| | 4 feet down. | 18 feet down. | 24 feet down. |
|---|---|---|---|
| Silica | 6.19 | 3.05 | 97.76 |
| Iron oxide and alumina | .45 | .31 | .55 |
| Magnesium carbonate | 43.53 | 44.59 | 1.43 |
| Calcium carbonate | 50.12 | 52.72 | 1.14 |
| Difference | —.29 | —.67 | —.88 |
| | 100.00 | 100.00 | 100.00 |

The first sample may have been derived from either bed A or B, depending upon the part of the quarry from which it was taken. The second very probably came from the bed E, while the third, representing a typical sandstone, must have been a poorly selected sample from beds F or G. The three upper beds of the Woolmith quarry are also seen in the small opening upon the adjoining property, to the south, belonging to John Hoffman. From four to six feet of clay stripping cover the rock, which has been entered ten to twelve feet.

§ 5. Raisinville quarries.

A series of six quarries occurs near the river in Raisinville township, which owing to their location and the similarity in their strata may be conveniently grouped together for description. The largest and most important of the six is owned by Robinson and Taylor, of Detroit, and is operated by Silas A. Kring for lime. It is located upon claim 516 (North River Raisin), at Grape and consists of two main excavations, one upon either side of the highway. From twelve to fifteen feet of strata are exposed, corresponding to the lower part of bed H and to bed I of the Woolmith quarry above described. The stripping is reduced in places to but a few inches of clay, charged with irregular fragments of the shattered dolomitic beds. The rock is estimated to dip 2° to 3° toward a little south of west. Upon the north side of the road the silicious dolomite forms the uppermost ledge on the west quarry wall. It is of a buffish gray color, gritty from the numerous sand grains, with numerous small irregular cavities, many of which are filled with calcite and give a spotted effect to the rock. The main quarry rock consists of a buffish gray, compact dolomite, faintly glistening with minute cleavage faces. It is thin bedded and much fissured towards the top but more heavily bedded, and more silicious toward the bottom. Nodules of impure chert occur and lenticular masses several feet long and five to six inch thick through the center. The following analysis was reported to have been made by J. D. Pennock, chemist for the Solvay Company, Detroit:



| | |
|---|---|
| Magnesium carbonate | 45.01 |
| Calcium carbonate | 51.69 |
| Silica | 3.45 |
| Iron oxide and alumina | .20 |
| Calcium sulphate | .43 |
| Difference | —.78 |
| | 100.00 |

Just west of the quarry, upon land belonging to John Knaggs, (claim 428, North River Raisin) there is an outcrop of the same strata upon the south side of the road. A quarry was opened at this place and rock removed to a depth of twelve feet for building purposes. Not having been operated for some time the small excavation is now filled with debris and there are exposed only the protruding upper layers. Over a considerable area about this outcrop rock can be struck with a three foot probe. A quarry similar to that of Robinson and Taylor might be here developed. Beneath each the Sylvania sandstone must be expected to be reached very soon, so that neither could be extended to any depth with a yield of dolomite. The main stratum of dolomite in these two quarries, bed I of the Woolmith quarry and the bed found to overlie the Sylvania at the Toll pits, are apparently identical.

Directly south of these two quarries, upon the opposite side of the river, Fritz Rath has opened up two small quarries upon claim 685. The most northern is located some 250 paces northeast of the residence and consists of a rectangular opening, 70 by 85 feet. This was worked for lime about twenty years ago, the quality of which was reported to be good. At the time of the visit the quarry was filled with water but numerous fragments of the rock were found scattered about. These indicate that the beds are a dark brownish dolomite, streaked and finely specked with a creamy white, looking very much like a very obscure oölitic structure. Upon dissolving a flake of the rock in acid there is left behind a quantity of pure white rounded sand grains, varying considerably in size. These are secondarily enlarged against the rhombohedrons of dolomite, and oölitic granules, as in the case of the Woolmith rock previously described, giving their surfaces a very rough appearance under the low power of the microscope. The clay covering here is said to be eight to twelve feet thick. South of the Rath residence about one quarter of a mile a natural exposure occurs, at which three small linear excavations have been made for rock for building purposes, exposing five to six feet of the series. The upper bed is four feet thick and is a light to dark brown dolomitic oölite in which the structure is much obliterated. Upon dissolving small fragments in acid a considerable quantity of fine snow-white sand grains remain. These resemble those previously described, being secondarily enlarged and roughened. Occasionally one is seen with crystal facets developed or with the pyramidal termination. The rock appears to be a dolomite, enclosing sand grains and quantities of the varied oölitic structures previously described. It is associated with a gray, compact dolomite which resembles the main quarry rock upon the opposite side of the river, but shows some thin, narrow plant stems or leaves. Unless there is some local faulting here which would bring the Woolmith oölite down about thirty feet, it seems most probable that this represents a local modification of the lower layers of bed H of the latter quarry. In thickness and general appearance it resembles the Woolmith stratum but the latter upon being dissolved yields much more bituminous matter. In the well of John Nicols a core was taken out at the N. E. ¼, N. W. ¼, Sec. 26, T. 6 S., R. 7 E., to a depth of sixty-three feet. After passing through some hard pan this same silicious oölite was struck at nine feet, of which a three and a half inch core was secured. At a depth of about twenty feet a bed of white sand-rock was reached which Mr. Nicols believed to have been seven to eight feet thick. Dolomite was then entered, which so far as may be judged from a single sample saved, was highly silicious.

Upon the lower portion of this same claim 685, Frederick Milhahn has opened a small quarry where the rock lies but one foot from the surface. Just across the fence to the west a second small opening has been made upon the land of Mrs. Nora Sullivan, claim 683. These lie about one and one-quarter miles southwest of the Grape quarries and have been operated ten years, mostly during the winter months, for building stone. The rock has been entered but three to four feet and is seen to be a heavily bedded, brown to gray silicious dolomite, having a rough gritty feel.



§ 6. Ida quarries.

One and one-half miles west of the village of Ida the rock strata again appear at the surface owing to local flexures. Just where the north and south quarter section line of Sec. 4 intersects the Adrian branch of the Lake Shore R. R., three quarries have been opened. The principal one has been operated for lime and building stone for many years by Nelson Davis. This is located to the south of the railroad in a field of about eight acres, one mile east of the Ann Arbor R. R. Superficial excavations have been made over a considerable portion of the field. The beds have no perceptible dip within the limits of the quarry and are drained by a small stream flowing southeastward. Mr. Davis recognizes two separate beds which he terms the first and second formations respectively. The uppermost attains a maximum thickness of seven to eight feet in the central portion of the quarry. Based upon excavations about the quarry, Mr. Davis believes that this bed gives out in each direction, from ten to fifteen rods north and east, about one-half mile west, and before it reaches Lulu, two and one-half miles to the southwest. It consists of a light gray dolomite which in places assumes a creamy white, owing to its partial or complete conversion into strontium carbonate *(strontianite)*. Near the middle of the quarry nearly a foot of the dolomite has been so altered, giving a soft, mealy rock with seams and films of the pure mineral. Some slabs are covered with a layer of slender well formed, orthorhombic prisms of this strontianite. The bedding is thin, varying from an inch, or less, to six or seven inches. Near the surface of the bed certain slabs show a remarkable amount of what may best be described as *gashing*. The rock looks as though, when it was only very slightly plastic, it had been jabbed in every direction with a thin bladed, double edged knife point. The gashes are almost always open, intersect one another irregularly and vary greatly in size, some being two-thirds of an inch long, while others can scarcely be seen without the magnifier. The cross section of each gash shows that it is thickest at the center and that it slopes gradually and symmetrically to a very thin edge. Traces of this peculiar structure are found throughout the Monroe series, from the highest rock seen at Petersburg to the lowest outcropping at Stony Point. It is not known what mineral could have crystallized in the dolomitic matrix and left these openings by its removal. One specimen from the Raisin bed shows them filled with calcite, but this may represent a secondary deposition.* In his report of 1860, Winchell refers to this as an *acicular* structure and infers that it is characteristic of gypsum. Rominger uses the term acicular also in describing the Ida rocks and calls attention to the widespread character of the phenomenon, but does not name the substance by which it may have been produced. It is to be noted that the crystals, however, were not needle shaped and only the cavities in cross-section give this appearance. In weathered specimens there are shown plainly the frondescent structures associated with the spherical granules in the beds of oölite previously described. These make up the body of the rock in places, their dim outlines showing in the solid dolomite. The oölitic granules are much obscured but are recognizable, proving that this bed is, in part at least, an oölite. In position it is the equivalent of the bed struck in the Nicol's well, above mentioned, and in the Rath quarry. The characteristic chocolate brown blotches are locally abundant. No fossils were collected from any of the strata. Rominger determined the amount of calcium carbonate in a sample to be 59% and of magnesium carbonate 39%.

Underlying this bed is the so called "second formation," which is well exposed in some of the deeper excavations of the quarry. This is a firm dolomite, dark when damp, but drying to a light gray. The surface of the bed is rough and irregular and the upper three to four inches porous and open, containing numerous moulds and casts of gasteropods, brachiopods and corals. Distinct lamination is to be seen in places. A drill core of this and the deeper beds was taken out in 1895; but the cores had been disturbed and some lost, so that the record obtained from them was unsatisfactory, except in a few cases where the depth had been penciled upon the core at the time of its removal. A silicious dolomite, streaked with blue, was found to overlie the bed of white sandrock struck in the Nicol's well. This latter appears to be six to seven feet thick, but contains much dolomitic matrix, and extends from about twenty-four to thirty feet of depth in the well. Beneath this bed lies a compact silicious dolomite, streaked and blotched with blue, which in turn, cannot be many feet above the surface of the Sylvania sandstone.

Just west of the Davis quarry there are two small excavations which have entered the "first formation" to a depth of two to three

*I am inclined to refer it to calcite. It seems to be a widespread phenomenon at about this point in the geological scale, as I have noticed it frequently in the Upper Peninsula. See also Rominger Geol. Sur. Mich., Vol. I, Part III. p. 27, and Dana's Geology, p. 247 of the first edition. L.



feet. The larger lies just west of the highway and north of the railroad upon the property of Michael Voight and the other to the south, upon the opposite side of the railroad, and belongs to Byron Wilcox.

§ 7. Lulu quarry.

In Sec. 16, N. W. ¼, N. W. ¼, the rock rises to within three to five feet of the surface, upon land now belonging to Henry McCarthy. Rock for local building purposes was removed here fifty years ago and the main part of the quarry for many years was in possession of Henry Y. West, now of Lulu. The excavation contained too much water at the time visited to allow a satisfactory inspection of the beds, but they were seen to correspond with those penetrated by the drill in the Ida quarry. The strata have here been thrown into a fold giving a high local dip to the east and west by south. This might be a good place to test for oil. A v-shaped break extends northeast and southwest across the quarry on either side of which the strata are said to overlap "like shingles on a roof." The quarry has followed this break for nearly one hundred yards and the layers have been removed for a short distance on either side, the west wall furnishing the best exposure. An upper layer nine to ten inches thick, is a buff dolomite, highly charged with rounded sand grains, varying considerably in size. Beneath is a twelve inch layer of a less gritty, tough, light gray dolomite, succeeded by a white sandstone layer of the same thickness. These three feet represent the lower portion of the sandrock of which cores were obtained in the Davis and Nicol's wells. The main quarry rock consists of those dolomites which lie between this bed and the Sylvania proper, of which eight to nine feet have been exposed. These are compact gray dolomites, more or less mottled, streaked and blotched with rather vivid blue coloring matter. Some of the rocks much resemble in appearance, as Rominger suggests, castile soap. According to Mr. West there are two acres here over which rock could be easily quarried, lying within one quarter of a mile of the Ann Arbor R. R. An analysis of the dolomite gave Rominger the following:

| | |
|---|---|
| Calcium carbonate | 54% |
| Magnesium carbonate | 42 |
| Quartz sand | 4 |

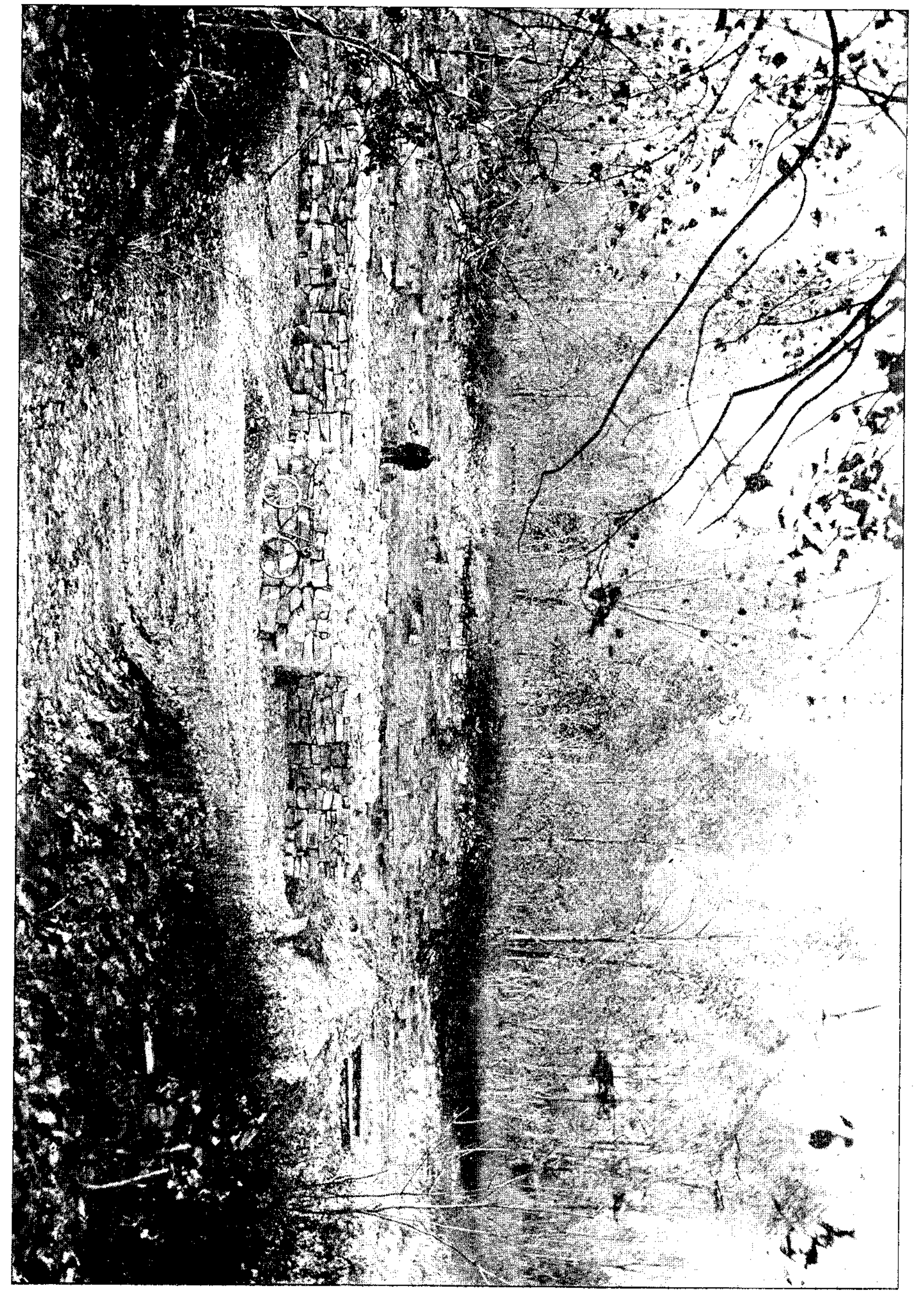
§ 8. Little Sink quarry.

A small but interesting quarry has been opened upon the eastern edge of what is known as the "Little Sink," to be later described. The excavation lies in the S. E. ¼ S. E. ¼ Sec. 2, Whiteford township upon land owned by Morris Cummins. Over an area of ten to fifteen acres the rock lies very near the surface, so that the scanty soil is practically unfit for agricultural purposes. The rock in some places is entirely bare of soil, while in others its thickness varies from one to two feet. Upon the west side of the quarry there is practically no stripping, but this reaches a thickness of one to one and one-half feet upon the eastern side. In passing southwestward from Lulu the surface of the rock is depressed, covered with a heavy belt of sand, and next reappears here at the surface in consequence of having attained an elevation above sea level of about 670 feet. The quarry is nearly equi-distant from the Ann Arbor R. R. and the Toledo-Adrian branch of the Lake Shore railroads, being about five miles from each in a direct line. In consequence, the markets are entirely local the demand being simply for building stone. The present quarry was opened about thirty-five years ago, but previously stone had been superficially quarried for building purposes and for the manufacture of lime upon a small scale. The opening is in the form of an irregular quadrilateral about 100 by 50 feet, and the strata have been penetrated from nine to ten feet. The water enters the crevices of the rocks through which it drains away except in the early spring, when the entire region is liable to be flooded.

Two fairly distinct beds may be recognized which overlie a pure white sandrock in which the grains are cemented by a dolomitic matrix. A comparison of these beds with those previously described shows that they are intermediate between the beds exposed in the Ida and Lulu quarries, being, indeed, those penetrated by the drill in the Davis quarry before the white sandrock was reached. The Lulu strata will then be exposed here by going deeper. The uppermost bed is thin-bedded and varies in thickness, within the limits of the quarry, from three to five and one-half feet. Typically it is a compact, tough, gray dolomite, showing a rather bright greenish stain in places. Towards the surface it is fissured and weathered considerably, showing a rusty iron coloration. The rock is penetrated with numerous channels which seem to be the preserved bur-







"LITTLE SINK." CUMMINS QUARRY. SHOWS ALSO SCANTY SOIL AND STUNTED FOREST GROWTH.

rows of marine annelids. Fossils are abundant at certain levels. The second bed is three and one-half feet thick and is a gray dolomite streaked horizontally with blue, as seen in the Lulu quarry. In the upper foot of this bed these blue streaks are altered to a rusty brown, suggesting that the blue coloration is due to some oxidizable compound of iron. No fossils were observed in this bed except a faint trace of a cephalopod. A few cavities occur in which are found crystallized masses of calcite and strontianite. There also occur some peculiar stylolites, in the form of sub-cylindrical plugs, in diameter ranging from one and one-half to eight inches and in length from one and one-half to seven inches. They are set vertically in the strata with their upper ends on a level with the surface of the rock. They separate quite readily from the rock in which they are embedded and show the peculiar splintery surface, which characterizes these structures. Occasionally one is seen which is well defined above but which gradually merges into the rock of the stratum and its form disappears. The film of carbonaceous matter commonly present is here represented by an iron stain, or by the blue coloring matter with which the bed is streaked. These plugs have the same composition as the surrounding rock and on being broken show no internal structure. The upper end of each is deeply concave and in every one observed there is a small handful of angular chips of dolomite loosely cemented together. The most plausible explanation seems to be that in the general disturbance of the region the rubbing of the strata over one another detached the small chips. Some of these collected in the cavities at the upper ends of the stylolitic plugs and were preserved, while those which remained between the strata were ground to powder. The structures themselves strongly suggest an organic origin but are believed to have been caused, in some unknown way, by pressure. A small sink and quarry occur upon the place of Daniel Rabideu at the S. W. ¼, N. W. ¼, Sec. 10. This lies about half way between the quarry just described and those to be described in the next paragraph. Only a small amount of stone has been removed. It is a horizontally streaked dolomite, of a dark drab color, containing some minute calcite crystallizations.

§ 9. Ottawa Lake quarries.

These are located near the head of the lake in the east central part of Sec. 7 and the west central part of Sec. 8, Whiteford township. They represent one nearly continuous irregular excavation but lie upon the adjoining properties of no less than seven different individuals. The main excavations belong to Ezra Daniels and Frank Kane and are in the S. E. ¼, N. E. ¼, Sec. 7. The rock in this region attains the highest elevation of any in the county, being about 680 feet above tide, or 107 feet above the level of Lake Erie. The dip of the beds is irregular, but high compared with that in other quarries of the county. In the Daniel's quarry it ranges from four to nine degrees and in direction is approximately W. 20° S. Owing to the elevation and channeled condition of the strata there seems to be no trouble with quarry water. Ottawa Lake station is distant two and one-half miles but the railroad itself is less than two miles from the quarry in a direct line.

Four beds may be recognized which may be conveniently referred to by letters as in preceding descriptions. The uppermost, or bed A, is a compact, gritty dolomite of a buffish brown color. Dilute acid applied directly to the cold solid rock gives but little action, but when the rock is powdered and the acid heated the action is vigorous and continues for a considerable time. There is finally left a little brownish sediment and a considerable quantity of fine sand grains, which give the same appearance under the microscope as those found in the Woolmith silicious dolomites. The surface of the bed is more or less broken and softened by water action, the dolomitic matrix being partially dissolved, leaving behind a rock relatively richer in sand. The entire stratum thickens in the direction of the dip, becoming thinner and thinner bedded toward the north and east. Bed B is a cherty layer having a thickness of twelve to eighteen inches in the Daniels quarry, but thinning rapidly northward and disappearing upon the west wall of the Kane quarry. The chert is much shattered as by earth movements and is impure, being altered in places to a soft, gray, mealy substance. Considerable clay has been deposited in the crevices, undoubtedly from surface water. The bed yields some fossils. The main quarry rock is obtained from bed C which is a compact dolomite of the same general character as that of bed A. The lower layers have a deep blue color, which in the upper part of the bed has all been altered to a buff. The same change in color has occurred lower down along seams and near the surfaces of the individual strata, so that much of the rock quarried from this bed shows only a blue core. Numerous ellipsoidal concretions occur, reaching a diameter of five to six inches, and one stylolitic plug was found, similar to those seen in the Little Sink quarry. This bed attains a thickness of nine to ten feet with two quite distinct structural breaks. Bed D forms the floor of the Daniels quarry and shows two feet in the McQuarrie quarry to the northeast, where it was burned for lime but found to yield a poor quality. It is a buff to gray compact dolomite, gritty to the feel and showing some carbonaceous films. In the latter quarry the strata are nearly horizontal, but in the Daniels quarry drop off rapidly in the direction of the dip from an open seam which extended in a northeast and southwest direction. In the quarries immediately adjoining those above mentioned the same silicious dolomite is exposed. About two hundred paces eastward a small opening was made and rock was quarried for lime to a depth of three to four feet.



At the northern end of the lake, upon a level with the water when it is full, there occurs an outcrop of a gray dolomite, S. E. ¼, S. E. ¼, Sec. 7. An old side hill lime kiln was operated here thirty-five years ago by Walter K. Hadley, now deceased. The rock was quarried only while the lake was dry. In general appearance and fossils it much resembles the upper bed in the Little Sink quarry. At the lower end of the lake a buffish brown compact dolomite outcrops in the bed of the small stream known as the Inlet, S. E. ¼, S. E. ¼, Sec. 19. On the north bank of this stream and just west of the railroad there stands the ruins of an old lime kiln, showing that rock was quarried from the Inlet and here burned. A small artificial opening, two to three feet deep, lies north of the stream and east of the highway and furnished rock also for the burning. This is a fine grained, drab dolomite smooth to the feel and much resembling bed I of the Woolmith quarry, with which it should be correlated. The silicious dolomites at the head of the lake are believed to be the equivalent of the overlying silicious beds of the Woolmith, differing chiefly in the character of the bedding.

The foregoing descriptions are believed to cover all the localities from which rock has been thus far quarried for any purpose from the Monroe series above the Sylvania. The dolomites seen at Flat Rock, Gibraltar and Grosse Isle belong to the same set, lying between the Sylvania sandstone and the Dundee formation exposed at Trenton. An analysis of material obtained by a drill from these beds in the N. E. ¼, S. W. ¼, Sec. 8, Ash township is kindly supplied by General Manager S. T. Crapo, of the Pere Marquette R. R.:

| | |
|---|---|
| Calcium carbonate | 55.03% |
| Magnesium carbonate | 42.17 |
| Iron oxide and alumina | .48 |
| Silica and other insoluble residue | 2.32 |
| | 100.00 |

*(b) Quarries Below the Sylvania Sandstone.*

§ 10. Newport quarries.

