RIPPLE MARKS AS INDICATORS OF SMALL UNCONFORMITIES[1]

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As every student of geology knows, unconformities are as important to an understanding of the stratigraphic column as are the rocks that lie between them, and a great deal of time and effort has been spent on working out their presence and extent. As a result, the methods of determining unconformities covering the longer time intervals are well known.

But there are many unconformities in which the time interval was too short to cause a discernible break in the life sequence or for enough erosion to occur to give direct evidence of a halt in deposition. In shallow water formations like the Pennsylvanian of eastern North America, such small unconformities are very numerous. In the identification of them, the presence of minor physiographic features such as ripple marks, rill marks, and swash marks can be very helpful. Even wave-formed ripple marks, since they are produced in water of not more than half a wave length in depth, indicate a nearby shoreline and the probability of an unconformity in the immediate area.

Ripple marks are numerous in both the Pennsylvanian and Permian rocks of Oklahoma. Most of these are of the wave-formed type but some are current-formed. About two miles north of Tulsa, where the highway crosses a little stream known as Flat Rock Creek, there is a considerable exposure of thin bedded sandstone that has every indication of having been laid down in the bed of an ancient stream. So far as known to the authors, no unconformities have ever been found in this area in the section between the Checkerboard and Hogshooter limestones where these ripple-marked sandstones lie. This is the more remarkable as it is in an oil-producing area which has probably been worked by geologists as many times as any equal area in Oklahoma. According to a geological section made at the University of Tulsa, these ripple-marked sandstones are about 225 feet above the top of the Checkerboard limestone. Although the sandstone is, in general, of a massive nature the ripple marked beds are relatively thin, varying from 1 to 12 inches in thickness. Flat Rock Creek has cut down through a number of these beds and it is possible, by examining them, to determine the direction of flow of the stream at the time each one was laid down. They show a surprising variation in the direction of flow. Because of this and the number of beds it seems probable that the old stream may have been of considerable size and swinging widely from side to side over a broad sandy bottom as do modern streams like the Canadian and the Arkansas. Measurements of direction of flow taken just above and just below the highway bridge gives the following: N 72° W, N 85° W, N 95° W, S 75° W, S 25° W, S 5°W, N 62° E.

According to these figures, the flow of the old stream at this place averaged a little south of west. It will be noted that one current movement was north of east and that the others vary from almost northwest to nearly south. But this variation is similar to what would be found in making measurements of direction of stream flow in a modern river like the Canadian. This is because the whole broad sandy river bed swings widely from side to side during times of flood while at times of moderate flow, a smaller stream also swings back and forth across the broad sand bottom. At the same time, both sets of curves migrate downstream. Thus, at any given point in the stream, the direction of flow over a period of a few years is toward nearly every point of the compass.

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It is evident that a stream flowing for a long enough time to lay down several feet of sandstone implies the formation of an unconformity even though the time involved was not enough to show in the fossil life. And if the area lay at a low elevation and had only a small relief, the sediments below and above the break might be so well blended by the advancing sea as to make it very difficult to detect such an unconformity in the rocks themselves. At higher elevations in the area and at distances of a mile to 4 or 5 miles to the north, west, and south are other exposures of ripple marked rocks but none of them give as good evidence of stream action as do the ones in Flat Rock Creek. One of the best developed of these is on the top of Reservoir Hill in the north edge of Tulsa about 170 feet above Flat Rock Creek. This does not mean that 170 feet of sediments have been laid down in the area by a single stream. More likely several streams were involved.

According to the known geological history of the region, these streams appear to fit into a series of events something like the following:

1. A widespread marine invasion of short duration which resulted in the deposition of the Checkerboard limestone followed by a gentle uplift of the Ozark Dome area which caused a slow withdrawal of the seas to the west and the deposition of sandy beds, strongly crossbedded.

2. Then came a gentle transgression of the seas to the east resulting in the deposition of sandy shales of marine origin followed by a more vigorous uplift of the Ozark Dome area that again forced the sea westward and caused a return of deltaic conditions over the area. It was probably during this time that the sandstones of Flat Rock Creek were deposited.

3. A third slow invasion of the sea was followed by another uplift in the Ozark region causing another return to deltaic conditions and subaerial deposition during which the Reservoir Hill rocks were laid down.