Journal of the Minnesota Academy of Science

Volume 3 | Number 1 Article 7

1886

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est points of the Leaf hills, 1,600 to about 1,750; of the Coteau des Prairies, 1,800 to about 1,900; lake Traverse, 970. and Big Stone lake 962; lake Benton, 1,754; lake Shetek about 1,475; Heron lake, 1,403; Mille Lacs, 1,251. and lake Minnetonka, 928.

The average elevation of the whole state cannot be less than 1,200 feet, which is 370 feet above the plain of modified drift on which Minneapolis is built; and it may be found, when carefully estimated throughout, even as high as a quarter of a mile, 1,320 feet above the sea. This is about half the average altitude of the whole United States, which is approximately 2,600 feet above the sea; but probably no state east of the Mississippi river has a greater mean altitude than Minnesota. Humboldt estimated the mean height of all North America to be 1,500 feet, and of Europe, 1,340 feet.

[*Paper G.*]

NOTES ON THE LOCAL GEOLOGY OF MANKATO. A PRE-GLACIAL RIVER CHANNEL. *A. F. Bechdolt.*

What is locally known as Van Brunt's Slough lies in the western part of the city of Mankato, opens on the flood plain of the Minnesota river, and has a devious course in a direction slightly west of south.

The sides of the Slough resemble the banks of a river rather than those of a lake. In all their windings the opposite shores remain parallel.

This feature holds true for the entire length of the Slough except at one point where the concave side is not concentric with the opposite bank but makes a noticeable bay. This want of uniformity will be explained a little farther on. South of the point referred to lies Indian lake, an oblong pond, gradually filling up with silt. The depression of the Slough, above the head of the lake, turns to the west, along a small affluent of the lake, which is usually dry in mid-summer, to its source in a swamp. From this swamp another small stream flows west along the depression emptying into the Le Sueur river, not over one-fourth mile above the railroad bridge. Chalk run, as this stream is called, at its source, the highest place in the Slough depression, is probably not over twenty feet above low water in the Le Sueur. The outlet of Indian lake runs north along the slough, loses itself in the swamp.

to become a stream again near the city limits and flows into the Minnesota river at Mankato. Drift material is spread upon the sides of this valley and at several places terraces are clearly marked. This therefore must be regarded as a valley made in preglacial times and re-opened at the close of the Ice age. No terraces can be seen along the Le Sueur below the point where this depression opens into the valley of this river or along the Blue Earth river north of their union. From above the dam at the Red Jacket Mill to the river, just below the mill, the water falls eleven feet, and there is a marked fall in the Le Sueur below this point to where the Le Sueur and Blue Earth rivers join. I deem it therefore safe to estimate the fall in the Le Sueur from Chalk run to its mouth at fifteen feet. Where the Slough and the Blue Earth valley make the closest approach there is a ridge of sand and gravel, modified drift in fact. This ridge is lower than those on either side which are underlaid by the Shakopee and Jordan formations. Man has taken advantage of this low sandy ridge to carry the wagon and railroad from the Slough valley over to that of the Le Sueur river. From the facts here stated we conclude that the Slough valley marks a former channel of the Le Sueur and Blue Earth rivers; that these rivers united north of Indian Lake; that the Blue Earth river changed its course because of the ridge of modified drift extending across it near the junction, and by uniting more recently with the Le Sueur river at Red Jacket Mills left the valley of the Slough dry throughout its length, except where the retiring water left a pool, at Indian Lake, to mark the deepest places in the channel. An inspection of the locality will show even better than a chart, that at a time when the Le Sueur yet held its course along the Slough, the Blue Earth wound in a sharp curve round by Red Jacket Mill, leaving the knoll near the mill, now surrounded by meadows, as a bench or terrace on its northern bank. The two rivers were then separated by a narrow ridge underlaid by friable Jordan sandstone, tangent to the wearing side of the channel of both rivers. A gully, such as exists on the south bank today and is used by the railroad, may have materially lessened the distance. Sometime when the Le Sueur was gorged with ice it broke down the wall and left its old and tortuous course by the slough for a channel more direct and steeper.

