NOTES ON SOME ROCKS OF NORTH DEVON.

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Sir Henry de la Beche, in his *Report on the Geology of Cornwall, Devon, and West Somerset*, has the following passage:

"Between Bull Point and Morte Point . . . large blocks of porphyry, similar to the Cornish *elvans*, are found on the beach, too numerous and of too large a size to have been brought there by man. Though we were unable to detect any porphyry or elvan dyke in place, the end of such a dyke may, nevertheless, be visible at very low spring-tides."[1]

Writing of the same locality, Mr. Townshend M. Hall, F.G.S., at our Ilfracombe meeting,[2] described the occurrence in Rockham Bay of "porphyries of various colours, with occasional small boulders of dark, almost black trap." The largest porphyry boulder noted by him was over three feet in length, and Mr. Hall suggested—"the parent rocks are probably not far distant, concealed beneath the sea."

During our Barnstaple meeting I paid a visit to Rockham Bay, and speedily collected a large number of porphyritic and other pebbles alien to the cliffs of that coast-line. My first idea, before I had fully ascertained their nature and variety, was that they must have drifted from Lundy; and as I was unable to reach the island, I became gratefully indebted to Mr. J. G. Hamling for a number of specimens of the granites, slates, and dykes of that locality, which speedily satisfied me that this hypothesis had to be abandoned.

Closer examination of the Rockham pebbles further showed that they represented too wide a geological field to be assigned any narrow local origin; and closer still revealed the fact

[1] *Op. cit.* 49. [2] *Trans. Devon. Assoc.* xi. 279.

that they included examples of rocks not now known to occur in Devonshire *in situ*, and some curious correspondences to the rarer contents of the Cattedown detritus (with its andesites and other volcanic materials), described by me at the Tavistock meeting of this Association.[3] They seemed also to bear a near, if partial relationship to the igneous materials of the South Devon Triassic breccias and conglomerates, to which I have assigned a Devonian origin.[4] And in short they appeared to fall into place as to some extent derived from the denuded superstructure of the ancient volcano, of which I have suggested that the present Dartmoor is the base. Naturally, if there was such a pile, the agents of denudation would be active in every direction, and we should expect to find traces equally in the estuaries of our northern as of our southern streams. That these Rockham pebbles are original constituents in any direct sense of existing tidal strands is not assumed. They may have been washed out of such raised beaches as that of which the Saunton boulder forms a part; they may have descended from such ancient high-level gravels as that which contained the andesites and volcanic grits on Cattedown; they may have come, as on Teignmouth and Dawlish and Slapton beaches, from wasting or wasted Triassic conglomerates. Nor is this occurrence of particular kinds of alien pebbles in special localities of our coast-line at all an isolated fact. It is equally true, for example, by way of illustration, of the isolated presence of granitic pebbles in Greylake Cove, outside the mouth of the Yealm; and in the little cove at the east of the mouth of the Erme, and not elsewhere in that vicinity.

Rocks of Rockham Bay.

The varieties of alien pebbles at Rockham Bay are so numerous that in a very short time I gathered upwards of fifty. The following are the more noteworthy of the granitic series:

Yellowish-brown granite.
Greenish-grey schorlaceous granite.
Massive red-brown felsite or vitrophyre.
Purplish-red compact felsite (ditto).
Red-brown felspar porphyry.
Warm brown felspar porphyry.
Greenish-brown felspar porphyry with zoned felspars.

[3] *Trans. Devon. Assoc.* xxi. 77–80.
[4] *Quar. Jour. Geo. Soc.* xlvi. 69–83.

Brown-grey granular compact felspar porphyry.
Brown-red compact quartz-felspar porphyry—(*a*) with crystals small and sparse; (*b*) more defined.
Greenish felspar porphyry, compact, but with granular aspect.
Felspar porphyry with greenish-grey base, orange porphyritic felspars.
Brownish felspar porphyry with dark brown mottlings.

In type, if not in identical variety, nearly all of these may be matched on Dartmoor; while others of intermediate character have analogues in the Triassic breccias and conglomerates.