The fold in the dolomite layers which constitutes the "ridge" passing from Sylvania northeast to Stony Point, has brought the rock very near the surface in many places and a large number of small quarries have been opened upon it. Following the strike of the beds very closely, as does this fold, there is much sameness in the general appearance and composition of the rock exposed in the numerous openings. Towards the base of the Sylvania sandstone the dolomite becomes highly charged with rather coarse sand grains, as seen in the Smith quarry west of Newport, and in the rock removed from the bed of the Raisin. The deeper beds are more homogeneous and compact, of a light or dark drab color and are all true dolomites. Fossils, in the form of moulds or casts occur in many places and will be treated in the last chapter of this report. The bed of oölite which has been previously traced and described, happens to occupy the crest of the ridge for a long distance and is much in evidence for a bed of such thickness. The most northern openings in this series may be conveniently grouped as the Newport quarries. The most important of these lies in the N. E. ¼, S. E. ¼, Sec. 1, Berlin (T. 6 S., R. 9 E.) just south of the village of Newport Center, upon the west side of the Michigan Central R. R. The quarry consists of a roughly rectangular opening about 200 by 50 feet. At the time of visit it was filled with water, so that its depth and the beds represented could not be satisfactorily determined. The rock is of a dark drab color, certain layers being charged with fossils, but all the calcium carbonate has been dissolved. A small crusher was operated for a time in connection with the quarry, but work has ceased and the building and machinery have been removed. In the village of Newport Center, from the Lake Shore R. R. bridge, up Swan Creek for a distance of a quarter to a third of a mile, rock is readily reached in the stream and along the banks. Irregular openings have been made upon the places of Cartwright and Brancheau and rock removed for local building and construction work. Samples taken



show that it is of the same character as that above noted. One and one-half miles west, upon the land of Mrs. Lizzie Smith, S. E. ¼, S. E. ¼, Sec. 34, of Ash township, a rectangular quarry has been opened having the approximate dimensions 100 by 80 feet. This also was full of water at the time of the visit. The hand samples taken show that the beds here are more or less silicious, of coarse, rounded sand grains embedded in a drab, dolomitic matrix. One specimen is a buffish gray grit, with dolomitic cement. These beds are the highest in the series of any exposed in the quarries that remain to be described and are from twenty to thirty feet below the base of the Sylvania sandstone.

§ 11. Frenchtown quarries.

In the southern part of this township the ridge changes its northeasterly course rather abruptly, swings around to the southeast and strikes the Lake at Stony Point and Point aux Peaux. In its course across the township it furnishes the sites for several quarries. The most northern of these is that upon claim 529 (south of Swan Creek), belonging to Henry G. Sissung. There are said to be here 160 acres of land over which the stripping will not average more than two feet. The quarry was opened at an outcrop some fifteen years ago where the stripping increases to the southwest. The rock dips southward a few degrees. The strata average eight inches in thickness and about seven feet have been penetrated in the deeper portions of the quarry. They furnish good building stone for the local market, consisting of compact gray and drab dolomite. A much larger opening lies upon the same claim to the southwest upon the place of Richard Labeau. Its dimensions at the time of visit were about 240 by 175 feet, superficially quarried. The character of the beds and of the rock resembles that of the Sissung quarry. In the bed and along the banks of Stony Creek, at Brest, a small amount of rock has been quarried for the local market. The exposures extend from the highway up stream for a third of a mile. The lower bed consists of a gray dolomite, filled with small, irregular cavities from which fossils have been removed by solution. Above this lies a bed of more compact darker dolomite, mottled with blue as in the case of the Lulu and other quarries located above the Sylvania sandstone. Still higher lies the bed of oölite previously described and best seen upon the property of Mrs. Mary Emerson. Following southwestward where Sandy Creek crosses the ridge, for a distance of three-fourths of a mile, rock can be struck with a probe and appears at frequent intervals in the bed of the stream. A small amount of the rock has been removed upon the place of Peter Suzore. It is a tough, compact rock of a grayish drab color.

The most important quarry in the eastern part of the county is the one now being operated by the Monroe Stone Company. This is located in the southern part of Frenchtown, about two miles north of the city of Monroe, claim 64, North River Raisin. It lies between the Lake Shore and Michigan Central tracks and is connected with the Pere Marquette by means of a switch, so that the shipping facilities are all that could be desired. The quarry was opened in September, 1895, since which time work has been actively pushed and an immense amount of rock crushed and marketed. The stripping averages about two and one-half feet varying but little toward the east and west. Two hundred feet to the south it equals four feet in thickness while one hundred feet north it equals three feet. The upper layer is glaciated above, as is uniformly the case in the county. For fourteen feet the rock is thin bedded, the strata varying in thickness from two inches at the top to ten inches below, and is shattered and broken so as to have no value for building purposes. It is a dark drab dolomite, of fine grain and even texture, breaking with rough conchoidal fracture and sharp edges. Thin, wavy carbonaceous films traverse the rock. Between the strata are layers of a soft putty-like clay which hardens upon exposure. These sometimes reach a thickness of two inches and represent surface material brought in by percolating waters. A good view of the bed as seen upon the west wall of the quarry is shown in Plate IV. At the base of these beds there is a thin stratum of *breccia* made up of angular fragments of a deep blue dolomite, another which is finely laminated and further, fragments of oölite, all contained in a drab, dolomitic matrix. Beneath this lies a bluish gray layer, streaked and mottled with a deeper blue coloring substance. Two large sink holes were encountered in the quarry, which at the time of examination was in the form of a semicircle, with a radius of about 130 feet. These holes were well like openings with a diameter of six to ten feet, containing at the bottom a mass of irregular fragments, cemented with crystallized calcium carbonate. The following analyses of the rock from the upper and main beds were kindly supplied by Mr. K. J. Sundstrom:



| | 2 feet down. | 7 feet down. | 10 feet down. |
|---|---|---|---|
| Calcium carbonate | 54.54% | 54.47% | 54.94% |
| Magnesium carbonate | 42.75 | 43.59 | 42.84 |
| Silica | 2.00 | .74 | 1.33 |
| Iron oxide and alumina | .70 | .98 | .58 |
| Difference | .01 | .22 | .31 |
| | 100.00% | 100.00% | 100 00% |

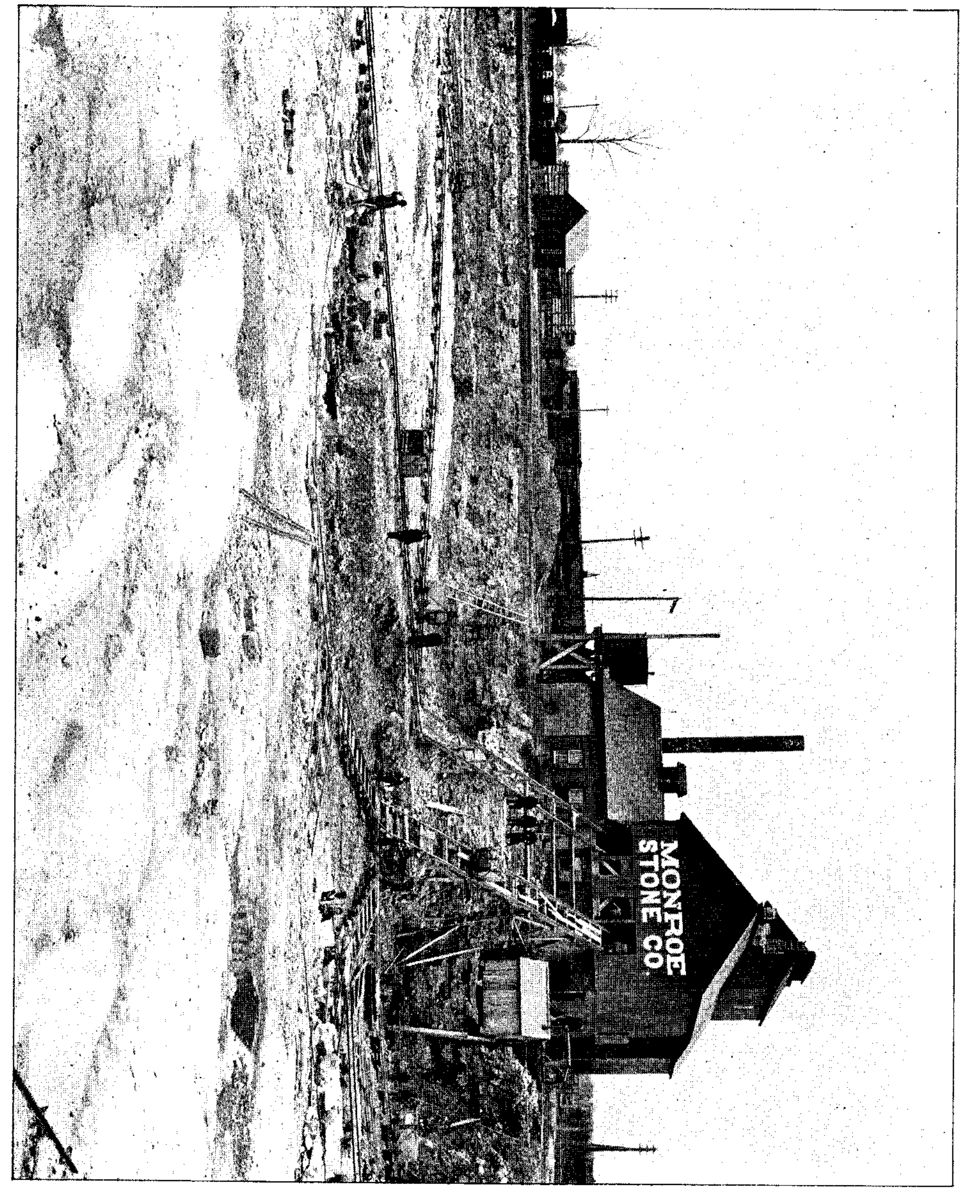
§ 12. Monroe quarries.

To the south of the city of Monroe there have been opened several quarries of more or less importance, chiefly in the immediate vicinity of Plum Creek. Some of these furnished building stone and lime in an early day to the French settlers of the region. The main excavations are upon the north side of the creek and lie upon adjoining divisions of claim 498, belonging to Alexander T. Navarre and Mrs. Mary T. Navarre. The stripping consists of a stony, yellowish brown clay, from three and one-half to five feet thick, deepening mainly towards the west. In the northeastern part of the irregular excavation two fairly well defined folds intersect one another, one bearing N. 45° E. and the other N. 60° W. From these ridges the rock dips in four directions from two to five degrees. In the A. T. Navarre quarry the dip is approximately one to two degrees toward N. 61° W. Here four beds may be recognized, the upper of which is termed the "white bed." This is a gray to creamy white dolomite, six to seven feet thick, thin bedded and fissured above, but thicker toward the base. Many loose pieces of this bed are in the clay stripping, softened upon the surface to a mealy powder. At the lower part this bed passes into a nine to ten inch stratum, which is very compact, even grained, somewhat laminated, and sparingly streaked with blue. The rock is brittle, gives sharp edges and coarse, conchoidal fracture. Owing to its higher specific gravity it is known in the quarry as the "lead bed." Beneath this lies a two foot "gray bed," made up of a fossiliferous, light drab dolomite, carrying some films of carbonaceous material. The lowest bed exposed in the quarry at the time of the visit is the so called "blue bed." This is a compact heavily bedded dolomite, inclining to drab on fresh fracture but having a decided bluish surface upon standing. Struck with a hammer the slabs give out quite a ringing sound. The individual strata have very rough upper surfaces, covered with black carbonaceous deposit. The blue color is not so marked in the portion of the quarry belonging to Mrs. Navarre and the bed not so sharply separated from the overlying one. A local deposit of brecciated material similar to that found in the sink holes of the Monroe Stone Company quarry, was observed at one place. Upon the south side of the creek the rock lies very near the surface and a linear excavation extends for a considerable distance parallel with the stream. It is here that the bed of oölite, previously described, appears. Above it is a creamy dolomite, becoming somewhat blue, while beneath is a compact, laminated bed, streaked horizontally with a rusty brown. Judging from the alteration in the mottled dolomite seen in the Little Sink quarry this bed is of the blue streaked variety. These beds underlie those above described, as well as those in the quarries north of the city.

One-half mile down stream a large quarry has been opened between the two railroad tracks by the Michigan Stone and Supply Co., the owners of the Woolmith quarry. The excavation is in the form of an irregular rectangle about 450 by 125 feet. At the time of the visit it was well filled with clear blue water so that the strata could not be examined. Toward the north side the depth is said to be thirty-two feet, penetrating a lower series of beds than are seen elsewhere in the county. The rock was used entirely for road purposes and a crusher was operated in connection with the quarry. For five years no work has been done here, owing, it is reported, to the damage done to neighboring houses by the blasting. The ledges exposed above the water are thin-bedded fissured dolomites, of a light color. In the stone pile at the crusher there are seen fragments of a compact, fossiliferous, drab dolomite; another of a bluish color and conchoidal fracture and a third blue shaly rock, friable and carrying carbonaceous seams. The former foreman says that the strata are very much disturbed in this quarry and "run every way."

During periods of low water in the Raisin, rock is quarried directly from the bed opposite the city and for a distance of three to four miles above, at frequent intervals. The lower beds thus exposed consist of gray and drab dolomites, the latter finely laminated. A view of these layers is shown in Plate VIII, but was not taken at the lowest stage of the water. Opposite claims 65 and 88 (North River Raisin) the rock is a creamy yellow dolomite, in some






MONROE STONE COMPANY, CRUSHER AND WEST WALL OF QUARRY.

layers very finely laminated. Further up the river the higher beds occur and are seen to become more silicious as the Sylvania sandstone is approached. In Willow Run, at its mouth a thin layer of sandstone occurs, which much resembles the Sylvania except for the greater coarseness of its grains. Near the top of the series there occurs a stratum of bluish gray and brown chert, somewhat brecciated and carrying obscure fossil remains.

Within a distance of a half mile south of the Plum Creek quarries four small openings have been made and rock removed for local purposes. Some two hundred paces south a small field quarry has been opened upon claim 498, belonging to Alexander T. Navarre. From three to five feet of bluish to buff dolomite are exposed. Locally the strata are laminated, in places homogeneous. The rock weathers to a soft, mealy substance of a creamy color. Numerous fragments are loose in the clay stripping, which varies in thickness from a few inches to three feet. About one hundred paces to the southwest of this quarry Dennis Navarre has a small field quarry into the same bed. Some of the rock shows the brownish mottled effect seen on Plum Creek in the beds associated with the oölite. The two other quarries are upon the same claim and are upon the banks of Tamarack Creek. The most westerly one belongs also to Dennis Navarre and is located near his residence. The opening is three to four feet deep and was filled with water at the time of the visit. The bed of oölite is here exposed and some of the overlying dolomite, which is creamy and slightly mottled. For a distance of about 300 paces down stream the rock appears in outcrop and an irregular quarry has been opened upon the property of Patrick Navarre. The rock is thin-bedded and fissured above, but the deeper layers attain a thickness of nine to ten inches. The upper strata are buff to gray and mottled with brown to a depth of four feet. Beneath this the rock is compact and of a drab color. The strata here dip 7° toward N. 16° E., both of which are abnormal.

§ 13. La Salle quarries.

No quarries of any magnitude or especial importance have yet been opened south of Plum Creek, but the rock is near the surface in many localities and the railroads are near at hand to give the necessary shipping facilities. Excepting the bed of oölite previously noted, the rock is a gray to drab dolomite, generally compact and adapted for road metal, of which the region generally stands in great need. Within the limits of La Salle township a number of minor quarries have been started, of which but little more than mention may be here made. In the bed of Otter Creek, just west of the Pere Marquette bridge, rock is now being quarried and for a distance of a mile up stream rock is accessible. Upon claim 436 (South River Raisin) Charles Heck has removed a small amount of stone from the south bank of the creek. In Sec. 20 along the south branch of Otter Creek, the surface of the rock has been reached by the stream for a considerable distance. In the N. W. ¼, N. E. ¼ of this section a quarry was opened along this branch and considerable rock removed by Jacob Clock. In the northern part of Sec. 32 and southern part of Sec. 29, along Muddy Creek, the rock is so near the surface that it had to be blasted out in deepening the stream. Some rods south in the N. W. ¼, S. E. ¼, Sec. 32, an irregular quarry, with ruins of a lime-kiln, is situated upon the land of W. W. Green. Further south in the same section, S. W. ¼ S. E. ¼, Mr. Edward Green has a small opening south of his residence. A still smaller opening was made in the N. W. ¼, S. W. ¼, upon the place of Saml. B. Cousino. Eastward in the S. W. ¼, S. W. ¼, of Sec. 33, a considerably large opening has been made upon the ridge by Eli Cousino. The quarry is an irregular one 300 by 75 feet and eight to ten feet deep, with a small test hole a short distance to the southwest. These openings are very near the north and south section line, to the east of the residence. The rock is the common type of drab dolomite, in rather thin layers.

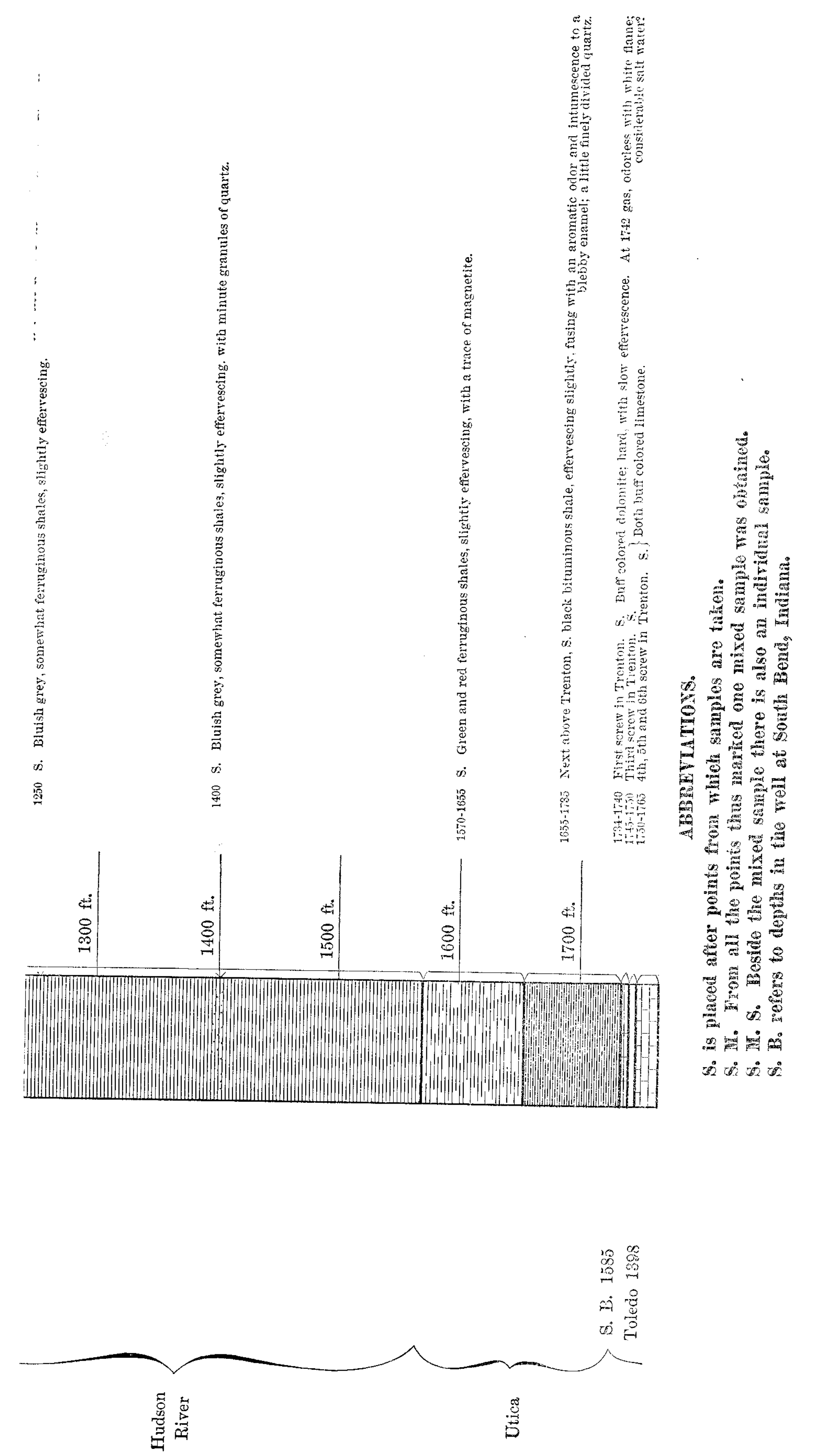
§ 14. Bedford quarries.

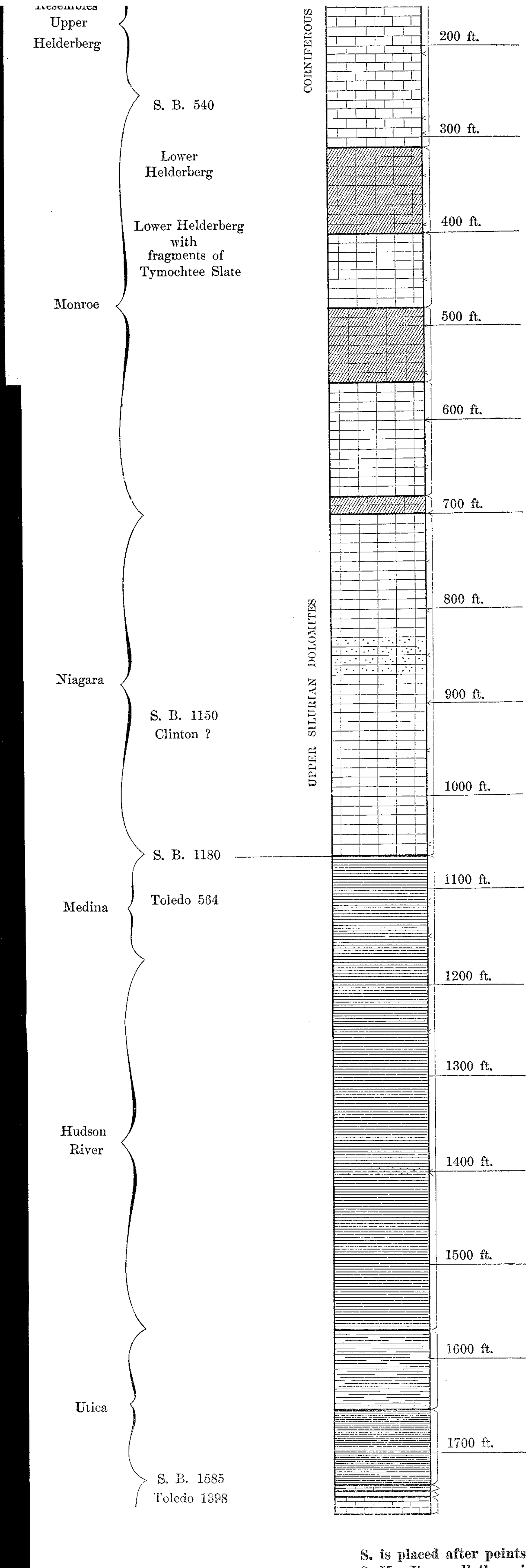
Three small quarries have been opened near together and excavated to a depth of two to three feet at the center of Sec. 12, Bedford township. The largest of the three belongs to M. Butler and is in the S. W. ¼, N. E. ¼. At the time of the visit it was filled with water as is usual in the case of quarries that stand idle for a length of time. The rock samples collected show that the rock is a somewhat incoherent and not homogeneous drab dolomite. In the N. E. ¼, N. E. ¼, of this same section Thomas Blouch has opened a quarry in Bay Creek ditch, which extends some 200 yards along the stream. The stripping varies in thickness from two to four feet and the rock is a compact, drab dolomite. On the opposite side of the road, upon the place of C. L. Osgood, S. E. ¼, S. E. ¼, Sec. 1, similar rock has also been quarried. About Little Lake in Sec. 15, the rock again approaches the surface and furnishes the sites for five small irregular quarries, exposing a few feet of the beds associated with the oölitic stratum. Three of these quarries are located on adjoining land at the center of the N. W. ¼ of Sec. 15, and belong to Misses J. and N. Ferguson, Mrs. White and C. Willis. The White quarry consists of a shallow excavation extending over an area of four to five acres. The oölite previously described is here eighteen to twenty inches thick. Above this is a thin bedded, light colored dolomite and beneath is a more compact brittle variety. Lime was at one time burned here. In the Willis quarry the oölite also appears and a compact drab dolomite, streaked horizontally with bands of faint blue. The excavation is here eight to ten feet deep. In the Ferguson quarry the upper bed is much fissured and broken into angular fragments, which are recemented into a breccia. It is interesting to note that this breccia occurs at the same horizon as that seen in the quarry of the Monroe Stone Company, and the layer exposed at Stony Point (see Plate XII). Beneath the brecciated stratum there is a compact, bluish-gray dolomite. To the northwest from this group of quarries about one-quarter to one-third of a mile occur two others. One belongs to Elisha Sorter and is located in the N. E. ¼, N. E. ¼, Sec. 16, upon the ridge. This is a small triangular opening from which rock has been taken to a depth of three feet and burned into lime. The dolomite here is compact, bluish-gray and contains numerous fossil casts and moulds. To the naked eye and still better under the magnifier, it shows a very fine crystalline structure the reflections from the minute cleavage faces causing it to sparkle. Some 200 paces west a small test opening was made into the same beds and a second about 130 paces to the south, the latter showing the oölite. In the S. W. ¼, S. W. ¼, Sec. 10, upon the land of William Dunbar an irregular quarry has been opened in a meadow 100 paces east of the residence. The main rock shown here is the oölite with a small amount of overlying dolomite. One-quarter mile north similar rock has been removed from a ditch. In the N. E. ¼ of Sec. 21, a small quarry has been opened upon the road side by George Carr. Two to three feet of the bed are exposed showing it to be a thin-bedded and shattered faintly-streaked dolomite.

