Some Neglected Principles of Physiography.

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All sciences suffer from errors and misconceptions, which have in one way and another crept in; and as such are difficult to eliminate. Many are passed on from older to younger workers, and are used in both theory and practice. Of such in geology are the popular notions of the characteristics of entrenched meanders; the origin of limestone sink-holes; and (in the opinion of the writer) of anticlinal valleys, and possibly of some transverse drainage.

The Entrenched Meander. It is an accepted principle of physiography that after a stream reaches base-level, it begins to meander. Uninterrupted by diastrophic movement, the meandering continues until the region on either side has been reduced to a plain, the width of which depends upon the size and strength of the stream. If such a region be elevated, the stream, from renewed vigor, will resume the downward cutting of its bed, producing a new (entrenched or incised) valley within the old one. Thus far, the popular notion of the entrenched meander can be accepted without question; but it is also the popular though erroneous notion that the new valley occupies the bed of the old one, and is V-shaped.

While it appears that some rejuvenated streams do have V-shaped valleys, such are rare. The rule is that the valleys of such streams are unsymmetrical. The slopes above the insides of the curves are of comparatively low gradient, while those on the outside are steep. This may be seen by inspecting almost any good topographical map of an area with rejuvenated streams. The explanation is simple. In an old stream, the downward cutting is little or nothing, while the lateral cutting on the outside of the bends may be relatively great. In rejuvenated streams, the downward cutting is resumed, but the lateral cutting does not cease. On the contrary, it becomes more rapid, because the impingement upon the banks is greater than before. The resulting topography is shown in Fig. 1, A and B. As all bends become greater, the rejuvenated stream is more crooked than when in its previous stage of old age, which of course means that it has shifted from its old bed.

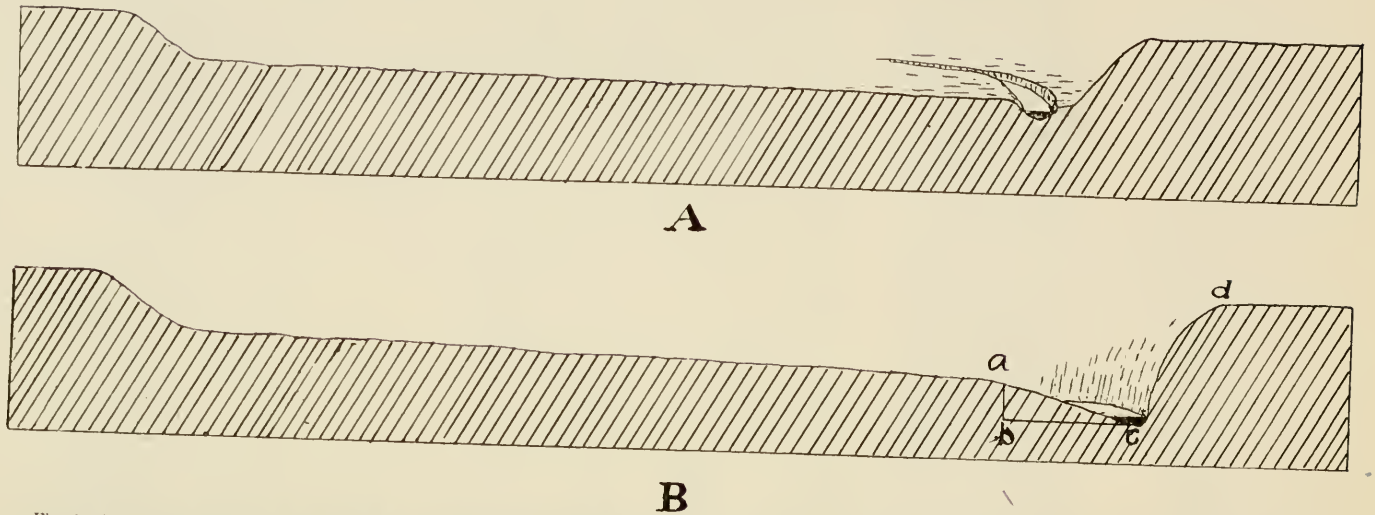

Fig. 1. Diagram showing the lateral shifting of a rejuvenated stream at a bend. The old stream (A) has base-leveled a wide valley. After rejuvenation (B), it has cut vertically the distance ab, and horizontally the distance bc, producing the flat slope ac, and the steep one, cd.

