

CHAPTER III.

TESTS AND ANALYSES OF MICHIGAN COALS.

Tests and analyses of the earlier mined coals of Jackson, Corunna and Grand Ledge showed them to be of a decidedly low grade. They were as a rule light and friable, resulting in much slack or waste coal, high in ash, moisture, volatile combustible matter, and sulphur, and low in fixed carbon. The amount of fixed carbon was often only 40% and rarely over 45% with 2% to 3½% and more of sulphur and often over 10% of ash present. Then too the coals in burning would tend to run together on the grate, making them difficult of handling. Special grates have since been devised for such coals.

These early tests and analyses gave the general impression that all Michigan coal was alike and of very inferior grade. Thus in the commercial world Michigan coal has had a black eye which has been hard to remove.

Michigan coals vary greatly. The above mentioned coals are high in sulphur, those of the Saginaw seams are not. The heating power of the former is low to fair while the latter is decidedly high. Most of the coals lean toward gas and coking types, yet the high content of sulphur and moisture are objectionable features, affecting the quality of both the gas and the coke. The Verne seams are coking coals, but the coke is generally so poor that all of the coke made in Michigan is from Ohio or other imported coals. One quality, however, seems to be nearly in common; they all are fair to excellent steam and domestic coals. The coals of Corunna and Jackson were locally favorite steaming coals, that of the former being for years almost wholly consumed by the Pere Marquette railroad. The later mined coals of Saginaw valley, especially of the Saginaw seam, running well above fifty per cent in fixed carbon with little or no sulphur, are much higher in grade. Their steaming qualities are so superior that several mines successfully compete in markets beyond the limits of the state, in spite of the deeply rooted prejudice against Michigan coals. The Saginaw coal in comparative tests with Hocking Valley, a most famous steam coal, proved the superior in several of the tests. (See test by E. C. Fisher.)

Heating Power-Boiler Tests. Under a boiler, the full amount of heat, obtainable in calorimeter or other such apparatus, cannot be practically obtained. The combustion is not perfect. Much of the gas as steam, carbon monoxide, and carbon dioxide escapes-carrying away much heat, and other heat is lost in the ash and clinker, boiler material, etc. The kind of boiler, draft, and coal are factors making the amount of heat realized greater or less, as they are good or poor. The amount is highest (55-65% of the theoretical) when unburned air equals one-third of the chimney gas. Coal, showing an average of 7,500 calories, when subjected to a practical test, theoretically should have evaporated 13.37 pounds of water but actually evaporated only 8.17 pounds. Michigan coal of somewhat higher calorage showed the same result, evaporating but 9 to 12 pounds. By convention, commercial evaporation is fixed as the evaporation from a feed water temperature of 100° F. to steam of 70 lbs. gauge pressure. The commonest methods of expressing heating power are in units of evaporation (U. E.), i. e. pounds of water changed to steam at a temperature of 212° F. or British Thermal Units (B. T. U.), i. e. pounds of water raised one degree.

To estimate fully the heating power of coal, a great many factors such as, temperature of feed water, steam pressure, type of boiler, kinds of grates and draughts, size and kind of coal, the amount of ash and clinker, manner of firing, etc., must be taken into account. Comparative tests show mainly what coal is best suited to a given boiler outfit. A coal, ranking first with one boiler might not with another. Michigan coals, to get the best results, usually require a special grate and experience in handling. Thus the absolute efficiency of the same coal in different boiler tests varies much, though, often, the same relative efficiency is seen in all the various series of tests.

The following is a test, showing the comparative value of Hocking Valley and Saginaw coal for a certain boiler outfit, in which, pound for pound, the latter coal is slightly less efficient in actual heating power, but considerably more efficient when the price quoted is considered.

TEST BY E. C. FISHER ON ONE WICKES' PATENT WATER TUBE SAFETY STEAM BOILER.

	Saginaw.	Hocking Valley.
Fuel—Kind of Coal:		
Amount used, lbs.	6,092.0	5,808.5
Moisture in coal	5.5	5
Dry coal..... (lbs.)	5,757	5,518.08
Total refuse, lbs. (Per cent.)	4.2	6.1
Total combustible	245.5	338.5
Dry coal consumed per hour	5,511.5	5,179.5
Combustible consumed per hour	575.7	551.808
Results of Calorimetric Tests:	551.15	517.95
Quality of steam	0.9925	0.9927
Percentage of moisture	0.75	0.73
Economic Evaporation:		
Water actually evaporated per lb., dry coal (U. E.)	6.93	6.99
Water evaporated per lb., dry coal from and at 212° F.	8.26	8.32
Water evaporated per lb., combustible from and at 212° F. lbs.	8.63	8.87
Rate of Combustion:		
Dry coal burned per sq. ft. grate per hour, lbs.	25.6	24.5
Dry coal burned per sq. ft. water heating surface per hour, lbs.	0.363	0.34
Rate of Evaporation:		
Water evaporated from and at 212° F. per sq. ft. grate surface per hour, lbs.	211.04	204.1
Water evaporated from and at 212° F. per sq. ft. heating surface.	3.00	2.90
Commercial Horse Power:		
On basis of 34.5 lbs. water evaporated per hour from and at 212° H. P.	137.9	133.2
Builder's rating, H. P.	144.0	144.0
Cost in coal to evaporate 100 lbs. of water from and at 212° F.	cts. 14.4	cts. 15.8
Cost of coal per ton (2,000 lbs)	\$2.25	\$2.50
Water evaporated from and at 212° F., per lb. wet coal, lbs.	7.8	7.91
Efficiency of boiler, lbs.	71.10	

For more complete details concerning the items taken into account in accurate testing see Vol. VIII, Pt. II, pp. 68-69.

For ordinary purposes, the "Alternate method though much less elaborate, gives results very instructive in a comparative way. These tests consist of twelve hour runs with each coal, keeping the conditions throughout as nearly uniform as possible. Obviously, this is impossible from a standpoint of exactness, but the general average of conditions can be maintained quite satisfactorily. Mr. Edgerton, at the Municipal Water Works Plant of Lansing, obtained the following results from the several coals used:

	U. E.* 1st Series.	U. E. 2nd Series.	U. E. 3rd Series.
Average of Hocking Valley coals			
Saginaw	7.38	8.32	
St. Charles	7.23		7.32
Corunna		8.16	7.41
Williamston	6.49		
Bay City (Upper Verne)	6.51		
Bay City (Lower Verne)	6.94		
			7.56
			6.75

*U. E.—Units of evaporation, i. e. pounds of water evaporated per pound of coal burned.

These figures are much lower than those obtained by Mr. Fisher but the relative values agree very closely indeed. It must be kept in mind that different boiler outfits vary in efficiency in developing heating power. Also one kind of coal may work fine with one type of boiler and not with another. Michigan coals have a tendency to run together on the grate, so that a special kind of grate had to be devised for their use on locomotives. Thus it is not the absolute but the relative values which are the more instructive. The first measures the efficiency of the boiler for the given coal, the latter measures, in a general way, the quality of the coal as compared with other coals.

Boilers are expected to develop about 60 per cent of the theoretical heat values. Those, which do not, are of inferior type or are poorly handled. The three sets of tests given below are very complete and instructive. The sets were made by Mr. Edgerton, preliminary to the awarding of contracts for coal. The first was made in 1898, the second in 1899, and the third ran from June, 1900, to February, 1901.

LANSING WATER WORKS TEST—FIRST SERIES.

Name of coal.	Grade of coal.	Pounds of coal burned during the test.	Pounds of ash.	Pounds of water evaporated during the test; 110° F. = 61.89 lbs. per cubic foot.	Pounds of water evaporated per pound of coal.	Price of coal delivered in bins.	Pounds of water evaporated for \$1.00.
Cedar Grove.....	Steam lump.....	8,471	804	62,581	7.387	\$2.45	6,030
Coshen Hill.....	Run of mine.....	10,162	995	71,433	7.020	2.25	6,248
Black Diamond.....	Run of mine.....	11,106	1,293	70,875	6.381	2.26	5,647
Wasson.....	Run of mine.....	10,407	808	72,547	6.971	2.23	5,932
Hocking Lump.....	Run of mine.....	11,163	949	74,400	6.634	2.35	5,646
New River.....	Run of mine.....	18,765	524	68,471	7.852	3.20	4,907
Hocking Valley.....	Run of mine.....	10,706	808	71,618	6.680	2.31	5,701
Cedar Grove.....	Run of mine.....	10,000	1,048	65,614	6.561	2.35	5,583
Hocking Valley.....	Pea.....	12,845	1,558	75,332	5.864	1.94	6,046
Mingo.....	Run of mine.....	9,669	682	71,486	7.393	2.80	5,281
Jackson Hill.....	Run of mine.....	10,397	513	71,185	6.846	2.50	5,477
Riverside.....	Run of mine.....	9,062	491	74,280	8.136	2.60	6,304
Hocking Valley.....	Run of mine.....	11,645	1,021	74,899	6.452	2.34	5,497
<i>Saginaw.</i>	Run of mine.....	10,754	895	67,471	6.274	2.20	5,703
<i>Corunna.</i>	Run of mine.....	15,551	1,440	59,550	5.633	2.25	5,006
South Side.....	Run of mine.....	7,896	565	63,076	7.988	2.50	6,390
Wellston Shaft.....	Run of mine.....	8,405	120	64,066	7.622	2.25	6,775
Pocahontas.....	Run of mine.....	7,089	285	65,468	9.229	3.00	6,153
Not known.....	Run of mine.....	10,073	1,097	65,362	6.538	2.09	6,317
<i>Williamston.</i>	Run of mine.....	11,178	.....	62,335	3.659	2.40	.....
.....	Run of mine.....	10,391	440	62,015	6.021	.....	.....

Michigan coal italicized.

The tests in general show that, while St. Charles coal did not rank in efficiency with Pocahontas, it is better than several other coals and nearly equal to the best Hocking Valley. The practical side of such tests is of great economic importance to consumers by showing in dollars and cents the relative efficiency of different coals with a given plant. The greater cost of some of the coals per ton more than offsets their greater efficiency.

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LANSING WATER WORKS TEST—SECOND SERIES.

Grades of coal.	Pounds of coal burned during the test.	Pounds of ash.	Per cent of ashes.	Pounds of water evaporated during the test. Temp. of feed water 110° F. 62 lbs. = 1 cu. ft.	Pounds of water evaporated per lb. of coal.
Montana Coal & Coke Co., clinkers, not satisfactory to burn.	Run of mine.	1,142	11.2	74,648	6.332
Casner, Curran & Bullett, Pocahontas, no smoke for clinkers.	Run of mine.	892	10.0	83,143	9.312
Michigan Coal Co., St. Charles, Black Pearl; very light clinkers, heavy smoke.	Steam lump.	868	7.8	78,616	6.802
W. H. Vance & Co., St. Charles, light clinkers, heavy smoke.	Run of mine.	1,118	11.8	96,552	7.311
W. H. Vance & Co., Kelley's Creek, no clinkers, heavy smoke.	Run of mine.	1,545	13.4	81,034	7.672
M. A. Hanna & Co., Younghoehy, no clinkers, smoke medium.	Run of mine.	1,092	10.6	79,298	7.132
Pittsburg Coal Co., Hocking, no clinkers; good burning coal.	Three-quarter lump.	945	9.0	78,132	7.432
Milton Coal Co., Wellston Shaft; light clinkers, smoke medium.	Run of mine.	10,532	10.5	78,306	7.596
Lowery Coal Co., Hocking Congo; clinkers and bad smoke.	Steam lump.	10,110	9.0	70,494	6.972
Lowery Coal Co., Boomer, W. Va.; no clinkers, light smoke.	Run of mine.	825	9.0	75,392	7.172
O. W. Shipman Co., Peerless, Cedar Grove; very light clinkers, smoke medium.	Run of mine.	9,340	7.9	69,750	7.470
W. H. Vance & Co., Massilon, no clinkers, light smoke.	Run of mine.	8,608	7.8	69,006	8.019

LANSING WATER WORKS TEST—THIRD SERIES.

	Date of test.	Coal burned during test.	Ash.	Per cent of ash.	Pounds of water.	Water evaporated with 1 lb. of coal.	Water evaporated for \$1.00.
Sandy Creek.	1900.	10,124	1,041	10	58,280	5.756	4.343
Boomer R. M.	June 8	8,895	1,730	18.2	65,410	7.352	5.636
New Pittsburgh R. M.	June 9	9,640	1,105	11.5	58,590	6.077	4.801
Milton Coal, R. M.	June 12	9,512	594	6.2	62,116	6.635	4.823
Pittsburgh & Wheeling.	June 13	8,520	593	6.9	57,350	6.737	5.280
Somers Coal Co., St. Charles.	June 14	10,110	805	8.8	64,380	6.377	5.051
Somers Coal Co., St. Charles, different shaft.	June 16	9,770	783	8.8	62,092	6.377	5.051
Pere Marquette Steam Lump (No. 2 Shaft).	June 21	9,350	595	6.4	59,210	6.332	5.137
Michigan Coal & Mining Co., Steam Lump.	Nov. 11	14,626	1,255	8.6	95,604	6.536	5.389
Pittsburgh Coal Co.	1901.	13,033	1,510	8.6	101,982	7.820	6.133
Silver Mather Co., Bay City.	Jan. 4	15,916	3,180	19.9	103,318	5.846	5.314
Pittsburgh Coal Co., No. 8.	Feb. 8	14,890	1,835	8.1	103,168	0.928	5.522
Pittsburgh Coal Co., three-fourths coal.	Jan. 10	12,970	1,430	11.5	101,122	7.796	5.846

Analyses of Coal. The analysis of a coal shows the amount of possible available combustible, but this does not mean that it is all used in combustion. The physical and chemical qualities of a coal affect its burning qualities very much. For instance the tendency of some Michigan coals to run together often causes very unsatisfactory results, for special grates and experience in handling such coals are required to insure the highest efficiency. The high content of water, vaporized into steam, carries away no negligible quantity of the heat generated. So many other kindred factors have to be taken into account, that analyses must be taken to represent more the probable value of a coal than its absolute.

TABLE OF ANALYSES.

	Moisture.	Vol. Mat.	Fixed C.	Ash.	Total sulphur.	B. T. U.	Coke Bu.
*Pocahontas.....	0.50	20.43	74.07	4.98	0.605	14,579	.....
§Hocking Valley.....	5.42	35.27	52.79	6.52	2.09	13,151	.....
Pittsburg.....	1.49	32.57	57.87	8.07	1.13	13,867	.....
Massilon.....	1.7	40.48	51.2	6.55	2.99	12,103	.....
Robert Gage (Saginaw Seam).....	2.37	35.67	58.47	2.46	1.03	13,438	.....
Barnard (Saginaw Seam).....	9.28	31.67	53.70	5.35	.98	12,456	59.5
Somers No. 1 (Saginaw Seam).....	7.79	34.74	52.58	4.89	1.01	12,836	.....
What Cheer (Saginaw Seam).....	2.864	†91.283	.....	5.853	0.128	13,383	.....
Wenona Coke.....	1.68	3.12	79.46	15.74	7.41	.....	.....
Wolverine No. 2.....	8.92	36.49	51.92	2.67	1.49	12,987	.....
Wolverine No. 3 (Upper Verne).....	4.14	45.70	42.14	8.02	3.53	12,520	.....
Wenona (Upper Verne).....	3.78	41.18	49.34	5.70	2.50	.....	55.04
Wenona (Washed).....	3.78	41.40	50.48	4.34	1.82	.....	.....
Central (Lower Verne).....	4.52	40.57	42.16	12.75	6.92	12,128	.....
Michigan (Lower Verne).....	5.01	39.62	41.67	13.70	6.66	12,183	.....
Sebewaing.....	6.09	39.54	46.06	8.26	5.72	12,711	.....
Jackson.....	5.93	46.59	44.64	2.84	3.07	13,502	.....
Owosso (Verne).....	7.59	35.70	52.58	3.76	1.50	13,016	.....
Grand Ledge (Verne).....	7.00	39.10	46.40	7.50	3.42	.....	.....
Upper Rider.....	.....	45.02	45.50	9.48	4.19	13,838	.....

*Calorimeter tests upon dry coal.
 ‡Analyses upon thoroughly dried coal.
 †And fixed carbon.

The analyses of Michigan coals by different chemists vary considerably in the item of moisture and somewhat in volatile combustible for the same grade or vein of coal. This arises from the fact that analysts have not agreed at all in drawing the line between moisture and volatile combustible. Since the usual high hygroscopic content of water is one of the factors affecting quite markedly the heating and gas making qualities of our coals, it is important to have rather accurate information. In some of the analyses of the Saginaw coals given in the table of analyses (Chap. III), the water content is much below the average (usually above 7%) for this coal and, very possibly, part of the moisture was included in the volatile combustible.

From the several analyses, it can be seen that some of the coals are remarkably low in ash. Many analyses, made by different investigators, seem to show that the sulphur, is always in almost exact proportion for combining with the iron. This means no excess sulphur in the form of sulphates. A general principle can also be deduced for the relations between the ash, fixed carbon, and volatile combustible. The fixed carbon drops faster than the volatile combustible, when slate, bone, or cannel coal is introduced. The amount of ash is thus very indicative of the heating power of a coal.

Summary. Only three seams of the 10 to 12 or more seams have been well developed possibly excepting the Middle Rider. All are bituminous, rather high in moisture, inclining toward gas coals and passing into low grade cannel or bone coal. The Upper Verne or Monitor seam apparently is the only gassy one and is a coking coal though a poor one with a medium amount of sulphur. The Upper Rider and the Verne coals are near the lignite end of the bituminous group. Probably burial has been so shallow, that the original woody material has been little changed.

The Lower Verne, the next seam, often close enough to be mined with the Upper Verne is decidedly poorer in grade. It is a coking coal high in sulphur and ash and often below .50 in fixed carbon.

The Saginaw seam is of much higher grade, usually having well above 50% of fixed carbon, with little ash and sulphur. Its higher moisture content than the Verne coals is a bad quality, especially for gas making with ordinary producers. It is also unlike the Verne seams in not being a coking coal. Its other good qualities make it a fine domestic coal and a steaming coal much in favor with railroads, it is said.

Some of the East Saginaw mines possibly have their shafts in

the middle Rider just above the Saginaw seam. The decidedly lower grade of the coal in some of these mines, certainly is indicative that the Saginaw seam either varies a great deal in quality in a short distance, or that the mines in East and West Saginaw are in wholly different veins.

CHAPTER IV.

EROSION AND DISTURBANCE OF COAL.

After the formation of the beds of coal, present and past rivers have cut into them and carried them partly away. Some of the channels are occupied by our present rivers, others are filled with unconsolidated gravel, sand, till, etc., and still older channels are filled with rock, usually sandstone. This gives rise to three kinds of channels,—open channels, gravel channels or “washouts,” and sandstone channels.

Unfortunately, for the early development of coal mining in Michigan the open channels with exposures of coal along their sides are not at all numerous or deep. The development of the Saginaw and Bay county veins would have been tardier still had it not been for the numerous drillings for salt and water. As mentioned previously, the coal basin is covered with a thick mantle of drift varying from a few feet to six hundred or more, through which the bed rock exposes itself at few and scattered places, chiefly of course along stream courses. As the drift is thinner on the eastern, southern and southwestern parts of the basin, it is in these that most of the outcrops occur. Beginning on the east of Saginaw Bay, the first outcrop occurs along Coats Creek, near Tuscola where coal was dug for many years from the bank. Coal measure sandstones also occur in the bed of Cass River, a little way above the town. Going south the next exposures are on Flint River near Flushing and along the Shiawassee from just above Corunna down to Saginaw county. At intervals, other outcrops occur all along the southern border of the basin in the stream beds about Jackson, Chelsea, Eaton Rapids, and Dimondale. Exposures also occur on the Cedar and the Grand from Williamston to nearly six miles below Grand Ledge. The thickening of the drift on the southwest allows only a few glimpses of coal measure sandstone as at Ionia and in Kent county. But, over the whole northwestern and northern parts of the coal basin, the 300-600 feet or more of drift completely conceals the bed rock from Kent county north around to Rifle river in Arenac county. The center of the coal basin is also covered heavily with drift.

None of the rivers, except the Grand at Grand Ledge, has cut

valleys deep enough to expose coal on the banks, which can be effectively worked. The small mines near Grand Ledge are the only self draining mines in the state. All the important ones are under a greater or less hydrostatic pressure and require costly pumping machinery to keep them from flooding. The abundance of water, one of Michigan's greatest blessings, is not such to the coal operator. The rivers in the states to the south, as in Ohio have cut much deeper valleys, extensively exposing the coal along the hillsides, so that mining is easy and inexpensive. It is this factor together with that of the much thicker veins that allows the Ohio operator in seasons of dull iron trade, to lay down, at a small profit, his excess coal at the tipples of Michigan mines, at prices ruinous to Michigan operators.

Drift Filled Channels. The states to the south were somewhat plastered over with drift, but Michigan received two full coats; first a rough one of gravel and till from the Ice Sheet itself and then a finishing coat from the deposits of the Great Lakes system, whose waters were 200 or more feet higher than now and flowed southwest from a lake in Saginaw Bay.

Previous to the invasion of the ice-sheet, pre-glacial streams had carved steep channels 100 to 150 ft. deep or more in the coal measures. Remove the drift and the coal would be well exposed along the channels. Many of these channels have been found by boring and the courses of some, have been fairly well determined wherever the borings have been numerous enough. In a general way, many of them unite with a trunk channel which probably passes from near the head of the region of Saginaw Bay to the southwest toward Alma and then veers to the northwest, entering Lake Michigan below sea level somewhere between Manistee and Ludington.

These channels locally cut out a great deal of the coal, especially the upper veins, and, since bed rock is effectually concealed by the thick screen of drift, the amount and distribution of coal in a given tract is very uncertain. It may be nearly all cut out or but little. Drillers often find bed rock and coal at comparatively shallow depths, yet, a few hundred feet away, bed rock is far beneath the surface, with no trace of coal. It is this uncertainty in finding the coal that makes it hazardous for explorers with limited means, to attempt proper development work.

In Ohio and Kentucky, the soil mantle is so thin that the coal is easily discovered and the areas are readily determined. The beds are thicker, more persistent, and have fewer washouts, thus require

very little drilling for proving. Michigan areas require thorough proving by the drill before any approximation can be made of the amount and extent of workable coal.

"*Toward an outcrop* or washout, the coal is likely to rise" is a rule of possible practical value. This phenomenon, observed at Grand Ledge and at other places, may be due possibly to the fact that outcrops are more liable to appear in erosion channels along faults or anticlines.

Sandstone Channels. Sandstone Channels, like the "washouts," cut out the coal, but unlike them, are filled with rock,—sandstone nearly always. These represent the channels of streams existent at the time the coal was formed or, at least, shortly after. These streams cut out the coal measures depositing sand, now sandstone, in the channels. But, in some cases, where we have a heavy sandstone cutting out the coal for a considerable distance, it is more probable that the coal was never laid down, the sandstone representing the ridge of land cutting off the lagoon or basin in which the coal was formed. Real sandstone channels, however, are positively known elsewhere, so doubtless they exist in the Michigan formations. For instance, Mr. Liken near Sebewaing found three feet of coal 36 feet from a previous boring, which, at the same level, was in the midst of over 20 feet of sandstone.

These sandstone beds give trouble as they let in much water and cut out the coal as well. If the absence of coal is due to a cutting down from above it is less liable to be cut out as extensively as it would in the case of a cutting out from below.

Faults or Displacements. Coal beds commonly show disturbance, interruption, or deterioration. Faults are displacements, which in coal beds are almost always normal, that is, the fault plane slopes toward the side which dropped, just as though the coal had slid down. The fault planes are usually occupied by clay seams or veins traversing the coal "sulphur partings," that is veins or seams of iron sulphide or "Spar seams" or veins of calcite, gypsum or other white mineral.

Miners use the term fault very loosely and apply it to anything that cuts out the coal, be it rolls, horsebacks, bars, channels, or sandstone. Faults are common, though usually of small throw or displacement in coal, as would be expected from the slumping due to the settling and compacting of the vegetable material in the process of coal formation. The faults at Sebewaing and Jackson are the two best known instances of faulting in Michigan. The throw is hardly more than two feet. The coal rises toward the

faults as though there had been "drag," commonly observed in larger faults. The slipping along the fault plane has polished the surfaces of the coal and slate into bright shining faces called slickensides.

