

A short distance north of Monticello are sandy ridges which doubtless marked the southern limit of the glacial lake, so that this town is near the upper end of this part of the valley, although the gorge-like character of the valley has extended up to the town of Buffalo.

At Monticello the river flows in a valley not over half a mile wide and about eighty feet deep. Farther down the valley widens and deepens so that at some points the valley is a mile wide and the bluffs about one hundred feet in height. The only exposure of bedrock, New Albany shale and Devonian limestone, in this part of the valley is found a short distance above Monticello. Nowhere in the valley were wells found that were cut down to bedrock. The slope is great, the river falling almost 100 feet from Monticello to the mouth.

At this time no explanation as to the causes of the existing features is offered, the writer preferring to present these conditions for interpretation by more competent members of the Academy. This study of the Tippecanoe River will be continued, and some results of this work may be presented at future meetings.

CONCERNING WELL-DEFINED RIPPLE MARKS IN HUDSON RIVER LIMESTONE, RICHMOND, INDIANA.

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In the Proceedings of the Indiana Academy of Science for 1894, page 53, Mr. W. P. Shannon, under the title, "Wave Marks on Cincinnati Limestone," gives an interesting description of undulations in strata in the southwest part of Franklin County, Indiana. The present paper is a record of similar phenomena in Wayne County, Indiana.

In the spring of 1901 Prof. Joseph Moore observed what appear to be well-defined ripple marks in an exposed stratum of Hudson River limestone. The exposure occurs about five miles southwest from Richmond, Indiana, in the bed of a small tributary of the Whitewater River. The stream at this point flows approximately N. 35° E., and the series of undulations, which will be called "ripple marks" in this paper, are nearly, though not exactly, parallel, and lie in a direction about N. 72° 30' E. This direction is the mean of the measured direction of several axes. The width of the stream is from ten to fifteen feet, and the ripple marks are exposed more or less plainly for a distance of two hundred feet in the bed of the stream.

The ripple marks have rounded crests and hollows, the slopes on the two sides of a crest being in general symmetrical about the axis. The mean distance from crest to crest is approximately uniform for the series, and the average for twenty such distances is found to be 2.63 feet. The average depth of lowest part of troughs below crests is one and one-half to one and six-tenths inches; total number of crests exposed is forty. The ripple marks in the up-stream portion of the exposed area, constituting the majority of the number named, extend entirely across the bed of the stream; in the down-stream portion, a part of the ripple marks have been worn away by erosion of the stream, leaving the crests only near the margins.

The stratum which has the ripple marks is about three inches in thickness, measured to top of crests; the bottom of this layer is as nearly plane as are the surfaces of the other layers of Hudson River rock in this locality; that is, no indication of the undulations (which are on the upper surface), is found on the lower side of the layer; and this layer containing the ripple marks is not noticeably different in thickness from that of the other layers of the same formation just above or just below it geologically.

The ripple-marked stratum, in the southwesterly (up-stream) direction, disappears beneath other strata of Hudson River limestone. This stratum above, when broken up and removed, showed a layer of blue shale or mud, filling the hollows, and barely covering the crests of the ripples; the ripple marks, however, were as clearly defined where the upper stratum was broken away as in the exposed portion farther down the stream.

The right bank of the stream is steep and higher than the left bank; and here the Hudson River rock outcrops up to a height seven or eight feet above the water; the upper stratum of Hudson River rock in this vicinity is estimated at forty feet above the ripple-marked stratum. The left bank is a part of a flood-plain. At one point a trench was dug back from the water's edge on this side. When soil, sand and gravel were removed, the ripple marks were found clearly defined as far as the digging extended, some of the blue shale being found adhering to the surface.

The under side of the ripple-marked stratum is paved in nearly every square inch with well-preserved fossils, consisting in far the greater part of *Leptaena sericea*. These are associated with *Rafinesquina alternata*, *Orthis occidentalis*, *Rhynchotrema capax*, and a very few other brachiopods.

