

## CHAPTER III.

### LOCAL DESCRIPTIONS.

§ 1. (a) The records of well-borings which are given herein may be divided into three groups: those already published, those collected and more or less worked up by Mr. C. E. Wright, and those whose collection or working up has been made by this Survey since Mr. Wright's time.

In all cases we give in the text, first the township, then the county, then in the few wells from adjacent states, the state. Next follows the altitude of the place, generally on Mr. Gannett's authority, and intended to give some idea of the elevation above sea level of the mouth of the well. In only two or three cases do we know the altitude of the top of the well more nearly.

Next follows (when known) the name of the well, or the firm or the company for whom it was sunk, then the depth. Then finally we give the authorities for it. When the record of a well has been already published we do not repeat it, unless we intend to use it for comparison, or desire to throw it into more convenient shape, or wish to show into what groups we should divide it.

Of the wells whose records are now, for the first time, published, plates have in most cases been made. We give in them, in parallel columns,—

1. The formations into which I divide the series.
2. The formations into which Mr. Wright divided it, whenever he divided it at all.
3. References to equivalent depths in other wells; *e. g.*, "S. B., 385," means that the beds opposite to which this symbol is placed are equivalent to those encountered at a depth of 385 feet in sinking the well at South Bend, Indiana.
4. The plate representing schematically the succession of the beds.
5. The depths at which samples were taken and also the

depths between which the nature of the rock remained tolerably constant.

6. Either in the same or in separate columns, the drillers' record of what was encountered, and the notes by Wright or myself on the nature of the samples. I have left Wright's notes untouched except where I was certain of inaccuracies, and where the main part of the work is Wright's, or (I often cannot tell which) was derived by him from some one else unknown, my additions are enclosed in parentheses and matters I consider very dubious, in brackets. It is not always easy to distinguish the drillers' log from Mr. Wright's own notes. I have tried to give the reader as much information as I myself possessed.

One thing I should perhaps explain: Mr. Wright, in the diagrams which he correlated, was accustomed to unite the formations into larger divisions or series and refer them to their systems. These columns I have often left out, partly for the sake of compactness, partly because his work, as well as mine, is purely lithological and stratigraphical, and hence lacks validity in attempting to correlate the local formations into the universally applicable series and systems. As he borrowed his names largely from the Ohio Survey, this arrangement of them is his, generally speaking. Of course, therefore, he ran the Devonian down to include what he called Oriskany sandstone, etc.

Often the well-record is so imperfect that, although worth giving, exact divisions of parts of it cannot be given. In this case I have sometimes given the names of the formations without indicating by braces their exact limits.

(b) We also give a map of the Lower Peninsula. On this the names of the towns from which we give records are underlined in red. It thus serves as a geographical key to the records. On the same map are irregularly concentric lines, whose use has been explained above. They give a rough geological map of the state and show where it is supposed that the lines of division between the formations would come to the surface, were all the surface soil removed.

They are, as stated in the legend of the map,

1. Line between the base of the Coal Measures (the Parma white sandstone or conglomerate generally), and the top of the Grand Rapids group (generally a limestone).
2. Top of the Marshall sandstone.

3. Bottom of the Marshall sandstone.
4. Bottom of the Richmondville sandstone.
5. Line between the St. Clair bituminous Black shale and the Traverse blue limestone or shale.
6. Line between the Traverse bluish shaly beds and the light Dundee limestones.
7. Line at the bottom of the Dundee limestone, marking the change to dolomite. (N. B. Dolomites burn to a milder lime than genuine limestones.)
8. Line marking the sandstone of Ida and Sylvania.

It will be noticed that the last five lines cross the state line into Ohio much nearer Toledo than Rominger's map of 1876 would make them. This is justified not only by the well-records but by the connecting work of the Ohio geologists.

The transgression of the Subcarboniferous shales into Ohio and Indiana has not hitherto been noticed. This is probably due to two causes. In the first place, the region in question is heavily coated with surface deposits, and shows no outcrops. Furthermore, Winchell ignored the Richmondville sandstone, whose importance seems to have been first appreciated by Wright, and placed the base of the Carboniferous at the bottom of the Marshall group. Now this line, as our map shows, remains within the state.

(c) On the map we also indicate by narrow lines the courses of the geological sections which are given in the other plates, and which show, as nearly as we know them, the depths of the different beds of rock and their ups and downs beneath the lines aforesaid. The same signs are used for the different kinds of rocks as in the engravings of the different wells.

Three of these cross-sections run nearly through the center of the basin, viz.: 1. One from Niles to Bay City, running not far from Caseville and Port Austin; 2. From Hillsdale to Bay City and thence up the coast to Alpena; 3. From Detroit to Saginaw, thence extending through Grand Traverse Bay.

The names of places, as for example Port Austin, that do not lie exactly on these cross-sections, I have placed on the nearest cross-section at points where the places would be, if projected directly upon it, but it is obvious that if the rocks were in a mathematically perfect basin, the point of the cross-section which would have the same record as Port Austin would be

found at the intersection of the line of section with a circle through Port Austin having the same center as the basin. And as a matter of fact, I have taken the southeast corner of T. 11 N., R. 1 W., as near enough to the center of the basin (it is probably not far enough west, but I could not tell this until after I had constructed the sections) and have, by circles around it, found the points on any particular line of section corresponding to places off it, and at *these points* laid off the *geological columns* revealed by the borings.

The two methods, direct projection and projection by circles, generally lead to points of projection close together, as I have chosen the sections to run near to as many of the wells as possible. These points of projection are connected by curved arrows.

It will be noticed that the more frequent the well-records are, the more minor inflections there are shown to be in the beds. The question then arises, when there are not enough records shall we put in ideal flexures or unconformities to indicate the fact that there are flexures and unconformities, or shall we sweep the lines along in graceful curves.

Much may be said on both sides, but the latter plan has the advantage that the depth of a bed at a given point, as derived from the section, will in general not be so much in error as if we put in minor bends at random.

(d) Now, one use to which these sections may be put is to ascertain what succession of rocks may be expected to be found under any given place. To determine this, describe on the map, about the center of the basin, a circle passing through the point at which it is proposed to sink a well. Suppose, for example, that this is Allegan. This circle will cut the cross-section lines on the map, the Niles-Bay City section (A-B), near Kalamazoo, the Muskegon-Charlotte section (J-K), near Muskegon. Take the point of intersection on the nearest section line, *e. g.*, near Kalamazoo, and find by the scale of the map its distance in miles from the nearest point for which a well-section is given, *i. e.*, Kalamazoo. Then on the profile line of the same cross-section, *i. e.* A-B, plate LXVII, take a point at the same distance horizontally (from Kalamazoo). Draw a vertical line from it. Mark off on this line a distance corresponding to the estimated altitude of the point at which boring is proposed above

lake or sea-level, and the vertical distances from the new point thus found to the various lines which mark the important divisions of the rock column will represent on the same scale as the rest of the figure, the depths at which these divisions ought to be found. If the place, whose underlying rocks, *i. e.*, geological column, are in question, is not much nearer one cross-section than another, it would be better to project as above on the two nearest sections, and find thus two rock columns which will in general differ considerably. The true depths will probably lie between them.

The three other sections, viz.:

4. Niles-Frankfort,
5. Charlotte-Muskegon,

6. Monroe-Port Huron, do not run near the center of the basin and the circular method of projection cannot be applied to them. Places off the cross-section lines are projected directly upon them and either their well-record directly described or a somewhat arbitrary allowance made for their being nearer to or further from the center of the basin, depending on general apparent dip. But after the depth of some one important horizon has been fixed, the distance of the other horizons above and below it are given exactly as in the boring.

Among the more important suggestions brought out by these sections is the possibility of a slight elevation of the strata, or an anticlinal, south of Saginaw, and of other such flexures near Tawas City, south from Hat Point, in Huron county, toward Lake St. Clair, and about Manistee.

§ 2. The references to Rominger and Winchell are to their reports for the Geological Survey of Michigan. Local authorities for information—the officers of the Survey owe many thanks to those who have so courteously and generously assisted them in the interests of science—precede the descriptions of the wells.

ADRIAN, Lenawee County. (Plate I.)

ALBION, Calhoun County. Alt. 943 feet.

Rominger, III, 81.

Total Depth.	Formation.
10 feet.....	Drift.
281 ".....	Solid sandrock; drinking water. (Marshall sandstone, of Jackson well, 88-373.)
381 ".....	Blue shales.

ALCONA, Alcona County. Altitude (lake-level 590 feet?).

According to Wright, the (Ohio) Huron or Genesee shales come in here.

ALGONAC, St. Clair County. (Two wells. Plates II and III.)

ALLEGAN, Allegan County. Altitude 708 feet. (Plate IV.)

There was a well bored here in 1887, by a company of which H. H. Pope was president and W. B. Williams, jr., secretary.

Hon. David Stockdale writes: "Three wells were put down here, at a depth of about 1,300 feet, and each time struck oil; but in such small quantities \* \* \* \*." Julius C. Ellinger, president of another company, writes: "It took over three months to drill No. 1 well; contractors, Shaler & Thompson, Findlay, Ohio; depth, 1,275 feet. No. 2 was drilled in fourteen days, 1,400 feet 6 inches; No. 3, 1,407 feet, in thirteen days, by Long & Kostetter of Pittsburg, Pennsylvania. No. 1 well would produce, before shooting, about five barrels per day" (not essentially increased by shooting); "we strike considerable salt water in the Brown shale between 1,120 and 1,200 feet, \* \* \*. The last two wells were drilled from 100 to 125 feet below oil sand, in solid lime rock, dry as a bone." The section is appended.