Sulphur partings are streaks of pyrite or marcasite more or less mixed with other impurities. They are found not only along fault planes but often they follow the partings of the coal or the bedding planes. These thin streaks affect the value of the coal as they are often the source of the high sulphur content of some coals like the Lower Verne. It is impossible to get the pyritous material all out, or to prevent the thin streak near the roof of the Lower Verne from being included. The waste pyrite of the Lower Verne seam is large enough to be of economic importance, if a practical way is devised for using it in fertilizers or for cheap large scale disinfection.

Before the Sebewaing mine was abandoned, an attempt was made to mine the pyrites for commercial purposes using the coal as a by-product. This, however, was unsuccessful at the time, but may have future possibilities.

CHAPTER V.

DEVELOPMENT OF COAL MINES.

As has already been noted here and there on previous pages, there are some peculiarities in the occurrence of coal in Michigan, which have retarded and will continue to more or less retard its further development. All, but the unimportant "drift" coals around Grand Ledge, are below the water table and largely in artesian well country. Some coal areas are much wetter than others, because the overlying beds are porous sandstones and drift. Sometimes the roof is a porous sandstone or is full of fissures, allowing free circulation of water, but usually the water comes from the coal itself or from the foot-walls. The coal basin is full of wet spots such as troughs, "washouts," and depressions, which act as catch basins. Slopes or troughs leading down to the coal have been encountered in sinking shafts at Jackson, Elk, Williamston, and Corunna with disastrous results, as the water could not be kept out. Heavy beds of sand and gravel in the drift carry a great deal of water and prove formidable obstacles to sinking shafts. The Auburn Coal Company lost two shafts in quicksand and nearly lost a third. (See Lane 1905.) At best, the amount of water to be handled will be a very serious problem. In the past, this problem has been a most annoying one and a cause of more than one failure. The heavy cost of adequate machinery and of raising the water to the surface consumes a large part of the operator's margin of profit. For the most economic handling, shafts should be sunk into the lowest part of the coal, so that all of the water will run toward the pumping shafts. To find the most advantageous point for beginning mining operations requires much preliminary drilling.

Deep drift channels should not only be avoided because of their large water content, but, also, on account of the too often weak and treacherous roof over the coal under such channels. Coal without an adequate roof to support the overlying strata is worthless as a mining proposition. This condition often obtains in drift filled channels, and near the margin of the coal basin. The early discoveries of coal along Rifle River come to naught on this account and several mines have had to be abandoned. Some of the larger mines have poor roofs of rotten shale or "slate" and

require much timbering. Frequently a shale roof much desired from its impervious qualities, slakes with exposure to air and scales off, making work extremely hazardous. The Gage Mine No. 2 at St. Charles has such an unstable roof, that it has been a constant source of trouble and expense. A new shaft at Owosso, sunk by the Robert Gage Company, was abandoned on account of the poor "slate" roof.

The coal seams are some 10 or 12 in number with only three developed to any great extent. They are somewhat disturbed, quite variable in thickness, extent, quality and character. The thickest veins rarely run more than three to four feet and, while some of the others are locally of workable thickness, most of them are too prevailingly thin for possible exploitation under present economic conditions.

Dr. H. M. Chance reported to the State Tax Commission that veins in Michigan much below three feet in thickness could not be worked at a profit, at present prices, and under the average conditions. The thin veins at Grand Ledge owe their exploitation to their natural system of drainage and ventilation, or to their association with so-called fire clay, which is of far more value than the coal. Reported thicknesses of five to six feet of coal are almost always exaggerations. The four and five foot veins are few and far between. The old Wenona mine had one of the thickest veins in the state, being above 4 ft. 6 in. in thickness.

With all these discouraging conditions, Michigan operators, on the other hand, may be thankful, that fire damp and coal dust explosions are hardly known, while noxious gases such as choke damp are little troublesome, the mines are too wet for dust explosions. The United Coal Co. and the Pittsburg Coal Co. mines are the only ones which have had any gas. Good precautions as to thorough ventilation and examination of the working places have prevented any serious trouble. Only a few miners have ever been injured by such explosions in Michigan mines.

Principles to guide Exploration. 1. Favorable places for preliminary exploration lie in a belt a few miles within the coal margin. Nearer the center of the basin coal beds are liable to give way to shales, unless other beds of later and higher horizon come in. From records in Bay county there seem to be coals of higher horizons than the Salzburg, though their existence is inferred from rather meagre records. Coal nearer the margin is apt to be cut out by some channel or may lack sufficient roof.

2. Coal once located, though thin, may thicken especially in

a direction parallel to the margin. Further borings may locate a workable area. If the money spent in haphazard drilling about the state, could have been used in proving known favorable areas, the results undoubtedly would have been far more satisfactory.

3. Coal generally rises toward the margin, except for minor undulations, thus shafts should not be located until the lowest part of the coal vein has been determined by drilling. This is essential for the most economic handling of the coal and water.

4. Up to the present, most of the exploration and development has been along the eastern and southeastern side of the basin. A line from Sebewaing to Jackson and a parallel one from just west of Bay City toward Grand Ledge would mark two belts containing practically all the mines, which have mined coal in any quantity. The more recent prospecting and exploration has been to the west and northwest of Bay City toward and into Midland and Arenac counties. Explorations near Flint promise much and recent developments indicate a large body of workable coal. Along the southwestern margin the drift is comparatively thin and as coal has been found in several places northeast of Bellevue, Eaton county, in veins reported to be four to six (doubtless the higher figure is an exaggeration) feet thick. This part of the field looks promising and deserves further exploration. (See Fig. No. 12.) Much coal has been found in the drift of Montcalm county and the valley of the Upper Muskegon river. The coal must have come from underlying coal beds. The drift is so deep (300-600+), however, that little exploration has been attempted.

5. Most of the coal basin from the center westward and northward to the margin and beyond has been deeply covered with drift, so that exploration for coal alone would probably be too expensive to pay. Even if coal was found in good thickness and extent, the wealth of water in the drift to say nothing of the probably quicksand beds, would make the sinking of shafts very difficult indeed and the mining of the coal very expensive.

6. The finding of a good bed of coal near the surface is not an unfavorable sign of more coal below. Many prospectors stop at the first good seam, when the probabilities are that more coal could be found by going deeper. The suggestion also has been made that much of the drilling in the past has been altogether too shallow.

The map in Figure No. 12 gives a general idea of the proven areas of coal, and the possible ones, and shows how relatively small is the percentage of workable coal to the area of the whole basin. Either the workable beds are woefully insignificant in ex-

tent or there are many yet to be found. Probably there is a good deal of truth in both.

Methods of Exploration and Developing. In general, since the drift is so thick, test pitting or digging wells down to the coal is wholly impracticable. The abundance of water, treacherous veins of gravel and quicksand, and large boulders would form almost unsurmountable obstacles, except where the drift is very thin. Then the coal beds being on the whole near the horizontal would probably be concealed under heavy masses of sandstone. If exposed, they would be useless as a mining proposition from lack of good roof.

The early prospecting for coal in Michigan was mainly done by churn drills. These are very satisfactory for finding the coal and running it into a "valley" or "swamp," but do not give sufficiently accurate data concerning the thickness of the beds. Black shale usually occurs above and below the coal, and it is hard to tell by a churn drill just where the shale ends and the coal begins or vice versa. The records from churn drills always tend to exaggerate the thickness of a coal bed, so that many areas have never yielded nearly as much coal as had been previously estimated from the drill records.

In the last few years, core drills have been used very largely, especially in proving coal territory. They give much more reliable data concerning the thickness of beds and the estimates, based upon their records, more nearly approach the product actually realized afterwards in mining.

CHAPTER VI.

VALUE OF COAL LANDS AND COAL RIGHTS.¹

The value of coal lands in Michigan depends primarily upon the geographical position of the Coal Basin. It is the only one lying in the Great Lakes system, and is in the midst of a rich and populous manufacturing region. Further, the means for the distribution of the coal product is almost unparalleled through the network of railroads traversing the region, and the system of water routes with Saginaw River and Bay penetrating to the very heart of the most productive part of the Basin. It is this central position with markets almost at the shafts of the mines, that made possible, during the years 1896 to 1907, the unparalleled growth of Michigan's coal industry, in spite of other most discouraging conditions.

It must be borne in mind, that Michigan Coal Measures are buried under a deep deposit of glacial materials, carrying heavy water bearing strata, and dangerous quicksands, that the workable areas are smaller, more irregular, scattered, more variable, thinner veined, and of lower grade than in other fields, and that the expense of prospecting and proving up the areas, of sinking shafts, of mining thin veins, of timbering the bad roof, and of handling the abundance of water is far greater than in the states to the south. Higher mining and wage scales, besides a more generous computation of the extra allowances for narrow work, etc., tends to swell the expense roll in Michigan mines.

As can be seen from the table of production the average cost of placing a ton of coal on the car in 1910 was \$1.79 or about 60 to 80 cents more than that in West Virginia. Of course, a large part of this increased cost is due to keeping up the mines during the summer. The water makes it imperative that the pumps be kept working, so that many operators mine throughout the summer, marketing the coal at a loss.

As an offset, the Michigan operator has markets almost at his shaft, especially is this true in the region of Saginaw and Bay City, and the territory to the north and west. Thus the freight rates run from 25 cents up, and rarely exceed 70 cents, and the

¹ H. M. Chance, Appraisal of Mining Properties, Report of State Board of Tax Commissioners, 1911, p. 66.

difference between these and the ones from Ohio and West Virginia forms a protective tariff. The rates from Ohio range from \$1.40 to \$1.50 and more per ton and \$1.65 to \$1.85 per ton from West Virginia. Subtracting from these the amount (70-80 cts.) of the increased cost of mining in Michigan, there is a net margin of protection for the Michigan operator, ranging from nothing for the more remote deliveries to 45 cents or more for purely local ones.

But, another factor has to be considered and this is the quality and the use of the coal. A ton of average Ohio and West Virginia coal is worth in actual heating power more than a ton of average Michigan coal. This difference in quality, measured in British Thermal Units (B. T. U.) has a money value ranging from 20 to 30 cents. Then obviously Michigan coals cannot compete with the former at the same prices. The high content of water and usually of sulphur and the generally lower average of fixed carbon do not make them as efficient for all around heating purposes as the dryer coals low in sulphur. For steaming purposes and domestic uses the Saginaw Coal is a very superior coal, but unfortunately a large part of our coal product comes from the Verne and other veins which are decidedly inferior to the first, yet the latter are what are called good steam and domestic coals.

For coking and gas making, Michigan coals are no competitors of those coming from Ohio or West Virginia. Not that coke or gas cannot be made from them for the Verne Coals are both coking and rich in gas, but that the water or sulphur content or both makes them less fitted for making coke and gas satisfactory for commercial purposes.

It is the lower quality that tends to wipe out the margin of protection so that in periods of depression in the iron trade as in 1908, the Ohio operator can place his excess coal at a small profit on the market at prices ruinous to the Michigan operators.

From the preceding facts it is seen that the Michigan coal lands have a value over and above their value as agricultural lands.* This may be reckoned at 10 cents per ton for coal to be immediately mined. This small value represents the difference between the average cost of putting the coal on the cars and the average price received. To find the total amount of coal per acre of an area, the average thickness must be known. The amount of available coal, that which can be mined at a possible profit, is hard to determine. Experience has shown that, in Michigan, hardly half of the computed tonnage is ever realized in actual mining. This

* See H. M. Chance, Appraisal of Mining Properties, 1911, pp. 66-75.

is due partly to incomplete or unreliable drilling, which has not shown channels or sudden and unexpected variations in thickness, or revealed the presence of a weak or treacherous roof. The first reduces the total amount of coal present, the second, the amount of workable coal, and the third, the available coal. In the last case a large amount of coal must be left in pillars for the support of the roof. Indiana, Ohio, and West Virginia give yields per acre foot (an acre of coal 1 ft. thick) of 1,200 to 1,350 tons, but in Michigan the yield rarely runs much above 1,000 tons per acre foot. Thus a three foot vein of coal in Michigan would yield about 3,000 tons. With such a yield, at the base price of 10 cents per ton the coal land would be worth \$300 per acre. But this is too high, for coal remote from the shaft may not be mined for a term of years and thus should be discounted for such estimated period. As undeveloped but proven mining properties sell at about half the price of developed ones, 5 cents a ton would represent the base price. But this must be discounted according to the length of time elapsing before mining begins and the number of years in the average life of a colliery, so that the present value of a ton of coal in undeveloped but proven property has been estimated at $1\frac{1}{4}$ cents a ton, giving a value of \$37.50 per acre for coal land like that noted above. The average cost (See Ann. Rept. Michigan Bureau of Labor, 1911), of mining a ton of coal in 1910 was \$1.79 and the average selling price (See U. S. Min. Resources, 1910), was \$1.91, making an average net profit of 12 cents per ton. Some mines averaged better, some much less, and some sold at a loss. (See Production and Distribution.) The value given above for the cost is somewhat higher than that given by Chance, who quotes the cost at \$1.60 per ton. If this is correct and the selling price, \$1.91, is not correspondingly higher, the margin of profit would be considerably larger. This is hardly possible as such a margin would be large enough to successfully compete with outside coals under almost any conditions of trade. Unproven coal land can hardly have a value above that for agricultural, or purposes other than mining, when investors have not and do not now purchase mineral rights to such lands.

The map in Fig. No. 12 gives a general idea of the proven areas of coal. A glance is sufficient to observe the relatively small proportion of proven coal land as compared with the area of the whole basin. The areas plotted do not refer to the areas where coal is known to occur, but where it is known to occur in thicknesses great enough for profitable mining. The following table

PROVEN COAL IN MICHIGAN.

County.	Acres.	Tons.	Appraised value.
Bay	4,607	14,945,746	\$484,709
Saginaw	3,297	9,556,583	350,924
Midland	343	1,029,000	12,862
Tuscola	10	35,000	3,500
Shiawassee	260	780,000	9,750
Genesee	936	2,836,333	
Ingham	0		
Eaton	0		
Clinton	0		
Jackson	0		
Total	9,453	29,182,662	\$861,745

Average value per acre of appraised land \$101.18.

gives the area of proven coal lands by counties: This table and the map were prepared in 1911 by Mr. H. F. Lunt as a part of Dr. H. M. Chance's report to the State Board of Tax Commissioners, on The Value of Coal Property and Coal Rights in Michigan. The data necessary for such map and table was compiled from the mine and property maps of the operators or owners. Either the thicker areas are extremely limited in extent, or they remain as a hidden reward of discovery for future prospectors.

CHAPTER VII.

PRODUCTION

Although coal mining began in Michigan more than seventy-five years ago, it was not till 1896 that Michigan began to be reckoned among the coal producing states. As can be seen from table of production, there was a steady but extremely slow increase from 2,320 tons in 1860, the first recorded production, to above 135,000 tons in 1882, the 100,000 ton mark being realized only in the years from 1880 to 1882 inclusive. The panic in the early eighties wholly demoralized the struggling industry, so that the production fell to about 35,000 tons. The recovery was very slow indeed. In fact, the years following, up to 1895 were ones of alternate indifferent success and failure. The severe financial depression of 1894 again reduced the production to little more than 45,000 tons or 10,000 tons less than it was twenty years before.

As has been noted on other pages, 1896 signalized the rapid sinking of shafts in Bay and Saginaw counties. The production of the year following is most suggestive of this activity in coal mining, as the production had increased from about 93,000 tons in 1896 to more than 223,000 tons. The production in 1901 was 13 times that of 1896, or over 1,240,000 tons. Each successive year saw the production grow by leaps and bounds until it reached the high water mark of over 2,000,000 tons in 1907.

It will be recalled that the sale of Michigan coal is limited mainly to its home markets. It is true that the cities along the Lower Lakes had been growing rapidly and consuming the coal product, but coal mining wholly outstripped them in the rapidity of its growth, so that, in 1907, production was much greater than their capacity to consume. The year following thus shows a decided falling off in production, which has continued to the present.

Of course, other factors were influential in bringing about this condition of affairs. The capacity for consumption doubtless had been exceeded before this, but local strikes and those in other fields at different times, as in 1902 and 1906, tended to reduce any surplus and even cause deficits in the coal supplies, which allowed great increases in production without serious consequences. The banner production of 1907 glutted the coal markets so that

coal prices fell to points ruinous to operators. To make matters worse, the dull iron season in 1908 following the financial depression of 1907, caused the Ohio operators to seek new markets for their surplus coal. With cheap mining facilities, they were able to put their product at a small profit upon Michigan markets at prices, that meant bankruptcy to Michigan operators.

With the increase in production, there grew up also the keenest competition among the numerous producers. As a result of local competition and that from the Ohio and West Virginia districts, some of the weaker operators were forced out of business in 1909. In order to cut out the ruinous local competition, to reduce mining costs, and to better adapt their output to the demands of trade, many of the operators had consolidated prior to 1906. The consolidation has continued with most evident good results, seen in the better equipped and better managed mines. The output also has been so adjusted to the demands of trade that equilibrium between production and demand seems nearly accomplished and Michigan operators may soon be enabled to earn profits on a par with those earned in other districts. It may not be too optimistic to believe that the coal mining industry is, in a fair way, of attaining a stable and satisfactory industrial basis.

CHAPTER VIII.

MINING METHODS.

The thin and variable seams of coal, the treacherous shale roofs, and the abundance of water are the three factors determining the methods of mining in Michigan.

The first means that, in general, operators must pin their faith to good pumps. The pumping shaft should reach the lowest part of the coal so that all water will run to the pumps, thus keeping the entries dry. In the case of the dry mines of Ohio and West Virginia, the operators, during the summer months, when coal prices are lowest, can close down without facing a heavy pumping expense in the following fall. This also enables them to mine a minimum amount of coal with loss. In Michigan, the wealth of water makes it imperative that the pumps be kept going. In order to keep the pumping charges at the lowest average, many of the mines are kept in operation at a loss during the summer.

The mines at Grand Ledge, due to the deep channel cut by the river, are dry and it is this fact together with a natural ventilation that has made the mining of such thin veins of low grade coal possible. The workings now have been extended so far from the shaft openings that water is beginning to be troublesome.

The roof of most of the seams in Michigan is a black shale. Unfortunately this, though apparently hard and firm when first exposed, often slakes with exposure to air and flakes off. Such roofs require a great deal of support. Usually large pillars of coal are left standing for this purpose, but these cut out a great deal of coal per acre. The low yield of about 1,000 tons per acre foot is largely due to the use of the room and pillar system. Timbering is more or less resorted to, but adequate timber is now not only very expensive but almost unobtainable, due to the exhaustion of the state's timber supplies. Heavy timbering must accompany robbery of the supporting pillars of coal.

From practical experience, a four foot vein can be worked as cheaply as one thicker. The mining of thinner veins is more expensive on account of the narrow working quarters and the greater amount of dead work. Naturally the average cost per ton in mining a 4 foot vein is less than that for a 3 ft. From Dr. H.

M. Chance's investigations, it appears that veins less than 2 ft. 6 in. in thickness cannot possibly be mined at a profit under present mining and economic conditions. Seams less than three feet in thickness are doubtfully workable, unless under favorable conditions. Of course, in mines working beds more than 3 feet thick, it is very possible to extend operations into areas much thinner in thickness providing the coal is of good quality and the roof good.

Often, in the best of coal areas the veins decrease to less than workable thickness. This local thinning together with the general thinness of the seams in Michigan has much hindered the introduction of mining machines. Michigan operators have lagged behind in up-to-date methods of mining. Shooting from the solid in thin veins always results in much slack or waste coal. A small charge of explosive merely loosens up the coal, so that it would have to be tediously picked out. On the other hand, a larger charge shatters the coal, so that it quickly deteriorates upon exposure to the air and sun. Miners generally use the larger charge, resulting in a considerable loss to the operators.

Mining machines were originally designed to meet the conditions, obtaining in fields where the veins are much thicker, so they were not adapted to the narrow workings common in Michigan. Naturally, the first attempts to use these machines were far from satisfactory, and a wrong impression grew up among the operators as to their practical value, but some types were found to be better adapted to the conditions and have given very satisfactory results. Some of the larger mines now use machines almost exclusively except in very narrow workings. Many of the smaller mines, and a few of the larger ones still persist in the old wasteful methods of shooting from the solid, though operators, in general, are now realizing that the best methods and the best equipments are absolutely necessary for successful mining in Michigan.

The first coal cutting machines were introduced in 1898 and materially increased the quality as well as the quantity of coal mined. They were so successful that twenty-five such machines were used the following year. The number gradually increased until 1908, when the maximum number of 120 was reached, but the rate of introduction of the cutting machines did not keep pace with the growth of the industry, so that, after 1905, the percentage (about 30%) of machine mined coal did not increase materially until the present year when the percentage was nearly forty.

The Mines. The mines are mainly in Saginaw and Bay counties,

the first having sixteen and the latter twelve in active operation out of the total of thirty-seven for the state. These mines produced upwards of 92 per cent of the total mined in the state. Saginaw county up to the past year, had led by a good margin but the greater development in Bay county in the last year enabled the latter to take the lead as can be seen in Fig. 13. In order to mine coal the most economically and thus be able to compete more successfully with outside coals, a number of mines prior to 1906 had consolidated under the firm name of The Consolidated Coal Company. The mines operated and controlled by this corporation includes the following active mines: Saginaw, Northern ("Jintown"), Uncle Henry, Riverside, Central, Shiawassee, Barnard, Wolverine No. 2 and No. 3. This organization also has three new mines ready for operation as soon as the present market conditions improve.

The Robert Gage Coal Co., and the Handy Bros. Coal Co., are two other firms having a group of large mines. The three organizations own or control 18 of the 31 active mines. It is largely due to the united efforts of these three organizations that much of the progress in coal mining has been made. The management and the equipment in all three is much above that possible under the old regime of independent operators, each competing against the other, with disastrous consequences to all.

The general expenses are so much less in management, etc., and the ability to produce through up-to-date equipment is so much greater than formerly, that Michigan coal industry bids fair to hold its rightful share of the local trade against outside competitors.

PRODUCTION OF COAL IN MICHIGAN, 1860-1910, IN SHORT TONS.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1860	2,320	1871	32,000	1882	135,339	1893	45,979	1904	1,342,840
1861	3,000	1872	33,600	1883	71,206	1894	70,022	1905	1,473,211
1862	5,000	1873	56,000	1884	36,712	1895	112,322	1906	1,346,538
1863	8,000	1874	58,000	1885	45,178	1896	92,882	1907	2,035,858
1864	12,000	1875	62,500	1886	60,431	1897	223,592	1908	1,835,019
1865	15,000	1876	66,000	1887	71,461	1898	315,722	1909	1,784,692
1866	20,000	1877	69,197	1888	81,407	1899	624,708	1910	1,534,967
1867	25,000	1878	85,322	1889	67,431	1900	849,475		
1868	28,000	1879	82,015	1901	74,977	1901	1,241,241		
1869	29,980	1880	100,800	1902	80,307	1902	1,064,718		
1870	28,150	1881	112,000	1892	77,990	1903	1,367,619		
								Total	18,997,621

DISTRIBUTION OF COAL PRODUCTS OF MICHIGAN, 1886-1910, IN SHORT TONS.