This does not however exhaust the list of porphyritic rocks, for there were also several varieties of porphyritic "greenstones," some of which had been subjected to considerable alteration, and which it would be a work of considerable time and difficulty more closely and accurately to classify. They include: Black hornblendic greenstones, compact aphanites, black compact greenstone with pyrites and small porphyritic felspars, a similar rock with porphyritic quartz, grey rock with porphyritic felspar and quartz, compact greenish rock with greenish porphyritic felspars (possibly a highly altered tuff). The bulk are no doubt dolerites, though gabbros are probably represented; and they are mainly, if not wholly, dyke rocks, and some at least of no very distant origin.

Still other igneous varieties present are a hypersthene-augite-andesite; and a pale green much-altered quartziferous rock with light imperfect porphyritic patches, suggesting a highly altered tuff; as does, but less distinctly, a fine-grained greyish rock with mottled patching.

A further leading feature in the Rockham Bay pebbles is the prevalence of grits and quartzites, comprising among others: Compact greenish quartzite with reddish veins, compact grey quartzite, greenish quartzite, pink-brown quartzite, fine-grained reddish-brown quartzite, drab grit; and a highly silicified dark grey grit containing angular grains of quartz and felspar, with a few fragments of volcanic origin, in an exceedingly hard quartzose matrix.

I also found jasper; a curiously streaked rock, consisting of a wavy mixture of olive and black with a few crystals of felspar, no doubt igneous; and one small pebble that casually suggested serpentine, and probably contained that mineral.

The Cattedown detritus yielded examples both of hyper-

sthene- and augite-andesite. Rockham Bay supplies us with a rock which partakes both characters—hypersthene-augite-andesite. Macroscopically it is compact, dark purplish-brown in colour, with light green porphyritic crystals, and blackish patches rather granular than crystalline. It is quite unlike any western rock with which I am familiar, and when it was sliced I was once more indebted to the kindness of Professor Bonney for an authoritative opinion on its peculiarities. He kindly noted—although much pressed with work—as follows:

"The base appears to have been a brownish glass crowded with felspar microliths, granules of iron oxide, &c. Whether it is all devitrified it is hard to say. In this are felspar crystals, seemingly plagioclase—these belong to an early stage in consolidation, and appear to have been broken or corroded afterwards, perhaps affected in other ways (no uncommon thing). There are grains of augite (not numerous) also affected in like way, and numerous grains (some regular crystals) of a greenish mineral, with a rather fibrous or platy structure. I have little doubt this is a ferro-magnesian silicate, but does it replace olivine or hypersthene? It is somewhat dichroic, and has straight extinction. I have seen the mineral before in like circumstances, and think the latter more probable. A mineral rather like it is figured by *Fouque and Levy*, plate xxvii. and named 'bastite'—see also xxvi. I think this is probably the alteration of a mineral nearer to hypersthene, which (or amblystegite) is rather common in andesites. So I think your rock has been a 'hypersthene-augite-andesite.'"

Rocks of Lundy.

None of the granitic or felsitic rocks of Rockham Bay could be matched among the specimens of Lundy rocks so kindly procured for me by Mr. Hamling, through his friend Mr. Wright, the occupier of the island; though certain of the greenstones probably can. It may be of interest to the student of North Devon geology if I make some general notes upon my Lundy examples.

The quantity and freedom from colouration of the felspar gives the Lundy granite a prevailing white hue, and porphyritic characters are not prominent. There is no reason to regard it as differing in general age or origin from other local granites; and Professor Bonney, who has the very widest experience on this matter, remarks, "I should say there could be little doubt that it belonged to the same group of 'emissions' as the other granites of Devon and Cornwall, and, I might add, of Brittany."

Roughly speaking, about four-fifths of Lundy consists of granite, the slates being confined to some sixty acres at the south-eastern corner. I have the following notes on specimens from different localities.

