STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION

DIVISION OF

GEOLOGICAL SURVEY

Publication 32

Geological Series 26

MINERAL RESOURCES OF MICHIGAN

WITH

STATISTICAL TABLES OF PRODUCTION
AND VALUE OF MINERAL PRODUCTS

FOR

1920 AND PRIOR YEARS

PREPARED UNDER THE DIRECTION OF

R. A. SMITH, State Geologist

IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE BOARD OF
GEOLOGICAL AND BIOLOGICAL SURVEY FOR 1920

LETTER OF TRANSMITTAL

To the Honorable, the Director and the Board of Commissioners of the Department of Conservation of the State of Michigan

Hon. John Baird, Director
Hon. W. H. Wallace.
Hon. John L. A. Galster.
Hon. Chas. E. Lawrence.
Hon. T. F. Marston.
Hon. Geo. W. Miller.
Hon. Fred Z. Pantlind.
Hon. Filibert A. Roth.

Gentlemen: Under authority of Act No. 7 Public Acts of Michigan, Session of 1911, I have the honor to present herewith Publication 32, Geological Series 26, the ninth of a series of annual statements of the production and value of the mineral products of Michigan. This publication is a part of the Annual Report of the Board of Geological and Biological Survey for 1920, publication of which has been delayed by delay in receiving returns from the United States Bureau of the Census.

Very respectfully,
R. A. Smith,
State Geologist.

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L. P. BARRETT

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MICHIGAN COPPER INDUSTRY IN 1919-1920

GENERAL STATEMENT

In 1920 Michigan produced 161,343,880 pounds of copper as against 179,082,970 pounds in 1919. Sales of copper in 1920 totalled 135,043,121 pounds which netted $24,457,996.21 or an average of 18.111 cents per pound. Copper sales in 1919 totalled 139,706,574 pounds for which $26,289,837.86 was received or an average of 18.81 cents per pound. Computations based upon the average receipts per pound for the year 1919 and the year of 1920 show that the total value of copper produced in Michigan amounted to $33,696,537 in 1919 and $29,220,990 in 1920. Michigan copper production for the years 1919 and 1920 shows a considerable falling off from the total of $226,224,305 in 1918.

Copper mining, unlike practically every other industry in the United States, failed to participate in the boom period of 1919 and 1920. The sudden termination of the World War was accompanied by an abrupt end to the sale of copper. Contracts were cancelled indiscriminately but the copper producers were requested not to curtail operations until 1919 in order that industrial operations might receive less disturbance. Very little copper was sold during 1917 and 1918 and with operators producing the maximum capacity a large surplus of stock was accumulated. This situation was further aggravated during 1919 by the Government throwing on the market a large amount of copper stock in its disposal of War supplies. During 1919 and 1920 copper production over all the country was curtailed but the expansion due to the War demand was so great that the curtailment was insufficient. The output continued to exceed consumption and the surplus stocks of copper continued to increase. Domestic consumption of copper in 1919 was good, being slightly in excess of pre-War requirements, but European demands were of course greatly reduced. Toward the close of 1920 the business depression in this country arrived, curtailing the copper consumption in the United States, and the price dropped to 13½ cents in December or below the cost of production for all except three or four mines in the United States and for practically all Michigan properties. This condition was responsible for the general closing down of all the large producers in the United States in 1921. In Michigan the depression in the copper industry in 1920 was reflected in the closing down of most of the high cost producers. Among the mines which failed to produce any copper in 1920 were Franklyn, Mass, Hancock, Lake and Winona. The larger companies produced practically the same amount of copper as in 1920, and the decrease in Michigan production for the year 1920 may be accounted for by the closing down of the high cost operations.

The silver production of the Michigan copper mines amounted to 425,610 fine ounces, valued at $477,054 in 1919 and 510,601 fine ounces valued at $518,326 in 1920.

Statistics covering Michigan copper production compiled from annual report to the stockholders of the various mining companies are to be found on the following page.

MICHIGAN COPPER PRODUCTION BY COMPANIES IN 1919 and 1920

	1919	1920
Ahmeek Mining Co.	$17,223,111	20,489,438
Allouez Mining Co.	3,749,984	2,499,239
Arcadian Consolidated Mining Co.	.....	.....
Calumet & Hecla Mining Co.	52,859,146	57,627,883
Centennial Copper Mining Co.	1,365,148	561,284
Copper Range Company, Baltic Mine	7,864,653	6,613,918
Champion Copper Co.	19,886,917	13,610,324
Franklyn Mining Co.	1,062,879	.....
Gratiot Mining Co.	.....	33,704
Isle Royale Copper Co.	13,007,647	10,621,801
Lake Copper Co.	717,403	.....
La Salle Copper Co.	340,719	59,713
Maas Consolidated Mining Co.	1,963,178	.....
Michigan Copper Mining Co.	1,697,107	1,075,492
Mohawk Mining Co.	12,857,392	10,269,824
Osceola Consolidat d Mining Co.	10,824,331	7,465,773
Quincy Mining Co.	19,476,320	19,219,070
Seneca Copper Corporation	.....	497,680
Superior Copper Co.	563,935	322,871
Trimountain Mining Co.	5,274,387	3,532,025
Victoria Copper Mining Co.	1,245,590	1,060,829
White Pine Copper Co.	1,979,268	1,850,787
Winona Copper Co.	561,238	.....
Wolverine Copper Mining Co.	4,562,617	3,932,225
Total	179,082,970	161,343,880

SUMMARY OF FINANCIAL STATE-

	Idle Mine Expense	Total production cost and Exploration	Expended for construction
Ahmeek		3,294,392.97	
Algomah	6,033.81		
Allouez		597,490.19	
Arcadian		68,119.60	
Atlantic	11,205.00		
Calumet & Hecla		11,944,025.00	186,954.88
Centennial		203,023.94	
Champion		1,946,028.54	
Cliff	2,597.83		
Copper Range		4,129,256.68	
Franklyn		137,859.82	
Indiana	8,882.19		
Isle Royale		2,135,098.12	88,932.56
Lake	15,328.65		
LaSalle		77,495.97	
Mass	75,742.26		
Mayflower		121,947.97	
Michigan		342,357.92	
Mohawk		1,424,846.49	74,971.71
North Lake	12,614.80		
Osceola		1,805,123.97	46,267.52
Quincy		4,218,664.89	307,690.17
Seneca			
South Lake	22,767.79		
Superior		144,156.91	
Trimountain		901,237.04	
Victoria		272,610.65	
White Pine		535,032.55	
Winona		208,424.86	
Wolverine		939,040.55	45,668.56

MENTS MICHIGAN COPPER MINES 1920

Receipts				Dividends paid 1920	Balance of Current Assets (+) Liabilities (—)
Sales of Copper	Silver and Interest Received and Misc.	Assessments	Total		
2,391,358.40	47,340.99		2,438,699.39	300,000.00	+ 3,235,288.83
	85.98		85.98		
513,864.44	11,042.81		524,907.25		+ 589,604.74
	63,221.13	14,399.50	77,620.63		
	19,563.45		19,563.45		+ 416,511.49
8,069,949.00	564,745.88		8,634,694.88	500,000.00	+12,901,087.65
172,829.13	4,933.33		177,762.46		+ 223,403.59
2,337,318.60	8,482.59		2,345,801.19	600,000.00	+ 1,721,756.39
	37,103.77		37,103.77		+ 49,640.95
4,073,883.82	250,420.50		4,324,304.32	591,625.50	+ 5,437,488.46
19,000.00	23,688.14		42,688.14		+ 162,957.32
	1,051.91		1,051.91		
1,865,445.56	82,262.84		1,947,738.40		+ 1,684,195.95
	19,934.88		19,934.88		+ 217,265.69
10,574.66	19,781.12		30,353.78		+ 321,241.68
	27,338.92		27,338.92		
	4,646.42	174,136.50	178,782.92		+ 71,657.78
202,025.30	6,155.40		208,180.70		— 332,654.67
1,627,150.14	51,951.40		1,679,101.54	550,000.00	+ 2,211,421.57
	3,886.03		3,886.03		
1,440,016.58	51,024.62		1,491,041.20	96,150.00	+ 2,600,367.00
3,210,112.65	22,492.76		3,232,605.41	110,000.00	+ 1,879,265.42
	1,160.09	67,089.00	68,249.09		— 104,834.93
33,651.71	19,932.12		53,583.83		+ 400,650.90
604,536.40	49,310.32		653,846.72		+ 1,626,238.00
137,907.77	9,215.47		147,123.24		+ 103,967.22
251,785.82	28,856.89		280,642.71		+ 240,000.99
170,093.14	292.71	1,787.48	172,173.33		
660,727.62	12,272.68			90,000.00	+ 785,096.04

UMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINES 1914-1920

(Compiled from annual reports to stockholders)

	Tons of Ore treated.	Cost of mining, transportation and stamping per ton.	Pounds Refined Copper produced.	Pounds refined copper per cent ton of ore treated.	Cost per pound at mine, excluding construction.	Other costs per pound.*	Total cost per pound.	Price received for copper sold.
Ahmeek:								
1920	822,162	2.62	20,489,438	24.9	10.49c	6.15c	16.64c	18.60c
1919	756,870	2.59	17,223,111	22.8	11.39	3.12	14.51	18.81
1918	1,196,541	2.18	24,851,235	20.8	10.52	4.27	14.79	24.30
1917	1,271,275	1.74	27,919,812	22.0	7.91	1.51	9.42	26.84
1916	1,164,010	1.46	24,142,158	20.7	7.04	4.50	11.54	25.72
1915	948,874	1.26	21,800,492	23.0	5.48	2.48	7.96	18.28
Allouez:								
1920	131,643	3.528	2,499,239	18.98	18.59	5.87	24.46	18.65
1919	235,312	3.043	3,749,984	15.94	19.10	2.95	22.05	18.76
1918	514,888	2.119	7,071,218	13.73	15.45	4.77	20.22	24.49
1917	566,674	1.869	8,892,915	15.69	11.91	1.93	13.84	27.95
1916	566,960	1.589	10,219,290	18.02	8.82	2.03	10.85	25.305
1915	534,705	1.365	10,043,459	18.78	7.27	2.04	9.31	18.166
Copper Range (Baltic Mine):								
1920	175,357	.....	6,613,918	37.71	.....	.....	18.02	17.11
1919	235,832	.....	7,864,653	33.35	.....	.....	.....	18.668
1918	293,601	.....	10,406,097	34.440	.....	.....	.....	24.757
1917	325,342	.....	11,214,861	34.47	.....	.....	13.769	28.735
1916	369,287	.....	12,425,804	33.65	.....	.....	10.85	25.28
1915	378,443	.....	12,028,947	31.79	.....	.....	09.50	17.40
C. & H. (all mine ore):								
1920	1,560,240	4.22	43,489,643	27.87	15.42	8.03	23.45	18.76
1919	1,830,760	3.85	43,776,194	23.91	16.10	6.00	22.10	18.81
1918	2,876,392	3.07	58,722,969	20.40	13.95	7.60	21.55	24.28
1917	3,159,570	2.52	68,419,826	21.65	11.66	.....	13.01	28.39
1916	3,166,274	2.03	71,349,591	22.53	.....	.....	11.63	25.48
1915	3,188,583	1.71	71,030,518	22.28	.....	.....	9.33	18.11

C. & H. (Conglomerate):								
1920	978,000	5.16	34,324,660	35.10	.....	.....	.....	.....
1919	1,111,080	4.87	32,895,816	29.61	.....	.....	.....	.....
1918	1,547,603	4.09	43,329,816	28.00	.....	.....	.....	.....
1917	1,751,621	3.26	50,415,860	28.76	.....	.....	.....	.....
1916	1,727,794	2.63	51,785,016	29.97	.....	.....	10.75	.....
1915	1,739,984	2.13	51,738,588	29.74	.....	.....	8.69	.....
C. & H. (Osceola lode):								
1920	582,240	2.62	9,164,983	15.74	.....	.....	.....	.....
1919	719,680	2.28	10,880,378	15.57	.....	.....	.....	.....
1918	1,328,789	1.88	15,393,153	11.58	.....	.....	.....	.....
1917	1,407,949	1.60	18,003,966	12.97	.....	.....	.....	.....
1916	1,438,480	1.32	19,564,575	13.60	.....	.....	11.84	.....
1915	1,448,599	1.07	19,291,930	13.32	.....	.....	9.71	.....
Centennial:								
1920	41,418	4.327	561,284	13.55	31.94	4.79	36.73	18.66
1919	87,688	3.331	1,365,148	15.57	21.40	3.75	25.15	18.84
1918	159,040	2.275	2,492,857	15.67	14.52	4.62	19.14	24.61
1917	148,332	2.331	2,062,857	13.50	17.26	1.41	18.67	26.96
1916	150,617	1.916	2,367,400	15.72	12.18	1.26	13.44	25.02
1915	150,191	1.753	2,347,500	15.63	11.21	1.24	12.45	18.145
Champion:								
1920	321,664	.....	13,610,324	42.419	.....	.....	14.40	17.17
1919	503,030	.....	19,886,917	39.053	.....	.....	11.77	18.668
1918	594,235	.....	21,748,514	36.599	.....	.....	11.92	24.757
1917	776,036	2.42	27,550,343	35.50	.....	.....	10.40	28.735
1916	936,656	2.42	33,601,136	35.87	6.08	.72	7.80	25.28
1915	923,743	1.95	33,417,599	36.17	5.12	1.18	6.30	17.40
Franklin:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919	109,565	.....	1,062,879	.....	.....	.....	.....	15.
1918	296,182	.....	2,827,313	.....	.....	.....	.....	24.349
1917	303,625	.....	3,155,574	.....	.....	.....	.....	26.74
1916	267,286	.....	3,116,566	.....	.....	.....	.....	25.432
1915	122,018	.....	1,314,969	.....	.....	.....	.....	19.83
Hancock:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1918	227,049	.....	3,041,504	13.40	.....	.....	.....	24.2992
1917	302,725	.....	4,047,053	13.223	.....	.....	.....	28.229
1916	203,112	.....	2,824,934	13.908	.....	.....	.....	28.093
1915	.....	.....	871,124	.....	.....	.....	.....	18.57

*Includes smelting, refining, corporation taxes, eastern offices, freight, insurance, commissions, etc., on copper delivered.