§ 15. Whiteford quarries.

There remain but two small quarries to be briefly described and these are located in the southern part of Whiteford township. Those lying above the Sylvania sandstone have been described in a previous section of this chapter. In each of these two quarries the oölitic stratum occurs in a peculiarly modified form, termed locally "bastard limestone." This is best seen in the quarry of Nelson Bush in the S. W. ¼, S. E. ¼, Sec. 25, just north of the east and west road. The rock here seems much disturbed and broken and suitable only for road work, for which it has been used. At the time of the visit a portable crusher was at work preparing stone for a road leading into the city of Toledo. The uppermost strata consist of a very compact bluish-gray dolomite which passes into the oölite, both forming a bed five to six feet thick. Beneath lies a gray compact bed which has been entered but a short distance. East a few rods considerable rock has had to be blasted from the bed of Bay Creek, in order to suitably deepen it for drainage purposes. Large blocks of the oölite and compact dolomite are found upon the bank, along the stream, for a considerable distance.

The second quarry of this group belongs to Stephen Young and is situated in the N. E. ¼, N. E. ¼, Sec. 4 (T. 9 S., R. 6 E.) about twenty-five rods northeast of the residence. The excavation is an irregular quadrilateral about fifty feet long and has a depth of five feet. Near the center of the quarry the rock strata are said to have been horizontal but about the sides appear much disturbed. The rock is the compact, modified oölite of a buff color and gritty feel, so that it is easily mistaken for a sandstone, upon superficial examination.






210 Yellowish limestone, briskly effervescing.

260 S. M. Here and at 350, 500 and 650, samples of a white earthly powder of calcite and dolomite, with a trace of gypsum, [probably a chemical precipitate from underground water.]

{ 280 / 297 } Water, 3000 gallons per hour.

340 S. Dolomite; effervesces slowly when in fine powder; contains much anhydrite of a dark buff color.

S. M.

370 S. Buff dolomite; effervesces slowly in splinters as though from a massive layer, with anhydrite.

390 S. Buff dolomite like the sample above, mixed with greenish dolomitic shale ? with gypsum.

450 S. Buff dolomite like the sample above, effervescing moderately fast, with an occasional fragment of the green shale, little or no sulphate of lime.

500 S. M. S. Light colored calcareous dolomite, effervescing moderately, with much anhydrite.

550 S. Light colored calcareous dolomite, effervescing slowly; in course chips, with much anhydrite.

600 Trace of gas. S. Light colored dolomite; effervesces slowly; an occasional grain of sand; no anhydrite.

650 S. M. S. Light grey dolomite; effervesces slowly; an occasional grain of sand.

700 S. Light grey dolomite; effervesces slowly; reacts for gypsum.

750 S. Light yellowish dolomite; effervesces slowly; quite ferruginous; no gypsum.

800 S. Bluish grey dolomite; effervesces slowly.

850 S. White arenaceous dolomite; effervesces slowly; with grains of quartz, sand and a very little magnetite.

900 S. White arenaceous dolomite; effervesces slowly; with grains of quartz sand; contains a little magnetite; like the formation at 1150 of the South Bend well, Indiana.

950 Salt?

1050 Last limestone before shale. S. grey dolomite, effervescing slowly with a trace of quartz.

1110 S. Greenish and reddish shales, effervescing slightly; mostly clay.

1150 S. Greenish and reddish shales, effervescing slightly; mostly clay.

1250 S. Bluish grey, somewhat ferruginous shales, slightly effervescing.

1400 S. Bluish grey, somewhat ferruginous shales, slightly effervescing, with minute granules of quartz.

1570-1655 S. Green and red ferruginous shales, slightly effervescing, with a trace of magnetite.

1655-1735 Next above Trenton, S. black bituminous shale, effervescing slightly, fusing with an aromatic odor and intumescence to a blebby enamel; a little finely divided quartz.

1734-1740 First screw in Trenton. S. Buff colored dolomite; hard, with slow effervescence. At 1742 gas, odorless with white flame; considerable salt water?

1745-1750 Third screw in Trenton. S. } Both buff colored limestone.
1750-1765 4th, 5th and 6th screw in Trenton. S. }

## ABBREVIATIONS.

**S. is placed after points from which samples are taken.**
**S. M. From all the points thus marked one mixed sample was obtained.**
**S. M. S. Beside the mixed sample there is also an individual sample.**
**S. B. refers to depths in the well at South Bend, Indiana.**

# CHAPTER V.

## PHYSICAL GEOGRAPHY.

§ 1. Climate.

The geographical position of Monroe county, its proximity to Lake Erie, its topography, and the prevailing direction of wind combine to make it one exceptionally favored so far as productive climate is concerned. It corresponds, in all essential particulars, with the noted fruit belts of western New York and northern Ohio. Lying low and flat, hemmed in on the west and northwest by morainic ridges, with the great body of water, which forms its entire eastern boundary, slowly radiating its summer heat, fall frosts are delayed sufficiently for crops to mature. Upon an average, not until October 12th does the first killing frost occur in the center of the county. During the past ten years the earliest date at which this has occurred was Sept. 21st and the latest was Oct. 30th. During the greater part of each year the wind blows from the quarter of the compass lying between south and west, as will be seen by examining Tables II and III. In consequence, the mean temperature is higher than it might otherwise be and the annual precipitation is abundant. According to statistics published in Walling's Atlas of Michigan by Dr. A. Winchell, the average annual precipitation at Monroe for eighteen years (1853 to 1870 inclusive) was 31.8 inches, with a minimum of 26.17 inches. This was distributed through the seasons as follows: spring, 8.11 inches, summer, 9.85 inches, fall, 8.27 inches, winter, 5.56 inches. During the past twelve years at Grape the precipitation has averaged about three inches less being 28.724 inches. At Toledo where approximately the same weather conditions prevail, as in the southeastern part of Monroe county, the mean annual precipitation for the past twenty-nine years is 30.68 inches, rather evenly distributed throughout the year as will appear from an inspection of Table IV. During the winter months, of course, some of this is precipitated as snow, ten inches of which are regarded as equal to one inch of rain. The average snow-fall

TABLE II.—ANNUAL CLIMATIC DATA, GRAPE, MONROE COUNTY, MICH.—J. W. MORRIS, OBSERVER.

| Year. | Temperature. | | | | | Precipitation expressed in inches. | | | | Frost. | Wind. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean annual. | Highest. | Date. | Lowest. | Date. | Total annual. | Greatest in 24 hours. | Date. | Total snowfall. | First killing frost in fall. | Prevailing direction of wind for the year. |
| 1888 | ... | ... | ... | ... | ... | 23.99 | 1.60 | November 11 | 22.5 | ... | ... |
| 1889 | ... | ... | ... | ... | ... | 31.50 | 1.35 | March 31 | 24.3 | ... | ... |
| 1890 | 49.4 | 99 | June 4 | 0 | March 6 | 30.44 | 2.92 | August 21 | 35.1 | October 21 | West. |
| 1891 | 50.0 | 96 | August 9 | 3 | February 4 | 25.77 | 1.12 | November 10 | 27.2 | October 30 | West. |
| 1892 | 48.4 | 95 | July 24 | —18 | January 20 | 36.82 | 2.94 | September 13 | 31.4 | October 24 | West. |
| 1893 | 47.9 | 94 | July 25 | —10 | January 14 and 15 | 27.40 | 1.83 | October 3 | 59.7 | September 26 | West. |
| 1894 | 50.0 | 96 | July 19 | — 8 | February 24 | 27.41 | 2.35 | September 5 | 30.0 | October 14 | Southwest. |
| 1895 | 47.5 | 94 | * | —14 | February 5 | 20.66 | 1.95 | December 19 | 59.9 | October 21 | Southwest. |
| 1896 | 49.4 | 97 | August 9 | — 8 | February 17 | 30.73 | 1.87 | July 26-27 | 33.5 | September 23 | Southwest. |
| 1897 | 49.1 | 98 | July 4 | — 9 | January 25 | 30.98 | 2.05 | July 26 | 37.5 | September 21 | East. |
| 1898 | 49.99 | 98 | September 2 | — 5 | February 3 | 32.43 | 1.41 | March 19 | 32.5 | October 26 | Southwest. |
| 1899 | 49.7 | 98 | August 11, 19 | —15 | February 10, 13 | 26.56 | 1.13 | December 11-12 | 34.6 | Sept. 30, Oct. 1 | Southwest to west. |
| Average | 49.14 | 96.5 | July 27 | — 8.4 | February 5 | 28.724 | 1.88 | September 1 | 35.7 | October 12 | Southwest. |

*June 3, July 16, August 10 and September 11.



at Toledo for the past fifteen years has been 33.6 inches, the greatest fall occurring during the winter of 1895-96, giving a total for that year of 63.7 inches. The least snow-fall during this period of years occurred during 1889-90 when there fell the surprisingly small amount of only 6.0 inches. For the past twelve years at Grape the amount is slightly in excess of the Toledo average, as would be expected. Here it has averaged 35.7 inches, with a maximum in 1895 of 59.9 inches and a minimum in 1888 of 22.5 inches. It is evident from these figures that even during winters of greatest snow-fall the bulk of the moisture received from the air is precipitated as rain. During the twelve years over which records have been kept at Grape, located near the center of the county, the maximum amount of rain-fall in twenty-four consecutive hours equaled 2.94 inches and this fell Sept. 13th, 1892. This was nearly equaled on Aug. 21st, 1890, when 2.92 inches fell.

TABLE III.—ANNUAL CLIMATIC DATA, TOLEDO, OHIO.—RECORDS OF THE U. S. WEATHER BUREAU.

| Year. | Mean temperature. | Total precipitation in inches. | Total snowfall in inches. | Prevailing direction of wind. |
|---|---|---|---|---|
| 1871 | 49.5 | 31.38 | ... | Southwest. |
| 1872 | 48.1 | 27.56 | ... | Southwest. |
| 1873 | 49.3 | 35.52 | ... | Southwest. |
| 1874 | 50.1 | 25.83 | ... | South. |
| 1875 | 46.4 | 28.03 | ... | Southwest. |
| 1876 | 49.0 | 34.55 | ... | Southwest. |
| 1877 | 50.7 | 35.17 | ... | Southwest. |
| 1878 | 51.8 | 32.67 | ... | West and northeast. |
| 1879 | 50.4 | 30.27 | ... | Southwest. |
| 1880 | 52.0 | 35.72 | ... | Southwest. |
| 1881 | 51.6 | 45.91 | ... | West. |
| 1882 | 51.1 | 33.03 | ... | South. |
| 1883 | 48.6 | 34.24 | ... | South and southwest. |
| 1884 | 50.0 | 28.43 | ... | Southwest. |
| 1885 | 47.0 | 33.19 | 41.9 | Southwest. |
| 1886 | 48.1 | 32.70 | 51.9 | Southwest. |
| 1887 | 48.9 | 32.01 | 36.2 | Northeast and southwest. |
| 1888 | 47.6 | 25.86 | 25.2 | Southwest. |
| 1889 | 49.8 | [illegible]1.84 | 18.7 | Southwest. |
| 1890 | 50.7 | 33.64 | 22.9 | Southwest. |
| 1891 | 50.3 | 27.12 | 26.7 | Southwest. |
| 1892 | 48.6 | 36.70 | 30.1 | Northwest. |
| 1893 | 48.3 | 23.81 | 44.9 | Northwest. |
| 1894 | 51.1 | 21.34 | 20.9 | Southwest. |
| 1895 | 48.2 | 25 31 | 58.6 | Southwest. |
| 1896 | 50.0 | 33.10 | 44.5 | Southwest. |
| 1897 | 49.6 | 30.35 | 31.5 | West. |
| 1898 | 51.0 | 28.10 | 20.9 | West. |
| 1899 | 50.0 | 27.06 | 28.4 | Southwest. |
| Average | 49.6 | 30.68 | 33.6 | Southwest. |

Of still greater importance to the agricultural interests of the county is the question of temperature, particularly its distribution through the year and the minimum reached during the winter. At

Grape for the last ten years the mean annual temperature as determined by standard instruments has averaged 49.14°, while at Toledo for the last twenty-nine years this average has been 49.6°. So far as we may judge from our data the minimum is most liable to be reached during the first week in February, but may range from the middle of January to the first week in March. The lowest temperature reached at Grape since 1890 was 18° below zero, Jan. 20th,

TABLE IV.—AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION, 1871 TO 1899.

| Month. | Temperature. | Percipitation. |
|---|---|---|
| January | 25.8° | 2.03 |
| February | 27.8 | 2.02 |
| March | 34.8 | 2.23 |
| April | 47.6 | 2.19 |
| May | 59.2 | 3.39 |
| June | 69.1 | 3.29 |
| July | 73.1 | 3.10 |
| August | 70.7 | 2.60 |
| September | 64.0 | 2.38 |
| October | 52.4 | 2.32 |
| November | 39.6 | 2.84 |
| December | 30.6 | 2.29 |

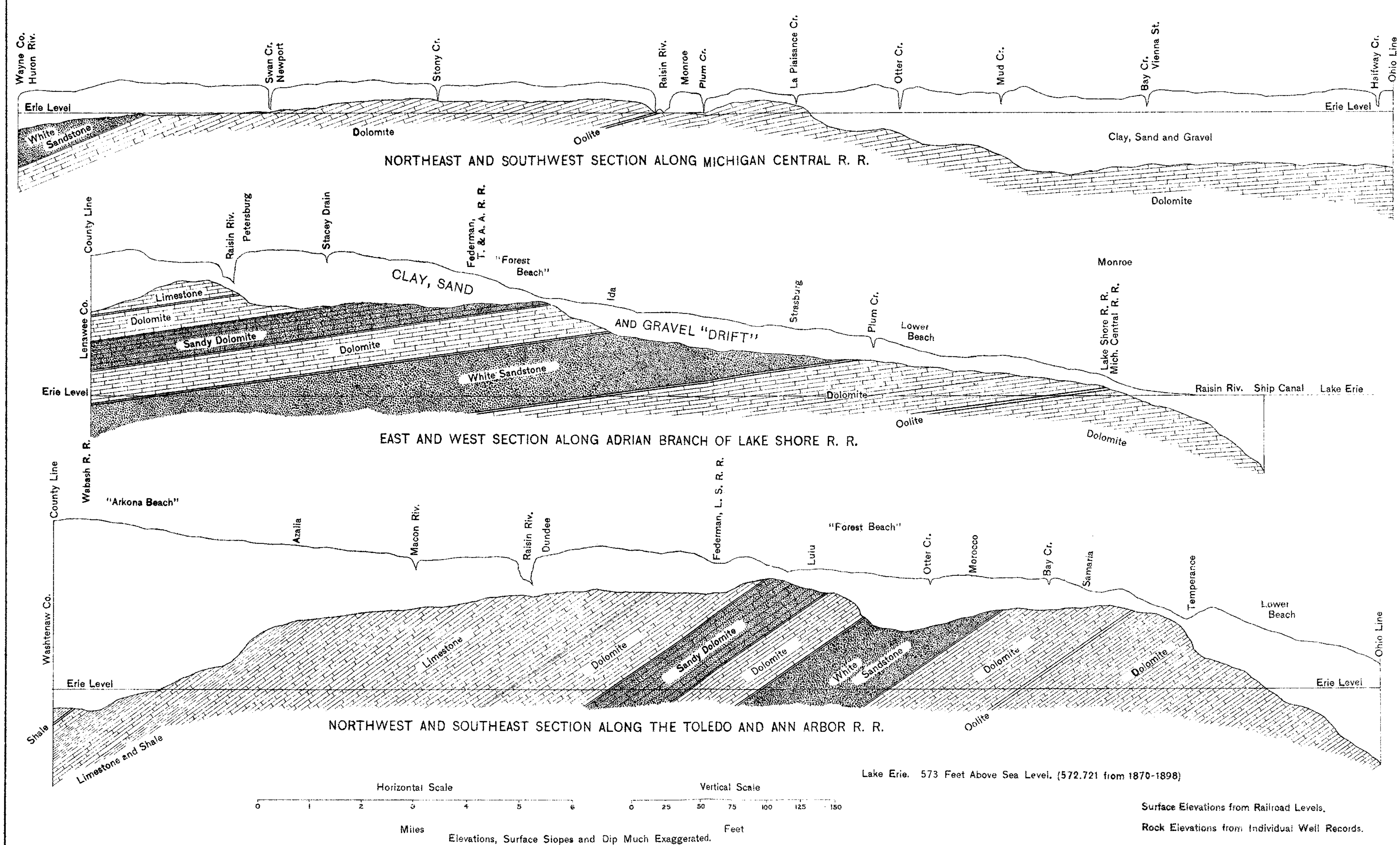
1892. The highest temperature recorded for this period was 99° on June 4th, 1890; unusually early in the season, the maximum averaging the last week in July. The summer isotherm of 70°, which marks the theoretical position of the sugar beet belt, cuts diagonally across the county. The distribution of the heat and moisture over the year is shown quite satisfactorily in Table IV, based upon the records taken at Toledo by the U. S. Weather Bureau.

TABLE V.—ANNUAL CLIMATIC DATA, TOLEDO, 1860-1869.

| Year. | Mean temperature. | Maximum temperature, F. | Minimum temperature, F. | Total precipitation. |
|---|---|---|---|---|
| 1860 | 49.343° | 94°, Aug. 6 | —10°, Jan. 2 | ........ |
| 1861 | 50.368 | 96°, Aug. 2 | — 4°, Feb. 8 | 36.4660 in. |
| 1862 | 51.732 | 97°, July 6 | — 2°, Feb. 15 | 42.9980 |
| 1863 | 51.069 | 95°, Aug. 6 | 6°, Feb. 3 | 32.6370 |
| 1864 | 49.987 | 98°, July 28 | —15°, Jan. 1 | 37.1545 |
| 1865 | 49.639 | 94°, July 6 | — 1°, Jan. 11 | 39.3120 |
| 1866 | 47.994 | 95°, July 16 | —16°, Jan. 16 | 40.6878 |
| 1867 | 48.819 | 94°, July 23 | — 6°, Jan. 14 | 31.0620 |
| 1868 | 47.761 | 100°, July 14 | —10°, Feb. 3 | 42.9375 |
| 1869 | 48.512 | 95°, Aug. 20 | 3°, Feb. 28 | 42.2500 |
| Average | 49.554° | 95.8°, July 25 | —5.5°, Jan. 26 | 38.9087 in. |

In the first volume of the Ohio Geological Survey the observations of Dr. J. B. Trembly are published in the form of two tables. These were taken at Toledo from Jan. 1st, 1861, to Dec. 31st, 1869,

# GEOLOGICAL CROSS SECTIONS ACROSS MONROE COUNTY.




W. H. SHERZER, Fecit

GRAND RAPIDS LITHO CO

and may be assumed to approximately represent the meteorological conditions that prevailed in Monroe county during this decade. Table V is compiled from these statistics and contains the more important data. It is interesting to notice that the rainfall is much in excess of that recorded from 1888 to 1899, and the lake level was higher at that time. Compare Plate V of Part II of this volume.

§ 2. General configuration of the county.

If it were not for the local mounds and irregular ridges which characterize the sand hills indicated on Plate VII, as well as the eroded stream valleys, the entire county would present the appearance of nearly unbroken horizontal plain. From the northwest corner, towards the southeast, there is an average downward slope of about seven feet to the mile, but this is imperceptible to the eye. A very gentle rise marks the position of the "stony ridge," extending from Sylvania to Stony Point, and varying in width from one-half mile to one mile. This peculiar flat effect has been produced by wave action, which cut down the natural eminences and filled in the depressions, thus grading the surface of the county until it retained barely enough slope for its own drainage. The irregularities above referred to as now to be seen, have been impressed upon the surface in a way to be presently described, after this wave action over the region affected had ceased. Upon Plate VI there is shown a series of vertical sections, across the county, along the line of the railroads, based upon the profiles of these roads and numerous well records. The upper section is along the Michigan Central, at right angles to the general direction of the surface slope, and shows the remarkably level character of the county when taken parallel with the lake shore. The lower section is along the Ann Arbor R. R. and the middle along the Adrian-Monroe branch of the Lake Shore, each cutting the direction of the slope at about 45°. The inclination of the surface is greatly exaggerated, however, by the vertical scale adopted, in order to bring out the irregularities. An inspection of these diagrams shows that the surface slopes more gently down to the broad sand belt, known as the Forest Beach, and then more rapidly to the present shore of the lake. The average grade within the limits of the county, along the Lake Shore road is 5.5 feet to the mile, and along the Ann Arbor about 4 feet.

§ 3. Elevations within the county.

Data relating to altitudes have been procured from four different sources, more or less reliable, and from these it has been possible to construct a map (Plate VII) upon which the approximate elevations are represented by a system of contour lines, drawn at intervals of ten feet above mean tide level (A. T.) at New York City. This would not have been possible in a county with broken surface features, without a much more accurate topographic survey. The contour lines must be regarded as only approximately located and are much smoother than they would appear if determined by detailed work with a spirit-level. Over the sand areas no attempt was made to represent the position of the numerous mounds and ridges of blown sand. These are frequently rapidly changed through the agency of wind and water and ordinarily their height falls within the contour interval. Upon each contour line its elevation above Lake Erie is placed in parenthesis.

