The Origin of Derbyshire Scenery.

BY GEORGE FLETCHER.

THE surface-conformation of Derbyshire exhibits in a remarkable degree the close relationship which subsists between the physical structure of rock-masses and the effects of sub-aerial denudation. There are comparatively few people at the present day, although in recent years their number was legion, who believe that the surface of the earth has remained much the same from the beginning of time. The "everlasting hills" are eternal only in the sense that the materials of which they are composed are indestructible. Their shapes are as changeful as those of the summer cloud,—

> "All the forms are fugitive,
> But the substances survive."

Minute observation of the effects of the weather on rocks, as well as determinations of the amount of material carried out to sea annually by rivers, have shown that the surface is gradually being worn down by various agents, chief among which must be included water in its different forms.

The most superficial observer will have noticed that the softer rocks are worn down most rapidly; but the fact is scarcely recognised as the cause of the different varieties of scenery met with in Britain. The softer rocks of our southern counties give rise to a gently undulating surface, while the harder and older rocks of Wales, the lakes, and the highlands give rise to their characteristic rugged scenery; and where, as in Derbyshire, we get a series of strata exposed at the surface, widely differing in hardness, the effects of this difference upon the contour of the

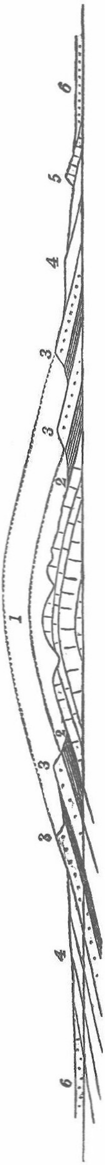

Fig. 1.
1. Carboniferous Limestone.
2. Yoredale Shales.
3. Terraced Escarpments of hard Millstone Grit.
4. Coal Measures.
5. Escarpment of Magnesian Limestone (Permian), overlaid by
6. New Red Sandstone.

surface may be conveniently studied. It may not be out of place here to briefly mention the chief kinds of rock met with in Derbyshire. First must be mentioned the mountain limestone, which forms a broad anticlinal curve, the axis of which runs north and south. Fig. 1 is a section across Derbyshire from west to east, and shows this anticlinal. Overlying the limestone are certain shales and grits known as the Yoredale rocks; and above these lie a group of grits and shales, constituting the millstone grit formation. Over large areas the Yoredale and millstone grit have been completely removed by various denuding agencies, and the limestone thus brought to the surface. It is flanked east and west by the millstone grit, coal measures, and newer formations. The limestone differs very markedly as regards hardness in different localities, and "weathers" in a very characteristic manner, presenting bold turreted cliffs and tors. The millstone grit also produces striking scenery, although of a different type. This is especially the case where it is associated with softer rocks such as the Yoredale shales. Thus we find the hard millstone grit capping hills, while the softer Yoredale shales frequently form the valleys. Fig. 2 is from a sketch made of the district near Ashover, in which this is well seen. Fig. 3 is a section across this district, showing the dip on either side of the anticlinal, along the ridge of which the Amber has cut its channel. It will be seen how well the grit withstands the action of the weather, while the shales are removed. There are many similar examples in Derbyshire, but space forbids their citation. The *modus operandi* of valley formation is peculiarly

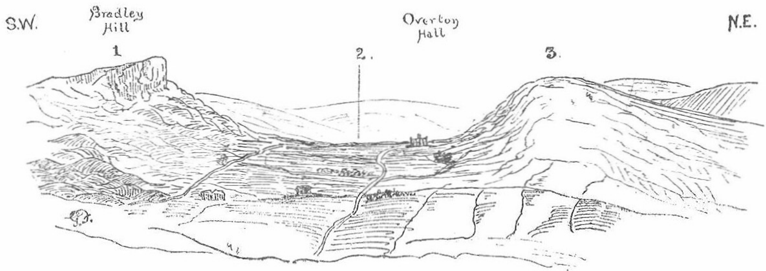

Fig. 2. Near Ashover

1. Lower Millstone Grit
2. Yoredale
3. Carboniferous Limestone

interesting and instructive ; and in many places our Derbyshire valleys afford characteristic examples of limestone erosion. The minute structure of the rocks and inequalities in hardness give rise to peculiarities in the weathering of such rocks, which are