A similar change has come about in the Blue Earth river

near its mouth. From the middle of the south line of section 23, a low valley stretches to the middle of the north line of section 22 in the village of South Bend and there connects with the flood plain of the Minnesota river. This valley is closed in on either side by ridges of Shakopee and Jordan sandstone. There are several ponds in this valley with their longest measure along the line of the valley. Wells sunk in the valley, have found no water and have been dug in black sandy loam for their entire depth. At the time when the Blue Earth river flowed along this course the Minnesota flowed along the north shore of its flood plain, swept southeast to where the wagon bridge crosses the Blue Earth river at Mankato, and then turned northeast; thus establishing the same conditions as existed before between the Blue Earth and Le Sueur rivers, and the same result followed, the old channel was forsaken and a new one, across the ridge tangent to the two curves, was taken. In my own thoughts, I have been in the habit of regarding an ice gorge as the occasion for the first break in the channel. Recent observations on the immense amount of sand carried by the waters of the Le Sueur and Blue Earth, the way in which this sand is heaped up into sand banks, the current changed and the eroding effect of such current on the banks against which it impinges directly, while it is powerless to move the sand bank, incline me to the view that this heaping up of sand in the channel may have been a cause, if not the cause, for the changes of channel in these rivers. Why the Minnesota and Blue Earth cut through and formed the terrace like knolls, situated one on either side of the Blue Earth at its mouth, and parted them from the Nicollet county bank of the river is to me a puzzle for which I can not offer any satisfactory solution.

THE GEOLOGIC AGE OF SOME CLAYS FOUND ABOUT MANKATO.

At the Kunz quarry, four miles northeast of Mankato, in the C. St. P. M. & O. R. R. cuts at West Mankato and South Bend, above the wagon road behind the brewery at the Blue Earth river, in the quarries at the cement works, at the "Mound" on the west bank of the Blue Earth river near the mouth and along the banks of the Le Sueur river are found banks of clay, generally white in color, filling fissures on the Shakopee limestone and upon which is found the material of the drift, as yellow clay, boulders of granite and limestone and now and then masses of ferruginous sand, forming

at places a conglomerate with here and there lumps of a fair limonite ore.

These clays have been called cretaceous by Professor N. H. Winchell, State Geologist, in a paper read before this body and published in the *Bulletins*. This fact first made these clays a source of interest to me and has led to a somewhat fragmentary study of their age and origin.

The recent laying bare of a large surface of the Shakopee formation at the cement works gave me an unusually good opportunity to concentrate and crystalize all that I had observed as peculiar to them. From what I have seen I am led to regard these deposits, not as cretaceous but as belonging to Silurian time.

The position of these clays:—They lie in fissures of varying width along joints in the Shakopee limestone. These fissures have their sides rounded, polished and moulded as by trickling water. The surface of the Shakopee limestone, where it has been recently laid bare, at the cement works, is embossed and rounded, suggesting *roches moutonnees* and indicating extensive denudation, the clays are not spread out upon the upper surface of the Shakopee, but extend down, within these fissures, at times through the Shakopee and are spread out upon the planes of bedding of the Shakopee and underlying Jordan sandstone.

In several fissures at the cement works, the beds of clay are spread out conformably to, and upon, the Jordan and under the Shakopee for more than one hundred feet on either side of the fissures. The sides of many of these fissures are lined with a layer of iron rust or bog manganese of varying thickness. Upon the clays and mixed with true glacial material are found, more especially along the Le Sueur river, the deposits of limonite to which reference has already been made.

The structure of the fissures:—The rounded sides of these fissures indicate the action of trickling water. They are not potholes as a cross section of any one of them shows, the clay is filled into these fissures with the angle or convex side toward the upper surface showing the action of a trickling stream, as a spring carrying the clay as an impurity. In no case is the bedding of the clays concentric with the sides of the inclosing cavity as would be the case had they been deposited from still waters filling the cavity and holding the clays in suspension.

