DERBYSHIRE ARCHÆOLOGICAL

AND

NATURAL HISTORY SOCIETY.

Tideswell Dale Quarry.

BY GEORGE FLETCHER.

ABOUT a mile from the railway station at Miller's Dale, near the lower road towards Tideswell, is a limestone quarry. To a casual observer it appears to be very uninteresting, but a geological eye discerns much that will afford valuable aid in elucidating the past physical geography of the district.

I have said that it is a limestone quarry, but it contains a large quantity of hard, dark-coloured rock, found in many other parts of Derbyshire, interstratified with the limestone. This rock, which occupies a considerable portion of the quarry, presents features of great interest. It occurs at Miller's Dale, Matlock Bath, Ashover, Elton, and many other places in the county. The different exposures present various points of difference, but all resemble each other in certain distinguishing characteristics. For example, the rock is crystalline in structure, and examination of a thin section under the microscope proves it to be a volcanic lava. This conclusion rests, not merely upon the nature of the crystalline constituents of the rock, but upon what may be termed its macroscopic peculiarities and its mode of occurrence. Its mineralogical constitution differs slightly in different districts. The following are the minerals which enter the composition of that found in Tideswell Dale :—Olivine Augite, and Plagioclase Felspar. Magnetite is also present. In many places, as at Matlock, the rock contains hollow vesicles, produced when the rock was in a molten condition. Water, doubtless disseminated throughout the molten mass prior to its eruption, passed on the withdrawal of pressure consequent upon ejection, into the condition of steam, expanding, and thus producing the cavities. They are common in modern lavas.

There is very good reason for thinking that the volcano which gave rise to the rock described was submarine, and in some districts the vesicles are filled with calcite and other minerals, doubtless subsequently deposited from an aqueous solution. In some places the white patches of calcite give to a freshly fractured surface of the rock a peculiar appearance, which has been considered so like the marks on the body of a toad that the rock is known as Toadstone. The name has also come to be applied to the Derbyshire basalt generally. The toadstone (dolerite) in this quarry is particularly interesting, because it well illustrates—on a small scale, it is true—several peculiar phenomena observed to accompany the cooling of volcanic lavas. It is a well-known fact that in the case of almost all known bodies, decrease of temperature is accompanied by contraction. It will be seen that in a stream of molten lava the cooling will not proceed uniformly in all parts of the mass. The upper surface will cool more rapidly than the lower surface, and the surface generally will cool before the interior. There are thus set up in the mass stresses which ultimately overcome the cohesion between the particles, and the stream becomes broken up by a number of divisional planes termed "joints." Under certain circumstances, if the mass be homogeneous, it will, in cooling, split up into a number of prismatic columns, sometimes of remarkable regularity, and having their axes perpendicular to the main cooling surfaces. The number of sides possessed by the columns are various, but they are usually hexagonal. It is not my purpose in this short paper to go into the question of the production of the prismatic structure, but to give several typical examples. That of the Giant's Causeway is sufficiently well known. Here, as is frequently the case, the columns are divided at regular intervals by transverse joints, the segments exhibiting a cup and ball structure, doubtless the result of further contraction. In Wales the columns are commonly used for gate-posts. A magnificent example occurs in the Horngraben Valley, in the Eifel district of Germany. In a quarry cut into a lava stream which flowed from one of the craters of the neighbouring Mosenberg, are to be seen numerous columns, some of which are over three feet in width, and considerably more than one hundred feet in length (Fig. 1).

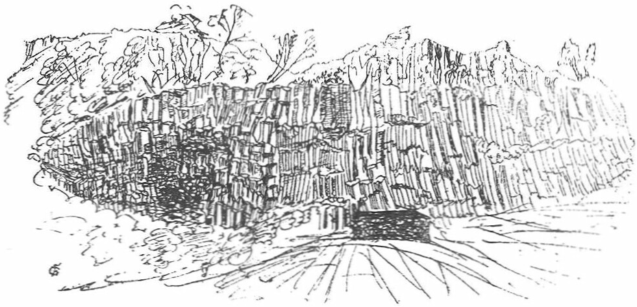


Fig. 1.

