal axis in it southward, so as to fall nearly on the third conglomerate² (3 in fig. 2, p. 590; and 3, near Boat-house in map, p. 594). Again and again, in the little crags just above the railway, the dips are well exposed—towards a north-westerly point on the one side, towards a south-easterly point on the other side of a line which is thus clearly anticlinal.

We are told, however, that the unconformity is distinctly proved at one place, and it is drawn as shown in Mr. Blake's fig. 1 (*op. cit.* p. 445). A conglomerate *A* lies unconformably upon the slate-breccia *g*, and Mr. Blake states that Prof. Green, Sir A. Geikie,³ and himself have recognized the difference, "which others have failed to do." Even the latter statement is incorrect, for one of us called special attention in 1879 to the fact that the section shows conglomerate and a sort of 'rain-spot' rock underlying the conglomerate.⁴ In the conglomerate, as shown in the cliff-section, the pebbles are rounded or subrotund, larger, and fairly close, but with a finer gritty matrix between.⁵ The upper part is weathered, and this causes the pebbles therein to stand out in relief, but they are present equally in the lower unweathered part, the two clearly forming a single mass. The underlying 'rain-spot' rock is more strongly cleaved, as stated by Sir A. Geikie. This character, however,

¹ T. G. Bonney, 'On the Quartz-felsite and Associated Rocks at the Base of the Cambrian Series in North-western Caernarvonshire,' *Quart. Journ. Geol. Soc.* vol. xxxv. (1879) p. 309.

² The greater thickness of the third conglomerate might be due, partly at least, to the anticlinal roll. Some, however, of the first conglomerate might be cut out by the fault which limits it on the south.

³ Sir A. Geikie, however, does not admit the existence of the unconformity. *Quart. Journ. Geol. Soc.* vol. xlvii. (1891) *Pres. Addr. Proc.* p. 95, note.

⁴ 'A sort of 'rain-spot' rock at the base of the middle mass,' T. G. Bonney, *op. supra cit.* p. 315.

⁵ The pebbles are not unusually $1\frac{1}{2}$ " or 2" long by $1\frac{1}{2}$ " broad, but most commonly from $\frac{1}{2}$ " to $\frac{3}{4}$ ". In the 'rain-spot' rock the fragments are smaller and more elongated along the cleavage.

Fig. 2.—Section along Slate Railway, east of Llyn Padarn.

1. Quartz-felsite.
2. Greenstone dykes.
3. Conglomerates, supposed identical.
4. Felsitic grits. (The nature of 4 ? is doubtful; the block to the S. marked by a simple ? may not be *in situ*.)
5. 'Rain-spot' breccia.
6. Conglomerate.
7. Purple banded grit and argillite, sometimes conglomeratic or approaching breccia; seemingly related to 6.
8. Banded argillites and fine grits. At *a* and *b* a kind of 'rain-spot' breccia and a grit.
9. Massive green grits. (We are not quite certain whether the most northerly mass is quite the same as the more southerly beds.)
10. Purple slate.
11. Rocks like 9 and 10 interbanded.
12. This mass shows an ascending succession of (a) purple banded grit and argillite, (b) breccia, (c) purplish grit.
13. A grit, probably related to 4, but with some resemblance to 7.
14. Quarries.
15. Probably a small fault.
16. Dyke in line of fault.
17. Junction obscure, probably a fault.

The lines of shading are not intended to represent the direction of the dips: these are roughly indicated by the stronger lines shown at intervals in 8, 9, 10, and by the lines in 7. The figures placed above the section indicate approximately the position, on the hillside, of outcrops of the rock which the numbers express; the dip is in the general direction of the arrows.

[Horizontal scale (roughly) 22 yards = 1 inch.]

is still more clearly marked in the banded grit and argillite, which occur above the rounded conglomerate. That the upper conglomeratic part was deposited continuously on the lower breccia is proved by the finer matrix graduating from the one to the other. This is seen unmistakably both in the cliff and in a microscope section cut from a junction-specimen.¹

Not only, however, is the unconformity quite disproved, but the only line which might be supposed, and has been supposed (by Prof. Green), to mark it is not shown by Mr. Blake. His drawing improves on the earlier sketch by altering the actual line to a non-existent division. The conglomerate is not mast-headed on the top of the lower part of the cliff as shown by him. The line of separation is not a 'nearly horizontal line.' It more closely approaches that position just at its southern end, but soon curves and slants down to the railway, as is shown roughly in Prof. Green's drawing, and with a little more detail² in the sketch on the following page (fig. 3).³

