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26. *The* Elvans *and* Volcanic Rocks *of* Dartmoor.

By R. N. Worth, Esq., F.G.S. (Read April 3, 1889.)

In the course of an inquiry into the physical history of Dartmoor, which led to the conclusion that this great granitic upland represents the basal portion of a volcano some 16,000 feet high, special attention was necessarily paid to the felsites or elvans of the district, as filling the gap between the plutonic members of the series, the granites, and the true volcanic rocks no longer found *in situ*. Search for traces of the latter was also made. Hence were gathered the facts now briefly set forth. The less definite term "elvan" is used here in preference to the more distinct "felstone" or "quartz-" or "felspar-porphyry," because the intention is to include under that head all the dyke-rocks of granitoid material connected with the Dartmoor granite; and because it is one of the chief objects of this paper to show that there is no fundamental distinction between the rocks so named, as they occur in the Dartmoor environment, but that different portions of the same dyke may exhibit all these varieties of structure, and present a graduated series between granite and a compact felsite, in which differentiation has yet to be set up. An "elvan" may be any species of rock that has developed from a granitic magma under conditions intermediate between plutonic and volcanic.

One of the first points to attract attention in the inquiry was the great disproportion existing between the characteristic varieties of elvans to be found *in situ* (I am speaking generally of the south-western borders of Dartmoor) and those occurring in the detritus which covers large areas of bottom land in the border valleys of the Moor. Elvans, too, are far more largely represented in the latter than in the adjacent modern river-beds.

Tracing back the history of denudation, next came the allied fact that while granitoid pebbles are to be found in quantity on many of the beaches near the mouths of the rivers of Dartmoor origin, on the shores of the English Channel, there, again, elvans largely predominate. That these accumulations represent in the main an ancient as distinct from a modern denudation seems clear. For example, while in the beaches immediately within the mouth of the Yealm no such pebbles occur, on the beaches immediately outside they are plentiful. Mr. Pengelly, F.R.S., has described similar phenomena at the mouth of the Erme*. Granitoid pebbles abound in a cove close to the mouth of that river; but for two and a half miles upward thence Mr. Pengelly failed to detect any granitoid rocks on the course of the Erme. The conclusion that these pebbles were not brought down by the rivers, "but cast up by the sea," seemed therefore a natural one. So far as my experience goes, however, these pebbles are quite as clearly of Dartmoor origin as those of the old valley-detritus; and whether they were brought to the shore in

* Trans. Dev. Association, xi. pp. 329–30.

connexion with the present river-system or not, I have no hesitation in giving the great bulk of them, at least, a Dartmoor birthplace.

Some of these pebbles, found on Slapton Sands, suggested a possible secondary origin in the degradation of the Triassic conglomerate which extends westward in mass to Torbay, and remnants of a still further extension of which are to be found at Thurlestone in Bigbury Bay, and at Cawsand in Plymouth Sound. This led to an examination of a number of the fragments of igneous rocks included in the Triassic conglomerates of Devon. Among these indubitable pieces of Dartmoor granite have been from time to time identified, but far less numerous in comparison than the examples of so-called "porphyritic trap," with which they are largely associated. The results of that examination speedily convinced me that many of these "porphyritic traps" were really "elvans," whilst others presented a nearer approach to volcanic types. Probably this would have been recognized long since had there not been a kind of tacit assumption that the covering rocks under which the granite of Dartmoor consolidated were wholly sedimentary. Had the volcanic character of at least the central pile been suggested, it would have been clear that in such an early stage of denudation as that which afforded material for the Triassic conglomerates of Devon, rocks of intermediate and volcanic types must play a far more prominent part than granites.

It is evident that the "felsites" of the higher stage of Dartmoor must have been much more important and wide-spread than the "elvans" or dyke-rocks by which they are now alone represented, or they never could have yielded the enormous quantity of material which is still traceable.

