V.—*Hints on the Geology of Cornwall.*

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Communicated in a Letter to Henry Boase, Esq. Treasurer.

I SHALL in this letter comply with the request that you did me the honour to make, of offering a few hints respecting the geology of Cornwall. I can hardly venture to hope that they will be worth the attention of the Society: most of the members have had much better opportunities than have occurred to me, of examining our interesting county; and I dare say that many of the observations which I shall make, will have been anticipated by others: at all events, this communication will shew the desire I have to co-operate in promoting the useful objects of the Society, and I trust they will consider it as a proof of my respect.

Cornwall may be regarded κατ᾽ ἐξοχην as the *Country of Veins*. It is in veins that the

most useful as well as the most valuable minerals generally exist; that the pure specimens are found which serve to determine the mineralogical species, and that the appearances seem most interesting in their connexion with geological theory. Thus veins, which now may be considered in the light of the most valuable cabinets of nature, were once her most active laboratories; and they are equally important to the practical miner, and to the mineralogical philosopher.

Amongst the veins of Cornwall, most curious in a geological point of view, are those of *granite*. These formations are extremely numerous. As far as I am acquainted with them, they intersect either micaceous schist, or other granite rocks. The most remarkable instances known to me in Cornwall, are those on the south-east extremity of St. Michael's Mount, those near Mousehole Cove, those at Zennor, and on the east and west sides of Cape Cornwall.* At St. Michael's Mount the granite veins contain fragments of micaceous schist, and whoever examines without prejudice the different formations, cannot, I think, doubt that the vein has been produced in a chasm of

* I first observed the granite veins of Cornwall about eighteen years ago; probably before, and certainly to a great extent since, they have occupied the attention of geologists, and they are too well known to the Geological Society to require any topographical history from me.

the rock in which it occurs, and that it is consequently *posterior* in formation.

Similar instances of veins of granite are described by mineralogists; a very interesting one was shewn to me at Killiney near Dublin, by Dr. Blake: some in the Isle of Arran, and in other parts of Scotland, are well known. I have seen several cases of granite veins near Morlaix in Brittany. I do not know that any analogous formations have been observed in the great mountain chains of Europe. I have looked for them in vain in the points of junction of the schist with granite, both in the Maritime, Savoy, Swiss, and Tyrolese Alps, and likewise in the Oriental Pyrenees. My researches have not been extensive or minute, but I should be disposed to conclude from what I have seen, that granite veins are peculiar to the low metalliferous granite and mica schist formations.

There are deposited in the museum of the Royal Institution, three specimens of fragments of micaceous schist included in granite, which are from Cornwall; two from St. Michael's Mount, and one from St. Just. At the points of junction of micaceous schist with the low granite, in various cases which I have seen, rocks of granite occur, containing considerable portions of the schist; this is particularly the case at Killiney in Ireland, and near Balyhulish in Scotland. I have seen similar instances in the granite used for building in Mayence, in

France; and in a pillar of granite, which was erected some years ago to Buonaparte at Marseilles, there is a very large fragment of mica schist.

The place where the granite joins the schist in St. Michael's Mount, is remarkable for the number of crystallized substances it contains; oxide of tin, wolfram, phosphate and fluate of lime, quartz, mica, felspar, topaz, are all well known to occur in the same veins; and the particular investigation and history of the nature of the crystallized bodies occurring in this beautiful and remarkable spot, appears well worthy of the attention of the Geological Society, established so immediately in its neighbourhood.

An opinion has been expressed by a foreign naturalist, who was extensively employed in geological researches some time ago by the Geological Society of London, that the granite veins of Cornwall are mere protuberances of primary granite in which mica schist has formed. This opinion does not merit discussion, and could only have been formed in consequence of very superficial examination. It might, with nearly as much reason, be stated, that the veins of copper and tin belong to a great interior metallic mass, and that they existed prior to the rocks in which they are found. The notion that these veins are contemporaneous with the rock is more plausible, and a forced explanation of many of the phe-

nomena might be given on this view; but it is contradicted by the fragments of mica schist found in the veins.

The porphyry of Cornwall in general seems to belong to the dyke or vein formation, and its history is an object of considerable geological interest. The northern shores of Mount's Bay exhibit great varieties of this substance, and it contains a number of crystallized substances which intersect it in veins. A most remarkable vein of this kind was worked some years ago at the Wherry mine near Penzance; the principal metals were oxide of tin, and sulphuret of copper; but ores of cobalt and lead likewise occurred, and the variety of metallic substances found with them in minute quantities was very extraordinary. I have seen in the refuse heaps blende, oxide of uranium, oxide of titanium and of iron, pechblende, nickel, and arsenical pyrites; and in a single piece of the vein, of a few inches square, many of these substances might be found imbedded in quartz or chlorite.