Year.	Loaded at mines for shipment.	Sold to local trade and employees.	Used at mines for steam and heat.	Total product.	Total value.	Average price per ton.	Average number of days active.	Average number of employees.	Number of machines used.	Total mined by machines.	Per cent mined by machines.
1910.	1,355,819	110,473	68,675	1,534,967	2,930,771	\$1.91	211	3,575	101	570,480	38
1909.	1,619,221	95,195	70,276	1,784,692	3,190,351	1.79	207	3,496	120	511,895	28.70
1908.	1,674,453	87,223	73,371	1,835,019	3,322,904	1.81	207	4,247	120	535,543	29.18
1907.	1,742,598	129,434	113,826	2,035,858	3,662,833	1.80	234	3,982	103	606,748	29.8
1906.	1,189,972	106,538	49,828	1,346,338	2,427,404	1.80	173	3,971	110	417,073	30.98
1905.	1,350,584	66,728	55,899	1,473,211	2,512,607	1.71	186	3,696	106	432,266	29.34
1904.	1,270,414	58,009	14,417	1,342,840	2,432,095	1.81	183	3,549	85	310,007	23.09
1903.	1,203,166	123,677	40,776	1,367,619	2,707,552	1.97	222	2,768	46	180,943	13.23
1902.	1,118,687	117,978	28,053	1,364,718	1,653,132	1.71	171	2,344	58	196,248	20.34
1901.	1,158,096	44,749	38,396	1,241,241	1,753,064	1.41	247	2,276	31	177,669	14.33
1900.	792,679	40,258	16,538	849,475	1,250,683	1.48	261	1,704	33	191,577	22.55
1899.	574,280	34,191	16,237	624,708	870,152	1.39	232	1,291	25	64,055	10.20
1898.	232,135	75,622	7,945	315,722	462,711	1.47	245	1,715	7	1,456	0.46
1897.	188,636	24,686	10,270	223,592	325,416	1.46	230	537	7	1,456	0.46
1896.	83,130	6,547	3,185	92,862	150,631	1.62	157	320	7	1,456	0.46
1895.	80,403	27,019	4,900	112,322	180,016	1.60	186	320	7	1,456	0.46
1894.	60,817	7,055	2,150	70,022	103,049	1.47	224	224	7	1,456	0.46
1893.	27,787	16,367	1,825	45,979	82,462	1.79	154	162	7	1,456	0.46
1892.	27,200	45,180	5,610	77,990	121,314	1.56	195	230	7	1,456	0.46
1891.	53,113	21,515	5,659	80,307	133,387	1.66	205	223	7	1,456	0.46
1890.	57,100	12,885	4,992	74,977	149,195	1.99	229	180	7	1,456	0.46
1889.	53,104	9,110	5,217	67,431	119,011	1.71	171	180	7	1,456	0.46
1888.	71,461	81,407	7,461	160,329	235,221	1.46	166	180	7	1,456	0.46
1887.	71,461	107,191	7,461	186,113	307,191	1.50	150	180	7	1,456	0.46
1886.	71,461	60,434	7,461	139,356	207,191	1.50	150	180	7	1,456	0.46

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Distribution of total product.				Total value.
			Loaded at mine for shipment.	Sold to local trade and employees.	Used at mine for steam and heat.	Total quantity.	
BAY COUNTY:							
Black Diamond	Black Diamond Coal Mining Co.	Bay City	No. 7 mine of 62,974	Robt. 647	Gage Coal 3,570	\$126,294	
Monitor	Handy Bros Mining Co.	Bay City	20,000	7,353	1,725	37,000	
Beaver (Hecla No. 1)	Beaver Coal Co. (Hecla Portland Cement & Coal Co.)	Bay City	7,420	3,011	11,862	33,750	
Michigan	Michigan Coal Co.	Bay City	151,841	9,172	4,745	166,714	
No. 6	Robert Gage Coal Co.	Bay City	106,969	2,288	6,927	301,838	
No. 6	Robert Gage Coal Co.	Bay City	5,110	14,166	113,567	202,801	
United City	United City Coal Mining Co.	Bay City	104,352	87,427	14,166	33,020	
What Cheer	What Cheer Coal Mining Co.	Saginaw	87,427	153,451	87,427	227,920	
Central	Central Coal Mining Co.	Saginaw	153,451	699,544	30,289	28,403	
Wolverine No. 2	Wolverine Coal Co.	Saginaw	699,544	36,637	30,289	167,510	
Wolverine No. 3	Wolverine Coal Co.	Saginaw	699,544	36,637	30,289	273,757	
County total			699,544	36,637	30,289	\$1,432,293	
CLINTON COUNTY:							
	F. L. Reed	Grand Ledge		2,000		\$5,000	
EATON COUNTY:							
Schumaker (Grand Ledge Sewer Pipe Co.)	A. B. Schumaker (American Sewer Pipe Co.)	Grand Ledge (Akron)		Out of business.			
	Allen & Walker	Grand Ledge		100		\$250	
	Grand Ledge Clay Products Co.	Grand Ledge		100			
	Grand Ledge Coal Co.	Grand Ledge		100			
GENESEE COUNTY:							
	Burton Coal Mining Co.	Flint	7,500	Not yet in operation.		\$33,000	
	Genesee Coal Mining Co.	Flint	7,500	2,500	7,000	17,000	
INGHAM COUNTY:							
	T. W. Jenkins	Williamston		1,232	270	1,502	
						\$3,438	

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Average price per ton.	Average No. of days active.	Average No. of employees.	No. of machines.	Total mined coal.	Total pick mined coal.
BAY COUNTY:								
Black Diamond	Black Diamond Coal Mining Co.	Bay City	\$1 92	205	130			
Monitor	Handy Bros. Mining Co.	Bay City	1 85	200	20			
Beaver (Hecla No. 1)	Beaver Coal Co. (Hecla Portland Cement & Coal Co.)	Bay City	2 21	208	34			
	Michigan Coal Co.	Bay City	1 85	232	330			
No. 5	Robert Gage Coal Co.	Bay City	1 84	235	200			
No. 6	United City Coal Co.	Bay City	2 31	215	30			
What Cheer	What Cheer Coal Mining Co.	Bay City	2 14	230	160			
Central	Central Coal Mining Co.	Saginaw	2 00	125	75			
Wolverine No. 2	Wolverine Coal Co.	Saginaw	1 92	205	225			
Wolverine No. 3	Wolverine Coal Co.	Saginaw	1 78	236	350			
County total			\$1 87	220	1,554		304,730	416,233
CLINTON COUNTY:								
	F. L. Reed	Grand Ledge	\$2 50	250	4			
EATON COUNTY:								
Schumaker (Grand Ledge Sewer Pipe Co.)	A. B. Schumaker (American Sewer Pipe Co.)	Grand Ledge (Akron)						
	Allen & Walker	Grand Ledge						
	Grand Ledge Clay Products Co.	Grand Ledge	\$2 50					61,737
	Grand Ledge Coal Co.	Grand Ledge						
GENESEE COUNTY:								
	Burton Coal Mining Co.	Flint	\$1 96	190	52			
	Genesee Coal Mining Co.	Flint						13,351
INGHAM COUNTY:								
	T. W. Jenkins	Williamston	\$2 79	220	8			1,607

a Includes Clinton mines.

c Taken from the State Coal Mine Inspectors report for 1910.

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Distribution of total product.				Total value.
			Loaded at mine for shipment.	Sold to local trade and employees.	Used at mine for steam and heat.	Total quantity.	
SAGINAW COUNTY:							
No. 1	Robert Gage Coal Co.	Bay City	107,996		14,235	\$242,209	
No. 2	Robert Gage Coal Co.	Bay City	51,543		8,030	110,137	
No. 3	Robert Gage Coal Co.	Bay City		302			
No. 4	Robert Gage Coal Co.	Bay City					
Barnard	Barnard Coal Co.	Saginaw	13,077		13,077	24,114	
Buena Vista	Buena Vista Coal Co.	Saginaw		22,358	1,000	40,981	
Caledonia No. 2	Caledonia Coal Co., Ltd.	Saginaw		29,837	3,000	78,737	
	Consumers Coal	Saginaw	25,000			48,250	
	Northern Coal & Transit Co.	Saginaw	60,058			111,888	
	Consolidated Coal Co.	Saginaw			1910.		
Pere Marquette No. 3	Riverside Coal Co.	Saginaw	77,678			151,101	
Saginaw	Saginaw Coal Co.	Saginaw	58,408			118,276	
Shiawassee	Shiawassee Coal Co.	Saginaw	93,748			177,652	
Uncle Henry	Uncle Henry Coal Co.	Saginaw	25,922			51,714	
Swan Creek	Bliss Coal Co.	Swan Creek	69,960			134,461	
Carbon	Savage & Smith	Bent.		4,555	111	1,413	
County total			583,399	57,507	26,376	\$1,290,933	
SHIAWASSEE COUNTY:							
Peak	Detroit Vitrified Brick Co.	Corunna		3,000		\$6,000	
New Haven	New Haven Coal Mining Co.	Owosso	6,000	3,000	1,000	20,000	
County total			6,000	6,000	1,000	\$26,000	
TUSCOLA COUNTY:							
Akron	Handy Bros Mining Co.	Bay City	59,376	3,311	3,740	\$136,892	
Small coal banks						\$2,965	
Grand total			1,355,819	110,473	68,675	\$2,930,771	

b Included in county totals above.

COAL PRODUCTION OF MICHIGAN IN 1910, BY COUNTIES AND MINES, IN SHORT TONS.

Colliery.	Operator.	Office.	Average price per ton.	Average No. of days active.	Average No. of employees.	No. of machines.	Total machine mined coal.	Total pick mined coal.
SAGINAW COUNTY:								
No. 1	Robert Gage Coal Co.	Bay City	\$2 08	225	260			
No. 2	Robert Gage Coal Co.	Bay City	1 93	228	130			
No. 3	Robert Gage Coal Co.	Bay City	1 84	69	100			
No. 4	Barnard Coal Co.	Saginaw	1 83	253	47			
Barnard	Buena Vista Coal Co.	Saginaw	2 11	250	80			
Buena Vista	Calcedonia Coal Co., Ltd.	Saginaw	1 93	200	60			
Calcedonia No. 2	Consumers Coal.	Saginaw	1 86	207	175			
Northern, or "Jintown"	Northern Coal & Transit Co.	Saginaw	1 95	207	200			
Pere Marquette No. 3	Consolidated Coal Co.	Saginaw	2 03	214	200			
Riverside	Riverside Coal Co.	Saginaw	1 90	112	160			
Saginaw	Shiawassee Coal Co.	Saginaw	2 00	252	300			
Shiawassee	Uncle Henry Coal Co.	Saginaw	1 80	209	75			
Uncle Henry	Bliss Coal Co.	Swan Creek	2 50	205	150			
Swan Creek	Savage & Smith.	Bent.			3			
Carbon								
County total			\$1 93	206	1,740		250,782	400,032
SHIawassee COUNTY:								
Peak	Detroit Vitrified Brick Co.	Corunna	\$2 00	300	4			
New Haven	New Haven Coal Mining Co.	Owosso	2 00	80	60			
County total			\$2 00	94	64			9,371
TUSCOLA COUNTY:								
Akron	Handy Bros. Mining Co.	Bay City	\$2 10	224	153		15,387	51,041
Small coal banks								
Grand total			\$1 91	211	3,575		570,489	893,372

PRODUCTION OF COAL BY COUNTIES, 1899-1910.

	Bay.	Eaton.	Jackson.	Saginaw.	Other counties.
1910	766,470	100		667,282	101,215
1909	822,577	558	1,500	859,434	100,623
1908	782,503	2,286	5,539	999,338	45,353
1907	962,574	5,982	5,645	1,047,927	13,730
1906	481,398	18,507	8,658	835,475	2,300
1905	544,154	4,058	9,196	915,803	
1904	410,634	9,057	16,860	906,289	
1903	325,021	7,393	23,307	1,011,898	
1902	248,645	8,800	23,889	670,304	13,400
1901	253,821	4,803	20,288	938,042	24,284
1900	190,814	4,530	23,317	601,112	
1899	104,588	3,421	21,600	455,607	39,492

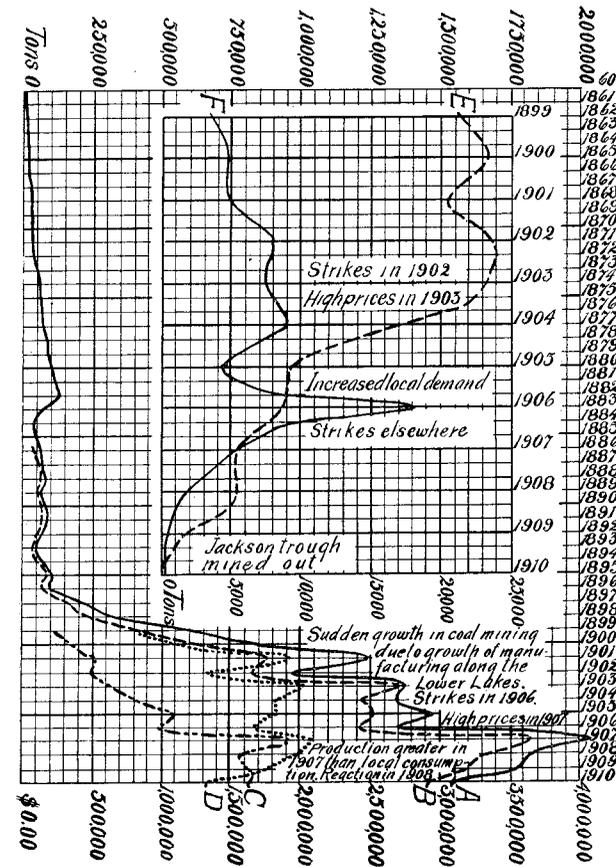


Fig. 13. Graphic representation of the annual production and value of coal in Michigan and by counties, 1860-1910. (Amounts read from the left margins and values on the right.)
 A. Curve showing total annual production of coal in Michigan.
 B. Total annual value.
 C. Total annual production for Saginaw county.
 D. Total annual production for Bay county.
 E. (See inset) Total annual production for Jackson county, illustrating the decline of the industry in that county.
 F. Total annual production for Eaton county, showing effect of strikes upon local production.

GYPSUM AND GYPSUM PRODUCTS.

BY R. A. SMITH.

CONTENTS.

Composition of Gypsum.
Varieties.
Occurrence.
Geological Horizons.
Origin.
Manufacture of Calcined Gypsum.
Gypsum Products.
Production.

COMPOSITION OF GYPSUM.

Gypsum is a hydrous sulphate of lime, containing one molecule of lime sulphate and two of water. Its chemical formula is thus: $\text{CaSO}_4, 2\text{H}_2\text{O}$, of which 79.1% is lime sulphate and 20.9% water. Workable deposits of gypsum rarely approach this degree of purity, as they commonly carry impurities of clay, limestone, iron oxide, etc., up to 20%.

Pure gypsum is usually white or translucent, when crystalline. The common fine grained, massive variety of the mine, such as occurs at Alabaster, Michigan, is usually white to reddish gray or even brown. Gypsum is very soft, being easily scratched by the finger nail. It does not effervesce with acids. Heated above a certain temperature, it loses its water of crystallization and becomes a chalky white. Michigan gypsum varies in purity from the almost absolutely pure alabaster to that mixed with clay, shale and limestone.

VARIETIES.

Rock gypsum is the ordinary massive kind. *Alabaster* is the pure fine grained massive rock gypsum used for statuary, etc. The term *selenite* is applied to the translucent crystalline variety, occurring here and there throughout massive deposits. These varieties are characteristic of Michigan gypsum, but the massive variety is by far the most important. The *earthy gypsum*, *gypsum earth*, or *gypsite*, which occurs in the west, contains earthy material up to 20%. *White sands*, or *gypsum sands*, occur in dunes or heaps in certain western states.

OCCURRENCE AND DISTRIBUTION IN MICHIGAN.

Gypsum occurs usually in beds associated with salt deposits, limestone and shale. Often there are many layers intercalated in the shales and associated rocks. The beds are usually more



Fig. 14. Sketch map showing location of gypsum producing areas and gypsum deposits.

or less lenticular, thickening and thinning and often pinching out. Sometimes the lentils unite and form one bed. They vary in thickness from a fraction of an inch to 50 feet or more, but usually commercial deposits as in Michigan run from 6 to 25

feet. There are three areas in Michigan where gypsum is mined or is known to occur in deposits of commercial importance; namely, the Grand Rapids-Grandville, the Alabaster or Alabaster-Turner, and the St. Ignace districts. (See figure 14.)

In the Grand Rapids-Grandville district there are usually three workable beds. The first, a 6-foot ledge, is quarried; the second, a 12-foot ledge, is both quarried and mined; and the third, a 22-foot bed, which is some 60 feet below the second, is mined. The upper ledge is often absent from erosion, and the second is sometimes very thin, apparently in some instances from solution. The various beds are overlain and separated mainly by shale, limestones, or sandstones. There are also many other smaller lentils of gypsum intercalated in the associated rocks. They vary in thickness from a few inches to 5 feet or more. The thick lower bed is really composed of two nearly equal beds, separated by a foot of dark shale. Up to 3 or 4 years ago, only the two upper beds had been developed, for it was currently supposed that water would be a serious obstacle to the mining of the deeper beds. Some of the companies, having exhausted their supply of easily accessible gypsum in the surface beds, sunk shafts into the 22-foot bed and found ideal mining conditions, for little or no water was found. At Grandville this lower bed (or another one) was 14 feet thick. From drill records it appears to be continuous and very uniform in thickness and, doubtless, will form the base of extensive mining operations in the future.

At Alabaster, there is quarried a single ledge 18 to 23 feet thick; covered toward Saginaw Bay only by 5 to 8 feet of gravel and toward the west by 9 to 11 feet of boulder clay. Toward the bay, the single thick bed was composed of two layers separated by a layer of hard fossiliferous limestone and shale which has disappeared with the progress of the quarrying to the westward. According to Prof. W. M. Gregory (Arenac county report, 1909), well drillers near Turner and Twining, Arenac county, have discovered the presence of another extensive bed of gypsum. Its depth below surface ranged from about 50 to 100 feet near Turner and Twining to that of an outcrop near the deserted village of Harmon City on Saginaw Bay. Drillers reported thicknesses varying from 6 to 22 feet. This bed, now called the Turner bed, generally lies from 50 to 100 feet or more above the Alabaster. Both beds are very persistent, and, dipping very gently to the southward, they almost certainly have been traced in wells into Bay City and Saginaw.

Prof. Gregory has mapped two probable workable areas, one

of which includes the district about Turner and Twining and the other, the region from Harmon City westward several miles. As the drift is rarely less than 30 feet in thickness and sometimes more than a hundred, the Turner bed in most cases will have to be mined instead of quarried.

Beds 5, 13 and 21 feet thick have been reported from the St. Ignace area but their extent and commercial value are unknown. A few miles north of St. Ignace there are deposits which appear to be of probable great value, especially in the region of St. Martins island and Rabbits Back point.

The Salina, or Lower Monroe, formation outcrops in the north Beaver islands and, according to Dr. Lane, there are many indications that the gypsum formation of the St. Ignace area extends westward to these islands, and that gypsum may be found in commercial quantities. Gypsum and anhydrite beds also occur in the Salina in southeastern Michigan, but they are too deep to be of commercial value.

The size of the Grand Rapids area is not well known on account of the depth of the overlying drift to the west and north of the city. Its known area of commercial importance is about 25 square miles, though the gypsum formation extends over a much larger area. The workable area in the Alabaster district proper was formerly estimated at 10 to 15 square miles. But the discovery of the Turner bed to the south in Arenac county has added two more workable areas. Drillings indicate that the Alabaster-Turner district, as it may be called, has a workable area of possibly 30 to 40 square miles out of a total area of 600 square miles of known gypsum formation in eastern Michigan.

The gypsum formation probably extends from Grand Rapids in an arc around to the north and connects with the Alabaster district on the eastern side of Michigan. The Alabaster area doubtless continues under Saginaw Bay into Huron county where gypsum has been found in wells and in the drift. Toward the south, in Tuscola county, the beds die out.

GEOLOGICAL HORIZONS.

The commercially important gypsum deposits occur in the Lower Grand Rapids series of the Upper Carboniferous and in the Monroe formation of the Silurian. The Grand Rapids-Grandville district and the Alabaster-Turner are in the former, and the St. Ignace, in the latter.

ORIGIN.

There are many theories explaining the formation of gypsum deposits such as "Deposition from sulphur springs and volcanic agencies," "Hunt's chemical theory," "Deposition through action of pyrites upon limestone," "Precipitation in rivers," "Alteration of anhydrite to gypsum," and "Gypsum deposited by evaporation in a Mediterranean or closed sea." No one theory is applicable to all deposits, but the theory of deposition in a Mediterranean or closed sea seems most applicable to the larger rock gypsum deposits such as those in Michigan.

If, in an arid climate, an arm of the sea, like the Karaboghay on the eastern side of the Caspian, is separated from the main body of water by a very shallow bar, we have conditions favorable for the deposition of gypsum. Evaporation is very great in the gulf and, as there are no rivers to supply the great loss from evaporation, a constant current flows (3 miles an hour) from the Caspian into the gulf. Conditions are thus like those in a huge evaporating pan with a constant inlet but no outlet. Concentration has already gone on until the amount of contained salts is many times that of the Caspian itself. Continued evaporation will eventually lead to a precipitation of salts as has already occurred in other, though smaller, arms of the Caspian.

In a closed sea, evaporation and consequent concentration would result in a deposition of all the salts. In Salt Lake we have such conditions, beds of salt being laid down during the dry season, muds and silts during the mountain freshets in spring. Thus there is an alteration of muds or sands and salt.

Gypsum is more soluble than limestone but less so than salt, so that, with increasing concentration, we would have limestone, gypsum, and salt deposited in order. Thus gypsum is usually below salt deposits.

The Michigan Sea was a great gulf for most of the time from the Ordovician to the end of the Carboniferous. At times, it approached the conditions of a Mediterranean or even a closed sea. In the Salina or Lower Monroe of the Silurian, conditions favored the deposition of both gypsum and salt. In the Lower Grand Rapids series of the Carboniferous, gypsum, but not salt, was deposited (unless afterwards carried away by solution), the concentration apparently not having been carried to such a degree as that in the Salina.

MANUFACTURE OF CALCINED GYPSUM.

The rock is crushed first in a jaw crusher and then in a pot crusher. Next it goes to a rotary kiln drier, which drives out about 10% of the moisture. After sieving in a rather coarse trommel to get rid of the coarser material, which is afterwards ground to the proper fineness in a buhr mill, the dry product is boiled in a four-flue kettle, so constructed that the flues carry the heat to the bottom and sides of the kettle and upward to the stack. A shaft propels stirrers below the flues and mixing paddles above, until the boiling expels all of the remaining free moisture. This preliminary boiling must not be above 265° F., or the combined water will begin to separate before the right conditions are obtained for proper calcination. To expel the necessary three-fourths of the water of crystallization, the heat is steadily raised up to a temperature varying from 330° F. to 420° F., but a temperature of 390° F. to 395° F. is more commonly employed. If the boiling is carried on at a temperature above 400° F. nearly all of the combined water will be driven off and the plaster will lose most of its setting properties. Such plaster is said to be "dead burnt" and is used where slow setting is required. When properly boiled, the plaster settles and is drawn off through a gate near the bottom of the kettle. It is then screened through a fine sieve and the coarser residue is ground in a finishing buhr mill.

GYPSUM PRODUCTS.

The numerous varieties of calcined plasters are made by the grinding and partial or complete dehydration of the crude product. There are two general classes of plasters, one partially and the other completely dehydrated.

All plasters burned at a temperature below 400° F. are quick setting, if pure, and may be included under the term *plaster of Paris*. If impure, either naturally or artificially, the plaster sets much more slowly. These are known as "*cement plasters*."

The class of plasters burned above 400° F. are completely dehydrated or "dead burnt." If pure, the gypsum rock produces *flooring plaster*. If certain substances (usually alum or borax) have been added to the pure gypsum, a *hard finish plaster* is the result.

There are various trade names given to special forms of the above plasters. Stucco is almost synonymous with plaster of Paris, though the latter is usually more finely ground. Wall plasters are made by adding hair or wood fibre, as well as retarder, to the

calcined plaster. "Board plaster" or plaster-board, widely used because of its convenience, is pressed from plaster interlaminated with thin sheets of cardboard. Hollow blocks and tiles are made from plaster, mixed with suitable fibre, and these, as well as the plaster-board, are used in fire-proofing buildings.

Wall plasters are of two general grades, one a brown or gray coat, and the other a white or a tinted one for finishing. All gypsum wall plasters are commonly mixed with wood fibre or hair filler. These plasters are superior to the old time plasters, but their quick setting qualities makes experience in handling them necessary to get the best results.

Keene's "cement," Parian "cement," etc., belong to the group of dehydrated plasters and are used as hard finishes in buildings. Keene's cement is the base for artificial marble, oramental castings, etc.