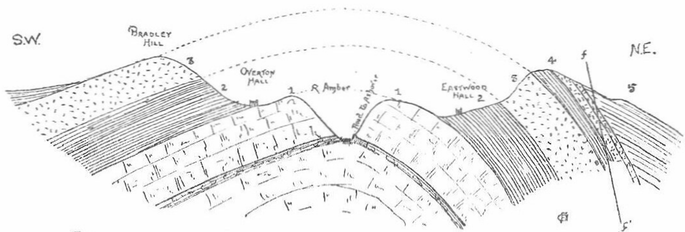

Fig. 3

1. Mountain Limestone with Toadstone
2. Yoredale Rocks
3. Lower Millstone Grit
4. Shales and Upper Grit
5. Coal Measures
f. f'. Fault

most interesting, but which it is not within the province of this paper to discuss. We must, however, take into account the influence which the divisional planes of the rock possess in inducing the disintegrating agents to work along certain lines. These divisional planes are of two kinds, (*a*) planes of stratification, and (*b*) joints. They can be very easily seen on the face of most cliffs, the planes of stratification giving to the rock a "bedded" character, while the joints appear as more or less vertical cracks. Indeed, the former may be seen in the stones of almost any old building. Old weathered sandstone blocks may be noticed in the walls of St. Peter's Church, Derby, which well show the effects of minor bedding planes. The planes of stratification must be referred to interruptions in the deposition of the material which formed the rock, to changes in the nature of this material, and other causes. Joints are crack-like divisional planes, generally crossing the planes of stratification at a high angle. These are probably partly due to shrinkage caused by the drying of the rocks, and partly to internal stresses and movements. They are present in igneous as well as sedimentary rocks, and the writer dealt with their production in the former, in the Journal for 1887. It is by means of these joints that rocks may be removed in blocks in quarrying, and to them we owe some of the most familiar features of Derbyshire scenery. They generally run in two directions at right angles to each other, and so make it possible, by taking advantage of the planes of stratification to remove the rock in large quadrangular blocks—indeed, the art of quarrying largely consists in taking advantage of these planes of weak cohesion. Sometimes the joints are open, but most frequently they are invisible. They permit entrance, however, to rain water, and this, in virtue of its chemical and mechanical properties soon widens the joint, and renders evident its previous existence. In virtue of the carbonic acid which rain water dissolves from the air and decaying vegetable matter, it possesses the power of dissolving the limestone, while, in freezing, its expansive force acts powerfully as a wedge in breaking up the mass. In Mr. Ward's article on Rain's Cave in the *Journal* for 1889, it gives an interesting example of the *underground* evasion of limestone. To these and certain other agencies must be attributed the gradual erosion of the surface, the formation of many of our valleys, and also many local phenomena. Take the case of the landslips which have occurred at Crich. Crich hill, which is somewhat remarkable in form, being of the shape of an elliptical dome, consists of mountain limestone. The western and south-western sides are steep, and below them lie the softer Yoredale shales. The limestone is faulted against the Yoredale strata, and these softer rocks have been worn down and carried away by denuding agents more rapidly than the limestone, and hence the steepness of these sides is easily accounted for. On the eastern side the slope is much more gentle. The western side is worked as a limestone quarry. The limestone is massive and thickly-bedded, the upper beds being separated from the lower ones by a band of clay. In working, the upper beds, which are traversed by long open joints running from top to bottom, are first removed down to the clay-band, which forms a kind of floor, the lower beds being then worked. About 1861 a landslip occurred. The upper beds had been worked back for some distance, terminating in a vertical face—the jointing plane—when a large mass of it slipped away, falling upon the upper floor referred to above. Another and more extensive slip will be remembered as occurring about the year 1880, when a house was destroyed. The cause is not difficult to find. The upper beds rest upon a clay floor which slopes towards the quarry. This becomes wet and slippery, and the over-lying masses of limestone, already naturally divided by joints, slip down and topple over. The diagrammatic section, Fig. 4, will explain itself, *a* represents