A very good account of the working of this mine has been drawn up by Mr. Hawkins, one of the members of our Society, and published in german; and I have seen a french translation of it in the Journal des Mines. This paper, in an english dress, ought to be placed in the archives of the Geological Society of Cornwall, and is worthy of being inserted in their first publication, as a record of the in-

dustry and ingenuity with which great natural obstacles were overcome. The Wherry mine is the only instance, I believe, that has ever occurred of a shaft sunk in the ocean; and of a mine worked, the only access to which is below low water mark.—(See pl. 1).

The *serpentine* district of Cornwall has not yet met with the attention it deserves. I have seen no formation in which the nature of serpentine is so distinctly displayed. The true constituent parts of this rock appear to be resplendent hornblende and felspar; it seems to differ from sienite only in the nature of the hornblende, and in the chemical composition of its parts, and in being intersected by numerous veins of steatite and calcareous spar. Near Coverack cove, the felspar and resplendent hornblende forming the rock, occur in crystals of some inches in size; and from this size there is a gradation to crystals so minute, that the rock appears of a simple nature. The green or red colour of the hornblende is generally the cause of the peculiar tints of the rock; the felspar is generally white, but in instances at Coverack, some of the large crystals of felspar are of a reddish hue.

The nature and origin of the veins of steatite in serpentine, are curious subjects of enquiry. Were they originally crystallized and the result of chemical deposition? or have they been (as for the most part they are now found), mere mechanical deposites? I am inclined to

the last opinion. The felspar in serpentine is very liable to decompose, probably from the action of carbonic acid and water on its alkaline, calcareous, and magnesian elements; and its parts, washed down by water and deposited in the chasms of the rock, would necessarily gain that kind of loose aggregation belonging to steatite.

I made, some years ago, a rude comparative analysis of the felspar in serpentine, and of the soap rock. I found the same constituents in both of them, except that there was no alkali nor calcareous earth in the steatite, but my experiments were not so exact as to determine the proportions. It is not easy to conceive that steatite was originally a crystallized substance which has been since decomposed; for in that case it ought to be found in its primitive state in veins excluded from the action of water and air; and it is not difficult to account for the hardness of some species of steatite on the hypothesis which I have stated. Mere mechanical deposites, when very finely divided, and very slowly made, adhere with a considerable degree of force. A remarkable instance of this kind has occurred to me; amongst the chemical preparations of the late Henry Cavendish, Esq. which were given me by Lord George Cavendish, there was a bottle which had originally contained a solution of silica by potassa; the cork had become decayed during the lapse of years, and the carbo-

nic acid of the atmosphere had gradually precipitated the earth, so that it was found in a state of solid cohesion; the upper part was as soft as the steatite of the soap rock, but the lower part was very hard, was broken with some difficulty, and had an appearance similar to that of chalcedony.

The felspar of serpentine seems to differ from that of other rocks, in containing a much larger proportion of magnesian earth; but many varieties of felspar are liable to decomposition; the porcelain clay of St. Stephens is well known to be the result of a process of this kind.

I have seen a specimen of porcelain clay from a mine in the west of St. Just, which contained a quantity of magnesia, and which appeared to be produced by the disintegration of felspar. It occurred in a quartzose vein, which afforded oxide of tin. Copper, I believe, is the only metallic substance that has been found in any quantity in the serpentine formation of Cornwall, and crystallized substances in general are rare in the cavities of this rock. In America, chromate of iron is found in serpentine; and in the serpentine of the coast of Genoa, Professor Viviani has shewn me arragonite, and a peculiar crystallized stone analogous to crysolite. The relation of the Cornish serpentine to the neighbouring rocks is worthy of examination; towards the north it seems to pass into micaceous schist; at the point of Cape Lizard it is bounded by stratified sienite, and

white micaceous schist. In Kynan's Cove, so remarkable for the beauty of the forms of its cliffs, and for the number of their caverns, there is a protuberance of granite above the white sand. I do not believe that the Cornish serpentine has, as yet, been applied to any purposes of architecture or sculpture, and in general at the surface its parts are too small, and contain too many fissures to be worked with advantage; but I am convinced, that by making proper excavations, many parts of the serpentine district would afford large and beautiful blocks of great fineness and beauty of colour.