To the kindness of Mr. Ellinger we owe the records and samples from which the cut has been made.

ALMA, Gratiot County. Altitude 797 feet.

Alma Sanitarium Company. Depth 2863 feet.

J. H. Lancashire, M. D., Vice President and Secretary.

Boring begun December, 1889, finished June, 1890.

The sand pump was filled with water from the bottom of the well. This water, emptied into a barrel, showed a temperature of 98° F. This indicates an earth temperature gradient of 1° F. in 54 feet.

The following remarkable analysis confirms what has been suggested on p. 34, as to the predominance in the deep parts of the basin near its center, of bromides that were left in solution after the crystallization of other salts. This analysis is of a mixture of the water from the bottom of the well, with that which comes in at 1053 feet. The water rises five feet above the ground in the well-casing.

New York, May 24, 1894.

"The sample of water marked 'Alma Mineral Water' submitted to us for examination contains in one U. S. gallon\* of 231 cubic inches:

Potassium chloride.....	63.7845 grains.
Sodium chloride.....	9581.3242 "
Lithium chloride.....	traces
Ammonium chloride.....	43.0859 "
Calcium chloride.....	6304.2741 "
Magnesium chloride.....	2256.9909 "
Ferrous chloride.....	15.4101 "
Sodium bromide.....	80.8238 "
Sodium iodide.....	traces
Potassium sulphate.....	58.1949 "
Sodium Phosphate.....	traces
Alumina.....	3.9005 "
Silica.....	0.8324 "
Total.....	18,408.6213

C. F. CHANDLER, PH. D.  
CHAS. E. PELLEW, E. M."

A set of samples of the formations passed through in sinking the well is preserved at the sanitarium.

"At about 1053 feet we struck a large flow of water, which strongly resembled the Michigan salt wells." This is doubtless the horizon of the Marshall.

"The last 1500 feet was through shale rock the entire distance without striking a drop of water, the shale varying from blue to black." These are the Coldwater and St. Clair shales. "In going through this shale we averaged 25 feet per day" (24 hours).

"Our water was struck in limerock, which was so hard that we with difficulty went three feet per day." This corresponds to the cherty Corniferous or Dundee.

ALPENA, Alpena County. Altitude 609 feet. (Plate V.)

1. T. Sterry Hunt (Geological Survey of Canada, 1876, p. 240), quotes Winchell (1874?) that salt was struck at 1,164 feet. I have not found the reference, as there is no paper published by

\* As water analyses are variously estimated, it may be worth while to state that  
1 U. S. liquid gallon=231 cu. in. or 8.33888 lbs. Av.=58.372 grains.  
1 Imperial " =277.274 cu. in. or 10. lbs. Av.=70.000 "  
" =very nearly 6-5 of 1 U. S. gallon.  
1 Litre=.264179 U. S. liquid gallon.  
" =.220090 Imperial "  
1 Gramme=15.432 grains.

Winchell in 1874, given in the bibliography published in the American Geologist.

2. Rominger, III, 39 (analysis), 40, 63. Two wells, one earlier than 1866; another, close to the bed of Thunder Bay River. The record of the latter is given in Plate V.

3. A third well was sunk in 1891. Depth, 1,267 feet.

Hon. E. K. Potter. The record is not as complete as that of No. 2.

ANN ARBOR, Washtenaw County. Altitude of M. C. R. R. track, according to Gannett, 771 feet. According to Winchell, the altitude of the same point is 764 feet; of the Observatory, 909 feet; of the University grounds, 867 feet; of the top of the boring given below, 781 feet. Depth, 770 feet.

"In the south part of Washtenaw County and in the north-western corner of Monroe County, in well borings, the black shales are found usually not more than about 100 feet below the surface. Frequently a stream of \* \* \* gas escapes \* \* \*."

Rominger, III, 68,\* 92.

Rominger's record is as follows:

Lane.	Rominger.	Thickness.	Formation.
		1-155 feet.	
Coldwater.....	Cuyahoga.....	155-305	Blue arenaceous shales with seams of fine-grained sandstones.
		305-333	Black bituminous shales, gas, and drops of oil.
Richmondville.....	Berea.....	333-425	Coarse, gray sandstone, with a brine of Sp. Wt. 1.142, 19% Na Cl by evaporation.
	Bedford.....	425-525	Blue shales with subordinate sandstone layers and seams of pyrite.
St. Clair.....	Cleveland.....	525-610	Black shales, very bituminous, with iron pyrite.
	Erie.....	610-632	Dark blue, arenaceous shales, with iron pyrite and traces of fossils.
	Ohio.....	632-700	Black bituminous shales, with iron pyrite.
Traverse.....	Helderberg.....	700-770	Limestone, bluish colored, with flint.

\* p. 68. Black shales struck at 525, their thickness there being 85 feet.

Winchell, Geology of Washtenaw County, in the History of Washtenaw County, 1881. Boring on Main street, Court House square.

Winchell's record is as follows:

ARTESIAN BORING, ANN ARBOR, 1871.

At depth of	Thick-ness.	Thick-ness of Group.	Descriptions.
0	30		DRIFT— Soil, gravel, etc.
30	101		Clay, bluish and adhesive, with alternating seams of quicksand.
65			Bottom of shaft and beginning of boring.
131	1/2		Quicksand, rendering tubing necessary.
131 1/2	28 1/2		Compactly bedded, shale-like materials. Tubed to here.
160	4	164	Partially cemented sand. Drove two more lengths of pipe.
164	51		MICHIGAN SALT GROUP— Shale, light bluish, varying to dark gray, not effervescing with acid, fine, laminated, with minute disseminated scales of white mica. Some portions—apparently thin seams—buffish, rather hard, very slightly effervescing with acid. Drove four feet more of pipe to this shale. Water from shaft was shut off. A little water continued to appear in the pipe.
215	1/2		Crevice. Fresh water arose immediately to within 25 or 30 feet of the surface.
215 1/2	104 1/2		Shale, as above the crevice.
320	6		A cavity from which issued inflammable gas, and a little black oil.
326	4	166	Black shale, not effervescing with acids.
330	62		MARSHAL GROUP— Sandstone, dun, earthy, porous, actively effervescing with acid. Contains brine. At a depth of three feet in it, a sample of brine stands 50° salometer.
366	26		Same rock continuing, but more distinctly arenaceous.
392	35		Fine buffish, calciferous or magnesian sandrock—about one-fourth dissolving in sulphuric acid.
		123	Brine here 64° salometer.

At depth of	Thick-ness.	Thick-ness of Group.	Descriptions.
427	13		HURON GROUP— Shale, argillaceous, bluish. The sand pump brings, with chips of shale, much sand.
430			Shale continuing. Water lowers to 40 ft. from surface. Brine here 68° salometer.
433			Shale continuing. Sand pump brings up no sediment.
440	29		Silicious shale, excessively fine, compact, bluish-gray, accompanied by gas, which caused an overflow of water at the top of the well. Water afterward subsided, but some gas continued to escape.
453			Same continuing. When lighted paper is thrown down, numerous detonations occur in the well.
469	251	293	Silico-argillaceous shale, not effervescing. Some beds of black bituminous shale.
720			HAMILTON—CORNIFEROUS Limestone (with ferruginous specks) apparently somewhat cherty.
745			Chips of earthy magnesian limestone with some sand.
755			Chips quite sandy, with magnesian limestone, iron and clay. Work discontinued.

An analysis of the solid residue was made by Mr. J. R. Jones, with the following result:

Percentage solid matter in brine.....	17.48
	Per cent.
Iron (in the residue after evaporation).....	2.506
Magnesium chloride.....	3.976
Calcium chloride.....	14.022
Sodium chloride (common salt).....	79.496
Total.....	100.000

BANKS (West Bay City), Bay County, two miles north of Bay City. Altitude, 592 feet (?).

Rominger, III, 200.

Wells.	Total Depth. Rominger.
Moore & Smith.....	830 feet.
Long & Bradfield.....	800 "
Taylor & Moulthrop.....	840 "
Keystone Lumber and Salt Company.....	980 "
Bangor Salt Manufacturing Company; 95° brine.....	774 "

The above wells are in the lower salt rock=Napoleon; *i. e.*, the Marshall sandstone is the source of the brines.

BATTLE CREEK, Calhoun County. Altitude, 819 feet. Depth, 440 feet.

Rominger, III, 83.

Total Depth.	Thick-ness.	Formation.
	70 feet.	Drift.
113 feet.	43 "	Sandrock.
116 "	3 "	Cavity; stream of water (compare a similar phenomenon at Marshall).
442 "	326 "	Blue shales.
	440 "	

BAY CITY, Bay County. Altitude, 592 feet. (Plate VI.)

C. E. Wright. See also Winchell, 1860, 154; also Rominger, III, 107, 182, 200.

Beside the deep well which is engraved,\* there are a large number of shallower wells down to the brine, *e. g.*,

\*This well is reported to have been driven further than is shown by the engraved record.—down to 3,000 feet. Wright quotes Zacharias Mason as saying that at 2,900 feet it was in rock the same as that at 1,300 feet in Morley's well (Plate XXXVII), one-half mile north of Marine City.

