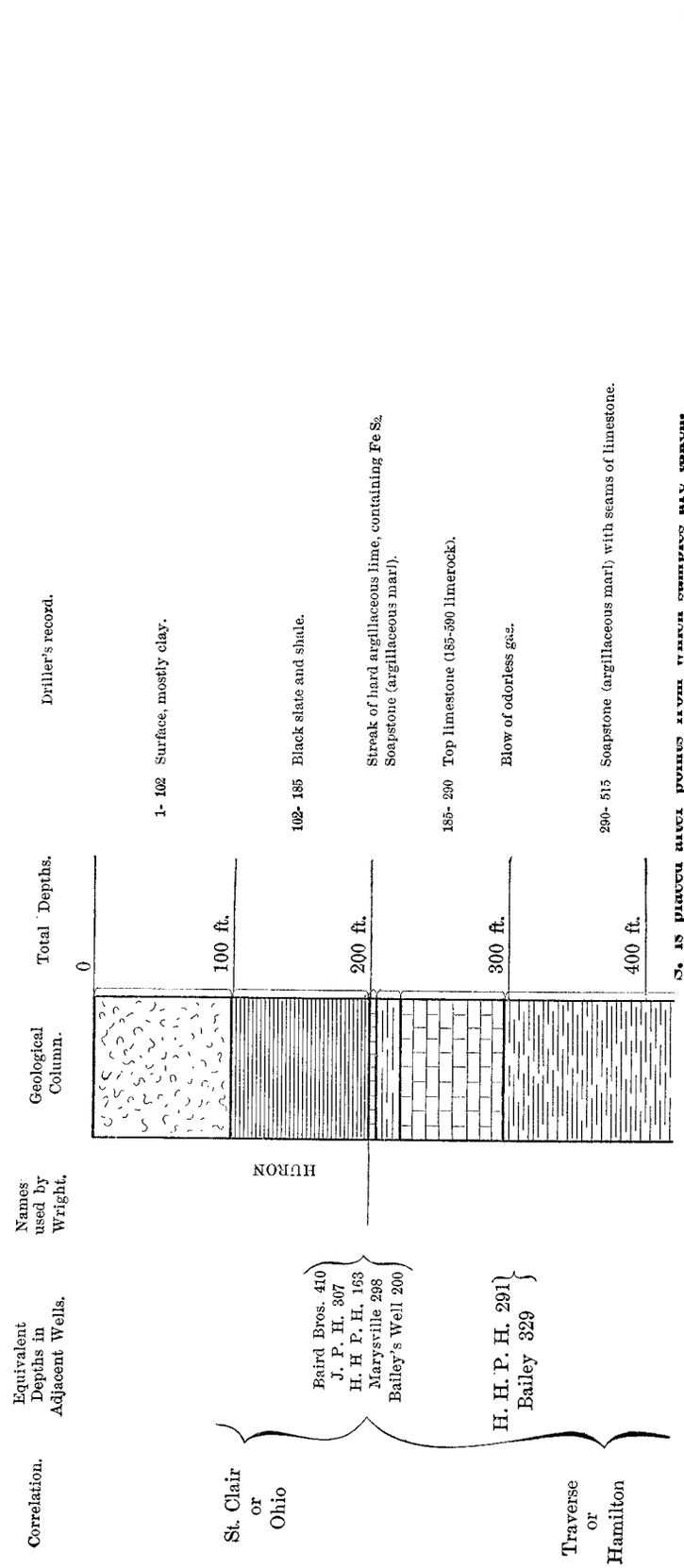
PORT HURON, No. 12.

St. Clair Co., Alt. 633 ft. to 589 ft.
F. L. Wells; begun Aug. 1st, 1886. Depth 1685 ft. +
Port Huron Daily Times, May 28th, 1887. C. E. Wright; with samples.



Geological Survey of Michigan.

GEOLOGICAL SURVEY OF MICHIGAN

ALFRED C. LANE, STATE GEOLOGIST

VOL. VII

PART III

GEOLOGICAL REPORT

ON

SANILAC COUNTY

MICHIGAN

BY

C. H. GORDON

ACCOMPANIED BY FIVE PLATES AND TWO FIGURES
INCLUDING ONE COLORED MAP

PUBLISHED BY AUTHORITY OF THE LAWS OF
MICHIGAN
UNDER THE DIRECTION OF
THE BOARD OF GEOLOGICAL SURVEY

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1900

OFFICE OF THE STATE GEOLOGICAL SURVEY,
LANSING, MICHIGAN, Sept. 15, 1900.

To the Honorable, the Board of Geological Survey of Michigan:

HON. HAZEN S. PINGREE, *President.*
HON. PERRY F. POWERS.
HON. JASON E. HAMMOND, *Secretary.*

GENTLEMEN—Herewith I transmit as Part III of Vol. VII, a report by Dr. C. H. Gordon containing the results of his examination of Sanilac county in the summer of 1896, together with a few data since received.

This report is much shorter than the two previous parts of this volume. I do not intend to pad the county reports to make them of equal size. In the case before us the exposures of bed rock, and the deep wells of this county are much fewer than in Monroe or Huron counties, and there has been less development of the resources. Its shales, especially, deserve further attention. Moreover some general matters have been treated of in Part I and Part II, and need not be repeated here.

Finally Dr. Gordon has been absent from the State and not able to give as much recent revision, as he otherwise might.

Permit me to call attention to the fact that the three parts of this volume together cover all the rocks of the Lower Peninsula, so that no matter where one may dwell therein, he will find in this volume descriptions which will be more or less applicable to his home.

With great respect I am your obedient servant,

ALFRED C. LANE,
State Geologist.

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CHAPTER I.

INTRODUCTION.

§ 1. Location and dimensions.

Sanilac county is situated on the eastern side of the Lower Peninsula adjoining the lower end of Lake Huron and is bounded on the north by Huron county, on the west by Tuscola and Lapeer counties and on the south by St. Clair county. It is a somewhat irregular parallelogram measuring in its greatest dimensions something more than forty-two miles from north to south and thirty from east to west, and embraces an area of about 972 square miles, or 622,080 acres. The banks of the lake forming the eastern boundary are on an average about 40 feet in height and afford a fine view of the lake.

§ 2. Industries.

Formerly the county was heavily timbered with white pine which was run down the Cass and Black rivers to Saginaw and Port Huron respectively, or manufactured into lumber on the lake shore. These supplies, however, are now exhausted and agriculture is the principal industry. The soil of the county is generally fertile, consisting mainly of sandy and clay loams overlaid by a variable thickness of vegetable mold, and produces abundant crops of wheat, hay, oats, barley, peas and potatoes. Over a large area in the central part of the county this mold is especially thick, this region being until recent years mainly an uninhabitable swamp. Drainage, however, is effecting notable changes in the region and the lands thus being reclaimed are destined to constitute the richest agricultural lands of the district.

§ 3. Vegetation and animals.

In addition to white pine, the county was originally heavily timbered with cedar, hemlock, maple, beech, oak, ash, elm, basswood and hickory with an occasional balm of Gilead and cottonwood, while tamarack covered the more inaccessible portions of the swamps. Of the natural fruits blackberries and whortleberries were abundant

in certain parts, while raspberries (black and red), strawberries, various kinds of wild cherry, wild plums, and the crab apple were plentifully distributed.

The forest abounded in wild game such as elk, moose, deer, bear, wolf, lynx, fox, otter, beaver, mink, marten, raccoon, muskrat, wild turkey, ducks and other small fowl. The country was remarkably free from reptiles, there being found only the small striped snake, *Eutœnia sertalis*, water snakes of several kinds, *Trepidonotus*, and the light spotted snake commonly called milk snake, house snake, or spotted adder, *Oppibolus, doliatus var. triangulus*, and rarely a small rattle snake, the massasauga, *Caudisona catenata*.

§ 4. Towns, railways.

The most important towns are Croswell, Brown City, Marlette and Port Sanilac. The population of the county according to the census of 1890 was 32,589.

The only railway which traverses the county is the Port Huron & Northwestern, absorbed in the Pere Marquette system. One division, the Port Austin, a narrow gauge road, traverses the county from north to south following the left bank of the Black River, while the Port Huron division, a broad gauge road, intersects the southwestern corner of the county.

§ 5. Previous geological work.

No records exist to show that any geological work has ever been done in the county, the absence of rock exposures and of prominent geological features being evidently the reason for this apparent neglect. That it is not wholly wanting in features of interest geologically, however, will appear in the following pages.*

Acknowledgments.—The author acknowledges indebtedness for many favors received during the progress of the work. Thanks are especially due G. Schraeder, and D. Reynolds, well drillers, for records of wells and to many others for various courtesies and favors.

*Since this was written there has appeared in the Bulletin of the Geological Society of America, Vol. 8, a paper by F. B. Taylor on the Correlation of Erie-Huron Beaches with Outlets and Moraines in Southeastern Michigan, which deals mainly with observations made in Sanilac and adjoining counties.

CHAPTER II.

PHYSIOGRAPHY.

§ 1. Topography.

The larger part of the county consists of a plain with an average elevation of about 200 feet above the level of Lake Michigan, and bounded on the east, north, and west by morainic hills ranging from 60 to 100 feet above the general plain level. An isolated area of similar knobby topography also occupies the south central portion of the county in the vicinity of Melvin.

The eastern boundary of the plain is marked approximately by the Harbor Beach Railway which follows the base of the ridge from Palms to the southern boundary of the county. From Palms the range of hills swings around to the west and southwest crossing over into Tuscola county, extending southward through Tuscola and Lapeer counties just outside the limits of Sanilac. A spur or outlier of this range of hills occurs two miles southwest of Brown City and is known locally as the "Mountain." The elevation of this morainic ridge varies from 20 to 100 feet above the level of the interior plain. The greater part of the interior plain is imperfectly drained and until recent years was covered with swamps. The swamp area has been rapidly encroached upon of late and at the present rate of progress a few years more will see the whole under profitable cultivation.

On the east, the plain is drained by Black River emptying into Lake Huron at Port Huron, and on the west its waters find their outlet by Cass River into Saginaw Bay. The plain surface is relieved here and there by ridges and hills of sand representing marginal deposits of the lake which formerly occupied the region. Its elevation above the lake level varies from 150 feet at the south to 200 feet at the north. The belt of hills constituting the eastern boundary of the "swamp area" varies in width from four or five miles at the north to less than one mile at the southern boundary of the

county. The surface of this belt represents a somewhat irregular plateau level except as modified by lateral drainage, chiefly lakeward, and has an elevation of nearly 300 feet above lake level at the north, descending gradually toward the south to about 180 feet. From Minden to Croswell the descent is very gradual not exceeding 60 feet, or less than three feet per mile. South of this the descent is more rapid and the ridge is scarcely observable a few miles south of the boundary of the county. At Amadore, the ridge has been intersected by lateral drainage so as to form a natural outlet for the railroad which at this point passes to the eastern side. The moraine belt consists of two or more simple ridges, the one along the western margin being the higher. East of the moraine, the surface descends uniformly from the base of the ridge to the margin of the lake where the bluff has an average height of about 40 feet. The surface is trenched by numerous short streams which flow in narrow steep sided channels. The average width of this plain is about five miles with an eastern slope of 25 to 30 feet per mile.