South Quarry, East Side.—Granite—bulk white felspar, quartz generally in blebs and granules, but some with definite crystalline form. Bronzy mica, not in quantity. Texture coarse and irregular. A little purple fluor, zoning kaolinised felspar. (There is by the way a considerable quantity of china clay on the island, but much impregnated with iron oxides.)

Middle Quarry, East Side.—Granite—(*a*) has a stratiform appearance. The specimen is a platy fragment about half-inch thick; the bulk white felspar; bronzy mica in nests; very little trace of crystallization. (*b*) More granular and crystalline variety, with some kaolinization.

Middle West Side.—Granite—(*a*) coarse variety with large felspar crystals, some twinned after the ordinary Dartmoor type; quartz has definite crystalline leanings; mica chiefly black, with a casual flake of white. (*b*) Fine even-grained variety, with black, bronzy, and white micas; general texture granular-crystalline. (*c*) Quartz-felspar porphyry, with finely granular quartzose ground mass; some felspars twinned, some kaolinised; very little mica.

North Quarry, East Side.—Granite—fairly fine and regular texture, with felspar crystals; some kaolinization, and traces of purple fluor about a decayed felspar crystal.

Workings for copper have been carried on next the granite, and an adit driven on the "dyke," or lode, yielded the following examples:—(*a*) Quartz lodestone; (*b*) gnarly massive schistose rock with quartz, and specks and veins of metallic mineral, chiefly, if not wholly, iron pyrites—a coarse killas indicating considerable disturbance; (*c*) a decayed ferruginous greenstone.

From other parts of these workings came:—(*a*) Dark grey micaceous slate, with iron pyrites and traces of copper; (*b*) massive cupriferous rock, the origin of which is doubtful—may be igneous; (*c*) gnarly brecciated quartzose slate, with pyrites, copper, and chlorite—a lode rock; (*d*) quartz crystals, with crystals of chalybite.

Slates, &c., from South End.—(*a*) Olive-grey fine textured slate, well cleaved, with Devonian facies; (*b*) dark-grey slightly micaceous slate, rather coarser than preceding, with somewhat indefinite striation—may be an altered rock; (*c*) coarse-textured wrinkled ferruginous shale; (*d*) quartz vein with iron.

The "dykes" in Lundy are very numerous. There are said to be 137 running east and west, and traversing the slates and granites alike. But the term appears to be used in a very inclusive sense, and to comprise fissures as well as dykes proper. The latter are intrusive greenstones, which are, therefore, among the latest igneous rocks of Devon.

Dyke in Slate.—(*a*) Coarsish rusty gnarly shale, with somewhat of a Carboniferous facies; (*b*) creamy fine-grained granular rock, the dyke proper—a decayed felspathic rock, with a few long crystals still distinguishable in matrix, and apparently a little quartz; *c*, *d*, ditto, but less clearly defined. (As to *b* and *c* see post.)

Dyke at South End.—Epidiorite—this is a very curious rock, and at a cursory glance might almost be taken for a fine-grained sandstone, with veins of quartz, though its method of occurrence points plainly enough to an igneous character. Examination in microscopic section does not by any means at first remove all difficulty, for it emphasizes a granular and foliated aspect, which Professor Bonney attributes to slight fluxional movements during consolidation. Professor Judd has pointed out that a granular structure may come from disturbance in cooling; and uniformity of direction, as Professor Bonney remarks, would give a slight foliation. The rock is by no means an easy one to name, but epidiorite is suggested. There is apparently a little quartz as well as felspar, and the veins, which are of later origin, are filled mainly with quartz.

Dyke Traversing the Granite.—Olivine-dolerite—this rock is ophitic in structure, and contains "plagioclase felspar, brown augite, olivine for the most part changed into a greenish to brownish or yellowish serpentinous mineral; iron oxide, mostly ilmenite, perhaps sometimes hematite; two or three small flakes of iron glance or iron mica, probably a little apatite." For this note I am again indebted to Professor Bonney, to whom I submitted the section, the rock being one not hitherto recognised, so far as I am aware, in the county. It decays to a loose-textured rusty-brown aggregate; but when fresh is dark and heavy and highly crystalline; and the constituents in section, the felspar crystals especially, are beautifully fresh.

