avail ourselves of them to the fullest extent; and I decline to believe that the existing or even the Quaternary distribution of birds and mammals throws much light on the physical geography of the earth when birds were still toothed, and even the primary groups of mammals were scarcely differentiated.

V.—WOODWARDIAN LABORATORY NOTES, N. WALES ROCKS III.

By E. B. TAWNEY, M.A., F.G.S.

(Continued from Vol. VII. 1880, p. 458.)

AT Penyrhiwan, Clynnog, in the middle of fields, is a protruding boss of dark-coloured rock which has been well broken into, in order apparently to see whether it was available for making "sets" or pitching stones, which form the staple trade of the adjoining district. Its surface is well rounded, as if by glaciation. The boss consists of at least three varieties of rock. Most noticeable is a coarse-grained hornblendic one of handsome appearance, the glistening cleavage planes of the brown hornblende standing out from the remaining green actinolitic portion. A second variety is a fine-grained greenstone, which is separated from the preceding by a hard definite line, so that it may be taken to be of the nature of a dyke intruded into it.

A thin slice was taken at the contact so as to show the absolute junction. In the coarse-grained hornblendic rock microscopic examination showed that felspar was almost absent, there was only a very little decomposed pseudomorph that could be put down to this species. The rest consisted either of brown hornblende which passed by all variations into green actinolite of various shades, or decomposition products of the above, chloritic and viridite substances. Apatite is present inclosed in hornblende. Moreover, some secondary brown mica exists pseudomorphing hornblende apparently. The rock to the unassisted eye is very much like one collected by Sedgwick as a loose block under Girn Goch, and a similar rock is much used in the walls. That described however by Prof. Bonney [Cl. 15, Sedgwick Coll.], *GEOLOGICAL MAGAZINE*, Decade II. Vol. VII. p. 457, does not quite agree with ours. Our slice has no augite, while Sedgwick's has abundant octagonal sections of augite showing its cleavage.

Possibly, however, both have come from the same spot, for there is no other greenstone rock mapped by the Geological Survey near here, nor have we been able to find any. We may perhaps assume that the rock varies in different portions, sometimes augite being present, sometimes not. The present case taken at the junction may be considered therefore a hornblendic-dabase, in which augite happens to be absent, and the felspar at a minimum.

The dearth of felspar gives the rock an outward resemblance to pikrite, which is also kept up by the dark inclosures which break the reflection of light from the cleavage planes of the hornblende, but we have been unable to determine any olivine pseudomorphs among these.

The fine-grained rock at the immediate junction is seen to be a diabase. The plagioclase prisms are set mostly parallel to the junction face, and are much decomposed; the augite is entirely so, only tracts of viridite represent it; the ground is darkened by the quantity of magnetite grains, while between them is a greenish-grey granular substance, probably the remains of decomposed feldspathic substance and chlorite.

The third variety of rock is a medium-grained diabase with some hornblende, or proterobase as some might call it. I could find no hard junction between it and the coarse-grained rock, and though such may be hidden among the furze, it seems to me more likely that the one rock passes gradually into the other; I infer this from the relative position of the two kinds at their outcrops among the vegetation.

The chief constituents are augite in large crystals inclosing feldspar, etc., and plagioclase; some of the augite is quite fresh, but there are many patches and aggregates of decomposition products, viridite, etc., which must be put down to it; the plagioclase is also very much decomposed, and was apparently rich in lime from the calcareous look of its products. There is a little green hornblende with basal sections giving the characteristic cleavage, but it is in a minority. Brown mica is also present connected with ferric stains and other decomposition products: whether the mica is in an incipient stage—just forming, or whether it is a remnant decomposing—I am not sure. The ferric stains are also accompanied with opaque black oxide (ilmenite?).