Old beach lines representing successive stages of lake subsidence occur at various distances from the present shore. The highest and most prominent of these is the Charleston Beach* which is well developed at Charleston Post Office and near Amadore. At the former place it is about 170 feet, and at the latter 145 feet above lake level.

The surface of the northern townships, Minden, Austin and Greenleaf, is marked by the rolling topography characteristic of morainic regions. Along the southern border of the moraine in Minden and Austin townships, the hills are lenticular in shape and lie with their longer axes in a general north-south direction. A prominent hill of this type occurs about $1\frac{1}{4}$ miles east of Tyre in the S. E. $\frac{1}{4}$, Sec. 6, Minden township. It is about $1\frac{1}{2}$ miles long in a N. W. and S. E. direction and $\frac{1}{2}$ to $\frac{3}{4}$ of a mile broad. It has an elevation of about 85 feet above the marsh which surrounds it on all sides. It is canoe shaped with steep slopes at the sides and tapers out gradually at the ends.

§ 2. Altitudes.

Following is a list of known altitudes as shown by the profiles of the branches of the Pere Marquette R. R. which traverse the county:

*Gilbert who visited this region in 1896 identifies this as the Forest Beach.

PORT AUSTIN DIVISION.

	Distance from Port Huron, miles.	Elevation above Lake Huron.	Elevation above sea level.
Port Huron, North street	0	55	637
Old crossing G. T. R. R. crossing	.....	10	692
Grant Center	15	163	745
*Jeddo	17	160	742
Amadore	20	182	764
Croswell	26	150	732
Anderson	32	157	739
Carsonville	38	185	767
Wilber Road	.....	190	772
Deckerville	46	197	779
Cooley Road	.....	213	795
Palms	52	231	813
Minden	56	237	819
*Harbor Beach†	70	18	600
Tyre	60	200	782
*Ubly†	63	204	786
*Badaxe†	70	170	752

† See report on Huron county.

PORT HURON DIVISION.

	Distance from Port Huron, miles.	Elevation above Lake Huron.	Elevation above sea level.
*Port Huron, old crossing G. T. R. R. grade	.....	10	592
*Brockway Centre (Yale)	25	215	797
Melvin	.....	245	827
York Station (Valley Center)	33	220	802
Brown City	37	230	812
Index	.....	255	837
Marlette	45	260	842

* Not in the county.

Numerous aneroid readings were taken in the progress of the field work and from the data thus obtained the accompanying topographical map was prepared. This collection of data is not complete enough for the preparation of a map that will bear close inspection as to details. It will be found serviceable, however, as showing in a general way the topography of the county.

§ 3. Drainage.

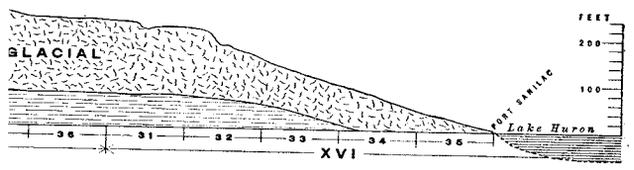
The drainage of the larger part of Sanilac county is effected by the Black and Cass Rivers, the former flowing southward and then eastward into Lake Huron, the latter westward and northward into Saginaw Bay. Black River rises in the southern part of Huron county, and flowing southward bearing eastward, follows along the western base of the morainic ridge to the southern line of the county in the western part of Worth township. In the southern part of the county, the river flows in a deep channel with precipitous

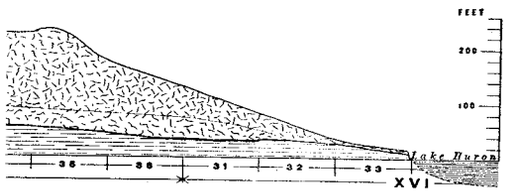
slopes of boulder clay marked locally by deposits of stratified sand. The most important tributary of Black River is Elk creek which rises in the southwestern part of the county and after flowing northeastward enters Black River about 2½ miles southwest of Carsonville.

Cass River takes its rise in several branches which drain the western portions of the swamp which originally occupied the interior of the county. Formerly the drainage of this large area was but imperfectly effected by these rivers but it is now being improved by ditching.

The area east of the crest of the morainic ridge is drained by numerous short streams for the most part dry in summer, which flow directly into the lake. These flow in deep steep-sided channels the width of which, though unimportant, is sometimes great in proportion to the size of the stream.

Vol. VII Part III (Sanilac County) Plate II





CHAPTER III.

STRATIGRAPHY.

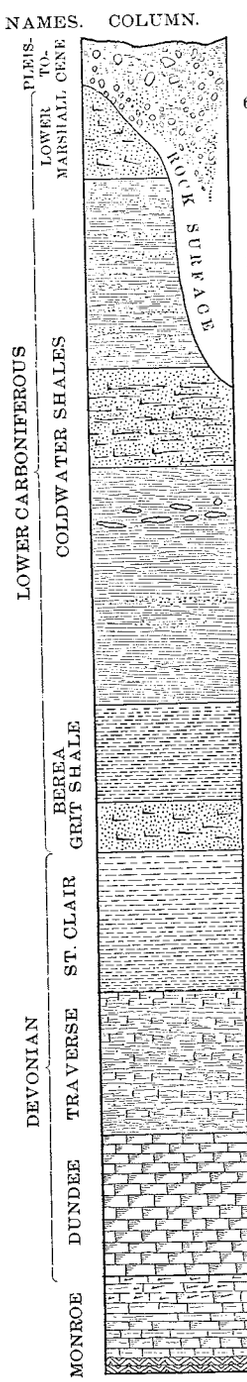
§ 1. The Coldwater shales.

The only indurated rocks appearing at the surface within the limits of the county are sandstones and shales belonging to the Marshall group, and the underlying Coldwater shales. Exposures are few and confined entirely to the northern portion of the county. Numerous wells have been drilled to the rock, however, and from the records thus obtained the surface area of the sandstone as shown in the cross sections, Plate II, and on the map Plate V, has been determined with a considerable degree of confidence.

The relation of these rocks to the underlying formations as determined from a study of exposures, and well records may be seen by comparing the general rock section of the county (Fig. 1) with the Port Huron section (Plate I), which we reprint from Volume V. As shown in that section the rock immediately underlying the drift belongs to the St. Clair formation.

The shales of the Coldwater formation constitute the oldest rocks observed in place within the limits of the county. Their surface area underneath the drift is to be found to the east of the boundary of the sandstone. One outcrop of the formation occurs on the lake shore near Richmondville and another near Forestville, (Plate III.) Three hundred paces south of the landing at Richmondville ten feet of shales outcrop in a vertical escarpment at the water's edge.

The shales are blue, thinly laminated and contain occasional thin beds of sandstone. The sandstone is fine grained, blue, and micaceous The layers of sandstone vary from a fraction of an inch to two or three inches in thickness. The exposure extends for half a mile along the shore. The only fossils observed were indistinct markings and casts. These shales are similar to the beds of the same formation used in Branch county for the manufacture of cement. About two miles south of this point, rock appears under water along the



THICKNESS.	CHARACTER.
0 ft. to 200 ft.	Glacial and recent; sand, clay, till
60 ft. to 100 ft.+	Sandstone Grindstone quarries
100 ft. to 200 ft.	Blue shales
	Forestville
50 ft. to 80 ft.	Sandstone Richmondville
200 ft. to 250 ft.	Blue shales
50 ft. to 150 ft.	Black shales
30 ft. to 50 ft.	Sandstone
100 ft. to 150 ft.	Shales, darker below
100 ft. to 150 ft.	Blue calcareous shales, and limestones, frequently dolomitic
125 ft. ±	Limestone
800 ft. ±	Dolomite, calcareous and argillaceous marls, anhydrite and rock salt

Fig. 1. General section of rock formations underlying Sanilac county.

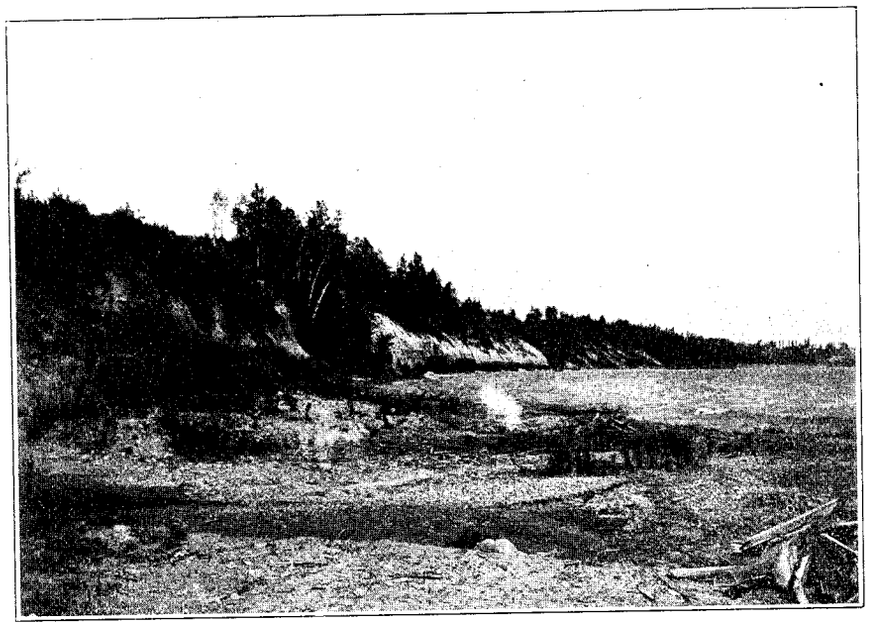
shore. At this point it is more decidedly arenaceous, the sandstone occurring in layers about six inches thick. The sandstone exposed here, known as the Richmondville sandstone, was correlated with the Berea sandstone of the Ohio reports in Volume V of the Michigan Geological Reports.* This is clearly an error as the rocks exposed at Richmondville can not be lower than the middle of the Coldwater shales and are probably within 100 or 200 feet of the top of that formation. It has been found that a bed of sandstone occurs at about this horizon in brine wells, and sometimes yields a brine comparable to that from the Berea. Several wells in the western part of the county show the presence of arenaceous beds at depths varying from 40 to 130 feet below the top of the shales and the Richmondville formation is evidently the equivalent of some of these. At White Rock, the Berea is found at a depth of from 495 to 555 feet.† The top of the White Rock well is about on a level with the top of the exposure at Richmondville. The distance between the two places is 12 miles. It would therefore require a rise of 40 feet per mile and more to bring the rocks to the surface at Richmondville.‡ At Port Hope, 16 miles north of White Rock, the Berea is only 237 feet deeper, showing a dip of only 15 feet per mile between these points. At Forestville four miles south of White Rock the Berea was reached at a depth of 465 feet showing that the southward rise of the beds does not exceed 20 feet per mile. At Port Huron the borings show the surface rock under the drift to be the black shale immediately underlying the Berea sandstone. The distance between Richmondville and Port Huron is about 40 miles. It is evident that a dip of 40 feet per mile would bring to the surface at Port Huron rocks much lower in the scale. The record of the Croswell well (p. 11) indicates the presence of the Berea at 105 feet below the level of the lake. The distance in a north-south direction between Forestville and Croswell is 26 miles. The vertical distance between the positions of the sandstone in these two places is 360 feet showing a uniform rise of 14 feet per mile. The correspondence in dip in all these cases confirms the identification and shows that if not removed by erosion, as it is, or affected by a change of dip, the Berea would outcrop at the lake level about five or six miles south of Lexington.