In many places the clay has been filled in upon the Jordan just

as fast as this was removed because the overlying strata have not been disturbed.

Character of the clays:—I have not been able, after repeated search, to detect the slightest trace of any fossil, animal or vegetable, large or minute, in these clays. Regarding them as cretaceous, this was a surprise to me, even the miscroscope would reveal no fragment of vegetable or animal organism.

These clays are not uniform in color, while the prevailing tint is white, bands of a pink, and a drab color are found; there is no uniformity of arrangement.

They are not uniform in composition, while most of the clays do not effervesce with chloric hydrate, (a surprise to me and in this respect not agreeing with a sample of cretaceous clay from Dakota) other layers may effervesce. Calcic carbonate as well as ferric oxide are therefore to be regarded as accidental impurities. Some of the layers are very free from grit, smooth and soapy to the touch, others are gritty and this grit varies from an impalpable powder, only distinguishable under the teeth or with a microscope, to rounded grains of white siliceous sand. As a rule the clay along the sides is finest and the most grit is in the centre of the fissure and in the lower layers. In some of the larger fissures, throughout the length of the fissure and in the direction of the former flow of the trickling water are found angular fragments of white sandstone, resembling the Jordan sandstone as seen here or the St. Peter as exposed in the bluffs at St. Paul. These angular fragments of white sandstone are also found in crevices in the Shakopee above Mr. Beatty's quarry, northeast of the city.

These are the facts that make it seem more than likely to me, that these clay deposits were formed from material taken up by water precolating through the St. Peter sandstone, while it was yet in position over the Shakopee, carrying away the clay, fine sand, etc., in suspension to deposit it in the lower and slower part of the underground course, just as a stream does. I have had no opportunity to examine the St. Peter sandstone, but presume that like the Jordan it contains throughout its mass lumps of clay, the source of these deposits. The origin and character of the rock makes this almost necessary. During the Drift period the St. Peter and at places nearly all of the Shakopee were ground up, dissolved, and swept away. They left behind broken fragments, sand, iron rust

and wad. The incrustation along the sides of the fissures is iron and manganese from the surrounding rock, which were held in solution by the water and dropped along the line of the flow; this, since the clay has filled the fissures, has been along the sides, between the clay and limestone.

I do not doubt the existence of cretaceous deposits in this part of the state. On the sand banks near the mouth of the Blue Earth river are found bits of lignite that must come from somewhere along either the Blue Earth or Minnesota river. Also fragments of cretaceous corals and teeth of fish in the stream drift show the presence of beds of material belonging to this period not far away, but certainly these beds of white clay must be counted out.

[*Paper II.*]

NOTES ON THE FLORA OF WESTERN DAKOTA AND EASTERN MONTANA ADJACENT TO THE NORTHERN PACIFIC RAILROAD—*By John B. Leiberg.*

[Read before the Minnesota Academy of Natural Sciences, March 4th, 1884.]

While in the service of the Northern Pacific railroad company during the past year in the interest of tree culture, I had abundant opportunity to examine the interesting and to some extent peculiar flora of western Dakota, and to a limited degree the eastern portion also, and the eastern part of Montana as far west as the Yellowstone river at Glendive, and to make large and full collections of the same. Copious and interesting notes were made respecting the botanical features of the region, and a few of the more prominent are presented for the consideration of the Academy.

The climate of eastern Dakota, in both rain-fall and temperature, does not appear to present any great varation from that of the prairie region of western Minnesota, except perhaps a somewhat longer winter. The climate of the western portion is very different. The summer is very dry; showers are of rare occurance; and the temperature varies excessively. Thus in the month of July the mercury rose to 115° Fahrenheit, and fell to 32.° Such great variations cannot fail to modify plant life to a very great extent. The hot, scorching winds that generally accompany the high temperatures quickly dry up all vegetation, except along the