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINES 1914-1920—*Continued*

	Tons of Ore treated.	Cost of mining, transportation and stamping per ton.	Pounds Refined Copper produced.	Pounds refined copper per cent ton of ore treated.	Cost per pound at mine, excluding construction.	Other costs per pound.*	Total cost per pound.	Price received for copper sold.
Isle Royale:								
1920	591,971	2.73	10,621,801	17.94	15.20	5.46	20.66	18.61
1919	724,667	2.35	13,007,647	17.95	13.12	3.18	16.30	18.60
1918	974,508	2.14	15,442,508	15.9	13.49	3.51	17.00	24.46
1917	922,162	2.02	13,480,921	14.6	13.80	1.94	15.74	26.87
1916	925,419	1.53	12,412,111	13.4	11.38	4.37	15.75	25.86
1915	680,270	1.45	9,342,106	13.7	10.56	4.38	14.94	18.36
Houghton:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1918 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1917	15,628.40	.....	179,012	11.45	.....	.....	.....	28.14
1916	19,444.35	.....	204,274	10.55	.....	.....	.....	.....
1915	14,656.92	.....	156,766	10.69	.....	.....	.....	29.21
Lake:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1918	.....	.....	717,403	.....	.....	.....	.....	26.05
1917	63,191	.....	1,461,893	23.13	.....	.....	.....	25.57
1916	70,440	.....	1,489,247	21.14	.....	.....	.....	29.726
1915	59,848	.....	1,581,071	26.42	.....	.....	.....	20.149
LaSalle:								
1920	3,430	.....	59,713	17.41	112.00	18.62	130.62	18.76
1919	32,995	2.55	340,719	10.326	34.96	6.39	41.35	18.13
1918	176,423	1.893	1,832,665	10.38	18.27	4.03	22.30	24.35
1917	185,014	1.87	1,919,775	10.38	18.03	2.11	20.14	28.45
1916	144,829	1.79	1,380,352	9.53	18.80	2.16	20.96	25.68
1915	80,959	.....	782,493	9.67	.....	.....	.....	18.22
Mass:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919	123,780	.....	1,963,178	15.86	.....	.....	27.87	21.7
1918	196,456	.....	3,403,827	17.33	.....	.....	23.82	24.31
1917	244,671	.....	3,984,616	16.29	.....	.....	19.81	26.2
1916	287,900	.....	4,752,588	16.51	.....	.....	15.37	26.276
1915	323,335	.....	4,638,452	14.35	13.06	1.71	14.77	18.363
Michigan:								
1920	46,289	.....	1,075,492	23.23	.....	.....	.....	18.78
1919	62,373	.....	1,697,107	27.21	.....	.....	.....	17.68
1918	40,865	.....	1,177,176	28.56	.....	.....	.....	24.7
Mohawk:								
1920	434,988	2.502	10,269,824	23.61	11.244	6.311	17.545	19.08
1919	560,734	2.049	12,857,392	22.93	8.935	5.048	13.983	17.914
1918	454,293	2.259	10,781,041	23.73	9.521	5.12	14.641	24.73
1917	605.202	1.88	12,313,887	20.35	9.25	2.07	11.32	27.94
1916	664,547	1.54	13,834,034	20.82	7.35	1.17	8.85	25.28
1915	829,789	1.20	15,882,914	19.15	6.24	1.24	7.48	17.0
New Arcadian:								
1920 Exploring, no refined copper								
1919 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1918	10,195	.....	164,794	16.00	.....	.....	.....	.....
1917	4,900	.....	53,278	.....	.....	.....	.....	.....
1916	1,391	.....	32,307	.....	.....	.....	.....	.....
1915	3,845	.....	79,209	20.62	.....	.....	.....	24.0
1914	.....	.....	.....	.....	.....	.....	.....	17.856
Osceola:								
1920	455,982	2.97	7,465,773	16.37	18.14	6.60	24.74	18.61
1919	739,364	2.21	10,824,331	14.6	15.15	3.42	18.57	18.65
1918	1,194,967	1.78	15,919,647	13.3	13.35	4.81	18.16	24.41
1917	1,237,805	1.63	16,084,958	13.0	12.53	1.33	13.86	27.89
1916	1,284,681	1.36	19,586,501	15.2	8.91	2.78	11.69	25.73
1915	1,361,089	1.18	19,731,472	14.5	8.17	1.86	10.03	18.19
Quincy:								
1920	809,263	.....	19,216,070	23.75	.....	.....	.....	16.27
1919	960,393	.....	19,476,320	20.28	.....	.....	.....	19.38
1918	1,174,147	.....	19,948,965	16.99	.....	.....	.....	24.00
1917	1,280,837	.....	22,195,577	17.33	.....	.....	.....	28.6
1916	1,204,026	.....	21,065,612	17.5	.....	.....	.....	25.5
1915	1,269,000	.....	22,054,813	.....	.....	.....	.....	18.0
South Lake:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1918	76,947	.....	365,936	.....	.....	.....	.....	.....
1917	48,331	.....	533,091	.....	.....	.....	.....	.....
1916	20,057	.....	285,600	11.03	.....	.....	.....	.....
1915	3,993.5	.....	61,637	.....	.....	.....	.....	.....

*Includes smelting, refining, corporation taxes, eastern offices, freight, insurance, commissions, etc., on copper delivered.

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINES 1914-1920—*Continued*

	Tons of Ore treated.	Cost of mining, transportation and stamping per ton.	Pounds Refined Copper produced.	Pounds refined copper per cent ton of ore treated.	Cost per pound at mine, excluding construction.	Other costs per pound.*	Total cost per pound.	Price received for copper sold.
Superior:								
1920	9,549		322,871	33 81	37,60	7.66	45.26	18.26
1919	27,267	6.605	563,935	20.68	31.94	5.38	37.32	18.67
1918	106,213	2.68	1,676,446	15.78	16.99	8.55	25.54	24.22
1917	129,587	2.50	2,201,672	16.99	14.74	2.14	16.88	29.39
1916	185,315	2.07	3,034,656	16.38	12 62	1.99	14.61	24.67
1915	212,051	1.88	3,865,484	18 23	10.31	1.98	12 29	18.125
Trimountain:								
1920	116,768	.....	3,532,025	30 24	.....	.....	24.12	17.115
1919	171,995	.....	5,274,387	30.66	.....	.....	19.39	18.668
1918	201,433	.....	5,343,586	20.52	.....	.....	18.42	24.757
1917	264,655	.....	6,278,097	23.72	.....	.....	15.22	28.735
1916	349,504	.....	8,720,558	24.94	9.95	1.15	11.10	25.28
1915	349,684	2 02	8,302,896	23.75	8.38	1.14	9.52	17.40
Victoria:								
1920	61,031	.....	1,060,829	17.38	.....	.....	.....	.....
1919	89,206	.....	1,245,590†	.....	.....	.....	.....	.....
1918	106.730	.....	1,533,536	.....	.....	.....	.....	.....
1917	137,286	.....	1,612,640	.....	.....	.....	.....	.....
1916	146,690	.....	1,661,832	.....	.....	.....	.....	.....
1915	133,984	.....	1,499,695	.....	.....	.....	.....	.....
White Pine:								
1920	93,260	3.797	1,850,787	19.85	19.14	10.35	29.49	18.69
1919	84,008	3.841	1,979,268	23.56	16.30	8.50	24.80	18.74
1918	194,568	2 984	3,273,680	16.83	17.73	7.05	24.78	24.34
1917	212,889	2.365	4,067,529	19.11	12.38	2.61	14.99	28.30
1916	188,890	2.082	4,207,449	22.27	9.35	3.35	12.70	25.26
1915	114.039	2.182	2,824,145	24.76	8.80	7.84	16.64	18.353
Winona:								
1920 (idle)	.....	.....	.....	.....	.....	.....	.....	.....
1919	39,654	.....	561,238	14.153	.....	.....	.....	18.50
1918	57,837	.....	819,857††	14.157	.....	.....	.....	26.00
1917	112,082.55	.....	1,494,472	13.33	.....	.....	.....	29.05
1916	161,828.55	.....	2,167,255	13.39	.....	.....	.....	28.03
1915	102,594.05	.....	1,722,638	16.79	.....	.....	.....	17.4
Wolverine:**								
1919-1920	257,294	2.336	3,932,225	15.28	15.238	6.811	22.049	19.11
1918-1919	298,279	2.117	4,562,617	15.306	13.839	6.461	20.300	20.6
1917-1918	303,498	1.914	4,608,865	15.185	12.604	6.323	18.927	24.2
1916-1917	352,845	1.63	5,856,889	16.60	9.28	2.26	11.54	29.15
1915-1916	388,898	1.39	6,641,492	17.07	8.11	1.43	9.54	12.81
1914-1915	397,614	1.30	7,250,866	18.23	7.13	.....	8.43	14.09

*Includes smelting, refining, corporation taxes, eastern offices, freight, insurance, commissions, etc., on copper delivered.
†Partly estimated.
††717,403 pounds copper additional produced from Winona Mine during first four months of 1918 by R. R. Seeber, Lessee.
**Wolverine Fiscal year ends June 30.

LIST ACTIVE MICHIGAN COPPER MINING COMPANIES

Name of Company	Location of Mine	Principal Michigan Office	Chief Michigan Official
Arcadian Consolidated Mining Co.	Hancock, Houghton Co.	Houghton	Robert Shields, Pres.
Ahmeek Mining Co.	Kearsarge, Keweenaw Co.	Calumet	James McNaughton, Vice Pres.
Allouez Mining Co.	Allouez, Keweenaw Co.	Calumet	James McNaughton, Vice Pres.
Calumet & Hecla Mining Co.	Calumet, Houghton Co.	Calumet	James McNaughton, Vice Pres.
Centennial Copper Mining Co.	Calumet, Houghton Co.	Calumet	James McNaughton, Vice Pres.
Champion Copper Co.	Painesdale, Houghton Co.	Painesdale	F. W. Denton, Managing Director
Copper Range Co.	Painesdale, Houghton Co.	Painesdale	F. W. Denton, Vice Pres.
Franklyn Mining Co	Demmon, Houghton Co.	Demmon	Enoch Henderson, Supt.
Gratiot Mining Co.	Mohawk, Keweenaw Co.	Calumet	W. J. Uren, Gen, Mgr.
Hancock Consolidated Mining Co.	Hancock, Houghton Co.	Hancock	John D. Cudahy, Pres.
Isle Royale Copper Co	Houghton, Keweenaw Co.	Calumet	James McNaughton, Vice Pres.
Lake Copper Co.	Lake Mine, Ontonagon Co.	Ontonagon	C. J. McKie, (resigned) Supt.
LaSalle Copper Co.	Calumet, Houghton Co.	Calumet	James McNaughton, Vice Pres.
Mass Consolidated Mining Co.	Mass City, Ontonagon Co.	Mass City	Elton W. Walker, Supt.
Mayflower Old Colony Copper Co.	Calumet, Houghton Co.	Houghton	G. S. Goodale, Supt.
Michigan Copper Mining Co.	Rockland, Ontonagon Co.	Calumet	Theo. Dengler, Gen. Mgr.
Mohawk Mining Co.	Mohawk, Keweenaw Co.	Calumet	Theo. Dengler, Agent.
Osceola Consolidated Mining Co.	Calumet, Houghton Co.	Calumet	James McNaughton, Vice Pres.
Quincy Mining Co.	Hancock, Houghton Co.	Hancock	Chas. L. Lawton, Gen. Mgr.
Seneca Copper Corporation	Mohawk, Keweenaw Co.	Calumet	W. J. Uren, Gen. Mgr.
Superior Copper Co.	Calumet, Houghton Co.	Calumet	James McNaughton,
Trimountain Mining Co.	Painesdale, Houghton Co.	Painesdale	F. W. Denton, Managing Director.
Victoria Copper Mining Co.	Rockland, Ontonagon Co.	Rockland	George Hooper, Supt.
White Pine Copper Co.	Ontonagon, Ontonagon Co.	Calumet	James McNaughton, Vice Pres.
Winona Copper Co.	Winona, Houghton Co.	Winona	G. A. Braun, Supt.
Wolverine Copper Mining Co.	Calumet, Houghton Co.	Calumet	Theo. Dengler, Agent.