*1881-1893, p. 78.
†Mich. Geol. Sur. Vol. V., pp. 58, 86.
‡Loc. cit., p. 76.

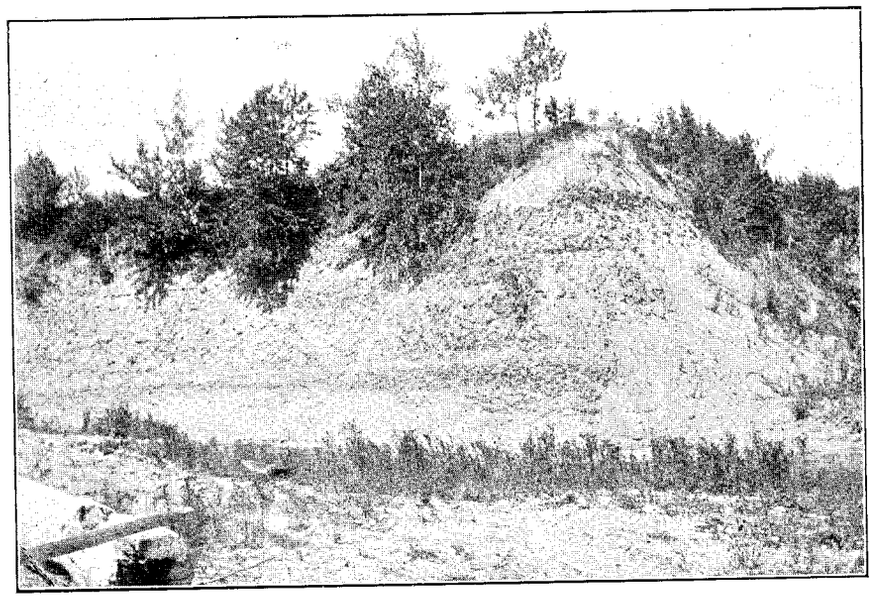
The exposure at Forestville was examined by Professor Ries who writes as follows concerning it: "Excellent exposures of Coldwater shales occur along Lake Huron at Forestville but they have not yet been utilized. The shale forms a line of cliffs and when fresh appears brittle and gritty. In places, however, it has mellowed down to a tough clay." The Forestville outcrop represents an horizon somewhat higher in the series than that at Richmondville and is characterized by a diminution in the amount of arenaceous material. Plate III is from photographs taken by Professor Ries at this point.

For a distance of five or six miles away from the margin of the Marshall sandstone, wells reach the shale at depths varying from 50 to 100 feet. E. Seaman's well (No. 2) (N. W. ¼, Sec. 7, Delaware township) is evidently just at the margin of the sandstone, as the drill appeared to penetrate a thin seam of broken sandstone underlain by the shale. East of a north and south line passing through this point, the wells show that the drift is underlain by shale yielding a brackish water. At Frederich's less than a mile southeast of Seaman's, the shale is reached at 60 feet. Two holes were put down here (Nos. 52 and 53) one of which extended into the shale to a depth of 225 feet, the total depth of the well being 285 feet. At Deckerville, Dr. Alderton's well (No. 62) reached shale at 90 feet while Renelt's well (No. 29) at the station shows a cavernous sandstone at 46 feet from the surface. The distance between the two wells is three-fourths of a mile and the difference in elevation at the surface is about 60 feet. At the Sanilac Stock Farm (No. 69) shale with brackish water was encountered at a depth of 37 feet.

At Brown City a well at the Harrington Hotel (No. 78) was said to have reached a depth of 212 feet without penetrating the full thickness of the drift. Lane's well (No. 76) on Section 16, Flynn township, reached what was taken to be a soft broken sandstone at 240 feet but doubt is expressed as to the character of the rock. The land surface here is about on a level with the rock surface at Marlette. A boring now (Jan. 1900) in operation at Valley Center has reached a depth of 685 feet with the following record: (Elevation 220 A. L., 800 A. T.)



(a) SHALE OUTCROPS NEAR FORESTVILLE.



(b) SHALE NEAR WHITE ROCK, ABOUT 2½ MILES NORTH OF FORESTVILLE.

Valley Center Well:

	Driller's record.	Thickness, feet.	Total	
1.	Red sand loam	5	5	Glacial, 149.
2.	Quicksand	90	95	
3.	Clay	22	117	
4.	Sand and gravel, with plenty of pure water	32	149	
*5.	Sandstone	5	154	Coldwater, 390.
*6.	"Conglomerate"	20	174	
*7.	Sandstone	30	204	
8.	"Slate" (blue shale)	10	214	
9.	"Soapstone" (blue shale)	175	389	
10.	"Slate"	150	539	
11.	"Limestone"	10	549	Berea, 30.
12.	"Grindstone"	20	569	
13.	"Slate" (blue shale)	116	685	St. Clair, 116.

*NOTE.—While these beds (5, 6, 7) presumably belong to the Coldwater series it is not improbable that they represent the lower portion of the Marshall sandstone. A consideration of the dip, however, would seem to indicate that the base of the Marshall sandstone if this formation were present, would be sixty to one hundred feet above the rock surface. (No. 5.)

The first indurated rock (sandstone) penetrated by the drill in this well corresponds to the Richmondville sandstone.* The Berea, here showing no evidence of gas, was reached at a depth of 539 feet.

The well for the Croswell waterworks (No. 79) shows a thickness of 190 feet of drift to which must be added 25 feet, as the well is located in the valley that much below the level of the station. The first rock reached in the Croswell well was black shale, probably representing the lower portion of No. 10 in the Valley Center well.

According to Mr. Marquette, the record of the water works well at Croswell is as follows: (Elevation at the top of the well 125 A. L., 705 A. T.)

Croswell Well:

		Thickness.	Total.	
1.	Clay and hard pan	20	20	Berea.*
2.	Sand and gravel	170	190	
3.	Black shale	40	230	
4.	Limestone	20+	250	
5.	Sandstone	425	675	
		675		

* Probably includes a part of No. 5.

The complete record of this well was not preserved and some doubt is to be entertained as to the correctness of the above figures, especially of No. 5 which with the exception of the upper 20 or 30

*Compare also, however, the sandy layers at Rock Falls, in Huron County.

feet probably represents the St. Clair and Traverse shales. A test boring 100 feet deep was made at this place a number of years ago but no record of this could be obtained.

Mr. R. Papst kindly furnishes the following record of a test well put down by him on his farm three miles south of Lexington. The well is located on the flats of Mills Creek 60 rods from the lake shore. (Elevation 20 A. L., 600 A. T.)

Papst Well:

	Thickness.	Total.
1. Hard clay	50	50
2. Quicksand	60	110
3. Gravel (flowing well)	42	152
4. Shale	136	288
5. Dark shale	17	305
6. Unknown (stopped in sandstone)	595	900
	900	

The first rock reached in this well belongs to the Saint Clair shales and represents an horizon probably 20 or 30 feet below the top of the formation.

A boring at Blaine, a station on the Port Austin Division of the F. & P. M. R. R. a few miles south of the southern boundary of the county, was still working in drift at a depth of 220 feet at the time of our visit.

§ 2. Marshall sandstone.

As shown on the accompanying map, Plate V, the Marshall sandstone underlies about three-fifths of the county. Within the boundaries as defined, wells generally reach rock at depths varying from twenty to sixty feet, though in some cases the depth to rock is 125 feet or more. The greatest thickness of the overlying mantle of drift is found in the vicinity of Minden. West of the moraine, rock may be found almost anywhere at a depth of 20 to 40 feet.

The only exposures of the sandstone observed are in the townships of Austin and Greenleaf. At Tyre the sandstone outcrops over a considerable area in the vicinity of the railroad station. The attempt was made some years ago to quarry the rock here for shipment to Port Huron and elsewhere, but it was found to be too soft for building purposes and the enterprise was abandoned.

In the northwest $\frac{1}{4}$ of Sec. 17, Austin township (T. 14, N., R. 13 E.) in the valley of the Tyre branch of the Cass river, the rock is exposed by stripping. The sandstone here is blue with an even, moderate fine grain, and resembles the same beds quarried for grindstones at Huron City. The making of grindstones has been carried on here on a small scale but the beds have not been sufficiently exposed to determine whether their character and extent are such as to warrant more extensive working. About two miles west of this point, the sandstone crops out in the road a short distance east of the Holbrook post office. At this point the rock appears to be coarser.

The area underlain by the sandstone as shown by well records is approximately as represented on the accompanying map. Its maximum thickness within the limits of the county has not been ascertained as no wells are reported to have extended through the beds except along the attenuated margin. The greatest thickness is shown by a test hole put down at Tyre. This hole started in sandstone at the surface and, at the time of our visit, had reached a depth of 90 feet said to be all in sandstone.

§ 3. Pleistocene deposits.