(a). U. S. Survey levels. For all practical purposes the elevation of Lake Erie at the present time may be taken as 573 feet. The mean elevation for the period 1870 to 1898 is more accurately 572.721 feet. The highest level of which there is definite record was reached in 1838, when it equaled 575.2 feet; the lowest was attained in November, 1895, being then but 570.79 feet. During this sixty years the fluctuation has been 4.41 feet, enough to produce a marked effect upon the low-lying shores of the lake. Within the memory of the older residents flat-bottomed boats were loaded where now the land is under cultivation. The Board of Engineers of the Deep Waterways Commission has recommended the regulation of the lake level by the construction of weirs at the foot of the lake just below Buffalo harbor, so as to maintain a level of 574.5 feet, and insure a sufficient amount of water for navigation purposes in the fall when the traffic is greatest and the water liable to be lowest.

A geodetic station is located in the cemetery of the Monroe county Poor Farm, about four miles west of the city, the elevation of which has been confused with that of the city itself. The geodetic point is a small hole drilled in the top of a stone post set in the ground, the elevation of which at the base of the post is 43.9 feet above the mean level of Lake Erie. This mean level referred to is one that was earlier determined than that given in the above paragraph



and equaled 572.86 feet. The elevation of the land then at the point indicated is 616.76 feet above tide. A second station, the elevation of which has been determined with some accuracy, lies between Dundee and Petersburg, south of the Raisin. This was also a geodetic station marked with a stone post and three reference posts. It is located in the extreme N. W. ¼, N. W. ¼, Sec. 36, Summerfield township T. 6 S., R. 6 E., on the northwest side of the diagonal road leading from Dundee to Petersburg. One reference post bears N. 76° 51′ E. and is 22.4 meters distant; a second bears S. 4° 49′ E., distant 17.55 meters. These two lie on the northwest side of the road, while the third is upon the southeast side, bears S. 18° 53′ E. and is distant from the geodetic point 34.05 meters.

The corner of Secs. 25, 26, 35 and 36 bears N. 87° 32′ W. and is 110.25 meters distant. The elevation of the ground at this point is 681 feet. A photolith copy of the Toledo topographic sheet, now being prepared by the U. S. Geological Survey, has been received during the final stage in the preparation of this report. It gives the contours of 600, 620, 640, 660, 680 and 700 feet above mean sea level for the region to the north and west of Toledo and continues them into Michigan for a distance of one and one-half to two miles. There is thus furnished an accurate and very important check upon the work based, in the main, upon railroad levels.

(b). Railroad levels. In the construction of the contour map, referred to above, reliance had to be placed mainly upon the series of railroad levels, very kindly supplied by the roads which intersect the county in so many different directions. Assuming that the profiles of these roads were approximately correct it was found that they could not be adjusted to one another with the datum plane given by the various offices; wide discrepancies appearing in the elevation of the same point. For various reasons it is best to explain here how this adjustment was made. It seemed most desirable to settle first a datum for the Lake Shore system, with its branches, with reference to lake level. The county surveyor, Mr. A. F. Winney, of Monroe, has determined that the top of the rail on the bridge at the Raisin is 19.4 feet above bed rock in the river beneath. The profiles of this branch of the road shows the rail here to have an elevation of +17 feet and that of the bed —2. The water has here become stagnant and if we assume a few inches of deposit upon the rock the figures are in agreement. Owing to the drowned condition of the mouths of all the rivers which empty into the lake, the level of the Raisin here represents approximately the mean level of the lake, and is so considered in the Michigan Central levels. The figures obtained from the Lake Shore office then are regarded as elevations above mean Erie level and, upon this supposition, are in substantial agreement with those of the Michigan Central and the Pere Marquette, referred to the same datum.

In the case of the Ann Arbor road two sets of elevations were obtained about a year apart. In one case the datum was given as the mean level of Lake Michigan (582 feet) and in the second case was stated to be unknown. At its junction with the Adrian-Monroe branch of the Lake Shore, according to the profile of the latter road, which is assumed to be practically correct, the elevation of the rail is 93.07 feet above Lake Erie level. With Lake Michigan level as a datum the profile of the Ann Arbor road gives the same point an elevation of 112.4 feet above Lake Erie. The profile of the road was assumed to be approximately correct within the limits of the county, the actual elevation of the junction with the Lake Shore, at Federman, was regarded as 93 feet above Lake Erie and the difference adjusted along the line in either direction. This brings these elevations into substantial agreement with those of the Pere Marquette, in both the southern and northern part of the county through the Detroit and Lima Northern. In the case of the latter road the datum could not be secured, but the series of actual elevations was obtained similarly by knowing the elevation of its junction with the Pere Marquette at Carleton. Upon the above basis the approximate elevation of the rail at the following stations has been computed. The elevation above mean sea level may be obtained by adding 573 feet to each. Most of them

TABLE VI.—ALTITUDES OF RAILROAD STATIONS.

(Approximate elevation of rail above Lake Erie.)

| | Feet. | | Feet. | | Feet. |
|---|---|---|---|---|---|
| Azalia | 102 | Monroe— | | South Rockwood— | |
| Carleton | 41 | Michigan Central | 15 | Michigan Central | 14 |
| Cone | 141 | Lake Shore | 16 | Lake Shore | 16 |
| Dundee | 95 | P. M. | 28 | Steiner | 41 |
| Federman | 93 | Morocco | 79 | Stony Creek— | |
| Grafton | 41 | Newport— | | Michigan Central | 21 |
| Ida | 70 | Michigan Central | 18 | Lake Shore | 24 |
| LaSalle— | | Lake Shore | 19 | Strasburg | 53 |
| Michigan Central | 15 | Ottawa Lake | 119 | Temperance | 46 |
| Lake Shore | 17 | Petersburg | 105 | Vienna— | |
| P. M. | 25 | Rea | 116 | Lake Shore | 13 |
| Lulu | 83 | Samaria | 71 | Mi·higan Central | 13 |
| Maybee | 61 | Scofield | 52 | P. M. | 24 |
| Milan | 122 | | | | |



will be found to differ materially from those given in Gannett's table of railroad elevations.*

(c). Elevated beach levels. At periods when the waters of the Great Lakes stood at successively higher levels a series of beaches was impressed upon the surface of the county. These beaches thus mark actual physical contours, the approximate elevations of which are known from outside data. Their position is indicated upon Plate VII, where they furnish a check upon the accuracy of the work based upon the railroad levels. These beaches will be described in another connection and it may simply be said here that the highest marks the altitude of 170 feet above the lake, the second that of 121 feet, the third about 85 feet and the lowest about 42 feet.

(d). Aneroid levels. By means of an aneroid barometer a great many readings were taken in the course of the survey upon railroads, well curbs and rock ledg . Except where the points were near together, and but a short time elapsed between readings, no great reliance could be placed upon such determination of difference in elevation. Some of this material has been used in making up the body of this report. The barometer was found chiefly serviceable in getting the approximate height of the river terraces and banks, where these could not be measured directly. The northwestern corner of the county was found to be four feet lower than the "gravel ridge," which constitutes the 170 foot beach referred to above, and so has an elevation of 166 feet above Erie level. This beach which cuts diagonally across the N. W. ¼, Sec. 6 of Milan, is the highest strip of land within the county and functions as a minor watershed. Although a great deal of accurate levelling has been done in connection with the numerous drains, there is but little of it utilizable. The lines of levels run for but short distances and are entirely disconnected.

§ 4. Surface drainage.

A glance at the map of the county shows that the drainage is, in general, southeastward and from what has been said in regard to the surface slope it is apparent why this should be the case. Consult "Water Resources of the Lower Peninsula of Michigan." Lane, No.30 of the Water Supply and Irrigation Papers of the U. S. Geol. Survey, 1899, especially p. 62. Most of the streams make their way independ-

*Bull. U. S. Geol. Sur., No. 76, 1891.

ently to the lake and are not united into a system, so as to form a central stream of some magnitude. The Raisin is the largest and most centrally located river but the greater part of its water it possesses upon entering the county. This has been obtained from the eastern part of Lenawee, the southwestern part of Washtenaw and the southeastern part of Jackson counties. Measured in a straight line the river is about 80 miles long but this is increased several times over, by the great amount of meandering. Owing to the very even surface slope the streams which might have become tributary to the Raisin continue their course to the lake. This is well illustrated by Plum Creek which rises within a mile of the Raisin, and for fully 18 miles flows parallel with it, entering the lake separately. At no time does it get beyond three miles from the main stream, approaches to within two-thirds of a mile for a short distance, without breaking through, and then continues lakeward for a dozen miles further. North of the river there are some minor tributaries which join it finally, only after paralleling it for a number of miles. Following the Raisin upon the south side and along many of the other streams there is more or less sand deposit outside of the main valleys. This was probably deposited as a delta upon either side of the stream as the waters of the lakes were gradually withdrawn from the land.

Two streams worthy of the names of rivers, do enter the Raisin, however, in the southeastern part of Dundee township, the Macon and the Saline. These streams appear to have had a common bed from this point to the lake. From their point of union a broad depression extends southwestward for a number of miles into Lenawee county as shown by the surface contours. It is quite probable that this depression was occupied by a third small stream which also joined the Macon and Saline. The natural direction of the Raisin is southeastward across Lenawee county, but it takes a very abrupt turn and enters Monroe county flowing northeastward across Summerfield and Dundee townships. It seems very probable that this third stream referred to cut its way back into the watershed which separated it from the Raisin, until the latter stream was tapped and "captured." This bed furnishes a more direct route to the lake and the Raisin turned northeastward until it reached the common bed of the Macon and Saline. This bed was also appropriated, since it furnished a direct course across the two lower beaches and the Macon and Saline became tributary to the Raisin while the third stream was obliterated.

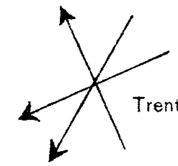


As the river swings from side to side there is cut out of the drift deposits which cover the rock, a broad valley partly filled with river silt. During times of highest flood the river leaves its channel, spreads over all the region between the outer banks, and as the velocity of its water is checked, there is deposited a layer of sediment. In the course of time there is built up a flat terrace, the height of which is determined by the height to which the water may rise at each particular part of the stream. This constitutes the flood-plain of the river. In the case of the Raisin it may be followed from near the lake, continuously up stream, across the county. Where the valley is broad and the river has a chance to spread most during flood its height is less. On the other hand where the valley is narrowest, the flood-plain terrace is highest, as is well shown at Petersburg. Here the valley, which is ordinarily from one-quarter to one-half mile in width, narrows to about 700 feet and the terrace is fully eight feet above the general level of the river. In the western part of the county the banks vary from twenty to thirty feet above the bed of the stream, are 26 feet high at Dundee and gradually diminish towards the mouth.

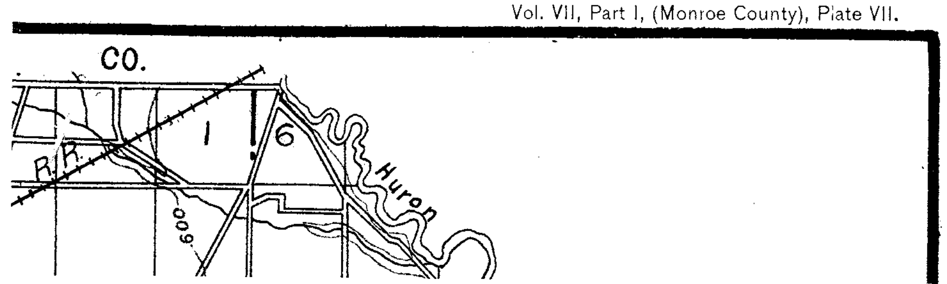
For each individual stream there seems to be a limit to the amount of wandering of which it is capable, and hence to the breadth of its valley. In the formation of the great ox-bows a neck of land is produced into which the stream cuts on opposite sides until it is completely eaten across and the channel is straightened. The abandoned portion of the bed forms a crescent shaped marsh or lagoon, numerous examples of which may be found along nearly all of the streams. The erosive action of the water is thus confined mainly to the terrace deposit of its own making, rather than to the valley banks and this is torn down and built up many times over in the history of the river. In places, however, new work is being done upon the original drift deposits and the valley correspondingly broadened until the stream is again straightened and the water withdrawn. Besides the one above mentioned, other factors contribute to the periodic straightening of the river channel. As the stream cuts laterally into its banks, owing to the deflection of the main current, it forms an ox-bow and its length is correspondingly increased. In one case noted in the Huron, near

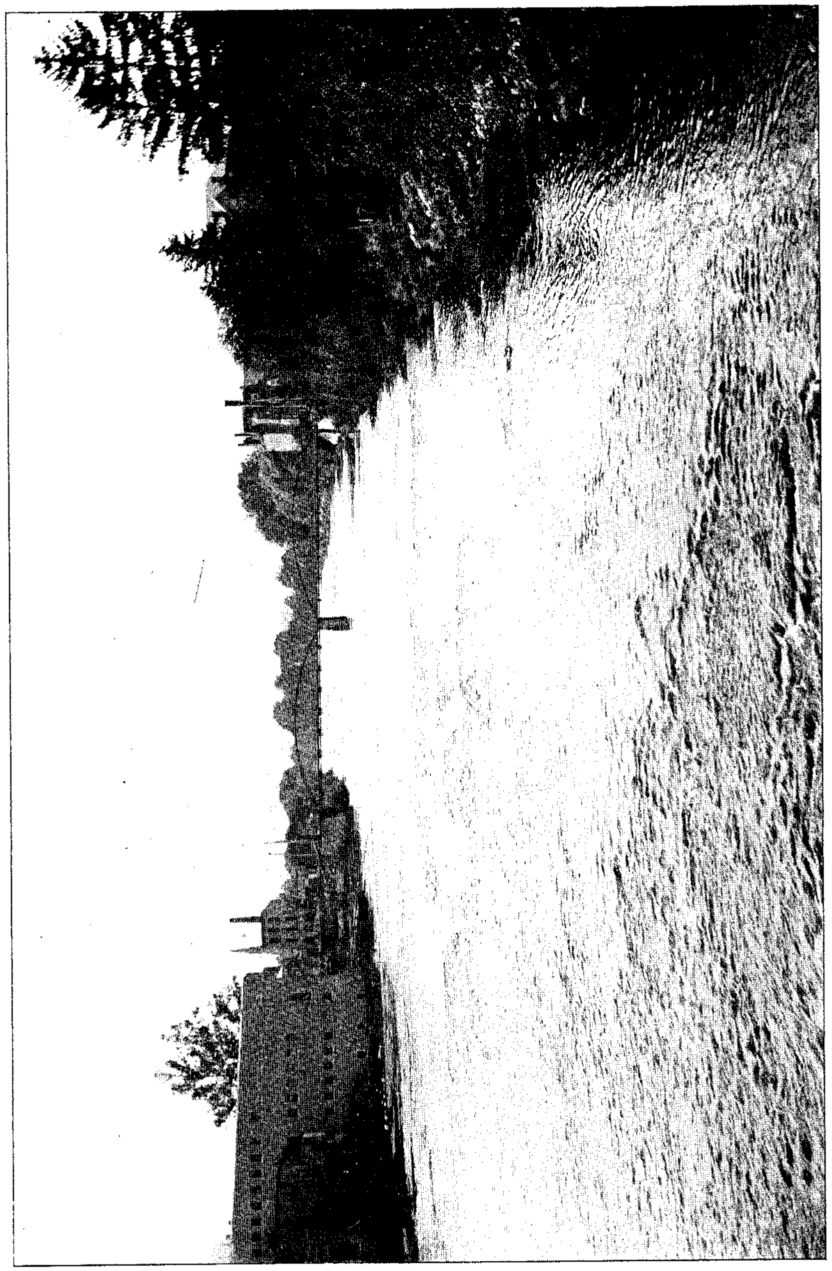
Flat Rock, the river has meandered a mile and advanced less than one hundred feet. The actual amount of fall remains the same, while with the great increase in the length of the stream the rate of fall is much diminished. The effect of this decrease in rate is to check the velocity of the stream and to cause it to stand at a higher level at the beginning of the ox-bow referred to. The amount of this damming effect bears a direct relation to the distance which the stream has moved sidewise and tends to prevent its ever exceeding a certain amount for any particular stream. This is because the time arrives when only a slight rise in the stream will cause it to overflow across the narrow neck, and the main current will cut out a straight channel in a few hours. This action may be aided by the surface drainage, which may cut channels across this neck and reaching backward may finally tap the main stream, or form a depression through which the water may more readily find its way. This alternate meandering and straightening of the Raisin has gone on many times. Within the easy memory of the older inhabitants marked changes have occurred in the course of the stream, forest trees of respectable size now growing where there had been boating and fishing.

As has been previously stated rock occurs in the bed of the river just above Petersburg and again at Dundee. At the mouth of the Macon where the water is low, heavily bedded, glaciated limestone ledges project in the bed. For a distance of four to five miles further down the river is deep and sluggish and has a mud bottom. Just above Grape the rock again appears, and then occurs at frequent intervals to Monroe. A view of the river at Monroe is shown in Plate VIII, where the stream is from 210 to 220 feet across, being rendered shallow and broad by the layers of dolomite in its bed. Ice jams periodically form opposite the city by which the river is forced out of its banks. An unusually heavy freshet occurred this past spring (1900) from this cause and another in 1887, by which one of the passenger bridges was destroyed. The fall from the Macon to Monroe is about sixty feet, giving an average of about four feet to the mile, as measured in a straight line. Dams have been constructed at Petersburg, Dundee, Grape and above Monroe and the power of the stream utilized for milling purposes. In conjunction with Plum Creek a well defined delta has been formed between Monroe and the present shore of the lake, consisting of a




Vol. VII, Part I, (Monroe County), Plate VII.





RAISIN RIVER AT MONROE.



low, flat marsh but little elevated above lake level, across which the river reaches the lake by several mouths. While Michigan was still a territory a canal was constructed by the general government through which more direct communication with the lake was established. Work was begun in 1835 upon this canal and the next year the city itself constructed the "city canal" cutting off the ox-bow of claim 653, by which this part of the river was rendered navigable for the lake craft of those days.

The Macon and the Saline rivers, with their branches, drain the northwestern part of the county, the southern part of Washtenaw and the northeastern portion of Lenawee. They are simply the Raisin in miniature, each showing the broad valley, the elevated flood-plain over which they pursue their winding courses. The banks are about twenty-five feet high where they join the Raisin, but gradually diminish to less than half this height.

The Huron forms the northern boundary of Berlin township, but receives no tributaries of any size from the county. It has about the same length as the Raisin and carries nearly the same amount of water. It rises in the western part of Oakland county, flows southwest across the southeastern part of Livingston, between great morainic ridges and through a chain of lakes, taking then a winding southeasterly course across Washtenaw and Wayne and entering the lake just below the mouth of the Detroit river. Rock is encountered in the bed of the stream only at Flat Rock, where it has been quarried to a small extent. The banks here are from fifteen to sixteen feet high and about sixty rods apart with a flood-plain terrace of river silt which varies in height from five to six feet. The stream itself is about ninety feet across and flows with a swift current. From Flat Rock to South Rockwood the river forms numerous characteristic meanders, similar to those above described for the Raisin. At the latter place the valley banks are eighteen feet above the general water level and about 125 rods apart. The same terrace appears as at Flat Rock, sloping upward from the low water channel to the sides of the valley. The stream maintains about the same size throughout this portion of its course to the lake. The banks are gradually reduced in size until in Sec. 23, of Berlin, they are but two feet high and the flood-plain merges into the broad, flat delta. The stream current has here been lost, although two miles from its mouth, and there is simply an ebb and

15

flow from the lake. A strong easterly wind is said to raise the level of the water two feet. The depth of the stream is ten to twelve feet and toward the mouth is reported as in places twenty-five feet. The U. S. Coast Chart shows a depth of ten to sixteen feet. Such a depth in this portion of the stream, where there is practically no current calls for special explanation (Chapter VI, § 13). Between the Huron and the Raisin, Swan Creek, Stony Creek and Sandy Creek enter the lake directly, each with relatively broad valleys and flood-plain terraces. As has been previously pointed out rock is struck for a short distance in the bed of each. South of the Raisin we have an essentially similar set of streams, Plum, Otter, Muddy, Bay and Halfway Creeks being the principal ones. These drain mainly the region that lies east of the Forest Beach, but in the case of the latter stream the surface drainage of Whiteford to the west is brought to the lake. This cuts through the beach one and one-half miles south of Lambertville, being assisted by considerable dredging and blasting. The presence of the Arkona and Forest beaches has considerably interfered with the natural drainage of Whiteford and the southern half of Summerfield townships and has necessitated the construction of extensive artificial drains.

§ 5. Underground drainage.

In the region of obstructed drainage just referred to, nature has in part obviated the difficulty by sending the surplus water to the lake under the beach, instead of over it. Sink holes and subterranean rock channels have been produced by the solution of the dolomite, so that farms are sometimes drained into old wells. In deepening wells which enter the rock it sometimes happens that the entire quantity of water is lost by opening communication with one of these underground channels. It is reported that sometimes running water may be heard by placing the ear to the ground. In the southern part of Sec. 2, of Whiteford, there occur two large depressions, known respectively as the "Big Sink" and "Little Sink." The latter is the site of Cummins' quarry described in Chapter IV, § 15 and shown on Plate III. The "Big Sink" is a large depression, fifteen to eighteen feet deep, one-half mile long and about one-quarter broad. A ditch from the northwest drains into this and in the spring the depression fills to overflowing and becomes confluent with "Little Sink," forming a veritable lake as



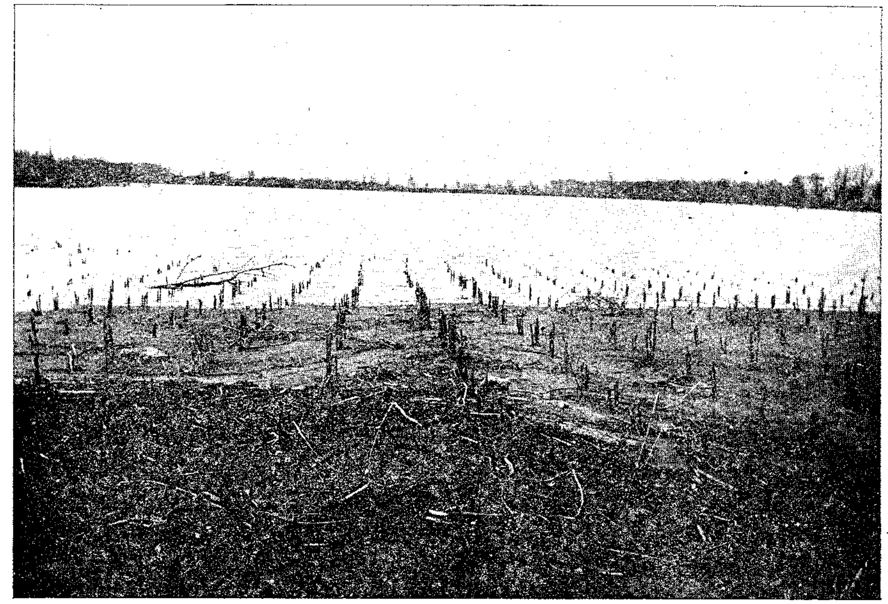


Fig. 2. The "Big Sink" doing service as a lake, March 26, 1898.