From the minute quantity of hornblende this rock seems quite different to the coarse-grained, yet it is quite possible that there are intermediate passages at Penyrhiwan. The case would be only similar to that which Dr. E. Reyer of Gratz describes (as "Schliere") in massive eruptions. We may mention the case described by Prof. Geikie of pikrite passing into diabase at Blackburn near Bathgate (Trans. R. Soc. Edinburgh, vol. xxix. p. 507).

The Penyrhiwan boss is apparently protruded through the Cambrian shales, the exact age of these I am not able to give, not having found fossils.

Carn Boduan.—In 1878 I had the advantage of accompanying Dr. Hicks when he collected the specimens from this hill, and which were determined for him by Prof. Bonney [Quart. Journ. Geol. Soc. vol. xxxv. p. 305], as a quartz-felsite or quartz-porphryite. A quarry a few hundred yards to the east, but also on the south side of the mountain, visited at that time, yielded us a rock which on examination I found to be a porphyrite. As Dr. Hicks seems to consider these only as dykes, since the hill is included in his Arvonian in the sketch-map [*ibid.* p. 297], I felt a desire to examine the hill more closely. Accordingly in 1880 I collected from various points round the hill, and also from the summit.

We will describe first the rock of the quarry a few hundred feet east of the turnpike on the south side of the hill. In the hand specimen it is a black glistening rock with small separate feldspar crystals.

Under the microscope the felspar is found to be all plagioclase fairly clear and fresh, the extinction angle on either side of the twin face being small, points to their being oligoclase. The ground contains some glassy base in interstices, but is made up chiefly of plagioclase microlites with calcareous patches of decomposition, and a crowd of magnetite particles, giving doubtless the dark colour to the rock. Separate crystals of green hornblende are fairly numerous, and with them are a few crystals of augite. Largish crystals of black oxide of iron (ilmenite?) are often connected with the hornblende; apatite, which is abundant, is usually in the same connexion. This is a freshly-preserved porphyrite with andesitic structure. While the rock at one side of the quarry is nearly black, at the other side may be found a pale greenish variety in which are occasional segregations of crystalline calcite up to an inch in diameter. It is, however, only the same rock weathered. A slice off a specimen in the Sedgwick Collection [P. 59] is to be referred here. Its felspars are nearly entirely decomposed, the hornblende has disappeared, as have also the small felspar prisms of the ground, their place being taken by nuclei or patches of crystalline calcite showing cleavage and twinning; the ground is largely occupied by a greyish-brown granulated material, which runs together into most involved forms; under high powers it is seen to be not opaque, but to polarize very feebly, probably several decomposition products enter into its constitution. Very minute grains and nests of secondary quartz lie in its folds. Apatite alone remains unchanged.

Another example collected by me shows an intermediate stage of decomposition, and serves to explain the great change wrought in the arrangement of the rock by decomposition. It would have been impossible to determine the extreme case unless it had been recognized as coming from this quarry, in which all stages are found. This porphyrite may be found to extend for some hundred yards in breadth. Turning to other parts of the hill, we find it composed mostly of a fine-grained grey rock, not so dark as the porphyrite of the quarry just mentioned; it contains minute felspars; when weathered, however, it becomes a brownish-grey, more or less speckled with feldspathic portions of pale ochrey tint. It may be recognized as having to the eye the same characters all over the hill. Examples of it from various points were submitted to microscopical analysis, the specimens chosen being as little weathered as was possible to obtain.

Carn Boduan, from quarry on west side of hill by the encircling wall.—This is a fine-grained rock, quite compact-looking, of a more greenish-grey tint than usual. Under the microscope it is seen to be much decomposed, the larger felspars almost entirely converted to aggregates of variegatedly polarizing particles. The ground has the same structure as that of the first-mentioned quarry, consisting of micropisms of elongated form, their long axes here being often parallel; they are less decomposed than the larger ones, and extinguish in a way which proves their triclinic nature; some of their outlines are, however, merged into decomposing material, though

enough remains to show their general fluidal arrangement. There is similarly amorphous base between the crystals, partly globulitically devitrified. Calcite aggregates and scattered specks are distributed through the ground, and permeate the felspars. Of hornblende there is nothing left but small shapeless patches of chloritic material. Magnetite grains occur throughout the ground. This rock is evidently a porphyrite of the same type and composition as the blacker one above described.