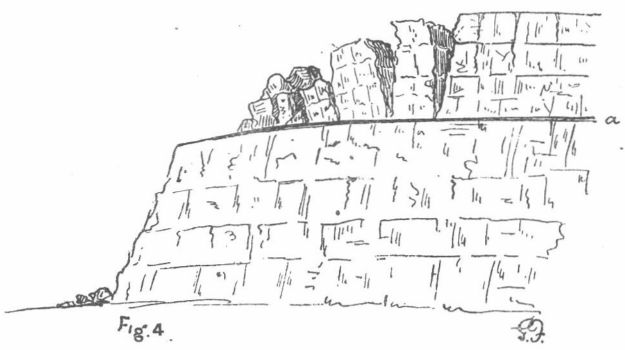

Fig. 4.

the clay band. This also serves to illustrate the way in which steep limestone cliffs originate. The older geologists believed that precipices and cliffs had their origin in some convulsion, and their writings bristle with earth-throes and catastrophes. But with added knowledge the true explanation comes, and we now attribute these cliffs to the long continued action of water aided by the joints. These divisional planes, which are frequently vertical, give entrance to water, and the rest is merely a matter of time. Such cliffs as the High Tor at Matlock are excellent examples. Here we see the process referred to going on. The river has cut its channel from a level far higher than that of the tops of any of the neighbouring hills. Let us take a retrospect. When the rocks of the district rose above the level of the sea, the surface of the land would most probably be approximately flat. We may look upon the plateau of Kinder Scout as representing the remains of this surface, although this has no doubt sustained a certain amount of erosion. Fig. 5 is a diagrammatic representation of the plateau, which consists of a coarse quartzose sandstone—Millstone grit. The drawing gives such a view as

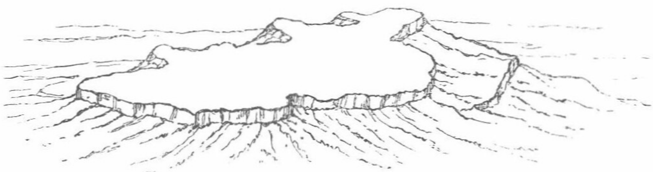

Fig. 5. Diagram of Kinder Scout.

would be obtained from a balloon at a height such that the smaller details would disappear. It is about six miles long by two miles broad, and is covered in many places by a bed of peat about 12 feet in thickness. The strata of which it is formed are approximately flat, forming the centre of a long, low, anticlinal curve. Upon its surface are many fine examples of sandstone weathering, due in a large degree to the decomposition of the felspar, a constituent of the rock.

Soon fallen rain would cut for itself channels in this "plane of marine erosion," and the course of these channels would be, in a very large measure, determined by the homogeneity or want of homogeneity of the rock. An obstruction in the form of a harder mass of rock would determine a bend, and this would, as will be explained shortly, determine other bends, and the stream would carve for itself a sinuous course, wearing its channel vertically and laterally. The slope which the banks of the river would assume would depend largely upon the natural divisional planes of the rock, and these are well marked and regular in limestone. Take a case where the strata have a gentle "dip" as in Fig. 6. Here the running water wears its way most easily along the stratification and jointing planes, and it will readily be seen from the diagram—which represents a section across the river