IRON INDUSTRY

STATISTICAL TABLES

DICKINSON COUNTY IRON MINES

Table of Shipments 1916 to 1920

Mine	1916	1917	1918	1919	1920	Grand Total of Shipments From Present Active Mines
Aragon	244,478	276,434	305,726	188,098	445,102	8,706,078
Chapin	557,485	682,349	705,803	545,050	843,736	22,765,986
Clifford	113,362	115,823	118,944	.....	128,489	2,262,056
Indiana	44,162	46,479	59,220	13,545	11,025	224,949
Loretto	174,173	193,951	155,891	82,259	122,905	2,467,449
Munro	17,622	46,960	53,031	30,920	45,970	487,953
Penn Group	419,340	452,710	210,632	160,485	524,192	12,464,845
Pewabic	301,125	153,256	113,999	.....	.....	9,340,282
Total	1,871,747	1,967,962	1,722,796	1,020,357	2,121,419	58,719,598

GOGEBIC COUNTY IRON MINES

Table of Shipments 1916 to 1920

Mine	1916	1917	1918	1919	1920	Grand Total Shipment From Present Active Mines to 1920
Anvil	.....	54,027	14,277	4,158	8,406	868,335
Ashland	70,466	27,636	41,486	28,083	57,305	6,427,962
Asteroid	89,876	93,265	121,152	64,719	197,136	847,317
Brotherton	107,814	84,524	6,904	5,002	36,059	2,534,417
Castile	133,162	82,248	73,065	48,596	115,504	838,702
Colby-Ironton Group	571,739	598,397	509,358	480,336	669,229	6,687,429
Eureka	207,959	191,631	189,696	146,303	265,494	1,705,629
Keweenaw	120,355	129,498	141,756	122,465	261,033	822,825
Mikado	23,741	30,833	.....	995	.....	1,141,619
Newport-Bonnie	1,310,595	998,193	1,035,673	872,700	836,700	17,518,475
Norrie Group	1,855,863	1,646,606	1,550,802	1,335,473	1,611,305	39,667,266
Palms	528,746	475,352	677,415	463,534	595,033	4,770,830
Plymouth	330,496	658,284	821,867	498,840	712,806	3,020,416
Puritan Group	460,050	410,171	381,624	199,256	270,043	2,419,594
Sunday Lake	188,771	198,144	131,426	184,550	225,932	2,863,773
Tilden	110,172	108,023	125,137	129,089	150,132	6,429,158
Townsite	.....	25,965	83,428	80,204	107,961	297,558
Wakefield	1,061,753	1,116,802	1,130,432	595,944	978,694	5,865,238
Yale	149,154	73,632	103,490	246,316	337,034	1,774,086
Total	7,320,712	7,003,231	7,138,988	5,506,623	7,435,806	106,500,629

IRON COUNTY IRON MINES

Table of Shipment 1916 to 1920

Mine	1916	1917	1918	1919	1920	Grand Total of Shipments from Present Active Mines
Balkan	229,195	261,014	262,293	159,922	173,094	1,229,802
Baltic-Fogarty	200,471	126,970	166,509	15,405	16,384	2,691,723
Bates	57,127	155,703	98,194	88,988	93,548	539,050
Bengal	140,961	261,350	302,815	229,501	265,035	1,268,075
Berkshire	38,470	57,791	38,439	49,075	159,990	574,436
Bristol	462,801	188,688	245,279	58,138	368,487	5,404,252
Carpenter	240,114	269,178	384,234	396,224	123,409	1,748,408
Caspian	448,631	412,313	345,420	315,328	421,822	4,169,691
Chicagon	100,640	90,758	109,572	82,656	135,700	1,185,480
Chatham	188,807	245,744	245,842	51,758	15,624	1,382,276
Cottrell	75,089	.....	.....	.....	.....	75,134
Davidson, No. 1	96,518	115,132	52,316	152,495	113,832	830,606
Delta	.....	.....	.....	42,979	8,366	51,345
Davidson, No. 2	67,731	108,858	61,462	95,803	96,102	771,897
Davidson, No. 3	.....	.....	.....	.....	11,058	11,058
Davidson, No. 4	.....	16,033	5,070	40,666	51,330	113,099
Dunn Richards	29,381	43,980	56,087	111,116	87,465	1,635,546
Forbes	121,010	.....	.....	.....	126,581	494,205
Great Western	.....	7,692	63,449	42	.....	1,983,300
Hiawatha	187,070	62,847	126,962	86,142	125,031	1,647,037
Hilltop	.....	19,341	32,164	.....	.....	79,957
Homer	156,528	200,566	213,249	208,681	305,392	1,179,850
Judson	162,519	60,236	197,091	108,021	49,594	580,585
Monongahela	21,920	.....	25,739	66,013	179,433	293,105
Michigan	28,483	.....	.....	.....	.....	350,301
Odgers	53,176	169,668	257,637	100,061	222,336	802,878
Osana	136,645	171,001	158,903	131,635	154,980	1,462,085
Porter	80,492	116,762	65,325	33,067	105,211	423,616
Riverton Group	175,147	.....	100,527	72,875	161,778	3,681,032
Rogers	81,842	117,324	84,193	50,339	94,061	507,998
Ravenna	3,476	37,848	.....	.....	.....	296,563
Spies	.....	6,310	48,739	113,434	190,593	359,076
Tobin	146,113	188,590	202,775	97,674	153,544	3,855,435
Tully	236,302	121,426	125,087	134,141	.....	950,116
Victoria	.....	16,946	.....	.....	.....	16,946
Virgil	35,948	.....	39,918	.....	.....	133,983
Warner	33,751	74,814	78,855	77,028	98,785	363,281
Wauseca	30,470	.....	42,187	5,944	15,901	128,988
Youngs	53,691	23,197	2,601	.....	8,376	778,276
Zimmerman	138,881	230,123	131,248	197,360	170,439	1,649,973
Total	4,259,400	3,978,203	4,370,181	3,353,915	4,303,281	45,727,464

MARQUETTE RANGE IRON MINES

Table of Shipments 1916 to 1920 and Grand Total of Present Active Mines.

Mine	1916	1917	1918	1919	1920	Grand Total Of Shipments from Active Mines.
Adams	.....	22,560	32,924	15,700	.....	71,184
American Boston	246,163	142,488	120,714	71,739	88,639	1,723,389
Argentine	.....	54,673	50,947	36,473	42,800	9,284 791
Athens	.....	.....	23,096	74,500	188,337	285,932
Austin	64,521	44,420	8,533	2,335	3,665	1,302,057
Breitung, No. 1	70,328	109,962	95,568	52,170	52,412	686,766
Breitung, No. 2	80,655	80,073	98,182	19,472	25,771	1,001,711
Cambria	195,612	114,283	143,305	91,008	201,422	3,526,321
Cleveland Cliff Group	1,022,461	933,803	954,542	438,252	651,004	22,586,287
Empire	47,110	38,393	45,947	.....	53,279	529,937
Francis	.....	.....	30,755	26,936	34,200	91,910
Gwinn	143,708	188,070	182,541	66,667	196,932	856,217
Hematite	65,436	19,047	2,269	10,723	.....	7,199,159
Himrod	65,029	80,092	65,358	74,553	85,933	430,919
Holmes	3,379	53,726	117,957	47,804	195,973	427,325
Iron Mountain	5,893	.....	.....	.....	.....	17,093
Isabella	97,368	63,276	84,133	38,805	119,732	438,008
Jackson	.....	47,836	15,879	56,840	69,222	4,278,014
Lake Superior	357,037	293,398	343,439	263,747	299,741	10,424,814
Maas	259,897	313,399	354,410	241,059	379,132	2,552,141
Maitland	.....	.....	19,580	56,506	67,095	142,726
Mary Charlotte	164,447	165,461	213,023	156,867	141,318	3,164,995
Mackinaw Gardner	.....	.....	.....	36,753	49,051	81,383
Morris Lloyd	333,381	316,019	315,563	190,557	200,388	2,006,026
Negaunee	493,965	516,417	490,597	411,296	550,297	8,109,683
Ohio	40,007	108,901	3,229	.....	3,804	769,895
Princeton	.....	150,375	66,244	111,617	153,611	2,124,677
Queen Group	.....	.....	.....	.....	.....	.....
Republic	210,130	165,182	165,490	69,035	187,749	7,803,892
Richmond	181,154	148,831	144,025	155,984	179,551	2,200,558
Rolling Mill	253,943	.....	.....	116,046	274,012	1,942,675
Stephenson	368,739	496,712	75,162	1,965	110,925	2,185,604
Stegmiller	65,420	41,526	.....	.....	.....	418,417
Volunteer	106,987	23,806	.....	.....	.....	1,688,725
Washington	6,631	12,606	.....	.....	3,853	375,580
Total	4,949,401	4,745,335	4,263,412	2,935,409	4,609,848	100,728,811

AVERAGE ANALYSES 1920 SHIPMENTS BY IRON RANGES

From Compilations made by Lake Superior Iron Ore Association*

Range	Class of Ore	Tons Shipped	Iron (Natural)	Phos.	Silica	Manganese	Moisture
Gogebic	Bessemer	3,195,609	53.60	.045	8.30	0.35	11.06
Marquette	Bessemer	688,532	56.34	.043	8.64	0.15	7.20
Menominee (Iron & Dickinson Cos.)	Bessemer	534,783	51,30	.043	8.00	0.27	6.56
Gogebic	Low Phos. Non-Bessemer.	4,043,786	53.06	.081	6.60	0.55	12.73
Marquette	Low Phos. Non-Bessemer.	2,517,607	52 54	.094	8.82	0.35	10.27
Menominee (Iron & Dickinson Cos.)	Low Phos. Non-Bessemer.	1,423,243	50 78	.072	9.34	0.23	7.05
Marquette	High Phos. Non-Bessemer	557,111	51.83	.378	5.92	0.55	13.27
Menominee	High Phos. Non-Bessemer	3,749,069	51.16	.473	7.35	0.35	8.32
Gogebic	Manganiferous Ores	762,984	48.81	.074	7.86	3.76	11.64
Menominee	Manganiferous Ores	388,393	45.08	.604	7.76	4.67	7.34
Gogebic	Silicious ore	96,058	42.60	.068	26.38	0.48	9.38
Marquette	Silicious ore	444,898	39.30	.059	34.39	0.56	5.76
Menominee	Silicious ore	364,756	41.76	.038	31.24	0.13	4.60
Gogebic	All ores	8,098,437	52.75	.066	7.63	0.77	11.93
Marquette	All ores	4,208,148	51.70	.122	11.11	0.36	9.69
Menominee	All ores	6,460,244	50.20	.332	9.22	0.57	7.62

*Gogebic Range includes Gogebic County, Michigan, and Iron County, Wisconsin. Menominee Range includes Dickinson, and Iron counties, Michigan, and Florence County, Wisconsin.

LIST OF ACTIVE MICHIGAN IRON MINES

Name	Location	Owner	Principal Michigan Office	Principal Michigan Official
Angeline	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Anvil	Bessemer, Gogebic Co.	Steel & Tube Co. of America.	Ironwood	Alex. Chisholm, Manager.
Aragon	Norway, Dickinson Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen'l. Supt.
Ashland	Ironwood, Gogebic Co.	Hayes Mining Co.	Ironwood	Robert King, Supt.
Asteroid	Ramsay, Gogebic Co.	Castile Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Athens	Negaunee, Marquette Co.	Athens Iron Mining Co.	Ishpeming	M. M. Duncan, Gen. Mgr.
Austin	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Balkan	Alpha, Iron Co.	Balkan Mining Co.	Caspian	Chas. E. Lawrence, Gen. Supt.
Baltic-Fogarty	Caspian, Iron Co.	Verona Mining Co.	Caspian.	Chas E. Lawrence, Gen. Supt.
Barnes-Hecker	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Ducnan, Vice Pres.
Bates	Iron River, Iron Co.	Bates Iron Co.	Iron River	Andre Formis, Gen. Supt.
Bengal	Stambaugh, Iron Co.	Verona Mining Co.	Caspian	Chas E. Lawrence, Gen. Supt.
Berkshire	Caspian, Iron Co.	Brule Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Breitung, No. 1	Negaunee, Marquette Co.	Interstate Iron Co.	Ishpeming	E. E. Peterson, Supt.
Breitung, No. 2	Negaunee, Marquette Co.	Marquette Ore Co.	Negaunee	W. B. Pattison, Supt.
Bristol	Crystal Falls, Iron Co.	Bristol Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Brotherton	Wakefield, Gogebic Co.	Brotherton Iron Mining Co.	Wakefield	L. M. Hardenburgh, Gen. Supt.
Chicagon	Chicagon Mine, Iron Co.	Munro Iron Mining Co.	Iron River	G. L. Woodworth, Manager.
Cambria	Negaunee, Marquette Co.	Republic Iron & Steel Co.	Negaunee	J. E. Nelson, Gen. Supt.
Carpenter	Crystal Falls, Iron Co.	Hanna Furnace Co.	Crytsal Falls	Alfred Martin, Supt.

LIST OF ACTIVE MICHIGAN IRON MINES—*Continued*

Name	Location	Owner	Principal Michigan Office	Principal Michigan Official
Caspian	Caspian, Iron Co.	Verona Mining Co.	Caspian	Chas. E. Lawrence, Gen. Supt.
Castile	Ramsay, Gogebic Co.	Castile Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Chapin	Iron Mountain, Dickinson Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen. Supt.
Clifford	Iron Mountain, Dickinson Co.	Antoine Ore Co.	Negaunee	J. E. Nelson, Gen. Supt.
Cliffs Shaft	Ishpeming, Marquette Co.	Cleveland Cliffs, Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Colby-Ironton	Bessemer, Gogebic Co.	McKinney Steel Co.	Bessemer.	E. D. McNeil, Gen. Supt.
Delta	Iron River, Iron Co.	St. Clair Mining Co.	Iron River	J. C. Kirkpatrick, President
Dunn-Richards	Crystal Falls, Iron Co.	McKinney Steel Co.	Bessemer	E. D. McNeil. Gen. Supt.
Davidson Group	Iron River, Iron Co.	Davidson Ore Mining Co.	Iron River	Rudolph Erickson, Gen. Supt.
Eureka	Ramsay, Gogebic Co.	Castile Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Empire	Palmer, Marquette Co.	Empire Mining Co.	Negaunee	E. G. Klinglund, Agent
Forbes	Iron River, Iron Co.	Jones & Laughlin Ore Co.	Ishpeming	E. E. Peterson, Supt.
Francis	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Gardner-Mackinaw	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Great Western	Crystal Falls, Iron Co.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Gwinn	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Hiawatha	Iron River, Iron Co.	Munro Iron Mining Co.	Iron River	G. L. Woodworth, Manager.
Himrod	Negaunee, Marquette Co.	Marquette Ore Co.	Negaunee	W. B. Pattison
Holmes	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.

LIST OF ACTIVE MICHIGAN IRON MINES—*Continued*

Name	Location	Owner	Principal Michigan Office	Principal Michigan Official
Homer	Iron River, Iron County	Buffalo Iron Mining Co.	Iron River	E. C. Brown, Secretary.
Indiana	Iron Mountain, Dickinson Co.	Thomas Furnace Co.	Iron Mountain	G. A. Richards, Supt.
Isabella	Palmer, Marquette Co.	Steel & Tube Co. of America	Ironwood	A. D. Chisholm, Gen. Manager.
Jackson	Negaunee, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Judson	Alpha, Iron Co.	Judson Mining Co.	Alpha	Stephen Royce, Agent.
Keweenaw	Bessemer, Gogebic Co.	Steel & Tube Co. of America	Ironwood	A. D. Chisholm, Gen. Mgr.
Lake	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan. Vice Pres.
Loretto	Loretto, Dickinson Co.	Loretto Iron Co.	Loretto	C. H. Baxter, Supt.
Lucky Star	Negaunee, Marquette Co.	Lucky Star Mining Co.	Ishpeming	E. E. Peterson, Supt.
Maas	Negaunee, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan. Vice Pres.
Maitland	Palmer. Marquette Co.	A. F. Maitland.	Negaunee	A. F. Maitland. Supt.
Mary Charlotte	Palmer, Marquette Co.	Marquette Ore Co.	Negaunee	W. B. Pattison, Supt.
Monongahela	Crystal Falls, Iron Co.	Hanna Furnace Co.	Crystal Falls	Alfred Martin. Supt.
Morris Lloyd	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Munro	Norway, Dickinson Co.	Munro Iron Mining Co.	Iron River	G. L. Woodworth, Manager.
Negaunee	Negaunee, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Newport-Bonnie	Ironwood, Gogebic Co.	Steel & Tube Co. of America	Ironwood	A. D. Chisholm, Gen. Mgr.
Norrie Group	Ironwood, Gogebic Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen. Supt.
Odgers	Crystal Falls, Iron Co.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Osana	Iron River, Iron Co.	Mineral Mining Co.	Iron Mountain	E. F. Brown, Gen. Mgr.