The serpentine of the Appenines is in general very like that of Cornwall. During an examination of the coast of Italy, that I made between Genoa and Massa, I found, a few miles from Sestri di Levanto, an ancient quarry bearing marks of having been worked by the Romans; but which, amongst the profusion of marble furnished by the neighbourhood of Carrara, and amidst the quantities of ancient remains of verd antique, is neglected by the modern Italians.

I hope some members of the Society will examine the black marble of the north coast of Cornwall. From a superficial examination that I made of a part of this district, it appeared to me to be of the same formation as the Plymouth marble.

I am ignorant whether any true basalt exists in Cornwall. Near Port Isaac I have seen on

the road wacké or mandelstein, but I do not know where it was quarried. A sienite, resembling the Scotch grunstein, is very common on the eastern border of the county: but I am inclined to believe that it belongs to the primary formation.

Though the whole of Cornwall is of a very peculiar mineralogical construction compared with the rest of Britain, and even of Ireland, yet it bears very a considerable relation to the opposite coast of France. The mica and chlorite schist, and the granite (the killas and growan) in the neighbourhood of Morlaix in Brittany, I find precisely similar to those of Mount's Bay, and containing similar kinds of actinolyte and thumerstein; and I saw at Morlaix specimens of serpentine (said to have been brought from the neighbourhood of Rosloff) similar to those of Cape Lizard.

Veins of tin have been worked in the low French granite formation; but as yet they have not been productive.

The conformation of Cornwall is in the highest degree curious, and the facts it offers are illustrative of many important points of geological theory. It exhibits very extraordinary instances of rocks broken in almost every direction, but principally from east to west, and filled with veins again broken in, diversified by cross lines, and filled with other veins, and exhibiting marks of various successive phenomena of this kind.

Respecting the agents that produced the chasms in the primary strata, and the power by which they were filled with stony and metallic matter, it would be easy to speculate, but very difficult to reason by legitimate philosophical induction.

The water-worn pebbles of chlorite schist found cemented by oxide of tin, and of which an interesting account has been given by a member of the Society, render it probable that the operation of water, either in the beds of rivers, or on the shores of lakes, or the ocean, preceded or accompanied the operations by which veins were produced and filled. All *crystallization* must be preceded by *chemical solution*, or by a division of matter tantamount to *solution*: and elevation of temperature offers the most obvious means of explaining the production of combinations capable of depositing crystals.

Amongst the ancient lavas of Radicofani, I have seen crystals having the characters of felspar imbedded in a black semi-crystalline mass, so as to constitute porphyry; and I am in possession of a specimen from Vesuvius which I ascertained to belong to a stratum of lava containing a cavity, in which felspar and mica have crystallized in their regular forms, and the separation and geometrical arrangement of their elements have evidently been the result of slow cooling.

The lavas of Languedoc, of the Vivarais, of Andernach, and of the Siennese, and Roman states, offer numerous instances of the formation of tufas, which consist of *separate* crystals, and which have assumed the columnar arrangement. Near Aix in Provence, I have seen a dyke between strata of limestone, which, at its lower extremity, has the character of *basalt*, and it is arranged like a basaltic dyke in regular horizontal prisms; but its upper edge has the characters of amorphous lava; and where it has been decomposed and worn to a great depth by the operation of a torrent, it has all the characters of a primitive sienite, being composed of large crystals of hornblende and felspar.

It is amongst extinct volcanoes, the surfaces of which have been removed by the action of air and water, and in which the interior parts of strata of lavas are exposed, that the most instructive examples of the operation of slow cooling upon heated masses are to be found. It is difficult to conceive that water could have been the solvent of the different granitic and porphyritic formations; for in this case, some combinations of water with the pure earths ought to be found in them. Quartz ought to exist in the state of hydrate; and wavellite, not corundum, ought to be the state of alumina in granite.

To suppose the primary rocks in general to have been produced by the slow cooling of a

mass formed by the combustion of the metallic bases of the earths, appears to me the most reasonable hypothesis; yet aqueous fusion must not be entirely excluded from our geological views. In many cases of crystallization, even in volcanic countries, this cause operates. Thus in Ischia, as well as in Iceland, siliceous tufas are formed from hot springs; and in the Lake Albula, or the Lake of Solfaterra, near Tivoli, crystals of calcareous spar and of sulphur, separate from water impregnated with carbonic acid and hepatic gas; and large strata of calcareous rocks, formed evidently in late times by water impregnated with carbonic acid, exist in various parts of Europe. The Travertine marble, (marmor Tiburtinum) is a production of this kind, and it is of this species of stone that the coliseum at Rome, and the cathedral of St. Peter, are built. It is likewise employed in the ancient temples of Pæstum, and it rivals in durability, if not in beauty, the primary marble of Paris and Carrara.