THE VALLEYS OF THE COTSWOLD HILLS.

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SEVERAL years ago I contributed to THE PROCEEDINGS OF THE GEOLOGISTS' ASSOCIATION an article on "The Drainage of Cuestas,"* in which the effort was made to set forth certain systematic features of repeated occurrence in two districts of similar origin, namely, the Swabian Alp of Southern Germany, and the Cotswold Hills of Central England. In each district a resistant formation, gently inclined to the south-east, overlies a weaker formation; the resistant formation therefore stands up in strong relief, its south-eastern slope descends gradually as younger and younger strata overlap it; its steep north-westward escarpment overlooks a broad lowland that has been eroded in the weaker underlying strata. In the absence of any generally accepted name for such a form of relief, I have used *cuesta* to designate it, the term having been brought to the notice of geographers by R. T. Hill, who found it used for an unsymmetrical relief in the south-western United States. There has been some objection to the term; I have therefore disclaimed any undue wish to press its acceptance, and have expressed myself as ready to adopt any other term upon which all other geographers—or a large majority of geographers—will unite; but this remark on terminology is only by the way.

The consequent streams, by which the dip-slope of a *cuesta* like the Swabian Alp or the Cotswold Hills is drained, are believed to be the beheaded or shortened modern representatives of streams that were originally much longer, when the *cuesta*-making formation stretched far over the weaker underlying formations; and the valleys of the consequent streams in the dip-slope of the *cuestas* were explained in my previous article as having been for the most part eroded before their streams had been diminished to the present small volume by progressive beheading. It is believed that good reasons can be given in support of the general principles on which this view of the origin of the *cuesta* was based; indeed, no other satisfactory explanation for the relation of the Oolite *cuesta* and the Triassic lowland north-west of it has been offered. But among the facts adduced in support of the idea that the existing valleys were for the most part eroded before the consequent streams were beheaded, was the manifest disproportion or misfit between the present valley curves and the present stream curves; and for this

* *Proc. Geol. Assoc.*, vol. xvi (1893), p. 75.

disproportion I have now another suggestion to make, which occurred to me on the occasion of a visit to the valley of the Evenlode with members of the Oxford Summer School of Geography in August, 1908, and which I now desire to present to the Association.

Professor Sollas has reported the occurrence of glacial drift on the Cotswolds; hence it would seem necessary to believe that an ice-sheet of the Glacial period once filled the lowland of the Midlands and overflowed on the uplands of the Cotswolds. In case this is proved to be correct, some peculiar features of drainage may have been developed during the phase of ice retreat.

Imagine, for example, a stage of retreat when the ice-sheet had disappeared from the uplands, but still lay heavily on the lowlands, and when some of the ice-water streams, finding no easy escape to the north-east or south-west, accumulated in small lakes between the northward slope of the cuesta and the southward slope of the ice, and ran over the lowest depressions in the cuesta crest. If we may judge of the amount of work that such overflowing streams could do by the amount done in well-attested examples of the same kind in the northern United States—or in such examples as Kendall has described in northern England—it will not seem unreasonable to regard the Cotswold ice-water streams as competent to produce a significant modification of the pre-existent valleys; and as these streams must have been added to the present streams, it follows that the curves of the valleys that they eroded would not be followed by the present streams.

The advantage possessed by this explanation is that it gives better reason for the fresh, little altered forms of the Evenlode and other valleys, as well as for their over-large size in proportion to the streams that now occupy them. Whether the explanation is correct or not, I cannot say, but it seems to be worth the consideration of those who have opportunity of studying the district. The following supplementary facts speak in its favour.

If the misfit of the Evenlode and its fellows were due to normal beheading, without glacial complication, it follows that as the tributaries of the Thames on the dip-slope or back of the cuesta suffered loss of volume, the tributaries of the Severn, which drain the escarpment of the cuesta and the neighbouring lowland, must have experienced a corresponding increase of volume. In such case, these streams would be continually growing too large to be satisfied with their valley curves, and hence might be described as overfit, in contrast to the other streams which are underfit. On the other hand, if the former larger volume of the Thames headwaters were due to glacial constraint, a similar increase of volume might have been produced in the tributaries of the Severn at a somewhat later stage of glacial retreat, and the present streams would be too small for their

valleys. As a matter of fact, several of the Severn tributaries, among which is the Stratford Avon, are underfit and not overfit streams, though not so conspicuously underfit as the Evenlode. As far as this goes, it accords with the explanation of the over-large valley curves of the Thames headwaters by the glacial constraint of drainage.

It is manifest that this discussion is based on the postulate that when the curves of a stream are too small for the curves of its valley, a diminution of stream volume is to be inferred ; and this postulate is not accepted by all observers. Nevertheless, no other explanation of the disproportion of stream curves and valley curves can account for the valley curves and for the peculiar form of the trimmed spurs that project into such valleys ; while these features, which are so beautifully developed in the Evenlode valley and its fellows, as well as in many other valleys eroded in all kinds of rocks, are perfectly accounted for on the assumption of larger stream volume : hence it seems warrantable to accept this assumption as correct.