Carn Boduan, from the base on south side near the turnpike.—The rock here is a fine-grained grey rock weathering brownish-grey. This is from the same spot as Dr. Hicks's specimen [Q.J.G.S. vol. xxxv. p. 305], collected in 1878. It is somewhat less decomposed than the last, but has much the same structure. The ground is microcrystalline, with interstitial glassy base; it consists of plagioclase micropisms, the extinction on each side of the twin boundary measured in some cases as 3° – 4° ; the parallel arrangement is not so marked as in the last case. The micropisms preserve their twinning better than the larger plagioclase crystals, which are partly changing into calcite by patches, in which cleavage is sometimes developed. There are also aggregates of calcite in the ground. No hornblende has escaped decomposition; some chloritic patches beset with magnetite indicate its existence, but generally the viridite or chloritic matter shows no definite shape, and is almost apolar. Magnetite grains as in the other cases.

The rock at the summit of Carn Boduan has the same appearance as that at the base, being a fine-grained grey rock weathering brownish-grey. I found it at the summit inclosing a dark black-grey piece of a different rock, looking like a piece of shale which had been converted into a sort of lydianite. This specimen was sliced and examined with the microscope. Its outline is sharp such as an inclosure would have.

Under high powers the numerous closely-crowded brown particles, which look half opaque, are broken up into aggregates of yellow scales which seem to be epidote, together with black-brown grains, which are magnetite changing into a higher state of oxidation; between are very minute grains of quartz. There are also some angular brown dichroic scales about $\frac{1}{10}$ mm. which seem to be mica. The square magnetite grains and the rounded yellow scales are from $\frac{1}{10}$ mm. to a little over $\frac{1}{10}$ mm. on an average. Under a power of 50 diameters, in which these details are not to be seen, numerous groups of epidote crystals are seen scattered through the rock, and also minute garnets of about $\frac{1}{10}$ mm.; there are also smaller garnets visible with high powers, so that they in size vary from $\frac{1}{10}$ mm. to $\frac{1}{10}$ mm.; they inclose magnetite particles. It seems probable that this is an inclosed fragment, in which garnets, etc., have been produced by the contact-action of the porphyrite.

The rock immediately inclosing the said fragment has the same microscopic characters as that from previously described parts of the hill: the plagioclase micropisms are here set parallel to the line of contact. Much secondary epidote is developed, this and viridite are

scattered throughout the ground, but none of the original hornblende is preserved.

Hence we consider the whole mass of Carn Boduan to consist of grey porphyry. The principal divisional planes of the rock are nearly vertical; this is well seen in walking over the hill, or even from below on the W. side, the vegetation finding root in the cracks accentuates this feature; these planes strike N. 25 E.—S. 25 W. Notwithstanding its being opposed to Dr. Hicks's remarks [*l.c.* p. 299], I must advocate a return to the view of the Geological Survey. There is every appearance of the mass being an intrusive rock protruding through Cambrian shales, which are seen lying at a steep angle in the vicinity; I could not find an actual junction. Plainly the rock is not metamorphic, it has the jointing and structure of an igneous rock throughout. Microscopic analysis applied to pieces from various parts of the hill confirms this view, so that there is every appearance of its being an intrusive boss.

I pass now to the consideration of a series of igneous masses which extend with more or less interruption from Nevin to Clynnog. Most of these are included by Dr. Hicks among his Pre-Cambrian series; he in the text acknowledges the partial intrusive origin of one of the Yr Eifl hills [*l.c.* p. 299] on receiving Prof. Bonney's report on the rock from Trevor quarries, but in the sketch-map they seem included as Arvonian. It seems to me, however, that there is sufficient evidence that these are all igneous rocks intruded through Cambrian shales in the manner delineated on the map of the Geological Survey. These rocks, though diversified in colour, appearance, and grain, vary chiefly between granite-porphry and syenite-porphry to porphyry or diorite. They are called "felspar-porphry often syenitic" on the Survey Map (and sometimes diorite in the text), which well expresses their appearance.