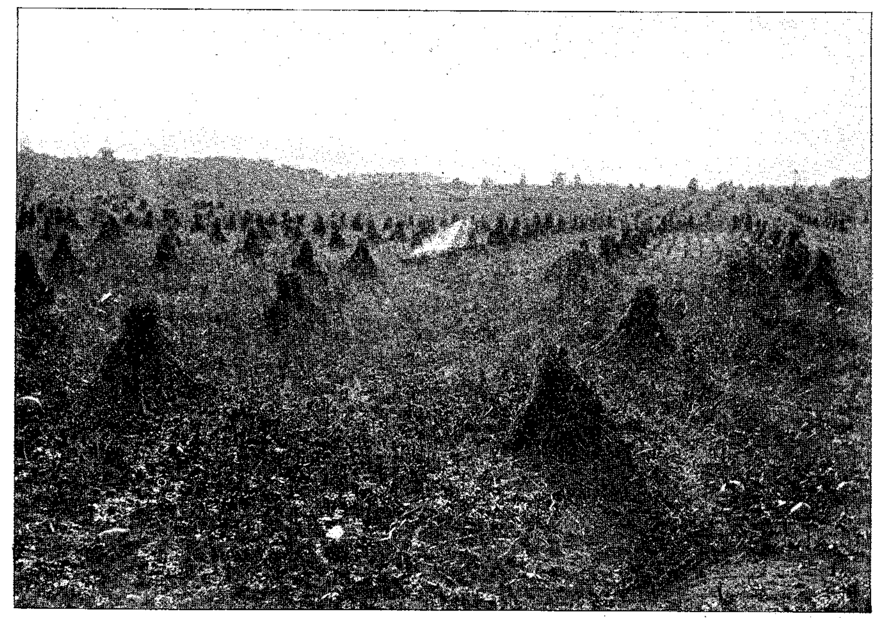
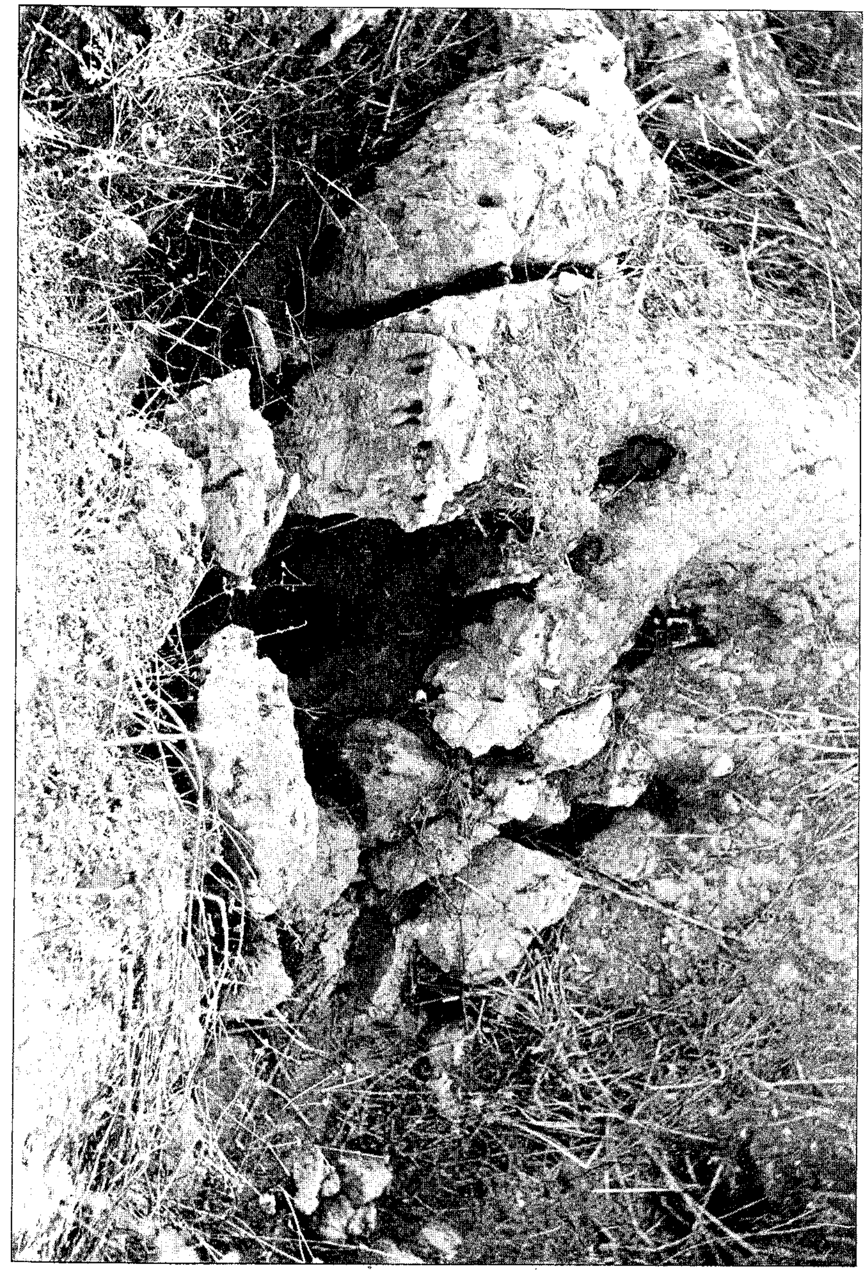


Fig. 3. The "Big Sink" under cultivation, October 15, 1898.

shown in Fig. 2. Each season it becomes stocked with fish from Lake Erie, by means of Halfway Creek, and carp weighing ten to fifteen pounds are said to be caught. In the bottom of the bed there is a small ravine in which occurs the opening shown in Plate IX. Through this the water finally escapes, sometimes very rapidly and with whirlpool effect. It is possible that an ice plug may be formed during the winter and as long as this remains intact the sink retains its water. Whatever the obstruction may be, it is always disposed of in time for the cultivation of the land and Fig. 3 shows the sink in corn. Figs. 2 and 3 were taken from about the same point, one in March and the other in October.

Southwest of these two sinks occurs a much larger one known as Ottawa Lake, lying mainly in Secs. 17, 18, 19 and 20 of Whiteford townships. This has a length of more than two miles and exceeds one-half mile in its greatest breadth, although it is narrow throughout the greater part of its extent. Each season this fills up and becomes stocked with bass, perch, carp and pike as in the above instance. By midfall this lake has practically disappeared, partly by evaporation but mainly through openings into the rock beneath. Plate X shows the bed of the lake, taken from the head looking south, when all the water has gone except the small pool in the foreground. Fish are said to be caught in large numbers as the water subsides, while those left behind to die render the air offensive for some distance. Mr. Edward Montgomery, a local well driller, informed the writer that near the foot of the lake he had seen an opening "as large as a room" leading into the rock and that he had entered it twelve to fourteen feet, but that he could see some distance further and that it contained much mud with fish, turtles and snakes. Search was made last season for this opening but all that was found was a bowl shaped depression in the mud fifteen to sixteen feet in diameter and five feet deep containing about a peck of young cat fish. During the past summer the bed of the outlet has been lowered by the county so that the level of the full lake will be reduced four feet, by which means many acres of marsh land on the south and east will be reclaimed. In the northern part of Sec. 15, Bedford township, there is a small body of water upon the "ridge," known as Little Lake. At the time of Rominger's survey of this region (1873 to 1876) this was dry and showed conspicuous rock crevices in its bed. It has not been dry for a number of years and is not now regarded by local residents as a sink. It seems prob-





ROCK OPENING THROUGH WHICH THE WATER OF THE "BIG SINK" ESCAPES.

able that the subterranean exits have become temporarily clogged and that they may again become functional upon being cleared. A somewhat similar case has occurred just south of the Lulu quarry in Sec. 16, of Ida township, where there is a depression covering five acres and about nine feet deep. This has filled each spring with water which has had to slowly evaporate. In 1896 it appears to have found an outlet, or to have opened a former one, since it was filled several times and each time emptied itself in three days. Just south of the Big Sink, in the N. W. ¼, Sec. 11, Whiteford, there is situated a sink which has become inoperative. Upon the place of Daniel Rabideu there are two small sinks in the S. W. ¼, N. W. ¼, Sec. 10 of Whiteford. In Sec. 8, N. E. ¼, N. W. ¼, there are minor sinks and sink holes, into one of which a man and horse are said to have broken through.

It is very probable that there exists throughout this region a series of underground galleries and chambers, but probably of no great dimensions. The openings are not known to show air currents, which would probably be the case if they communicated with extensive caverns. These subterranean channels seem to extend below the level of the lake and hence must have been cut when the land stood at a higher level. The water which enters these sinks supplies the great springs, which are found to the east along the lake shore. Some of it also very probably reappears in the artesian wells of the region and some of it may reach the lake directly, without coming to the surface.

There is evidence that these underground waters are inhabited by a special fauna similar to that found in caverns. Sometime in the 70's there were pumped from a well in the N. W. ¼, N. W. ¼, Sec. 32, of Summerfield township, three small fish which are said to have showed no trace of eyes. The well was eighty to ninety feet deep and stands upon land now belonging to J. Cosgroy. The fish were seen swimming in a pail by Mr. Ezra Lockwood, who gives the length of the largest as about one and one-half inches, dark brown in color, slender in form, "shaped like a mullet" but with much enlarged paired fins and the dorsal fin extending to the tail. A similar find was reported from Utica, north of Detroit, in Macomb county, some two years ago. Two larger fish were obtained from a well, neither of which according to the owner, showed any trace of eyes. Very unfortunately a cat made a meal of them before they could be secured by the writer. Similar discoveries may be expected in the future and it is to be hoped that the material will fall into friendly hands.

§ 6. Diagonal features.

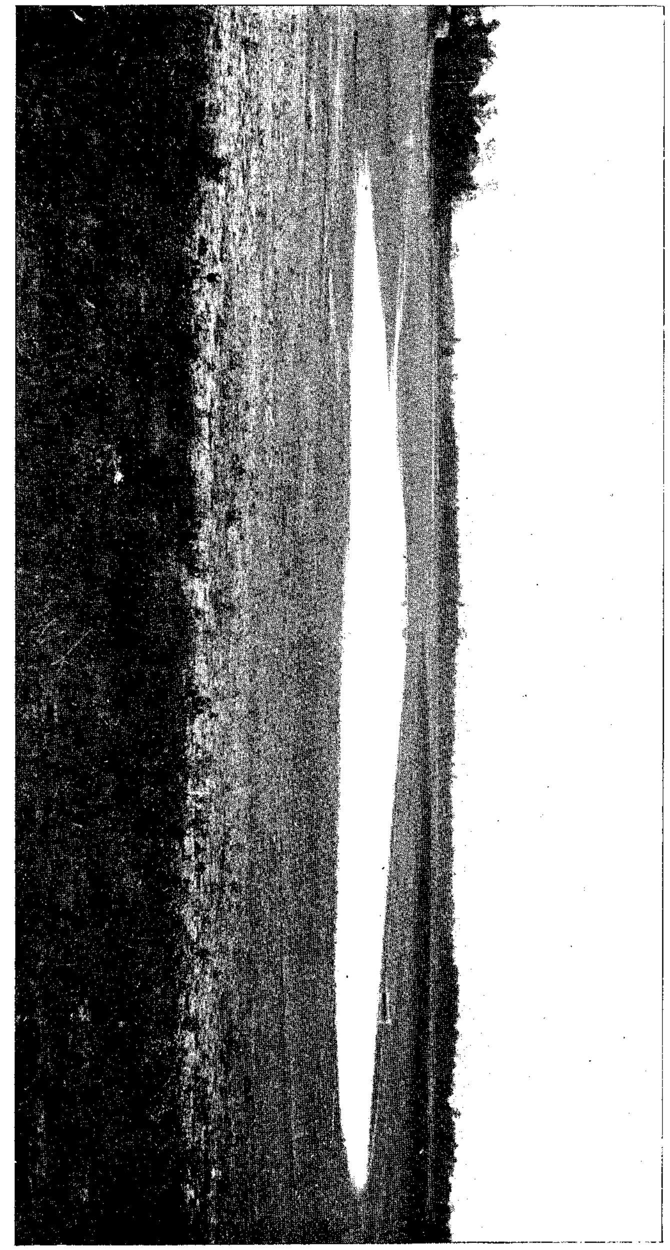
In 1873 Dr. Alexander Winchell read a paper before the American Association for the Advancement of Science entitled, "The Diagonal System of the Physical Features of Michigan."* Attention was here called to the frequency with which the directions, intermediate between the cardinal points, enter into the physical features of our southern peninsula, and Monroe county might have been selected as a type locality. The far reaching influence of geological forces is well shown in tracing to its cause this diagonal system. The reader will recall the frequency with which the terms northeast, northwest, southeast and southwest have appeared in this report, it being almost impossible to point out a single natural feature in which this diagonal character is not apparent to a greater or less extent. The southeasterly slope causes the streams to take this general direction, the only exceptions being the Raisin, the south branch of the Macon and Halfway Creek. When these streams are not flowing southeast they are, however, flowing northeast. The present Lake Erie shore, the ancient beaches, the sand and clay belts, the outcrops of rocl., the belts of artesian water and gas, all have a northeast and southwest direction. The lines joining places of equal elevation, of equal temperature, of equal rainfall and even the prevailing direction of the wind, are diagonal in the county. In consequence of the above facts the distribution of the natural flora and fauna partakes of the same character.

In the days of early French occupancy each claimant of government land was allowed any amount, up to 640 acres, for the surveying of which he was willing to pay. With no system of roads yet established the streams were the highways and each farm must have its water front. The claims were laid out at approximately right angles to the Raisin, Stony, Plaisance and Otter Creeks and what they lacked in width they made up in length, as is apparent from an inspection of the map. For mutual protection, social intercourse, water and fish, the houses were located near the streams and faced them. When the settler went to or from his work, after

*American Journal of Science, 3d series, Vol. VI, page 36. See also "Michigan," extracted from Walling's Atlas, page 32.





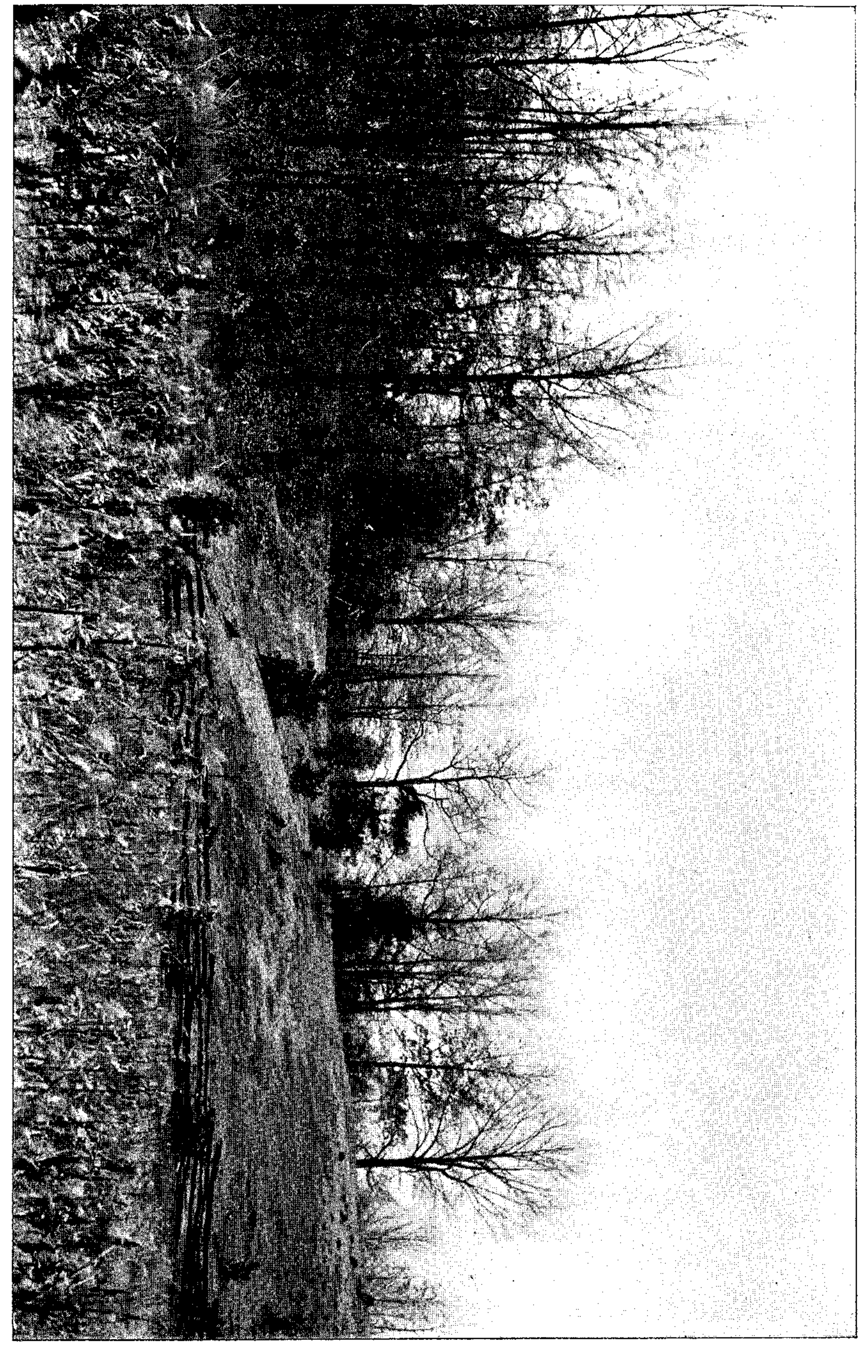


BED OF OTTAWA LAKE (SINK), LOOKING SOUTH FROM HEAD, OCT. 15, 1898.

game, to the traders or to visit his neighbor, he moved, in general, parallel with, or at right angles to the stream. The activities of the home itself were similarly directed largely by the southeasterly course of the rivers and creeks. Later when roads were established they were laid out between the claims, or so as to cut directly across them at certain distances back from the river front and in the eastern and central parts of the county many of these diagonal roads still remain. As the settling of the country progressed the gravel and sand ridges of the beaches were utilized for roads. The old territorial road from Pontiac to Adrian, laid out in 1832, occupies the crest of the Belmore Beach for many miles. The farmers select these higher ridges as sites for their dwellings, because of their accessibility, better drainage and the ease with which water can be secured. For the same reason school houses, churches and cemeteries are frequently similarly located. For over a hundred years a large proportion of the residents of the county have moved, eaten, slept, worshipped and now lie buried upon the bias. When the farmer's son began business for himself he desired the same conditions to which he had become accustomed on the homestead, and these he found by migrating either northeastward or to the southwest. The topography has determined the position of the larger lakes and rivers of southeastern Michigan. These have, in turn, determined the sites of our larger cities, and between the cities run the railroads, which with but one minor exception cut the county diagonally. Along the lines of these roads have sprung up nearly all the villages of the county.

So long ago that the time cannot be expressed in years certain internal forces of the earth disturbed the originally horizontal beds of shale, limestone, dolomite and sandstone. These were tilted so that they dipped to the northwest in this region and their outcropping edges were thus given a northeast and southwest direction. The different degrees of hardness of these beds caused them to weather unevenly and subjected them to unequal degrees of aqueous erosion, so that broad valleys were cut out having the same direction as the beds themselves. To a greater or less extent the preglacial topography determined the direction of local movement of the great ice sheet and hence the direction of maximum ice gouging. The direction of the advance of the ice disposed the deposits of till, moraines, and boulders as we find them and gave to the county its present topography. This topography determined the direction of drainage, the boundaries of the series of lakes resulting from the melting of the ice and the direction of their shore lines. From the above mentioned remote cause an endless chain of causes and effects has been permanently impressed upon the county and all its inhabitants. But the forces by which the rock beds were originally disturbed represent a single link in this chain which reaches backward as well as forward. We have no means of knowing, at this remote day, what factors determined the direction of the operation of these potent forces. Could these but be identified and traced to their origin we should better understand the remark of some farseeing scholar, that if a single grain of sand on the seashore occupied the position of its neighbor, the history of the earth would have been different.





SAND RIDGE OF BEACH, WEST OF ERIE; SHOWING TYPICAL GROWTH OF OAK AND EVERGREENS.

# CHAPTER VI.

## THE GLACIAL EPOCH IN SOUTHEASTERN MICHIGAN.

### *A. Rock Surface Topography.*

§ 1. Introduction.

No satisfactory knowledge of the peculiar topography, the nature and distribution of the soils of the county, can be had except through an understanding of the recent geological history of the region. Between the formation of the strata which have been described and the series of events about to be presented in this chapter, a very long period intervened. During this time the land had arisen from its long immersion in the sea and was probably not again submerged for any great length of time. It was acted upon by the meteorological and chemical agencies which operate to produce soil, the removal of which by erosion gradually brought the rock surface to a lower level. Broad, shallow valleys were cut across the county in a general northeasterly direction, which with their low, narrow divides characterize an aged river system. It is quite probable that tongues of ice moved along these valleys at times and somewhat modified their form, although their general direction does not coincide with that of the ice movement. The topography of the rock surface is shown by the contours given upon Plate I, each drawn to connect points where the rock surface is at equal elevation above mean sea level. The data for these contours were obtained by subtracting from the actual elevation of the surface, the thickness of the drift covering, so that there was a double chance of error in determining the result at any particular point. The contours must then be regarded only as approximately located, simply the best that could be done under the circumstances. The highest rock in the county extends northward through the western half of Whiteford township into Summerfield, ranging from 660 to 682 feet A. T., the latter elevation being reached at the head of Ottawa Lake. The maximum rock relief, within the limits of the county, is about two hundred feet. An inspection of the contours shows that there are three fairly well defined valleys within the limits of the county, which may conveniently be referred to by the names of the geological formations out of which they have been carved.

§ 2. Traverse valley.

This strikes northeastward across Milan township, approximately along the line of the Wabash railroad, having been cut out of the softer beds of the Traverse group. It is limited on the northwest by a narrow divide of harder rock (the Tully limestone?) which extends northeastward through sections 18, 7, 8, 9, 4, 3 and 2. This low ridge divides the Traverse valley from another which has been formed in the St. Clair shale and the two unite in the southeastern part of Washtenaw county. The stream which occupies the St. Clair was apparently tributary to that which flowed through the Traverse valley. This latter valley extended from the divide above located as far as Azalia and varied in breadth from about six miles in southwestern Milan to three to four in the northeastern part. Within the township the elevation of the central part drops from 610 to 549 feet, giving an average fall of about nine feet to the mile towards the northeast. The stream seems to have passed directly beneath the village of Milan about twenty-four feet below the present level of Lake Erie, or thirty-three feet lower than that of Lake Huron. The valley itself here was about sixty feet deep so far as we may judge from the present rock topography. Plate VI shows a section of this valley along the line of the Ann Arbor road. From well records collected in Wayne county this stream appears to have continued northeastward across Washtenaw, into Wayne and on towards Detroit, where its elevation is not far from 470 feet A. T., or about 100 feet below the level of Lake Erie.

§ 3. Dundee valley.

This is a broad, shallow trough, confined mostly to the richer and softer beds of the Dundee formation. It seems to head in the higher rocks in the northern part of Ida township, cutting across the upper Monroe beds and entering the Dundee at Raisinville. It then follows the strike of the softer beds into Wayne county, there cuts across the upper Dundee beds and opens into the main Traverse valley, showing that its stream was tributary. Within Monroe county the central part of the valley falls from 643 to 580 feet, or



an average fall of four to five feet to the mile. At only one place does the stream channel itself appear to have been struck in well boring. In Sec. 18 of Exeter township, the rock averages 50 to 55 feet from the surface, but G. W. Palmer, (N. W. ¼, N. W. ¼) went 72.5 feet without reaching rock and ended in gravel. This stream probably left the county from Sec. 3 of Exeter at a somewhat higher level than did the Traverse to the west.

§ 4. Sylvania valley.