Gypsum is also used in calomines, water paints, and dry colors, such as the Venetian reds. Ordinary paints often contain so much gypsum that it is considered an adulterant.

PRODUCTION.

In the early days, most of the gypsum mined was ground into land plaster. The unlimited supply of gypsum in Michigan soon enabled the producers to more than meet the demand for land plaster. The bulky nature and the low price of the product did not permit shipments for any great distances, so that the producers were forced to turn their attention to the manufacture of the calcined product. With the introduction of the new methods and the flue kilns from New York in 1871, the calcining of gypsum became the more important industry. After 1887 the calcined product always exceeded in amount that of the land plaster which has now become a product of little importance, when compared with the former.

In 1892, the demand for gypsum plasters in the construction of the temporary buildings at the World's Fair at Chicago gave a great impetus to the industry. The wide spread use of such plasters as plaster of Paris, floor, "cement," and wall plaster, has since raised the production of 66,000 tons in 1895 to the high water mark of 394,000 tons in 1909. This was surpassed only by New York which mined 403,000 tons. In 1868 the total production was valued at \$165,000, that of 1909 at more than \$1,200,000. The total production in 1910 was considerably less, being but 357,000 tons. As the market price in Michigan was slightly

lower in 1910, the value was correspondingly less, being only \$667,000. New York, on the other hand, increased her production to more than 467,000 tons, valued at about \$1,500,000.

Although the World's Fair trade gave a great impetus to the gypsum industry in Michigan, it was not until 1901 that the remarkable growth began. Up to this time, the industry was in the hands of individuals, or separate companies. Competition had kept profits down to such a point that proper equipments for mining and manufacturing were not possible. In 1901, the era of consolidation began with the incorporation of some of the mills with the United States Gypsum Company. The consolidation of interests has continued, until the gypsum industry has been placed upon a sound financial and industrial basis. The mines of the state are now owned or controlled by a few large companies which mine and manufacture with equipments much superior to those possible under the old regime of individual operators. A glance at the table of production (Figure 15) shows that the production of 1900 had been trebled in the short interval of nine years, following the consolidation in 1901.

Most of the crude gypsum mined in Michigan is calcined into the various plasters, such as plaster of Paris, stuccos, wall, floor, and "cement" plasters. Only a few thousand tons was ground into land plaster. A large amount of crude gypsum is sold to cement factories for use in making Portland cement. A smaller amount is sold to paint factories for use as a pigment. Glass factories use large quantities as a flux. The finer grade of the calcined plaster is used for bedding in grinding plate glass. A smaller quantity finds its way into dental cement. The Alabaster variety of gypsum is much used by sculptors and artisans in interior decorations.

Although Michigan has produced more than 5,300,000 tons of gypsum, valued at nearly \$16,000,000, its deposits even in the two districts of Grand Rapids-Grandville and Alabaster-Turner have been hardly more than opened up. The full extent of the minable gypsum in these areas is, as yet, unknown. The St. Ignace area has been little prospected, but it has gypsum deposits of very probable great commercial value. With these almost inexhaustible supplies and with the industry already on an established basis, Michigan bids fair, for many years to come, to be one of the leading gypsum producing states in the country.

TABLE SHOWING PRODUCTION OF GYPSUM IN MICHIGAN.

Year.	Ground into land plaster. Tons.	Gypsum calcined into plaster. Tons.	Sold crude. Tons.	Total production. Tons.	Total value.
Before 1868.....	132,043	14,285		146,328	\$671,022
1868.....	28,837	6,244		35,081	165,298
1869.....	29,996	7,355		37,351	178,824
1870.....	31,437	8,246		39,683	191,718
1871.....	41,126	8,694		49,820	234,054
1872.....	43,536	10,673		54,209	259,524
1873.....	44,972	14,724		59,696	297,678
1874.....	39,126	14,723		53,849	274,284
1875.....	27,019	10,914		37,933	195,386
1876.....	39,131	11,498		50,629	248,504
1877.....	40,000	9,819		49,819	238,550
1878.....	40,000	8,634		48,634	229,070
1879.....	43,658	9,070		52,728	247,192
1880.....	49,570	18,929		68,499	349,710
1881.....	33,178	20,145		53,323	293,872
1882.....	37,821	24,136		61,957	344,374
1883.....	40,082	28,410		68,492	377,567
1884.....	27,888	27,959		55,847	335,382
1885.....	28,184	25,281		53,465	286,802
1886.....	29,373	27,370		56,748	308,094
1887.....	28,794	30,376		59,170	329,392
1888.....	22,177	35,125		57,302	347,531
1889.....	19,823	36,800		56,623	353,869
1890.....	12,714	47,163	15,000	74,877	192,099
1891.....	15,100	53,600	11,000	97,700	223,725
1892.....	14,458	77,599	47,500	139,557	306,527
1893.....	16,263	77,327	31,000	124,590	303,921
1894.....	11,982	47,976	20,000	79,958	189,620
1895.....	9,003	51,028	6,488	66,519	174,007
1896.....	6,582	60,352	700	67,634	146,424
1897.....	7,193	71,680	16,001	94,874	193,576
1898.....	13,345	77,852	1,984	93,181	204,310
1899.....	17,196	88,315	39,266	144,776	283,537
1900.....	10,354	86,972	33,328	129,654	285,119
1901.....	9,808	129,256	46,086	185,150	267,243
1902.....	13,022	158,320	68,885	240,227	459,621
1903.....	18,409	198,119	52,565	269,093	700,912
1904.....	18,294	185,422	34,669	238,385	541,197
1905.....	20,285	203,313	24,284	247,882	634,434
1906.....	30,220	208,715	27,517	341,716	753,878
1907.....	15,500	197,666	36,543	317,261	681,351
1908.....	11,414	192,403	40,324	327,810	491,928
1909.....	11,890	344,171	45,781	394,907	1,213,347
1910.....	7,097	240,905	64,566	357,174	667,199
1911.....	15,548	206,299	79,050	347,296	523,926
Total.....	1,184,452	3,402,863	717,253	5,669,317	\$16,244,490

See Michigan mining statistics 1891 for further data.

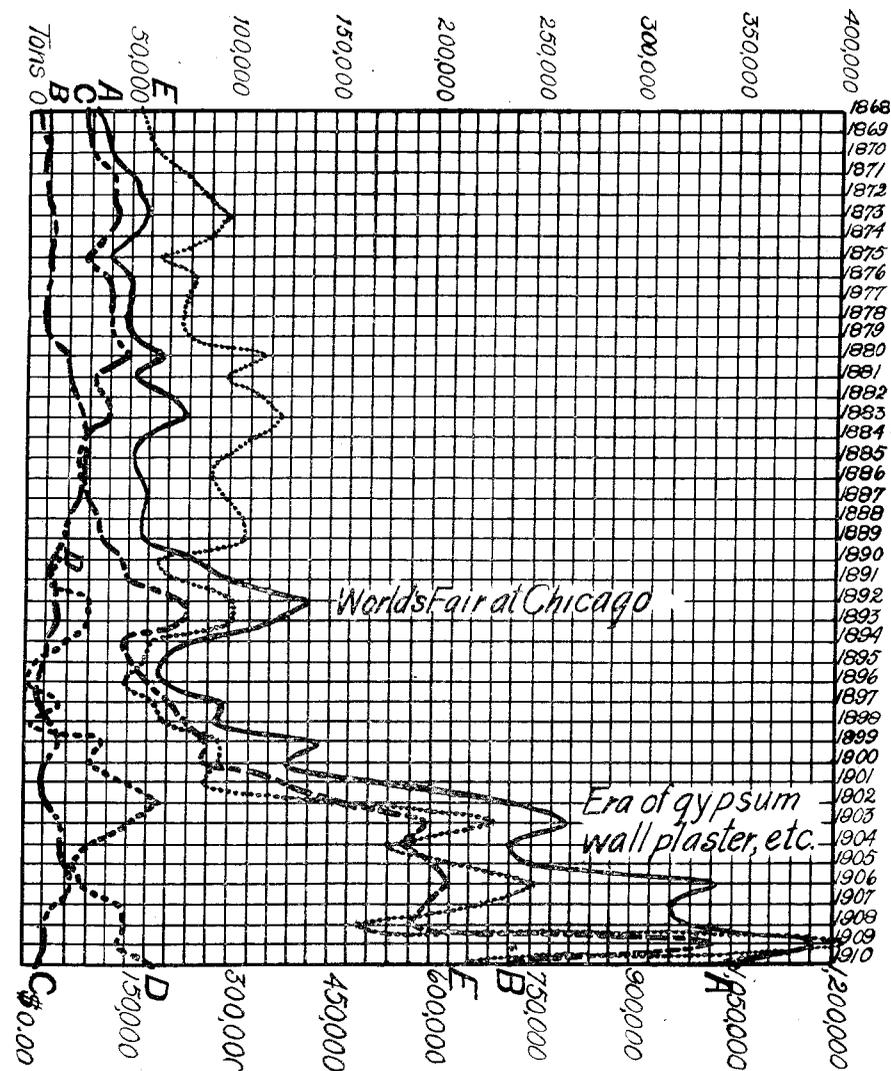


Fig. 15. Graphic representation of the annual production of gypsum, gypsum products, and values, 1868-1910.

- A. Total mined.
 B. Total calcined into plaster.
 C. Total ground into land plaster.
 D. Total sold crude to cement and to glass factories, etc.
 E. Total value of gypsum and gypsum products.

THE SALT INDUSTRY OF MICHIGAN.

BY C. W. COOK.

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 Michigan Salt Works.
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 Pennsylvania Salt Manufacturing Co.
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 Bibliography.

 HISTORICAL.

Two periods of development are to be noted in the salt industry of Michigan; the first covering the time from the admission of Michigan into the Union until 1859, the second, from 1859 to date. The first period was one of governmental initiative and was a complete failure; the second period has been characterized very largely by private initiative and has been as markedly successful as the previous period was the reverse.

By the statehood act of 1836, the state of Michigan was permitted to reserve seventy-two sections of saline lands. Immediately, preparations were made for the selection and development of these lands, among which were areas on the Grand River in Kent county and on the Tittabawassee River in Saginaw county. The sinking of wells was begun at each of these localities but after the expenditure of considerable money both undertakings were abandoned. Next, an attempt was made to lease the lands to individuals on a royalty basis, but this was likewise unsuccessful.

Although the state attempted to stimulate the interest of individuals by offering a bounty on all salt produced within the state, yet the disgraceful action of the state in attempting to evade payment of the bounty, renders the less said of it the better.

The first successful attempt to manufacture salt in Michigan was made by the East Saginaw Salt Manufacturing Co. in 1859. The success of this company led to a rapid development of the industry in the Saginaw Valley where the blocks were operated in connection with sawmills. The industry soon spread to Midland and St. Louis and the lumbering towns on the shores of Lake Huron, such as Caseville, Pt. Crescent, Pt. Austin, New River, Pt. Hope, Harbor Beach, and White Rock on the south side of Saginaw Bay; and Tawas City, East Tawas, Au Sable, and Oscoda to the north.

At first the kettle process was used, slabs and saw-dust being employed for fuel. The rapid development of the industry was however not confined to an increase in the number of blocks but improvements in manufacture soon appeared and the kettle process was forced to give way to the open pan and grainer processes.

That the salt industry was very largely dependent upon lumber is shown by its decline as the timber was used up. All of the lake shore plants have long since disappeared and in some instances such as Pt. Crescent and New River the towns themselves no longer exist. Within the Saginaw Valley itself, the industry is on the wane as is shown by the fact that now there is not one block where formerly there were ten.

Correlative with the decline of the industry in the Saginaw Valley, has been the rise of the Ludington-Manistee district and the region along the Detroit and St. Clair rivers.

As in the case of the Saginaw Valley, the production of salt in the Ludington-Manistee district has been very closely associated with the manufacture of lumber. Only one company, the Anchor Salt Co. of Ludington, is operated independent of the saw-mills. The history of the district also shows that when a company has cut all of its timber the salt block which was operated in connection with the saw-mill has been closed.

From the standpoint of improvements in manufacture, this district has made as rapid strides as it has in increasing its production. It was here that the vacuum pan was first employed in Michigan in the manufacture of salt and it was also the first district to employ the "double effect" and "triple effect" pans. As the last step, there has been installed during the past year a "quadruple pan."

The development of the industry along the St. Clair and Detroit rivers is distinguished from that of the other districts in that its growth has been independent of the lumber industry. This has been possible very largely through the manufacture of table salt, the entire output of which, for the state, comes from this district. Also this district has another advantage in a lower freight rate on coal. One feature of the industry here which has been developed nowhere else in the state is the sinking of a shaft to mine rock salt. The shaft is located at Oakwood in Wayne county and is fully described in the Engineering and Mining Journal for March 18, 1911, pp. 565-569.

RAW MATERIALS.

With the exception of the rocksalt produced at Oakwood, salt is manufactured in Michigan by the evaporation of brines, both natural and artificial. At various times, three different natural brines, each of which is obtained from a sandstone, has been employed. These brine-bearing sandstones are the Parma, the Napoleon, and the Berea.

The Parma brine, while no longer used on account of its being weaker than the underlying Napoleon brine, is characterized by its purity. As may be seen from the analyses in Table I, it is distinguished from the Napoleon and Berea brines by a higher percentage of calcium sulphate relatively to the earthy chlorides. This brine was one of the first used in Michigan and its utilization was limited to the Saginaw Valley.

TABLE I.

	1.	2.	3.	4.	5.
Calcium sulphate.....	3.951	.....	.....	0.129	0.33
Calcium chloride.....	5.302	41.1	83.00	31.274	110.00
Magnesium chloride.....	4.115	17.6	31.00	15.675	33.47
Magnesium bromide.....	.....	0.712	1.00	.....	.....
Ferric oxide and Alumina.....	.....	.....	.....	.....	1.14
Ferrous chloride.....	.....	0.050	Trace.	.....	.....
Sodium chloride.....	152.674	167.3	141.00	176.161	186.19
Total solids.....	166.052	226.675	256.00	232.803	331.73

1, 2, 3, and 4 represents grams per kilogram.

5 represents grams per litre.

1. Parma brine from Gilmore well, Bay City, Michigan. Analysis by Dr. A. C. Goesmann, October, 1862. (Geol. Sur. of Mich. Vol. III, p. 181.)

2. Napoleon brine from Saginaw Salt Co., St. Charles, Michigan. Analysis by J. C. Graves, furnished by O. C. Diehl.

3. Marshall brine from the Dow Chemical Co., Midland, Michigan. Analysis furnished by H. W. Dow.

4. Berea brine from the Ayres well, Pt. Austin, Michigan. (Geol. Sur. of Mich., Vol. III, p. 183.)

5. Berea brine from the North American Chemical Co., Bay City, Michigan. (Geol. Sur. of Mich. report 1905, p. 388.)

The Napoleon brines (Nos. 2 and 3, Table 1) which are the source of the salt of the Saginaw Valley, are characterized by the small percentage of calcium sulphate and the presence of considerable amounts of bromine. It will be noted that the amount

of bromine and earthy chlorides increases relatively to the sodium chloride as we go toward the center of the basin. While no analyses are available, Dr. Dow informs me that there is a considerable increase at Mt. Pleasant over Midland.

The Napoleon sandstone is found at a depth of about 650-800 feet at Saginaw, 800 feet at Bay City, 1,300 feet at Midland, and 1,400 feet at Mt. Pleasant.

Besides salt, a number of other products are obtained from this brine. The Dow Chemical Co., of Midland manufactures a large number of chemicals, among which may be mentioned, bromine, bromides, bleaching powder, and chloroform; the Van Schaack Calcium Works of Mt. Pleasant produces bromine and calcium chloride; the Saginaw Plate Glass Co. has recently installed apparatus to recover the calcium chloride from the mother liquors from the salt block; and the North American Chemical Co. of Bay City uses the brine in the preparation of chlorates.

The Berea brine (Nos 4 and 5, Table 1) was used by the plants along the lake shore in Huron and Iosco counties. It contains an appreciable amount of bromine, not shown in the analyses, which was recovered from the bittern at some of the plants.

The artificial brines, employed in the Ludington-Manistee and Detroit-St. Clair rivers districts, are formed by solution of the rock salt of the Salina formation. In the former the flow of ground water in the super-imposed strata is sufficient to form the brine and the pumping is done mostly with compressed air. At most of the plants in the southeastern part of the state, it is necessary to pump water into the wells and the brine when formed is forced up by water pressure.

At Ludington and Manistee the salt layer has a thickness of 20 to 30 feet and is found at a depth of about 1900 feet at Manistee and 2,300 feet at Ludington. It has been thought that but one bed existed in this district.¹ However, the No. 4 well of the Anchor Salt Co. at Ludington shows the presence of four beds, respectively 20, 12, 7, and 5 feet in thickness. The extent of this area is not known, but wells at Frankfort and Muskegon, which should have pierced it had it been present, failed to disclose any salt.

The salt beds of the southeastern area are much greater both in number and thickness, one being over 250 feet thick. In a general way they seem to dip away from the Cincinnati anticline and to increase in thickness along the dip. How far this increase continues we do not know, as no records are available beyond

¹A. C. Lane, Geol. Sur. Mich., Ann. Rep. for 1908, p. 59.

Royal Oak, where nine beds have an aggregate thickness of 609 feet.

Another area in which rock salt has been found in considerable quantities, but has not, as yet, been exploited, is in the vicinity of Alpena. Five beds of salt with streaks of anhydrite here show an aggregate thickness of over 300 feet.

Although we have no positive evidence on the subject, from a consideration of the general geology of the state and the apparent increase in thickness of the beds along the dip, it seems reasonable to believe that these three areas are but portions of one larger area. Rock salt is therefore likely to be found anywhere within lines joining the outer limits of the different proved areas.

The composition of the brines may be seen from the following analyses:

	1.	2.
Specific gravity.....	1.138	.....
Calcium sulphate.....	5.66	2.3
Calcium chloride.....	.....	1.0
Magnesium sulphate.....	.....	.....
Magnesium chloride.....	2.015	0.7
Sodium chloride.....	247.4	265.7
Total solids.....	255.075	269.7

The above represents grams per kilogram.

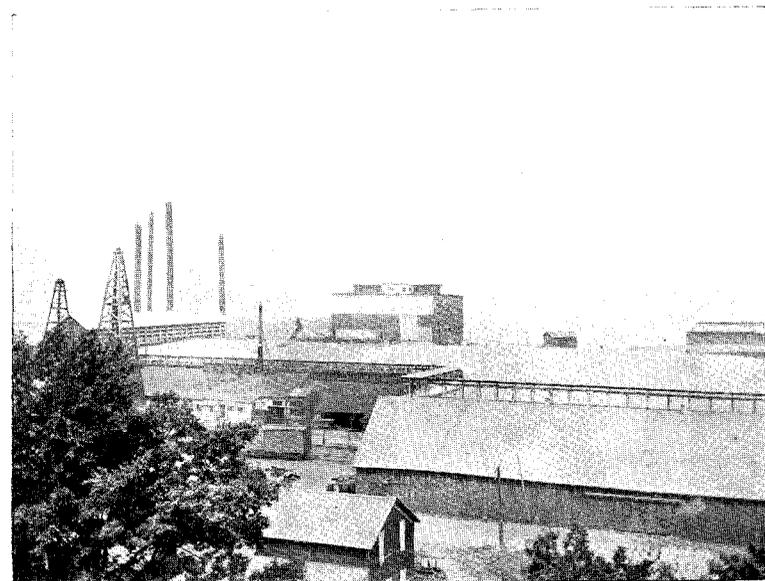
1. Filer and Sons, Filer City, Michigan. Analysis by W. and H. Heim, Saginaw, Michigan. Analysis furnished by Mr. E. G. Filer.

2. Michigan Salt Co., Marine City, Michigan. Analysis by Robt. E. Devine, Detroit, Michigan. Analysis furnished by Mr. S. C. McLouth.

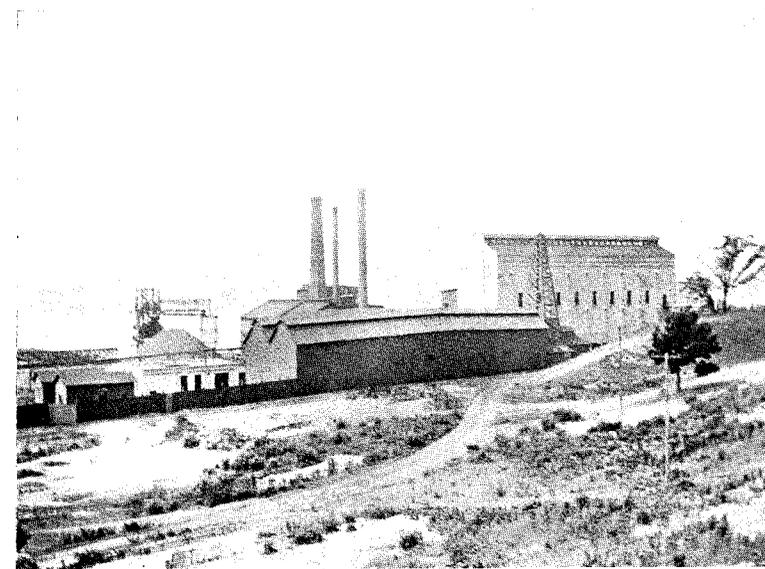
EVAPORATING METHODS.

Four different types of apparatus are employed in Michigan for the evaporation of the brines, namely, the open pan, the grainer, the vacuum pan, and the Allsberger system.

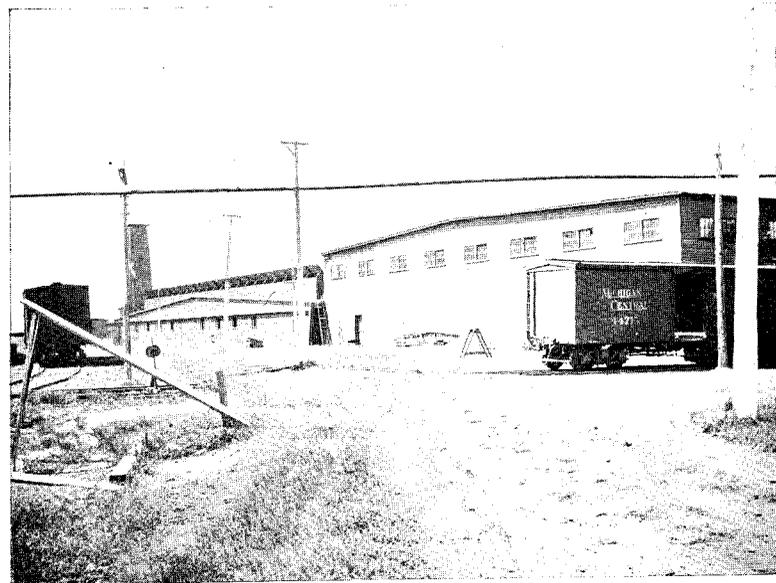
The open pan is made of quarter-inch boiler plate iron riveted together to form a shallow pan, 80 to 90 feet long, 18 to 20 feet wide, and about 12 inches deep, with flanging sides bolted to draining boards, which are about three feet wide and inclined toward the pan. The pan is supported on three sides by brick walls, while the fourth side is occupied by the furnace. The two methods of applying the heat are in use. In one, the heat passes from the



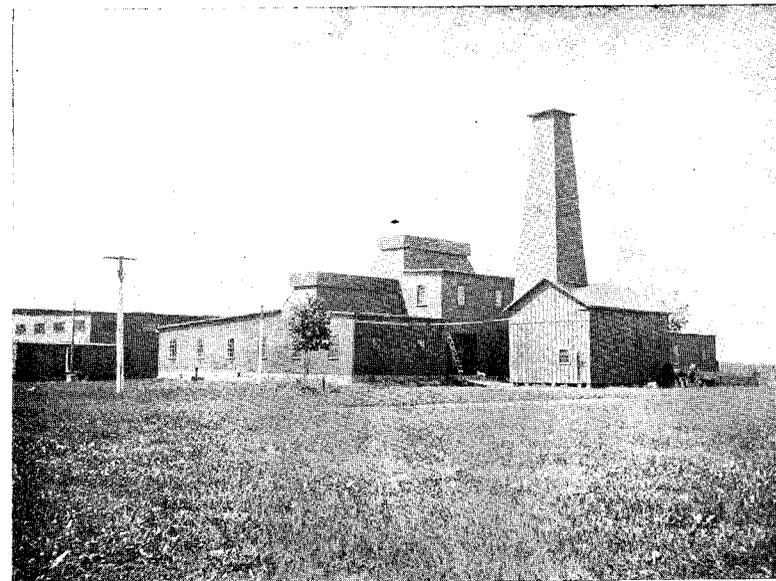
A. SALT PLANT OF THE R. G. PETERS SALT AND LUMBER COMPANY.