The Port Huron-Saginaw Moraine—This represents the last land-laid moraine of the Huron ice lobe and lies close to the east side of Black River all the way northward from a point five or six miles north of Port Huron. Near Ubly in the southern part of Huron county it joins a similar moraine that trends southwest through the northwestern part of Sanilac county and thence around the head of Saginaw Bay. The salient thus formed by the two moraines comprises a considerable portion of the county and is occupied by the Black River swamp. The moraine is wider and higher at the north diminishing both in width and height southward. It is made up of two or three parallel ridges from one to one and one-half miles apart, that on the west being the highest. The height of the moraine is from 80 to 100 feet above the level of Black River at the north, descending to about 30 to 40 near Croswell. The surface of the moraine belt is rolling and is marked by rather abrupt slopes on either side. In the vicinity of Tyre the southern border of the moraine is characterized by isolated lenticular hills lying with the longer axis extending nearly north and south. Boulders are abundant in this vicinity, in places being scattered over the marshes as well as the adjoining uplands. The lenticular hills have an abundance of boulders, often of large size, scattered over their surface.

The slope east of the moraine is occupied by lacustrine clay with occasional belts of sand representing former halting stages in the recession of the lake shore.

Detroit Moraine.—In the southern part of the county in the vicinity of Melvin is an isolated area of kames and kame moraines representing the northern extremity of the Detroit moraine. They consist of an aggregation of rounded hills of smooth flowing outlines (mammillary hills of Chamberlin). The central mass is made up chiefly of moraine deposits while the marginal portion is made up of hills and ridges of kame deposits, viz., hills and ridges of sand and gravel evidently deposited in the recess in the border of the ice lobe. One of these kame ridges extends northwest from Moore's Corners (N. E. cor., Sec. 22, T. 19 N., R. 14 E.) for a distance of several miles. In Washington township a well developed ridge occupies the angle between Elk Creek and Black River. Taylor* who visited this locality in 1896 observed a well marked beach on its eastern slope at an elevation of about 190 feet, which he identified as the Belmore beach. A low ridge or beach extends northeastward from Peck that may connect with the one just described. Another kame area occurs north of Peck and an isolated ridge was seen four miles west of Croswell. Similar sand ridges occur also east of Marlette.

Overwash Plains.—Adjoining the moraines in places occur plains of varying extent covered with overwash sand and gravel derived from the melting glacier. One well marked plain of this character occurs at the west foot of the Port Huron-Saginaw moraine near Carsonville. Something of this overwash character is seen also along the top of the moraine toward the south, where the subdued character of the moraine indicates that it was waterlaid. North of Marlette in Lamotte township the upland plain is covered by overwash in which gravel plays a conspicuous part.

Esker (Hogback.)—In the southern part of Lamotte township, extending across sections 33 to 36 inclusive, occurs a narrow sharp ridge of gravel known locally as the "Hogback." This ridge represents a type of glacial deposit known as the esker. It appears in the southeastern part of Section 36, extends westward bearing to the north across the sections named, then turns northward crossing the north line of Section 33 into Section 28 near the half section line.

*Bulletin Geol. Society of America, Vol. 8, p. 40.

It is broken in places and at MacDonald post office, where it is intersected by the highway, it is 15 to 20 feet high and 80 feet wide at the base. In cross-section it is seen to consist of stratified sand and gravel of varying coarseness. In general the stratification planes conform to the surface, though more or less disturbed and broken at the lower sides. The gravel is often firmly cemented by lime and in places the layers of sand have become hardened by iron oxide into an incoherent sandstone.

The "Hogback" or esker probably dates from the time when this region was occupied by the glacier and represents the location of a glacial stream flowing in a channel within the ice. As the glacier melted away, the gravel filling the channel would settle down upon the land and being no longer contained by ice walls would naturally take the form now seen. The narrow serpent-like form and concentric stratification support this view of its origin.

Glacial Drainage and Delta Deposits.—The north fork of Cass River which flows through Greenleaf township takes its rise in two branches, one of which rises north of Ubly in Huron county, the other in the swamps south of Tyre. These streams are small and insignificant but occupy valleys of considerable width. The valley of the north branch and that of the fork below their junction is filled with gravel and several well marked terraces occur up to a height of 35 feet above the present stream bed. Above its junction with the south fork north and east of Cass City the valley has a width of several miles. In this vicinity two gravel terraces were recognized, one about 15-20 feet above the flood plain of the present stream, the second about the same height above the first. The first or Cass City terrace is one to two miles broad in places. These gravels belong to what is known as Valley Train deposits. No information could be obtained as to the depth of the gravel, but wells 25 feet deep do not pass through it. It is usually coarse, pebbles the size of walnuts and hens' eggs being abundant, and those of larger size frequent. The second terrace occurs only in remnants along the sides of the valley. It is found along the north side of the valley north and east of Cass City and along the north side of a flat topped ridge extending through Sections 30 and 31, Greenleaf twp., T. 14 N., R. 12 E. The elevation of the Cass City terrace is about 170 feet, thus corresponding with that of the Forest beach on the opposite side of the county. The evidence appears to support Taylor's* view

*Bulletin Geol. Soc. Am., Vol. 8, p. 41.

that the gravel plain at Cass City may be a delta of the outlet of Lake Whittlesey, the name given to the body of water having for its limits the shore line represented by the Belmore beach. From Ubly to Cass City, the channel is from three-fourths to one mile wide. The floor of the channel is covered with great numbers of boulders.

In Greenfield township (T. 14 N., R. 12 E.) a long narrow swamp extends from the eastern part of Section 13 southwestward to the southwestern corner of the township, and on across the south part of Cass River southward into Tuscola county. The swamp is separated from the valley of the north fork of Cass river on the north by a narrow ridge intersected at the southwest corner of section 15 by a small stream flowing into Cass River. This swamp called the "Stone wall swamp" connects with the valley of the east branch of north fork southeast to Holbrook post office and was evidently the outlet for the waters derived from the wasting glacier at the time the edge rested on the ridge along its northern side. This outlet Taylor calls the Cumber spillway and considers it to have been open only a short time during the active period of glacial recession and soon abandoned for the more important Tyre-Ubly channel now occupied toward the west by the North Fork of Cass River and toward the east by the upper part of Black River.

At the time the Tyre-Ubly outlet was active the drainage was evidently northward past Tyre, joining the Ubly channel about two miles below Ubly. The evidence of reversed drainage due to northward elevation is also well marked in the course of Elk Creek and the channel of Black River in the lower part of its course.

Pebbleless Clays.— Deposits of pebble-free stratified clay occur filling depressions in the surface of the moraine between Minden City and Deckerville and probably farther south. They are utilized for the making of brick at several places. At Weber and Ahner's brickyard in the southwest part of Section 19, T. 14 N., R. 15 E. the clay is eight feet thick, stratified throughout. For a depth of two feet the clay is blue, making a red brick. Below this the clay is of a dirty white or gray color and furnishes a light colored brick.*

Lake Beaches.—The strip of land varying from three to five miles in width between the moraine and the lake is marked by several

*"This is a wide spread phenomenon in the state and is probably due to the leaching of lime from the upper layers. Lime is usually present in clays in quantity sufficient to neutralize the coloring effect of the iron."—Lane.

belts of sand, representing former lake beaches. Between these the surface is flat with a pronounced lakeward slope. The surface deposit is a fine dark lacustrine clay.

Belmore Beach.—This is the highest beach recognized by Taylor within the limits of the county, and was found by him on the flanks of the kame ridge west and north of Abbotsford. We did not visit this locality but observed indications of shore lines at about the same elevation (190 feet A. L.) in the vicinity of Peck. In the vicinity of Cass City, Taylor observed a beach at about the same distance above the Forest Beach, viz., 20 or 30 feet, but this he identifies as the DuPlain Beach. If the Peck Beach has been correctly identified as the Belmore Beach, it would seem safe to correlate the Belmore and DuPlain beaches.

Forest Beach.—The most prominent beach is that passing through Charleston Corners in Delaware township. At this point it constitutes a ridge four to six feet above the general level and has an altitude here of about 170 feet above the lake. In Marion, Forestville and Sanilac townships the beach is not strongly marked but is well developed in Lexington and Worth townships. It constitutes a pronounced ridge one mile east of Amadore Corners. At this point its elevation above the lake as shown by the aneroid barometer is about 145 feet. This shows a northward rise of about 25 or 30 feet between this point and Charleston. This beach is known as the Forest Beach and represents the margin of a body of water which included much of the Huron basin, all of the Erie basin and a small part of the Ontario basin.* It has been traced to Badaxe where it bends southwestward and passes through Gagetown and thence through the northwest corner of Ellington township about six miles west of Cass City. From this point the beach extends to a point southwest of Vassar, returning thence along the south side of the moraine lobe to Cass City and beyond, around the head of a long narrow bay which is suposed to have occupied the valley of Cass River. The level lands and swamps occupying the valley of the county evidently represent the site of an ancient lake which must have had its outlet along the front of the ice toward the west. Scattered over this region occur sand areas, hills and ridges marked by indications of shore lines. These deposits are best devel-

*It has been traced from Port Huron to a point opposite Richmondville by G. K. Gilbert of the U. S. Geological Survey and from there to Badaxe by F. B. Taylor. See Part I and Part II of this volume, on Monroe county and on Huron county.