A narrow and still better defined valley followed the Sylvania sandstone throughout almost its entire course, owing to the uncompacted nature of this bed and the ease with which it could be eroded. The valley appears to have been formed by the union of two short ones, the first of which followed eastward the town line between Whiteford and Summerfield and the second came in from the northwest and joined the former in the southwestern part of Ida. The contours show how faithfully the strike of the bed was followed turning eastward with it in Ash and Berlin and cutting across Brownstown, of Wayne county. The breadth of the valley was roughly limited by the resisting dolomite beds on either side of the sandstone outcrop. In the southwestern part of Summerfield the valley has an elevation at its center of about 660 feet and drops 100 feet in reaching South Rockwood, an average of about three feet to the mile. The actual depth of the stream channel itself is unknown. One mile east of South Rockwood, in about the center of the valley (Sec. 10, T. 5 S., R. 10 E), Mr. J. M. Morrison has a well in which the depth to rock is eighty feet, while a short distance east, across the road, the rock is within twelve to fourteen feet of the surface. The lower section on Pl. VI gives a cross-section of this valley, at the outcrop of the bed marked "white sandstone." A small portion of the valley is also shown in the same bed at the left of the section along the Michigan Central road. The stream which occupied this valley emptied to the east, or southeast, very probably into the ancient "Erigan River," which is believed to have occupied the deeper portions of the bed of Lake Erie and the lower part of the Detroit River. The other preglacial or interglacial streams located appear to have continued northeastward and probably formed part of the ancient system which occupied the present site of Lake Huron.

§ 5. Erie trough.

Upon the southeastern side of the rock fold which has been previously described as "stony ridge," the elevation of which slopes from 663 feet A. T. to 575 feet A. T. at Lake Erie, the surface drops very rapidly towards the lake. The dip of the beds, upon the other hand, is towards the northwest, in the opposite direction. The steepest descent is in the western part of Erie township, where there is a drop of seventy feet within a distance of one and one-half miles. A flat shelf with a maximum breadth of two miles, then extends northeastward across the township, mostly west of the railroads and parallel with them. For the next mile to the southeast a further descent of forty feet occurs, bringing the actual elevation down to about 490 feet A. T., or 83 feet below the mean level of the lake. This rock topography is well shown at the right of each of the sections on Pl. VI, previously referred to. Northeastward this trough extends past Monroe and between here and Stony Point turns to the eastward and continues an unknown distance beneath the lake. Judging from the character of the beds affected, the shape and position of the trough, it seems probable that this is due to the gouging action of the great "Erie lobe" of ice.

## *B. The Ice Invasion.*

§ 6. The early ice sheets.

The glacial history of the region covered by this report would be very unsatisfactory if read from this area alone. Data from widely distant localities are required in order to prepare even the most general account of this remarkable episode known as the Glacial Epoch. Two lines of evidence from within the county have been adduced to show that the land at one time stood at a higher altitude, at least, with reference to the present level of the great lakes. These evidences, it will be remembered, are the deep subterranean channels and the deeply buried river valleys. Supplemented with further evidence from other localities it is known that the land was considerably more elevated than at present and particularly so toward the north. This elevation combined with a possible change in the position of the earth with reference to the sun, the shifting of the great ocean currents or the withdrawal of a certain amount of carbon dioxide gas from the atmosphere, produced arctic conditions over the Dominion of Canada and northern United States.



A very heavy precipitation of snow over the region lying to the east and south of Hudson Bay, more falling each winter than could be melted away during the following summer, produced a great body of snow, which by its own weight and surface melting was compacted into ice, thousands of feet thick. It must have been just such a body of ice as now completely mantles Greenland and the Antarctic continent. On account of the peculiar quasi-plastic properties of ice and the elevation of the sheet, the ice moved slowly outward from the center as its production there continued.

As the ice moved to the south and west at a rate probably not greater than a quarter of a mile yearly, the frosty breath of this unwelcome visitor was finally felt about the northeastern boundary of our native state. Invading the lake region it slowly made its way southwestward, grinding and scouring the rocks, tearing loose and transporting great fragments, and annihilating every vestige of plant and animal life. The soil which had been accumulating for ages was scooped from the rocks and either pushed ahead of the ice or washed out from beneath by running water. We have no means of judging how long this great ice sheet tarried over this region, but it is known to have also crossed Ohio, Indiana, and Illinois, and to have entered Kentucky, before its progress was arrested. The ice front stood at its southern limit long enough to permit the accumulation of a great belt of debris, consisting of clay, sand, gravel, and boulders forming the line of hills known as the terminal moraine. During this stage of halt the backward melting of the ice just equaled the amount of its forward movement, so that the front was approximately stationary, and the materials undergoing transportation were indiscriminately heaped at its base. Climatic changes occurred and the rate of melting exceeded the forward movement of the ice itself, causing the ice front to slowly retreat northward. Practically nothing is known in this region of the details of this retreat; where or how often the ice front again became temporarily stationary and formed minor moraines, in what condition the drainage was left or where the water accumulated to form the great lakes of this stage. Beneath the ice sheet there had been formed the great "ground moraine," the rock grist of this great ice mill consisting typically of unstratified blue clay, charged with sand, pebbles and boulders, more or less bruised. The melting of the ice took place not only from the front but also from the upper surface and upon its complete disappearance the debris which it still contained was deposited over the surface of the clay. A forest growth of hardy trees sprang up and a dark soil bed was formed of varying thickness. Where conditions were favorable peat and marl beds and deposits of bog iron ore were formed. This first ice invasion was due to what has been termed by Leverett the Illinoian ice sheet, owing to its development in that state. A second sheet known as the Iowan is believed to have also crossed the state in the same general direction and to have restored arctic conditions. Data are not at hand for determining whether this second sheet was a simple extension of the first after a long interglacial period or whether it was developed anew as had been the first.

§ 7. The Wisconsin ice sheet.

In the same region east of Hudson Bay, over the Labrador peninsula a third great sheet of ice slowly mustered its strength and moved south and west. This was in consequence of a return to the unfavorable climatic conditions which had given rise to the first sheet. How long a time intervened we have no means of accurately judging, neither do we know how far northward the Iowan sheet had retreated. The time was sufficient to permit of the formations noted above, to allow the till to become leached of its soluble ingredients to a considerable depth, and oxidized into the reddish brown clay to which the term "ferretto" has been applied. The devastation wrought by the earlier sheets, from which our region had largely recovered, was repeated. The till covering of the bed rocks, with the superficial deposits, was in large part swept away, and the rock again heavily glaciated. The grooves and scratches produced by the Illinoian and Iowan sheets were in a large measure obliterated, and a new set substituted. From this further grinding of the rocks and the rearrangement of the materials of the former bed, a second sheet of till was formed. This differs from the earlier in being less compacted, less altered in color and of a generally fresher appearance. It is not impossible that some of the so called "hard-pan," which frequently occurs in the wells of the county, is to be referred to the deposits of the earlier ice sheets. But little trace could be obtained of a soil, or peat layer, separating the beds of till. Newspaper rumors, for several years back, have furnished some evidence of the occurrence of a layer of "coal'" embedded in the drift of the southern part of Wayne county. In Sec. 34, S. E. ¼, S. W. ¼, of Huron township, Timothy Hanrahan dug a thirty foot well to the rock passing through a ten inch layer of what he called coal. Six miles south, in Ash township of Monroe county, Sec. 30, S. E. ¼, S. E. ¼, Mathias Waldecker put down a well, thirty-four feet to rock. Just over the rock he found mixed with clay, fragments of "coal" which would burn. In Bedford township of Monroe county, N. W. ¼, N. E. ¼, Sec. 2, John Van Wormer has a well ninety feet in depth in which the rock was struck at seventy-five feet. Six inch seams of a coaly substance were penetrated. The exact nature of this so called coal remains unknown but it is suggestive of compacted peat. The comparatively few wells in which this substance was reported, as well as of the dark soil bed which was probably formed on the surface of the earlier till, may be accounted for by considering the energy with which the last ice sheet operated in this region. The looser surface materials would be very liable to be destroyed, while the compact hardpan would more frequently remain undisturbed.



This Wisconsin ice sheet did not quite reach the Ohio River, so that between its terminal moraine and that of the Illinoian the oldest bed of till was undisturbed by ice agency. Its final retreat was marked by periods of halt and short advance, of a more or less rhythmic character as pointed out by Taylor.*

Between Cincinnati and Mackinac this investigator counts fifteen terminal moraines produced by this behavior of the ice sheet. The position and form of these moraines, when traced in either direction, gives the exact position and form of the ice front at these successive stages. Great streams of water, due to the friction of the ice upon its bed and the surface melting, made their way through and beneath the ice. These streams rounded and assorted the smaller rock fragments within reach and produced great quantities of sand and gravel. Some of this material was deposited in the tunnels and cavities about the margin of the ice, forming loosely stratified knolls and ridges known as kames and eskers. Much of it was washed out from beneath the ice and spread over the till froming a gravel plain upon the opposite side of the moraine from the ice. Where this material was brought to the ice front by a single stream, whose velocity was checked as soon as it emerged from the ice, a fan-shaped, delta-like deposit was formed. None of these glacial deposits occur within the limits of Monroe county, but good examples of all of them may be found in Lenawee and Washtenaw counties adjoining.

*Moraines of Recession and their significance in Glacial Theory. Journ. of Geol., Vol. 5, No. 5, 1897, p. 421.

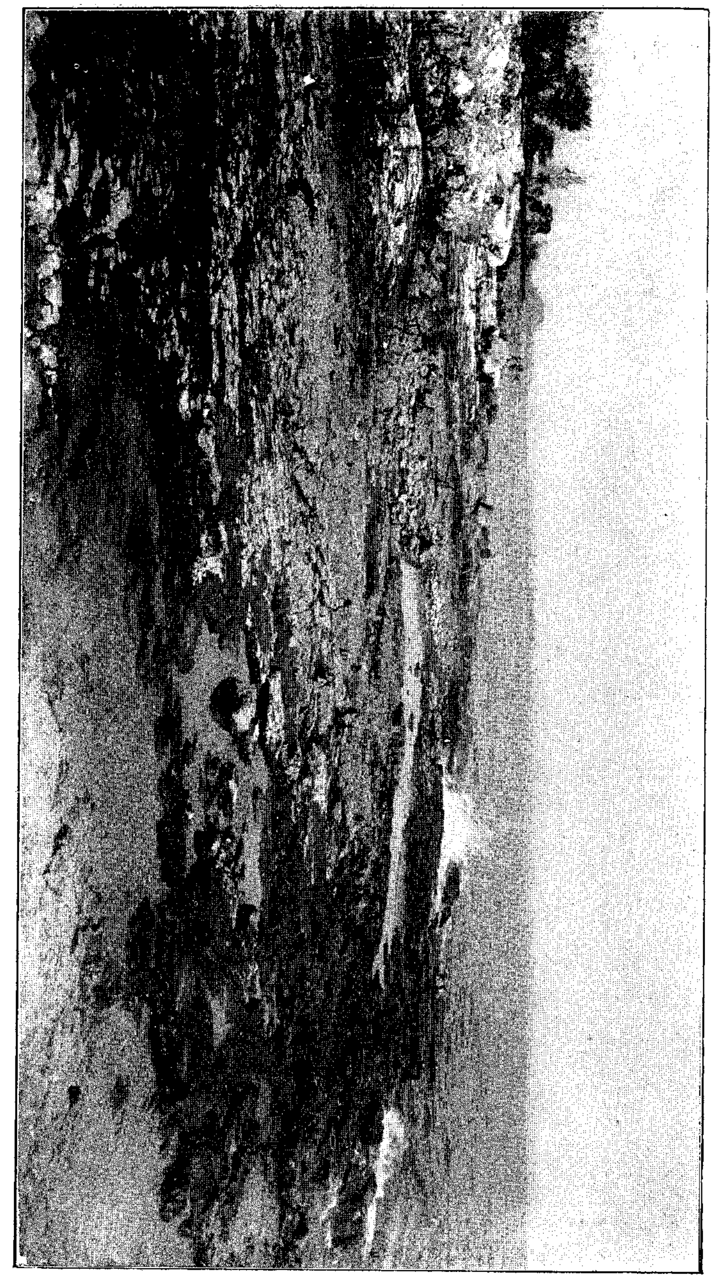
§ 8. Rock scorings.

As early as 1839 Bela Hubbard published the bearings of well defined scratches which he observed upon the rock surface at Point aux Peaux and at Brest.* These were due he then thought to "the attrition of hard bodies moving in a strong current." At the former place he determined their direction to be ("N. 60° E.") S. 60° W., and at Brest ("N. 50° E.") S. 50° W., and N. 65° W. Some twenty years later Winchell found the rock at Stony Point well exposed and "covered with a set of striæ running in perfectly parallel lines N. 60° W."† Crossing this set he found two parallel grooves, bearing N. 60° E. to S. 60° W., which were 4 ft. $6\frac{1}{2}$ inches apart, $1\frac{3}{8}$ inches deep, 2 inches wide and 25 feet long, much resembling wagon tracks in a yielding substance. The Ohio Geological Survey has at times published similar data in regard to the scorings observed in northern Ohio and the islands in the western part of Lake Erie. The first of these were collected by Gilbert and threw light upon the general direction of ice movement in southeastern Michigan.‡

In Lucas county, which adjoins Monroe county upon the south, the observations were made at four points. The mean of five observations at Sylvania gave S. 50° W.; near Holland one reading gave S. 55° W., four observations at Monclova averaged S. 62° W. and one reading at Whitehouse, the furthest south, equaled S. 50° W. Upon West Sister Island the general direction is S. 80° W., with a comparatively weak set crossing them due south. The effect of the ice upon the limestone where chert nodules protude is to produce the "knob and trail" phenomenon. The hard rock protects a ridge of limestone upon the lee side, while that in front of the nodule and along the sides is planed off and, in certain cases, grooved. This is convincing evidence of the direction of the ice movement, and as observed upon this island and at Monclova, proved that the movement was westward, rather than eastward. Upon South Bass Island the striæ run S. 80° W., with a second series S. 15° W. At Sandusky the direction is S. 80° W., at Ballville S. 65° W., and at Genoa S. 65° W. Vol. VI of the same Survey, in 1888 (page 754), devotes a paragraph to the glacial markings of Kelley's Island and the local deflection of the ice by prominent joints. The general direction of the striæ is given as S. 23° W., which striæ upon the

*2d Annual Report of the State Geologist, p. 113.
†Report of 1860, p. 127.
‡Ohio Geol. Sur., Vol. I, 1873, p. 538.





ICE POLISHED AND BRECCIATED OUTCROPS AT STONY POINT, LOOKING NORTHEAST.

eastern end of the island are found to be crossed by a later set extending S. 76° to 80° W.

In Wayne county, to the north of Monroe, an examination was made of the glacial striæ about the Sibley quarry. At the time of the first examination a few were found bearing S. 64° W. and these seemed to be the oldest. A recent inspection of the rock now stripped failed to show any of this series. Upon three sides of the quarry, and particularly the eastern, the rocks were heavily grooved by an ice sheet which moved about S. 28° W. Some of these grooves are from one to two feet deep, but mostly only a few inches. It is only in these grooves that these striæ are preserved. Outside they have been replaced by a newer set, the mean of 21 observations giving a bearing of N. 27° W. and a range of from N. 19° to 38° W. The evidence that the sheet moved northwestward, instead of southeastward as has been previously reported and believed, is very conclusively shown at the Sibley quarry. "Chatter marks" occur with their convexities directed toward the southeast, "disruptive gouges" are formed with their concavities in the same direction. Where the ice crossed a groove previously formed, it was not yielding enough to settle into it completely, so that the eastern side of the groove was but slightly striated while the opposite side was more or less affected, being rounded and irregularly scratched. Projecting knobs of limestone show the most bruising upon the eastern, or southeastern faces and but little upon the opposite, or lee faces. But the most conclusive evidence is furnished by one bed of limestone which contains irregular masses of chert. This bed shows the trails of limestone, extending northwestward from these harder masses, with a very decided frontal and two lateral grooves, surrounding each nodule. These phenomena have all been described and figured by Chamberlain in his paper on "The Rock-Scorings of the Great Ice Invasions," published in 1888.*

Within the limits of Monroe county there are a number of places where the glacial striæ may be observed and a few localities where they may be very satisfactorily studied. Although many irregular and more or less distinct striæ may be observed, still, so far as direction is concerned, the principal ones seem to fall into three groups which may be correlated with those observed at Trenton. These are not all equally well represented at each locality and it is not always

*Seventh Annual Rep. of the Director U. S. Geol. Sur., pp. 147-248.

true that the newer set predominates over the older, the latter at times having been protected apparently by clay from the work of the later sheet. The principal information relating to these Monroe county scorings, as collected by the writer, is given in the accompanying table and shown graphically upon Plate VII by means of arrows. The striæ observed by Hubbard and Winchell at Point aux Peaux, Stony Point and Brest running S. 50-60° W. "N. 50-60 E." correspond in direction with the oldest observed at Trenton, S. 64° W., and are believed to have been formed at the same time. The next oldest set has a more southerly course and was formed during an energetic stage of the ice sheet. The heaviest grooving was observed at Trenton where the direction of movement was S. 28° W. In the heavy grooves on Kelley's Island the direction of movement was S. 23° W., as given above by Orton, so that these grooves and striæ are apparently to be correlated. Between these points at numerous places striæ are found which should be referred to this same stage of glaciation. Upon the islands at the western end of Lake Erie, in the eastern part of Monroe county and at Trenton, the freshest striæ have a westerly course ranging from a few degrees south of west to 52 to 71° north of west. These were produced by the central and northern portions of the Erie lobe of the Wisconsin sheet and indicate simply that the ice moved out at right angles to its front wall, as located by the moraines. It would be natural to refer the two earlier sets of striæ to the Illinoian and Iowan sheets respectively but we have no warrant for so doing. It is true that when the next oldest set was formed the ice was much more vigorous in its action but this is only what would be expected of the Wisconsin sheet when it was first advancing across the region, or had attained its extreme southern limits. In the last stages of its retreat it was able simply to smooth, polish and striate the rock surface but not to form heavy grooves. The direction of movement of the same sheet would also be expected to differ greatly over the same area at different stages of the ice development. Quite generally, however, there is a noticeable difference in the relative degree of freshness of the striæ, the older set having preceptibly aged. In the case of the newer series there is sometimes a question in one's mind as to whether a given short scratch was produced by the ice, or by the tool with which the stripping of clay was removed. The doubt rarely arises with regard to the older set, its striæ being duller, less sharply cut and slightly weathered. In some instances, however, it



seems impossible to detect such differences between the older and newer series, where they both presumably have been well protected by clay. Near Brest there is a knob of dolomite, which appears at the side of the road just south of Stony Creek. The bearings of delicate scratches were taken here sixty years ago and still appear fresh in the case of the later series. Upon the lee side of the knob the older set was protected from the last ice sheet and although plainly

TABLE VII.—GLACIAL STRIÆ IN MONROE COUNTY.

| Locality. | Relative age. | Relative abundance. | True bearings of striæ. | Mean. |
|---|---|---|---|---|
| Sissung quarry....... | Newer........ | Most.......... | N. 58° W., N. 55° W., N. 56° W., N. 59° W., N. 59° W.......... | N. 57° W. |
| | Older......... | Fewest....... | S. 37° W., S. 41.5° W., S. 31.5° W........................... | S. 37° W. |
| Point aux Peaux.... | Newer........ | Fewest....... | Not present or quite obliterated......................... | ............ |
| | Older......... | Most.......... | S. 20° W., S. 17° W., S 19.5° W., S. 28.5° W., S. 18.5° W.. | S. 21° W. |
| Stony Point.......... | Newer........ | Fewest....... | N. 51° W., N. 44° W., N. 51° W., N. 79° W., N. 54° W., N. 46° W. | N. 54° W. |
| | Older......... | Most.... ..... | S. 8° W., S. 6° W., S. 9° W., S. 8° W., S. 8° W., S. 20° W.... | S. 10° W. |
| Brest................. | Newer........ | Most.......... | N. 57° W., N. 58° W., N. 59° W., N. 53.5° W., N. 59° W........ | N. 57° W. |
| | Older......... | Fewest....... | S. 10° W., S. 7° W., S. 8° W., S. 11° W., S. 9° W........... | S. 9° W. |
| Monroe stone quarry | Newer... .... | Most.......... | N. 54° W., N. 52° W., N. 46° W., N. 42.5° W., N. 47.5° W...... | N. 48° W. |
| | Older......... | Fewest....... | S. 12.5° W., S. 10.5° W., S. 14.5° W., S. 10° W., S. 13.5° W.... | S. 12° W. |
| Plum Creek.......... | Newer........ | Most.......... | N. 62° W., N. 60° W., N 61° W. | N. 61° W. |
| | Older......... | Fewest....... | S. 7° W., S. 5° W., S. 6 W..... | S. 6° W. |
| Head of Ottawa Lake............... | Newer........ | Fewest....... | S. 22° W., S. 22° W., S. 19° W. | S. 21° W. |
| | Older......... | Most.......... | S. 81° W., S. 91° W., S. 78° W., S. 107° W..................... | S. 89° W. |
| Ottawa Lake quarries............ | Newer........ | Fewest....... | S. 24.5° W., S. 25.5° W......... | S. 25° W. |
| | Older......... | Most.......... | S. 70° W., S. 70° W., S. 69° W., S. 70° W...................... | S. 70° W. |
| Macon river bed..... | Newer........ | Most.......... | S. 38° W., S. 39.5° W., S. 38° W., S. 38° W, S. 35° W...... | S. 38° W. |
| | Older......... | Fewest...... | N. 73.5° W., N. 76° W., N. 73° W.............................. | N. 74° W. |
| Woolmith quarry.... | ................ | ................ | S. 41° W., S. 36° W., S. 26° W., S. 26° W., S. 47° W.......... | S. 35° W. |
| Inlet Ottawa Lake, Sec. 19............. | ................ | ................ | S. 65 5° W.......................... | S. 65° W. |
| Halfway Creek, Sec. 35.................... | ................ | ................ | S. 56° W., S. 59° W., S. 55° W., S. 55° W...................... | S. 56° W. |

grooved the striæ are well nigh obliterated. This would seem to indicate that a considerable period of time elapsed between the making of the two sets, during which time the ordinary destructive agencies were at work upon the oldest. In the western part of the county the correlation of the striæ is rendered uncertain on account of the relative age which it seems necessary to assign to the two series observed at several localities. The rock in the bed of the

Macon and the Raisin at its mouth is heavily glaciated. The main direction is S. 38° W., but a few heavy scratches, apparently older, run N. 74° W. From their direction alone there should be no hesitation in referring the latter to the newer series observed to the east. At the Ottawa Lake quarries the older set runs S. 70° W. and the newer S. 25° W., while one-half mile south at the limited rock exposure at the head of the lake, the older set lies in a shallow groove, with its striæ S. 89° W. and the newer set S. 21° W. These striæ could be very satisfactorily correlated, with those in the eastern part of the county providing their age was reversed. It would seem that those having the westerly course must correspond with those made by the Erie lobe, in which case it is a problem to know how to dispose of the later series ranging from S. 19° to 39.5° W. Further observations might furnish a satisfactory explanation, but as it now appears it seems necessary to assume a local ice movement subsequent to that described as the latest in the eastern part of the county.

### *C. Lacustrine Stages.*

§ 9. Introduction.

For some reason, possibly on account of the great weight of the ice sheet, a marked subsidence of the earth's crust occurred over the region thus covered. This change, combined with others affecting the position of the earth with reference to the sun, or perhaps an increase in the amount of carbon dioxide in the atmosphere, restored the equable climate which this region had enjoyed previous to the great catastrophe and led to the disappearance of the ice sheet. The melting of such a body of ice, together with the normal precipitation, would furnish enormous quantities of water for the greatly disturbed river systems to take care of. The sub-glacial streams, contracted by narrow walls, would leave the ice with great velocity and carrying much sediment. Upon spreading out in the depressed and partly filled river channels, leading from the ice front, the velocity would be greatly checked and much sand and gravel deposited. This epoch was short when compared with the preceding and corresponds more or less with the Champlain epoch of the east. A reëlevation of the land followed the disappearance of the ice sheet, the streams were given greater fall, and hence greater velocity, and began clearing out their obstructed channels, forming a series of



terraces at successive levels. While this was the course of events in the east a very different program was carried out in southeastern Michigan and northwestern Ohio.

