On some Contorted Strata in the Yoredale Rocks, near Ashover.

By John Ward.

FOR field-work in structural and physiographical geology, perhaps no district in Derbyshire surpasses the Amber Valley at Ashover. Its lessons are easily learned; the extent of that portion of it which is geologically interesting is small, barely exceeding four miles in length; and from numerous points, comprehensive views of its salient features may be obtained. It furnishes the student with a wide range of rocks, and excellent examples of stratification and faulting, of river action and the relation of geological structure to scenery, all, it is true, of a homely character, but not the less valuable for that. But it is needless, in the present paper, to enter into the geology of the district beyond the requirements of our subject.

In this portion of the Amber Valley—that is, the mile below and the three miles above Ashover—the main characteristics of mid and northern Derbyshire are reproduced upon a small scale. In each case the strata form an arch or anticlinal curve, having its axis approximately N.N.W. and S.S.E., and tending to die out in the former direction, and abutting, by means of a fault, against the newer strata in the latter. The likeness to an arch may be carried further, if we confine ourselves to one constructed of several rims or layers of voussoirs, one above another; these rims representing the strata of the anticline. Suppose the summit of such an arch to be planed off, without, however, quite cutting through it; along the central line of the upper and now flat surface, will be exposed the lowest rim of voussoirs, and on either side the edges of the others, ranged in the order of their super-imposition. A similar state of things obtains in the two areas we are considering; natural denudation has brought down the larger anticline to almost the level of the surrounding country, and has positively hollowed out the Ashover anticline into a valley. In each, the lowest rock cut into—the Mountain limestone—is exposed along the axis, and on either side are ranged, at first Yoredale shales, then Millstone grits and Coal measures in irregular bands roughly parallel to the axis. It is outside the needs of our subject to discuss the origin of these curvatures; it is sufficient to observe that they are due to secular rather than local causes, and are vastly older than the contortions we now will consider.

These Yoredale flexures are to be found in various valleys in our country; good sections may be seen on the banks of the Ashop and other streams in its neighbourhood, and numerous small ones above Ashover. The latter examples occur near the bottom of the valley, between Kelstedge Dam and Whitefield Lane. They exhibit a continually varying dip (frequently attaining to 40 deg.) that falls into two sets, one ranging from E.N.E. to N.E., and the other more uniformly S.S.W. The rapidity with which the dip passes from the one to the other, indicates wave-like flexures having their axes N.W. and S.E., that is, in a direction approximately coincident with the "run" of this part of the valley. It is impossible to say what the width of these flexures (of which there are doubtless many) may be, but I do not think it can exceed 70 feet in those to which the sections belong.

There are reasons which lead me to think that these Yoredale contortions are not due to the same operation that resulted in the general rock curvature of this part of England. If it were so, the gritstone above and the limestone below must have partaken of the same crumpling, for throughout the north Midlands these three rocks are conformable one with another, and, in fact, pass into each other by natural transitions. Unfortunately, where I have observed the sections, the gritstone has been stripped away from above, and the limestone below covered from sight. But in all these cases, the neighbouring gritstones and limestones where exposed are free from contortion. For instance, along the Amber the gritstone that crests the sides and sweeps around the head of the valley; the Yoredales, when otherwise placed than in the bottom of the valley; and the limestone that comes to light half-a-mile nearer Ashover, partake only of the general curvature of the anticline. There can be little doubt, then, that these contortions are peculiar to the Yoredales of these districts.

A glance at the accompanying diagrammatic section across this part of the Amber valley will enable the reader to better understand the conditions of these contortions, and will suggest a clue as to their origin. The Yoredales (C) are there seen lying upon the Mountain limestone (B), and overlaid by the Millstone grit (D), the contortions being represented at (A). On the S.W. side is the broad elevated tract of Darley Moor, and on the N.E. the high ground above Amber House.

The Yoredale shales are a friable and yielding rock, and it will be observed that here they are squeezed between two harder and less yielding series of strata. Now we know that a yielding body, such as putty or stiff dough, when placed under a weight will spread out sideways. Movements of a similar nature in the softer rocks, as clays and shales in mines, are well known to miners as "creeps." Upon a similar principle, the heavy masses of gritstone of Darley Moor and Amber House must tend to press out the soft Yoredales below; and where the latter meet with no lateral resistance, as at the outcrop in the sides of the valley, there must consequently be a "creep," but there is little doubt that its rate is overmatched by that of subærial erosion. Where, however, such shales are continued across a valley-bottom, and whether covered or not along that interval, provided (as, indeed, in the nature of things can only be the case) the superior strata are thicker and therefore heavier beyond the valley sides, the pressing-out force will be unequally exerted, being strongest where the weight above is heaviest. Hence it is plain that these shales will be in a state of lateral compression where the covering-strata are lighter than the average; they may, however, be intrinsically strong enough, especially if aided by the weight of strata above, to resist this lateral push. But when the rock above is removed, or they themselves are being cut into, a point will eventually be reached when they will no longer be able to resist; and, as is usual, in thinly-bedded structures, the laminæ of which can freely slide one against another, their collapse will take the form of gentle flexures, and, as the valley is deepened, crumpling. The line of least strength will, of course, determine the direction of these flexures, and as this line in a valley is along the lowest part of it, the axes of the flexures will naturally coincide with the "run" of the valley.

If the above be the true explanation of the phenomena I have described, and it seems to fit in with all observed facts of the case, these Yoredale contortions are most interesting to the student, in that it furnishes him with a process still going on, and with an idea as to the lapse of time (not to be measured in years, though) since it began. It is clear that the valley is older than the contortions; it is clear, also, that the beds of Mill-stone grit, which are now more than two hundred feet above the valley bottom, must have been stripped away, at all events to a great extent, before the process began. So it is reasonable to think that this process of rock-folding has been contemporaneous with the deepening of the valley to the extent of two hundred feet.