LIST OF ACTIVE MICHIGAN IRON MINES—*Continued*

Name	Location	Owner	Principal Michigan Office	Principal Michigan Official
Palms	Bessemer, Gogebic Co.	Steel & Tube Co. of America.	Ironwood	A. D. Chisholm, Gen. Mgr.
Penn Group	Norway & Vulcan, Dickinson Co.	Penn Iron Mining Co.	Vulcan	Wm. Kelly, Gen. Mgr.
Plymouth	Wakefield, Gogebic Co.	Plymouth Mining Co.	Wakefield	L. M. Hardenburgh, Gen. Supt.
Porter	Crystal Falls, Iron Co.	Hemlock River Mining Co.	Caspian	Chas E. Lawrence, Gen. Supt.
Princeton	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Puritan Group	Ironwood, Gogebic Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen. Supt.
Republic	Republic, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan. Vice Pres.
Richmond	Palmer, Marquette Co.	Richmond Iron Co.	Palmer	John Hutala, Supt.
Riverton	Stambaugh. Iron Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen. Supt.
Rogers	Iron River. Iron County.	Munro Iron Mining Co.	Iron River	G. L. Woodworth, Manager.
Rolling Mill	Negaunee, Marquette Co.	Rolling Mill Mining Co.	Negaunee	R. S. Archibold, Manager.
Salisbury	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan. Vice Pres.
Spies	Iron River, Iron County.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Stephenson	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Vice Pres.
Sunday Lake	Wakefield, Gogebic Co.	Sunday Lake Iron Co.	Wakefield	L. M. Hardenburgh,
Section 16	Ishpeming, Marquette Co.	Lake Superior Iron Co.	Ishpeming	F. E. Keese, Gen. Supt.
Tilden	Bessemer. Gogebic Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen. Supt.
Tobin	Crystal Falls, Iron County.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Townsite	Ironwood, Gogebic Co.	Townsite Mining Co.	Negaunee	J. E. Nelson, Gen. Supt.

LIST OF ACTIVE MICHIGAN IRON MINES—*Continued*

Name	Location	Owner	Principal Michigan Office	Principal Michigan Official
Tully	Stambaugh, Iron County.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Wakefield	Wakefield, Gogebic Co.	Wakefield Iron Co.	Wakefield	W. C. Hart, Supt.
Warner	Amasa, Iron Co.	Hemlock River Mining Co.	Caspian	Chas. E. Lawrence, Gen. Supt.
Wauseca	Iron River. Iron County.	Mineral Mining Co.	Iron Mountain	E. F. Brown. Gen. Mgr.
Yale	Bessemer, Gogebic Co.	Charcoal Iron Co. of America.	Detroit	F. W. Blair. Pres.
Zimmerman	Gaastra, Iron Co.	Marting Ore Co.	Gaastra	J. E. Looney, Supt.

APPRAISED VALUE OF MICHIGAN IRON MINES[1]

Range	Previous appraisals.						
	1911	1912	1913	1914	1915	1916	1917
Gogebic	$28,338,100	$27,226,300	$25,849,873	$34,667,028	$34,377,792	$34,210,394	$34,288,150
Iron County: (Iron River District) (Crystal Falls District)	15,018,475	15,359,664	20,978,709	21,275,945	20,856,919	20,977,257	21,992,968
Menominee: (Dickinson County)	7,427,500	7,240,625	6,641,925	6,413,003	5,906,443	5,758,461	5,816,867
Marquette: (Baraga County) (Marquette County	34,745,000	*31,270,500	29,063,714	29,216,139	28,616,453	29,791,496	30,092,923
State	$85,529,075	$81,097,089	$82,534,221	$91,572,115	$89,757,607	$90,737,608	$92,190,908

*Ten per cent cut from 1911 assessment (approximate figure).

APPRAISED VALUE OF MICHIGAN IRON MINES[1]—*Concluded*

	1918	1919	1920 appraisal.		
			Combined value of mine and ore in stock.	Total tonnage in mine and in stock Jan. 1, 1919.	Assessed value per ton.
Gogebic	$43,996,011	$48,084,398	$48,140,987	$64,563,003	$0.7456
Iron County: (Iron River District) (Crystal Falls District)	25,654,157	26,390,036	26,247,854	54,632,863	0.4804
Menominee: (Dickinson County)	5,799,102	5,998,310	6,303,640	9,263,620	0.6804
Marquette: (Baraga County) (Marquette County)	32,568,169	33,384,545	33,284,226	70,633,369	0.4712
State	$108,017,439	$113,857,289	$113,976,707	$199,092,855	$ .57247

[1]By Board of State Tax Commissioners.

PART II. NON-METALLIC MINERALS

H. M. MARTIN

NON-METALLIC MINERAL INDUSTRY

SALT

From 1909 to 1919 the production and value of salt in Michigan increased annually, the maximum production of 17,800,564 barrels valued at $9,456,138 being reached in 1919. This represents an increase of $635,385 or 3 per cent in quantity and $407,488 or 4.5 per cent in value over 1918. That is in spite of the fact that the total United States production decreased by 4.9 per cent in quantity and increased but 0.5 per cent in value Michigan shows an increase in both quantity and value. That Michigan continued to show a gain is due to the fact that the greater part of the salt produced is salt in brine which is used by the chemical industries. Although the producers reported a decreased demand after the War and complained of increased cost of labor, material and fuel and a shortage of cars, the value continued to show an increase since the average price per barrel was $0.531 as compare with $0.52 in 1918, $0.421 in 1917 and $0.309 in 1916.

In 1920 the total United States production increased slightly but in Michigan production decreased to 16,161,739 barrels, a decrease of 1,640,-961 barrels or 9.2 per cent from 1919. This represents a production but 53,602 barrels greater than the 1917 production and probably represents a return to normal peace time demands on the industry, although due to post-War continued inflation of prices the value continues to increase. The value for 1920 increased to $10,698,674, an increase of $1,242,536 or 13.1 per cent above the value for 1919 and 49.7 per cent over 1917. The average price per barrel increased to $0.66, an increase of $0.13 per barrel or 26 per cent. The 1916 price was $0.309 per barrel. From the statements of producers it is evident that increase in operating costs was excessive and much greater than increase in prices. Producers reported that operating costs, coal, cooperage and labor, increased 20 per cent to 42 per cent with, in one case at least, business but 50 per cent normal. The decrease in production was principally in the production of manufactured salt.

From 1880 to 1892 Michigan held first rank in production in the United States. In 1893, New York gained first rank and held it continuously with the exception of the year 1901, until 1905 when Michigan again took the lead and continued first excepting in the two years 1910 and 1911 when New York again led by a narrow margin. With the exception of 1910, Michigan has also held first rank in value since 1908. In the production of rock salt however New York is the largest producer in the United States and Michigan follows Kansas, and Louisiana, in fourth place.

From 1880 to 1890 Michigan produced annually from about 42 to over 49 per cent of the salt produced in the United States. The percentage declined from 43.69 per cent in 1890 to only 22.89 per cent in 1896. This was not due to a decline of the industry in Michigan but to the rapid growth of production in New York, Ohio, and other States. Since 1896 Michigan has annually produced nearly one-third of the total output and since 1880 Michigan has produced 33.6 per cent or more than one-third of the salt used in the United States since records of production have been kept.

Thirty years ago the center of the salt industry was in Saginaw Valley, chiefly along Saginaw River from Saginaw to Bay City. The industry was carried on in connection with the lumber mills and waste steam and fuel from the mills were utilized by more than a hundred lumber concerns in evaporating natural brines which were obtained from the Upper Marshall sandstone at depths varying from about 600 feet in Saginaw to nearly 1,000 feet in Bay City. With the decline of the lumber industry in Saginaw Valley the salt industry became relatively unimportant. In 1917 only 3 per cent of the total output of the State was produced in this district. The War revived the industry through the great demand for bromide from abroad which was further increased when the United States entered the War.* Under present conditions in the Saginaw Valley, salt is largely manufactured as a by-product of the bromine industry. The total output of salt for this district in 1919 was only 539,428 barrels or 3.03 per cent of the total for the State and was valued at $427,657, or 4.5 per cent of the total State value. This quantity represents an increase of 31,221 barrels over the production for 1918 but falls short of the 1916 production by 21,754 barrels. The maximum production for 1916 represents the great foreign demand, which decreased in 1917 when other sources of bromine production partly met the demand but increased in 1918 and 1919 with the increased demand for bromine made by the United States government and increased production for pharmaceutical purposes.

At present the chief salt producing districts are in eastern Michigan along the Detroit-St. Clair rivers and in western Michigan at Ludington and Manistee. In these districts, artificial brines are used for the manufacture of salt. The brine is obtained by forcing water through casings down to rock salt beds and then back to the surface. Rock salt is mined by the Detroit Rock Salt Co., at Oakwood, a suburb on the west side of Detroit. The salt is obtained from a 20-foot bed at a depth of about 1,040 feet. The salt is crushed, screened and sized and sold for pickling, curing fish, meats, and hides, for the manufacture of ice cream, and for general refrigeration purposes. Almost 97 per cent of the State output

*See Bromine.

of salt for 1919 came from these two districts: 17,261,135 barrels or 96.97 per cent valued at 95.4 per cent total value.

The salt industry in Wayne County has made a most remarkable growth. Salt was first produced in this county in 1895, the output for that year being 13,077 barrels. In 1906 the production exceeded 1,000,000 barrels and in 1919 it was 11,539,258 barrels, or 64.8 per cent of the total for the State. The value was $2,324,164 or only 24.5 per cent of the total.

Much of the salt produced in Wayne County is in the form of brine which is used in the manufacture of soda ash, bleach, caustic, etc., and this accounts for the low relative value as compared with other counties. The Solvay Process Co., at Delray, the Michigan Alkali Co., at Ford City and Wyandotte, and the Pennsylvania Salt Co., at Wyandotte, use great quantities of brine in the manufacture of these products.

In St. Clair County, the chief salt producing centers are Port Huron and St. Clair. The output of St. Clair County in 1919 was only 2,563,100 barrels or 14.3 per cent of the State output but the value was $4,328,723 or 46.8 per cent of the total value for the State. The exceptionally high value for this county is due to the fact that much of the salt produced is of the better grades, practically 50 per cent being table and dairy salt.

During 1917 pressed blocks of salt were placed on the market as a substitute for the large lumps of rock salt formerly used in field and stable to salt cattle. The blocks are made by hydraulic press, and dispose of the refined salt spilled around the machines in the evaporating and packing departments. Although the profit from the industry is not great, the demand for the pressed block has increased so that production increased more than 85 per cent in the four years 1917-1920. For the United States the average price per ton ranged from $7.10 in 1917 to $12.31 in 1920.

In the Manistee-Ludington district, salt is made at Manistee, Manistee County, and at Ludington, Mason County. In this district, the salt industry is still largely carried on in connection with the lumber industry, waste steam and waste fuel being utilized for evaporating artificial brines. This district produced 3,158,778 barrels of salt valued at $2,375,694. This is equivalent to 17.7 per cent of the total quantity and 25.1 per cent of the value for the State. Most of the product is packer's salt, i.e., common fine and common coarse.

The rock salt occurs in the Salina formation of Silurian age. There are three known rock salt areas, one in southeastern Michigan, a second in Alpena and Presque Isle Counties, and a third in Mason and Manistee counties. South of the line from Muskegon through Kalamazoo to Trenton, Wayne County, no rock salt has been found, though at many places wells have penetrated completely through the rock salt bearing formation. The area of rock salt in southeastern Michigan so far known

extends from Trenton, Wayne County, northeast along Detroit and St. Clair rivers into western Ontario. The total area known to be underlain by rock salt in southeastern Michigan and western Ontario is several thousand square miles. The rock salt area extends northwest from Detroit River to and beyond Romulus and Dearborn in Wayne County, and Royal Oak in Oakland County but how far the salt area continues in this direction is unknown, since there are no wells northwest of these places deep enough to reach the salt bearing horizons. The aggregate thickness of the salt beds at Royal Oak and Dearborn is greater than to the southeast along Detroit River, thus indicating a considerable extension to the northwest of these places. In southeastern Michigan, the salt beds are very numerous and some of them very thick. There is an upper, thick, and apparently persistent bed from 60 to 125 feet in thickness and a lower very thick and continuous bed having a maximum thickness of over 350 feet, though it probably contains partings of dolomite or shale. The average aggregate thickness of the salt beds along Detroit and St. Clair rivers is about 400 feet, but at Royal Oak and Dearborn 609 and 556 feet of salt respectively were penetrated and at the former place the bottom of the Salina apparently was not reached.

In Alpena and Presque Isle counties, the salt area although undoubtedly very large is of unknown extent. Rock salt was struck at Onaway, Grand Lake, and Alpena in great quantities, and the greatest aggregate thickness of rock salt yet penetrated in Michigan or in Ontario, Canada, is at Onaway, Presque Isle County. A test hole drilled for oil at Onaway penetrated over 800 feet of rock salt in a section of 1,200 feet. The lowest bed is 225 feet in thickness, and perhaps is to be correlated with the thick bed in the Detroit River region. At Grand Lake salt beds aggregating over 300 feet in thickness were penetrated in a deep well without reaching the bottom of the rock salt formation.

In the Manistee-Ludington district, the known salt beds are few and thin. In the vicinity of Manistee only one bed is known. This has a thickness of 20 to 30 feet. At Ludington, however, four beds respectively 20, 12, 7, and 5 feet in thickness have been penetrated in some of the wells.