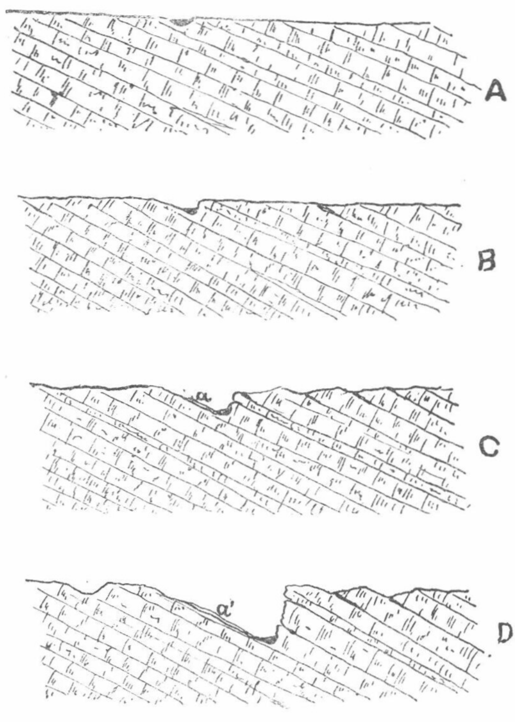

Fig. 6. G.J.

channel—that the tendency will be for the river to attack and encroach upon its eastern bank, undermining and separating the rock in rectangular masses, which become broken up and transported to lower levels—ultimately to the sea. It will be seen that as the jointing planes are inclined at a high angle to the horizon, the eastern bank will become precipitous, the western bank gentle.

In A the river is shallow and broad. In B it has deepened and become narrower, encroaching upon its eastern bank. At C and D the process has continued still further, sand and gravel (alluvium) being left at *a* and *a'* on its western bank. Many of our Derbyshire valleys well illustrate this. Take only the Matlock Valley at Matlock Bath. Here the course of the river is tortuous.

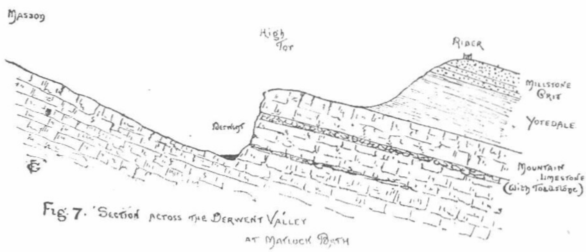

Fig. 7. Section across the Derwent Valley at Matlock Bath

Fig. 7 is a section across the valley, and may be compared with Fig. 6 which is an ideal section. The section also exhibits the superior resisting power of the millstone grit which forms the capping of the hill on which Riber Castle is built. The effect of

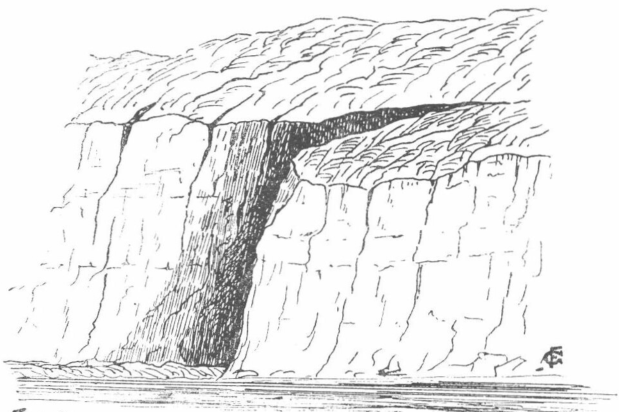

Fig. 8.

the joints on scenery is still more plainly seen in the diagrammatic sketch, Fig. 8, where the fissure of the High Tor Cavern is shown.

The line of this fissure coincides in direction with the face of the High Tor, and has been produced along the plane of joint. The waters of the Derwent assisted by atmospheric agencies have attacked the massive limestone along this plane and has removed the material which once occupied the fissure, and what is now the eastern face of the High Tor Cavern will some day form a precipice similar to the High Tor, the mass of rock between which and the fissure being disintegrated and removed. At the present rate of erosion no fears as to the early removal of this beautiful cliff need be entertained.