To begin with the mass about one mile N.E. of Clynnog at Cil y Coed; this is a quartz-felsite of pinkish-grey colour, with some green patches, the quartzites more numerous than the felspar crystals. Some of the latter are seen with a hand lens to have triclinic twinning. It is of a different type of rock to the following.

Bwlch Mawr, a hill S. of Clynnog, from the N. side of the hill below the summit.—The ground is dark grey, and looks fine-grained to the eye; in it are scattered numerous whitish felspars averaging about $\frac{1}{2}$ inch in diameter. Even a hand lens shows that many are plagioclase.

The microscope confirms the fact that many of the larger felspars are plagioclase, and from the predominance of crystals with a small extinction angle, they should belong to the oligoclase group. The ground was apparently microcrystalline, but it is now so decomposed that not much is to be made out. Under crossed Nicols there are clearer spaces of doubly refracting matter rendered turbid by fine dust, and darker granulated interstitial matter which seems almost optically inert; a few nests of quartz seem due to secondary action. Magnified only fifty diameters, part of the ground is found heaped together to form dirty grey granulated more or less opaque areas,

which is an effect of decomposition. Apatite exists, and a few small crystals of secondary epidote. There is some ilmenite covered with leucoxene. If any bisilicate existed, it has decomposed. The effect of decomposition is to give a quite different appearance under the microscope to that taken from the top of the hill. The hand specimen looked, however, fairly fresh, and in appearance much like the rock of Girn Dhu quarries.

(I regret that we are unable to offer any chemical analyses of these rocks, but in our present locale we have no facilities for carrying out such.)

(*To be continued.*)

VI.—TRACES OF A GREAT POST-GLACIAL FLOOD.

5. EVIDENCE OF THE MARINE DRIFT.

By HENRY H. HOWORTH, F.S.A.

THERE is an unfortunate Nemesis attaching to great discoveries and generalizations, which has not been sufficiently noticed. When men have been floundering about for years in a quagmire of confusion and difficulty, and some brilliant pen points out a clear way by which the tangle may be threaded,—a way which is so ingenious and simple that it at once seizes upon the current scientific thought, and compels the adhesion of everybody,—it inevitably produces a period of stagnation and for a while dwarfs inquiry. What is so palpably true and simple as the explanation of a very perplexing difficulty is taken to explain *all the difficulty*, and, for a while at all events, men's energies are devoted to bringing every apparently aberrant and stubborn fact within the new law or the new process; and every effect, however remote, is traced by a direct way or by a zigzag to the prime cause which has proved so fruitful. It is only after an interval, when men have digested and incorporated the new theory into their daily creed, and it no longer overawes them by its freshness, that they are in a mood to ask soberly whether, after all, too much has not been demanded from one cause,—whether, after all, the intricate and far-fetched explanations, which are necessary to connect that cause with effects with which we are familiar, is not illegitimate,—and whether we must not supplement it by some other cause, which has modified and altered its work, if we are to solve the whole riddle. A very admirable concrete example of the matter we are discussing may be found in the Glacial Theory. When the Glacial Theory was proposed by Agassiz, working on the lines of Playfair, to explain the rounded and polished surfaces we find in Scandinavia and Scotland, the striated and furrowed rocks, and the vast congeries of boulders of all sizes that strew the surface of Northern Europe, it was felt that one of those critical turns had been taken in Geology which enable us to map out a vast and complicated field with precision. Since this turn was taken it is surely no exaggeration to say that the history of so-called Quaternary Geology has been the history of the efforts made to explain every kind of problem presenting itself in the surface deposits of Northern Europe