The depths to the first salt bed in southeastern Michigan varies from a minimum of 730 feet at Detroit to 1,500 and 1,600 feet at Port Huron and St. Clair, St. Clair County. In northeastern Michigan the depth at Alpena, Alpena County, is about 1,270 feet, at Grand Lake, 1,284 feet, and at Onaway, Presque Isle County, 1,630 feet.

The total area of the rock salt region in Michigan is unknown but it is undoubtedly several thousand square miles and presumably many thousands of square miles since present evidence, though not conclusive, indicates that the three known salt districts are parts of one great salt area underlying most of the northern three-fourths of the Southern Peninsula.

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES, 1880–1920**

Year.	U. S. Production. Quantity bbls.	Michigan production.		Per Cent. of Total Michigan.	Rank Quantity.	Value Michigan	Michigan.	
		State Salt Inspectors* Quantity bbls.	U. S. G. S.† Quantity. bbls.				Rank Value.	Price bbl.
1880	5,961,060	2,676,588	2,485,177	41.69	1	2,271,931	.....	0.75
1881	6,200,000	2,750,299	.....	44.35	1	2,418,171	.....	0.85
1882	6,412,373	3,037,317	3,036,317	47.36	1	2,126,122	.....	0.70
1883	6,192,231	2,894,672	2,894,672	46.74	1	2,344,684	.....	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648	.....	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	1	2,967,663	.....	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	1	2,426,989	.....	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	1	2,291,842	.....	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	1	2,261,743	.....	0.585
1889	8,005,565	3,846,979	3,856,929	48.17	1	2,088,909	.....	0.541
1890	8,776,991	3,838,637	3,838,632	43.72	1	2,302,579	.....	0.600
1891	9,987,945	3,927,671	3,966,748	39.52	1	2,037,289	.....	0.513
1892	11,698,890	3,812,504	3,829,478	32.81	1	2,046,963	.....	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	2	888,837	.....	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619	.....	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	2	1,048,251	.....	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	2	718,408	.....	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	2	1,243,619	.....	0.313
1898	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081	.....	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2	2,205,924	.....	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2	2,033,731	2	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	1	2,437,677	1	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	2	1,535,823	2	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	2	1,119,984	2	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	2	1,579,206	2	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1	1,851,332	2	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	1	2,018,760	2	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	1	2,231,129	2	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	1	2,458,303	1	0.241
1909	30,107,646‡	6,055,661	9,966,744	33.10	1	2,732,556	1	0.274
1910	30,305,656‡	5,097,276	9,452,022	31.18	2	2,231,262	2	0.236
1911	31,183,968‡	.....	10,320,074	33.10	2	2,633,155	1	0.255
1912	33,324,808‡	.....	10,946,739	32.84	1	2,974,429	1	0.277
1913	34,393,227‡	.....	11,528,800	33.52	1	3,293,032	1	0.285
1914	34,402,772‡	.....	11,670,976	33.92	1	3,299,005	1	0.283
1915	38,231,496‡	.....	12,588,788	32.93	1	4,304,731	1	0.342
1916	45,449,329‡	.....	14,918,278	32.84	1	4,612,567	1	0.309
1917	49,844,125‡	.....	16,078,136	32.25	1	6,817,202	1	0.421
1918	51,705,317‡	.....	17,165,178	33.19	1	9,048,650	1	0.520
1919	49,157,686‡	.....	17,800,564	.....	1	9,456,138	1	0.531
1920	49,745,373‡	.....	16,163,679	.....	1	10,698,674	1	0.662
1921	.....	.....	.....	.....	.....	.....	.....	.....
Total	903,035,439	.....	303,929,494	.....	.....	134,895,725	.....	.....

*Office of State Salt Inspector abolished in 1911.
†In cooperation with the Michigan Geological Survey after 1909.
‡Includes production of Hawaii and Porto Rico 1909–1913, 1915–1916 and of Porto Rico 1914–1917–8.
**For State total 1865–1879 see Pub. 29, G.S. 24 Michigan Geological Survey

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY GRADES, 1906–1920

Year	Table and dairy		Packers				Packers		Other rock, etc.		Brine and other*		Total	
			Common fine		Common Coarse									
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	Barrels		Barrels		Barrels								Barrels	
1906	509,905	$362,368	2,927,478	$757,470	2,021,287	$618,727	91,098	$33,733	.....	.....	4,387,043	$246,462	9,936,802	$2,018,760
1907	657,509	392,641	3,601,270	914,154	1,743,840	471,378	119,459	48,455	.....	.....	4,664,552	235,729	10,786,630	2,062,357
1908	584,452	620,647	3,454,062	968,617	2,020,956	610,286	134,726	53,669	.....	.....	3,991,083	205,084	10,194,270	2,458,303
1909	585,370	732,907	3,530,303	1,125,095	2,103,719	647,878	93,357	3,983	.....	.....	3,648,395	185,051	9,966,744	2,732,556
1910	798,434	565,653	2,216,181	734,828	1,992,465	596,301	92,426	43,942	.....	.....	4,104,934	211,317	9,452,022	2,231,262
1911	817,486	742,702	2,362,075	698,203	2,070,745	745,720	105,401	45,421	576,595	$181,865	4,387,772	219,244	10,320,074	2,633,155
1912	905,593	920,782	2,225,337	645,692	2,086,492	835,673	223,866	84,638	763,908	250,680	4,737,038	236,852	10,946,739	2,974,429
1913	1,028,000	1,037,402	2,704,936	852,135	2,259,164	896,521	50,557	25,371	727,364	244,172	4,756,779	237,431	11,528,800	3,293,032
1914	1,092,344	1,025,164	2,668,989	911,016	2,380,378	870,715	†	†	712,530	252,024	4,816,735	240,086	11,670,976	3,299,005
1915	1,233,117	1,420,382	3,096,644	1,181,337	2,265,352	1,001,167	†	†	919,735	321,354	5,073,940	380,491	12,588,788	4,304,731
1916	1,305,950	1,461,085	3,109,857	1,221,901	2,133,600	1,064,709	†	†	1,012,942	368,022	7,365,927	506,850	14,918,278	4,612,567
1917	1,388,700	2,143,004	2,881,000	2,106,241	1,964,093	1,480,666	†	†	1,204,543	568,717	8,639,800	578,574	16,078,136	6,877,202
1918	1,612,207	2,560,439	3,181,121	2,743,657	2,514,600	2,375,831	†	†	1,405,671	827,348	8,451,578	541,375	17,165,178	9,048,650
1919**	1,549,084	2,695,388	3,056,570	2,808,274	2,416,146	2,501,051	†	†	1,350,634	972,517	9,430,264	660,119	17,800,564	9,456,138
1920	1,633,093	3,463,419	2,786,878	2,928,307	2,032,814	2,285,382	†	†	1,511,050	1,186,682	8,199,843	549,824	16,163,678	10,698,674

*Brine only after 1910.
†See common fine and common coarse after 1913.
**1919 computed from census returns and subject to revision and corrections.

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES, 1919–1920

County	1919 Total		1919 County	1919 Table and dairy		1919 Packers Common fine		1919 Packers Common coarse		1919 Other rock, pressed blocks, etc.	
	Tons	Value		Tons	Value	Tons	Value	Tons	Value	Tons	Value
Bay	5,094	$43,984	Bay	a	a	201,132	$1,501,855	27,352	$148,171	a	a
Midland	26,320	134,624	Midland								
Manistee	131,814	1,034,024	Manistee					147,730	1,288,312		
Mason	310,468	1,341,670	Mason			35,597	265,248	18,965	176,776	a	a
Saginaw	43,548	249,049	Saginaw			99,478	750,605	72,353	522,966	a	a
St. Clair	358,877	4,328,723	St. Clair	162,191	$2,530,738	53,956	410,599	18,194	149,157	a	a
Wayne	1,815,690	2,324,164	Wayne	52,981	724,955						
Total Tons	2,492,378	$9,456,138		228,633	$3,463,419	390,163	$2,928,307	284,594	$2,285,382	251,558	$1,186,682
Total Bbls.	17,802,700			1,633,093		2,786,879		2,032,814			

1920—*Concluded*

County	Brine		Total		Bromine		Calcium Chloride	
	Tons	Value	Tons	Value	Pounds	Value	Tons	Value
Bay	a	a	106,032	$504,591				
Midland								
Manistee			378,103	3,182,038				
Mason								
Saginaw	a	a	60,694	443,760				
St. Clair	a	a	358,187	4,057,496				
Wayne	a	a	1,359,899	2,510,789				
Total Tons	1,147,978	$834,884	2,262,915	$10,698,674	1,046,165	$692,100	19,182	$398,633
Total Bbls.			16,163,679					

a. Included in total, less than three producers.

BROMINE AND CALCIUM CHLORIDE

The brines of the Marshall sandstones especially near the center of the State contain appreciable quantities of bromine in the form of magnesium bromide and considerable quantities of chlorides other than sodium chloride or salt. In the early days of the salt industry the bitterns or "mother liquors" left after the precipitation of the salt were thrown away. The discovery that the bitterns were rich in bromine and calcium chloride led some of the salt companies to install suitable machinery and equipment for the recovery of one or both of these products. Chemical plants were also built for the recovery of bromine and the manufacture of chemicals from the brine.

In 1885 the Midland district began producing bromine and a production of 40,000 pounds was reported for that year. Large quantities of bromine, chiefly in the form of bromides and calcium chloride were produced. The Marshall brines are said to contain four times as much bromine as those of Ohio and West Virginia, and the exclusive Dow process results in a maximum recovery of the element.

Over-production, dullness of trade, and competition with German bromine forced the price of bromine so low that for a number of years prior to the War the recovery of bromine was abandoned by all of the salt manufacturing concerns. The Dow Chemical Company of Midland however continued to produce large quantities of bromine and other chemicals derived from the brines. The production in the Midland district increased rapidly until by 1904 Michigans' productions was far ahead of any other State.

Bromine dropped in value to 25 cents and 30 cents a pound in 1913. In 1914 when the World War cut off the supplies of German bromine France, Italy and England became largely dependent upon the United States for their supplies. The price of bromine advanced to unprecedented figures, reaching the peak price of $6.50 a pound in New York* in the spring of 1916, the average price for that year being $1.31 a pound, the highest since 1885. The industry was revived in the Saginaw valley. In 1917 there were five producers. In 1917 brombenzylcyanide, a tear gas for use in the trenches, was invented and in 1918 the Government ordered new wells driven at Midland to increase the supply of bromine since with the entrance of the United States into the war and the increased use of asphyxiating gases the needs of the United States as well as of the Allies had vastly increased.

Prior to the War the bromine of Michigan was marketed largely as bromides but the increased demand caused the marketing of a large amount of bromide in the crude state—a heavy, reddish brown mobile liquid. Bromine is used in many chemical reactions, in separating gold from

*It should be remembered that prices quoted in the New York market are much higher than those representing value of the marketed product in large lots f.o.b. at the point of shipment.

platinum and silver, in the manufacturing of disinfectants, dyes and drugs. During the War because of its effect upon the eyes and throat bromine was extensively used in the manufacture of tear and asphyxiating gases but after the Armistice was signed the large demand for this purpose naturally fell off, but the price still remained twice as high as the pre-war normal. After the War production increased due to the demand for new dyes, for potassium bromide used as a depressant in the treatment of certain nervous diseases, and to the continued demand for bromides in the photographic trade especially for moving picture films.

In 1919 the quantity of bromine marketed in Michigan was 1,736,633 pounds valued at $1,179,834 or 93.6 per cent of the total United States production at 95.5 percent of the total United States valuation of $1,234,969. The increased production over 1918 was 130,937 pounds or 8.08 per cent; the increase in value was $209,735 or 46.5 per cent. This increase in value was due to the increase in price of bromine to $.679 a pound. The price for the United States remained steady at about $.75 until the Armistice was signed when the foreign demand fell off and the price dropped to $.56, but the chemical and photographic demand continued to keep production and price up.

In 1920 Michigan produced 1,046,165 pounds of bromine valued at $692,100, a decrease of 690,468 pounds or 39.7 per cent in quantity and of $487,734 or 41.3 per cent in value; and being 90.1 per cent of the total United States production at 92.8 per cent total United States value. The average price per pound for Michigan was $0.66 and for the United States $0.64 although during the year the price ranged from 90 to 95 cents in February and March and dropped to 50 to 52 cents in December.

Calcium Chloride

Calcium chloride is used in large quantities for the prevention of dust, in refrigerating plants, in protective fire apparatus, in cement mixtures to prevent freezing, as a drying agent in chemicals processes, as a bleaching agent, as a preservative of wood, and for many other purposes. Because of its strong affinity for water a sprinkling of a solution of calcium chloride will keep a road moist and therefore dustless for several weeks under favorable conditions. It is thus extensively used in the place of crude oil for sprinkling streets. And could be used to great advantage on the hundreds of dusty summer-play-grounds. Since the playground movement is becoming so widespread and since ground treated with calcium chloride presents a hard, dry dustless surface a few hours after treatment it is advised that greater use be made of the product to provide clean, dust-free playgrounds.

The output of calcium chloride for 1919 was 21,668 tons or 82 per cent of the United States total, valued at $256,091 or $11.81 a ton and 79.6 per cent, United States value, an increase in output of 1,053 tons or 5.1 per cent but a decrease in value of $138,109 or 34.7 per cent.

In 1920, 49,937 tons valued at $1,905,013 were produced, an increase of 28,296 pounds or 130.4 per cent in quantity and $1,648,922 or 643.88 per cent in value at an average price of $38.14 per ton. Elsewhere in the United Stares prices ranged from $15 to $23 per ton; but the Michigan product brought a higher return as it was for the most part a highly refined calcium chloride used as a bleaching agent.

Michigan produced 85 per cent of the total United States quantity at 93 per cent of the total value for the country.

MAGNESIUM.

The latest product recovered from the Marshall brines is metallic magnesium.

Before the War magnesium was an almost exclusively German product, but early in the War when the German supply was cut off, the Dow Chemical Company of Midland began the production of metallic magnesium.

Magnesium chloride is obtained from the brines and decomposed by passing a heavy direct current through a molten bath of the salt; the extremely light metal, magnesium, floats to the surface from which it is skimmed off. The recovery method is expensive and accounts for the high cost of the metal.