Having said so much about the influence of these natural planes of the rock on the results of erosion, attention may be called to the step-like appearance of many hills, which is produced by the outcrop of strata in which alternate beds are of differing hardness. This may be seen at and near Ashover, Ravensnest, and Butterlee. Or frequently if the strata do not differ in this respect, the divisional planes will lead to the production of the appearance referred to. Mr. Ward calls my attention to the Harboro' Rocks as well illustrating this point

Now let the case of a river flowing through a broad alluvial valley be considered. The width of such valleys when compared to the stream, by the action of which they are alleged to have had their origin, is sometimes very astonishing. It need not be so, however, when it is considered that frequently the rivers must have been much wider than at present, and also that sub-aerial denudation is tending constantly to widen the valley by reducing the abruptness of the slopes, removing the material to lower levels to be eventually transported to the sea, the final resting-place of whatever is now raised above its surface. Almost invariably, also, the river-course is extremely sinuous.

Derbyshire offers several good instances of such rivers, as, for example, the Wye from Rowsley to Bakewell, the Dove from Rocester to Egginton, and other places. The former example may be taken as typical, and the neighbourhood is well-known. Fig. 9, B, is an enlargement from the Geological Survey Map of the district. It will be seen that the river is very sinuous, and, indeed, the tendency of a river flowing through any flat plain would be to become so. It is not difficult to see how its serpentine course has been produced. A slight weakness in one of its banks permits an encroachment. Gradually a concavity is formed round which the water is swirled, being directed against the opposite bank. This

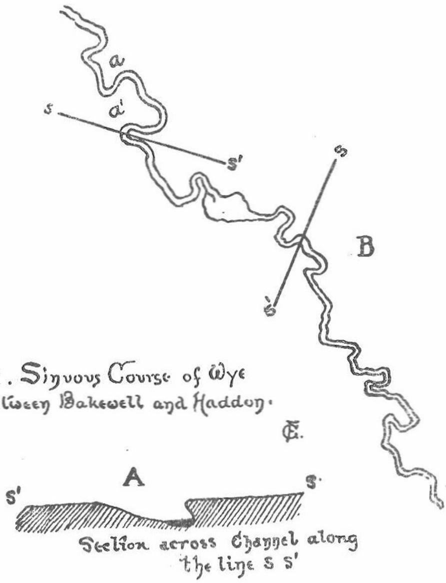

Fig. 9. Sinuous Course of Wye between Bakewell and Haddon.

is accordingly cut back, a similar concavity formed, and the water rushing round this is driven against the opposite bank; thus the action is, as it were, reflected from side to side, and a serpentine course is the result. Alluvium—gravel, sand, and mud—accumulates opposite the concavities and reaches the surface, forming a sloping and sandy bank, while the concavities are steep and frequently undercut, as shown in A. This process may be well seen in small streams at Duffield and elsewhere. Sometimes a river will cut through the neck of land as in B at *a* or *a'*, and thus temporarily shortens its course. The old loop forms a lake, which subsequently dries up, and may be readily detected by the nature of the vegetation and is frequently indicated by a line of willows.

The river course has been referred to as "serpentine;" and the geologist, in surveying it from some neighbouring height, sees in it as it glides along a stronger resemblance to a serpent than is conveyed by its form alone. Its motions are snake-like. The imagination perceiving only the *effects* of long-continued processes, becomes oblivious of the immense periods of time necessary for their accomplishment. A millennium becomes an hour, and the river is a living thing, winding hither and thither, ever the same, yet ever changing its form. The sunlight falls across the cliff; it is transformed to the shape it possessed ten thousand years ago, and the work of the cutting-tools of nature is revealed to the vision. And from the effect the mind seeks the cause, and perceives in the shining orb above the source of the energy of watery vapour, falling rain, and rushing torrent. It sees in it the source of the gentle motions of the air, and the mighty tempest, and of the ever-changing outlines of the face of the earth—nay, the sustainer of life and physical beauty. Still further, and the restless mind seeks the final cause, and can find no resting-place but in that beneficent, all-pervading, all-sustaining Power, which, in the beginning, "created the heavens and the earth."

In conclusion, I desire to express thanks to my friend, Mr. John Ward, for valuable suggestions and information. It has only been possible, in the limits of such an article as this, to touch the fringe of the subject, and indicate some of the leading facts, but I hope at some future time to deal with it in a fuller and more detailed manner.