B. ANCHOR SALT COMPANY PLANT, LUDINGTON, MICHIGAN.



A. GRAINER BLOCK. SAGINAW PLATE GLASS COMPANY, SAGINAW, MICHIGAN.



B. CHEMICAL PLANT. SAGINAW PLATE GLASS COMPANY, SAGINAW, MICHIGAN.

furnace at the front to the chimney in the rear; in the other, the space under the pan is partitioned off into three flues. Two of these pass from the furnace to the back of the pan, where they open into the third flue which returns the smoke and heated gases to the chimney, located beside the furnace.

As the evaporation takes place at or near the boiling point, the formation of the salt is very rapid, and it is raked onto the draining boards as fast as formed. This constant removal of salt is necessary not only to prevent its baking, but also because when left it forms a coating which retards the conduction of the heat to the brine and therefore increases the fuel consumption.

The grainer consists of a rectangular vat, 40 to 160 feet long, 8 to 18 feet wide, and 14 to 24 inches deep, near the bottom of which are placed pipes through which steam, either live or exhaust, is conducted. As the water evaporates from the brine, the salt crystallizes out at the surface and then sinks to the bottom of the grainer from which it is either constantly removed by automatic rakers or is allowed to accumulate for twenty-four or forty-eight hours and then removed with shovels. The earlier grainers were constructed of wood. More recently, steel and cement have been employed in their construction.

The vacuum pan consists of a vertical steel cylinder tapering at both ends, in the middle of which is a steam belt, through which the brine tubes pass, with a large tube in the center. A partial vacuum is maintained in the pan so that the boiling point of the brine is considerably lowered. If the pan is run "single effect," the steam formed by the evaporation is taken care of by a condenser. On the other hand, when two or more pans are run in "multiple effect" the steam formed in the first pan is conducted to the belt of the second pan on which a greater vacuum is carried, and is used to furnish the heat for the second pan. The steam from the evaporation in the second pan may be carried to the belt of a third pan and so on. The quadruple effect pan is now in operation in Michigan although in this case the pans differ somewhat from the others in that they are rectangular in shape. The central opening in the steam belt is also rectangular and the brine tubes are inclined. The salt as it forms drops to the bottom of the pan and is removed by a bucket elevator.

The Allsberger system is employed by only one plant. The principle involved is that of preheating the brine under pressure and then running it into pans in which the deposition of the salt takes place without the further addition of heat. The ground plant of the pans resembles a figure eight, with a major diameter

of 88 feet and a minor diameter of 44 feet. The depth is 12 inches. In each loop of the pan are revolving arms which sweep the salt into a well in the bottom of one loop from which well the salt is drawn off into a centrifuge and separated from the brine.



Fig. 16. Map showing producing salt districts of Michigan. Circles represent present producing districts. Crossed circles represent former producing districts.

INSPECTION AND GRADING.

All salt manufactured in Michigan is subject to state inspection. This inspection is under the supervision of the state salt inspector and his deputies. It is their duty to see that the salt is properly aged, that the weights are correct, and to grade the product, the inspector placing his seal upon each package. The

classification of salt used in Michigan is table and dairy, granulated, medium, and packers. Also the salt is graded on the basis of quality into No. 1, and No. 2, these grades applying only to the granulated, medium and packer's. No. 2 grade is any of the above which were intended for No. 1 but have been contaminated in some way so as to show discoloration. The classification into granulated, medium and packer's is on the basis of the size of the particles, the granulated being the finest and the packer's the coarsest. Table and dairy salt are made from either granulated or medium by drying and sizing, either with tubular screens or patent separators. In some instance small amounts of foreign substances are added to certain brands of table salt to prevent caking.

LIST OF COMPANIES.

BUCKLEY AND DOUGLAS LUMBER Co., Manistee, Mich. Incorporated, December 31, 1892. Edward Buckley, Pres., Treas., and Gen. Mgr.; T. J. Elton, Sec.

The production of salt was begun in August, 1897 at what is now the No. 1 plant. As in the case of all the plants in the Manistee district, salt is manufactured from an artificial brine formed by dissolving the rock salt of the Salina formation. Both the vacuum pan and grainer processes are employed in evaporating the brine which is supplied by four wells, the salt being struck at 1,985 feet. The grainer block contains fifteen cement grainers (12' x 150' x 22") twelve of which produce medium salt and three (using the tail-water from the other grainers) produce packer's salt. The vacuum pan block contains two single effect pans with a diameter of eleven feet. Both exhaust and live steam are used to supply the heat and some coal is employed in addition to the offal from the saw-mill for fuel. The annual capacity of the plant is 672,000 barrels and the storage capacity, 450,000 barrels. 175 men are employed in operating the plant.

The No. 2 plant was formerly the plant of the State Lumber Co., which was taken over by the Buckley and Douglas Co. in the fall of 1910. At this plant, only the grainer process is employed. The evaporation is carried on in seventeen wooden grainers (10.5-12' x 170' x 14") the brine being furnished by three wells ranging in depth from 1,993 to 2,003 feet. The heat used in evaporating the brine is obtained chiefly from exhaust steam from the saw-mill. The annual capacity is 290,000 barrels and the storage capacity, 75,000 barrels. About sixty men are employed.

FILER AND SONS, Filer City, Manistee county, Michigan. Not incorporated. E. G. Filer, Managing partner.

The production of salt by this company was begun in 1888. The salt block contains one B vacuum pan 13 feet in diameter with a daily capacity of 700 barrels. The brine is obtained from one well which reaches the rock salt at a depth of 1,955 feet, the salt bed having a thickness of 31 feet. The evaporation is carried on with exhaust steam from the saw-mill, the output being about 500 barrels per day when operating. The storage capacity is 80,000 barrels and 50 men are employed.

R. G. PETERS SALT AND LUMBER CO., East Lake, Manistee county, Michigan. Incorporated March 2, 1884. Capital Stock, \$1,000,000. R. G. Peters, Pres.; Wm. H. Anderson, Vice-pres; A. W. Farr, Sec.; J. R. Peters, Asst. Sec. and Treas.

This plant which is operated in connection with the saw-mill contains both vacuum pan and grainer blocks. The grainer block contains twenty-one wooden grainers (16' x 120' x 22") with a daily capacity of 4,500 barrels of medium salt. They are operated at about 60% capacity. The vacuum pan block contains three pans, thirty feet in diameter, run "triple effect," with a daily capacity of 3,200 barrels. The vacuum pans are run at about 50% capacity. The brine is furnished by seven wells which reach the rock salt at 1,980 to 1,985 feet. The thickness of the bed varies from 20 to 30 feet in the different wells with a tendency toward the lower value. The storage capacity is 325,000 barrels, and 220 men are employed in operating the plant.

LOUIS SANDS SALT AND LUMBER CO., Manistee, Michigan. Incorporated March 16, 1905. Capital stock, \$1,000,000. R. W. Smith, Pres., and Gen. Mgr.; Isabella Sands, 1st Vice-Pres.; Louis M. Sands, 2nd Vice-President.; Geo. M. Clifton, Sec; Geo. M. Burr, Treas.

Two plants are operated by this company, both in connection with saw-mills. The No. 1 plant consists of a grainer block containing fifteen cement grainers (12' x 150' x 22"). The brine is furnished by two wells, respectively 2,012 and 2,014 feet in depth. The annual capacity is 200,000 barrels and the storage capacity, 67,000 barrels. About 100 men are employed.

The No. 2 plant (formerly the Rietz plant and the first producer in the district) contains eleven grainers (10'-12' x 150' x 20"). The brine is supplied by two wells respectively 1,962 and 1,969 feet in depth. The thickness of the salt in these wells is 32 feet. The annual capacity is 175,000 barrels and the storage capacity, approximately 70,000 barrels.

ANCHOR SALT Co., Ludington, Michigan. Joy Morton, Pres.; Mark Morton, Vice-Pres.; Sterling Morton, Sec.; Daniel Peterkin, Treas.

This company is the only one in the Ludington-Manistee district operating independently of the lumber industry. The vacuum pan process is employed the evaporation being carried on in three pans (18, 19, and 20 feet in diameter), run "triple effect." Live steam is used entirely with coal for fuel. The brine which as in the case of the Manistee district, is formed by the solution of the rock salt of the Salina formation, is supplied by five wells ranging in depth from 2,286 to 2,404 feet. The daily capacity of the plant is 2,000 barrels and the storage capacity, 156,000 barrels. The plant is operated only a portion of the year and employes about sixty men.

STEARNS SALT AND LUMBER CO., Ludington, Michigan. Capital stock, \$500,000. J. S. Stearns, Pres.; W. T. Culver, Vice-Pres. and Gen. Mgr.; R. L. Stearns, Sec.-Treas.

The Stearns company operates two plants. The No. 1 plant contains both grainer and vacuum pan blocks. The grainer block consists of nineteen wooden grainers (12' x 150' x 22") with an average daily capacity of 1,000 barrels. The vacuum pan block contains a single effect pan twelve feet in diameter. Exhaust steam is employed in both the grainer and vacuum pan blocks, the steam being obtained from the saw-mill and the Stearns Light and Power Co. The brine is furnished by five wells having a depth of about 2,300 feet. The storage capacity is 167,000 barrels. Eighty men are employed.

At the No. 1 plant an experimental quadruple effect vacuum pan of the Fallar type has been installed by the Rapid Evaporator Co., Detroit, Michigan, for the operation of which the Stearns company furnishes the brine and steam.

The No. 2 plant which is leased from the Cartier Lumber Co., contains six wooden grainers (12' x 150' x 22"). There are no wells connected with this plant, the brine being furnished by the No. 1 plant. The daily capacity is 400 barrels and the storage capacity, about 20,000 barrels. Twenty men are employed.

NORTH AMERICAN CHEMICAL Co., Bay City, Michigan. Capital stock, \$1,000,000. John Brock, Pres.; W. L. Davies, Gen. Mgr.

A grainer block and a vacuum pan block are operated by this company to utilize the exhaust steam from the chemical works. The grainer block contains eight wooden grainers (11' x 144' x 22") and the vacuum pan block contains two twelve-foot single effect pans. The brine which is the natural brine of the Napoleon

sandstone, is furnished by twenty-five wells having an average depth of 950 feet. About thirty-five men are employed.

MERSHON, BACON AND Co., Bay City, Michigan. Capital stock, \$50,000. A. W. Bacon, Pres.; E. C. Mershon, Vice-Pres.; W. B. Mershon, Sec.-Treas.

This company operates a small grainer block in connection with their saw-mill. It consists of four wooden grainers (12' x 145' x 18") with a daily capacity of about 90 barrels of packer's salt. The Napoleon brine is employed and is supplied by three wells having a depth of approximately 1,000 feet. Five men are employed in the salt block.

THEO. HIME & Co., Bay City, Michigan.

This company operates in connection with a planing mill, a small salt block containing two wooden grainers, (12' x 150' x 18"). The brine (Napoleon) is furnished by one well. The capacity of the block is about 50 barrels per day and four men are employed.

SAGINAW PLATE GLASS Co., Saginaw, Michigan. Incorporated, December, 1909. W. J. Wicks, Pres.; A. D. Eddy, Vice-Pres.; Geo. C. Eastwood, Sec.-Treas.

The salt block of this company contains twelve grainers (12' x 150' x 18" sloping to 21"). Exhaust steam from the glass works is used to evaporate the brine which is that of the Napoleon sandstone and which is supplied by ten wells ranging in depth from 893 to 917 feet. A chemical plant for recovering the calcium chloride from the mother liquors was recently installed. The daily capacity is about 1,000 barrels, both medium and packer's salt being manufactured. Fifteen men are employed.

BRAND AND HARDIN MILLING Co., Saginaw, Michigan. Incorporated, June 16, 1908. Capital stock, \$50,000. J. F. Brand, Pres.; C. H. Brand, Vice-Pres.; W. E. DeWitt, Sec.-Treas.

The salt block of this company is the only one in the Saginaw Valley which is not operated in connection with some other industry. It contains two wooden grainers (10' x 120' x 22") with a daily capacity of 100 barrels. The brine is supplied by one well having a depth of about 800 feet. Live steam is used to evaporate the brine and the salt is removed from the grainers by hand. Six men are employed in operating the plant.

BLISS AND VAN AUKEN (Arron P. Bliss and W. G. Van Auken), Saginaw, Michigan.

This company operates, in connection with their saw-mill, a small salt block containing two wooden grainers (10' x 170' x 18") with a daily capacity of 100 barrels. The brine is supplied by four wells ranging depth from 800 to 1,008 feet, and exhaust steam from

the saw-mill is used in evaporating the brine. The storage capacity is 12,000 barrels. Six men are employed.

E. GERMAIN, Saginaw, Michigan.

The salt block of E. Germain is operated in connection with a planing mill and a piano factory from which the exhaust steam used in evaporating the brine is obtained. There are four grainers (12' x 150' x 22") the brine for which is furnished by two wells 725 feet in depth. The daily capacity is about 100 barrels and the storage capacity, 8,400 barrels. Six men are employed.

MERSHON, EDDY, PARKER, Co., Saginaw, Michigan. Re-incorporated, February, 1909. Capital stock, \$500,000. F. E. Parker, Pres.; C. A. Eddy, Vice-Pres.; A. H. Hempstead, Sec.-Treas.

The plant of this company which is located in Carrollton Township, is operated in connection with the planing mill, box factory, etc., of the same company. The salt block contains four wooden grainers (10' x 112' x 18") with a daily capacity of 150 barrels. The brine is furnished by two wells with a depth of about 700 feet. The storage capacity of the plant is 5,500 barrels and five men are employed in operating the block.

S. L. EASTMAN FLOORING Co., Saginaw, Michigan. Incorporated, January 1, 1904. Capital stock, \$80,000. S. L. Eastman, Pres. and Treas.; W. H. Erwin, Sec.

The salt block of this company is located in Carrollton Township and contains four wooden grainers (8' x 110' x 18") with a daily capacity of 100 barrels. The brine is supplied by two wells, 740 feet in depth, the evaporation being carried on by exhaust steam from the flooring mill. Six men are employed.

SAGINAW SALT Co., Offices, Bay City, Plant, St. Charles, Michigan. Capital stock, \$50,000. Chas. Coryell, Pres.; F. T. Woodworth, Vice-Pres.; F. W. Urch, Sec.-Treas.

This company has two blocks located at the shafts of the Robt. Gage Coal Co., from which exhaust steam for evaporating the brine is obtained. Each block contains five wooden grainers (12' x 160' x 30") with a daily capacity of 150 barrels. The brine, that of the Napoleon sandstone, is furnished by two wells at each block. The wells have a depth of about 800 feet. The storage capacity at each plant is 20,000 barrels. Formerly bromine was recovered from the bittern. This practice has been discontinued, however, for the present.

PETER VAN SCHAAACK AND SONS, Offices, 140 Lake St., Chicago, Ill.; Plant, Mt. Pleasant, Michigan.

A small amount of salt is produced by this concern as a by-product in the manufacture of calcium chloride and bromine.

PORT HURON SALT Co., Offices, 717 Ry. Exchange Bldg., Chicago, Ill.; Plant, Port Huron, Michigan. Incorporated, January, 1900. Joy Morton, Pres.; Mark Morton, Vice-Pres.; Sterling Morton, Sec.; Daniel Peterkin, Treas.; Otto Huette, Gen. Mgr.

Two plants are operated by this company. The No. 1 plant is located at Port Huron and contains both a grainer and a vacuum pan block in addition to which the plant has apparatus for the manufacture of table salt. The grainer block contains nine grainers, five 18 feet wide and four 14 feet wide. The vacuum pan block contains one twelve-foot pan. Live steam supplied by fourteen Wicks boilers is employed in evaporating the brine which is obtained by dissolving the rocksalt of the Salina formation through the medium of eight wells. The wells have a depth of about 2,200 feet although the first salt bed is encountered between 1,500 and 1,600 feet. The annual production is about 400,000 barrels of which approximately one-half is table salt. The daily capacity is 3,000 barrels and the number of men employed is two hundred.

The Number 2 plant is located at St. Clair and was formerly operated by Thomson Bros. It is an open pan block containing five English direct heat pans (three, 18' x 77' and two, 18' x 87'). The brine is furnished by one well, about 1,700 feet in depth. Coal is used for fuel and about 40 men are employed in operating the plant.

DIAMOND CRYSTAL SALT Co., St. Clair, Michigan. Capital stock, \$650,000. C. F. Moore, Pres.; P. R. Moore, Vice-Pres.; F. Moore, Sec.-Treas.; H. Whiting, Gen. Mgr.

Three different processes, the vacuum pan, grainer, and the Allsberger, are employed by this company. The chief process is the Allsberger and the block contains five pans (44' x 88' x 12"). The grainer block contains six steel grainers and the vacuum pan block, one six-foot vacuum pan. Live steam, supplied by sixteen Wicks boilers, is used in evaporating the brine which is furnished by seven wells, ranging in depth from 1,630 to 2,200 feet. The daily capacity is 2,850 barrels. At present, the plant is operated at about fifty per cent capacity and about eighty per cent of the output is turned into table and dairy salt. 200 men are employed.

CRYSTAL FLAKE SALT Co., Ltd., Plant, Marine City, Michigan; Offices, Minneapolis, Minnesota, J. E. Vebleu, Pres.

The plant operated by this company contains six cement grainers (12' x 128' x 22"). Live steam is employed in evaporating the brine which is furnished by one well, 1,675 feet in depth. The average daily output is 45 tons of medium and 2.5 tons of packer's

salt. The storage capacity is 1,600 tons and the number of employes, eight.

DAVIDSON AND WONSEY, Marine City, Michigan. Capital stock, \$60,000. Jas. Davidson, Pres.; C. L. Doyle, Vice-Pres.; Palmer Davidson, Sec.-Treas.

The company operates a vacuum pan block containing two-single-effect pans, 12 feet in diameter. Live steam for the evaporation of the brine is furnished by five Marine boilers. The brine is supplied by two wells, respectively 1,750 and 1,900 feet in depth. The daily capacity is 140 tons and the storage capacity, 6,000 tons. Forty men are employed.

MICHIGAN SALT WORKS, Marine City, Michigan. Re-incorporated, 1903. Capital stock, \$100,000. Wm. A. Hazard, Pres.; Edwin J. O'Byran, Vice-Pres.; Sidney C. McLouth, Sec.-Treas.

The salt block is located about two miles south of Marine City and contains eight grainers, as follows: Two cement grainers (18' x 164' x 22"), two steel V-grainers (18' x 100' x 6'), one wood and three cement grainers (12' x 120' x 22"). Steam for evaporating the brine is furnished by five Marine boilers. The brine is supplied by two wells, respectively 1,630 and 1,851 feet in depth. The daily capacity is 800 barrels about twenty per cent of the output being turned into tablesalt. The storage capacity is 60,000 barrels and the number of employes seventy-five.

DELRAY SALT Co., Delray, Michigan. Incorporated, 1901. Capital stock \$100,000. N. W. Clayton, Pres.; A. A. Nelson, Sec.-Treas.; Jos. P. Tracy, Gen. Mgr.

This company operates both grainer and vacuum pan blocks and also manufactures table salt. The grainer block contains six cement grainers (16' x 160' x 22") and the vacuum pan block, three pans (respectively 9, 10, and 11 feet in diameter) run "triple effect." Live steam furnished by three 335 H. P. boiler is used in evaporating the brine supplied by two wells. The daily capacity is 2,000 barrels and the storage capacity 100,000 barrels. Fifty men are employed.

WORCESTER SALT Co., Ecorse, Michigan. Main offices, 168 Duane St., New York City, N. Y., Lorenzo Burdick, Pres. and Sec.

Both grainer and vacuum pan blocks are operated by this company. The grainer block contains eight iron grainers (12' x 140' x 22") and the vacuum pan block three ten-foot pans, two of which are run "double effect" and the third "single effect." Steam is furnished by six boilers and the brine is supplied by two wells, about 1,525 feet in depth. The company owns a third well but the

derrick is down. The daily capacity is 2,500 barrels and table salt constitutes about forty per cent of the output. Fifty men are employed.

PENNSYLVANIA SALT MANUFACTURING Co., Offices, 115 Chestnut St., Philadelphia, Pa.; Plant, Wyandotte, Michigan. Capital stock, \$10,000,000. Theo. Armstrong, Pres.; Austin Purvis, Vice-Pres.; J. T. Lee, Sec.; Arthur E. Rice, Treas.

Salt is manufactured by this company only as a by-product in the manufacture of caustic and bleach, the exhaust steam from the chemical plant being employed to evaporate the brine. One twenty-foot single effect vacuum pan is operated with a daily capacity of 200 tons.

DETROIT SALT Co., Offices, 1102-4 Penobscot Bldg., Detroit, Michigan; Plant, Oakwood, Michigan. John M. Mulkey, Pres.; A. E. Jennings, Sec.; Owen W. Mulkey, Treas. Receiver appointed, March, 1911.

This company operates a pan block containing six open pans with a daily capacity of 1,000 barrels. The heat is applied directly to the pans and coal is used as fuel. The brine is supplied by three wells. About one-third of the output is table salt. The storage capacity is 30,000 barrels and 125 men are employed.

The salt shaft at Oakwood was also sunk by this company. The depth of the shaft is 1,060 feet, the thickness of the salt bed at that point being twenty feet. For a complete description of the shaft and surface equipment the reader is referred to the Engineering and Mining Journal, March 18, 1911.

MORTON SALT Co., Offices 717 Ry. Exchange Bldg., Chicago, Ill.; Plant, Wyandotte, Mich. Joy Morton, Pres.; Mark Morton, Vice-Pres.; Sterling Morton, Sec.; Daniel Peterkin, Treas.

This company owns a grainer plant containing five wooden grainers. The steam is supplied by twelve 150 H. P. boilers and the brine by four wells. The plant has not been operated for several years.

PENINSULAR SALT Co., Offices, Detroit, Mich.; Plant, Ecorse, Mich.

The plant of this company was open pan affair. It has not been operated for several years and is in such state of repair that it is doubtful if it will ever be operated again.

WOLTON SALT ASSOCIATION, Pearl Beach, St. Clair Co., Mich.

Operations were never satisfactory and were suspended several years ago.

PRODUCTION.

The development of the salt industry in Michigan was so rapid, that, in 1876, after only sixteen years of production, the state became the leading producer of salt in the United States. This position it held until 1893, when New York reassumed first place. Since 1893, the leadership has vacillated between New York and Michigan, New York holding it during the years 1893-1900, 1902, 1910; and Michigan, during the years 1901, and 1905-09.

The annual production of salt in Michigan, from the foundation of the industry to 1911, as reported by the state salt inspector is given in Table I, column 3. Since these figures represent inspection rather than actual production, they are only approximate. In column 4, the figures, as given in Mineral Resources, U. S. G. S., are shown. From 1893 on, these statistics were obtained directly from the manufactures and therefore represent the true annual production. They also include the salt in the brine used in the manufacture of soda ash, etc., or what is known as "brine salt." While this salt is not produced in the solid form, yet it should properly be considered as part of the saline wealth of the state. The large discrepancy between the production as given by the state salt inspector and that given by the United States Geological Survey is due very largely to the inclusion of the "brine salt" by the latter.

Column 2 represents the total production of the United States, and column 4, Michigan's percentage of the total, based on data given by the United States Geological Survey. From this it will be seen that, since 1880, Michigan has never produced much less than one-quarter, with a number of years approaching one-half, and an average of nearly two-fifths of the entire production.