The metal has been used chiefly in the chemical laboratory, in metallurgy as a deoxidizing agent, and in the finely powdered state, as a flash light powder for military and photographic purposes. No alloy using magnesium as the main constituent had been made although very light but strong alloys are becoming more and more needed.

The Dow Company realized that an alloy combining the lightness of magnesium with the mechanical strength of iron would satisfy a demand and secure a wide market, and in 1916 established a special research department to extensively investigate the subject. After many experiments an alloy was produced which on account of "its light weight, great tensile strength, machinability, durability, abscence of permanent growth on repeated heating and cooling and non-abrasiveness to cast iron make it an ideal piston material."* This alloy has been named "Dow-Metal" and "has been developed to a point where it is now recommended to the automobile industry as a casting alloy particularly adapted for use as a piston material."* It has been made into pistons and tested in forty motor plants and in various types of motor cars including racing cars.

The first test was made in a 1918 model Ford car equipped with Dow-Metal pistons on a 5,000-mile test run. Accurate account was kept of gas and oil consumed and it was found that 23½ miles were made to a gallon of gasoline and 101 miles to a quart of oil. The car has since made over 18,000 miles with the same set of pistons and when disassembled it

*From a statement issued by the Dow Chemical Company, Midland, Michigan, January 19, 1921.

was found that there was very little wear on the piston and none at all on the cast iron cylinders.

"Dow-Metal is the lightest alloy made being 45 per cent lighter than alloys of aluminum and one-fourth the weight of cast iron and has a greater tensile strength than either. Its tensile strength in sand castings ranges from 24,000 to 26,000 pounds per square inch. The thermal expansion is approximately the same as that of aluminum alloys, but Dow-Metal has no permanent growth on repeated heating and cooling." The United States Bureau of Standards found that a bar subjected to twenty-one heatings of two hours each at 426.6°C (800°F) showed a permanent growth of only 0.003 inch per inch. It is not abrasive, is rigid and tough (does not "fly" when cracked in a vise), has excellent machining qualities, taking a brilliant polish and machining in one-third of the time required for cast iron. It has a high conductivity, can be repeatedly recast without altering physical or chemical properties. "A report from the Government laboratories at McCook Field, Dayton, Ohio, states that the Dow-Metal castings are more free from blow holes than is usual in light alloy castings."

Metallic magnesium (and also aluminum) is highly inflammable when finely powdered but when solid it is not, as is shown by the fact that "carbon can be removed from cylinders of an automobile engine equipped with Dow-Metal pistons by burning with oxygen in the usual manner without the least damage to the piston or the motor."

The specific gravity of Dow-Metal is 1.79; its rigidity per unit weight 0.25; weight per unit rigidity 0.34; weight in ounces per cubic inch 1.04.

"The following table gives some of the most important physical constants of Dow-Metal

Tensile strength sand castings	24—26,000 lbs. per sq. in.
Tensile strength heat treated	28—30,000 " " " "
Tensile strength forged	45—50,000 " " " "
Elastic limit	12—14,000 " " " "
Elongation per two inches	3—4%
Reduction in area	3—4%
Compression strength	43—45,000 lbs. per sq. in.
Transverse	48—50,000 " " " "
Shear	14,000 " " " "
Torsion	17,000 " " " "
Modulus of Elasticity—Tension	9,000,000
Modulus of Elasticity—Transverse	5—740,000
Impact (Charpy)	14.66 feet—pounds
Scleroscope hardness	24
Brinnell hardness	55
Specific gravity	1.79
Electrical resistance	14.0 microhms per cu. in.
Thermal conductivity	0.295
Coefficient of thermal expansion	0.000029 per degree C.
Permanent set (upon heating)	None"

At present the cost of production of Dow-Metal is high but the company is optimistic that with increased demand for a light piston, gears, connecting rods and other motor castings, the price can be so reduced that Dow-Metal may compete directly with aluminum.

CEMENT*

The first attempts to manufacture Portland cement in the United States were made in Michigan in 1872 when an experimental vertical kiln plant was constructed at Kalamazoo, using marl and clay in the process. The venture was a failure and exercised little or no influence in the New York and Pennsylvania developments beginning in 1875. The early "wet process" of manufacture in the vertical kiln was expensive and it was not until 1896 that the successful introduction of the rotary kiln and the use of powdered coal as a fuel revolutionized cement manufacture and enabled the industry in the United States to excel that of Europe, and thus inaugurate the present era of concrete construction. The growth of the industry from 1895 to 1907 was phenomenal, the production in 1907 reaching 48,000,000 barrels. The growth was checked by the financial depression of 1907 but it was resumed the following year and continued almost uninterruptedly until 1917, when 92,814,202 barrels were made. The War caused relatively small decreases in production in 1914 and 1916. In 1917 there was a slight increase in production but the restrictions imposed by the Government upon fuel supplies, transportation facilities, labor, and private construction in general caused a marked decrease in output in 1918, production falling to 71,081,-663 barrels, the lowest production since 1909. This was somewhat offset by the increased price of cement, $1.596 per barrel. The total value for the entire country was $113,153,513. During 1919 production and shipment gained by 13.7 per cent and 20.7 per cent respectively over 1918, production being 80,777,935 barrels and shipments were valued at $146,-734,844 with the average price per barrel at $1.71. In 1920 production reached the unprecedented figure of 100,023,245 barrels with shipments of 96,311,719 barrels valued at $194,439,025, an increase of 13 per cent in quantity shipped over 1919 and of 32.5 per cent in value of shipments. The average price for cement in the United States was $2.02 an increase of $.31 or 18 per cent per barrel.

After the failure of the Kalamazoo venture, no second attempt was made to reestablish the industry in Michigan until 1896 in which year the Peerless Portland Cement Company erected a vertical kiln plant at Union City, Branch County, and began the successful manufacture of Portland cement from marl and shale. By 1902, the old vertical kilns had been replaced by rotary types. In 1897, the Bronson Portland Cement Company erected a plant at Bronson, Branch County, and in 1898 the Coldwater Cement Company, now the Wolverine Portland Cement Company, built plants at Coldwater and Quincy, also in Branch County.

*For more detailed reports see Pub. 24 Geol. Series 17. Michigan Geological Survey, Mineral Resources for 1916, and Bulletin 522, United States Geological Survey.

The period between 1899 and 1901 was the "boom" years of the industry, twenty companies being organized in this period for the manufacture of Portland cement from marl and clay or shale. In 1900 Michigan with six plants attained third rank with Pennsylvania and New Jersey holding first and second rank respectively. Extensive investigations of marl and clay deposits and elaborate plans were made by many of the companies. Only ten reached the productive stage and but five of these are still in operation. Since 1896, thirty-six different cement plants have been projected or built in Michigan. Eleven plants were in operation in 1919 and 1920.

In 1918 Michigan shared with other States the general decrease in output due to War conditions, only seven of the ten operating plants operating the entire year. After the Armistice the expectation of a decline in prices deterred building operations until the middle of 1919, when the "underbuilt" conditions of the country forced construction in spite of the high prices, thus causing a shortage of Portland cement and increasing prices. Stocks of cement in Michigan were lower at the end of 1919 than they had been since 1910.

At the beginning of 1920 there was the usual winter lull in building activities and also many of the plants using the wet process were closed during the winter months. The demand was heavy the first ten months of 1920 but fell off the last two. However, the difficulty in obtaining either coal or cars for transportation of raw materials and the finished product caused the companies to report "demand better but manufacturing conditions bad," "business unfavorable," "demand heavy but counterbalanced by inability to receive cars and the high price of coal." This condition resulted in forcing Michigan cement to $2.46 per barrel (compared with $1.70 in 1919), a price greater than ever received in Michigan and greater than received in any other State in 1920. The average factory price per barrel in the United States was $2.02 ranging from $1.83 in Indiana to $2.26 in Utah and Oregon to $2.46 in Michigan. Stocks held at the end of 1920 were greater than ever before, being 666,071 barrels as compared with 219,699 barrels at the end of 1919.

The principal raw materials used in Michigan in the manufacture of Portland cement are marl or limestone and clay or shale, though the lime refuse from a soda ash plant near Detroit is also being utilized. The early companies planned to use marl and clay or shale. Because of the greater kiln capacity and lower fuel costs, limestone has been substituted for marl wherever practical. Of eleven plants five are reported to be using marl and clay, five using limestone and clay or shale, and one using clay and the waste from the Michigan Alkali Company. All plants use coal as fuel, nine manufacture cement by the wet process and two by the dry process.

The New Egyptian Portland Cement Company which in April 1918 was obliged to close its plant near Fenton because of shortage of coal, scarcity of labor and government restrictions, resumed operations in July, 1919, under the direction of a syndicate which acquired the property from the Security Trust Company receivers. The company manufactures cement from the marl obtained from the company's holdings of 800 acres of marl land.

In 1917 it was reported that the Petoskey Portland Cement Company would erect a plant on the limestone deposits on Little Traverse Bay about two and a half miles west of Petoskey, and manufacture cement from limestone of the company's holdings on Little Traverse Bay and shale from a quarry at Ellsworth in Charlevoix County twenty-seven miles southwest of Petoskey. The plant began operating March 21, 1921, with a capacity of 2,500 barrels a day. The mill building contains all the machinery for the manufacture of cement, including waste heat boilers which supply all the energy used in driving the mill. This plant is pronounced "the best and most efficient wet process plant" and is attracting attention of all American as well as foreign cement manufacturers.*

The National Portland Cement Company has been organized and it purposes to erect a plant at Coldwater Lake near Mount Pleasant to utilize the marl beds surrounding the lakes, in the manufacture of cement.

In December, 1921, the Aetna Portland Cement Company which has a plant at Fenton, purchased thirty-three acres on the Saginaw river near Bay City and proposes to erect the largest cement plant in the world.

It will thus be seen that despite the depression of 1920 the outlook for 1921-1922 is very promising.

When the War caused restrictions in potash imports and the shortage of potash in the United States became acute the attention of Portland cement manufacturers was turned to the recovery of potash from cement dust. It has been estimated that nearly one-third of the annual requirements of potash are going to waste in cement dusts, and without foreign competition production of potash by recovery from cement dusts could be maintained; use of the dust would rid nearby towns of an ever-present dust nuisance. Because of these facts several Michigan companies have the project under consideration and the Newaygo Portland Cement Company began the recovery of potash by the Cottrell process in June, 1918.

With potash at $500 a ton, operating the plant was a success, but after the Armistice the "perpendicular drop in the market for potash" was too great to permit successful operations and potash recovery was discontinued.

*For a comprehensive discussion of the Petoskey Portland Cement Company plant, see Cement Mill and Quarry, Volume 19, No. 10, p. 17-22, November, 1921.

In 1919 Michigan held fourth place in the production and shipment of cement, being ranked by Pennsylvania, Indiana and Missouri respectively in first, second and third place, but dropped to seventh place in 1920, although Michigan with eleven operating plants ranks second to Pennsylvania which State has twenty-one plants. In value of shipments Michigan ranked fifth in 1919 and sixth in 1920, but in 1920 ranked first in average factory price per barrel. In 1920 the estimated per capita consumption of cement in Michigan was 1.37 barrels.

The following table shows that Michigan produced 4,679,244 barrels of cement in 1919, an increase of 1,120,372 barrels or 32 per cent over 1918. In 1920 production reached 4,891,457 barrels, an increase of 216,203 barrels or 4.6 per cent over 1919. The 1920 production was but 27,566 barrels or 0.5 per cent less than the maximum production of 1916 which was 4,919,023 barrels. Shipments reached a total of 4,990,308 barrels valued at $8,468,196, an increase of 1,273,220 barrels or 38 per cent in quantity and of $2,390,029 or 39.3 per cent in value. Shipments for 1919 were but 0.7 per cent less than the maximum pre-War shipment of 1916. Despite the increased production of 1920, unfavorable trade and transportation conditions caused a decrease in shipments as compared with 1919, shipments for 1920 being 4,442,455 barrels, a decrease of 547,853 barrels or 10.9 per cent.

The decrease in shipments was offset by the increase in value from $8,468,196 in 1919 to $10,939,633 in 1920, an increase of $2,471,437 or 29.1 per cent. This increase was due to the greatly increased average factory price per barrel which was $2.46, as compared with $1.70 in 1919, an increase of $.76 or 44.7 per cent per barrel. This represents an increase of 110.6 per cent over the pre-War (1916) maximum and cannot be ascribed entirely to post-War conditions. It is interesting in this connection to compare the average factory price with the average wholesale price per barrel in carload lots. In 1919 the average wholesale price in Detroit was $2.436 per barrel, in 1920 it was $2.512. Stocks on hand at the end of 1919 were but 219,641 barrels, a decrease of 415,806 barrels or 67 per cent. Stocks at the end of 1920 were 666,071, an increase over 1919 of 446,430 barrels or 203 per cent.