Just why some V-shaped valleys occur in older, wide, flat ones is not clear to the writer. Whether the inner gorge of the Grand Canyon is the result of rejuvenation or not, there has been little lateral erosion accompanying the great vertical cutting. Whether lateral cutting takes place or not, may depend upon the acceleration of the stream's force, which in turn would depend upon the rate and amount of elevation; or, it may depend upon the character and structure of the rocks. Unmetamorphosed, horizontal rocks of alternating hard and soft beds would favor lateral erosion, while metamorphosed crumpled beds, such as occur in the inner gorge of the Grand Canyon, probably would retard it.

Limestone Sink-holes. The common notion, and the teaching of most text-books, that limestone sink-holes are formed by the collapsing of the roofs of caves, is erroneous. That some sink-holes have had such origin doubtless is true, but they are the rare exception. Most of them are the result of solution by descending groundwater. As this has been discussed somewhat at length elsewhere, it will be only mentioned here.

Anticlinal Valleys. The common explanation of anticlinal valleys is that streams have gradually shifted from synclines to anticlines, the shifting having been invited by the excessive fracturing of the latter over the former. The writer believes that most anticlinal valleys have had a different history. It will be conceded that most folds had their inception while yet submerged. This granted, the first part of the folds to appear at sea level were the crests of the anticlines. Except at considerable depths, all the sedimentary material but that of calcareous nature was in the incoherent state at the time of elevation, and consequently was easily eroded. As soon as the anticlinal crests came within the effective force of the waves, they were thereby truncated. The rate of rise was greater than we are accustomed to admit, if the truncation did not for a long time equal the elevation. As the truncated material was shifted to the synclinal troughs, the whole process was a leveling one. It is not unreasonable to suppose that many folded areas emerged as practically level plains, and that streams were at least as free to flow along anticlines as synclines.

In those cases where the rise of any anticlines was rapid enough to overtake the erosive action of the waves, that action was still effective on the sides of the resulting islands. Added to this, was the work of the subaerial agencies. On the whole, the direction of the resulting small

[1] A. H. Purdue, *Science,* Vol. XXVI, p. 120.

streams was transverse to the anticlines. The anticlines did not everywhere emerge at a uniform rate, but appeared as rows of islands over each of which streams flowed radially. Consequently, some of the streams were, from the start, longitudinal to the direction of the anticlines, and others nearly so.

If at this stage the streams were still on incoherent material, the longitudinal ones had no particular advantage over the transverse ones; but if the indurated or partly indurated material had been reached, they had the special advantage of being able easily to seek out the soft beds and follow their strike. In the meantime, the material lapped off the sides by the waves and that washed into the sea by the streams was still filling up the adjacent synclines.

During the elevation, the synclines were occupied first by lagoons of salt, then brackish, and after complete emergence by those of fresh water. Even during the last stage they continued to be lines of deposition until the lagoons dwindled into lakelets and finally disappeared. Meanwhile, the anticlines were lines of degradation, and it is not improbable that as many synclinal lakelets were drained into streams that followed anticlines as into those that followed synclines; and it seems not unreasonable to suppose that in the course of stream adjustment, as many have shifted from anticlines to synclines as from synclines to anticlines, if, indeed, the former has not been the rule.

Major Streams Transverse to Folds. Folds are parallel to the old land areas from which the clastic material of their rocks was derived. In the addition of new land areas to old, the growth was often exogeneous. If a newly added area was folded, and the folds were leveled as above supposed, the streams from the old land gradually extended themselves over the new and in general were at right angles to the folds. As the clastic sediments were yet incoherent and nonresistant, it seems probable that many streams so thoroughly established themselves across the folds as to maintain this course as the elevation continued and after the indurated rocks were reached. May it not be that this has been the history of some of our transverse drainage? This conception, while closely related to that of antecedent streams, is different because it contemplates folding that antedates the streams, while the latter contemplates a well established stream before folding takes place.

In cases where anticlinoria emerged, not contiguous to existing land areas, it seems wholly within the probabilities that many of the transverse streams assumed and maintained their courses across the minor folds of the limbs. It has occurred to the writer that possibly this has been the history of some of the numerous transverse streams in the Ouachita area of Arkansas.