§ 10. Lake Maumee.

(a). Van Wert stage. As the ice began its retreat northeastward down the Maumee valley from Ft. Wayne, Indiana, lower and lower land was successively exposed. This depression filled with water as the ice receded, and a lake of correspondingly greater proportions was formed, to which the name of Maumee was appropriately given by Dryer, in 1888.*

When the apex of the lobe had reached Defiance, Ohio, the ice front halted, or made a slight advance, and a moraine formed to mark this episode in its history. This moraine may be followed southeastward through Findlay from Defiance and northeastward through Adrian, being known as the Defiance moraine. It consists of one or more rows of rather subdued hills, passing to the west of Ypsilanti, near Northville to Rochester, where it turns northward into Lapeer county. It marks the approximate position of the ice front which was acting as a great retaining wall to prevent the water now spreading over the upper part of the Maumee valley from flowing in the natural direction of drainage. Where the waves of this lake impinged upon the land a gravel and sand beach was formed at an elevation, in the region under study, of about 220 feet above Lake Erie level, or 793 feet above tide, thus marking the approximate elevation of the surface of the lake itself. Some half dozen different names have been assigned to this beach in Ohio and Michigan, which it would cause confusion even to mention. The latest to be suggested is Maumee, as being the simplest but if two stages of Lake Maumee are to be recognized, there is no reason why one beach should be so named rather than the other. Since this same term has also been applied to the Leipsic Beach, and since they both are frequently referred to as the upper and lower Maumee, it seems best to the writer to retain one of the original names, the one most frequently used and to reserve Maumee for general use, when one or both beaches are to be designated.

According to Leverett who has now followed this beach more continuously than any other investigator, its normal height varies from five to ten feet and its breadth from ten to twenty rods. It is known

*Sixteenth Annual Report of State Geologist of Indiana, Geology of Allen County, pp. 107 to 126.

to extend from Findlay, westward to Ft. Wayne and thence northeastward to Adrian, where it is supposed to have temporarily met the retaining ice wall. As pointed out by Taylor the lake was in the form of an arrow-head, with the point at Fort Wayne and a barb each at Findlay and Adrian. It is to the latter author that we are especially indebted for the facts pertaining to the lacustrine geology of eastern Michigan.* The distance across the barbs is about 75 miles, and about 40 miles from Ft. Wayne back to the ice wall at Defiance, where the lake is estimated to have been 60 feet deep. The lake drained southwestward from Ft. Wayne, through a now abandoned channel and entered the Wabash River near Huntington.

When the ice again began its retreat it withdrew from the Defiance moraine and the lake (still at the same level), filled in between this moraine and the ice wall, forming a long narrow arm, extending farther and farther to the northeast. In consequence, the Maumee Beach was continued beyond Adrian and was formed upon the inner (iceward) side of the Defiance moraine for many miles, finally reaching Imlay in Lapeer county. Thus far we are simply dealing with the gradually enlarging, first stage of Lake Maumee.

During this stage of the lake the ice front is believed to have made two periods of halt and advance, as marked in this region by the Defiance and the Cleveland moraines. The moraine designated by Taylor as the Toledo was supposed by him to pass southwestward across Monroe county around Toledo and to connect with Leverett's Cleveland moraine. This moraine could not be recognized by the writer in Wayne and Monroe counties, as a surface feature, although there is suggestive aggregation of boulders and cobbles in the eastern part of Whiteford township, which may be in the line of such a moraine. Possibly because of its waterlaid character it may have been so completely obliterated as to be easily overlooked. There is some little evidence that it strikes southeastward from Birmingham toward Detroit, where it may pass under the Detroit moraine. If this should prove to be the case it would be necessary to conclude that the ice receded from the Toledo moraine, halted and in its advance near Detroit had pushed beyond the position which it had occupied when the Toledo was laid down. Between Wyandotte and Trenton there swings in from the river a series of gentle till swells, carrying boulders and cobbles, which are believed to constitute the western edge of the Detroit moraine. Similar ridges occur on Grosse Isle with a direction a little south of west. West and southwest of Trenton these low ridges are well defined and are charged with small rock fragments. Their direction in Monguagon township is southward turning to the southsoutheast as they pass in to Brownstown and then again due south as they approach the Huron River. From the Huron southward the ridges have disappeared but there is an aggregation of cobbles and boulders to the east and southeast of Newport which proves that the Detroit moraine really extends across Berlin and the eastern part of Frenchtown to Stony Point where it enters the lake. Southwest of Brest for a mile or more there is a mere suggestion of morainic topography, the swells running east and west.

*Correlation of Erie-Huron Beaches with Outlets and Moraines in southeastern Michigan; Bull. Geol. Soc. of America, Vol. 8, page 31, 1897. The Great Ice-dams of Lakes Maumee, Whittlesey and Warren; Amer. Geol., Vol. XXIV, 1899, page 6; A short History of the Great Lakes: Inland Educator, Vol. II, 1896: pp. 101, 138, 216. The correlation of the Toledo moraine above suggested Mr. Taylor now considers uncertain. The subject is now (summer of 1900) under investigation by Messrs. Leverett and Taylor. Prof. Sherzer's proof has been revised by them so as to bring his references to them in harmony with their present information. L.



(b). Leipsic stage. When the great tongue of ice had withdrawn from beyond the present site of Imlay, ground was uncovered which was at a lower level than that of the lake itself and an outlet, northwest to the Flint River was opened. This was neither large enough, nor low enough to entirely take care of the surplus water that was rapidly supplied and the Ft. Wayne outlet also continued to serve. The level of the lake fell ten feet or more in consequence of the opening of the Imlay outlet and a new beach, known as the Leipsic was formed entirely around the margin of the now lowered Lake Maumee. During the greater part of the first stage described Monroe county was probably covered with the ice, but during the latter part of this stage and practically the whole of the second, the county was under water, about two hundred feet of which covered the site of the city of Monroe.

§ 11. Lake Whittlesey.

Beginning again its slow retreat the ice front receded in the direction of Port Huron and northeastward down the bed of Lake Erie, dividing into respectively the Huron and Erie lobes. The former withdrew as far as Port Huron and formed the Port Huron moraine, which extends from near this city, northwestward between Black River and the present Lake Huron shore, meeting at Ubly the contemporaneous moraine formed by a lobe of ice which occupied the Saginaw valley. The ice thus uncovered lower land lying between Ubly and Tyre, in the southern part of Huron county, a new outlet was formed leading southwest into the Cass River and the level of the glacial lake fell about forty feet., forming the lake to which Taylor has given the name Whittlesey. The new beach formed by this body of water stands at an elevation of 743 feet, in southeastern Michigan, or 170 feet above Lake Erie level, and is now generally known as the Belmore. It is a gravel and sand ridge from twelve to fifteen feet high and several hundred feet broad, the best defined of the entire series of beaches in this part of the state. It lies to the east of the Van Wert and Leipsic beaches and approximately parallel with them, its distance depending upon the topography of the county, but averaging from two to four miles. It enters the state from Ohio, about twelve miles west of the southeastern corner of Lenawee county, passes northward to Lenawee Junction and then turns to the northeast, passing through Ridgeway, York, Stony Creek, Plymouth etc., to the outlet noted. The "ridge," as it is called locally, cuts the extreme northwestern corner of Sec. 6, of Milan, the diagonal road following its crest for many miles between Pontiac and Adrian. A good section of the upper part of the beach is shown in a gravel pit just west of where it is cut by the Ann Arbor road, north of Milan. The section here shows at one point; $5\frac{1}{2}$ inches of brown, gravelly, unstratified clay soil; 30 inches of light brown, roughly stratified clay sub-soil, becoming a deep rusty red. The clay passes into a coarse sand and this into fine gravel, with some pebbles as large as hens' eggs. This gravel is well stratified; 6 inches of perfectly stratified, fine sand; 10 inches of grit, obliquely laminated; 1 inch layer of fine gray sand mixed with some clay; 48 inches of stratified gravel, with the strata dipping towards the lake side. The gravel is very fine towards the upper part of the bed, becomes gradually coarser and then finer. One layer is thoroughly washed from fine sediment and is loose and open, the remainder of the bed has more or less sand.

Total thickness of section equals 8 feet $4\frac{1}{2}$ inches.

The farmers living upon the beach very generally report that the gravel layers extend to a depth of twelve to fifteen feet and that water is readily secured from the lower beds.

Owing to the inaccessibility of the early geological reports of the state, credit is not usually given Bela Hubbard for his observations upon the surface geology of the region and for his sagacious interpretations of the same. The Belmore Beach he had followed for many miles and in 1840 he described it under the name



"Ancient lake ridge,* as a continuous gravelly ridge having a course parallel with the present shore of Lake Erie and the Detroit river. He observed its structure and the sudden change which it marks in topography, the surface to the east being low and flat, while that to the west is more elevated and rolling. He recognized the differences also in the character of the soil and of the timber upon opposite sides of the beach. The elevation he gave erroneously as 107 to 108 feet above Lake Erie but he clearly saw that it marked the level of a great sheet of water. The difficulties in the way of such an interpretation were stated to be in accounting for such a supply of water and in finding barriers capable of confining it. The possibility of an Appalachian uplift across the St. Lawrence and the Highlands across the Hudson, serving as barriers is suggested, in which case

> "a single communication only would then exist with the ocean, viz.: through the valley of the Mississippi. * * * That the lakes once discharged their waters in this direction, such additional evidence is furnished by the appearance of the country, that in this our argument but serves to add confirmation to the general opinion."

The existence of a barrier at Mackinac, cutting off Lakes Michigan and Superior, with the closing of the outlet to the Mississippi would cause the level of the water to rise until it would break through the Mohawk and Hudson and finally through the St. Lawrence. (p. 106.) From fossils found in the Saginaw and Niagara valley deposits he concluded that the water was *fresh*, although he suggests the probability of a subsidence to ocean level, with barriers cutting off the influx of the sea and "disproportionate elevations." In the report above referred to, a topographic map of Wayne county is published, the work of S. W. Higgins, upon which the Belmore Beach is located. Instead of entering Livonia township at the northwestern corner of Sec. 18 and cutting diagonally across Secs. 7 and 5 the beach is represented as following the town line north between Livonia and Plymouth. This error arose from the fact that the Maumee Beach leaves Wayne county on this town line and the two beaches were, in consequence, confused. A glance at the drainage of the region should have made the error apparent. Hubbard followed the beach across Oakland and Macomb counties, into St. Clair, and discovered a number of other inferior ridges between this and the Lake Huron shore. On his map of Lenawee county issued by the Geological Survey it is traced

*H. R., No. 8, p. 102; H. D., No. 27, p. 278; S. D., No. 7, p. 138.

from a quarter of a mile south of the northeast corner to Sec. 19, Palmyra township. "This ridge is from 10 to 20 feet high, the former boundary of the lake shore composed of sand and gravel." The strip of land lying between the Belmore and Maumee Beaches, including the extreme northwestern corner of Monroe county, was uncovered by water during the existence of Lake Whittlesey and gives evidence of long continued surface erosion. This feature, combined with the great strength of the beach, leads to the conclusion that this lake persisted for a relatively long time.

§ 12. Arkona beach.

The recession of the ice front from the Port Huron moraine opened an outlet, or series of "spillways" from fifty to sixty feet lower than the level of Lake Whittlesey. The position of these outlets was located by Taylor across the "thumb" north of Ubly rather than around it to the north, and correlated hypothetically with this beach, so that the general direction of drainage of the former lake was continued. The great difference in level between this body of water and that of Lake Whittlesey, with the consequent changes in form and drainage, justify its separation from the latter lake. The fact that it was not confluent with Lake Saginaw seems a ground for not regarding it as simply an early stage of Lake Warren. See Part II of this volume, upon Huron county.

It seems probable that this stage in the lake history continued only while the ice was retreating from the Arkona outlets to the position it occupied when Lake Warren was formed. This was of relatively short duration and the beach, so far as it has been followed in Michigan, is of a weak, tortuous character. In Wayne, Monroe and Lenawee counties it is a rather wide, but flat sand ridge, from two to four feet above the general level. Broad areas of pebbly sand are occasionally associated with the faintly developed swell of sand, and cuts into it at the roadside show fine gravel layers to a depth of from two to three feet. From the beach lakeward there is a gradual surface slope apparent, by which the Arkona may be recognized aside from the materials of which it is composed and its surface elevation. Aside from its weak development the beach is peculiar in the fact that it does not take a direct course. It seems to have simply followed its surface contour, its course being determined very largely by the topography instead of determining the topography. An inspection of Plate VII shows



the beach entering Monroe county from Washtenaw, about 1¾ miles east of the village of Milan. It passes southwestward across Milan and Dundee townships, following closely the 690 foot contour, but lying to the west. Leaving the county in Sec. 6 of Summerfield the topography causes it to make a curve to the west in Lenawee county, crossing the Raisin and reëntering Summerfield township south of the river in Sec. 18. It then passes eastward to the south of the river road and turns northeast toward Petersburg. Southward for nearly three miles its sand is mingled with that of the next lower, or Forest Beach. In Sec. 21, it swings westward, leaves the county again and makes another but larger curve to the west owing to the relatively depressed and very flat character of the surface in southern Summerfield and northern Whiteford townships and the adjoining portions of Lenawee county. From Dundee township, through Summerfield the sand has been heaped into mounds and ridges through the agency of eastern winds. According to Spencer the beach extends westward to Blissfield where it has the same duny character and an elevation of 694 feet. It then turns eastward and makes a regular curve in the southwestern corner of Whiteford, west of the railroad. It here consists of a rather well defined swell of gravelly sand, the dunes seen to the west and north having disappeared. The beach turns westward, and enters Ohio from the southeastern corner of Lenawee county. Through this region it is separated from the sand of the Forest by a belt of heavy clay. In his map of the raised beaches north of the Maumee River* Gilbert did not recognize this as a separate beach. It enters Ohio between his third and fourth beaches about five miles east of the northwest corner of Lucas county. It is not improbable that to the southwest it may be incorporated in the broad belt of sand mapped as the Fourth Beach. Spencer gave the elevation of the Arkona at Dentons, on the Michigan Central in Wayne county, the same as at Blissfield, 694 feet, and this appears to be approximately correct. It would seem as though a very few years would suffice to construct a beach of such strength. In places a miniature ridge was observed, running parallel with the main one, but one-fourth of a mile distant, on the lakeward side, and from two to three feet lower. While this stage of the series of ice-dammed lakes persisted that portion of these townships lying to the west of the beach was

*Geol. Survey of Ohio, Vol. I, 1873.

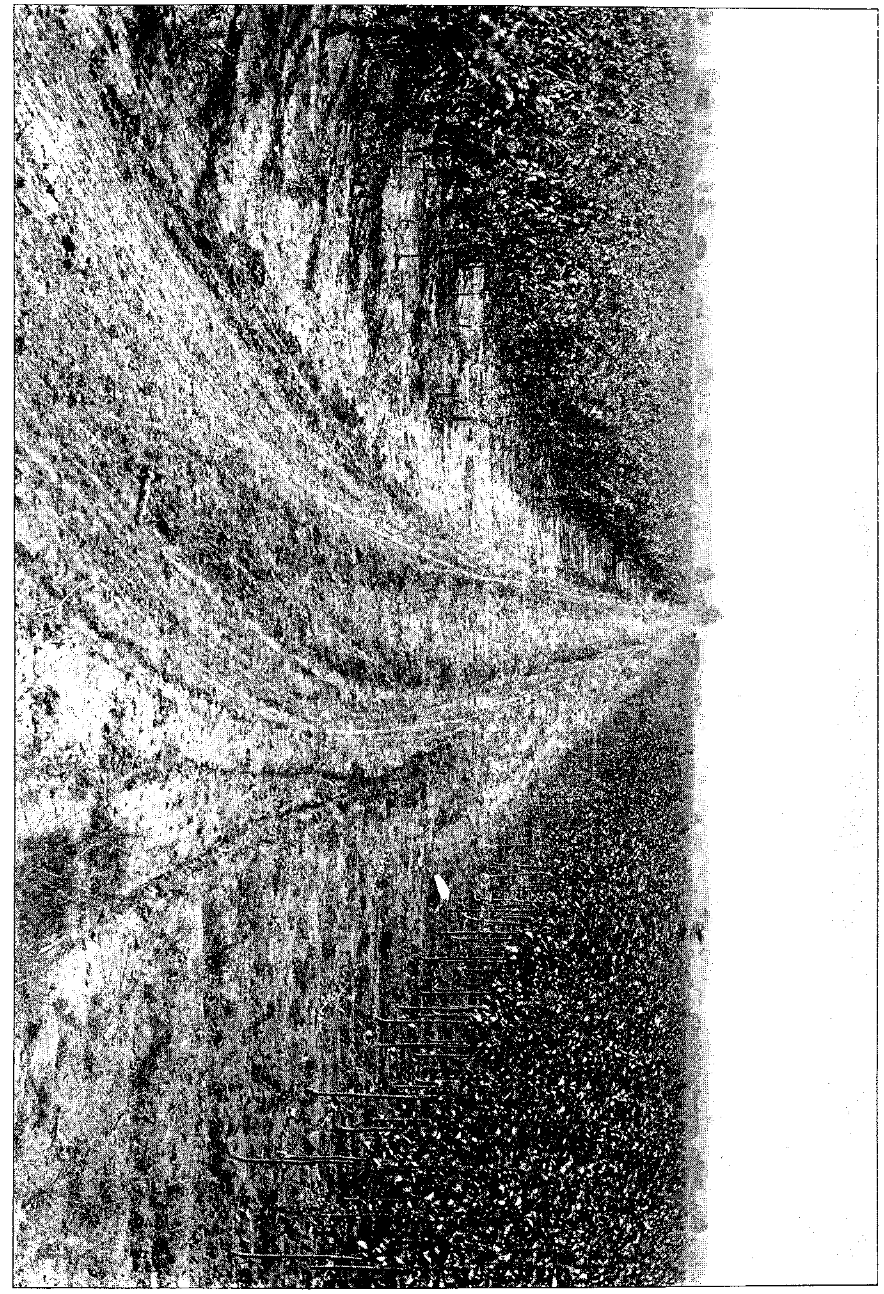
above water. Over Monroe City the water stood from 100 to 105 feet deep.

§ 13. Lake Warren.

(a). Forest stage. From near Sylvania, in Ohio, there enters Monroe county a broad belt of heavy yellow sand which was termed by Gilbert, in 1873, his beach No. 4. This he regarded as representing a gradual subsidence of the glacial water from 90 to 60 feet. In Bedford township this belt divides into two, as shown upon Plate VII, the main part of which passes northward through Ida, Dundee and London townships, lying between the contours of 90 to 80 feet above Erie level. This strip of sand has been called the Forest Beach by Spencer and it outlines a great sheet of water to which has been given the name Lake Warren. So far as seen in Monroe county there is no well defined ridge, as in the previous cases, but simply a belt varying in width from four to seven miles, over which the loose sand has been heaped by the wind into mounds and ridges. Some of these ridges continue for several miles and attain a height of twenty to twenty-five feet. In places heavy double ridges occur, parallel with the shore line. This Forest Beach cuts the southeastern corner of Washtenaw county, passes across Wayne county, intersecting the Michigan Central road at Wayne station, and continues northeastward by Port Huron into the "thumb." The elevation of the rail at Wayne is 87 feet above Erie level and this marks approximately the center of the belt. In passing northeastward from Dentons to Goodells, west of Port Huron, the Arkona rises seven feet owing to a differential uplift. In this vicinity the Forest has an elevation of 92 feet above Erie (665 above tide, according to Spencer) and if we assume the same differential movement the Forest in Wayne, Washtenaw and Monroe counties would have an elevation of 85 feet above Erie, or 658 feet above tide.

As the ice front retreated from the Port Huron moraine, beyond the place at which the Arkona outlet had been opened, it made its next halt and slight readvance along a line extending from the point of the "thumb," northwestward through Harrisville and Alcona, in a curve to Petoskey, depositing the Alcona moraine. As the ice moved down the northern slope of the "thumb" a series of temporary outlets were opened into the Saginaw valley, and finally the waters in front of it thereafter known as Lake Warren became confluent with those of Lake Saginaw. (See Part II of this vol-





MONROE NURSERY, TYPICAL OLD LAKE BOTTOM, AND WAVE-WASHED FLAT.

ume, Geology of Huron county, Fig. 4, Plate VIII.) According to the observations of Gilbert, Taylor and Lane the Forest Beach in this northern region is characteristically double, showing two well defined gravel and sand ridges, with a difference in level of eight to fifteen feet. In the southeastern part of the state it is very probable that similar beach ridges were also formed, which were later covered by shifting sand and completely obscured. The shape of Lake Warren during this stage was such that with a prevailing northeast wind the waves would strike with greater force upon the shelving shore of southeastern Michigan, than upon the "thumb." A greater amount of sand would thus be tossed up by the waves and carried inland. The common outlet of the Saginaw and Warren lakes is known to have been through the Pewamo channel, extending from Maple Rapids, by Pewamo, Muir, and Ionia to the Grand River. This channel is fifty miles long and from three-fourths to a mile wide, with a fall to the southwest of not more than a foot to the mile. Through this outlet the waters of all the glacial lakes described, except Lake Maumee in its first stage, drained to Lake Chicago, thence through the Chicago outlet and on to the Mississippi.

(b). Grassmere stage. A second beach, not hitherto recognized in this region, branches from the broad belt of sand which enters Bedford township from Ohio, and passes northeastward through Erie, La Salle, Monroe, Frenchtown and Ash townships (See Plate VII). As seen in Monroe and Wayne counties it consists of a belt of yellow sand, from two to three miles in width, covered with heavy ridges and knolls between the contours of 610 to 620 feet above tide (37 to 47 feet above Lake Erie level). It is the reduced counterpart of the Forest Beach and was made by Lake Warren after it had suffered a drop in its level of about 43 feet, caused by the clearing away of some obstruction in its outlet. That the drop was not sudden is evidenced by the fact that this beach is connected in places with the Forest by light coverings of sand and but little heavy surface clay separates the two. The drop from this stage of Lake Warren to the present Lake Erie level, a distance of about 42 feet, was apparently much more rapid. Plate XI gives a view of one of the heavy ridges of sand seen just west of Erie.

These are abundant and characteristic from the Ohio line to Dearborn, as far as the writer has followed the beach continuously. According to the Michigan Central profile the approximate elevation of the central portion of the belt is 615 feet A. T. and at Carleton about the same. In his survey of Huron county (See Part II of this volume) A. C. Lane has identified a series of beaches which are at the right elevation, below the Forest, to include this one. To this series he has given the name Grassmere. The subjoined table shows at a glance the main facts pertaining to the glacial lakes of southeastern Michigan. The glacial history outlined thus briefly in this chapter furnishes the key to an understanding of the physical features of Monroe county. It accounts for some peculiarities of the rock surface, the nature and distribution of the materials which cover the bed rock, and the surface topography with attendant drainage. All parts of the surface were successively subjected to wave action which cut down prominences and filled in depressions. A layer of sediment was spread over the entire county, thin to the west, thicker towards the east and southeast. This consists of a dark colored, finely divided clay, generally free from pebbles. A good impression of the effect of this action upon the topography is shown in Plate XIII. Much of this was removed by wave action as the water receded and much of it has since been removed by surface erosion, so that in many portions of the county the pebbly till reaches the surface, or is covered by only a few inches of vegetable mould. Over these regions the surface boulders are only slightly imbedded, while in the eastern and southeastern portions of the county the deposit is thicker and the boulders generally covered. The thickness observed in a number of places varies from two to three feet, and the maximum in Erie township is undoubtedly much greater. From the crest of "stony ridge" this deposit has been removed very largely through erosive agencies. The source of this clay was the till, from which the sand and pebbles were removed by waves and thrown upon the beach, while the finer clay particles were held in suspension, carried lakeward and deposited in the deeper water. The clay used in the Monroe brickyard must have sand added to it before it is suitable for brick and tile. In front of the Arkona beach in the southwestern part of Dundee township there are patches of wave washed till from which the waves removed the sand and fine clay but were not strong enough to disturb the pebbles. In consequence the soil is full of small pebbles and the beach is very largely composed of sand.