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896–1920

Year.	No. of plants in operation.	Michigan Rank.	No. of kilns. Rotary.	Daily capacity. Bbls.	Michigan, cement made. Bbls.	U. S., cement made. Bbls.	Michigan, per cent made.	*Change per cent cement made.	Michigan cement shipped. Bbls.	Michigan cement shipped. Value.	U. S. cement shipped. Value.	Michigan, per cent of value.	Michigan, stock on hand Dec. 31. Bbls.	Michigan, average price per barrel.	U. S. average price per barrel.
1896	1				4,000	1,543,023	0.25			$7,000	$2,244,011	0.29		$1.75	$1.57
1897	2				15,000	2,677,775	0.56	275.0		26,250	4,315,891	0.6		1.75	1.61
1898	2				77,000	3,692,284	2.11	413.3		134,750	5,970,773	2.3		1.747	1.62
1899	4	4			343,566	5,652,266	6.1	346.2		513,849	8,074,371	6.36		1.492	1.43
1900	6	2			664,750	8,482,020	7.8	93.4		830,990	9,280,525	8.9		1.25	1.09
1901	10	3			1,025,718	12,711,225	8.0	54.1		1,128,290	12,532,360	9.0		1.10	0.99
1902	10	3			1,577,006	17,230,644	9.1	53.7		2,134,396	20,864,078	10.2		1.353	1.21
1903	13	3			1,955,183	22,342,973	8.7	23.9		2,674,780	27,713,319	9.7		1.367	1.24
1904	16	4			2,247,160	26,505,881	8.5	14.9		2,365,656	23,355,119	10.1		1.052	0.88
1905	16	5			2,773,283	35,246,812	7.9	23.4		2,921,507	33,245,867	8.7		1.053	0.94
1906	14	4			3,747,525	46,463,424	8.06	35.5		4,814,965	52,466,186	9.2		1.284	1.13
1907	14	4			3,572,668	48,785,390	7.3	−4.6		4,384,731	53,992,551	8.1		1.227	1.11
1908	15	7			2,892,576	51,072,612	5.6	−19.0		2,556,215	43,547,679	5.8		0.883	0.85
1909	12	7			3,212,751	64,991,431	4.9	11.6		2,619,259	52,858,354	4.9		0.815	0.813
1910	12	8			3,687,719	76,549,951	4.8	11.7		3,378,940	68,205,800	4.9		0.916	0.891
1911	11	8	96	22,400	3,686,716	78,528,637	4.69	−0.03	3,651,094	3,024,676	66,248,817	4.56	506,758	0.82	0.843
1912	11	8	92	19,450	3,494,621	82,438,096	4.23	−5.21	4,228,879	3,145,001	69,109,800	4.55	370,956	0.861	0.813
1913	11	8	83	19,900	4,186,236	92,097,131	4.21	19.79	4,218,429	4,228,879	89,106,975	4.74	473,563	1.035	1.005
1914	11	7	77	19,100	4,285,345	88,230,170	4.85	2.37	4,727,768	4,064,781	80,118,475	5.07	538,846	0.964	0.927
1915	11	5	71	20,800	4,765,294	85,914,907	5.55	11.2	4,454,608	4,454,608	74,756,674	5.95	569,919	0.942	0.86
1916	11	6	68	20,650	4,919,023	91,521,198	5.37	3.2	5,151,818	6,017,911	104,258,216	5.77	338,035	1.168	1.103
1917	11	6	68	20,550	4,688,899	92,814,202	5.03	−4.47	4,313,771	6,122,887	122,775,088	4.98	701,919	1.419	1.354
1918	10	6	49	22,100	3,554,872	71,081,663	5.00	−24.2	3,618,088	6,078,167	113,153,513	5.37	635,447	1.680	1.596
1919	11	4	58	20,425	4,675,244	80,777,935	5.78	32.00	4,990,308	8,468,196	146,734,844	5.77	219,641	1.70	1.71
1920	11	7	58	22,700	4,891,457	100,023,245	4.89	5.00	4,442,455	10,939,633	194,439,025	5.62	666,071	2.46	2.02
1921															

*Minus sign indicates decrease.

POTASH

Though Michigan has deposits of rock salt of great extent they are not known to contain potash bearing salts. A small amount of potash is recovered from industrial wastes (cement dust and Steffens water from beet sugar manufacture) and wood ashes. In 1918 the production of potash reckoned as K_2O, amounted to 404 tons valued at $100,647, of which 196 tons were from industrial wastes and 206 tons from wood ashes. In 1919 the production of potash reckoned as K_2O amounted to but 166 tons (from 666 tons of crude potash) of which 149 tons valued at $48,581 were sold. This represents a decrease of 238 tons or 58.8 per cent in quantity and of $52,066 or 51.7 per cent in value. Production was further decreased in 1920 to 56 tons (from 93 tons of crude potash) of which 49 tons were sold for $18,312, a decrease from 1919 of 110 tons or 66.2 in quantity and $30,269 or 62.3 per cent in value. Eighteen plants reported production of potash in 1919. There were seven producers in 1920.

When the shortage of potash became acute, due to the restrictions in imports caused by the War, attention was turned to the development of all possible domestic sources, particularly to the recovery of potash from manufacturing wastes. Several Portland cement companies considered the project of recovering potash from cement dust. In June, 1918, the Newaygo Portland Cement Company began the recovery of potash by the Cottrell process, investigation showing that it was possible to recover about three tons of potash in the manufacture of 2,000 barrels of cement. During a four-month trial mechanical difficulties developed however, which rendered the recovery of potash unprofitable and after the Armistice the very rapid decline in price of potash caused the plant to be abandoned.

GYPSUM

The gypsum industry of Michigan dates from 1838. In that year Dr. Douglas Houghton then State Geologist, in selecting a location for a salt well in Grand Rapids discovered that the gypsum deposits of the region are extensive and in his reports to the State Legislature for 1838 and 1840 Dr. Houghton called attention to the extent and character of the beds and the utilization of gypsum for land plaster. About the same time the first Michigan gypsum was calcined and used to make ornamental stucco moldings for a house erected for Louis Campau. The gypsum was ground in an Indian mill and burned in a cauldron kettle. The second moldings made were successful and remained on the house until it was destroyed by fire in 1850. During 1840-45 a small industry developed in the manufacture of inside ornamental moldings, plaster ornaments and flower pots. The first mill for working the gypsum deposits was erected in 1841 and the commercial exploitations of Michigan's almost unlimited

resources of gypsum began in the Grand Rapids-Grandville district with the sale of forty tons of plaster at four dollars a ton. Judicious advertising of land plaster among the farmers increased the demand to such an extent that although the mills "ran night and day" and the price reached five dollars and fifty cents a ton, buyers were turned away with their orders unfulfilled. The first shaft for mining gypsum was put down in 1853 by the predecessors of the present Grand Rapids Plaster Company. At the present time five mines and one quarry are operated in the Grand Rapids-Grandville district. The gypsum of the Alabaster district was reported in 1837 by Bela Hubbard who recorded the discovery of gypsum in the mouth of the Au Gres river. Later an outcrop was discovered on land and quarried with profit. In 1862 a quarry was opened in the beds at Alabaster, the land having been purchased from an old squatter for two dogs and ten dollars. Other quarries were opened in the district and the gypsum sold for land plaster, but all except the Alabaster quarry have been abandoned. This quarry is now operated by the United States Gypsum Company.

The presence of gypsum in the St. Ignace region was first reported by Dr. J. J. Bigsby in a paper which he read before the Geological Society, February 1, 1823. The first quarry was opened early in 1850 at Pt. Aux Chenes, seven miles west of St. Ignace. A dock was built and the rock shipped to Chicago to be calcined. Difficulties beset the enterprise; a scourge of smallpox caused temporary abandonment and water in the quarry was a continued source of trouble. After a number of years of interrupted operations an ice-floe destroyed the dock and the quarry was abandoned.

Commercial gypsum occurs in the formation known as the Grand Rapids Group of the Upper Mississipian which directly underlies the Coal Measures and also in the Salina formation of the Silurian, a much older formation. Only the gypsum of the Grand Rapids group is mined and quarried at the present time. In Kent County at least three and probably four, gypsum beds are worked. The two upper beds at Grand Rapids, respectively 6 and 12 feet thick, are near the surface. Formerly these were quarried but, because of the heavy overburden and difficulties with water which increased with the progress of quarrying the quarries have given place to mines. In the western part of Grand Rapids a third bed about 22 feet thick with a parting of shale one foot thick near the center occurs about 60 feet below the surface. At Grandville an upper bed, about 11 feet thick is directly overlain by sand and gravel and is separated below from a 14-foot bed of gypsum by about four feet of hard limestone. These two beds may be equivalent to the 22-foot "split" in West Grand Rapids. The upper bed was formerly quarried but, because of heavy overburden and water, the quarries have been replaced by mines opened in the lower bed. Numerous explorations show that

there are several other minable gypsum beds in the Grand Rapids-Grandville district.

In the Alabaster district the upper gypsum bed which is extensively quarried at Alabaster is from 18 to 23 feet thick. Test holes north of Alabaster show the presence of a number of deeper gypsum beds, 5 to 25 feet thick.

In the vicinity of Turner, Twining, and the deserted village of Harmon City, Arenac County, a bed of gypsum, called the Turner bed occurs 50 to 100 feet above the Alabaster bed. Locally, as in the vicinity of Turner, this bed is of minable thickness.

The gypsum beds of the St. Ignace Peninsula, and St. Martins and other adjacent islands are of the Salina. The gypsum appears to be of as high quality as that of Grand Rapids but locally water would cause difficulty in quarrying.

Test holes in the vicinity of St. Ignace are reported to show beds of gypsum totalling 60 feet in thickness, three of the beds being 9, 13, and 21 feet thick, respectively. Available data indicate the presence of seven quarryable beds of gypsum in this district.

In the southern part of the State the gypsum of the Salina where it has been penetrated by deep wells, is for the most part in the form of anhydrite but is too deep to be considered capable of commercial exploitation.

From 1868 to 1889, the annual production of gypsum in Michigan never reached 70,000 tons. The production in 1890, however, attained a maximum of 74,877 tons. The maximum value of gypsum and gypsum products for the period was attained in 1883, the value being $377,567. The growth of the industry began in 1890. In 1892 the output reached 139,557 tons but the financial depression throughout the country during 1892-3 disorganized the industry, the production in 1895 decreasing to only 66,519 tons, or less than half that in 1892. From 1896 to 1916 the growth was almost uninterrupted, reaching the maximum production of 457,375 tons in that year, valued at $1,066,588.

The increased production in 1916 was due to the general activity and prosperity in industrial lines, particularly in the building trades. After the entry of the United States in the War in 1917, building operations, excepting for War purposes, were greatly curtailed. This is reflected in the marked decrease in the production of gypsum and gypsum products for 1917 and 1918, although the same year shows a 65.11 per cent increase in value over pre-War production.

In 1919, 339,125 tons of gypsum were mined an increase of 52,357 tons or 18.2 per cent. Gypsum products were valued at $2,390,367, an increase of $629,218 or 35.7 per cent over the 1918 value. Production continued to increase in 1920 reaching 382,212 tons and gypsum products valued at $3,521,028 were sold; these figures represent an increase over

1919 of 43,087 tons or 12.7 per cent in quantity mined and $1,130,661 or 47.3 per cent in value. Although the 1920 production was 83.5 per cent of the maximum production of 1916 (457,375 tons) the value of gypsum products was 330.1 per cent of the 1916 value. This great increase in value is due to increased cost of production including higher wages, higher cost of supplies and higher freight rates and also to the increased production of gypsum wall board.

The sale of crude gypsum increased from 46,608 tons in 1918 to 58,754 tons in 1919 and 73,842 tons in 1920 with values increasing from $131,438 in 1918 to $174,110 in 1919 and $268,968 in 1920.

Portland cement mills purchased 52,705 tons of crude gypsum valued at $188,591 as compared with 40,314 tons valued at $105,621 in 1918 and 48,789 tons valued at $136,611 in 1919.

In the early days of the gypsum industry four-fifths of the raw gypsum was ground into land plaster and from 1869 to 1887 more than half of the gypsum mined was ground into this product. With the more general use of patent fertilizers the demand for land plaster more or less gradually decreased so that the production in 1918 was only 5,892 tons as compared with the maximum of 49,570 tons in 1880, and in 1919 had further decreased to 1,597 tons. In 1919 the Gypsum Industries Association of Chicago, Ill., launched a campaign to induce greater use of gypsum as land plaster, as a deodorizer and fixative of ammonia in manure about stables, as a soil stimulant, and as a specific for black alkali. That the campaign was effective is shown by the fact that the production of agricultural gypsum for the United States increased from 40,000 to 107,000 tons. In Michigan the increase was from the minimum production of 1919 of 1,597 tons to 12,092 in 1920, an increase of 10,495 tons or 657 per cent. The value increased from $10,422 in 1919 to $54,050 in 1920, an increase of $43,628 or 418 per cent. Agricultural gypsum represents 16.3 per cent of the quantity and 20 per cent of the value of crude gypsum sold in 1920.

The growth of the gypsum industry is due largely to the invention and introduction into the building trades of gypsum plasters, plaster board, gypsum block, calcimines, and other gypsum products.

The most important of these products are mixed wall plaster; gypsum board, block and tile, and stucco follows in second and third place. In 1919, 152,162 tons of gypsum were made into wall plaster valued at $1,460,572 an increase in value over 1918 of $528,847 or 56.7 per cent The increase in value was due to increased costs inasmuch as the production was increased by only 34,260 tons or 29 per cent. Wall plaster represents 60.6 per cent of the quantity and 65.9 per cent of the value of calcined gypsum sold in 1919. Production of stucco shows a decrease in both quantity and value. The quantity decrease was from 52,132 tons in 1918 to 48,039 tons in 1919 a decrease of 4,093 tons or 7.8 per cent;

value decrease was $15,245 or 4.6 per cent. The production of plaster board and tile, first reported in any quantity in 1917, continues to increase. The very marked increase in 1918 was due in large part to the Government need for plaster board in the construction of cantonments, etc. The value of plaster board is well demonstrated and the demand continues, the 1919 production being 46,377 tons valued at $415,972, an increase over 1918 of 13,124 or 39.4 per cent in quantity and of $76,071 or 22.3 per cent in value. In 1919, plaster board, tile, etc., represent 18.4 per cent of the quantity and 18.7 per cent of the value of calcined gypsum produced and sold.

The character of the building activity inaugurated in 1919 and increased in 1920 is reflected in the 1920 production of gypsum products. The quantity of gypsum used for mixed plaster decreased but values for stucco, boards, blocks and tile continued to increase. Mixed wall plaster shows a production of 133,289 tons valued at $1,499,226, a decrease of 18,873 tons or 14.1 per cent in quantity but an increase of $38,654 or 2.6 per cent in value over 1919. Stucco produced was 62,458 tons valued at $446,381, an increase of 14,419 tons or 30 per cent in quantity and of $130,865 or 41.4 per cent in value. Plaster board and tile show a nominal increase in quantity but a very marked increase in value over 1919, production was 60,986 tons, an increase of 14,609 tons or 33.8 per cent; and the value $1,266,659, an increase of $850,687 or 204.5 per cent. The production of gypsum plaster board, wall board, tile and blocks grew in four years from 19,158 tons valued at $67,741 to 60,986 tons valued at $1,266,659, increases of 218.3 per cent in quantity and 1,769.7 per cent in value. Of the total quantity of gypsum calcined in 1920, 50.9 per cent was sold for wall plaster at 46.1 per cent of the total value for calcined products, and 23.3 per cent of the quantity at 38.9 per cent of the total value was sold as plater board, tile, etc. In four years plaster board increased from 4.3 per cent to 38.9 per cent of the State total value for calcined products.