The table shows, that with one or two exceptions, the growth of the industry in Michigan was steady up to 1887. Then for a period of about six years the production remained practically stationary. This was probably due to the drop in prices and also to the increased competition from new districts. The big decrease of nearly one million barrels, in 1893, is more apparent than real and was due to a change in method of obtaining statistics. The decrease recorded in the inspection for 1804 was undoubtedly due to the tariff act of 1894, which placed salt on the free list. The competition of the imported salt with that of the eastern producers forced the eastern salt to seek a new outlet which brought it into closer competition with the western salt. By the tariff act of 1897, a duty was again placed on salt. The results of this act are reflected in the increased production of 1898, as shown by the increased inspec-

tion. The still greater increase recorded by the United States Geological Survey was due to the development of the soda ash industry in Wayne county. The sudden and enormous decrease of over three million barrels, in 1903, was due in part to the closing down of a large number of plants, as a result of the great drop in the market price the year previous, which resulted in a decrease in

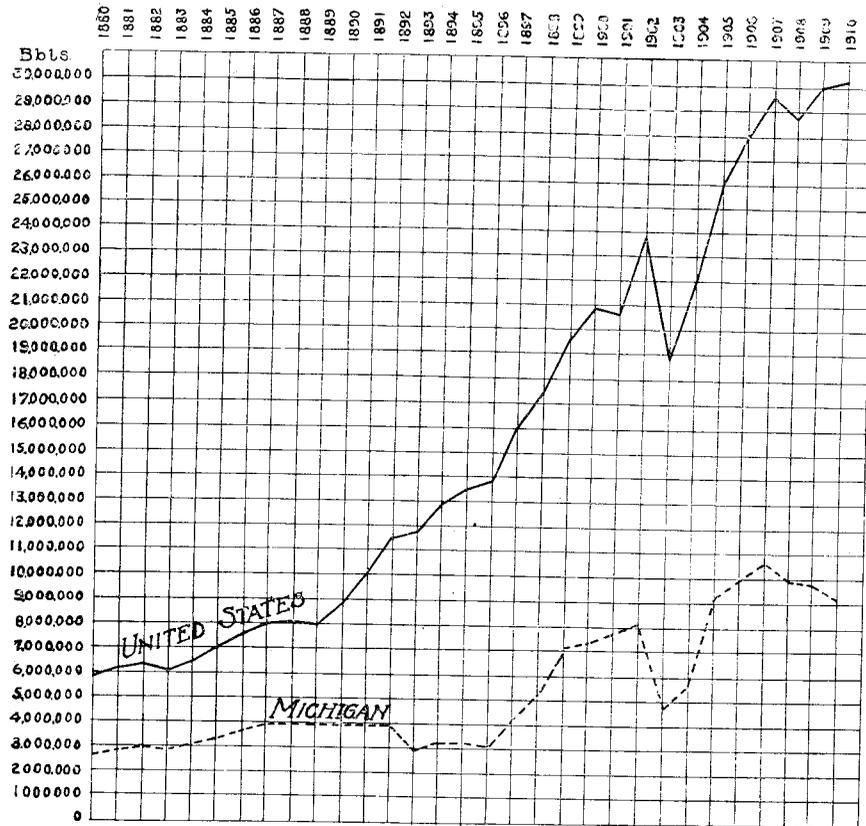


Fig. 17. Production curve for salt in Michigan and the United States.

manufacture of nearly a million barrels. The balance represents the decrease in brine salt. Although there was a decreased inspection in 1909, the salt inspectors report shows that there was an increase in production of over four hundred thousand barrels, in spite of the fact that a number of plants were closed either the whole or part of the year. However in 1910, with a decreased inspection of 450,000 barrels there was a decreased production of approximately 1,100,000 barrels. The fluctuations in the Michigan

production and their influence upon the United States production may be best seen from Fig. 17 in which the production curves for both Michigan and the United States are given.

TABLE I.

Year.	U. S. production.	Michigan production.		Per cent of total.	Value.	Price.
		State Salt Inspectors.	U. S. G. S.			
1860		4,000				
1861		125,000				
1862		243,000				
1863		466,000				
1864		529,073				
1865		477,200				
1866		407,997			\$734,395	\$1.80
1867		474,721			840,255	1.77
1868		555,690			1,028,027	1.85
1869		561,288			786,835	1.58
1870		621,352			820,185	1.32
1871		728,175			1,063,135	1.46
1872		724,481			1,057,742	1.46
1873		821,346			1,127,984	1.37
1874		1,026,970			1,220,094	1.19
1875		1,081,856			1,190,042	1.10
1876		1,482,729			1,556,865	1.05
1877		1,660,997			1,411,847	0.85
1878		1,855,884			1,577,501	0.85
1879		2,058,040			2,099,200	1.02
1880	5,961,060	2,676,588	2,485,177	41.69	2,271,931	0.75
1881	6,200,000	2,750,299		44.35	2,418,171	0.85
1882	6,412,373	3,037,317	3,037,317	47.36	2,126,122	0.70
1883	6,192,231	2,894,672	3,894,672	46.74	2,344,684	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	2,392,648	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	2,967,663	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	2,426,989	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	2,291,842	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	2,261,743	0.585
1889	8,005,565	3,846,979	3,856,929	48.17	2,088,909	0.541
1890	8,776,991	3,838,637	3,838,632	43.72	2,302,579	0.600
1891	9,987,945	3,927,671	3,966,748	39.52	2,037,289	0.513
1892	11,698,890	3,812,504	3,820,478	32.81	2,046,963	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	888,837	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	1,243,619	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	1,048,251	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	718,408	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	1,243,619	0.313
1898	17,612,634	4,171,916	5,263,564	29.88	1,628,081	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2,205,924	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2,033,731	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	2,437,677	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	1,535,823	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	1,119,984	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	1,579,206	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1,851,332	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	2,018,760	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	2,231,129	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	2,458,903	0.241
1909	30,107,646	6,055,661	9,966,744		2,732,556	0.274
1910	30,305,656	5,597,276	9,452,022		2,231,262	0.236

The annual inspection of salt, since the adoption of the state inspection law, according to grades is given in Tables II and III. Previous to 1898, table salt was included under "fine." The figures given under "Table" in Table III include all fancy grades.

TABLE II.

Year.	Fine.	Packers.	Solar.	Second quality.	Common coarse.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1869.....	513,989	12,918	15,264	19,117	
1870.....	568,326	17,869	15,507	19,650	
1871.....	655,923	14,677	37,675	19,930	
1872.....	672,034	11,110	21,461	19,876	
1873.....	746,762	23,671	32,267	20,706	
1874.....	960,757	20,090	29,391	16,741	
1875.....	1,027,886	10,233	24,336	19,410	
1876.....	1,402,410	14,233	24,418	21,668	
1877.....	1,590,841	20,389	22,949	26,818	
1878.....	1,770,361	19,367	33,541	36,615	
1879.....	1,997,350	15,641	18,020	27,029	
1880.....	2,598,037	16,691	22,237	48,623	
1881.....	2,673,910	13,885	9,683	52,821	
1882.....	2,928,542	17,208	31,335	60,222	
1883.....	2,828,987	15,424	16,735	33,526	
1884.....	3,087,033	19,308	16,957	38,508	
1885.....	3,230,646	15,480	19,849	31,428	
1886.....	3,548,731	22,221	31,177	71,235	3,893
1887.....	3,819,738	19,385	13,903	73,905	17,378
1888.....	3,720,319	18,126	26,174	87,694	13,915
1889.....	3,721,099	19,780	17,617	93,455	4,987
1890.....	3,655,331	20,337	18,986	143,068	
1891.....	3,764,108	11,400	17,335	121,269	13,559
1892.....					
1893.....	3,421,607	16,550	11,893	64,435	
1894.....	3,072,241	14,944	7,744	44,012	
1895.....	3,421,796	15,350	39,907	52,309	
1896.....	3,262,699	14,895	28,869	29,779	
1897.....	3,568,833	13,973	5,644	34,314	

TABLE III.

Year.	Medium.	Granulated.	Packers.	Solar.	Table.	Second quality.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1898.....	2,702,312	1,199,553	14,649		198,002	43,178
1899.....	2,706,430	1,744,961	29,892	17,353	189,107	44,922
1900.....	2,789,982	1,680,614	26,759	24,238	162,590	53,902
1901.....	3,361,616	1,895,093	39,490	11,523	188,068	84,311
1902.....	3,065,417	1,604,180	71,858		219,016	133,774
1903.....	2,601,932	1,459,029	92,316	8,571	281,514	44,600
1904.....	3,120,647	1,775,148	95,424	12,535	360,533	35,525
1905.....						
1906.....	2,977,518	1,988,759	120,658	7,200	520,313	30,111
1907.....	3,230,561	2,227,137	137,567	7,414	655,436	39,140
1908.....	3,309,365	2,192,486	119,454		575,681	50,770
1909.....	2,871,274	2,354,035	118,184		650,138	62,030
1910.....	2,702,372	1,910,680	112,561		779,756	91,907
1911.....						

The Value of the Product. The total value of the product and the average net price per barrel are given in columns 6 and 7 of Table I. Previous to 1880, the value has been calculated from the average price given by the United States Geological Survey; and from that time to date the price has been determined from the total value. It should be pointed out that the values given for 1893 and the following date, the cost of the package is included. This not only explains the apparently great drop in price in 1893 but also gives fictitious values for the preceding years.

If we allow twenty cents as the cost of the barrel (this is probably below the present cost), we see that the price per barrel has decreased from \$1.55 in 1868 to \$0.244. It should be kept in mind that the above figures are the average for all grades. Table IV gives the production for 1906-10, classified as to grades with the corresponding values. From this table, it will be apparent, that while table and dairy salt have commanded, for 1910, an average price of \$.708 per barrel, brine salt was worth but \$.051; common fine, \$.331; common coarse, \$.349; and packer's, \$.475 per barrel.

TABLE IV.²

Year.	Table and dairy.		Common fine.		Common coarse.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906.....	509,905	\$362,368	2,927,478	\$757,470	2,021,287	\$618,727
1907.....	657,509	392,641	3,601,270	914,154	1,743,840	471,378
1908.....	584,452	620,647	3,454,062	968,617	2,020,956	610,286
1909.....	585,370	732,907	3,530,303	1,125,095	2,103,719	647,878
1910.....	798,434	565,653	2,216,181	734,828	1,992,465	596,301

Year.	Packers.		Brine and other.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906.....	91,098	\$33,733	4,387,043	\$246,462	9,936,802	\$2,018,760
1907.....	119,459	48,455	4,664,552	235,729	10,786,630	2,062,357
1908.....	134,726	53,669	3,991,083	205,084	10,194,270	2,458,303
1909.....	93,357	3,983	3,648,395	185,051	9,966,744	2,732,556
1910.....	92,426	43,942	4,104,934	211,317	9,452,022	2,231,262

²Compiled from mineral resources, U. S. G. S.

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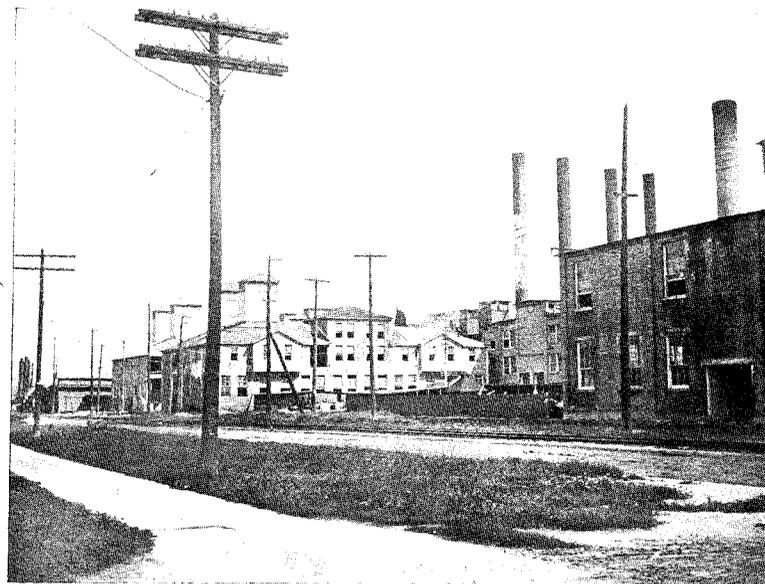
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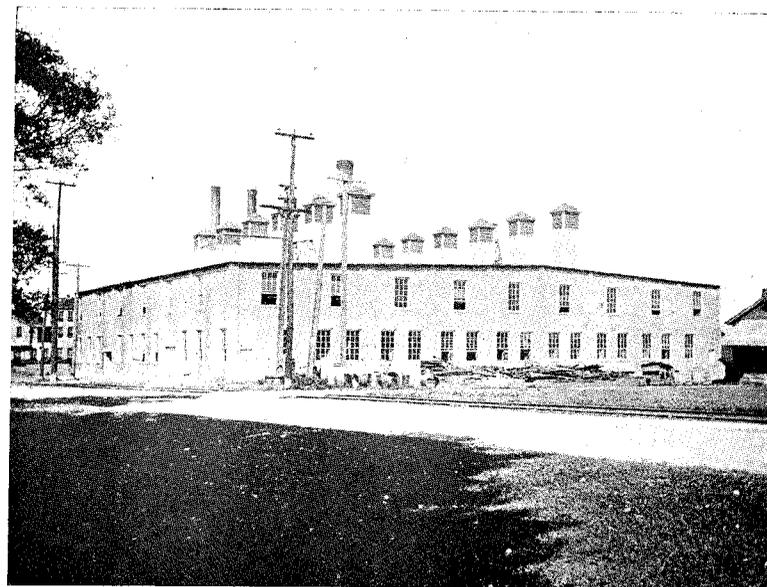
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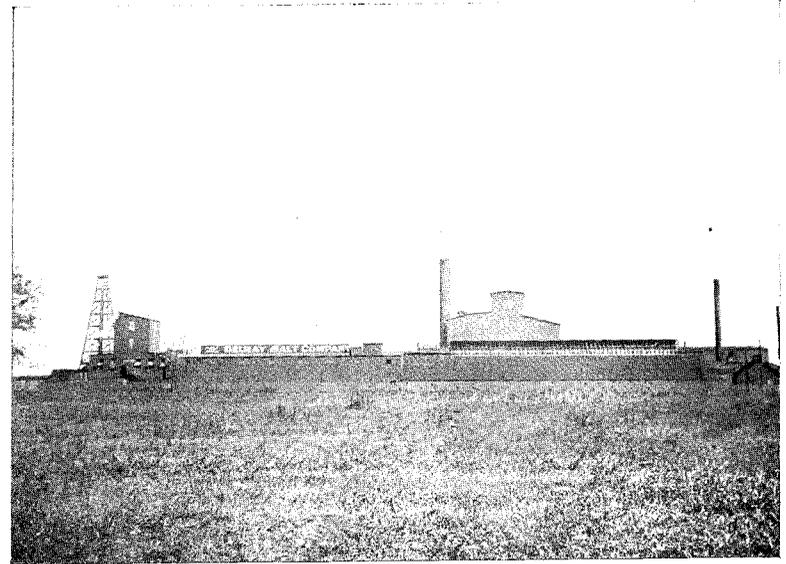
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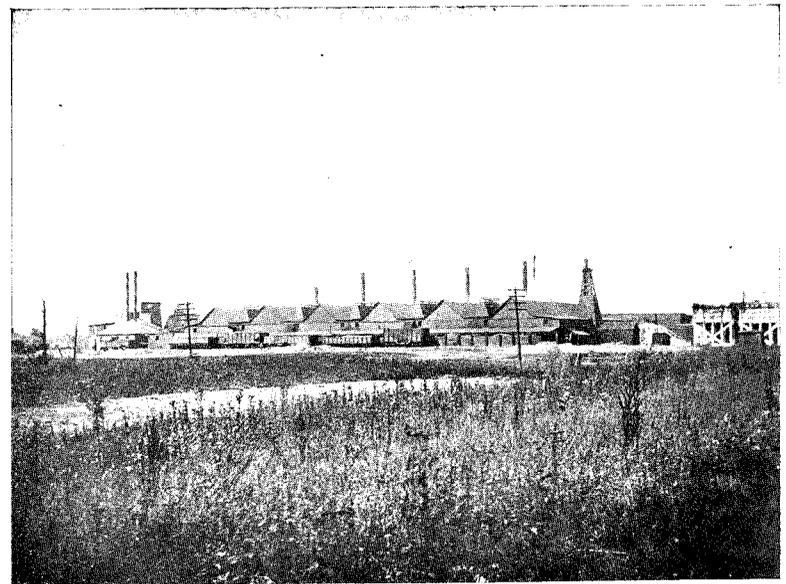
A. PLANT OF THE DIAMOND CRYSTAL SALT COMPANY, ST. CLAIR, MICHIGAN.



B. GRAINER BLOCK. DIAMOND CRYSTAL SALT COMPANY, ST. CLAIR, MICHIGAN.



A. PLANT OF THE DELRAY SALT COMPANY, DELRAY, MICHIGAN.



B. PLANT OF THE DETROIT SALT COMPANY, OAKWOOD, MICHIGAN.

MICHIGAN CEMENT.

BY C. W. COOK.

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HISTORICAL.

As early as 1878, a vertical kiln plant was erected for the manufacture of cement near Kalamazoo. The venture was, however, a financial failure on account of the high cost of production, and the plant was abandoned in 1882.

No further attempt was made to manufacture cement in Michigan until the organization of the Peerless Portland Cement Co., at Union City, Branch Co., August 23, 1896. The original mill erected by the company was a vertical kiln plant, which was replaced in 1902 by a modern rotary kiln mill (Plate XX, A.). The following year, the Bronson Portland Cement Co., erected a mill at Bronson in Branch Co. In 1898, the Coldwater Portland Cement Co., the forerunner of the Wolverine Portland Cement Co., was organized and mills were erected, first, at Coldwater, and, later, at Quincy.

The years 1899-1901 may be called the "boom years" of the cement industry in Michigan. During these three years, no less than twenty different companies were organized for the manufacture of cement from marl. The plans laid out by some of them were very elaborate but the realization of their hopes was obtained in few, if any, instances. But ten of the twenty ever reached the stage of production and of these five are no longer in operation. Since the "boom days," a number of companies have been projected. Only three of them, however, have become realities.

As far as construction is concerned, the present year (1911) has been marked by the installation of a modern rotary kiln mill by the Michigan Portland Cement Co., replacing the old vertical kiln plant of the Millen (formerly the White) Portland Cement Co. at Chelsea. These kilns are the largest in the state being nine feet in diameter and one hundred and twenty-five feet long. They are expected to have a daily capacity of twelve hundred barrels.

CLASSIFICATION OF CEMENTS.

On the basis of raw materials, cement may be classified as Pozzuolan, natural, and Portland cements.

Pozzuolan cements are produced from a mixture of slaked lime and material containing silica and alumina. The chief sources of the silica and alumina are volcanic ash and blast furnace slag. In this country, the latter is the more important. However, there are no plants in Michigan manufacturing this type of cement.

Natural cements are manufactured by burning impure limestones containing aluminous silicates, without altering the proportions of the ingredients in the rock. Natural cements, therefore, have an indefinite and varying composition. No cements of this class are manufactured in Michigan.

Portland cements, the only class of cements, manufactured in Michigan, are made by burning an artificial mixture containing

lime (CaO), silica (SiO₂), and alumina (Al₂O₃) as the essential ingredients, small amounts of ferric oxide (Fe₂O₃), magnesia (MgO), and sulphuric anhydride (SO₃) usually being present as impurities. The composition of the mixture may be seen from the following analyses, which represent actual mixtures ready for burning.¹

ANALYSES OF PORTLAND CEMENT MIXTURES.

	1.	2.	3.	4.
Silica (SiO ₂)	12.85	12.92	13.52	14.94
Alumina (Al ₂ O ₃)	4.92	4.83	6.56	2.66
Iron oxide (Fe ₂ O ₃)	1.21	1.77	.....	1.10
Lime carbonate (CaCO ₃)	76.36	75.53	75.13	75.59
Magnesium carb. (MgCO ₃)	2.13	4.34	4.32	4.64
Total	97.47	99.39	99.53	98.93

When alkalis and sulphates are present, they should not exceed three per cent, and five to six per cent is considered the upper limit of permissible magnesium carbonate. The proportions of silica to alumina and ferric oxide should lie between the limits expressed by the following formulae:

$$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3} > 2. \text{ and } \frac{\text{SiO}_2}{\text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3} < 3.5$$

RAW MATERIALS.

In Michigan, the lime is derived from limestone and marl, while clay and shale are employed as the source of the silica and alumina. Limestone and marl, as is also the case with clay and shale, differ from one another principally in their state of aggregation, their composition being essentially the same.

Although a number of limestones outcrop beneath the drift in the southern peninsula of Michigan, not all of them are suitable for the manufacture of Portland cement. As already stated a cement limestone should be low in magnesia and sulphur and only three of the Michigan limestones answer these requirements, namely, certain layers of the Traverse and Dundee formations, and of the Michigan series. Their composition is shown by the following analyses.²

¹U. S. Geological Sur. Min. Res. 1907, Part II, p. 483.

²For other analyses see I. C. Russell, The Portland Cement Industry in Michigan, U. S. G. S. Ann. Rpt., Pt. II, pp. 641-646; also David J. Hale and others, Geol. Sur. Mich. Vol. VIII, Pt. III; also, W. H. Sherzer, Geol. Sur. Mich., Vol. VII, Pt. I; also E. C. Eckel, U. S. G. S., Bul. 243, pp. 196-205.

MINERAL RESOURCES OF MICHIGAN.

ANALYSES OF MICHIGAN LIMESTONES.

	1. ³	2. ⁴	3. ⁵	4. ⁶
Silica.....	1.14	0.33	0.60	.....
Calcium carbonate.....	96.91	98.37	95.24	96.00
Magnesium carbonate.....	1.40	0.92	1.00	1.00
Iron oxide.....	.....	.....	.....	.....
Alumina.....	0.31	0.18	3.04	0.50
Organic matter.....	0.02	.....	.....	.....
Moisture.....	0.05	.....	.....	.....
Undetermined.....	0.17	.....	.....	1.40
Total.....	100.00	99.96	99.88	99.00

³Traverse limestone, Onaway Limestone Co., Onaway, Mich.
⁴Same, Alpena Portland Cement Co., Alpena, Mich., U. S. G. S. 22nd Ann. Rpt.
⁵Nine foot bed, Dundee, Bellevue, Wayne Co., Mich. U. S. G. S. 22nd Ann. Rpt.
⁶Michigan series, Bellevue, Eaton Co., Mich. Geol. Sur. Mich. Vol. VIII Pt. III.

Of the above named limestones, only the Traverse and Michigan are, at present quarried for the manufacture of cement,—the former at Alpena and Petoskey, and the latter at Bellevue, Eaton Co.

The other prominent series of limestones in Michigan, the Monroe series,⁷ is generally high in magnesia and therefore unfitted for use in the manufacture of cement.

It should be remembered that, for the most part, the limestones of Michigan outcrop underneath a covering of glacial drift of varying thickness. Therefore, in considering the exploitation of the various beds, it is essential to examine not only the composition of the limestone but also the thickness of the overburden. In addition to which, the economic factors resulting from location should also receive due consideration.

Marl⁸ is a surface deposit formed in lakes and swamps, and consists of calcium carbonate in a finely divided state of aggregation, so that when wet it appears as a mud. However, when dried, a certain amount of cementation occurs, producing a loosely aggregated, friable mass. The marl is apt to be contaminated with organic matter and is therefore, generally, although not necessarily, less pure than the limestone.

The composition of various marls is shown by the following analyses:⁹

The distribution of marl beds of varying quality within the southern peninsula of Michigan is rather wide-spread, no less than twenty-two counties being known to contain beds of workable size

ANALYSES OF MICHIGAN MARLS.

