A TERMINAL MORAINE IN CENTRAL INDIANA.

It has been said in another part of this volume, that the Drift material, which overlies so great an area in Indiana, has been modified by the action of the post-glacial forces to such an extent that it is extremely difficult to trace many of its original outlines; but there is a well-defined and most interesting moraine, or tangle of moraines, which lies in the form of an obtuse angle, whose lines cut the eastern and western border of the State and whose apex points southward. It passes into Illinois from Warren and Benton counties, and into Ohio from Randolph and Wayne counties. It is most obscure at its apex and most clearly defined along its western member in Tippecanoe, Clinton, Montgomery and Boone counties, and along its eastern member in Henry, Wayne and Randolph counties. The mass of this moraine is enormous, and at many points is heavily charged with bowlders mostly of igneous and crystalline formation, though a considerable number of large limestone fragments, chiefly Devonian and Upper Silurian, are found. Southward from the line of this moraine the Drift mass gradually thins out and finally disappears, and northward from it the depth of the Drift diminishes for a distance and then increases again. The valley of the Wabash is cut through the moraine in Tippecanoe County. The cuttings of the L., N. A & C. Railroad south of Lafayette show, in a very interesting way, the structure of the mass and the manner in which its surface has been modified by the action of water and by the operation of freezing and thawing. In the western part of Clinton County, and in the northern portion of Montgomery and Boone counties, the bowlder clay is immediately under the surface soil, and here great areas are thickly strewed with heavy granitic and gneissic bowlders. In Benton County a heavy swell or ridge of morainic material is the chief feature observable, while in Marion and Hendricks counties the Drift mass, though very thick in a general way, is superficially a great rolling plain cut through by numerous streams, the principal of which is White River. From Marion County through Hancock, Henry, Wayne and Randolph counties the Drift mass, though variable, preserves its morainic character. The foregoing rough description will be sufficient to enable the reader to trace on any map of Indiana the general course of the moraine and to note its position with reference to

the trend of the Wabash Valley. It must not be understood, however, that the moraine, in regard to its width or cross-section, is confined to the counties indicated; indeed, the deposit is of immense proportions, spreading over, besides the counties named already, a part of Newton, Warren, Fountain and Carroll counties, the southern part of Howard, and parts of Tipton, Hamilton, Madison, Jay and Delaware, with a projection at its apex into Morgan, Johnson, Shelby and Rush counties. At first glance this will appear to give very little symmetry of outline, and, indeed, the form of the mass as it now lies represents no more than the base of what was, at the close of the glacial period, a low, knobby or hilly ridge spanning the State at the angle indicated. The modification which this moraine has undergone since the return of a temperate climate has been in the direction of spreading and flattening the mass and of cutting many deep and oftentimes eccentric water channels in it. This modification is still going on as the result of the action of wind, rain and freezing and thawing.

No doubt the far greater part of this leveling and spreading process was accomplished during the long and necessarily dreary period between the time when the glacier withdrew from Indiana and that when the Drift area was covered with vegetation. This barren period must have been one of much greater extent than geologists have been inclined to admit, and if we take the rainfall as averaging as great as we now have, we can easily see how a vast heap or ridge of bowlder till, moraine dust and other *debris*, with no vegetation to protect it, would be rapidly reduced to a comparatively level mass.

To my mind the evidence is clear that what I here describe as a terminal moraine is really an accumulation of moraines, the effect of many glacial advances, retreats and returns during the great ice period. No doubt, at times when the morainic mass was frozen to adamantine hardness and there came a vigorous return of the glacier, the ice flowed over the huge barrier itself had formerly made and slowly ground it to a lower level. It is only by understanding this pendulum-like oscillation of the glaciers through a vast period of time that we can solve the problem of the intercalated lenticular masses of sand and water-bearing gravel found hermetically sealed within the blue clay of the Drift, as is shown in a foregoing chapter.

By referring to Dr. Phinney's report of his examinations in Henry and Randolph counties, it will be seen that he found the moraine well marked in its development. So in Dr. Brown's survey of Hancock, and in the reports upon Clinton, Tippecanoe and Benton counties by Prof. Gorby and W. H. Thompson, the features of the formation are minutely described. The highest part of the moraine is in Randolph County perhaps, where it forms the divide between the waters ultimately flowing into White and White Water rivers.

The Wabash River has cut its way through the great moraine, chiefly in Tippecanoe, Fountain and Warren counties. West of the river from Lafayette the high, picturesque knobs, overlooking the beautiful city and grand channel of the Wabash for miles, are heaps of Drift matter, showing every characteristic of moraine formation, while south of the city, near the Junction, the recent terraces are heaped against immense masses of bowlders and bowlder clay.

It is a curiously suggestive fact in this connection that White River, Sugar Creek and Wabash River (each in its turn) will be found, upon glancing at any map of the State, running in the higher parts of their course, parallel with the general trend of the eastern limb of the moraine and breaking through the formation to immediately take a more southerly course. This would seem to indicate that the moraine had acted as an obstruction to each of these streams for a time, and that they had all followed the northern side of it until some weak point was found through which a passage was forced by each in its own way.

A careful study of the Wabash River shows that its passage through the great rock dam and through the moraine are completed at the same point near Covington, in Fountain County, where the river turns into a course nearly due south; and it is this great rock dam at Momence, in Illinois, which the Kankakee must be made to overcome before its vast area of wet lands can be drained successfully.

Students of geology, who desire to give especial study to the more marked features of the great moraine herein so roughly and hastily sketched, will find Lafayette Junction, the eastern part of Clinton County, the northern part of Montgomery County and a large part of Wayne and Randolph counties the most favorable points of attack, and it is to be hoped that the students and scientists of the State will give this very interesting geological feature a patient and careful investigation.

The line of disturbance traced by Prof. Gorby across the State appears to bear a close relation to the formation of this terminal moraine. No doubt the great rock barrier formed a sort of dam against the free advance of the glacier, and thus it modified, in a large degree, the Drift or morainic formation in the first place, and afterward controlled the floods of iceberg-bearing water, which rushed southward from the foot of the retreating glacier, thus preventing the total destruction of the moraine's outlines by this agency and giving direction to the Wabash and White rivers. Indeed, evidence is present everywhere along the formation going to show that the northern rim of the moraine became the stranding place of icebergs loaded with bowlders, and that this stranding line was practically parallel with the flow of the Wabash, and with the trend of the great rock dam. Crowning the very highest parts of the moraine are found so-called dykes of great extent, formed chiefly of granitic bowlders. These bowlder areas, as I prefer to call them, are not areas of erosion.

On the contrary they are often deposits, and passing over the highest swells of the formation. I had the pleasure and profit of going over one of these areas with Prof. Chamberlain, of the United States Geological Survey. This was in the northern part of Montgomery County, where the so-called "Bowlder Dyke" practically ends.

I have, for mere convenience, called the morainic mass, thus roughly outlined, a terminal moraine; but I regard it as a cluster or tangle of a number of inseparable moraines, caused chiefly by the separating of the great glacier into lobes, and by successive advances and retreats of the ice masses, attended by great rivers of rapidly rushing water in the melting periods. One of the marked features of this formation is a succession of knobs or cones of sand and gravel, alternating irregularly with ridges and hills of bowlder clay, and with occasional undrained areas or basins.

Of course, to outline this great deposit with any close attention to details would require a minuteness of examination and an amount of time and expense wholly out of the limits set by my duties. I hope that this sketch will induce others to make a study of what is the most interesting scientific problem in connection with the superficial geology of Indiana.