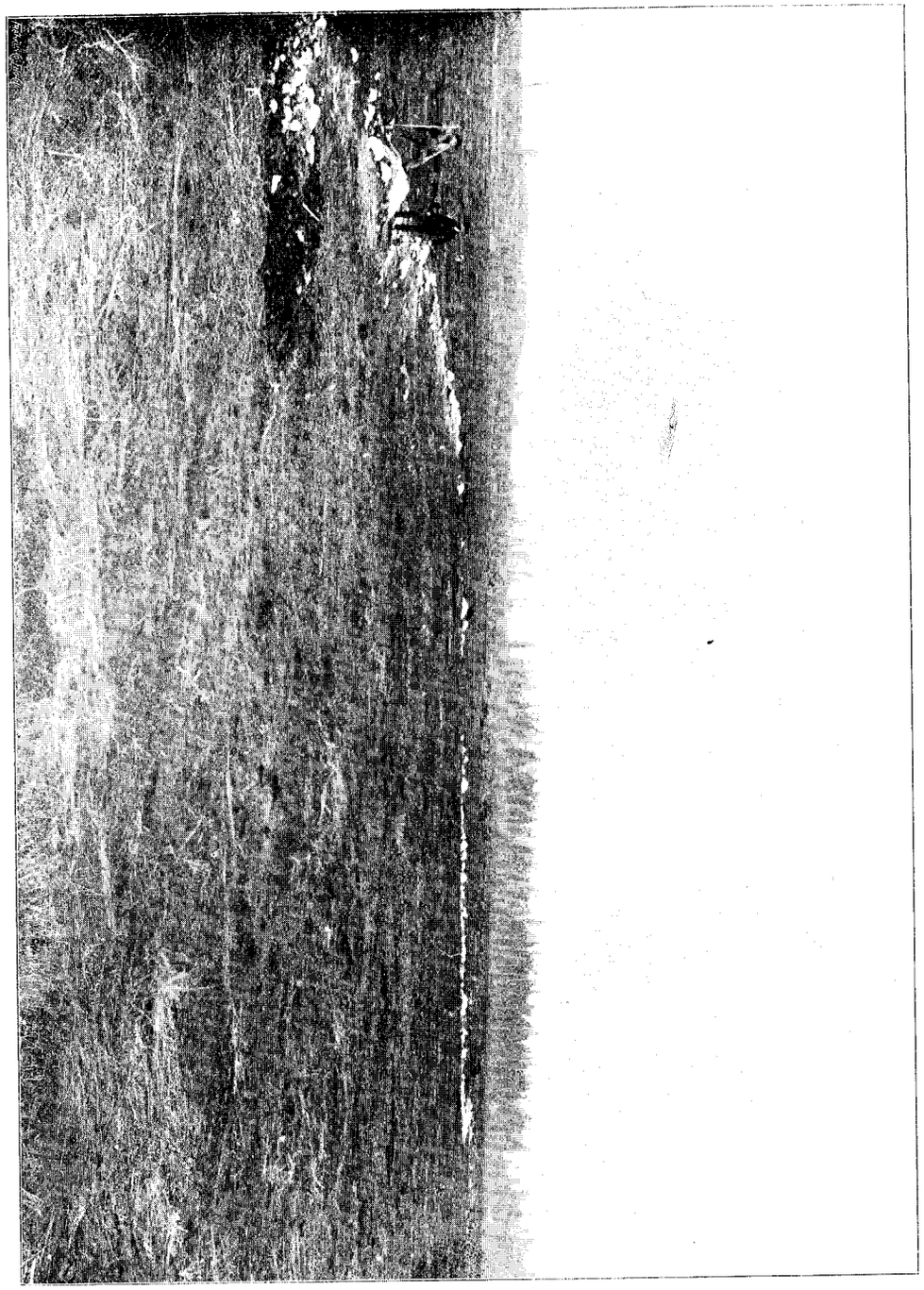
oped in the marginal areas adjoining higher ground. In some cases the sand hills are evidently the product of wind agency and correspond to dunes now forming on lake shores.

Boulder Walls.—In Sections 31 and 32 Greenleaf township, along the margin of the stone wall swamp occurs a low stony embankment which has received considerable notoriety from its fancied resemblance to a stone wall and which has been quite widely heralded as evidence of an ancient civilization. The "wall" occurs in the swamp and was originally covered to a slight depth by vegetable mold. By the burning of the mold in the process of clearing the swamp a few years ago, the wall was exposed (Plate IV). It lies adjacent to the west margin of the swamp and parallel with it. Its distance from the margin is about 150 yards. The embankment has been exposed for a distance of half a mile or more and beyond this it has been traced for a considerable distance through the marsh by a line of stones which probably mark its site. In places the "wall" is low or absent entirely. The width of the embankment at the base is about

Fig. 2. Cross-section of "stone wall" swamp showing conditions for formation of boulder walls by ice expansion.

8 to 10 feet and it rounds to a broad apex. It is composed chiefly of glacial boulders of various sizes imbedded in a stiff blue clay. In places the interstitial material is a sandy marl supposed by those who regard the "wall" as the work of prehistoric man to be the crumbled mortar of the original wall. This material is greenish and of the same character as the marl underlying the rest of the swamp.* Immediately under the embankment the sand is packed quite hard for a depth of two or three inches as shown by excavation. The height of the "wall" is usually about 18 inches to two feet, though in places somewhat higher. A marked feature of the embankment is the presence of large stones scattered along the surface while the lower portion is made up almost entirely of smaller stones. Some of the stones at the top are two or three feet in diameter. A similar but less distinct embankment was observed adjacent to the east side of the marsh. It is said that like occur-

*A collection of this marl has been examined by Mr. Bryant Walker and found to contain forms slightly different from the present fauna. His report will be found in the report on Huron county (Part II of this volume p. 248).



VIEW OF THE "STONE WALL" NEAR CASS CITY.

rences have been noted at various points in Greenleaf and Austin townships, but no effort was made to verify the report. Various theories to account for the presence of these embankments abound locally most of which ascribe them to human agencies. The prevailing belief seems to be that they represent a fortification. Another theory is that they are the remnants of a former breakwater or levee. From a study of the physiographical and structural features of the region, however, it is evident that the "wall" is due to natural agencies. Three theories have been proposed to account for the embankment by natural agencies:

(1). That they represent constructive river terraces formed by flood waters derived from the melting edge of the glacier. (2) That they are due to englacial or subglacial drainage, and (3) That they represent the well known ice-beaches or boulder walls due to ice thrust found around the borders of many of our northern lakes. The last is the most probable explanation. After the opening of the Tyre-Ubly channel the diversion of the drainage left this as a long narrow lake or bay possibly connected with a larger body of water toward the southwest. Further evidence of the former existence of a lake here is found in the marl deposits underneath the vegetable mold. The ice forming over this shallow lake would enclose the boulders resting on the bottom and by its expansion would thrust them shoreward. So also floating ice under the influence of a strong wind has been known to drive boulders of considerable size upon a bank several feet in height and some distance back from the edge of the water. Prof. T. C. Chamberlin commenting on this as a probable explanation says this action is much more likely to affect large boulders than small ones and, besides, the fine material is washed out to a greater or less extent so that the coarse heavy boulders appear on the surface while finer material lodges in the mass under their protection.* From the configuration of the surface it is evident that the lake must have been shallow at the time these embankments were formed, so that in winter the water was frozen to the bottom for a considerable distance from the shore if not over the whole lake. Whatever was on the bottom, therefore, would be enclosed in the ice and thrust shoreward by its expansive force.

The Walled Lakes of Iowa which have received considerable notoriety from the popular belief that the embankments on their borders

*Private letter to writer, dated Aug. 7, 1896.

were the work of aboriginal inhabitants have been shown by White* to be due to ice thrust. He says, "It is true that the motion resulting from one winter's freezing would hardly be preceptible, but the act repeated from year to year, and century to century, would ultimately move everything upon the bottom beyond the reach of the ice. The tracks of the boulders thus moved have been observed, being as unmistakable in their character as those which the river mussel leaves behind it in the sand." * * * "Below the line of freezing the material would of course remain unmoved upon the bottom because there is nothing to disturb it."

"The real embankments are only found separating a piece of low land from the lake, because the material thrust out by the ice against the steeper banks merely accumulates there upon the slope which rises above any such accumulation, and also, of course above the high water line of the lake. In such cases the shore is thickly studded with boulders thrust against it, but the material meeting no such obstruction on a marshy side accumulates in circular ridges around the lake, and these are the walls which have excited so much wonder."

The observations hitherto recorded apply solely to walls around the borders of lakes. In the present instance the lake has long since disappeared and its site has become covered to a considerable depth by vegetable mold.

*Geology of Iowa, 1870, Vol. I, p. 74.

CHAPTER IV.

ECONOMIC GEOLOGY.

§ 1. Coal.

The indurated rocks underlying Sanilac county are below the coal bearing formations of the state and there is, therefore, little probability of finding workable deposits of this valuable mineral. The Marshall sandstone sometimes contains a considerable amount of carbonaceous matter and wells sunk into this rock often pass through thin seams of coal. The well put down by E. Hunt (No. 24) in the S. E. ¼, N. E. ¼, Sec. 22, T. 14 N., R. 13 E. gave the following record:

	Feet.	Inches.
Sand and clay	49	.....
Sandstone	27	.....
Black coaly sandstone	..	6 to 8
Sandstone	..	4
Total	77	

The coal was immediately underlain by sandstone with no intervening clay deposit. Mr. J. Hunt's well (No. 23) one-fourth mile south of the preceding was said to have shown three feet of broken "slate," coal and gravel immediately below the drift with a 10 or 12 inch seam of coal beneath eight feet of sandstone. The full record is as follows:

	Feet.	Inches.
Sand and clay	29	.....
Broken slate and coal	3	.....
Sandstone	8	.....
Coal, quite hard	..	10 to 12
Sandstone	19	
Total	60	

The water is said to be bad, having a strong petroleum-like smell when the well is not in constant use. A black, tarry, oily substance was found just above the coal. Such indications are not unusual in the sandstone belonging to the Carboniferous era and cannot be looked upon as having special significance.

§ 2. Building stone.

In places the boulders of the drift constitute the best available supply of building stone. The Marshall sandstone sometimes furnishes a suitable rock for caps and sills, though it is usually too soft to supply a durable stone. At Tyre an effort was made some years since to quarry the rock for use in buildings in Port Huron but owing to the softness of the rock the attempt was abandoned.

§ 3. Grindstones.

The sandstone is being quarried on a small scale for grindstones in the N. W. $\frac{1}{4}$ of Sec. 17, T. 14 N., R. 13 E., on the land of R. Cleland. The rock is exposed on the floor of the valley by removing a thin covering of surface material. The stone is blue and closely resembles that quarried at Grindstone City. Only a small opening has been made, the rock taken out being in comparatively thin slabs and fitted chiefly for small grindstones.

§ 4. Shales.

Shale is an indurated clay whose consolidation has been effected under the influence of pressure assisted more or less by cementation. Except as to hardness clay and shale are alike in their properties and have similar uses.

Ordinary clay products constitute the most important uses to which shale is put at the present time. In addition to these, however, shale is used for the manufacture of Portland cement, mineral paint and for road material. The Coldwater shales constitute the most important source of supply in the state for the manufacture of Portland cement and are extensively quarried for that purpose at Bronson, Union City and Coldwater.

Professor Ries says (Vol. VIII, Part I), "The shales of this series (Coldwater) show, so far as tests go, the properties desirable in the manufacture of vitrified wares. They also burn to a good red color and vitrify at a moderate heat." Samples of the shale from near Forestville and White Rock (just over the line in Huron county) have been subjected to tests by Professor Ries and the results appear in the report on Huron county, Part II, p. 208. If the indication of usefulness suggested by these tests is borne out in practical application the favorable exposures of the beds in Sanilac county offer possibilities of a profitable industry.

§ 5. Marls.

Marl of good quality occurs in some of the marshes but the extent of these deposits is not known. A deposit of this kind near Tyre has been utilized on a small scale for the manufacture of a scouring polish. It is made up mostly of broken shells which are reduced to a powder by grinding.