Wells.	Total depth, through sandrock, either Parma (635 ft.) or Marshall (920 ft.) of main well.
Geo. F. Williams & Bro.....	835 feet.
Wiley Bros.....	765 "
Whittlesey.....	725 "
E. F. Gould.....	715 "
Sanborn & Bliss.....	750-765 "
C. L. Grant & Company, in Carrollton.....	770 "
Hamilton & McClure.....	860 "
Batchelor & Whitney.....	875 "
G. C. Meyers.....	940 "
Hay, Buttman & Company.....	1040 "
Bradley & Sons.....	1040 "
Eddy, Avery & Eddy.....	1040 "
F. E. Bradley.....	1010 "
Lockwood (Opp. side of river).....	860 "
Sage (Opp. side of river, W. Bay City).....	995 "
E. Hall.....	940 "
Eddy Bros.....	910 "
McEwan Bros.....	873 "
Rouse.....	853 "
J. R. Hall.....	830 "
Gilmore (Brine 65°, upper salt-bearing sand rock).....	505 "

(These records are taken from Wright's notes, and the wells are probably not all exactly in Bay City.) In some of the Bay City wells, a gypsum horizon occurs at 700 feet.

T. Sterry Hunt quotes from the Inter-Ocean, April 1877, the report of a bed of rock salt 115 feet thick at 2085 feet. This probably refers to the brine-bearing Berea sandstone.

BENTON HARBOR, Berrien County. (Plate VII.)

BLACKMAR, Taymouth Township, Saginaw County. Altitude 613 feet.

Mr. Blackmar. Depth 1764 feet (but the column adds up only 1677 feet).

Rominger, III, 96, 184.

References by Lane.	Total depth.		Thickness.	Formation.
	1-90 feet.	90 feet.		
Bay City, 920 } Flint, 170-278 }	360 "	270 "	90 "	Drift.
	450 "	90 "	90 "	Shale.
	495 "	45 "	45 "	Coarse sandrock.
	695 "	200 "	200 "	Blue shales.
Flint, 1200 .....	1545 "	850 "	850 "	Red shales.
Bay City, 2300, Berea (?) .....	1655 "	110 "	110 "	Gray arenaceous shales.
East Tawas, 905 (?) } Caseville, 1750 }	1675 "	20 "	20 "	Sandstone, strong brine at 1675 feet.
	1677 "	2 "	2 "	Gray shale.
				Limestone.

BRANCH STATION (near Coldwater, *q. v.*), Branch County.  
Altitude 927-983 feet.

Dr. Bennett. Depth 447 feet.

Rominger, III, 87.

Thickness.	Formation.
26 feet.	Drift.
26-203 "	Soft, blue shales.
203-216 "	Hard, blue shales, containing crinoid stems and Chonetes.
216-447 "	Below this, shale with sandy and calcareous streaks.

CARROLLTON, Saginaw County (just north of Saginaw). Altitude 590 feet (?). Depth 743-800 feet.

Rominger, III, 200.

C. E. Wright.

Wells.	Total depth acc. to Rominger.	Total depth through the sandrock acc. to Wright.
H. B. Allen .....	800 feet.	
E. F. Gould .....	800 "	715 feet.
T. Jerome & Co. ....	746 "	735 "
E. Litchfield .....	743 "	
H. Ballentine & Co. ....	763 "	
Saginaw Valley Salt Company .....	780 "	
H. P. Lyon & Co. ....		
C. L. Grant & Co. ....		770 "

CASEVILLE, Huron County. Altitude 594 feet.

(1) Frank Crawford. Depth 1760 feet (given variously 1750, 1760 and 1770).

(2) Pigeon River Furnace Company.

Rominger, III, 94, 184, 201.

C. E. Wright.

Surface, Subcarboniferous limestone. Rominger, III, 103, and A. Winchell, 1860.

Depths.	Formation.
1-900 feet.	Principally blue, more rarely red, shales.
850-950 "	White sandrock; large body of strong brine. Sandstone. Wright.
1650-1770 "	Sandstone. Wright.

CHARLOTTE, Eaton County. (Plate VIII.)

CHEBOYGAN, Cheboygan County. Altitude 604 feet.

J. J. Mason. Depth 700 feet.

C. E. Wright.

"Caved badly, conglomerate in part, much quartz, flint and boulders, a strong flow of fresh water, no brine."

See also paper by N. H. Winchell, 1871, on the economic geology of that region.

CHESTER, Eaton County. Altitude 883 feet.

Rominger, III, 131.

Depths.	Formation.
1-8 feet.	Drift.
8-16 "	Hard, black shale with thin coal.
16-23 "	Whitish fine-grained sandrock.
23-53 "	Whitish plastic fire clay.
53-83 "	Black shale with pyrite.
	White fire clay with hard ferruginous bands.

CLIFFORD, Lapeer County. (Plate IX.)

COLDWATER, Branch County. (X.)

CONSTANTINE, St. Joseph County. (Plate XI.)

CORUNNA, Shiawassee County. Altitude 776 feet. (Plate XII.)

No. 1 shaft has a depth of 80 feet. Rominger (III, 138) gives the following section from the oblique drift:

Total depth.	Thickness.	Formation.
	9 feet.	Drift (surface deposits).
	30 "	Shale, dark to black.
	4 "	Sandstone.
	6 "	Black, slaty shales, containing <i>Lingula</i> and <i>Discina</i> and compressed lamellibranchs.
49-50 feet.	1 "	Coal.
	4 "	Fire-clay.*
	8 "	Black, slaty shales, as above.
62-66 "	3 to 4 "	Coal.
	4 "	Fire-clay.*
	4 "	Black shales.
80 "		Arenaceous shales.

\* Fire-clay seams are usually arenaceous and contain *Stigmaria*. The shales contain lenticular kidney iron ore.

No. 2. Engineering and Mining Journal, Nov. 5, 1881. New shaft at Corunna has entered five feet and six inches of coal at seventy-five feet.

CORUNNA, Ontario, on the St. Clair River. Underneath it are 213 feet of St. Clair black shales. See Brumell, Bull. Geol. Soc. Am., 1893, IV, 227.

COURTWRIGHT, Ontario. (Plate XIII.)

DELPHI, Indiana. (Plate XIV.)

DETROIT, Wayne County. (Plate XV.)

DOWAGIAC, Cass County. (Plate XVI.)

The driller's record as given by Mr. Farr in a note to C. E. Wright, of Nov. 21, 1887, is slightly different from that of plate, which is constructed from the samples, viz.:

Total depths.	Thickness.	Formation.
0-202 feet.	202 feet.	Drift.
202-297 "	95 "	Blue slate.
297-309 "	12 "	Red slate.
309-358 "	49 "	Blue slate.
358-462 "	104 "	(274? or 106?) Hard rock.
462-582 "	120 "	Blue slate.
582-687 "	105 "	Black shale.
687-782 "	95 "	Brown shale.
782-819 "	37 "	Gray shale.
819-893 "	74 "	Lime with mineral water.
893-969 "	76 "	Lime (I think?).
969-994 "	25 "	Brown stone.
994-1009 "	15 "	Yellow stone.
1009-1052 "	43 "	Limestone.
1052-1069 "	17 "	Yellow stone.
1900 "		Well is now at 1900 feet, with no prospects of gas.

EAST SAGINAW, Saginaw County. Altitude 588 feet.

G. A. Lathrop, M. D. East Saginaw Salt Manufacturing Co. Winchell, 1860, 152, 153.

Rominger, III, 94, 181, 200.

Groups.	Total depth.	Formation.	Strength of brine, Rom., p. 181, at
JACKSON COAL GROUP	92 feet.	Drift	90 ft. 1°
Upper sandstone?	92-170 "	Sandstone	102 ft. 2°
	170-196 "	Dark shale.	
	196-210 "	Light shale	211 ft. 10°
	210-233 "	Sandstone with coal seams.	212 ft. 14°
	233-246 "	Shale.	
	246-256 "	Sand with coal seams.	
	256-292 "	Blue shale.	
Parma sandstone?	292-398 "	White sandstone.	

Groups.	Total depth.	Formation.	Strength of brine, Rom., p. 181. at	
GD. RAPIDS GROUP:				
	398-403 feet	Alternate limestone and sandstone.		
	403-408 "			
	408-412 "			
Subcarboniferous.	412-413 "			
	413-419 "			
	419-420 "			
	420-428 "			
	428-429 "			
	429-434 "			
	434-435 "			
	435-447 "			
	447-449 "			
	449-462 "		Limestone, sandstone and shale mixed.	
	462-465 "			
	465-476 "			
	476-514 "			
	514-516 "			487 ft. 26°
	516-530 "	Alternate shale and sandstone		516 ft. 40°
	530-532 "			
	532-535 "			531 ft. 44°
	535-536 "			
	536-540 "			
	540-558 ft.	Arenaceous shale.		
	558-566 "			
	566-568 "	Sandstone	559 ft. 60°	
	568-583 "			
	583-588 "	Alternate dark shales and sandstone	569 ft. 64°	
	588-591 "			
	591-592 "			
	592-595 "	Gray, coarse sandstone		
	595-602 "	Dark shales		
	602-607 "	Sandstone and shale	606 ft. 86° (Rom., p. 95, 612 ft. 90°)	
	607-612 "			
	612-617 "	White sandrock		
	617-623 "	Dark shales		
	623-624 "	Cherty calcareous rock		
	624-626 "	Dark shales		
	626-634 "	Sandrock and shales		
	634-733 "			
Marshall? Bay City	733-797 "	Sandstone	636 ft. 90° (Rom., p. 96, 733 ft. 94°)	
800?	797-800 "			Bright red shales.

EAST TAWAS, Iosco County. Altitude about 590 feet.

(1) Grant and Company. Depth 905 feet.

Rominger, III, 78-9, 184, 201.

The different figures given for thickness add up 883 feet instead of 905 feet as given by Rominger. According to Wright, from 800 feet to 900 feet is sandstone.