We are told, however, not only that there is a 'nearly horizontal line of separation,' but also that in the underlying rock 'different vertical sheets' have different characters.⁴ The 'nearly horizontal line,' as already stated, does not exist, neither do the 'vertical sheets.' Mr. Blake says that the conglomerate (which we prefer to call, for the sake of distinction, the 'rain-spot' breccia) is 'vertically bedded.' It has, indeed, a roughly vertical cleavage, but of stratification in this direction we could see no evidence. It is stated that it changes "in a horizontal direction to more and more felsitic material till it is almost a felsite or pure felsitic ash." Lithologically we should not object to this description, but the first distinct change, passing from the 'rain-spot' breccia to the southward, seems marked by a line dipping north-westerly at a moderate angle (about W.N.W. 35°), which hardly can be considered to mark a 'vertical sheet.' Also, in the underlying felsitic rock (which possibly may be a squeezed grit⁵), a band seems indicated (although indistinctly) showing a similar dip. Thus the dips in the section roughly agree: namely,

¹ In this slide an infiltrated mineral seems to us to be a kind of opaline silica. Other slides prepared from Mr. Blake's 'post-Llanberis unconformable conglomerate' A show that the materials are of the same character as those in the underlying breccia, and different from the conglomerates *a* and *i* with which he classes it.

² From drawings made on three separate occasions by two different observers.

³ It seems, then, since Mr. Blake himself has not succeeded in correctly representing the cliff, that my words—'the section is not so clear in nature as in the diagram'—were not unjustifiable after all.—T. G. B.

⁴ It must be remembered that the bands originally supposed to denote vertical layers of slate proved on examination to be thin dykes of compact diabase, C. A. Raisin, Quart. Journ. Geol. Soc. vol. xlvii. (1891) p. 333.

⁵ This rock is so much affected by pressure and micro-mineralogical changes that it is very difficult to determine whether it has been originally a felsite or a felsitic grit. In an earlier description by one of us it was regarded as possibly the former faulted up, but we now incline, though with hesitation, to the latter view. [Also, even if a faulted junction occurs, I doubt whether the line of it is visible, as was formerly suggested.—C. A. R.]

Fig. 3.—*The alleged unconformity. By the Slate Railway, eastern side of Llyn Padarn.*

2 = Greenstone.

5 = 'Rain-spot' Breccia.

6 = Conglomerate.

[The dotted line indicates the junction of the breccia and the conglomerate. Above the higher broken line in 6, the weathering of the upper part of the conglomerate is more than usually conspicuous. It must be remembered that the drawing is necessarily to a certain extent diagrammatic, and that the rocks are distinguished by conventional symbols.]

that in the so-called line of unconformity, that above it, and that in the possible banding below it.

The alleged unconformity, therefore, seems not only unsupported, but also actually contradicted by direct evidence. If further proof were needed, it would be found in the continuation of the section northward and southward. The dips in both directions and the lithological characters give some evidence. On the north Mr. Blake marks 'greenstone or green grit not properly examined' (*op. cit.* p. 445). We find here a greenstone which is partly compact, partly porphyritic, and grits (2 & 7 in our fig. 2; see also map, p. 594). The grits are distinctly banded, and continue the succession above the conglomerate, with purple argillite-laminæ of the typical interbanded character. In addition, some bands show distinctly the 'rain-spot' breccia-type, proving the recurrence of this same variety above the supposed unconformity.¹

We have discussed this section at some length, because it is the place of which Mr. Blake states that he 'cannot imagine a more satisfactory proof of unconformity in a single section' (*op. cit.* p. 446). If unconformity there be, we have never before seen one so successful in concealing itself.

VI. STRATIGRAPHICAL SUCCESSION.

Here, perhaps, a short summary may be given of the explanation which we venture to suggest for some of the sections described above.