The most important use to which marl has been applied in this state is as an accessory ingredient in the manufacture of Portland cement, which is usually made from a mixture of shale and marl. "The essential elements of such cement are silica, alumina and lime, the first two of which are supplied by the shale and the last by the marl or limestone. The best results are obtained from a mixture in which the lime percentage is equal to 2.8 times the silica plus 1.1 times the alumina." (Prof. Ries.)

Should the Forestville shales prove suitable for the manufacture of cement the occurrence of sufficient supplies of marls within available distance will be a matter of considerable economic importance.

§ 6. Clays and clay industries.

Drift Clay.—As a rule the clay belonging to the drift deposits is unsuited for manufacturing purposes owing to the presence of pebbles especially of limestone, and boulders which interfere with the working. Occasionally however, a locality is found furnishing a drift clay that may be utilized when nothing better offers. This clay is worked on a small scale at Forestville and at one or two other places, but the brick made from it is of inferior quality.

Lacustrine Clays.—At several places the shallow depressions in the surface of the drift is found filled with a deposit of fine pebbleless clay varying in thickness from one to twelve feet and usually well stratified. These are evidently of lacustrine origin dating from the time the county was in large part under water. These deposits constitute the source of supply for the clay used by nearly all the clay working industries of the county and in general yield a good quality of clay for brick and tiling. In the eastern part of the county the deposit is composed of two or three feet of dark reddish clay yielding a red brick, while below this there are four to nine feet of whitish gray clay yielding a light colored brick. A mottled brick is made by mixing these together.

BRICKYARDS.

Weber & Ahner.—Brickyard is located in the S. W. $\frac{1}{4}$, S. W. $\frac{1}{4}$ of Sec. 19, T. 14, N., R. 15 E., on the land of Wm. McDonald. The

clay is eight feet thick, consisting of two feet of dark blue clay above, underlain by six feet of whitish clay. The deeper portions are not worked owing to the presence of water. The clay contains no lime nor pebbles and according to the proprietors does not shrink in burning. The output in 1896 was 600,000 brick. No tile is made. The machine used is manufactured by Kills & Son of Adrian, Michigan.

R. Wyers & Son.—Deckerville: This yard is located one mile east of Deckerville in the northeast corner of Section 32, T. 13 N., R. 15 E. The clay is twelve feet thick—three feet of dark clay underlain by nine feet of light colored clay. The output for 1896 was about 200,000 brick and 15,000 tiling. A Kills & Son's machine is used.

John Rumptz.—Croswell: Brickyard is located east of the railroad in the northeast corner of Section 29, T. 10 N., R. 16 E. The clay is 10 feet thick, dark above, light colored below. Common brick only are made. Output in 1896 about 300,000. A Kills & Son's machine is used. Mr. Rumptz also operates a yard at Minden the output being about 200,000 for 1896.

Riley Bros.—Carsonville: This yard is located on the east bank of Black river in the N. E. $\frac{1}{4}$, N. E. $\frac{1}{4}$ of Sec. 15, T. 11 N., R. 15 E. The clay is about 14 feet thick, stratified and rests upon quicksand. The upper dark clay is three and the lower white clay is eleven feet thick. The bed wedges out quickly toward the east where it abuts upon the western slope of the moraine.

It is overlain by a thin covering of sand. This yard is located on the east bank of the Black river just at the narrows between the kame ridge on the west and the Port Huron-Saginaw moraine on the east. Both common brick and tiling are made here, the output for 1896 being 300,000 brick and 40,000 tiling. A Kills & Son's machine is used.

John Large.—Brown City: Yard located about a mile southeast of Brown City in the S. E. $\frac{1}{4}$, N. E. $\frac{1}{4}$, Section 18, T. 9 N., R. 13 E. The surface clay here is about four feet thick and is utilized chiefly for common brick and tiling. Some pressed brick are made to fill orders. The output for 1896 was 400,000 brick and 100,000 tiling.

O. L. Ballard.—Marlette: Yard situated in the western part of the village. The clay occurs here in pockets of limited extent and has been nearly exhausted. The works will probably close at the end of

this season. The clays of the drift underlying the pebbleless clays have been made use of to some extent, but more or less trouble is experienced from the presence of lime. The output for 1895 was 1,000,000 common brick and 60,000 tiling, and for 1896, 350,000 brick and 20,000 tiling.

§ 7. Soils.

The account already given of the Pleistocene deposits may be taken as an index of the character of the soils of the county. The area included in the Black River swamp is covered to a depth of one to several feet by a vegetable mold that under proper treatment will yield abundant crops. In the central portions where the mold is thick it is composed almost entirely of vegetable matter partially decomposed. On being drained and tilled this becomes dry and easily catches fire. Considerable areas are thus being burned over every year. If not thus destroyed, with further tillage the decomposition of the mold will become more complete and eventually yield a valuable soil. This process might doubtless be hastened by mixing with the mold some of the sand and clay soils from the uplands. Until it has reached a further stage of decomposition, however, the spread of the mold over lighter soils does not appear to be beneficial. The surface clays representing the water-laid deposits found over a considerable part of the county furnish an excellent soil, that yields abundant crops of hay, barley, corn, beans, peas, potatoes, etc. These areas occur east of the moraine and surrounding the swamps. The sand and gravelly soils found along the minor beaches are also valuable and readily worked. Adjoining the higher areas these lands are spread over with a thin layer of overwash sands and gravels which tend to enhance their value as soils. In some places, however, as south of Carsonville along the foot of the moraine, the overwash is abundant and furnishes a soil of much less value. Of still less value are some of the sandy soils found in some of the kame areas and among the duny sand hills. The commingling of sand and gravel in the kames associated with the moraines as at Melvin and elsewhere furnishes a fairly good soil. In the higher areas representing land-laid moraine deposits the soil is a boulder clay. These higher areas were the first brought under cultivation, and are generally occupied by old and well cultivated farms.

§ 8. Water supplies, wells.

Surface Wells.—In early days the water supplies were obtained

from surface wells usually from 15 to 20 feet in depth and seldom over 40 feet. The drying up of the swamps has affected these wells and made necessary a deeper search for more permanent supplies. With this removal of the surface waters and the procuring of more palatable water there has been a marked decrease in the prevalence of fevers since the day when "chills and fever" was the common lot of the hardy pioneers who undertook to make for themselves homes on the islands surrounded by tangled swamps.

Sandstone Wells.—In areas underlain by the Marshall sandstone, this formation furnishes an inexhaustible supply of water of excellent quality. West and south of the Port Huron-Saginaw moraine it can be reached by drill at a depth of 20 to 40 feet. In the moraine belt there is to be added to this the thickness of the drift above the interior plain level, making a maximum thickness of about 150 feet in the more elevated portions. For the most part wells reach sandstone here at depths considerably less than this. The water usually rises to a considerable height in these wells but in one instance only is it known to flow out at the surface viz., at E. Seaman's (No. 2) about a mile east of Minden. This well reaches water at a depth of 73 feet (67 feet to rock). At G. Schweigert's (No. 1) about 200 yards west the water rises to within two feet of the top of the well.

Shale Wells.—Throughout a belt four or five miles wide bordering the area covered by the Marshall sandstone, water is found in a layer of sandstone four to six feet thick at a depth of 40 to 100 feet below the top of the Coldwater shales. The water obtained from this horizon is brackish and often unfit for use. Drilling in this area is therefore usually attended with very unsatisfactory results. At still greater distances from the border of the sandstone few attempts have been made to penetrate the great thickness of drift and these have met with failure. At Brown City (No. 70), the attempt was abandoned after reaching a depth of 212 feet. At Lane's (No. 71) Section 17, Flynn township, it was given up at 240 feet and at Dorland's (No. 71) Section 21, same township, at 126 feet.* In that portion of the county southeast of the belt above defined the great thickness of drift stands in the way of successful efforts to obtain rock wells. Moreover, even when successfully penetrated, as at Croswell, Marlette and Valley Center, the limited supply and brackish character of the water found within several hundred

*The great thickness of drift here, if correctly reported, may indicate the presence of a buried river channel, a phenomenon not uncommon in Michigan.

feet of the surface of these formations render such attempts to secure satisfactory supplies disappointing. In this region, therefore, the drift itself must be relied upon as the only available source of supply of potable water. These supplies occur in beds of sand and gravel which are without recognized order or arrangement, intercalated between beds of clay in the drift. As the county becomes older the superficial beds will be inadequate to furnish needed supplies, a result already felt in many parts of the region. By sinking the well to a deeper stratum, however, new supplies may usually be found. While it may happen that in places deeper water-bearing beds may be wanting, the variable character of the drift deposits makes it quite improbable that such beds are wanting over any considerable area and by changing the location of the well a short distance new beds may be reached. There is generally a heavy water bearing bed of gravel and sand resting upon the rock surface at the base of the drift. The water from this, as at Valley Center, rises to within a few feet of the top of the well.

A PARTIAL LIST OF ROCK WELLS IN SANILAC COUNTY.—SANDSTONE WELLS.