Thickness.	Formation.
1-50 feet.	Surface drift.
50-170 "	Sandstones.
170-338 "	Shales.
338-378 "	Sandstone.
378-458 "	Shale and sandstone.
458-508 "	Mainly shale.
508-514 "	Shale, first indications of brine.
514-678 "	Shale, white and hard.
678-873 "	Sandstone, gray; abundant supply of strong brine, 85°.
873-883 "	Blue shale.

(2) Weekes Bros. Depth 835 feet.

EATON RAPIDS, Eaton County. Altitude 876 feet.

Mr. Frost.

Rominger, III, 130.

Depth.	Formation.
20 feet.	Drift.
20-120 "	Alternating shale and sandrock.
120 "	Coal.

ELKHART, Indiana. (Plate XVII.)

ESSEXVILLE, Bay County (near Bay City). Altitude about the same as that of Bay City, 592 feet.

C. E. Wright.

Depth.	Formation.
670 feet	To sandstone; brine.
755 "	Through sandstone; brine.

FLINT, Genesec County. Altitude 715 feet.

Dr. Clark. Depth 1200 feet.

Rominger, III, 97. Several borings with no trace of Subcarboniferous limestone, *c. g.*

Reference.	Total depth.	Thickness.	Formation.
	68 feet.	-----	Drift.
	68-135 "	67 feet.	Sandstone.
	135-170 "	35 "	Shales and sandstone, with seams of coal.
Blackmar, 450 (?)	170-278 "	108 "	Sandstone; at 260 feet strong stream of sweet water.
Blackmar, 1545 (?)	278-1200 "		Alternations of shale and sandstone; in the lower part strong brine.

FLORENCE, Saginaw County. Altitude (?).

(1) Chicago Salt Company. Depth 800 feet.

(2) Shaw and Williams.

Rominger, III, 200.

FORESTVILLE, Sanilac County. Altitude about 600 feet.

C. E. Wright. Depth 505 feet.

"It is 465 feet to the sandstone, which is forty feet thick."

FRANKFORT, Benzie County. (Plate XVIII.)

C. E. Wright. D. B. Butler.

There were two wells sunk, one—the first—is 1800 feet deep. Of that Mr. Wright collected the record so far as given in the plate. The water interfered so much with further boring that this well was given up, and a second one was begun about 500 feet to the southwest. The latter is 2200 feet deep. When the well was about 1800 feet deep the salinometer gave 20%. This corresponds evidently to the Stronach and Manistee salt horizon. See cross-section C-H from Niles to Frankfort. This well was continued to 2200 feet, but with lessening per cent of salt, until it gave out altogether. It doubtless pierced the Niagara.

The appended analysis of the water, which has quite a reputation as a mineral water, is reported. The well has a daily flow of over 8000 barrels; temperature, 58° F. As the mean annual temperature for Frankfort should be, according to Winchell's researches, between 44° and 45° F., this would give an increase in the earth's temperature of 1° F. for each 100 feet of depth. The flow begins at a depth of about 1400 feet, at a geological horizon near that of Ypsilanti, whose water it resembles.

"The water contains in the Imperial gallon of 10 lbs. 240.32 grains of solid matter, consisting of:

Sulphate of lime .....	85.40 grains.
Sulphate of magnesia.....	77.00 "
Sulphate of soda .....	40.60 "
Chloride of sodium .....	28.60 "
Chloride of potassium, traces .....	----- "
Carbonate of magnesia .....	6.30 "
Oxide of iron.....	1.26 "
Soluble silica .....	1.16 "
One gallon. Total.....	240.32 "

It also contains 44½ cubic inches of H<sub>2</sub>S in solution in each gallon.

R. C. KEDZIE,  
Michigan State Agricultural College."

FRUITPORT (near Grand Haven), Ottawa County. Altitude 596 feet (?).

(1) "Iron Magnetic Springs." June 2, 1871.

Thomas M. Nelson, Chicago. See also Peale, Bull. U. S. Geol. Survey, No. 32, p. 147.

Analysis by C. G. Wheeler.

Section.		Analysis.	
Surface sand	30 feet.	Temp. 48° F.	
Clay	140 "	Na <sub>2</sub> CO <sub>3</sub>	6.5156
Hardpan	9 "	Ca CO <sub>3</sub>	5.1100
Blue sandrock	24 "	Fe CO <sub>3</sub>	7.5600
Blue shale	5 "	Mg CO <sub>3</sub>	4.1511
Marshall (?) sandrock	41 "	Mn CO <sub>3</sub>	0.1050
Blue shale	6 "		
Total	255 feet.		23.4417
		K Cl	0.4312
		Ca Cl <sub>2</sub>	111.1110
		Na Cl	464.0319
		Mg Cl <sub>2</sub>	46.8072
		Mg Br <sub>2</sub> (?)	0.7666
		Na <sub>2</sub> SO <sub>4</sub>	45.9960
		SiO <sub>2</sub>	10.6050
		Al <sub>2</sub> O <sub>3</sub>	
			679.7489

(2) Spring Lake Iron Company.

(3) Magnetic Mineral Spring Co.

GOSHEN, Indiana. (Plate XIX.)

GODERICH, east shore of Lake Huron, Ontario, Canada. Altitude 780 feet.

Henry Atrill, Esq., New York City. Depth, 1517 feet.

T. Sterry Hunt. Trans. Am. I. Min. Eng., V, 538,—Geol. Survey of Canada, 1876-1877, p. 221-243,\* with plate.

Am. Geol. R. R. Guide, p. 64.

Thickness. Equivalent depth.	Formation.
78 ft. 9 in.	Drift.
Monroe } 278 ft. 3 in.	Dolomite with thin limestone layers.
100-300 { 276 ft.	Limestone with corals, chert and dolomite beds (colony of Upper Helderberg (?) L.).
243 ft.	Dolomite with seams of gypsum.
	The rest, marls with heavy beds of rocksalt and some anhydrite and dolomite.

GRAND HAVEN, Ottawa County. Altitude, 594 feet.

W. C. Sheldon.

T. S. Nelson. (See Fruitport.)

GRAND LEDGE, Eaton County. Altitude 860 feet.

Rominger, III, 131-133.

GRAND RAPIDS, Kent County. Altitude 605-639 feet. (1) and (2) (Plates XX and XXI.)

Winchell, 1860, p. 144-150, 153.

Rominger, III, 110, 180.

C. E. Wright.

One well was bored a number of years ago 700-800 feet deep. The Marshall sandstone is struck at 350 feet and is 100 feet thick.

(3) Beyrich's brewery, depth 236 feet.

(4) Powell's block, 204 feet.

\* p. 242. At Clinton, 13 miles southeast from Goderich, it was 1180 feet, 216 feet deeper than at Goderich, to reach rocksalt.

p. 241. Goderich was supposed to stand on the boundary line between Upper and Lower Helderberg.

The cherty limestone (276 feet) appears to be Upper Helderberg,—contains Favosites Winchelli, Favosites Emmonsii, Acervularia and Diphyphyllum.

GRINDSTONE CITY, Huron County. (Shore of Lake Huron.)  
Altitude 590 feet (?).

Worthington & Son. Depth 1080 feet.

C. E. Wright.

Thickness—1010-1080 feet. Formation—Sandstone.

HILLSDALE, Hillsdale County. Altitude 1095 feet.

Rominger, III, 81.

Two wells bored in the court house square.

(1) Thirteen hundred and fifty feet.

(2) Fifteen hundred and fifty feet, by hearsay as follows:

Thickness.	Formation.
(?) ft.	Drift.
20	Soft laminated micaceous sandrock.
-1120	Mainly bluish shales with arenaceous seams and harder, probably calcareous ledges. The color of the shales became dark, bituminous, in the lower part.
1120-1350(?)	Hard red rock with much iron pyrite, and strongly saline water.
1350-1400(?)	Fifty feet of white limestone.
1400(?) -1550	Soft calcareous rock to end.

HOWELL, Livingston County. Altitude (?).

Newspaper clipping (some Detroit daily).

“Howell, Mich., July 22.—(Special.)—While workmen were digging a well at Walter Papsworth’s residence, in the eastern part of the village, this morning a terrific roaring was heard and stones and dirt were blown 100 feet into the air. Natural gas had been struck. The flow was lighted, and a flame as large as a barrel ascended to a height of 30 feet. To-night the tap will be lighted again, and later a meeting will be held to determine what to do with the discovery.”

L. C. Smith, Secretary Board of Water Commissioners, private letter Feb. 15, 1893:

“Many years ago in boring near a tract of low, marsh ground, a pocket of inflammable gas was struck which burned for some time. \* \* \* \* no more was done about it.”

IMLAY CITY, Lapeer County. (Plate XXII.)

IONIA, Ionia County. Altitude 659 feet.

Mr. Blanchard. Depth 450 feet.

Rominger, III, 134. “At 300 feet below the surface a copious stream of sweet water.”

ITHACA, Gratiot County. Altitude (?).

Record in the Gratiot Journal, Ithaca, April 14, 1893.

“We give below the complete record of the new well as to the thickness and kind of strata through which the drill passes. The last 86 feet of sandstone will give, it is thought, an abundance of water.”

Comparisons.	Formation.	Total depth.	“Record of the new well.”
		10 ft.	10 feet surface clay.
		10-80	70 feet blue clay, stony.
		80-118	38 feet hardpan.
		118-119	1 foot gravel.
		119-149	30 feet hardpan.
		149-151	2 feet of gravel. Considerable water.
		151-191	40 feet hardpan.
		191-195	4 feet gravel.
	Quaternary	195-201	6 feet blue clay.
		201-211	10 feet hardpan.
		211-213	2 feet gravel.
		213-273	60 feet red clay.
		273-277	4 feet hardpan.
		277-302	25 feet white clay.
		302-310	8 feet blue clay.
		310-320	10 feet hardpan. Very hard.
		320-325	5 feet gravel.
		325-330	5 feet hardpan.