On the west of the lake the conglomerate next the felsite (and largely derived from it) extends above the road above Tan-y-pant, followed by a grit of similar material. Still higher up on the hill, interbanded grit and argillite occur, with pebbly layers and a kind of 'rain-spot' breccia. The oblique direction of the outcrop of these beds, and their general dip to a north-westerly point, *i. e.* towards the felsite, indicate the probability of a line of fault along the boundary of the igneous rock (F⁴ in map, p. 594), as was formerly suggested by one of us.²

The conglomerate, however, and other beds are abruptly terminated near the little streamlet already mentioned, beyond which a sudden change of dip is found, so that this also seems to be a parallel line of fault (F⁵ in map).³ By it the reappearance of the felsite towards the lake may be explained, as well as the crushed and schistose condition of some of the rock in the small 'stream quarry.' But this fault makes it more difficult to come to a

¹ Bands more or less similar occur at other places—in the syncline by this railway, on the railway west of Llyn Padarn, and on the hill above Tan-y-pant.

² T. G. Bonney, *Quart. Journ. Geol. Soc.* vol. xxxv. (1879) p. 314. This fault might account for the true felsitic conglomerate reappearing in small exposures near Groeslon, and for the crushed condition of other beds near.

³ A fault roughly near this seems to be marked on the Geological Survey map. Possibly another parallel fault occurs, bringing up the felsite N.W. of this, already mentioned. See note, p. 582.

conclusion as to the exact position of the purple felsite which has been described by Sir A. Geikie.¹ If we may infer from its high southerly dip that it is an interstratified band on the S.E. side of the fault, then, as Sir A. Geikie believes, it probably would be a small lava-flow higher in the succession than the great quartz-felsite, from which it differs lithologically. If, however, it be on the northern side of the fault, this difference would lead us to suppose it to be an external part of the lava-flow. At parts it has remained uncleaved, and this is especially the case in an outcrop well shown (in a dry season) at the edge of the lake. We have already dealt (p. 585) with the alleged junction of felsite and 'Cambrian slate' in the crag nearly between these two localities.

Neither of the faults before mentioned is great, not so large as many of the parallel displacements among higher strata which are shown in the Geological Survey memoir and map.² Beyond the stream fault, the interbanded argillite and grit probably belong to the syncline which is well marked, along and above the railway, by bands of purplish conglomerate. The next cutting through bastard slates and greenish grits, which, owing to undulations, extend for some distance, though they have proportionally a rather small thickness, exhibits not a few faults, so that probably the general result has been to let down the whole mass in a kind of trough. Unless this be so, these beds can hardly be equivalent to the green banded hálleffinta and grit on the east of Llyn Padarn. The rock adjacent to the conglomerate (south of the bridge in Glyn Padarn grounds) is slickensided and the junction probably is a faulted one. This conglomerate, as we have said, may be the representative of

[NOTE TO MAP.—A few outcrops in this area have not been visited, and others need re-examination to test the hypothesis here represented.³ Further, many variations occur (not possible to show on this map), apparently due partly to small faults or rolls, partly to the slope of the synclinal or anticlinal axis. This axis seems to dip with the slope of the hill, sometimes at a less angle. Also the different layers mentioned above are not always sharply distinct, gradations occurring between them, which would be expected, if (as the Authors believe) the rocks form a continuous series. The Authors are fully aware of the defects of the map, but they nevertheless insert it, since, notwithstanding its imperfections, it may be of use to make parts of the accompanying paper more easily understood.]

¹ Quart. Journ. Geol. Soc. vol. xlvii. (1891) Pres. Addr. *Proc.* pp. 96, 97.

² The stream fault, apparently the greater, might have a throw of 140 feet; but such an estimate is purely hypothetical.

³ Thus beyond the road south-west of the Moel Goronwy felsite (although part is grassed over) conglomerates are exposed, and possibly they include some representative of conglomerate 3, in which case its outcrop might extend continuously to the west of Moel Goronwy.

At * the ground is largely covered with slate tips, and is partly grass, with some outcrops of grits, etc.

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that next to the felsite, which lithologically it seems to resemble. In that case the fault probably would be as great as that north of the section east of the lake, while the throw of one to bring in the Purple Slate would have to be rather greater.¹

North-east of the lake the following seems to be the general succession of the beds:—(a) a lower conglomerate mainly derived from the quartz-felsite, often containing also some pebbles of quartzite and granitoid rock (3 in fig. 2, p. 590); (b) a grit of similar materials (4 in fig. 2); (c) coarse strata, including fairly numerous fragments of somewhat basic igneous rock,² as in the ‘rain-spot’ breccia, the overlying conglomerate, and other pebbly bands (5 and 6 in fig. 2); associated grit of similar composition interbanded with argillite (7 in fig. 2); (d) green banded finer grit, hállefinta, and argillite and purplish fine-grained rocks (8 in fig. 2), leading up to the Purple Slate. These last indicate the beginning of the continuous quiet deposition which characterizes so much of the Cambrian period. They appear to be associated with the green grits containing coloured quartz-grains, as already described.