Owner.	Location.	Elevation above Lake Huron.	Total depth.	Depth to rock.	Character of rock.
	Delaware Township (14-15.)				
1. C. Schweigert	N. W. Sec. 7		72	60	Blue sandstone, thin, broken. Water comes within two feet of the surface.
2. E. Seaman	N. W., Sec. 7	195	73	67	Flowing well.
3. Weber & Ahner	S. W., S. W.	240	111	91	Blue sandstone. Water came up within 26 feet of top.
4. Wm. O'Mara	N. W., S. W. Sec. 30	270	126	100	Sandstone?
5. James Donlon	N. W., N. W. Sec. 31	280	122	117	Sandstone?
	Minden Township (14 14.)				
6. D. Moore & Son (Woolen Mills)	200 paces S., N. E. cor. Sec. 11	260	110	88	Shaly sandstone.
7. Wm. Lloyd	180 p. N., S. E. cor. Sec. 2	265	123	110	Sandstone, Upper 6 to 8 ft. softer.
8. Canham & Ross (Roller Mill)	200 p. S., N. E. cor. N. W. ¼ Sec. 12	240	100	60	Sandstone.
9. Canham & Ross (store)	Near depot	240	72	60	Sandstone.
10. Norman Burley	N. E., Sec. 2	200	93	60	Soft, not tested.
11. John Fisher	N. E, cor. Sec. 9		55	50	Sandstone.
12. W. Fisher	N. W., N. E. Sec. 8		47	40	Sandstone.
13. John Pelot	S. E., S. W. Sec. 4		65	58	Sandstone.
14. Jas. Rezmack	N. E., N. W. Sec. 8		75	68	Sandstone.
15. Joseph Murdock	280 p. S., N. E. cor. Sec. 10	240	112	104	Sandstone.
16. Jno. O'Conner	N. E. cor. Sec. 11		150	135	Sandstone.
17. Wm. Donnor	N. E., Sec. 17		55	48	Sandstone.
18. A. Kolar, Jr	N. W., S. W. Sec. 16		60	50	Sandstone.
19. Chas. Postle	N. E, S. E. Sec. 17		35	30	Sandstone.
20. R. R. Well at Palms	20 p. S. Station	231	110	40	Sandstone.
	Austin Township (14-13.)				
21. Tyre Test Hole	At elevator near station	200	90		Sandstone. Micaceous at 60-70 feet.
22. T. Pollard	S. E., S. E. Sec. 22		33	25	Blue sandstone.
23. J. Hunt	N. E., S. E. Sec. 22		60	29	Sandstone 3 ft., Broken slate, coal and gravel on rock. Water bad.
24. E. Hunt	S. E., N. E. Sec. 22		77	49	Sandstone, 27. Coal 16-8 inches.
25. Robt. Gray	N. E., N. W. Sec. 21		84	60	"White marble." probably white sandstone.
26. J. S. Nesbitt	N. E., N. E. Sec. 30		84	65 to 70	Sandstone.
	Greenleaf Township (14 12.)				
27. H. N. Sanburn	S. W., Sec. 27		207	27	Sandstone, flinty.
28. J. McPhail	N. E., N. E. Sec. 34		60	30	Sandstone.
	Marion Township (13-15.)				
29. Renelt's (Deckerville Sta.)	S. W., S. W. Sec. 30	197	53	46	Sandstone. Drill dropped one foot.
	Wheatland Township (13-14.)				
30. S. A. Terpenning	S. E., S. E. Sec. 13		51	45	Sandstone.
	Argyle Township (13-13.)				
31. Various wells	About Argyle Postoffice			25 to 30	Sandstone.
	Evergreen Township (13-12.)				
32. J. McQueen	N. E., S. E. Sec. 11		75	45	Sandstone. "Hard rock."
	Custer Township (12-14.)				
33. County jail	S. E., S. E. Sec. 32	190	65	40	Sandstone.
34. L. Dadgerow	S. E., N. E. Sec. 31		82	44	Sandstone.
	Moore Township (12-13.)				
35. Elmer Hotel	S. E., S. E. Sec. 33	200	60	38	Sandstone.
36. W. H. Dorman	S. W., S. W. Sec. 20		60	40	Sandstone. "Hard white rock on top."
	Lamotte Township (12-12.)				
37. Robt. Bedford	S. W., N. W. Sec. 32		35	23	Sandstone.
	Watertown Township (11-14.)				
38. C. Murphy	S. W., N. W. Sec. 16		68	37	Sandstone.
39. W. Niemeyer	N. W., S. W. Sec. 6		90	40	Sandstone.
40. A. Hall	N. W., N. W. Sec. 6		72	43	Sandstone.
41. F. Eggert	N. E., S. E. Sec. 18		40	20	Sandstone.
42. Robert's Hotel (Sanilac Center)	N. W., N. W. Sec. 4		72	36	Sandstone.
43. J. Kasdorf	N. W., S. E. Sec. 32		95	70	Sandstone. "Hard white rock."
44. J. Paton	N. W., N. W. Sec. 27		125	83	Sandstone.
45. A. S. Parks	N. E, S. E. Sec. 34		82	37	"Hard white rock."
46. Geo. Potten	S. E, N. E. Sec. 17		50	37	Sandstone.
47. J. Bartley	N. E., N. W. Sec. 17		62	37	Sandstone.
	Elmer Township (11-13.)				
48. O. F. Teeple	S. E., S. E. Sec. 13		86	42	Sandstone. "Hard rock" 1 ft. Blue sandstone 20 ft.
49. Robt. Hall	N. E., S. E. Sec. 14		119	44	Sandstone.
	Marlette Township (11-12.)				
50. W. A. Ellis	N. E., N. E. Sec. 6		77	40	Sandstone.
51. E. L. Brown	N. E. Sec. 8 (9-13) Lapeer Co.		82	69	Sandstone. ("Grindstone.")

SHALE WELLS.

Owner.	Location.	Elevation above Lake Huron.	Total depth.	Depth to rock.	Character of rock.
52. W. Frederich	Delaware Township (14-15.) N. W., S. W. Sec. 8	.....	117	60	Shale. Water brackish.
53. W. Frederich, second well	N. W., S. W. Sec. 8	.....	285	60	Shale. Water brackish.
54. School house well	N. W. Sec. 8	.....	166	80	Shale.
55. Wm. McDonald	N. W., N. E. Sec. 30	.....	123	95	Shale. "Blue shale rock."
56. W. H. Varty	N. E., S. E. Sec. 33	.....	89	80	Shale.
57. John Uhl	N. E., S. E. Sec. 7	.....	85	68	Shale.
58. A. Reidel	S. W., S. W. Sec. 7 (14-16)	.....	260	68	Shale.
59. Geo. Luskowsky	S. W., S. W. Sec. 6 (14-16)	.....	86	80	Shale.
	Forester Township (13-16.)				
60. Christian Chittick	S. W., S. W. Sec. 7	.....	85	50	Shale.
	Marion Township (13-15.)				
61. Dr. H. F. Alderton	N. W., N. W. Sec. 32	.....	169	90	"Shale 70 ft., thin harder 9 ft."
62. W. Stipes	S. W., S. W. Sec. 32	.....	112	100	"Gray shale."
	Bridgehampton Township (12-15.)				
63. James Lane	N. E., N. E. Sec. 6	.....	168	100	Shale.
	Custer Township (12-14.)				
64. Sanilac Stock Farm	S. E., S. E. Sec. 35	190	90	37	Shale, brackish.
65. H. McRae	S. E., S. E. Sec. 14 (12-12)	.....	144	40	Shale 100 ft. Sandstone 4 to 6 ft.
66. W. Wilson	N. W., Sec. 18 (11-12)	.....	69	40	Shale and shaly sandstone 29 feet.
67. Jas. Ronald	N. E., Sec. 18 (11-12)	.....	80	50	Sandy shale 25 ft. Sandstone 50 feet.
68. Isaac Smith	S. W., S. W. Sec. 17 (11-12)	.....	195	60	Shale 130. Sandstone 5 ft.
69. Chas. Hunter	N. E., N. E. Sec. 19 (11-12)	.....	120	57	Shale 59 ft. Sandstone 4 ft.
70. A. W. Redmond	N. E., Sec. 34 (11-12)	.....	186	140	Shale 40 ft. Sandstone 6 ft.
71. D. Reynolds	N. W., Sec. 16 (10-12)	.....	180	150	Shale 26 ft. Sandstone 4 ft.
72. John Cook	S. W., 16 (10-12)	.....	123	99	Shale 20 ft. Sandstone 4 ft.
73. Marlette waterworks	S. E., S. W. Sec. 32 (11-12), lot 7, block 15, 250.	260	624	60	Shale, (probably S. S.) occasionally bands of very hard rock. At 150 ft. 8 to 12 ft. hard "limestone." Water brackish.
74. H. C. Butler	S. W., S. W. Sec. 28 (10-12) (Lapeer Co.)	.....	154	90	Shale.
75. A. Sinclair	S. E., S. E. Sec. 5 (9-13) (Lapeer Co.)	.....	208	100	Shale.
76. O. Lane	S. W., S. W. Sec. 17 (10-11)	.....	240	240	Rock; not certain.
77. E. Dorland	N. W., S. W. Sec. 21 (10 13)	.....	126	.....	No rock.
78. Harrington House, Brown City (9-13)	S. W., S. E. Sec. 7 (9-13)	230	212	.....	No rock.
79. Croswell waterworks	River bank 25 feet below railroad station	125	675	190	See record.
80. Valley Center	Near station	220	569	149	Sandstone Richmondville.

GENERAL INDEX.

N. B.—The tables of wells and owners on pp. 28 to 30 are not indexed.

ERRATA.

Page 2, line 8, for *Eutænia sertalis* read *Eutænia sirtalis.*

Page 2, line 8, for Trepidonotus read Tropidonotus.

Page 2, line 10, for Oppibolus read Ophibolus.

Page 2, line 11, the latest authorities change *Caudisona catenata* to *Sistrurus catenatus* or *Sistrurus tergeminus.*

LIST OF PUBLICATIONS

DOUGLASS HOUGHTON, State Geologist.

Reports from 1838-1846 were published with Legislative documents as follows: S. D. means Senate document; H. D., House document; J. D., joint document. State Geologist is abbreviated S. G., and State Geological Survey, S. G. S.

1838. Report of a select committee of the Board of Regents of the University on the collection of the S. G.
H. D. Vol. I, p. 1-2; S. D. No. 1, p. 1.
H. D. No. 55 is duplicate of No. 1.
Statement of the expenditures on account of the S. G. S. for the year 1837.
H. D. No. 8, pp. 115-118; S. D. No. 21
(First annual account of the S. G.), pp. 315-318.
Report of the S. G. (first annual).
H. D. No. 24, pp. 276-317; S. D. No. 16; separately, No. 14, pp. 1-39.
Communication from the S. G.
H. D. No. 46, pp. 457, 460.

1839. Report of the S. G. in relation to the improvement of State Salt Springs.
H. D. No. 2, pp. 39-45; S. D. No. 2, pp. 1-8.
Report of the committee on the S. G.'s report in relation to the improvement of the State Salt Spring.
H. D. No. 4, pp. 123.
Report of the S. G. in relation to the iron ore, etc., on the school section in town five south, range seven west, in Branch county.
H. D. No. 21, pp. 342-344.
Second annual report of the State Geologist.
H. D. No. 23, pp. 380-507; S. D. No. 12, pp. 264-391; also separately H. R. No. 23, and S. R. sometimes misprinted No. 13 and No. 23, pp. 39 and appendix of sub-reports 123 pp.
Report of the Committee of the Senate on Manufactures, to whom was referred the communication of the S. G. relative to salt springs and the salines of the State.
S. D. No. 3, pp. 85-86 (parallel to H. D. No. 4).
Communication from the S. G. relative to the G. S.
S. D. No. 25, pp. 463-466; J. D. No. 3, app.

1840. Report of S. G. relative to the improvement of the Salt Springs.
H. D. No. 2, Vol. I, pp. 18-23; S. D. No. 8, Vol. II, pp. 153-158.
Annual report of the State Geologist (third, map of Wayne county).
H. D. No. 27, Vol. II, pp. 206-293; S. D. No. 7, Vol. 2, pp. 66-153; separately, H. R. No. 8, pp. 1-124.
Report of the select committee to whom was referred the several reports of the S. G.
H. D. No. 46, Vol. II, pp. 455-461.
Report of the majority of the Committee of Finance on the communication and accounts of the S. G. for 1839.
Report of the minority of the Committee on Finance on the same subject.
Report of the select committee on S. G.'s report and accounts relative to improvement of Salt Springs, etc.
S. G.'s account for the year 1839, the same being the subject matter of the three preceding reports.
S. D. No. 15, 16, 17, 18, pp. 209-224.