	1. ¹⁰	2. ¹¹	3. ¹²	4. ¹³	5. ¹⁴
Silica.....	1.13	0.48	0.52	0.20	0.22
Alumina.....	0.44	0.17	0.51	0.50	0.76
Ferric oxide.....	.....	0.51	0.53	0.60	.....
Calcium carbonate.....	91.29	93.25	92.25	89.50	92.07
Magnesium carbonate.....	4.58	3.88	2.87	1.74	2.63
Sulphuric anhydride.....	Trace.	0.55	0.89	0.58	.....
Volatile less CO ₂ to satisfy CaO and MgO.....	1.90	.....	.....	4.32	.....
Total.....	99.34	98.84	97.57	97.44	95.68

⁷For analyses, see W. H. Sherzer, Geol. Sur. Mich., Vol. VII, Pt. I.
⁸For a more complete discussion of marl see the papers by Russell and Hale, already cited.
⁹For additional analyses, see references on limestone.
¹⁰Egyptian Portland Cement Co., Fenton, Mich. Analysis by C. W. Cook.
¹¹Aeina Portland Cement Co., Fenton, Mich. Analysis by E. D. Campbell, U. S. G. S., 22nd Ann. Rept., Pt. III, p. 650.
¹²Wolverine Portland Cement Co., Coldwater, Mich. Analysis by E. D. Campbell, U. S. G. S., 22nd Ann. Rpt., Pt. III, p. 650.
¹³Omega Portland Cement Co., Mosherville, Mich. Analysis by E. D. Campbell, U. S. G. S., 22nd Ann. Rpt. Pt. III, p. 651.
¹⁴Peninsular Portland Cement Co., Cement City, Mich. Analysis recalculated from analysis given in Geol. Sur. Mich. Vol. VIII, Pt. III, p. 236.



Fig. 18. Map showing cement plants in Michigan, 1911. Circles represent plants operating in 1911. Crossed circles represent plants not operating in 1911.

with a total area of over 26,000 acres, however, on account of impurities, economic considerations, etc. Not all of these beds are available for the manufacture of cement.

As in the case of limestone, there are a number of shales which outcrop in Michigan. Three of them have, thus far, been employed in the manufacture of cement,—namely, the Traverse, at Alpena, the Coldwater at Newaygo, Coldwater, and Quincy, and the Michigan at Bellevue. The composition of these shales is shown by the following analyses by H. Ries.¹⁵

ANALYSES OF MICHIGAN SHALES.

	1.16	2.17	2.18	4.19	5.20
Silica.....	58.70	65.60	62.10	53.44	61.09
Alumina.....	25.95	19.31	20.09	24.80	19.19
Ferric oxide.....		5.89	7.81		6.78
Calcium oxide.....	1.00	0.56	0.65	0.71	2.51
Magnesium oxide.....	0.74		0.96	0.25	0.65
Alkalies.....	5.54	5.98			3.16
Water.....					
Carbon dioxide.....	8.07	9.47	7.90	20.75	5.13
Sulphuric anhydride.....			0.49		1.42

Of the other shales, the Antrim and those of the Saginaw formation may be mentioned. The Antrim shale is characterized by a high percentage of silica relatively to the alumina and ferric oxide and also by a high percentage of organic matter, as is shown by the following analysis by W. H. Johnson:²¹

ANALYSES OF ANTRIM SHALE.

Volatile matter.....	17.96
Fixed carbon.....	6.49
Ash.....	75.55
Total.....	100.00

ANALYSES OF ASH.

Silica.....	70.54
Alumina.....	15.33
Ferric oxide.....	5.31
Calcium oxide.....	2.38
Magnesium oxide.....	0.78
Alkalies, etc., by difference.....	5.56
Total.....	100.00

¹⁵U. S. G. S., Prof. Paper, No. 11 and Geol. Sur. Mich., Vol. VIII, Pt. I.

¹⁶Michigan Series, Grand Rapids, Mich., Geol. Sur. Mich., Vol. VII, Pt. I, p. 40.

¹⁷Michigan series, Grand Rapids, Mich., *ibid.*, p. 41.

¹⁸Coldwater shale, Bronson, Mich., *ibid.*, p. 41.

¹⁹Coldwater Shale, Coldwater, Mich., *ibid.*, p. 43.

²⁰Traverse shale, Alpena, Mich., *ibid.*, p. 48.

²¹U. S. G. S., 22nd Ann. Rpt., Pt. III, p. 668.

The shales of the Saginaw formation on the other hand are relatively low in silica. The following analyses are given by Russell:²²

ANALYSES OF THE SHALES OF THE SAGINAW FORMATION.

	1.	2.	3.	4.	5.	6.
Silica.....	54.50	52.45	57.10	61.13	54.93	41.38
Alumina.....	30.75	23.27	20.02	26.90	31.43	27.02
Ferric oxide.....	3.50	7.93	8.18			
Calcium oxide.....	1.05			0.96	0.22	0.52
Calcium carbonate.....		1.82	0.71			
Magnesium oxide.....	1.69			0.96	1.58	0.90
Magnesium carbonate.....		1.06	1.47			
Sodium oxide.....	0.80	4.37	2.76	?	?	?
Potassium oxide.....	2.20			?	?	?
Water and organic matter.....	5.51	9.10	9.76	6.47	7.44	23.11
Total.....	100.00	100.00	100.00	96.58	95.60	92.93

Although surface clays formed during the Pleistocene period of glaciation are widely distributed over the southern peninsula of Michigan, they are for the most part not especially satisfactory for use in the manufacture of cement. For that reason, a number of the mills in the southern part of the state import their clay from Ohio. The only Pleistocene clays of Michigan which are being used at present in the manufacture of cement occur near Corunna, Shiawassee Co., and Gray village, Washtenaw Co. The former is utilized by the New Aetna Portland Cement Co., Fenton, Mich., and the latter by the Michigan Portland Cement Co. A more complete discussion of this subject may be found in the papers by Ries, Hale, and Russell already cited.

LIST OF MILLS.²³

BURT PORTLAND CEMENT Co., Bellevue, Eaton Co., Mich. W. R. Burt, Pres.; Geo. R. Burt, Treas. and Gen. Mgr.

The dry process is employed, the raw materials being limestone and shale of the Michigan series. The shale occurs underneath the limestone and the two are mixed in quarrying, the proper mixture being obtained before burning by combining the mixture from different bins. The burning is done in rotary kilns of which there are eight (6.5' x 60') with a daily capacity of 1,500 barrels.

HURON PORTLAND CEMENT Co., Alpena, Mich. Offices 1525 Ford Bldg., Detroit, Mich. Incorporated, January 26, 1907. Capital stock, preferred, \$800,000; common \$1,200,000. J. B. Ford, Pres.; E. L. Ford, Vice-Pres.; S. T. Crapo, Sec. and Treas.

²²*Ibid.*, p. 670.

²³For location of the various plants see Fig. 18.

The dry process is used, limestone and shale being employed as the raw materials. The limestone is that of the Traverse formation and is obtained from the quarry of the Michigan Alkali Co., Alpena. The shale, also of Traverse age, is quarried on the company's lands in Sec. 30, T. 31 N., R. 7 E. The mill contains six rotary kilns (8' x 110') with a daily capacity of 3,000 barrels. In as much as the mill is located on the shore of Thunder Bay, the company enjoys the advantage of water transportation for its fuel and also the finished product.

MICHIGAN PORTLAND CEMENT Co., Gray Village, Washtenaw Co., Mich. (Plate XX, B.) Incorporated June 14, 1911. Capital stock, preferred \$100,000, common, \$400,000. N. S. Potter, Pres.; N. S. Potter, Jr., Vice-Pres. and Gen. Mgr.; C. Z. Potter, Sec.; K. L. Potter, Treas.

This company, which took over the property and vertical kiln plant of the Millen (formerly the White) Portland Cement Co., has constructed a rotary kiln plant. There are three kilns (8' x 125') with a daily capacity of 1,200 barrels. The wet process is employed with marl and clay as the raw materials. Both the clay and marl are obtained from lands near the plant.

NEW AETNA PORTLAND CEMENT Co., Fenton, Mich. Offices, 50 Congress St., Boston, Mass., and 412 Union Trust Bldg., Detroit, Mich. Reincorporated under the laws of Maine, June, 1907. F. R. Johnson, Pres.; R. E. Payne, Sec. and Treas.; O. J. Linger-mann, Gen. Mgr.

The mill of this company, which is the successor to the Detroit Portland Cement Co., and the Aetna Portland Cement Co., is located on the shores of Mud Lake, two miles west of Fenton, Genesee Co. The wet process is employed with marl and clay as the raw materials. The marl is obtained from Mud Lake and the clay is shipped in from Corunna, Shiawassee Co. The mill contains eight rotary kilns (6' x 60') with a daily capacity of 1,000 barrels.

NEWAYGO PORTLAND CEMENT Co.,²⁴ Newaygo, Newaygo Co., Mich. Incorporated May 12, 1899; reincorporated June 16, 1911. Capital stock, \$500,000. D. McCool, Pres.; Wilder D. Stevens, Vice-Pres.; Clay H. Hollister, Sec. and Treas.; W. A. Ansorge, Asst. Sec. and Treas.

This company employs the wet process with limestone and shale as the raw materials. The plant was originally designed to manufacture cement from marl but the marl was found unsatisfactory

²⁴The name has recently been changed to the Grand Rapids Portland Cement Co. with offices at Grand Rapids. Cement and Engineering News, October, 1911.

and limestone was substituted. The Traverse limestone and the Coldwater shales, which are used, are purchased from the Petoskey Crushed Stone Co., the limestone quarries of which are located in Secs. 2 and 3, T. 34 N., R. 6 W., while the shale beds are in Sec. 26, T. 32 N., R. 8 W. The burning is done in rotary kilns of which there are eleven (1-6' x 60' and 10-6' x 90') with a daily capacity of 2,000 barrels. The plant is operated by electricity generated by water power from the Muskegon river.

OMEGA PORTLAND CEMENT Co., Mosherville, Hillsdale Co., Mich. Incorporated February 18, 1899. Capital stock, \$300,000. Bonds, \$20,000. F. M. Stewart, Pres.; Walter Sawyer, Vice-Pres.; H. J. Tubbs, Sec.; Amos Kendall, Treas. and Gen. Mgr.

The wet process is employed with marl and clay as the raw materials. The marl is obtained from Cobb's Lake on the shores of which the plant is located. The clay is shipped in from Ohio. The mill contains five rotary kilns (6' x 60') with a daily capacity of 500 barrels.

PEERLESS PORTLAND CEMENT Co., Union City, Branch Co., Mich. Incorporated August 19, 1897; reincorporated March 22, 1906. Capital stock, preferred, \$350,000, common, \$500,000, bonds, \$350,000. A. W. Wright, Pres.; S. O. Bush, Vice-Pres.; Wm. M. Hatch, Sec. and Treas.; J. R. Patterson, Gen. Mgr.

The plant employs the wet process with marl and shale as the raw materials. The marl is shipped in on the Michigan Central Railroad from Spring Arbor, T. 3 S., R. 2 W. The burning is done in nine rotary kilns (5.5' and 6.5' x 70') with a daily capacity of 1,350 barrels.

PENINSULAR PORTLAND CEMENT Co., Offices, Cooley Blk., Jackson; mill at Cement City, Lenawee Co., Mich. Incorporated June, 1899. Capital stock, preferred, \$700,000; common, \$593,000. Wm. F. Cowhan, Pres.; D. C. Griffin, Vice-Pres.; J. W. Shove, Sec.; N. S. Potter, Treas.

The wet process is employed with clay and marl as the raw materials. The marl is obtained from Goose Lake and the clay comes from Bryan, Ohio. The burning is done in nine rotary kilns (3-7' x 80' and 6-6' x 60') with a daily capacity of 1,250 barrels.

WOLVERINE PORTLAND CEMENT Co., Offices, Coldwater, Michigan; mills, Coldwater and Quincy, Michigan. Incorporated February, 1902. Capital stock, \$1,000,000. L. M. Wing, Pres. and Gen. Mgr.; C. T. Jones, Vice-Pres.; E. R. Root, Sec. and Treas.

This company operates two mills, one at Coldwater, (Plate XXI A.) and one at Quincy, (Plate XXI B.). The wet process is employed at both points with marl and shale as the raw materials. The

marl is obtained from lakes near the plant and the shale, the Coldwater, is quarried about an half mile from the Coldwater plant. The Coldwater plant contains fourteen kilns (6' x 60') and the Quincy mill seven kilns (6' x 120'), each having a daily capacity of 1,500 barrels. 150 men are employed at the Coldwater plant and 120 at the Quincy plant.

WYANDOTTE PORTLAND CEMENT Co., Offices, 1525 Ford Bldg., Detroit; plant, Wyandotte, Michigan. Incorporated, November 21, 1903. Capital stock, \$1,000. S. T. Crapo, Pres. and Treas.; J. B. Ford, Vice-Pres.; H. J. Paxton, Sec. and Gen. Mgr.

Both wet and dry processes are employed, limestone and clay being used as the raw materials. The limestone is furnished by the Michigan Alkali Co., a portion being dry and a portion pulverized and wet. The clay is obtained from Millbury, Ohio. The burning is done in three rotary kilns (7' x 100') with a daily capacity of 1,000 barrels. 110 men are employed.

In addition to the above named plants, the following non-producing plants may be mentioned.

ALPENA PORTLAND CEMENT Co., Alpena, Mich. Organized, August 9, 1899. Capital stock, \$500,000. Future operation doubtful.

EGYPTIAN PORTLAND CEMENT Co., Fenton, Mich. Incorporated, June 30, 1900. Capital stock, \$1,050,000; bonds, \$650,000. Reincorporated. Capital stock, preferred A, \$35,000; preferred B, \$500,000; common, \$1,050,000; bonds, \$200,000. This property has been ordered sold by the court. Future operation uncertain.

ELK CEMENT AND LIME Co., Elk Rapids, Mich. Incorporated as the Elk Rapids Portland Cement Co., March 3, 1900. Reincorporated, December 8, 1904. Capital stock, 1st preferred, \$50,000; 2nd preferred, \$150,000; common, \$300,000; bonds, \$250,000. F. R. Williams was appointed receiver, January 4, 1911. Future operation is doubtful.

NEW BRONSON PORTLAND CEMENT Co., Bronson, Mich. Reincorporated, April 15, 1910. Capital stock, \$110,000. F. M. Rudd, Pres.; J. S. Galloway, Vice-Pres.; C. H. Powley, Sec.; H. F. Mowery, Treas. This company purchased, at the receiver's sale, the plant of the Chamite Cement and Clay Product Co., (successor to the Bronson Portland Cement Co.). The present company has never operated the plant and future operations are doubtful.

THE HECLA Co., (successor to the Hecla Portland Cement Co.), Bay City, Mich. Henry Hertz is receiver of this company and it is very doubtful if the plant will every be operated again.

In Table I is given a list of all mills built or projected, together with the important facts concerning each.

TABLE I.

Name.	Location.	Capital stock and bonds.	Process.	Raw materials.	Fuel.	No. of kilns.	Rated capacity.
Aetna Portland Cement Co.	Fenton.	500,000	Wet.	Marl and clay.	Coal	8	1,000
Alpena Portland Cement Co.	Alpena.	500,000	Dry.	Limestone and clay.	Coal	6	1,000
Bellaire Portland Cement Co.	Bellaire.	Not Inc	Dry.	Limestone and shale.	Coal	8	1,500
Bronson Portland Cement Co.	Bronson.	500,000	Wet.	Marl and shale.	Coal	10	1,000
Chamite Cement and Clay Product Co.	Bronson.	1,000,000	Wet.	Marl and shale.	Coal	10	1,000
Clare Portland Cement Co.	Grant to Clare Co.	300,000	Wet.	Marl and shale.	Coal	8	1,000
Coldwater Portland Cement Co.	Coldwater.	1,000,000	Wet.	Marl and shale.	Coal	4	1,000
Detroit Portland Cement Co.	Fenton.	1,000,000	Vertical kilns.	Marl and clay.	Coke.	4	100
Eagle Portland Cement Co.	Kalamazoo.	1,650,000	Wet.	Marl and clay.	Coal	9	1,200
Egyptian Portland Cement Co.	Fenton.	500,000	Originally wet.	Originally marl and shale-later limestone.	Coal	5	1,000
Elk Rapids Portland Cement Co.	Elk Rapids.	750,000	Dry.	Limestone and shale.	Coal	5	1,000
Elk Cement and Lime Co.	Alpena.	525,000					
El Cajou Portland Cement Co.	Farwell.	300,000	Wet.	Marl and clay.			
Farwell Portland Cement Co.	White Pigeon.	5,000,000	Wet.	Marl and clay.			
German Portland Cement Co.	Charlevoix.	5,000,000	Wet.	Marl and clay.	Coal		
Great Lake Portland Cement Co.	Marlborough.	5,000,000	Wet.	Marl and clay.	Coal		
Great Northern Portland Cement Co.	Bay City.		Dry.	Limestone and clay.	Coal		
Hecla Cement and Coal Co.	Bay City.	2,000,000	Dry.	Limestone and clay.	Coal	6	3,000
Hecla Portland Cement Co.	Bay City.	1,250,000	Wet.	Marl and clay.	Coal	6	3,000
Hecla (The) Co.	Alpena.		Vertical kilns.	Marl and clay.	Coke		
Huron Portland Cement Co.	Lupton.						
Logan Portland Cement Co.	Chelsea.						
Millen Portland Cement Co.	Chelsea.						
Michigan Portland Cement Co.	Gray Village.	500,000	Wet.	Marl and clay.	Coal	3	1,200
Michigan Portland Cement Co.	Coldwater.	2,500,000					
Michigan Alkali Co.	Wyandotte.			Caustic soda refuse and shale.	Coal	8	1,000
New Aetna Portland Cement Co.	Fenton.	110,000	Wet.	Marl and clay.	Coal	10	1,000
New Bronson Portland Cement Co.	Bronson.		Wet.	Marl and shale.	Coal		

Name.	Location.	Employees.	Remarks.
Aetna Portland Cement Co.	Fenton.		Successor to Detroit P. C. Co. See new Aetna Portland Cement Co.
Alpena Portland Cement Co.	Alpena.		Has not operated in two years.
Bellaire Portland Cement Co.	Bellaire.		Plant never built.
Burt Portland Cement Co.	Bellevue.		Began producing September, 1905.
Bronson Portland Cement Co.	Bronson.		See Chamite and Clay Products Co.
Chamite Cement and Clay Product Co.	Bronson.		Successor to the Bronson Portland Cement Co. See New Bronson P. C. Co.
Clare Portland Cement Co.	Grant to Clare Co.		Plant never built.
Coldwater Portland Cement Co.	Coldwater.		See Michigan Portland Cement Co., Coldwater.
Detroit Portland Cement Co.	Detroit.		See Aetna Portland Cement Co.
Eagle Portland Cement Co.	Kalamazoo.		Suspended operations about 1882.
Egyptian Portland Cement Co.	Fenton.		Plant ordered sold by the courts. No operations for two years.
Elk Rapids Portland Cement Co.	Elk Rapids.	90	See Elk Cement and Lime Co.
Elk Cement and Lime Co.	Elk Rapids.		Successor to Elk Rapids Portland Cement Co. Receivers appointed January 4, 1911.
El Cajon Portland Cement Co.	Alpena.		Never built. Not operating.
Farwell Portland Cement Co.	Farwell.		Plant never completed.
German Portland Cement Co.	White Pigeon.		Never progressed beyond the newspaper stage.
Great Lake Portland Cement Co.	Charlevoix.		Plant dismantled.
Great Northern Portland Cement Co.	Marlborough.		See Hecla Portland Cement Co.
Hecla Cement and Coal Co.	Bay City.		Successor to Hecla Cement and Coal Co. See Hecla (The) Co.
Hecla (The) Co.	Bay City.		Successor to Hecla Portland Cement Co. In hands of receivers. Future operations doubtful.
Huron Portland Cement Co.	Alpena.	200	Successor to Twentieth Century Portland Cement Co. Plant never built.
Logan Portland Cement Co.	Lupton.		Plant never built.
Lupton Portland Cement Co.	Chelsea.		Successor to White Portland Cement Co. See Michigan Portland Cement Co., Gray Village.
Millen Portland Cement Co.	Gray Village.	65	Successor to the Millen Portland Cement Co. Began operations July 13, 1911.
Michigan Portland Cement Co.	Coldwater.		Successor to the Coldwater Portland Cement Co. See Wolverine Portland Cement Co.
Michigan Alkali Co.	Wyandotte.	100	See Wyandotte Portland Cement Co.
New Aetna Portland Cement Co.	Fenton.		Successor to the Aetna Portland Cement Co.
New Bronson Portland Cement Co.	Bronson.		Successor to the Chamite Cement and Clay Product Co. New company has never operated.

TABLE I.

Name.	Location.	Capital stock and bonds.	Process.	Raw materials.	Fuel.	No. of kilns.	Rated capacity.
Nowargo Portland Cement Co.	Nowargo.	\$500,000	Wet.	Limestone and shale.	Coal.	11	2,000
Omega Portland Cement Co.	Mosherville.	320,000	Wet.	Marl and clay.	Coal.	5	500
Pacific Portland Cement Co.	Union City.	1,200,000	Wet.	Marl and shale.	Coal.	9	1,350
Peninsula Portland Cement Co.	Cement City.	1,293,000	Wet.	Marl and clay.	Coal.	9	1,250
Pyramid Portland Cement Co.	Spring Arbor.	525,000	Wet.	Marl and clay.	Coal.		
Standard Portland Cement Co.	Lakeland.	1,000,000	Wet.	Marl and clay.	Coal.		
Standford Portland Cement Co.	Athens.		Wet.	Marl and clay.	Coal.		
Three Rivers Portland Cement Co.	Three Rivers.	20,000	Wet.	Marl and clay.	Coal.		
Totoco Portland Cement Co.	Manchester.		Wet.	Marl and clay.	Coal.		
Twentieth Century Portland Cement Co.	Fenton.	750,000	Wet.	Marl and clay.	Coal.		
Wayne Portland Cement Co.	Brighton.	800,000	Wet.	Marl and clay.	Coal.		
Wauvate Portland Cement Co.	Lima.	1,000,000	Wet.	Marl and clay.	Coal.		
West German Portland Cement Co.	Chelsea.	1,000,000	Vertical kilns.	Marl and clay.	Coke.		
White Portland Cement Co.	Chelsea.		Vertical kilns.	Marl and clay.	Coke.		
Wolverine Portland Cement Co.	Coldwater.	1,000,000	Wet.	Marl and shale.	Coal.	14	1,500
Wolverine Portland Cement Co.	Quincy.	1,000	Wet and dry.	Marl and shale.	Coal.	7	1,500
Wyandotte Portland Cement Co.	Wyandotte.		Wet.	Limestone and clay.	Coal.	3	1,000
Zenith Portland Cement Co.	Grass Lake.	1,000,000	Wet.	Marl and clay.	Coal.		

Name.	Location.	Employees.	Remarks.
Newaygo Portland Cement Co.	Newaygo	120	New company incorporated June 16, 1911. Old capital stock and bonds \$8,000,000. Name recently changed to Grand Portland Cement Co.
Omega Portland Cement Co.	Mosherville	80	Originally a vertical kiln plant.
Pearless Portland Cement Co.	Union City	135	Plant never built. Marl lands now owned and operated by the Peerless Portland Cement Co.
Pyramid Portland Cement Co.	Cement City		
	Spring Arbor		
Standard Portland Cement Co.	Lakeland		Plant never built.
Standiford Portland Cement Co.	Athens		Plant never built.
Three Rivers Portland Cement Co.	Three Rivers		Plant never built.
Toledo Portland Cement Co.	Manchester		Plant never completed.
Twentieth Century Portland Cement Co.	Fenton		Plant never built. See Logan Portland Cement Co.
Wayne Portland Cement Co.	Brighton		Plant never built.
Watervale Portland Cement Co.	Lima		Plant never built.
West German Portland Cement Co.	Lima		Plant never built.
White Portland Cement Co.	Chelsea		See Millien Portland Cement Co.
Wolverine Portland Cement Co.	Coldwater	150	Successor to Michigan Portland Cement Co., Coldwater.
Wolverine Portland Cement Co.	Quincy	120	Successor to Michigan Portland Cement Co., Coldwater.
Wyandotte Portland Cement Co.	Wyandotte	110	Successor to Michigan Alkali Co.
Zenith Portland Cement Co.	Grass Lake		Plant never built.

PRODUCTION.

The annual production of cement in Michigan together with the value of the same from 1896 to 1910 is given in Table II. In column 1, is indicated the number of plants in operation, while column 4 shows the percentage of increase or decrease over the preceding year.