In lithological character the third (or southern) mass of conglomerate in the railway-section seems to be similar to the first or northern. As already described, the dips above the third conglomerate indicate an anticlinal, and thus the grits, conglomerate, and banded series on the north may be taken as higher beds. If so, they are probably cut out to the north-west of the synclinal of green banded rocks, and to the south of the third conglomerate, by two faults, both of which are admitted by Mr. Blake (see F² and F³ in our map, p. 594). Probably the fault between the felsite and the conglomerate (F¹) is small, but that along which the greenstone is intruded on the south of the western conglomerate (F²) is greater, for it apparently cuts out beds 4, 5, 6 (figs. 2 and 4), perhaps a little of the upper part of 3, and some of the lower part of 7.

We believe that the anticline of the railway-section is indicated to the N.E. at various spots³ towards the Moel Goronwy felsite, and

¹ Possibly the first might be 400 feet, the second (still more difficult to estimate) 600–700 feet. But the fault at Nantlle is described by the Geological Survey as throwing the slate directly against the quartz-felsite.

² Probably similar to those mentioned by Sir A. Geikie (*Quart. Journ. Geol. Soc.* vol. xlvii. 1891, *Pres. Addr. Proc.* p. 96). We do not, however, see that there is proof of the contemporaneous ejection of these. It is difficult to conceive them as the ejectamenta of expiring volcanic eruptions, since they are different from any of the larger masses of igneous rock in the neighbourhood—unless, indeed, certain more distant rocks of similar composition (such as those in the Lleyn) could be proved to belong to this age.

³ At more than one place a close resemblance can be traced to the banded grit south of the third conglomerate on the railway, dipping south-easterly, and other dips to the north-westerly point are exposed. Between the two roads which join to the eastward at the School, a curious purplish rock occurs, and also a more normal-looking purple felsite (possibly a dyke—we have not examined its relations). The former shows in places a clean-welded junction with a greyish felsite and exhibits a structure like a flow; it even runs in among fragments of the felsite. Both rocks have been affected by subsequent pressure. The purplish rock rather reminds us of a specimen described by one of us from Baron Hill Park, near Beaumaris (*T. G. Bonney, Quart. Journ. Geol. Soc.* vol. xxxix. 1883, p. 472).

in the dip of some of the beds to the west of that hill. We notice that even the map given by Mr. Blake (*op. cit.* p. 447, fig. 2) would be more easily interpreted on our hypothesis (fig. 5 below).¹

In attempts to connect the readings on the two sides of the lake, we find there is a general correspondence. A double fault seems indicated near the felsite on both railways, the throw being greater on the north-east of the lake. It appears possible that the small

Fig. 5.—Section across Moel Goronwy, illustrating the probable relations of the beds mapped in *Quart. Journ. Geol. Soc.* vol. xlix. (1893) p. 447, fig. 2.

NOTE.—The conglomerate north-west of the Moel Goronwy felsite appears to resemble conglomerate 3 in our figs. 1, 2, and 4. The mass shown N.W. of the synclinal has not been examined by us, so that its similarity is merely inferred from the stratigraphical relations.

syncline on the south-west might be equivalent to the beds occupying the wider curve on the opposite shore; more probably, however, all the undulating beds on the former side are faulted representatives of the latter. But the want of exact agreement, together with the fact that the beds on the rising ground on each side seem to dip towards the lake, suggest that a fault may very likely extend along the line of the lake itself. Such a line of disturbance is shown on the Geological Survey map in the upper part of the valley.