The "elvans" which remain *in situ* are practically confined to the borders of the moorland, ranging at points up to the main mass of granite in the covering rocks, and stretching westward in parallel lines towards the next granitic boss, on the western side of the Tamar, at Hingston Down. Five of these dykes are set out on the Geological Map of Devon between Shillamill near Tavistock, on the north, and Cann Quarry near Plymouth, on the south; there are others, but of minor importance and yielding no additional facts.

Now the northern of these elvans traverse the lowest rocks exposed in this area, and the southern the highest; moreover the northern are nearest to the main mass of granite, and the southern most distant from it. The northern, therefore, have been formed, to all appearance, under conditions of greater depth and pressure than their successors southward. As a result of this, we find the most distinctly granitoid or plutonic varieties in the northern elvans, Shillamill and Grenofen, and the most even-grained and felsitic in the southern at Cann Quarry; while the Roborough Down elvan, which is intermediate, to some extent, combines the two characteristics, in its compact felsitic ground-mass and its well-developed porphyritic quartz-crystals.

But the chief point to which I wish to direct attention here is the wide amount of variation within narrow limits in the same dyke.

Some of the characteristics of the Shillamill elvan are set forth by Mr. Rutley, in his 'Eruptive Rocks of Brent Tor'*; but a far finer section than that exposed at the time of his visit has recently been opened across the dyke in the construction of the new London and South-Western extension, and I do not know of any spot where extreme features of elvanic variation can now be studied to better advantage. The centre of the dyke is, to quote Mr. Rutley's words, "a quartzose felspar-porphyry of the usual elvanitic type;" but on each margin the rock is dark grey, in part granular in texture, in part massive, and with unevenly distributed dots and patches of dark greenish hue. Some parts, again, would fall under the old name of "claystone-porphyry." The different phases graduate into each other, but it would be easy to select what, on a mere casual survey, might be taken to represent half a dozen different rocks from half a dozen distinct localities. Mr. Rutley notes that while the three sections which he describes "are identical in their original composition, yet they differ greatly in their general aspect;" and this is emphasized by the results of my examination of sections from this new exposure.

Microscopic investigation shows that while the leading constituents are, as Mr. Rutley says, orthoclase, quartz, and magnesian mica, with a varying amount of felsitic matter, and that the porphyritic felspars have been much decomposed, there is also present in portions of the dyke a considerable proportion of dark-green hornblende, chiefly associated with the more definite quartz and felspar. The occurrence of hornblende is so unusual in the Dartmoor granites and granitoid rocks that this is especially noteworthy. The proportion of felsitic matter varies greatly in different portions of the dyke, and some parts are distinctly granular. As accessories there occur casually iron and copper pyrites and some chlorite. This elvan has been the subject of great alteration, and there is hardly any that will better repay careful study.

The other elvan that claims special mention is the Grenofen, which is half a mile south of the Shillamill, and stretches from east to west four miles. Mr. Rutley observed this at the Lower Grenofen quarry, where it has a well-marked porphyritic character, and contains so little felsitic matter that it is essentially a fine-grained porphyritic granite, partially syenitic, seeing that hornblende is irregularly developed.

This elvan, unlike the Shillamill, retains its general characteristics in breadth, but varies greatly in its length. It has recently been intersected in a tunnel on the new railway not far from Shillamill, and is there essentially an even-grained, loose-textured granite, the kaolinization of the felspar having proceeded so far as to make the rock quite rotten. Still further west, about a mile distant, on Morwell Down, the dyke yields a variety with a compact semi-vitreous ground-mass, in which felspar, quartz, and mica are porphyritically developed. Under the microscope the felsitic base is seen to be remarkably even-textured, resembling ground glass, and

* Pp. 24, 41, 42.

the porphyritic crystals singularly perfect in outline and character. Though it is not an andesite, andesitic affinities seem to be suggested.

As it is simply intended to indicate the more typical features of the "elvans," and those of Grenofen and Shillamill surpass all others in interest, I pass on to consider the evidence afforded by Dartmoor of the existence of distinctly volcanic rocks as a part of its igneous series.

There are among the fragments of the local Triassic conglomerate examples of andesitic and similar rocks that may fairly be classed in this category, but I do not desire to lay any special stress upon them.