I am also beholden to Mr. Hamling for some pebbles from the *Beach at the landing-place* at Lundy. One of these was a schorl rock, with dark, close-textured matrix and porphyritic felspars, of an ordinary Dartmoor type (schorl is not common in the Lundy granite); another was unusually heavy, and

broke with a curious fracture, combining rippled and mammilated features, colour black, some part dull, some shining. But for the weight it might have been taken for an impure lump of anthracite, and I am indebted to my friend Mr. J. J. Beringer, County Analyst of Cornwall, for its determination. He found it to consist chiefly of carbonate of iron, with magnesia and lime, coloured with coaly or bituminous matter, which gave off too much tar to be anthracite. It probably came from a vein or nodule in the Carboniferous rocks of the district.

A third specimen proved of great interest. It was comparatively little worn by the waves, a greenish-grey rock, weathering inward rusty-brown, from an eighth to a quarter of an inch from the surface. This was the result of oxidation of ferruginous constituents, which were plentiful. The unweathered portion was greenish-grey, with a few small irregular cavities. A large number of small lath-shaped crystals lying in all directions gave the mass a felted texture; and scattered through it were slender prismatic crystals, the longest of which was nearly three-quarters of an inch in length, and about a twentieth of an inch in breadth. Careful examination, and the fortunate preservation of the longer crystals, showed that this was practically identical with the decayed dyke rock, already described under "Dyke in Slate," although the texture of that seemed granular, and of this felted. Under the microscope it is seen to consist mainly of lath felspars, radiating and interlocking in all directions, with a few porphyritic felspars, some of them twinned. Probably to be classed as an andesite, its characters are rather trachytic—in fact, it is the most distinctive rock of this kind that I have recognised in the county. Rocks with such an acicular or felted base occur, however, in the materials of our Triassic conglomerates, and are referred to by me in the paper already cited.

It is clear from what has been said that, given time and opportunity, Lundy offers a rich field to the petrographer—its igneous rocks thus including granites, quartz-felspar-porphyries, olivine-dolerites, epidiorites, and andesites or trachytes—a very wide range. Probably the numerous dykes afford still greater variety, and although the granite is said to have had little effect upon the slates, it seems probable to me that there has been more alteration than has commonly been recognised. But no mere passing visit to Lundy will suffice for what has to be done, and unhappily I can only play the part of a finger-post.

The Saunton Boulder.

The probability of the transport of the granitic and felsitic pebbles found in Rockham Bay from Dartmoor, to some extent re-opens the question of the transportation of the Saunton boulder, now generally attributed to ice action. Large as the boulder is, the hypothesis of local transportation seems, however, by no means out of the question; though so far as I am aware there is no granite in Devon that bears any close resemblance to the Saunton block, which indeed in some respects has rather a gneissic aspect, and in others suggests to me the idea that it formed part of a vein rather than of a mass. The possibility of the existence of such a vein, even locally, is indicated by the discovery of a granitic vein in the Trias near Portledge by Mr. Townshend M. Hall.[5] I was indebted to Mr. Hall for the loan of a specimen from this vein, and was fortunately able to identify it as a phase of familiar Triassic andesite, owing to the quarrying of an andesitic boss at Withnoe, in Cawsand Bay, which within a few feet passed from a rhyolitic pitchstone to a trachytic quartz-felsite. The Portledge vein carried the process one stage further;[6] and whether the Saunton boulder be traceable to any such vein or not, I cannot but feel that in the light of recent discoveries we must require additional proof of its transportation by ice, ere we can accept the important conclusions touching the physical history of North Devon in the Glacial Period, which follow from the maintenance of the old hypothesis.

[5] *Trans. Devon. Assoc.* xi. 430–32.

[6] This rock has a fine-grained granular base, rather pegmatitic than granitic, with apparently a little undifferentiated felsitic matter. The quartz is chiefly in blebs; the porphyritic felspars large, and the plates of mica (black) unusually large.