VII. COMPARISON OF MICROSCOPIC SECTIONS.

We have further examined microscopic slices of many typical specimens. The following brief summary of the details and of our

¹ This must be considered hypothetical, until further examination is made and the dips are recorded. We have only partially examined the section, but it seemed to us that a succession was indicated in the conglomerates and grits, which would agree with our interpretation of the outcrops to the S.W. and of the section by the lake.

conclusions is limited to rocks from the locality of Llyn Padarn¹, which Mr. Blake has definitely grouped with one of his two series.²

I. In the conglomerates or breccias of rather basic materials, taking specimens from critical parts on both sides of the lake,³ we find these to consist of fragments of the following:—

- (a) Ferruginous andesitic or basaltic rocks, recalling sometimes the character of masses described from the Llyn. They include
 - 1. Fragments, where lath-shaped feldspars, clear, but replaced by an aggregate of minute minerals, are embedded in a continuous black opaque ground;
 - 2. Fragments, where similar feldspars occur in a ground speckled with opacite;
 - 3. Fragments, with a felsitic cryptocrystalline ground, rich in ferrite.

Some of these fragments may represent lava with flow-structure.
- (b) Andesitic fragments, containing viridite or chlorite within crystals or in the groundmass: including
 - 4. Ferruginous rock with some viridite;
 - 5. Rock with a matrix of viridite, perhaps originally a kind of tuff.
- (c) 6. Andesite or felsite, deficient in iron oxide and viridite.

¹ Many more slices have been examined, and reference to other districts, or to slices from other rocks in this district, would rather strengthen the case, but it would extend the statement to too great a length. We may, however, add that we have compared the slices of grits and conglomerates from Mr. Blake's 'Cambrian' and 'post-Llanberis' beds in the neighbourhood of Llyn Padarn with a number of those from the area between Brithdir and Bangor (Tairffynon, etc.). Though varietal distinctions exist, to some of which attention has been called in former papers, these beds on the whole bear a general resemblance to the clastic rocks discussed in the present communication, and the lava-fragments occurring in the one set can often be identified in the other. Hence it is more probable that all belong to one and the same period than that they represent two periods separated by a vast physical break.

Mr. Blake, in an earlier paper (Quart. Journ. Geol. Soc. vol. xlviii. 1892, pl. vi.), admits the conglomerate north of Llyn Padarn to be the equivalent of the Bangor Conglomerate. (It is also referred to by one of us, C. A. Raisin, Quart. Journ. Geol. Soc. vol. xlvii. 1891, p. 335.) To us, however, the former seems very similar to the conglomerate immediately south of the main mass of felsite on both sides of the lake, which he claims as 'post-Llanberis.'

² The specimens were not directly cut to establish this comparison, so that the preponderance of any one group on one or the other side of the lake is often accidental. The references give the localities of the specimens as marked in Mr. Blake's figures and maps as nearly as is possible, Quart. Journ. Geol. Soc. vol. xlix. (1893) pp. 441 *et seq.*

³ A.—East of Llyn Padarn by slate-railway, 'rain-spot' breccia underlying supposed line of unconformity. Figs. 1 and 2, *g*. 'Cambrian.'

B.—East of Llyn Padarn near road north of Fachwen. Fig. 2 about N.W. of F in Fachwen. 'Cambrian.'

C.—East of Llyn Padarn by slate-railway. Conglomerate overlying supposed line of unconformity. Figs. 1 and 2, *d*. 'Post-Llanberis.'

D.—East of Llyn Padarn. Ditto. 'Post-Llanberis.'

E.—East of Llyn Padarn, to south-eastward of the top of Y Bigl. Fig. 2, ? about due S. of 23. 'Post-Llanberis.'

F.—West of Llyn Padarn, hillside above Tan-y-pant. Fig. 7, ? about due N. of 16. 'Post-Llanberis.'

There are gradations, and no absolute separation exists between the above-named groups, but the fact that these merely minor varieties recur in rocks at different horizons is a very strong argument for the view that denudation was proceeding continuously. We find all the six types of material present in rocks below and above the supposed break. Four of the varieties can be recognized in every slide examined, and five in nearly all the sections. There are also other points of likeness in the structure of the fragments, such as slight varieties of fluxional, scoriaceous, and other more microlithic structures. All these characters are common to the 'earlier' and the 'later' series.

In certain finer-grained clastic rocks, where bands of grit alternate with more compact layers, the materials are evidently of similar character, although the recognition of minor varieties cannot be so complete as in the case of larger fragments, and fewer slices have been prepared from what necessarily would be a less interesting series. Fragments, however, can be recognized of the above-mentioned types (*a*) and (*b*) in slices from 'Cambrian' and from 'post-Llanberis' rocks, while some of the structures mentioned are reproduced; the finer material also is of the kind which would be formed by the further wear of similar masses. Thus these banded rocks can be recognized microscopically (as we have previously shown that they can macroscopically) both above and below the supposed break.¹ Also they grade into the coarser as well as into the finer layers, and thus form part of a continuous series.