It is worthy of note that this prismatic columnar structure can be produced artificially, and not only as a result of contraction in cooling, but as a result of shrinkage, due to loss of moisture. Fig. 2 is a sketch kindly furnished by my friend, Mr. Ward (for the use of whose notes I am much indebted), of a piece of starch, in which the columnar structure has been developed by drying. He informs me that it was not produced at ordinary atmospheric temperatures, but that if a mass of starch, which had been allowed to slowly dry, and in which the structure had not been developed,

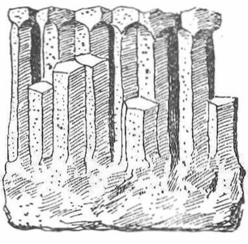


Fig. 2.

were held before a brisk fire, it would be produced. In a section by the roadside in Tideswell Dale, above the quarry, is a bed of what appears to be hardened clay, but which is most probably a volcanic mud, in which the columnar structure is exceedingly well shown on a small scale. The columns seldom exceed an inch in diameter, and run to a considerable length, being transversely divided by cracks which traverse several contiguous columns. The bed is about nine feet in thickness. This was seen on a somewhat larger scale in the quarry itself some time ago, when the columns averaged two or three inches in diameter, having a length of ten feet or more. This bed is not to be seen now. The relation of the bed on the roadside to the toadstone is not well seen, but in the quarry it immediately underlay it. There can be no doubt that the structure was produced in the mud by contact with the hot bed of lava.

Another peculiarity of structure, well seen in the quarry, is that known as "Spheroidal." Before describing it, however, it would be well to again mention the relation of the various beds in the quarry. We have, forming the floor of the quarry, a grey limestone, containing the hard parts of innumerable coral animals. This is overlaid by the bed of columnar volcanic material previously referred to, and this is followed by a rock, having a dirty black appearance—the "toadstone." The face of the quarry consists of this rock, and presents a peculiar appearance. It appears as though, when in a plastic condition, it had sustained a siege, and the cannon balls had imbedded themselves in its mass. These are the "spheroids" mentioned above (Fig. 5, *section*). If one of them be struck smartly with a hammer, one or more concentric shells or coats will fall away from the globular mass, and another knock may bring away several more. Indeed some of them possess as many as fourteen or sixteen coats, enclosing a hard nucleus or kernel—they cannot be likened to anything better than an onion. In size they range from two to nine or more inches in diameter. This structure has been observed elsewhere. The segments of columns of volcanic lavas often contain these spheroids. The drawing (Fig. 3) is a sketch of the famous Cheese Cellar or

Grotto near Bad-Bertrich, in the Eifel district. It is a passage cut through a lava stream which flowed from one of the neighbouring tertiary volcanos. Lava columns form the sides of the

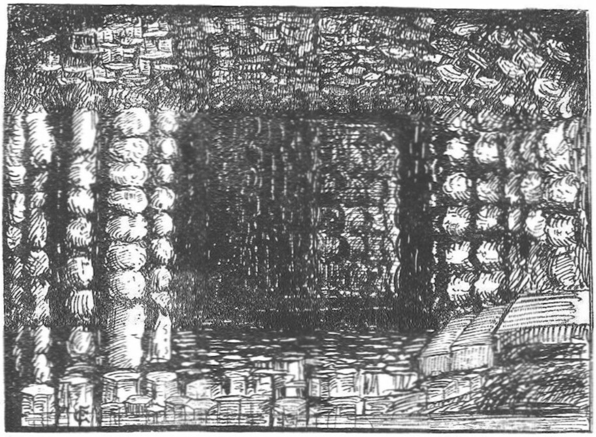


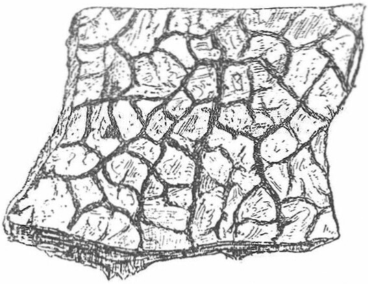
Fig. 3.

passage, the roof exhibiting transverse sections. They are divided by transverse joints at regular intervals, and the angles and edges of the sections having fallen away, the columns resemble piles of Gruyère cheeses. This falling away of the edges and angles results partly from the action of the weather, and partly from a pre-disposition in the segments to break away at these points. For my own part I cannot see how weathering can wholly account for the spheroidal structure. I append an interesting letter on the subject from Mr. Ward.