Comparisons.	Formation.	Total depth.	Record of the new well.	
	Woodville (?) sandstone	330-332 ft.	2 feet gray sandstone. Very hard. Bottom of eight-inch casing.	
		332-336 "	4 feet gray sandstone.	
		336-339 "	3 feet fireclay.	
		339-343 "	4 feet red sandstone.	
		343-345 "	2 feet red shale.	
		345-349 "	4 feet blue shale.	
			Bottom of seven-inch casing, with two 16 foot lengths, standing up into eight-inch pipe, 15 feet bagged and swedged out on top. Bottom of this casing is 349 feet by measurement.	
			349-355 "	6 feet blue shale.
			355-357 "	2 feet limerock.
			357-362 "	5 feet sandstone.
	Jackson Coal Group	362-367 "	5 feet blue shale.	
		367-368 "	1 foot dark lime.	
		368-383 "	15 feet white shale.	
		383-399 "	16 feet black shale.	
		399-414 "	15 feet light shale.	
		414-434 "	20 feet blue shale.	
		434-440 "	6 feet dark lime.	
		440-462 "	22 feet light shale.	
		462-470 "	8 feet dark lime.	
		470-478 "	8 feet sandrock.	
		478-480 "	2 feet dark lime.	
		480-482 "	8 feet sandrock.	
		482-490 "	2 feet light shale.	
		490-515 "	25 feet sandrock.	
		515-525 "	10 feet light shale.	
Ionia, 300	Parma	525-611 "	86 feet light sandstone.	
Owosso, 301-404				
Corunna, 300-431				
		611-613 "	2 feet light shale.	
Total depth of well.....		613 feet.		

It is possible that some of the "lime" might prove to be black band iron ore.

JACKSON, Jackson County. Altitude 928 feet. (Plates XXIII XXV.)

Rominger, III, 122 127.

Winchell, 1860, p. 151, 154.

KALAMAZOO, Kalamazoo County. (Plate XXVI.)

KAWKAWLIN, Bay County. Altitude 596 feet.

Two wells. Depths 810 and 1,133 feet.

Rominger, III, 96, 107.

Thickness.	Formation.
About 100 feet	Drift.
About 100-400 "	Shale and sandrock with coal seams.
About 400-500 "	Gypsum at 400 feet. Limestone and gypsiferous shales.
About 700-800 "	Sandstone with strong brine.
About 800-1133 "	Red shales.

KINGSTONE'S MILLS, Lambton County, Ontario.

See Brumell, Bull. Geol. Soc. Am., 1893, Vol. IV. p. 228.

Hunt, Geology of Canada, 1863, p. 362.

KINGSVILLE, Ontario.

Large gas well reported in Eng. and Min. J., February 9, 1889, owned by Detroit capitalists, and less than 25 miles from Detroit.

See Brumell, Bull. Geol. Soc. Am., 1893, Vol. IV, pp. 231, 238.

LANSING, Ingham County. Altitude 840 feet.

Rominger, III, 117, 118. Of borings made, only the shallowest recorded; (1) At the Reform School. Depth 506 feet.

(2) In the yard of the Lansing Hotel. Depth 740 feet.

(3) Lansing Magnetic well. Depth 1,400 feet. (Peale, Bull. U. S. G. S., No. 32, p. 145). Temperature of water 58°.5 F.; flowing 60 (?) gallons per hour, saline; analysis, p. 148; temperature gradient something less than 190 feet to 1° F.

(4) At the water works are wells showing 20 feet oxidized sand, 16 feet coarser stuff, then rock.

LONDON, Monroe County.

Artesian boring mentioned by Winchell, in 1873, as having reached the Niagara limestone.

Cf. also the boring on Macon Creek, Rominger, III, 27.

LUDINGTON, Mason County. (Plates XXVII-XXIX.)

MANISTEE, Manistee County. Altitude 604 feet. (Plates XXX-XXXII.)

Wells in this neighborhood are those of

	Date.	Depth.
Stronach Lumber Company, at the head of the lake. See Stronach .....		1970 feet.
Lewis Sands (Manistee Salt Well?); No. 1 .....		2012 "
Canfield (J.) and Wheeler (E. D.) No. 2 .....	} Sept., 1883	1947 "
John Canfield; next south of Peters' well .....		
Davies, Blacker & Co. ....		
Engleman and Kitzinger; on a little lake 1½ miles from Lake Michigan .....	Mar., 1883	
R. G. Peters; according to the Engineering and Min- ing Journal, June 13, 1885, a bed of solid salt, 34 feet thick, was struck at a depth of 2027 feet; No. 3.		
Wheeler, Magill & Co. ....	Mar., 1885	2026½ "
Rietz Bros.; west side of lake, going north .....	Feb., 1882	

MARENGO, Calhoun County. Altitude 921 feet.

Rominger, III, 82.

Thickness.	Formation.
1-60 feet .....	Drift.
60-260 " .....	Sandrock. (Marshall sandstone. L.)
260-460 " .....	Shales.

MARINE CITY, St. Clair County, not elevated much above lake level, *i. e.*, altitude about 600 feet. (Plates XXXIII-XXXIX.)

There have been very many wells sunk here, of which that of Lester & Roberts (No. 1) (D. Lester and W. S. Roberts) may be taken as typical. From this well the Geological Survey has a complete set of samples.

Other wells are those of

(No. 2) Baird Brothers,

(No. 3) Curtis & Lester (Toledo Salt Company, C. F. Curtis, W. S. Brainerd, D. Lester),

(4) National Salt Company, with samples,

(5) W. B. Morley, with samples,

(6) Dr. O. W. Owen, with samples,

J. A. Wonsey & Son,

H. C. Wonsey (only to the solid rock—yielding gas),

Antoine Halin (only to the solid rock—yielding gas),

Crockett McElroy (according to the E. and M. J., May 12, 1883, quoting an elaborate account in the Detroit Evening News, well begun over a year ago; at a depth of 1633 feet, struck a deposit of rock salt which the bore hole penetrated 115 feet without passing through; Compare the Baird Brothers' well).

MARSHALL, Calhoun County. Altitude 893 feet.

Rominger, III, 83.

Thickness.	Formation.
70 feet .....	Drift.
70-113 " .....	Sandrock.
113-116 " .....	Cavity; copious stream of water.
116-440 " .....	Blue shales.

MARYSVILLE, St. Clair County. Four and a half miles south of Port Huron, half a mile west of St. Clair River. Altitude about 600 feet. Church & Company. (Plate XL.)

James Geek struck gas when sinking a shallow well. See Plate XL.

MELBOURNE, Saginaw County.

W. R. Burt & Co. Depth 950 feet.

Rominger, III, 201.

MERIDIAN, Ingham County. Depth 52½ feet.

Rominger, III, 135 (boring four miles west of Williamston, close to the river).

MICHIGAN CITY, Laporte County, Indiana. Altitude 603 feet.

Indiana State Prison.

Rominger, III, 37.

Referred to sea level.	Total depth.	Formation.
603 feet	1-170 feet.	Drift.
433 "	170-246 "	Ohio black shale.
357 "	246+ "	Limestone of the Helderberg.

MIDLAND, Midland County. Altitude 608 feet.

C. E. Wright; John Larkin.

Notes on a map of C. E. Wright, to the effect that from 1200-1300 feet the formation is sandstone.

Well No. 1, 300 feet south of S. W. cor. Sec. 16, T. 14 N., R. 2 E., on bank of Tittabawassee River. Altitude 608 feet.

Eighteen to twenty-five feet above the water of Saginaw Bay and about on a level with the railroad track.

Begun in September, 1878; finished in 1879, for Larkin & Patrick (John Larkin, Wm. Patrick). John Mason, contractor, East Saginaw. Depth 1300-1325 feet.

	Depth.	Thickness.	Record by John Larkin, Esq.
Kawkawlin, 100-400	1-30 ft.	30 ft.	Sand, boulders and loose earth.
	100 "	70 "	Very hard red and white clay.
		5-6 "	Struck shale, and underneath it soft coal; several bushels taken out. Mostly lime rock. Very hard.
Bay City, 585. Kawkawlin, 900	800-820 "	15-20 "	Sand rock; brine, 65%. Hard lime rock.
Bay City, 920. Kawkawlin, 800?	At 1280 "	20-25 "	Salty sand rock. Brine 115°, <i>i. e.</i> , 65° to 75° salt brine, and bromides, etc., for balance.*

\* This would mean Sp. Gr. about 1.2395 and about 17% to 18% salt and somewhat less of the other matters. Bromine is made in large quantities from the refuse water after the salt water is taken out.

The first two wells sunk at Midland, to which the above description applies, were bored by Larkin and Patrick. Two others were sunk, in 1892, by H. W. Daw.

MILAN, Washtenaw County. Farm of Mr. Kinear on Saline River, Monroe County. Altitude about 700 feet.

Rominger, III, 68.

Well was bored with an auger 108 feet through drift, and struck the shales and a seam of gas.

MILWAUKEE, Milwaukee County, Wisconsin. Altitude 584 feet. Geological Survey of Wisconsin, II, 390-394.

Lower Helderberg barely present as a thin edge; also at Wauwatosha and at Fredonia, Osaukee County (?). Altitude 788 feet.

MONROE, Monroe County. (Plate XLI.)

Rominger, III, 30-31. [No gypsiferous shales underlie Monroe] \* \* \* "for several hundred feet downward limestones

of dolomitic character alternately follow each other." He gives some account of two wells. Samples of well No. 3, show noteworthy quantities of gypsum underneath Monroe.