The still finer gritty or banded argillites cannot, of course, afford much direct evidence. Still, those assigned to the two ages have a general similarity, especially noteworthy in the seams rich in angular fragments of felspar and quartz, and both frequently present resemblances to the groundmass of the aforementioned coarser rocks.²

Taking, lastly, rocks formed of more acid material, the frag-

¹ G.—East of Llyn Padarn. Slate Railway. Figs. 1 and 2, *f*. 'Cambrian.'
H.—West of Llyn Padarn. Hillside above Tan-y-pant. Fig. 7. 'Post-Llanberis.'

I.—West of Llyn Padarn. Ditto.

² J.—West of Llyn Padarn; near inlet of lake. Figs. 6, *b*; 7, No. 11. 'Cambrian.'

K.—East of Llyn Padarn, from syncline by slate-railway. Figs. 1 and 2, *d*. 'Cambrian.'

L.—East of Llyn Padarn, from syncline by slate-railway. Figs. 1 and 2, *c*. 'Cambrian.'

M.—East of Llyn Padarn, from syncline by slate-railway. Figs. 1 and 2, *b-d*. 'Cambrian.'

N.—East of Llyn Padarn, from syncline by slate-railway. Figs. 1 and 2, *b-d*. 'Cambrian.'

O.—East of Llyn Padarn, near the top of Y Bigl. Fig. 2. 'Post-Llanberis.'

P.—East of Llyn Padarn, near top of Y Bigl. Fig. 2. 'Post-Llanberis.'

Q.—East of Llyn Padarn, about S.W. of the top of Y Bigl. Fig. 2. 'Post-Llanberis.'

R.—East of Llyn Padarn, about S.E. of the top of Y Bigl. Fig. 2. 'Post-Llanberis.'

ments both in grits and in the well-known conglomerate¹ are mainly:—

- (1) Varieties of felsite which would find their counterparts in the 'Llyn Padarn' mass.
 - (2) Quartz-grains, often rounded, sometimes corroded.
 - (3) Felspar-crystals or grains, often twinned.
- All these may well be derived from the quartz-felsite by the lake.
- (4) Granitoid rock, and quartz and felspar, apparently from a rock of this nature.
 - (5) Quartzite which has a rather characteristic structure.²
 - (6) An altered-looking, often schistose mineral. It varies from pale yellowish to green, is slightly dichroic, and seems to give straight extinction. It bears some resemblance to an altered biotite, but cannot be certainly identified.

The altered mica-like mineral is especially found in two slides ('post-Llanberis'), but a small fragment of a similar variety occurs in one of the finer 'Cambrian' strata west of Llyn Padarn, and a similar mineral is seen in some of the quartz-felsite slides.³ Also fragments of a spherulitic felsite occur in both sets, *e. g.* in a 'Cambrian' grit from east of Llyn Padarn, and in one called 'post-Llanberis' from west of the lake; and a similar character, associated with a perlitic structure, can be identified in a Moel

¹ S.—East of Llyn Padarn, synclinal by slate-railway. Figs. 1 and 2, *d.* 'Cambrian.'

T.—East of Llyn Padarn, by slate-railway. Figs. 1 and 2, *g, h.* 'Cambrian.'

U, V, W.—Three slides from east of Llyn Padarn. Figs. 1 and 2, *i.*

X, Y.—Two slides from west of Llyn Padarn, road by Tan-y-pant Cottages. Figs. 7 and 6, *a.* 'Post-Llanberis.'

Z.—West of Llyn Padarn, by road south of Tan-y-pant. Fig. 7. 'Post-Llanberis.'

α, β, γ.—Three slides from west of Llyn Padarn, hillside above Tan-y-pant. Fig. 7. 'Post-Llanberis.'

δ, ε.—Two slides from east of Llyn Padarn by slate-railway. Figs. 1 and 2, *a.* 'Post-Llanberis.'