Close by the Cheese Grotto, the bed of the Uesbach is completely tesselated with the transverse sections of columns, which are remarkably regular.

The limestone strata underlying the toadstone contribute several important items of evidence as to the geographical and climatic conditions of the period. These strata, as has been said, are coralline, and there can be little doubt that they formed a coral reef in the limestone sea of the Carboniferous period.

In the quarry have been found slabs of a finely laminated limestone, the upper surfaces of which are traversed by a network of surface cracks. Their appearance is represented in Figure 4, which is a sketch of a portion of a slab, measuring about sixteen inches in length, in my possession.



Sun-cracked Surface of Coral Mud

Fig. 4.

The question of the origin of these cracks is extremely interesting. They resemble the cracks produced in the mud bottom of a pond dried by the sun's heat. How can we explain their production? It has been suggested that they might be produced by heated volcanic matter having been poured over the mud. This is, I think, a very unlikely explanation. The action of a stream of volcanic matter would be quite different. Instead of being quietly deposited upon it and cracking its surface, it would lead to considerable disturbance, and we might expect that the junction between the two would be anything but sharp. This seems the more certain when we reflect that, as the volcano was submarine, the material over which the volcanic matter flowed would be soft. Indeed, where we have been able to find the junction between the toadstone and the limestone, as in Ember Lane, near Bonsall, we find it to be characterised by a heterogeneous rock, consisting of volcanic matter, enclosing altered fragments of limestone. But the theory is completely and for ever disposed of, by the discovery in the quarry, of slabs of limestone, precisely similar in character to those containing the cracks, but bearing upon their surface the *casts* of the cracks. It could not therefore have been hot volcanic matter which produced the cracks. What then? The evidence is most striking and conclusive. They are undoubtedly the cracks produced by drying, and consequent shrinkage under the action of the sun's heat.

I have compared the cracks with those produced in the muddy bottom of a pond. There is, however, an important point of difference. Whereas the cracks produced in the bottom of a pond (resulting as they do from the continued action of the sun's heat during a dry season) are comparatively deep, those in our coral mud are merely surface cracks, the deepest of them being, in those specimens which I have seen, never more than $\frac{1}{8}$th of an inch in depth. From this, and several other considerations, I conclude that these cracks have been produced between the periods of high water. But then, why should they not have been obliterated by the returning tide? For the same reason that the ripple-marks, rain-pittings, and footprints, so well known in certain sandstones, were not obliterated. To make this clearer, let me briefly summarise the story of these stony hieroglyphics as I interpret it.

There existed in the region of our quarry, in the old limestone sea, a coral reef, on which, in the tropical climate of the period, myriads of coral polypes lived, reproduced their kind, and died. Existing coral reefs do not, however, consist entirely of the remains of the coral polypes. Large masses of the true coral rock are broken off by the action of the breakers on the outside of the reef, some of which are flung up and accumulate above high water mark. Others are ground down by the action of the waves into a fine calcareous mud. Observations on coral reefs show that a considerable portion of the shores of the lagoons are covered with this mud. Our laminated and cracked specimens are undoubtedly of this nature. The laminations indicate fresh additions of mud brought by the waves, and during one of the intervals between high water the cracks were produced. On the return of the tide a fresh layer of mud was deposited, which filled up the cracks, and protected them from the further action of the waves. The hammer of the quarryman or the geologist, has split the mass of hardened limestone along this plane of slight cohesion, and the cracks and their casts are revealed to the human eye.

It was during the time that this little page in the world's history was being written that the volcano which produced our Derbyshire toadstone sprung into activity.

These are some of the facts which a study of this quarry discloses. It is greatly to be regretted that in a county so geologically interesting as ours is, there are not more who would take up the study. It is a reproach to the county that it has not a representative geological association. There is ample work for such a body. It is, however, consoling to remember that the work is not wholly neglected—there are several gentlemen working among us devoting themselves to the study—and it is not too much to hope that before long we shall witness the fruit of their labours.