- (1) Court House Square. Depth 140 feet.
- (2) Received from Judge Christiancy. Depth 300 feet.
- (3) See Plate.

Mt. CLEMENS, Macomb County. Altitude 612-617 feet. (Plate XLII.)

Authority, T. M. Crocker, Esq.

There have been three wells sunk here, the first over twenty years ago (*i. e.*, before 1872). The second well is more recent, is within a few feet of the first and owned by the same proprietors. The driller's record is given. The third was put down in June-July, 1892. Of this the Survey has some samples, and an engraving has been made. The owner is Mr. Carsons (Cousin?) and the driller Mr. Nims. The surface of the ground where the well is located is a little higher than at the other wells, is about twenty-five feet above the surface of Lake St. Clair and is very nearly on a level with the railroad track. It is not on any government section, but on claim No. 141.

The following is an analysis by S. P. Duffield, in grains per imperial gallon:

Na Cl .....	11,900.00
K Cl .....	.....
MgCl <sub>2</sub> .....	648.48
Ca Cl <sub>2</sub> .....	934.50
MgCO <sub>3</sub> .....	.70
Ca CO <sub>3</sub> .....	.98
Fe CO <sub>3</sub> .....	5.60
MgI <sub>2</sub> .....	.07
MgBr <sub>2</sub> .....	6.37
Si O <sub>2</sub> .....	27.60
Al <sub>2</sub> O <sub>3</sub> .....	29.47
Ca SO <sub>4</sub> .....	100.335
	13,654.105

Mt. CLEMENS. No. 2.  
Driller's "log."

References.	Thickness.	Formation.
Royal Oak { 105..... } { 164..... }	1-102 ft.	Surface. { "Bed rock was reached at a depth of 102 feet."
Royal Oak { 230..... } { 305..... }	102-400 " 400-430 "	"Limestone with an occasional shell." "Black slate."
Royal Oak 520 .....	430-560 "	"Limestone returned, with an occasional shell and strata of slate."
Royal Oak 548 .....		At 560 feet "Sulphur water was first struck."
Royal Oak 836 .....	560-850 "	"Close, white sand" (probably dolomite?), "uninterrupted."
Royal Oak 836-1305 ..	850-890 "	"Richest slate" (? <i>i. e.</i> , plaster, anhydrite or gypsum marl).
Cf. Algonac 1130-1200	890-1000 "	"White sand," "again, interrupted by an occasional stratum of slate."
	1000-1010 "	"Salt vein, having a thickness of about ten feet."
	1010-1050 "	"Followed again by sand."
	1050-1090 "	"Dark slate."
	1090-1244 "	"Sand" (dolomite?), "with now and then a shell and strata of light slate to total depth."

MUSKEGON, Muskegon County. (Plate XLIII.)

Rominger, III, 84, 85, 94. Several borings.

- (1) Mr. Whitney. Depth 1230 feet; register to 657 feet.
- (2) Probably the same as that recorded by Wright, although the figures vary slightly. The salt water at 1250 feet (Rominger, III, 94) may mark the Berca sandstone.

NEWBERG (near Cleveland), Cuyahoga County, Ohio. Altitude 813 to 748.

Cleveland Rolling Mill Company. Depth 3000 feet.  
Geological Survey of Ohio, Vol. VI, p. 352-355.

Epoch acc. to Orton.	Thickness	Formation.
	40- ft.	Drift, sand, clay and gravel.
Ohio shale .....	40-1350 "	Shale, changing in color.
100 ft. Upper Helderberg	1350-1660 "	Limestone, solid (in part Upper Helderberg).
500 ft. Lower Helderberg	1660-1700 "	Sand (first salt-water vein Sylvania).
	1700-1990 "	Limestone.
	1990-2154 "	Rock salt and shale.
	2154-2169 "	"Shale" (Anhydrite).
	2169-2250 "	Limestone.
	2250-2300 "	Rock salt.
800 feet Salina .....	2300-2340 "	"Shale," bluish (Anhydrite).
	2340-2360 "	"Sand."
	2360-2378 "	Shale.
	2378-2400 "	Limestone.
	2400-2420 "	Rock salt.
	2420-2430 "	"Shale."
	2430-2470 "	Limestone.
	2470-2475 "	Rock salt.
	2475-2483 "	"Shale."
	2483-2650 "	Limestone (Dolomite).
Niagara (?).....	2650-2658 "	"Oil-sand" (Dolomite), rank with sulphur.
	2658-2680 "	Limestone.
	2680-2686 "	Oil-sand, free from sulphur.
	2686-2750 "	Limestone.
Niagara .....		Limestone of same general character.
Clinton .....	2750-3050 "	Bottom in red limestone with gas.

NEW RIVER (two miles south of grindstone quarries). Altitude 600 feet.

New River Salt Company. Depth 1029 feet.

Rominger, III, 77, 201. "Salt brine was already found at a depth of 90 feet below the surface, but it continued to increase in strength as a greater depth was reached."

Epoch.	Total depth.	Thickness.	Formation.
	1-15 ft.	15 ft.	Grindstone.
	15-45 "	30 "	Blue shale.
	45-800 "		Alternate shale and sandrock.
Berea shale (?).....	800-900? "		Rotten, bad smelling, soft rock.
Berea or Richmondville sandstone .....	900-1000? "	100 "	Porous, coarse grained white sandrock; brine 85°.
	-1029 "	{ Only a } { few ft. }	Blue shale.

NILES, Berrien County. (Plate XLIV.)

NORRIS (North Detroit), Wayne County, 628 feet or 631 feet.

Report of well sunk for water at the Lutheran Deaf and Dumb Asylum, in September, 1884; in Detroit Tribune for April 24, 1885, 1886 or 1887.

"An unexpected answer was discovered to this question in September, 1884. Workmen were engaged in sinking a well for water at the Lutheran Deaf and Dumb Asylum at Norris, this county. When down about ninety feet the drill broke and farther operations were suspended. One night there was a terrible explosion—drill, sand, water and gas were thrown high in air. Some one lighted a match near the well and the gas ignited and nearly burned up a tree twenty feet away, and frightened everybody who saw it.

"Professors Henry and Duffield of Detroit were invited to inspect the strange phenomenon. Prof. Henry at once made a proposition to rent the well, agreeing to light the institution with the natural gas, and to give a certain per cent of the profit to the institution. He desired to manufacture lamp black and had patented a machine for that purpose. Prof. Duffield said it was gas, and thought the gas escaped through a rift in the rock, and if the well was drilled deeper plenty of gas could be obtained. But nothing was done; water was plenty, two loads of brick were dumped into the bottom of the well to prevent the gas from

roiling the water, and the directors of the institution were satisfied.

"The well has, however, proven a source of annoyance to them, for, despite the water, gas accumulates with great rapidity, the mischievous boys take great advantage of this, and often cause great damage by dropping a lighted match into the well. The well was visited by a Tribune reporter yesterday. It is situated about four hundred feet to the left and in the rear of the deaf and dumb institute. Approaching the well, an offensive odor is first perceived. The water which comes from the pump is found to be brackish and warm. On removing a few boards from the covering of the well, a strange sight is witnessed: But a few feet below the brink the water boils up as in a cauldron. Tiny bubbles form and float along over the surface. The odor most approaches that of swamp gas. The well, which is ten feet across and bricked up, is as black as an oven from the smoke caused by the burning gas; bricks cracked by the intense heat, and even the rafters are in places burned away. A satisfactory test was made that proves the gas still flows in considerable quantities under the most discouraging circumstances.

"The well was dug through white clay until the rock was struck, when the drilling ceased. Whether it was the gas-bearing rock that has been struck is not known, but probably not, as it generally lies from one thousand to two thousand feet below the surface. Swamp gas, it would seem, would not continue to flow steadily for a year and a half. If the rock could be shot it could easily be told what the result would be. Several natives of Norris said that gas escaped from the ground in several places near there and had done so for years.

"Norris is but ten miles from this city, and if gas should be discovered in any quantity there it could be piped here at a small expense. But why pipe it here? If there is natural gas at Norris, and there is every reason to believe there is, there is natural gas in this city. The formation of the rock is the same, and the surface indications give better prospects. There are now at least two wells on Woodward Avenue from which gas escapes—gas that can be burned, that has been burned."

OSCODA, Au Sable City, Iosco County. Altitude about 590 feet.

Smith, Kelly and Dwight.

Rominger, III, 184, 186, 201.

Depth of wells 1103 feet and 1070 feet respectively; same formation as at East Tawas and at Caseville (?).

C. E. Wright notes on a map that from 960 to 1040 feet the formation is sandstone.

Owosso, Shiawassee County. (At the Detroit and Milwaukee Railroad Station.)

Depth 307 feet.

Rominger, III, 137. (In the record there must be some mistake, as the sum is greater than 307 feet.)

Owosso, Sec. 5. (Plate XLV.)

Mr. Courier. Depth 1000 feet.

Rominger, III, 97.

This is probably the same as the well engraved.

PAW PAW, Van Buren County. Altitude (?).

Hon. John E. Ferguson reports the well unsuccessful.

Hon. C. D. Lawton records the finding of wood.

PETROLIA, Ontario. (Plate XLVI.)

PONTIAC, Oakland County, (Plate XLVII.)

PORT AUSTIN, Huron County. Altitude 597 feet.

C. E. Wright notes on a map that it is 940 feet to sandstone which is 65 feet thick. Blue shales overlies it.

(1) Ayres & Co. Depth 1198 feet.

Rominger, III, 77, 183, 201.

T. Sterry Hunt, Geology of Canada, 1866-1869, p. 220. "Surface rock is a sandstone of the Chemung." "At a depth of 1198 feet from the surface ---- a brine ---- 88°."