TABLE VIII.—FORMER LAKE BEACHES IN MONROE COUNTY.

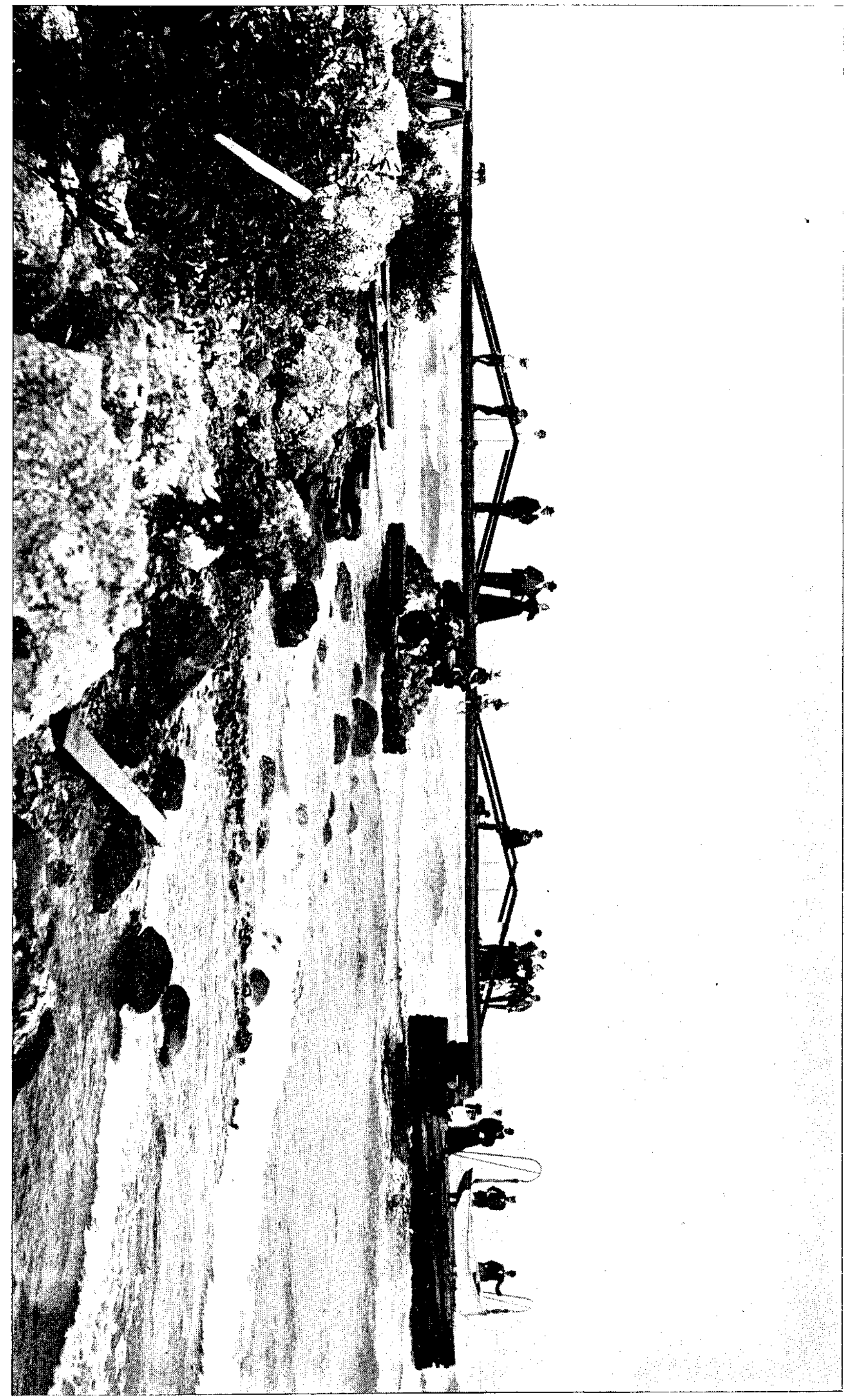
| Name of lake. | Outlet. | Location of ice dam. | Name of beach. | Elevation of beach in Monroe county. | |
|---|---|---|---|---|---|
| | | | | Above tide. | Erie level. |
| 1. Maumee— | | | | | |
| *a*. Van Wert stage | Fort Wayne | Defiance and Cleveland moraines | Van Wert | 793 | 220 |
| *b*. Leipsic stage | Fort Wayne and Imlay | Detroit moraine | Leipsic | 783 | 210 |
| 2. Whittlesey | Tyre Ubly | Port Huron moraine | Belmore | 743 | 170 |
| 3. Arkona | Spillways, Huron county. | Between Port Huron and Alcona | Arkona | 694 | 121 |
| 4. Warren— | | | | | |
| *a*. Forest stage | Pewamo | Alcona and Hagensville | Forest | 658 | 85 |
| *b*. Grassmere stage | Pewamo and-? | Hagensville and northward | Grassmere | 615 | 42 |

This table has been revised by Leverett and Taylor. L.

§ 14. Lake Erie.

The withdrawal of the ice sheet from the St. Lawrence valley, opened an outlet for the great lakes to the east and the level of Lake Warren fell sufficiently for Erie to separate from Lake Huron. The three upper great lakes were still confluent, forming the great Lake Algonquin which drained into Lake Erie as at present. The still further retreat of the ice from the Ottawa valley, opened an outlet through Georgian Bay, Lake Nipissing and the Mattawa valley, lowering the level of Lake Algonquin to what Taylor has named Nipissing Great Lake. During the existence of this latter lake its drainage was through the Ottawa River, and Lake Erie alone drained into the Niagara River, and supplied the water for the falls. During this time the level of Lake Erie was lower than now. A differential elevation of the region to the north finally cut off the flow through the Nipissing-Mattawa River and the St. Clair and the Detroit rivers again became the line of drainage bringing the present great volume of water into Lake Erie. The elevations and fluctuations of the level of the lake, so far as data have been obtained, are given in the preceding chapter. It seems necessary to conclude from the nature of the Warren beaches that the prevailing wind was from the east or northeast. During the Erie stage it has been from the opposite direction and, although there is a sand ridge bordering the lake for a considerable distance, the sand has not generally encroached upon the land. Between Stony Point and Point aux Peaux there occurs the outcrop of dolomite previously referred to and for this distance there is a gravel beach of rather angular fragments. (See Plates XII and XIV.) The crest of the ridge here is about six feet above the water level and from 30 to 35 feet back from its edge, making the slope quite steep. For the greater portion of the distance between the points there is a belt of sand from five to twenty feet broad, which skirts the water's edge, and in places extends well up the gravel slope. In the water itself there is a strip of fine to coarse gravel, mixed with sand. Landward from the crest of the gravel ridge the inclination downward is more gradual, giving a slope from 50 to 60 feet in breadth, which passes into a low marshy strip, supplied with water from the lake during times of storm. This marsh is, in general, very extensive, covering thousands of acres, and three areas may be recognized, separated by more highly cultivated land about the mouths of Stony and Otter creeks. These have been converted into hunting preserves





MONROE BEDS AT POINT AUX PEAUX, MONROE COUNTY.

and at certain seasons water fowl are abundant. The Point Mouillée marsh extends from the mouth of the Huron to Stony Point. The Monroe marsh begins about a mile south of Brest and extends to the mouth of Plum Creek. The Erie marsh, with interruptions, extends from near Otter Creek to the Ohio line, broadening in places and including patches of open water. Figs. 5 and 8 (p. 199) give views of the last two regions. Shelving off gradually from the beach there is a strip of sand which extends lakeward. The three fathom (18 foot) contour upon the government chart extends out $4\frac{1}{2}$ miles from the north cape of Maumee Bay, and gradually approaches the beach until opposite Stony Point and Point aux Peaux, where it is but one-sixth of a mile out. Northeastward it again pushed lakeward by the deposits from Mouillée Creek and the Huron River.

§ 15. Recent submergence.

Extending backward from the lake for a distance of three to four miles, the Huron is practically a stagnant stream, with an ebb and flow as the easterly winds drive the water in from the lake. A difference of two feet in the level of the water in this part of the river may thus be produced. The Lake Survey chart gives the soundings for a mile back from the mouth, which in the channel range from 10 to 16 feet. Residents say that there are holes in the bed 25 feet deep, from one to two miles back. In an early day lake craft were built at Rockwood, four miles from the lake, and with a little dredging this village could be made a lake port. In its present condition, with no current, the Huron is incapable of cutting such a channel. Further, it meanders over this low plain, showing that at one time there was some cutting and hence some current. Its condition is that of a "drowned stream." The same phenomena are shown, to a greater or less extent, by all the streams which enter the lake from Monroe county. The Raisin empties into the lake by several mouths, the central one of which was converted into a canal by the general government in 1835. A view of this is shown in Fig. 4, giving one a good impression of the inundated appearance of the region. One of the channels to the south of the canal, for a distance of two miles, averages $8\frac{1}{2}$ feet in depth. Back from the lake [illegible] mile a depth of 12 feet is shown upon the chart, while in the lake itself the depth is but two to three feet. Referring to the Raisin the coast chart says, "depths at this harbor vary but little from year to year, but dredged channels outside of piers are not permanent." It is probable that the ebb and flow from the influence of the lake serves to keep the channels open, but could not have originally produced them.

Another good illustration is furnished by Halfway Creek, which empties into North Maumee Bay in the southeastern part of the county. Attention was called to this in 1873 by Gilbert in the Ohio report.* Slack water was said to begin seven miles from its mouth. One-half mile from the bay the stream is sixty rods wide, with a central channel four rods wide, fifteen feet deep, and with its banks seven feet under water. Back where the slack water is first noticed the channel is twenty feet wide and six feet deep. The lake chart now shows a well defined submerged channel running back three miles from the bay and averaging 9.4 feet deep, with a maximum of 14 feet. This channel extends into the bay, giving soundings of 7, 10, 8 and 13 feet, through a strip over which the water ranges from 4 to 5 feet. Similar phenomena have been observed by Taylor in the streams which empty into the Detroit and St. Clair Rivers, and into Lake St. Clair.†

Fig. 4. View of the government canal, near Monroe, opening into Lake Erie. The view gives one an idea of the inundated "drowned" appearance near their mouths of all streams which empty into Lake Erie.

*Vol. I, Geology, page 555.
†Proceedings Amer. Assoc. for the Ad. of Science, 1897.



The explanation is that all these streams, in comparatively recent time, flowed to a lower base level and were thus given sufficient velocity to cut their channels and erode their banks. According to the conclusions of the above author this occurred during the Nipissing stage, while the drainage of Lakes Superior, Michigan and Huron was through the Ottawa River, leaving the bed of the Detroit River practically empty and, probably, much lowering the present level of Lake Erie.* When the present drainage was restored the strip of land bordering the river and lake would be again covered with water, much of the beach would be rendered marsh and the mouths of the rivers, for a considerable distance back became submerged, *drowned,* as shown in Fig. 4.

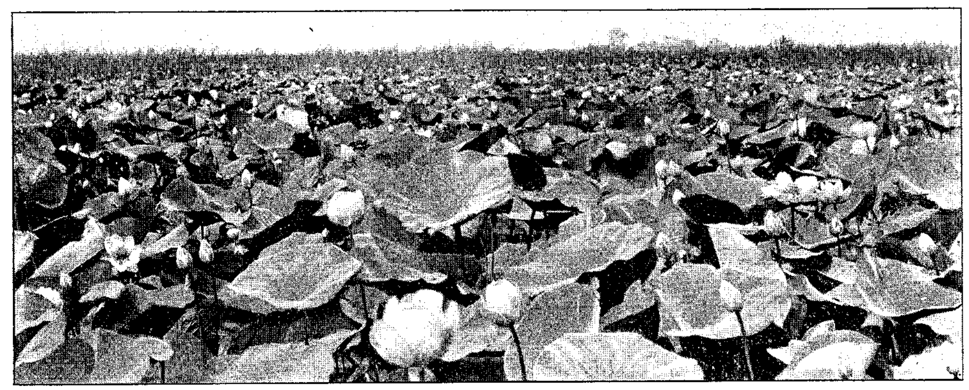


Fig. 5. Lotus bed in the marsh near Monroe. The marsh is due to recent submergence by the lake. Photographed August, 1890.

E. L. Moseley has shown† that this recent submergence accounts for the fact that the plants of the islands north of Sandusky Bay are the same as on the shore. He also calls attention to the fact that upon these islands are caves whose stalactites extend into the water, while the stalagmites are below the water 3 or 4 feet, and gives data regarding submergence of walnut stumps, etc.

### *D. Post-Glacial Warping.*

§ 16. Recent production of stony ridge.

The "stony ridge" which has frequently been referred to as a low anticline in the dolomites, passing from Sylvania northeastward

*Origin of the Gorge of the Whirlpool Rapids at Niagara. Bull. Geol. Soc. of Amer., Vol. 9, 1898, page 84.
†The Lakeside Magazine, Lakeside, Ohio, April, 1898, Vol. I, pp. 14-17.

through Monroe, gives evidence of having been produced since the withdrawal of the ice sheet. The deposits of till which overlie the rock appear to be conformable, to a greater or less extent, with the rock strata. There is produced, in consequence, a subdued swell in the surface topography, having a breadth of one-half to two miles and a maximum height of 12 to 15 feet. Had the formation of the rock anticline occurred before the Pleistocene deposits had been laid down we should expect no trace of it in the surface features. In Jefferson and Chautauqua counties of New York, Gilbert found similar low anticlines which he believed to be of post-glacial origin. These were described before the American Association for the advancement of science under the title "Some New Geological Wrinkles."* They were believed to have been caused by the lateral expansion of the superficial rock-strata as their temperature rose in consequence of the post-glacial amelioration of climate.

*Proc. Amer. Assoc. for the Ad. of Science, Vol. XXXV, 1886, page 227.

# CHAPTER VII.

## SOILS AND SUBSOILS.

### A. *Nature, Origin and Varieties.*

§ 1. Preglacial soils.

The different types of soil and their formation may be explained most simply by discussing first the effect of the various soil producing agencies upon the bed rock of the county. In determining what change occurred and what substances were produced during the countless ages that these rocks were exposed to the action of the air, rain and frost, it will be possible to bring into view again the original soil materials, with which the rocks were covered, and of which they were so thoroughly dispossessed by the ice sheet. One of the simplest transformations of rock into soil took place in connection with the St. Clair shale, in the northwestern part of the county. The material of which this formation is composed represents the indestructible elements of land areas, carried to the off shore region by streams, waves and ocean currents. It was completely altered, hydrated and deprived of all soluble ingredients. When elevated and exposed to atmospheric and aqueous agencies the principal change was purely a physical one, resulting in its softening and disintegration. There would result a heavy, compact clay soil. Other materials similarly introduced, would give character to the soil and add greatly to its fertility. Organisms which secrete calcium carbonate from the sea water would have become embedded in the ooze of the sea bottom and would add this substance, along with sulphur and iron. In weathering the iron would oxidize and stain the soil a brown or yellow. There must have existed then in the northwestern part of Milan township and adjoining portions of Lenawee and Washtenaw counties a dark brownish yellow or green, compact clay soil possessed of considerable fertility and lasting qualities. To the east of this small area, over the Traverse belt (see Pl. I), a somewhat similar soil resulted from the disintegration of the shales of this formation. It was, however, of a more bluish color and much richer in calcium carbonate because the shales themselves are richer in this substance and because of the interstratified layers of limestone.

A far greater change than that just described would take place in the case of the pure limestones of the Dundee formation which after exposure for a very great period would be unrecognizable. This alteration results largely from the solution of the carbonates of calcium and magnesium. Pure water cannot dissolve much of either of these substances, but when it contains carbon dioxide gas these carbonates are readily taken into solution as bicarbonates in proportion to the amount of this gas present. Ordinary rain water contains from .22 to .45% of this carbon dioxide by volume, but after percolating through a bed of vegetable mould this amount may be greatly increased. Expressed chemically the change by which the calcium carbonate is thus readily taken into solution is shown in the following equation:

$$CaCO_3 + H_2O + CO_2 = Ca(HCO_3)_2.$$

In solution the bicarbonate is carried to the sea where the myriads of organisms may break up this unstable compound, retain the calcium carbonate and liberate the carbon dioxide which will escape into the atmosphere to be again utilized in the destruction of the limestones exposed to its influence. By the leaching out of the carbonates the impurities present in the limestone are gradually concentrated and there results a mealy, siliceous clay, generally stained more or less red with iron oxide. Looking at the composition of one of the beds in the Christiancy quarry:

| | |
|---|---|
| Calcium carbonate | 86.80% |
| Magnesium carbonate | 11.60 |
| Iron and alumina | .12 |
| Silica | 1.10 |

it will be evident that the proportions of silica, iron and alumina will increase in the residue as the carbonates are slowly dissolved. The percentages of the latter may be reduced to simply a fraction of one per cent, or to a mere trace. Usually, however, the amount of carbonate left behind is considerable, and there results a calcareous soil. One foot of such soil might represent the destruction of one hundred feet of limestone, involving an enormous period of time. The following analyses from Merrill's "Rocks, Rock-



weathering and Soils" (page 359), show at a glance the changes that have thus been produced in a bed of pure Trenton limestone:

| | Unaltered limestone. | Soil from same. |
|---|---|---|
| Silica ($SiO_2$) | 0.44% | 43.07% |
| Alumina ($Al_2O_3$) | 0.42 | 25.07 |
| Ferric oxide ($Fe_2O_3$) | | 15.16 |
| Lime (CaO) | 34.77 | 0.63 |
| Magnesia (MgO) | Trace. | 0.03 |
| Potash ($K_2O$) | Not determined. | 2.50 |
| Soda ($Na_2O$) | Not determined. | 1.20 |
| Carbon dioxide ($CO_2$) | 42.72 | Trace. |
| Water and organic matter | 1.08 | 12.98 |

By an exactly similar process the dolomites which overlie and underlie the Sylvania sandstone gave rise to a soil in every respect similar. These changes are seen to be in progress at the Woolmith, Raisinville, Davis,' Cummins' and Plum Creek quarries, where the upper layer is softened and whitened and has a mealy look and gritty feel. No appreciable quantity of such soil has been formed, however, since the retreat of the ice, thus testifying to the recentness of this event or to the extreme slowness with which this change takes place. (See Pl. III.) A much simpler change would have occurred in the case of the Sylvania bed, which consists so largely of pure quartz grains. The small amount of calcium and magnesium carbonate which serves as a weak cement, would be dissolved and there would be formed a loose bed of sand, which from the absence of iron must have long remained of a pure white color. Such a soil could have supported only the scantiest vegetation and would eventually become stained with organic matter. It will be seen that the soil deposits which mantled the rock before the glacial episode were dependent for their character directly upon the bed rock itself and could have been traced by imperceptible gradations into it. Clay soil, with more or less silica and iron, covered the greater part of this county, gradually growing darker and heavier towards the northweastern part of Milan. The clay areas were separated by a white sand belt, diagonally crossing the county from southwest to northeast, and varying in width from one-half to four miles.

§ 2. Glacial subsoils.

No sharp line of division can be drawn between soil and subsoil, but by the latter term is commonly meant those loose deposits which are beyond reach in the ordinary processes of cultivation, say from eight to twelve inches deep. The subsoil of Monroe county consists very largely of the previously described till, the "ground moraine" of the great ice sheet. This consists of compact, unstratified, stony clay produced by the grinding of the bed rock over which the ice sheet moved and of the fragments which the ice was transporting. Without doubt the preglacial soils formed enter into the composition of this till to a greater or less extent. A deposit with such a history must obviously contain the greatest possible variety of materials, and be somewhat independent of the underlying rock strata. Such soils have been termed "residuary soils," or "soils of transportation," to distinguish them from the previously described "soils of disintegration." The former are characteristic of glaciated regions, the latter of regions not subjected to such ice action within recent geological time. Prof. W. O. Crosby has made a mechanical analysis of the till found in the vicinity of Boston and finds it to consist of 25% small pebbles, 20% of common sand, 40 to 45% of exceedingly fine sand, essentially quartz, and but 12% genuine clay, (alumina). It is quite probable that this represents approximately the composition of Monroe county till. Lenticular masses of stratified sand are found embedded in the clay and less frequently layers of gravel. Near the surface, within reach of percolating surface water, the iron compounds become oxidized and the till assumes a yellow, brown or red color. Otherwise it is of a characteristic blue color. At Dundee the discoloration of the clay is said to extend to a depth of 14 feet. In some of the stream cuts in Milan township the alteration of the till extends from 1½ to 3 feet only, and this would perhaps represent an average for many portions of the county. In Sec. 33 of Berlin there is said to be 15 feet of light colored clay and 5 feet of blue clay above the rock.

In many portions of the county the subsoils consist, in part, of the lake sediments and beach deposits described in the preceding chapter. A phenomenon for which we have no explanation at hand, was reported by a considerable number of farmers. They assert that, in the case of the isolated sand knolls, common about the margins of the sand belts, the underlying clay is blue and its surface the reverse of that of the upper surface of the sand, that is, concave. This gives the mass of sand a lenticular form and water accumulates in the clay basin so that such knolls are very damp and backward in the spring. They can be drained by simply



cutting a ditch through the rim of this basin upon the lower side. Captain Richard Ingersoll, Sec. 22, Dundee, says that the clay upon his lower land can be worked two weeks earlier in the spring than can these knolls. The clay encountered beneath the sand is reported as hardpan. This phenomenon was reported in Secs. 26 and 18 of Dundee and in Raisinville and Summerfield townships.

§ 3. Post-glacial soils.

Without attempting too fine a classification we may say that the Monroe farmers have to deal with five types of soil, which may shade into one another by imperceptible gradations; sand, clay, loam, silt and muck. From what has just been presented the source of the materials for these soils and the method of their formation will be readily comprehended.

(a). Sand and gravel. The great belts of sand, with limited patches of gravel, shown upon Pl. VII and described in the preceding chapter, have been produced by the wave action of the various bodies of water which covered the region after the withdrawal of the ice sheet. About the margins of this series of lakes and for some distance lakeward where the water continued shallow, the waves loosened and softened the till. A sorting of this material began at once, the coarser sand grains and small pebbles were worked shoreward and at times of the heaviest storms, were tossed back upon the beach in the form of a continuous ridge. The retreating wave, when its force had been spent, would drop first the heavier pebbles and carry back for a short distance the sand particles. In this way the beach ridge would be formed of gravel mostly, with a belt of sand upon the lake side. The separate particles, in the course of a year, would be moved backward and forward many times, some of them traveling miles, and owing to mutual attrition would have their corners and edges rounded. In certain places, out from the beach, as in Secs. 21, 22, 15 and 16 of Dundee the force of the waves was not sufficient to move the pebbles shoreward, the sand and clay particles only were removed and the pebbles accumulated on the till. For the same reason they seem to congregate wherever water drips upon a soil through which pebbles are disseminated. While the beaches of Lake Maumee, Whittlesey and Arkona were forming, a lake deposit was being spread over the central and eastern part of the county which covered the till and the boulders lying upon its surface. When the waters had fallen to the level of Lake Warren, the wave action would be directed very