² On examining a specimen from east of Llyn Padarn (from the hillside above the slate-railway) we find that it consists of subangular to partly rounded quartz-grains, which obviously have been slightly augmented by secondary quartz, though without losing their original outline. Between them, set as it were in the secondary quartz, are flakelets of a colourless mica. A few grains of felspar have also been present, most of them now replaced by the above-named mica and quartz, but two or three are unchanged (microcline, plagioclase, etc.). In the groundmass are several granules of yellow epidote, of pyrite?, hornblende?, and possibly rutil, with an opaque whitish decomposition-product, and two or three rather rounded zircons. The rock obviously was once a somewhat felspathic sandstone. It appears to have been converted into a quartzite before the pebble was made, and is rather more altered than is usual with a Palæozoic quartzite. This also, so far as one can judge from macroscopic observation, is true of the other pebbles.

³ Even some granules of hæmatite appear to have their equivalents in one or two of the felstones. (Compare Sir A. Geikie, *Quart. Journ. Geol. Soc.* vol. xlvii. 1891, *Pres. Addr. Proc.* p. 99, and T. G. Bonney, *Quart. Journ. Geol. Soc.* vol. xxxv. 1879, p. 311.)

Tryfaen slide ('post-Llanberis'). The other classes of fragments make up the bulk of the rocks enumerated, both the 'Cambrian' so-called and the 'post-Llanberis.' Very much of the ground-mass apparently has been derived from the felsstone, for in some cases it is by no means easily distinguished from a crushed variety of that rock.

To render the comparison more easy, we have separated the fragments of the acid from those of a basic type; but they may both occur in the same mass, as for instance, in the thinner bands of conglomerate or of grit at the synclinal by the railway on the western side of Llyn Padarn.

The results obtained from microscopic examination are thus clear and definite. Whether we compare rocks below the supposed unconformity with those above, on one side of the lake, or on the other, or on both—whether we compare the rocks of more basic or of more acid material, the coarser or (so far as they afford any evidence) the finer—the same kind of fragments can be recognized in both sets. Rocks of very different composition were being denuded before the supposed epoch of disturbance, and the same set of rocks was being worn down after that epoch. It would be a difficulty, as we have pointed out, if we had to suppose that the felsite was twice uncovered, but when we have in addition to believe that the same varieties of more basic rocks were in each case associated, so that identical conditions were reproduced before and after the great interval and interruption, this would be a coincidence suggesting the necessity for the strongest positive evidence of the unconformity. But at the crucial section, as we have shown, there is perfect gradation and continuity in the materials. Microscopically, as macroscopically, the unconformity does not exist.

DISCUSSION.

Prof. BLAKE was glad that the Authors had attempted seriously to examine the question dealt with. Criticisms in such a spirit were in any case of value. The points dealt with in the abstract¹ read to the Society were covered by the remarks in his original paper, some of which he repeated.

Dr. HICKS said that he could not understand the position now taken up by Prof. Blake, as the evidence given in the paper clearly showed that the great felsite-ridge was at the base, and evidently older than any of the recognized Cambrian rocks. The Conglomerate resting on the ridge was sometimes diminished in thickness by faults and in other places represented by grits; but it contained everywhere material derived by denudation from the ridge, along with pebbles of other pre-Cambrian rocks. On the table were pieces of this Conglomerate which contained cleaved felsstones, and large pebbles of a granitoid rock exactly like that forming the

¹ [This expression, unfortunately, is not quite accurate. I did not read an abstract, but gave an abridgment of the paper, sometimes reading, but mostly speaking from notes.—T. G. B., August, 1894.]

pre-Cambrian ridge at Caernarvon. The paper in his opinion gave the death-blow to the views put forward by Prof. Blake in regard to the succession of the older rocks in Caernarvonshire.

Mr. WHITAKER also spoke.

Prof. BONNEY replied that if Mr. Blake meant that another conglomerate was to be seen in the adit at Moel Tryfaen besides the one described by the Authors, it was in favour of their hypothesis of a fault. He could not admit that the felsite and purple slate were 'zigzagged together,' as Mr. Blake described. If the Authors had found the right place, the rock was not felsite but a felsitic grit. In the alleged unconformity by the slate-railway, the structure in the 'rain-spot breccia' was due to cleavage, not to bedding. Cleavage often disappeared in passing from finer to coarser strata—that was a matter of common experience. Moreover, cleavage could be just traced in the Conglomerate, and was perfectly developed in some interbanded fine grits or mudstones, a few steps uphill above the crag depicted. In answer to a question asked, he might remark that the Authors had carefully avoided the pre-Cambrian question, as foreign to the immediate issue of their paper, so he must decline to express his opinion on the subject.