TABLE II.

Year.	No. of plants in operation.	Product, barrels.	Value.	Change per cent.
1896	1	4,000	7,000	.....
1897	2	15,000	26,250	275.0
1898	2	77,000	134,750	413.3
1899	4	343,566	513,849	346.2
1900	6	664,750	830,940	93.4
1901	10	1,025,718	1,128,290	54.1
1902	10	1,577,006	2,134,396	53.7
1903	13	1,955,183	2,674,780	23.9
1904	16	2,247,160	2,365,656	14.9
1905	16	2,773,283	2,921,507	23.4
1906	14	3,747,525	4,814,965	35.5
1907	14	3,572,668	4,381,731	4.6 ^{2b}
1908	15	2,892,576	2,556,215	19.0 ^{2b}
1909	12	3,212,751	2,619,259	11.6
1910	12	3,687,719	3,378,940	11.7

^{2b}Decrease.

It will be seen that the maximum number of plants in operation was reached in 1904. However, the maximum production was not attained until 1906 when but 14 instead of 16 plants were operating. Following the maximum production of 1906, a decrease is shown for the next two years and, although increases are indicated for 1909 and 1910, the high water mark of 1906 has not been regained.

The figures for the number of plants in operation do not give the exact status of the case as in several instances the closing down of one plant has been offset by the opening of another.

In Table III, the Michigan production is compared with that of the United States. The Michigan production, the United States production, and Michigan's percentage of the same are given in columns 1, 2, and 3. In columns 4, 5, and 6, are indicated the values of the product together with Michigan's percentage.

TABLE III.

Year.	Michigan product.	U. S. product.	Michigan per cent.	Michigan value.	U. S. value.	Michigan per cent.
1896....	4,000	1,543,023	0.25	7,000	2,424,011	0.29
1897....	15,000	2,677,775	0.56	26,250	4,315,891	0.60
1898....	77,000	3,692,284	2.11	134,750	5,970,773	2.3
1899....	343,566	5,652,266	6.1	513,849	8,074,371	6.36
1900....	664,750	8,482,020	7.8	830,990	9,280,525	8.9
1901....	1,025,718	12,711,225	8.0	1,128,290	12,532,360	9.0
1902....	1,577,006	17,230,644	9.1	2,134,396	20,864,078	10.2
1903....	1,955,183	22,342,973	8.7	2,674,780	27,713,319	9.7
1904....	2,247,160	26,505,881	8.5	2,365,656	23,355,119	10.1
1905....	2,773,283	35,246,812	7.9	2,921,507	33,245,867	8.7
1906....	3,747,525	46,463,424	8.06	4,814,965	52,466,186	9.2
1907....	3,572,668	48,785,390	7.3	4,384,731	53,992,551	8.1
1908....	2,892,576	51,072,612	5.6	2,556,215	43,547,679	5.8
1909....	3,212,751	64,991,431	4.9	2,619,259	52,858,354	4.9
1910....	3,687,719	76,549,951	4.8	3,378,940	68,205,800	4.9

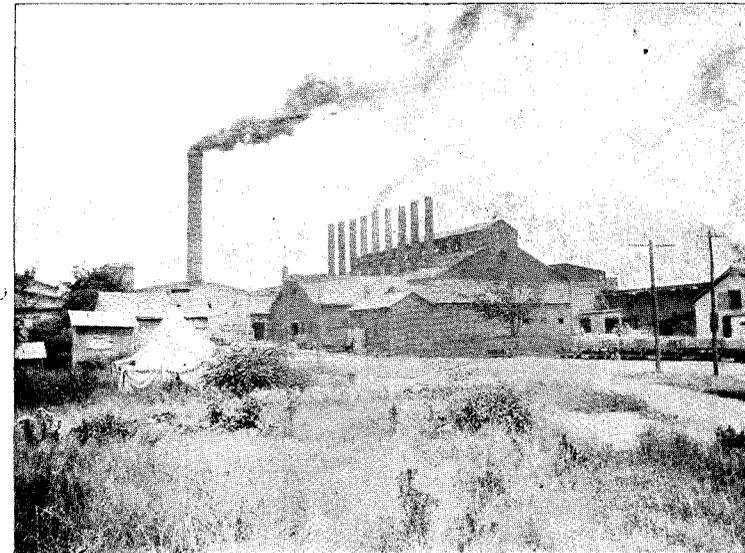
It is to be noted that the percentage of value is generally somewhat higher than the percentage of product indicating that the price received per barrel for Michigan cement has been slightly in advance of the average price for the United States. This is also shown in Table IV which gives the annual price per barrel for Michigan and for the United States.

TABLE IV.

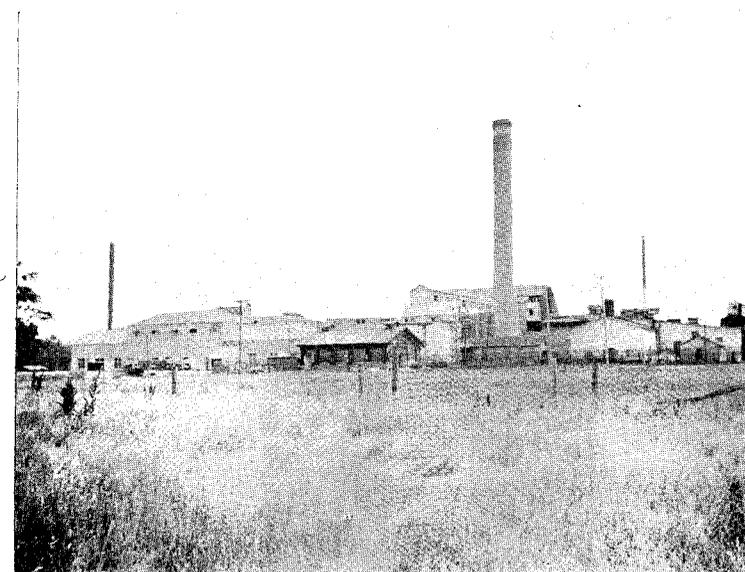
Year.	Price per barrel Michigan.	Price per barrel average U. S.
1896.....	\$1.75	\$1.57
1897.....	1.75	1.61
1898.....	1.747	1.62
1899.....	1.492	1.43
1900.....	1.25	1.09
1901.....	1.10	0.99
1902.....	1.353	1.21
1903.....	1.367	1.24
1904.....	1.052	0.88
1905.....	1.053	0.94
1906.....	1.284	1.13
1907.....	1.227	1.11
1908.....	0.883	0.85
1909.....	0.815	0.813
1910.....	0.916	0.891

The decrease in the number of plants indicated in Table II is undoubtedly explained by the low price per barrel which the manufacturers have received in recent years. That the average price per barrel is not far from the cost of manufacture is shown by the following compilation by Dr. F. M. Chance²⁶ from the reports of seven companies.

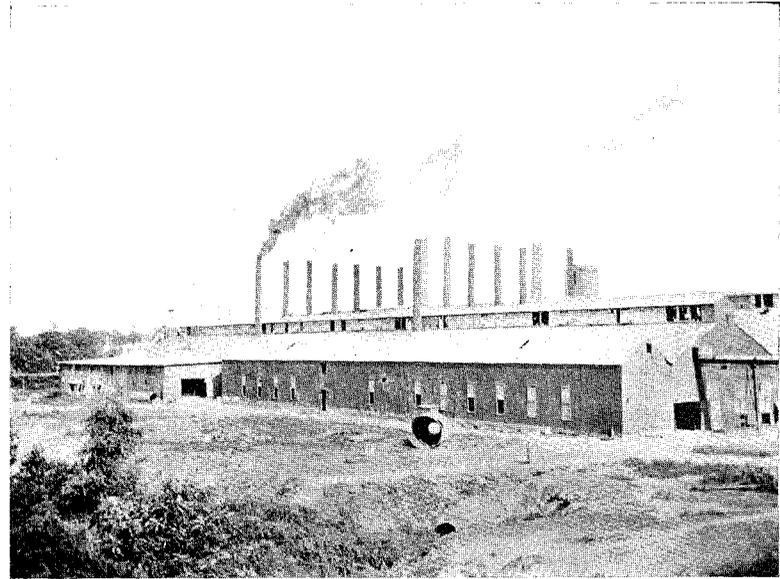
²⁶Appraisal of mining properties of Michigan, Lansing, Mich., 1911, p. 79.



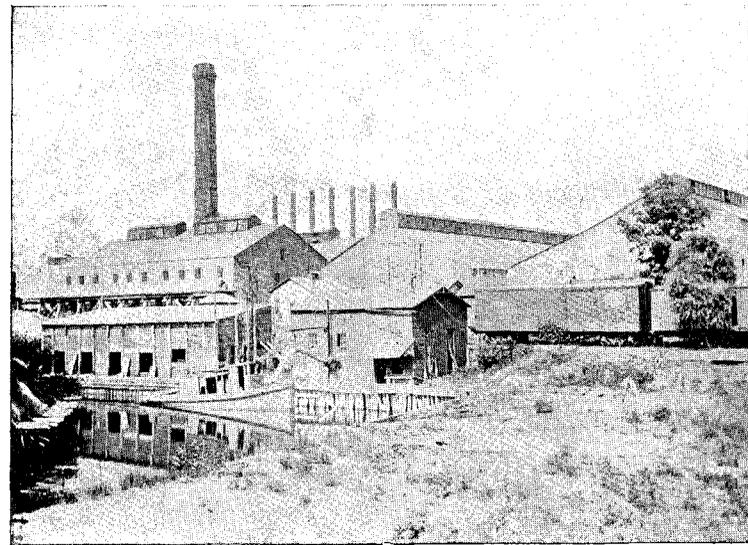
A. PLANT OF THE PEERLESS PORTLAND CEMENT COMPANY, UNION CITY, MICHIGAN.



B. PLANT OF THE MICHIGAN PORTLAND CEMENT COMPANY, GRAY VILLAGE, MICHIGAN.



A. PLANT OF THE WOLVERINE PORTLAND CEMENT COMPANY, COLDWATER,
MICHIGAN.



B. PLANT OF THE WOLVERINE PORTLAND CEMENT COMPANY, QUINCY, MICHIGAN.

	Output in barrels.	Cost.	Receipts.
1908.....	1,645,134	\$1,469,307	\$1,517,608
1909.....	1,188,197	1,485,794	1,520,081
1910.....	2,006,266	1,705,924	1,876,035
Total.....	5,540,597	\$4,661,025	\$4,913,724
Average of three years per barrel, cents.....		84.1	88.7

PRESENT OUTLOOK

It cannot be said that the present outlook is by any means promising. While the utilization of cement has increased very rapidly, yet it has by no means kept pace with the increased production.

The Michigan industry finds itself possessed of a very limited market due to its geographical position and the growth of the industry in adjacent states. This has narrowed the field practically to the confines of the state. The result is that such strong competition has been engendered among the Michigan companies that only those companies with exceptionally favorable conditions, such as location near market, cheap transportation, utilization of by-products, freedom from indebtedness, etc., have been able to operate without a loss. In addition to the local competition, the Michigan plants have also had to compete with the mills of other states which have used Michigan as a "dumping ground" for their surplus, while serving a better market, in other directions, from which Michigan is cut off by the high freight rates.

It is difficult to see any immediate relief from the above mentioned conditions. Attempts have been made to secure the reduction of freight rates to certain points but as yet nothing has been accomplished along that line. At present, it appears to be merely a case of survival of the fittest. It is possible that a considerable decrease in the number of producing plants might enable the remaining ones to earn a fair return on their investment.

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GOLD IN MICHIGAN.

BY R. C. ALLEN.

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Gold.
Discovery of Gold in Michigan.
The Ropes Mine.
The Michigan Gold Mine.
The Gold Lake.
The Superior Gold Mining Company.
The Peninsula Mining Company.
The Dead River District.
The Fire Centre Mining Company.
Placer Gold.

GOLD.

Mr. Geo. A. Newett of Ishpeming, formerly Commissioner of Mineral Statistics of Michigan, gives in his report of 1896 an interesting and full account of the discoveries and the mining of gold in Michigan. No gold has been produced in the state since the closing of the Ropes Mine in 1897, except an unknown amount obtained by a reworking of some of the tailings of this mine. In recent years no attempts have been made toward a resumption of operations at the old prospects which were located following and as a result of the Ropes discovery, nor have new gold deposits been searched for.

In this volume it seems proper to introduce in part Mr. Newett's account of gold mining not only for the historical interest which it has but also as a reminder that a resumption of gold mining in this state is a future possibility, vague as it may appear at present. The occurrences of gold ores as described by Mr. Newett are characteristic of the Lake Superior region in general, as are also the unsuccessful attempts at mining them. The ores of the Ropes Mine are native or free gold in a gangue of quartz occurring in veins in peridotite in the Keewatin rocks. The occurrence is not dissimilar in general to those in the Porcupine district of Ontario where success in a large way seems about for the first

time to be realized, if attained which will be all the more noteworthy in view of the long list of utter failures and near failures in past years in attempts to mine gold in the Lake Superior region. The following is a quotation of the essential parts of Mr. Newett's account written in 1896 to which reference is made above.

DISCOVERY OF GOLD IN MICHIGAN.

As early as the time in which Dr. Douglass Houghton, Michigan's first State Geologist, was engaged in the task of examining the Upper Peninsula rocks, it was known that gold existed in this portion of the State. Dr. Houghton, upon one of his brief trips from the camp at which he was temporarily located, secured enough gold to fill an eagle's quill. The gold, as remembered by those who saw it, was very coarse, and the doctor said he had obtained it from the bed of a little stream of water. The unfortunate drowning of Dr. Houghton occurred before he had disclosed the secret of the whereabouts of the discovery. Those who accompanied him during his work in the Upper Peninsula are not clear as to the exact place in which the camp was located at the time, and many points have been chosen as the correct one. It is generally believed that the spot was not far from where the most active work has since been done in the way of developing the gold-bearing veins of this region.

In January, 1864, DuBois & Williams, analytical chemists, of Philadelphia, Pa., in assaying specimens of quartz for silver, from the Holyoke silver district, eight miles north of the present city of Ishpeming, were surprised to find gold, the quartz holding it at the rate of several hundred dollars per ton. They reported this, but little attention was given the story, and no searching resulted.

The first discovery that led to anything of practical kind, and the one from which has sprung all that has been done in the Michigan gold fields, was made by Mr. Julius Ropes, of Ishpeming. This gentleman, a chemist, had noticed the presence of the metal in numerous rock samples he had taken, and he finally located a vein of quartz from which all subsequent excitement has resulted. This was in 1880, and the location was the south half of the north-west quarter of Sec. 29, 48-27, three miles northeast of Ishpeming City. It was in a range of serpentine rocks, and near the edge of a wet swamp. A company was formed, the fee of the mineral having been first been purchased, and here

THE ROPES MINE,

the first gold mine in the State of Michigan, was opened. It was not started on the spot at which the original find was made, but high ground, about 850 feet farther west, was selected, and here a shaft was sunk, a small mill erected, and the first milling work was done 1882. Since then the mill has been increased in size, and at one time 65 heads of Cornish stamps were dropping.

The Ropes was unfortunate in that it lacked sufficient funds to carry on its mining work as it should be done in order to secure the best results. In its earlier history there were many different managers who had charge of the business, and few of them were experienced in the work of milling. Like most gold mines, the Ropes has its peculiarities, and much time and money was expended in becoming familiar with them. About the time the best methods were learned, and the money had been spent, the people grew tired, the few assessments levied having discouraged them. In 1896 they were mining and milling a ton of rock for about \$1.85, which was certainly doing remarkably well considering the small amount treated per day, about 65 tons.

The Ropes rock is a hard one to stamp. It contains considerable talcose slate, this being sticky and soft, acting as a cushion under the heads. The rock has to be stamped fine, a 40-mesh screen being used, and the tonnage per head is small as compared to mines where a rock of different nature is met with. With all this understood, the management certainly made an excellent record, and deserved a better financial condition under which to labor.

The Ropes ore formation possesses a width of from 30 to 50 feet, and is made up of talcose slates in which the ore occurs in lenticular form and generally running transversely across the formation. Lenses are found in all imaginable positions, but the general course is as described. These lenses are made up of narrow bands of quartz and slate, and the minerals associated with the gold are galena, iron pyrites, gray and yellow copper ores. Occasionally one sees a speck of free gold, and at several places in the mine small vugs containing considerable free gold were found. At one such place about \$400 worth of the native metal was taken. Generally, however, the ore bodies have been of low grade, the average yielding something like \$2 or \$3 per ton. Could the mine have been opened up differently, and a selecting of the rock made, this average could have been considerably improved.

There is one shaft to the 15th level, a vertical depth of 850 feet. To the 12th level the lode has a slight dip to the south, but from this point to the present lowest level it inclines slightly in the opposite direction, the walls being nearly vertical. The ore lenses have a pitch to the west. The bottom of the first main lens was found at the 5th level, that of the second at the 9th, and in 1896 they were working upon the fourth lens in the bottom levels, the work here being entirely upon the east side of the shaft whereas in the upper levels the stoping was done to the west. In the lens encountered on the 16th level, the slate mixture is almost entirely missing, the vein being almost solid quartz, and giving an average of about \$6 per ton, this showing a better and stronger vein than has been found at any other point in the mine. The shaft does not reach to the bottom of this level, but stops at the 15th. An incline shaft was sunk at a distance of 150 feet east of the main shaft to secure the ore of this level. The hoisting was done from this sub-shaft by a small engine. They carried this shaft down until the shape of the new lens was determined. They had an idea that its westward pitch would carry it under the line of the main shaft, in which case the latter would have been continued downward and the lens would have been mined from this avenue. As the pitch of all the ore bodies thus far encountered has been westward, it is fair to argue that the position of this would prove no exception to the others.

The finding of ore of better quality, and in larger body than has heretofore been met with is particularly encouraging on this lowest level. It speaks well for the persistence of the gold, and offers substantial reasons why the Ropes should have been given a better show than was accorded it in the way of money to do business with.

A small territory was worked upon. A length of 550 feet on the trend of the lode embraces it all, and from this there was produced \$605,056.95 worth of gold and silver. This is the gross yield, and I give it to show that there is gold in the rock of this mine. This embraces the product from the commencement up to the first of January, 1896. The gold is generally free milling. What concentrates were saved were sent to Aurora, Ill., for treatment. Frue vanners were employed for the concentration. The bulk of the gold is held in the "quick" in the mortars and on the copper plates, the common form of amalgamation being observed.

An advantage the mine has is the solid walls that need no timbering and the freedom from water. In the 16th level not a drop of water came from the level. The vein was stoped out on the

overhand plan. The ground was drilled by machines. About 35 men were employed in 1896.

Another point of vantage was the cheapness with which the water supply was secured. The source is the Carp river something more than a mile distant. Here a dam was constructed, and, with a four-foot fall, a pump was operated by a turbine wheel that furnished all the water the mill needed, and the supply is ample for any future demand that may be made under a prosperous condition of things.

At the point where gold was first found by Mr. Ropes on this property, the vein was narrow, but very rich, giving about \$200 per ton, by assay. There is the territory lying between this and the shaft at the mine upon which practically nothing has been done in the way of exploration and where there should be something valuable disclosed by practical testing of the ground. The fact that the ore lenses in the mine pitch to the west, and that gold was found on surface so far east, is an encouraging sign.

Several years after mining work was discontinued by the Ropes Gold & Silver Company, Mr. W. H. Rood, of Ishpeming, erected several large vats and attempted to reclaim the gold in the tailings that had been wasted into the low ground immediately north of the mill. The cyanide process was employed, and the work was just fairly started when the death of Mr. Rood put an end to it. Several thousand dollars had been reclaimed and Mr. Rood stated that he was making a profit. Unfortunately, no one took up the cyaniding after this time. The plant was in the nature of an experiment and demonstrated the fact that the tailings could be successfully treated. Had the cyanide plant been operated simultaneously with mining and milling activities it might have enabled the company to secure the margin of profit necessary to success.

The product for 1895 was valued as follows: Gold \$34,838.69; silver, \$1,373.16; total, \$36,211.85.

Two miles and a half west of the Ropes mine, on Sec. 35, town 48, range 28, is

THE MICHIGAN GOLD MINE.

This property has produced some of the finest specimens of free gold ever seen. Many of these yielded gold at the rate of \$160,000 per ton. Indeed, so rich were they, that they offered too great a temptation to the miners who were employed there, and the trunk of one enterprising fellow who was all ready to take his departure for Europe was looked into and found to contain over two thousand dollars' worth of golden treasure, secured from this

property when the eyes of the bosses were not upon him. How many thousands were stolen is not known, but there probably were many of them. This property was its busiest in 1890, and for a time there was a lively trading in its shares. At a depth of about 80 feet in two shafts that were sunk, the gold had diminished to such a degree as to dishearten those who were conducting the exploration and work was abandoned. A little was done in 1895, but nothing of value accomplished. It consisted principally in making a test of some of the rock already mined.

The Michigan has several veins crossing its lands, and it was upon the largest of these that the work was done, although gold was found in the smaller ones. The veins are in diorite, differing in this respect from the Ropes. Their trend is nearly east and west, and they observe a nearly vertical position. There is little or no silver, and the gold where found is free milling, there being little mineral in the rock aside from the gold. The rock stamps freely, and under the ordinary Cornish head a large amount could be treated daily.

During the months of January, February and March, 1890, the mine produced \$12,675.35 worth of bullion, and this was the time when excitement regarding it ran highest. The total yield is valued at \$17,699.36. With the great diminished percentage of gold in the bottom of the exploring shafts interest also waned, and all work was finally abandoned, and those who invested in the shares of the company were out the money put in.

The shafts of the Michigan Gold Company were less than 100 feet in depth. What another one hundred feet would have shown can but be conjectured. The property was well equipped with machinery, there were several creditable buildings, and everything was in shape in 1896 to resume work on short notice.

THE GOLD LAKE.

This prospect is immediately west of the Michigan on lands belonging to the Lake Superior Iron Company. The latter company sunk a shaft, and secured many fine specimens, after which they leased it to the Gold Lake Company, by whom it was worked for a time in a very quiet manner. Specimens rich in gold, and comparing favorably with those from the Michigan, were secured. This vein is also in the diorite, and felsite shows in places cutting through the diorite. The vein "pinched" out at a depth of something like 60 feet, and its continuation was not sought beyond a few feet where lost sight of.

THE SUPERIOR GOLD MINING COMPANY

did some work on the northeast quarter of northwest quarter of Secs. 35, 48-28. This was immediately east of the Michigan property, and the vein was in the diorite. Some fine specimens were secured, but the work was given up soon after it was begun. The vein is said to have been cut out by the diorite.

THE PENINSULA MINING COMPANY,

made up of Detroit, Mich., capitalists, did some work under the above title on the southwest quarter of the southwest quarter of Secs. 25, 48-28. A shaft was sunk 70 feet. The quartz here is in granite and is in small stringers. Free gold was seen, and the company figured that they could treat all the granite impregnated with this quartz. Numerous assays were made and the company reported these to be satisfactory. They have not done anything in the way of equipping the property.

Other properties were worked more or less, the Grummett, Swains, Mocklers, Grayling and Giant being prominent at the time the excitement was at its height, but all work has stopped. These were all on the Michigan range.

THE DEAD RIVER DISTRICT.

One of the most promising territories for the existence of gold is known under the above title. In the sixties there was great excitement in the field due to the discoveries of silver secured from the Holyoke mine, but the lead did not prove rich enough in the more precious metal, and all work was finally abandoned.

This district begins in the Dead River valley starting about eight miles north of Ishpeming and extending northward to Lake Superior. The particular portion of this field as thus far exploited can be located by a line drawn centrally through it from east to west, which line would agree with the line of town 49. The eastern terminus can be placed at Lake Superior. Westward it extends several miles. The honor for first bringing this district to the attention of the people of the State was accorded Julius Ropes, who made his initial discovery here in June, 1890.

In town 27 there is a spur that leaves the main range, going at a sharp angle to the northwest. This is locally termed the north range, and the one from which it diverges, the south range. The south range appears to be the principal gold bearer so far as tests of the rock have been made. In width the range altogether is about three miles.