Let it be understood all the time that the under surface of this layer is entirely flat. The upper, or rippled surface, is very smooth and shows

almost no fossils in form to be identified, but only small fragmental and finely comminuted shells very firmly compacted. This triturated and very compact character of the rippled surface is not confined to the surface, but extends to a slight depth, gradually shading into coarser shell fragments.

The first layer below the stratum bearing the ripples contains substantially the same fossils, with possibly a still larger proportion of *Leptaena sericea*, and an occasional specimen of each of the following, viz.: *Zygospira modesta*, *Orthis testudinaria*, and *Crania scabiosa*. This layer indicates a somewhat agitated condition of the water in which it was deposited.

Above the layer of tough, pasty blue clay which covers the rippled surface, lies a consolidated layer consisting of whole and fragmental fossils cemented by hardened clay. The shells and fragments are, so far as examined, pitched at all angles and crowded together in a way to indicate an agitated condition of the waters during their deposition. There appear to be few, if any, species in this upper layer different from those already named.

We conclude that the undulations referred to in this paper are ripple marks for the following reasons:

1. The axes of the series in general are parallel, yet with some variation in direction and continuity such as is seen in ripple marks formed on sandy bottoms now.
2. The crests of the entire series are spaced with approximate uniformity; that is, there is no increase or decrease in distance from crest to crest in passing from one edge to the other of the exposed area, which might be the case if the undulations were beach marks.
3. The fragments composing the surface of this stratum are much finer than those found in the bottom, and finer than most of the fragments in the strata lying above and below.
4. The arrangement of fragments in the strata lying next above and next below give evidence of considerable agitation of the water at the time those strata were being deposited.

The accompanying plates show the appearance of the ripple marks. Plate I. is from a photograph, up-stream view; Plate II., the down-stream view; Plate III., a small portion of bed of stream, looking downwards from the high right bank of stream.

PLATE I.



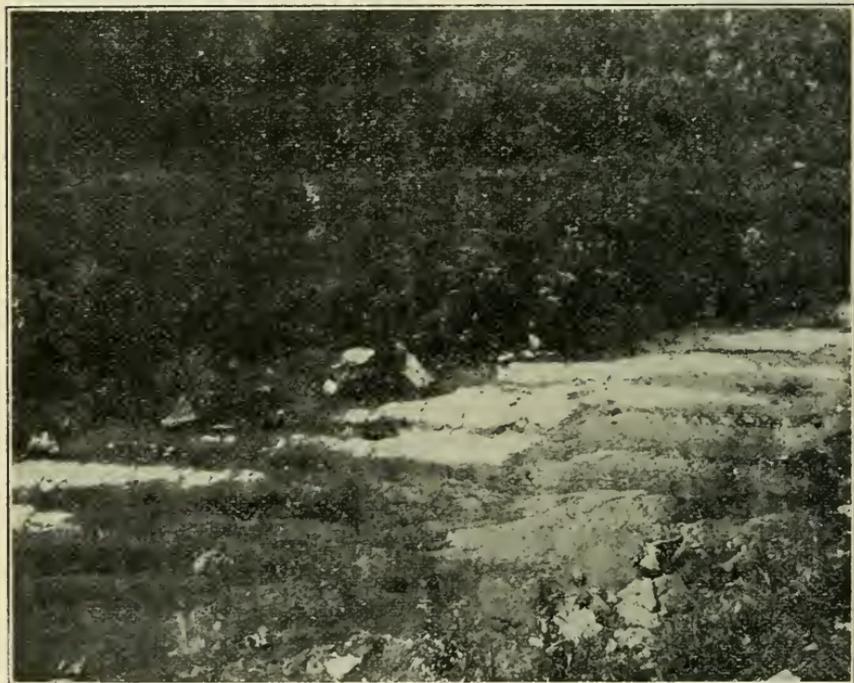
Ripple Marks—Up-stream View.

PLATE II.



Ripple Marks--Down-stream View.

PLATE III.



Ripple Marks—View from Right Bank.