It is more distinctly to the point that in October of last year there was found in undisturbed clay on the limestone of Cattedown, near Plymouth, a deposit of water-borne and water-worn detritus, which indicated a Dartmoor origin for a large proportion of its identifiable constituents, but contained associated therewith rolled flints and pebbles of Carboniferous, Liassic, and Cretaceous limestones, which could not have been brought to the place where they were found from any existing locality by any existing river. The inference seemed clear that these Carboniferous, Liassic, and Cretaceous remnants represented a very ancient denudation, when the western flanks of Dartmoor were partially covered by Carboniferous rocks which have now disappeared; by the Chalk, of which the nearest trace is now on Haldon; and by the Lias, which does not now extend further west than Lyme Regis.

And associated with these clearly identifiable and undoubtedly local rocks were others hitherto unknown in the West—examples of andesites which Professor Bonney has kindly examined for me, and has pronounced typical examples, closely resembling specimens from the Andes; and clastic igneous rocks, one of which, a volcanic grit, Professor Bonney regards as of very unusual interest, and as the result of the denudation of volcanic cones. Some of the fragments are felspar, but quartz and viridite also occur. Prof. Bonney remarks that the rock-fragments, so far as ascertained, are all of igneous origin. "Some are fairly clear, some a rich brown colour, some almost black with opacite; some are homogeneous, except for a little opacite and some belonites or trichites of a dark grey colour, which often are grouped in more or less dendritic forms or bundles like rootlets. A few of these grains are still isotropic, but most of those which are transparent exhibit devitrification-structure. Small spherulites are rather common; one fragment seems part of a large spherulite. Other fragments show flow-structure; one is perlitic. Clearly several varieties of rock are present, but I think the majority may be referred to andesites, some of which may not be far removed from basalt; others may have a tolerably high percentage of silica."

I believe I am perfectly safe in saying that there are no rocks in the county or in the West of England yet known that would yield either of these andesites or volcanic fragmental examples. If they belonged to the superstructure of Dartmoor, the denudation of which began in Triassic times, the absence of the parent-rocks is explained.

If they did not belong to Dartmoor, their association with rocks all of Dartmoor origin, assured or probable, has to be accounted for. And that enormous changes have taken place on the moor since the existing river-systems have been in operation, the deep gorges cut by the principal streams, and the fact that I have recently found remnants of an ancient Dartmoor river-gravel 300 feet above the present bed of the Tavy, near Tavistock, will attest.

However, the point need not be left to inference only. Among the specimens collected by me from the Dartmoor detritus at Lee Moor, within the granitic boundary, was a piece of compact grey felsitic rock which indicated fluxion-structure. This, on being sliced, proved to be a felsitic lava-breccia, containing numerous fragmental grains of quartz and also fragments of volcanic rock, some of which closely resemble certain fragments in the volcanic grit of Cattedown.

That the forces which upheaved the great granitic boss of Dartmoor found relief in a volcanic outburst seems therefore clear, though not a vestige of the volcanic pile remains.

The purpose of this paper is threefold:—

1. To give reasons for the belief that the present granite of Dartmoor passed upwards into felsitic and volcanic rocks, remnants of which are to be found in the Triassic conglomerate of Devon, in the detritus of the bottom lands of the moor itself, on the beaches of the Channel, and in ancient river-gravels and pebble-beds.

2. To indicate the wide range of character taken by the Devonian felsites of the Dartmoor district.

3. To point out some of the evidence that exists in the elvans *in situ* for the development of the most varied of their forms from one common magma, and the peculiar value of their study as bearing upon the wider questions of petrological research.

Discussion.

Prof. Bonney stated that the specimen of volcanic grit which he had examined for Mr. Worth was one of the most extraordinary samples ever sent to him. He agreed with the Author as to the importance of studying the Triassic conglomerates of the south-west. The term "elvan" should not be used as a scientific term, having been so vaguely applied.

Dr. Hinde called attention to the absence of specimens on the table as a check upon discussion.