1841. Special message concerning State Salt Springs.
H. S. and J. D. No. 5, pp. 235-254.
Annual report of the S. G. (fourth).
H. S. and J. D. No. 11, pp. 472-607; separately H. D. No. 27, pp. 1-184; S. D. No. 16, pp. 1-184.
Report of the S. G. relative to county state maps.
H. D. No. 35, pp. 94-98.

1842. Report of the S. G. relative to the State Salt Springs.
H. D. No. 2, pp. 15-21; S. D. No. 1, pp. 1-9.
Report of the select committee in relation to the report of the S. G.
H. D. No. 19, pp. 77-79.
Annual report of the S. G. (fifth).
H. D. No. 14, p. 6; J. D. No. 9, pp. 436-441.

1843. Annual report of S. G. (sixth).
H. D., S. D., and J. D. No. 8, pp. 398-402.
Report of the S. G. relative to the State Salt Springs.
S. D. No. 9, pp. 402-408.

1844. Annual report of the S. G. (seventh).
S. D. No. 11 (three pages).
Maps of Washtenaw, Calhoun, Jackson and Lenawee counties were published separately.

1846. Report from Geological Department by S. W. Higgins, principal assistant.
J. D. No. 12, 22 pp.
Report of the joint committee relative to the Geological Survey.
J. D. No. 15, 8 pages.
D. Houghton undertook an arrangement with the Linear Survey of the U. S. Land Office by which a certain amount of geological work was done, which was never published by the State, the results of which appear largely in the township plats of the Land Office, and in the report of C. T. Jackson, 1849, U. S. S. Ex. Doc. No. 1, pp. 371-935, H. Ex. Doc. No. 5, Vol. 3, Part 3, including sub-reports of W. A. Burt and Bela Hubbard on the geology of the subdivisions of the Linear Survey, First Session 31st Congress, and of Foster & Whitney, U. S. Geologists, Part I, H. Ex. D. No. 69, pp. 1-224 and 12 Plates, First Session 31st Congress; S. Ex. D. No. 2, Vol. 2, p. 147, Second Session 31st Congress; Part II S. Ex. D. No. 4, Vol. 3, p. 3, Special Session 32d Congress.

See also:
Reports on the Mineral Region of Lake Superior, with a correct map of the same and a chart of Lake Superior (first title page). Reports of Wm. A. Burt and Bela Hubbard, Esqs., on the geography, topography and geology of the U. S. Surveys of the Mineral Region of the South Shore of Lake Superior, for 1845: By J. Houghton, Jr., and T. W. Bristol, Detroit, 1846 (second title page).
A second edition was published the same year in Buffalo by J. Houghton, Jr., the title being "The Mineral Region of Lake Superior."
"Memoir of Douglass Houghton," Alva Bradish, Detroit, 1889; reprints the early reports almost in full.
A. WINCHELL, State Geologist.

1861. First biennial report of the progress of the G. S. of M. Embracing observations on the Geology, Zoology and Botany of the Lower Peninsula. Made to the Governor Dec. 31, 1860.
The Walling Tackabury State Atlas contains a paper with geological and topographic maps by A. Winchell, reprinted separately under the title "Michigan."

1869. Report of the Joint Committees on Geological Survey, made to the Legislature of Michigan, Lansing, W. S. George & Co., Printer to the State, pp. 1-15.

1871. Report of the progress of the S. G. S. of M., pamphlet, pp. 1-64.

1873. Vol. 1. Upper Peninsula, 1869-1873. Accompanied by an Atlas of maps. Edition 2,000.
Part I. Iron Bearing Rocks (Economic), T. B. Brooks. Of this an extra edition of 500 with thirteen accompanying atlas plates (1 to 13, No. 2 is misnumbered 11) was issued.
Part II. Copper Bearing Rocks, Raphael Pumpelly (Plates 14, 14a, 15-23 of the atlas accompanying. Chapters IV, VII, VIII are by A. R. Marvine).
Part III. Palæozoic Rocks, Dr. C. Rominger. (Plate 24 of the atlas accompanies. There was an extra edition of 500 dated 1872, without map or index, differing slightly in title page, introduction and paging).
Vol. II. Upper Peninsula. 1869-1873. appendices to Part I, Vol. 1. A Lithology by A. A. Julien. B. Lithology by T. B. Brooks and A. A. Julien, C. Lithology by Charles E. Wright. D. Ore deposits, E. Lithology (Notes by D. Houghton), F. Iron ore dock (by Jacob Houghton and Chas. H. Palmer, with Plate 20), G. Census statistics (1870). H. Magnetic Analyses (by F. B. Jenney), I. Mining laws (by C. D. Lawton), J. Metallurgical qualities by H. B. Tuttle, K. Contortions of Laminæ (by T. B. Brooks).
C. ROMINGER, State Geologist.

1876. Vol. III. Lower Peninsula. 1873-1876, accompanied by a geological map. Edition 2,000.
Part I. Geology of the Lower Peninsula, by C. Rominger.
Appendix A. Observations on the Ontonagon Silver Mining District and the State Quarries of Huron Bay, by C. Rominger. B. Report on the Salt Manufacture of Michigan, by S. S. Garrigues, Ph. D., State Salt Inspector.
Part II. Paleontology. Fossil corals, by C. Rominger (with 55 plates).

1881. Vol. IV. Upper Peninsula. 1878-1880, accompanied by a Geological map. (Edition 2,000.) Part I. Marquette Iron Region. Part II. Menominee Iron Region, by C. Rominger.
See also Vol. V, Part I.
See also reports by Brooks, Pumpelly and Wright in the reports of the Wisconsin Geological Survey.
C. E. WRIGHT AND M. E. WADSWORTH, State Geologists.
See Vol. II and Vol. V, also the reports of the Commissioners of Mineral Statistics and the following entry:

1893. Report of the State Board of Geological Survey for the years 1891 and 1892, to which are appended exhibits Setting Forth the Expenses of the Survey from its Inception to November, 1892, Exclusive of the Cost of Publication. Also the Reports of Dr. Carl Rominger for the years 1881-2; of Mr. Charles E. Wright for the years 1885-8; of Dr. M. E. Wadsworth for the years 1889, 1890, 1891, 1892, made to the State Board of Geological Survey for the years named; also a Provisional Report by Dr. M. E. Wadsworth, State Geologist, upon the Geology of the Iron, Gold and Copper Districts of Michigan.
L. L. HUBBARD, State Geologist.

1895. Vol. V. Upper Peninsula, 1881-1884; Lower Peninsula, 1885-1893. (Edition 2,500.)
Prefatory Historical Note by L. L. Hubbard.
Part I. Geological Report on the Upper Peninsula of Michigan, exhibiting the progress of work from 1881-1884. Iron and Copper Regions, by C. Rominger, accompanied by a map and two geological cross-sections.
Part II. The geology of Lower Michigan, with reference to deep borings. Edited from notes of C. E. Wright, late State Geologist, by Alfred C. Lane, Assistant State Geologist, with an introduction on the origin of salt, gypsum and petroleum, by Lucius L. Hubbard, and accompanied by seventy-three plates and a map.

1899. Extracts from the annual reports of the State Geologist of Michigan, Lucius L. Hubbard, for the years 1897-1898. (By an error in Lansing this report really contains only the report for 1898. Edition 500.)
Vol. VI. Upper Peninsula. 1893-1897 (edition 954, and 200 of each part privately printed).
Part I. Geological report on Isle Royale, Michigan, by Alfred C. Lane, Assistant State Geologist. Accompanied by 16 plates and 29 figures, including map in cover.
Part II. Keweenaw Point, with particular reference to the felsites and their associated rocks, by Lucius L. Hubbard, State Geologist. Accompanied by 10 plates and 11 figures.
Part II. Appendix. The crystallization of the calcite from the copper mines of Lake Superior, by Charles Palache. Accompanied by six plates (100 extra printed separately).
ALFRED C. LANE, State Geologist.
Coal in Lower Michigan, by Alfred C. Lane, published serially in the Michigan Miner, Vol. I, Nos. 3 to 10, February to September, 1899. (500 reprints).
Annual Report for the year 1899 Michigan Miner, Vol. II, No. 3, February, 1900 (500 reprints stitched in with the following No.).
Preliminary, inofficial, see Vol. VIII.
The Origin, Properties and Uses of Shale, by H. Ries, Special Agent for the State Geological Survey.
Preliminary, inofficial, see Vol. VIII, Part I.
Published in the Michigan Miner, Vol. I, No. 12, Vol. II, Nos. 1 and 3 (500 reprints).
The U. S. Survey have published Monographs on the Copper Bearing Rocks of Lake Superior, the Marquette Range, the Penokee Gogebic Range and other publications relative to the Geology of Michigan, for which address the Director, Washington, D. C. Also, Water Resources of the Lower Peninsula of Michigan, by Alfred C. Lane. Water Supply and Irrigation Paper No. 30, 1899.
Lower Michigan Mineral Waters, by Alfred C. Lane, Water Supply and Irrigation Paper No. 31, 1899.

1900. Vol. VII. Lower Peninsula. 1893-1899. (Edition 1500, and 500 of each part issued separately).
Part I. Geological Report on Monroe County, Michigan, by W. H. Sherzer. Accompanied by 17 plates and 8 figures, including three colored maps.
Part II. Geological Report on Huron County, Michigan, by Alfred C. Lane, accompanied by 11 plates, 12 figures and one inserted table, including two colored maps. (100 extras of Chapter IX, X § 2, and X, §3).
Part III. Geological Report on Sanilac County, Michigan, by C. H. Gordon, accompanied by 5 plates and 2 figures, including one colored map.
Vol. VIII. Economic Geology, 1899. (In press, edition 1500, 500 of each part bound separately).
Part I. Clays and Shales of Michigan, their Properties and Uses, by H. Ries.—Accompanied by four plates and six figures.
The distribution of the reports of the Commissioner of Mineral Statistics was under the direction of the Board of G. S. from 1877-1883, since when they have been distributed by each Commissioner independently:
C. D. Lawton, of Lawton, 1883-91; J. P. Edwards, of Houghton, 1891-93; J. B. Knight, of Norway, 1893-95; George A. Newett, of Ishpeming, 1895-99; Jas. Russell, of Marquette, 1899