Na Cl .....	17.6161 per cent.
Ca Cl <sub>2</sub> .....	3.1274
Mg Cl <sub>2</sub> .....	1.5675
Ca SO <sub>4</sub> .....	0.0129

(2) Mr. Skene. Depth 1225 feet.

One mile west of the village, 200 yards from the shore of the Bay.

Total depth.	Thickness.	Formation.
Few feet	Few feet.	Drift.
		Conglomerate band of grindstone series. Greenish blue micaceous sandrock.
125 feet.	Few feet.	Conglomerate. Current of fresh water.
-163 "		Arenaceous shales.
At 204 "		Gray sandstone.
204-315 "		Signs of brine.
317 "		Shales with arenaceous seams.
-336 "	20 feet.	Conglomerate sandstone.
336-1100 "	764 "	Bluish shale; but few sandstone strata; strong flow of fresh water.
1100-1120 "		(?)
1120-1160 "	40 feet.	Bright red and chocolate shales.
-1225 "		Sandstone, with brine. Shales.

Or, according to Wright,

1 275 feet, sandy shales.

275-1100 " blue and red shales.

1100-1200 " sandstone (porous).

PORT HOPE, Huron County. Altitude about 600 feet.

Depth 785 feet. (787 and 865 feet.)

C. E. Wright notes that it is 800 feet to the sandstone, which has a thickness of 65 feet. Rominger, III, 76, 201.

Thickness.	Formation.
1-16 feet	Drift.
16-22 "	Greenish micaceous sandstone.
22-532 "	Blue, sandy shales.
532-533 "	Hard rock.
533-687 "	Dark blue shales.
687-716 "	Arenaceous shales.
716-787 "	Sandstone; coarse; whitish; with strong brine.

PORTLAND, Ionia County.

In Engineering and Mining Journal, August 10, 1889, a strike of oil was reported here. Enquiry shows that nothing came of it, and that whatever happened was of no scientific importance.

PORT HURON, St. Clair County. Altitude 633 feet at the U. S. signal station, 589 feet at Port Huron, *i. e.*, at Fort Gratiot on the Grand Trunk railway track. (Plates XLVIII-LVII.)

There are a number of wells about here of which we have more or less of a record as given below. Mr. Bailey reports having sunk over thirty. These wells generally yield a little oil and gas.

Description of wells.	Depth of wells.
1. Bailey, C. A.; No. 1, 500 paces N., 1000 paces W., Sec. 9, T. 6, R. 17, one-half mile north and one and a half east of the Grand Trunk Junction well	668 feet.
2. Bailey, C. A.; No. 2	640 "
3. Bailey, C. A.; No. 3	530 "
4. Chadwick; east and west center line of S. 15, T. 6, R. 17. Church & Co. See Marysville.	498 "
5. Gordon, T. J. (Gordon and Hall)	572 "
6. Howard, Henry	498 "
7. Grand Trunk Junction well	772 "
8. McMorrان; No. 1	615 "
9. McMorrان; No. 2	550 "
10. Lakeport gas well, John Cole's farm. (Refer to Mr. Geo. P. Voorhees.)	
11. White, Edgar; gas well, corner of Military and Griswold streets, one-half mile north of the Chadwick well, supplying two houses	498 "
12. Wells, Fred L.; "Port Huron Gas well" and Port Huron salt well	1700 "

PORT LAMBTON, Ontario, Canada. (Plate LVIII.)

PORTSMOUTH, Bay City, Bay County. Altitude 592 feet (?).

Winchell, 1860, p. 154.

The bottom of the well is in the "Napoleon Group" (Marshall), which at this place is, according to Winchell, 88 feet thick.

C. E. Wright.

Rominger, III, 182, 200.

	Depth of wells.	
	Acc. to Rominger.	Acc. to Wright.
John W. McGraw & Co. ....	1000 feet.	925 feet.
N. Watrous & Son .....	1000 "	
A. M. Miller .....	1050 "	

At 664 feet, 54° brine, the upper salt-bearing rock containing more gypsum and less of chlorides.

RICHMONDVILLE, Sanilac county. Altitude 590 feet (?).

C. E. Wright.

The Berea (?) sandstone outcrops here and is found at steadily increasing dips, going north, at White Rock, Sand Beach, Port Hope and Port Austin.

RIFLE RIVER, Arenac County. (The Station, Alger, has the altitude 781 feet.)

Depths, 122 feet, 200 feet, etc.

Rominger, III, 141 144.

ROMEO, Macomb County. (Plate LIX.)

ROYAL OAK, Oakland County. Altitude 665 feet. (Plate LX.)

(1) "Developing Company." Depth 1400 feet.

Epoch.	Reference.	Thickness.	Formation.
Quaternary		1-40 ft.	Blue clay.
		40-50 "	Gravel.
		50-100 "	Blue clay.
		100-105 "	Black gravel (?).
Ohio or St. Clair	F. L. Wells, Port Huron, 185	105-230 "	Black shale.
Hamilton or Traverse	F. L. Wells, Port Huron, 290	250-392 "	Soft calcareous shale
	"Middle Lime"	392-520 "	Hard limestone.
Helderberg	F. L. Wells, Port Huron, 315	520-545 "	Calcareous shale.
	"Lower Lime"	545-1400 "	Hard limestone.

(2) See Plate.

SAGINAW, Saginaw County. Altitude 590 feet.

Rominger, III, 182, 200. A large number of firms with wells ranging in depth from 741 feet down to 830 feet.

C. E. Wright. See also East Saginaw, Carrollton, Zilwaukee.

	Total depth, acc. Rominger.	Total depth through sandstone, acc. to Wright.
Sturtevant and Green .....	830 feet.	860
Swift and Lockwood .....	860 "	860 { Rominger, III, 182, Lower salt rock.
Barnard and Binder .....	830 "	
Conrad Kull .....	802 "	
Geo. F. Williams & Bro. ....	800 "	835
C. T. Brenner .....	770 "	
Pierson, Wright & Co. ....	741 "	

SAINTE CLAIR, St. Clair County. (Plates LXI and LXII.)

SAINTE IGNACE, Mackinac County. (Plate LXIII.)

ST. JOHNS, Clinton County. Altitude (?)

A. W. Simmons (of Albion College, teacher at Calumet,) reports that there was a well sunk here for artesian water to the depth of 1200 feet, without finding good drinking water.

ST. LOUIS, Gratiot County. Altitude (?)

Mr. A. W. Simmons (see St. Johns) says that there used to be a famous sanitarium with a deep well there. This well is also mentioned in Peale's work on mineral waters. We have not been able to secure the record.

SALZBURG, West Bay City, Bay County. Altitude 590 feet (?)

Rominger, III, 200.

W. H. Malone, 1023 feet.

Ladrach Bros., 1000 "

L. L. Hotchkiss, 1013 "

SAND BEACH, Huron County. Altitude 600 feet.

(1) J. Jenks & Co. Depth 715 feet, Wright; 702 feet, Rominger; 800 to 900 feet, according to G. J. Jenks, private communication, 1893.

It is referred to by Garrigues in Rominger, III, 184, and an analysis by S. P. Duffield is given. It is about 430 feet north by east from well No. 2. It is said that 98.7% of the solids are Na Cl, but this is slightly purer than Duffield's analysis indicates. According to Wright's notes it is 650 feet to the sandstone, which is 65 feet thick.

(2) Sand Beach Mineral Bath Company. We owe our information about these wells largely to the kindness of Geo. J. Jenks. Located on a salt reserve 400 feet east of a point where State street crosses the Flint & Pere Marquette railroad. Begun and finished in August, 1890. We cannot from the record infer the position of the Dundee, *i. e.*, Corniferous, with certainty.

Formation. Local names.	Equivalent depths in adjacent wells.	Total depths.	Record.		
Coldwater or Waverly. Berea shale? .....	Bay City ..1548-1798	1-500 ft.	Blue slate or shale. Black slate.		
	Bay City ..1798-1883	500-603 "			
	Bay City ..2093-2118	603-623 "	Slate and sand		
	White Rock 450				
Cichmondville or Berea .....	Bay City 2118-2133	623 "	Small flow of bit- ter water .....		
	Forestville 505				
	White Rock 550	633 "	Large flow; passes through salt rock; 8 in. casing from the top of the well to a depth of 674ft.)		
	Port Hope. 787				
	Grindstone City.....1080				
	Pt. Austin 1200				
	Caseville ..1770				
	Bay City ..2300				
	Bay City ..2306-2371			664-850 "	Light colored slate.
	Bay City ..2371-2585			850-1120 "	
St. Clair .....	Port Huron 185			1120-1725"	Light slate or soap- stone, except 15 ft. of extremely hard rock at 1400.
	Muskegon 1700				
Traverse .....	Middle limestone of the St. Clair river (417-458 ?) or of the Corniferous (540), Cf. Bay City, 2822	1400 "	Limestone.		
	Bay City ..2822	At 172 "			
Dundee ? .....	Port Huron 540?	At 1844 "	Seemed to be lime and sand (dolomite ? L.) mixed and very fine at first, gradually growing coarser, which continued until drilling was stopped at 1920 ft.		
	Port Huron 660?				

Salt rock.

Formation. Local names.	Equivalent depths in adjacent wells.	Total depths.	Record.
Monroe ?	Cf. Port Huron, 735	At 1860 ft.	Small flow of bitter water enough to drill with, smelling of oil just before striking the bittern.
	Cf. Port Huron, 892 and 945	At 1875 "	Heavy flow of salt water which rose to within 60 ft. of the surface in a few moments.
		1920 "	

An analysis of this lower bittern, by Samuel P. Duffield, is as follows (columns 1 and 2); one by Prof. R. C. Kedzie, in August, 1890 (column 3):

Specific gravity at 60° Fahrenheit, 1.180.

	(1.) Grammes per litre. 1. 180kg.	(2.) Grains per imperial gallon.	(3.) Grains per imperial gallon.
Calcic sulphate	.9936	69.552	63.00
Calcic chloride	62.6636	4,386.459	3,982.30
Magnestic chloride	5.3542	374.798	339.50
Magnestic bromide	24.8400	1,738.800	1,575.00
Potassic chloride	37.7788	2,644.521	2,395.40
Sodic chloride	179.2391	12,546.739	11,384.80
Silica	.7303	51.131	
Total solids	311.5996	21,812.000	19,740.00

Hydric Sulphide Gas .2271. 10.745 cubic inches: 10.5 cubic inches

TOTAL SOLIDS PER LITRE.

By direct estimation..... 311.6000 Grammes.

By actual analysis..... 311.5996 "

Loss ..... .0004 Grammes.

The same bittern has also been analyzed by W. G. Merritt, with results almost identical with those of Duffield.

SANDSTONE, Jackson County. Altitude 956 feet.

Rominger, III, 128.

Winchell, 1860, p. 151.

SANDUSKY, Erie County, Ohio. Altitude 578 feet to 639 feet.

Bay City Natural Gas, Oil and Fuel Supply, and Electric Light Company.

Jacob Kuebler.

Geol. Survey of Ohio, VI, 194.

Thickness.	Epoch.
1-10 feet.	Drift.
10-110 "	Upper Helderberg.
110-1080 "	Lower Helderberg and Niagara. Gypsum at intervals from 110-980; at 960 water with sulphur; gypsum bed 9 feet thick at 275 feet.
1080-1185 "	Niagara and Clinton.
1185-1360 "	Medina.
1360-1860 "	Hudson River.
1860-2170 "	Utica. [Utica lies directly on Trenton. Forty feet not accounted for.]
2210-2260 "	Trenton. At bottom, gas, oil and salt water.

SEBEWAING, Huron County. Altitude 593 feet.

Lawton, Rept. Com. Min. Statistics, Mich., 1891, p. 66.

Coal 60-80 feet below the surface.

W. L. Webber (private communication May 24, 1891).

"There are two coal shafts \* \* \* taking out over 100 tons a day. \* \* \* In the vicinity there have probably been thirty or forty test holes put down. There are also many artesian wells, flowing and spouting water. \* \* \* The Bay Port quarries (lime) also have developed an opportunity for geological studies." Of the rock we have reported the following:

Test at Watertown Arsenal, Mass. Bay Port stone resisted a crushing test of 26,000 lbs. per square inch, and Capt. Butler, who made the test, says: "It looks as though you ought to be able to build a tower three miles high, without fear of the bottom courses."

Weight, per cubic foot, 170 lbs.

Specific gravity, 2.72.

One cubic yard Bay Port stone crushed and carefully spread three inches thick will cover 108 square feet.

Analysis by Professor Langley, of Pittsburgh, Penn.

	Per cent.
Silica .....	3.330
Oxide lime and alumina .....	1.334
Carbonate of magnesia .....	.944
Carbonate of lime .....	91.538
Phosphorus and sulphur .....	traces.
Organic matter and loss .....	2.854
(Quicklime, 51.29.)	

Prof. Langley says: "This is very pure limestone, and is unusually free from anything except carbonate of lime. It contains nothing injurious to iron, and in my opinion it will give entire satisfaction in the blast furnace."

The following analysis is of the coal of the Saginaw Bay Coal Company, on S., T. & H. R. R., W. L. Webber, President:

	By Dr. W. H. Coffron, of Washington, D. C., 1889.	By E. Speidel, of Chicago, Ill., 1892.
Moisture .....	4.46	4.82
Volatile carbon .....	47.92	44.58
Fixed carbon .....	40.45	41.52
Sulphur .....	3.05	3.38
Ash .....	4.04	5.70
	99.93	100.00

Bay Port Springs is a well from a sandstone about 15 feet above the level of the bay.

Analysis given on p. 32.

SOUTH BEND, Indiana. (Plate LXIV.)

SPRING LAKE, Ottawa County. Altitude 596 feet. (See Fruitport.)

STRONACH, Manistee County. (Plate LXV.)

SYLVANIA, Lucas County, Ohio. Altitude (?).

Geol. Survey of Ohio, VI, 225.

On the extension of the Findlay break (?); an anomalous section. Rominger, III, 28. A sandrock intercalated between Upper and Lower Helderberg limestones. P. 29. The upper part of the Lower Helderberg brecciated and recemented.

SWAN CREEK VILLAGE, Fair Haven, St. Clair County. Altitude about 600 feet (?).

Steven Rose's farm, nine miles west of Algonac. Depth 60 feet. C. E. Wright.

A large amount of gas in a shallow well.

TOLEDO, Lucas County, Ohio. Altitude 580 feet to 651 feet.

Geol. Survey of Ohio, VI, 208.

Four to five wells sunk here, of which the following is a sample:

Epoch.	Thickness.	Formation.
	1-80 feet.	Clay.
	80-120 "	Sand and gravel.
	120-585 "	Upper limestone.
	585-590 "	Blue slate.
	590-740 "	"Stray lime," gas at 700 feet.
Hudson R. and Utica	740-1415 "	Slate and shale.
	1415-1425 "	Trenton.

TRAVERSE CITY, Grand Traverse County. Altitude (?).

T. T. Bates (Editor Traverse City Herald). Well committee. To be sunk April, 1892 (?). No farther reports.

TUSCOLA, Tuscola County. Altitude (Cf. Vassar, 643 feet).

See Winchell, 1860, p. 154.

WEST SISTER ISLAND, Ohio.

Geol. Survey of Ohio, I, 589.

Section of 90 feet. Gypsiferous limestone with strontianite.

WHITE ROCK, Huron County. Altitude about 600 feet.

Thomson Brothers. Depths 555 feet, 700 feet, 1311 feet.

Rominger, III, 76-77, 184, 201 (at p. 106 the reference should be to White Stone Point).

C. E. Wright.

Thickness.	Formation.
(1) According to Wright:	
1-495 feet.....	Surface and blue shales.
495-555 ".....	Brown sandrock; brine 80° at 45° F., same as at Port Austin, Port Hope and Sand Beach.
555-1311 ".....	Alternating strata, blue shale and limestone, shale predominating 20 to 1. From 600 to 610 feet down, a three-foot stratum of gaseous black shale was found.  This latter is not far from the position of the Berea shale but comes below the sandstone which we take to be the Berea. Can it correspond to the Sulphur Island shales, and is the St. Clair formation black only in streaks? In that case very likely the Traverse really replaces it. L.
(2) Accord'g to Rominger:	
1-450 feet.....	Blue shales with sandy layers containing much pyrite.
450-550 ".....	Porous gray sandstone, with a strong, pure salt brine.

WILLIAMSTON, Ingham County. Altitude 891 feet.

Rominger, III, 135-136 (six sections in the Coal Measures).

WINONA, West Bay City, Bay County. Altitude 600 feet (?).

H. W. Sage & Co. Depth 1020 feet.

Rominger, III, 200.

WOODVILLE, Jackson County. (Three miles from Jackson.)

Rominger, III, 126.

Winchell, 1860, p. 154.

WYANDOTTE, Wayne County. (Plate LXVI.)

YORK, Washtenaw County. Altitude 703 feet.

Winchell. Geology of Washtenaw County, in history of Washtenaw County, p. 27.

See also Milan.

W. ½, N. E. ¼. Sec. 34, T. 4 S., R. 6 E.

Total depth.	Formation.
10 feet.....	Soil, subsoil and sand.
110 ".....	Clay, boulders and some sand; clay firm, sometimes dark.
112+ ".....	Shale very dark continuing.

YPSILANTI, Washtenaw County. Altitude 714 feet.

(1) T. C. Owen, "Atlantis Mineral Well." Depth 808 feet.

C. E. Wright.

(2) Moorman Well, A. A. Elliott, Superintendent.

(3) Ypsilanti Mineral Spring and Water Company.

ZILWAUKEE, Saginaw County. Altitude 590 feet (?).

Depth 800-860 feet.

C. E. Wright; Rominger, III, 185, 200.

	Total depth.	Total depth through sandrock. Wright.
A. T. Bliss & Bro.....	835 feet.	810 feet.
John F. Driggs & Co.....	840 "	
Rust, Eaton & Co.....	800 "	838 "
New York and Michigan Solar Salt Co.....	860 "	
Oneida Salt Co.....		

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## EXPLANATION OF PLATES AND MAP.

On the map the cross-sections are indicated by red lines. Places from which there are well-records are underlined in red. The other red lines (broken, dotted, etc.,) indicate outcrops of division lines between the formations. For farther explanations see text, p. 40.

In the geological column and in all of the sections, similar symbols are used for the same kind of rock, viz.:

Vertical and horizontal lines	Dolomite.
The same, broken-jointed	Limestone.
Dots, for an arenaceous ingredient or	Sandstone.
Dashes for an argillaceous ingredient or	Shale.
Oblique lines in one direction	Gypsum.
“ “ “ two directions	Salt.

In sections across the basin, the circular and direct projections of places are connected by arrows. See text, p. 43.

Other abbreviations are:

§	for point where one cross-section is cut by another.
B.	for horizon of brine, bittern or mineral water.
R.	for river.
R. R.	for railroad.
L. H.	for Lower Helderberg.
U. H.	for Upper Helderberg.