In 1919 and 1920, five mines, two quarries, and eight mills were in operation. Five mines, one quarry and six mills are located at Grand Rapids, Kent County, one quarry and mill at Alabaster, Iosco County. and one mill at Detroit, Wayne County.

PRODUCTION OF GYPSUM IN MICHIGAN, 1868-1920

Year.	Ground into land plaster. Tons.	Calcined into plaster. Tons.	Sold crude. Tons.	Total mined. Tons.	Gypsum and gypsum products. Total value.	Rank	
						Quantity.	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	284,054	.....	.....
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	18,920	.....	68,499	349,710	.....	.....
1881....	33,178	20,145	.....	53,323	298,872	.....	.....
1882....	37,821	24,136	.....	61,957	344,374	.....	.....
1883....	40,082	28,410	.....	68,492	377,567	.....	.....
1884....	27,888	27,950	.....	55,847	335,382	.....	.....
1885....	28,184	25,281	.....	53,465	286,892	.....	.....
1886....	20,373	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	67,633	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....	10,304	86,972	33,328	129,654	285,119	2	2
1901....	9,808	120,256	46,086	185,150	267,243	1	1
1902....	13,022	158,320	68,885	240,227	459,621	1	1
1903....	18,409	198,119	52,565	269,093	700,912	1	1
1904....	18,294	185,422	34,669	238,385	541,197	1	1
1905....	20,285	203,313	24,289	247,882	634,434	1	2
1906....	30,220	208,715	27,517	341,716	753,878	1	2
1907....	15,500	197,666	36,543	317,261	681,351	3	3
1908....	11,414	192,403	40,324	327,810	401,928	1	3
1909....	11,890	344,171	45,781	394,907	1,213,347	2	1
1910....	7,097	240,905	64,566	357,174	667,199	2	2
1911....	15,548	206,299	79,050	347,296	523,926	3	4
1912....	10,103	243,656	68,819	384,297	621,547	2	3
1913....	9,604	278,368	60,706	423,896	721,325	3	3
1914....	9,322	240,648	61,227	393,006	705,841	3	3
1915....	9,799	245,484	69,572	389,791	686,309	3	4
1916....	9,072	292,109	80,298	457,375	1,066,599	3	4
1917....	7,090	257,588	68,155	375,803	1,568,655	3	3
1918....	5,892	207,059	46,608	286,768	1,761,149	4	4
1919....	1,597	250,687	58,754	339,125	2,390,367	3	3
1920....	12,092	261,499	73,842	382,212	3,521,028	3	3
1921....	.....	.....	.....	.....	.....	.....	.....
Totals ..	1,278,019	5,700,151	1,325,518	9,125,650	29,239,418		

PRODUCTION OF GYPSUM IN MICHIGAN, 1913–1920

Year	Crude gypsum mined. Quantity.	Gypsum sold crude. To Portland cement mills. Quantity.	Value.	As land plaster. Quantity.	Value.	For other purposes. Quantity.	Value.	Total sold crude. Quantity.	Value.
	Tons.	Tons.		Tons.		Tons.		Tons.	
1913	423,896	*	*	9,604	$10,222	10,320	$9,011	60,706	$55,969
1914	393,006	*	*	9,322	10,761			61,227	51,242
1915	389,791	*	*	9,799	9,894	*	*	69,572	63,236
1916	457,375			9,072	16,658			80,298	90,973
1917	375,803	60,846	$92,874	7,090	22,903	*	*	68,155	116,653
1918	286,768	40,314	105,621	5,892	23,876	*	*	46,608	131,438
1919	339,125	48,798	138,611	1,597	10,422	*	*	58,754	174,110
1920	382,212	52,705	188,591	12,092	54,050	*	*	73,842	268,968
1921									

Year.	Gypsum sold calcined. As mixed wall plaster. Quantity.	Value.	As stucco. Quantity.	Value.	As boards, tile, etc. Quantity.	Value.	Total sold calcined.* Quantity.	Value.	Total value.	No. mines and quarries.	No. mills.
	Tons.		Tons.		Tons.		Tons.				
1913	166,711	$437,720	95,402	$202,675			278,368	$665,356	$721,325	7	8
1914	163,972	475,638	83,780	173,172			249,648	654,599	705,841	8	8
1915	155,861	426,432	80,172	177,317			245,484	623,073	686,309	8	8
1916	193,816	668,795	87,405	279,597			292,109	975,626	1,066,599	7	8
1917	147,371	949,511	85,426	384,661	19,158	$67,741	257,588	1,452,002	1,568,655	7	8
1918	117,902	931,725	52,132	330,761	33,253	339,901	207,059	1,629,711	1,761,149	7	8
1919	152,162	1,460,572	48,039	315,516	46,377	415,972	250,687	2,216,257	2,390,367	7	8
1920	133,289	1,499,226	62,458	446,381	60,986	1,266,659	261,499	3,252,060	3,521,028	7	8
1921											

*Included in the total are values for plaster of paris, Keene's cement, gypsum for plate glass works and for other purposes.

BRICK AND TILE PRODUCTS

Most of the surface clays (see Clay) in Michigan are of low grade and of three general classes (1) morainic clays or drift clays, (2) lake clays, and (3) river silts. The morainic clays are usually calcareous, containing from 10 to 15 per cent or more of lime. They also contain sand, pebbles, and boulders, hence the name boulder clay. Due to their sandy or calcareous nature, most of the clays are adapted for making only common brick and tile or low grade pottery. The high lime content causes most of the clays to burn white or cream colored. In some places, leaching has removed the lime to the depth of a few feet and clay from this surface portion burns red. Recent investigations indicate that the occurrence of low lime surface clays is more common than was formerly supposed.

Exposures of clay or shale beds suitable for the manufacture of fire, vitrified, and front brick, vitrified tile, fireproofing, and other high grade products are not abundant. Near Rockland, Ontonagon County, some of the lake clays belong to the slip varieties and are used for glazing pottery. At Grand Ledge, Eaton County, Jackson, Jackson County, Corunna, Shiawassee County, near Bay City, Bay County and Flushing Genessee County, shales belonging to the coal measures have been utilized for vitrified and front brick, vitrified tile, sewer pipe, conduits, fireproofing, etc.

Important deposits of blue gray shale occur near Ellsworth, Charlevoix County. The shale is quarried and sold for the manufacture of Portland cement, but no tests have been made to determine the suitability of the shale for clay products. Other deposits of shale occur in this vicinity but are undeveloped. Near East Jordan is a deposit of laminated blue to dark gray to black shale, suitable for brick and cement manufacture. At present a company is being formed to consider the development of the East Jordan deposits. Recently a deposit of high lime clay, possibly weathered shale, has been discovered west of Rogers, Michigan. Other undeveloped deposits of shale occur in Alpena, Cheboygan, Huron, Branch and Ingham counties. Some of the shales associated with the coal beds in Saginaw Valley are suitable for front brick and vitrified products.

In 1919 the brick and tile industry recovered somewhat from the War-induced slump of 1918. The total value of clay products exclusive of pottery (see Pottery) was $3,699,929, an increase of $1,991,193 or 116.5 per cent over the 1918 production. The quantity of common brick produced was 200,352,000 or 105,606,000 brick more than in 1918 but falling short of the maximum of 1916 by 78,823,000; this represents an increase of 111.4 per cent over 1918. The value of common brick was $2,734,503 or an average price of $13.64 a thousand as compared with $9.65 in 1918 and $6.65 in 1916. This is an increase in value over 1918 of $1,818,904 or 198.6 per cent and an advance in average price per ton

of $3.99. Drain tile also advanced in value from $565,398 in 1918 to $737,124 in 1919, an increase of $171,726 or 30.3 per cent.

The rise in production was not maintained during 1920. Only one producer reported 100 per cent normal business in 1920; others reported better sales but inability to meet demands due to coal and labor scarcity, and others report business in the brick industry as very dull. However, the value of the brick and tile products was greater than ever in the history of the industry. Scarcity of coal and labor and the transportation difficulties are responsible for both the decrease in production and increase in price. Decrease in the production of drain tile is ascribed to "scarcity of labor to lay drains," although the percentage decrease in drain tile production is much less than for other products. The production of common brick was $186,526,000 valued at $3,062,660, a decrease of 13,826,000 brick or 6.9 per cent in quantity but an increase of $328,157 or 12 per cent in value. The average price for common brick in 1920 was $16.42 per thousand. The production of drain tile decreased from 68,967 tons valued at $737,124 in 1919 to 69,225 tons valued at $690,816 in 1920.

The manufacture of common brick has made a great development in the vicinity of Springwells and West Detroit where extensive beds of suitable clays occur. Most of the common brick produced in the State are made in this vicinity. The growth of Detroit westward however, has made the land so valuable for building purposes that the brick companies are gradually being forced into other localities.

Drain tile is next in importance to common brick. Sewer pipe is made in large quantities at Grand Ledge, Eaton County and at Jackson, Jackson County. Grand Ledge is also the chief center for the manufacture of vitrified drain tile. The manufacture of face or front brick in Michigan is in its infancy, there being but two plants in operation, one at Saginaw and the other at Grand Ledge. In 1920 only the Grand Ledge plant reported the production of face brick.

Other brick and tile products are hollow building tile, faience tile, sewer pipe, fire brick, conduits, glass-house pots and supplies, blue lining and wall capping. In 1917 a plant was projected at Williamston, Ingham County, to utilize Coal Measures shales but it did not materialize. Plans are at present being developed to utilize the shales near East Jordan.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899–1920

Year.	Common brick. Quantity.	Common brick. Value.	Common brick. Average price per M.	Vitrified Brick Average price per M.	Drain tile. Value.	Fire-proofing. Value.	Miscellaneous.* Value.	Hollow building tile or blocks. Value.	Rank of state.	No. of firms operating.	Total Value.
1899	200,144,000	$933,176	$4.66	.....	$140,171	$5,900	$22,709	.....	13	196	$1,254,256
1900	180,892,000	803,250	4.77	$12.42	114,747	2,350	406	.....	17	189	1,147,378
1901	215,836,000	1,095,254	5.07	12.30	98,972	1,880	637	.....	14	180	1,497,169
1902	237,294,000	1,331,752	5.61	12.26	96,645	3,290	.....	.....	13	182	1,660,942
1903	215,791,000	1,251,572	5.80	13.27	129,028	.....	.....	$19,138	14	178	1,662,414
1904	205,196,000	1,116,714	5.44	13.28	208,088	.....	.....	8,080	14	168	1,670,892
1905	211,558,000	1,152,505	5.45	13.37	205,445	*	.....	3,585	16	154	1,719,746
1906	206,553,000	1,178,202	5.70	13.13	314,098	.....	.....	4,290	16	142	1,793,367
1907	200,817,000	1,181,015	5.88	11.96	289,868	.....	1,500	6,386	17	136	1,786,190
1908	181,049,000	994,525	5.49	12.43	327,630	4,100	40,100	.....	16	132	1,666,381
1909	219,820,000	1,250,787	5.69	12.34	364,006	*	66,128	.....	16	122	1,947,059
1910	232,551,000	1,363,316	5.86	12.82	348,205	.....	*	.....	15	118	2,083,525
1911	252,465,000	1,301,998	5.16	14.00	313,072	.....	228,530	*	15	111	1,953,442
1912	271,189,000	1,592,283	5.87	13.94	387,945	1,461	235,459	*	15	101	2,350,606
1913	273,571,000	1,626,287	5.94	14.71	415,543	*	350,000	*	13	95	2,451,242
1914	269,154,000	1,633,216	6.07	15.59	421,941	3,752	234,280	*	10	90	2,434,872
1915	277,399,000	1,461,188	5.23	14.50	305,156	10,850	49,755	*	11	82	2,248,068
1916	279,175,000	1,856,587	6.65	14.78	548,795	2,492	216,265	.....	13	73	2,705,054
1917	236,612,000	1,882,042	7.95	17.16	734,042	.....	79,996	4,621	12	69	2,846,264
1918	94,746,000	915,599	9.65	15.23	565,398	.....	73,511	*	12	61	1,708,736
1919	200,352,000	2,734,503	13.64	19.43	737,124	.....	132,844	6,901	.....	.....	3,699,929
1920	186,526,000	3,062,660	16.42	18.21	690,816	89,147	200,729	25,486	.....	.....	3,979,691
1921	.....	.....	.....	.....	.....	*	.....	.....	.....	.....	.....
Total	4,848,680,000	$31,778,431			$7,756,735	.....	.....	.....			$46,267,223

*For 1919 includes also vitrified brick, sewer pipe, faience tile; and in 1920 includes also face brick, faience tile, sewer pipe.

SHALE

Shale is quarried near Coldwater, Branch County, at Paxton, Alpena County, one mile south of Ellsworth, Antrim County, and at Bellevue, Eaton County, for use in the manufacture of Portland cement; at Grand Ledge, Eaton County, for vitrified sewer pipe, tile and conduit and front brick; six miles north of Jackson near the mouth of Portage River, Jackson County, for vitrified sewer pipe and tile, and at Flushing, Genesee County, for vitrified brick.

The Michigan Vitrified Brick Company of Bay City formerly mined shale from an abandoned coal mine for the manufacture of vitrified brick but this company ceased operating in 1916.

For several years a project was under way to develop shale beds at Williamston for the manufacture of front brick. A large area of shale land was explored and burning tests were made of the shale, but the plant did not materialize. Plans are also being made to construct a plant near East Jordan to utilize the shale beds in that vicinity.

The shale beds at Grand Ledge, Jackson, Flushing and Corunna belong to the Coal Measures. The beds vary from soft white, or light gray clay shale to compact, dark or black bituminous shale. Probably further tests will show that some of the beds are suitable for other products than those now made. The beds at Paxton belong to the lower portion of the Antrim formation of the Upper Devonian. The extent of the easily quarryable shale near Paxton is unknown but probably exploration would reveal the presence of a number of quarryable areas. Most of the shale exposed is dark brown and very bituminous but locally there are streaks of bluish to greenish gray shale and huge balls of iron carbonate and dolomite. The shale beds at Ellsworth belong to the upper part of the Antrim and are largely of soft blue gritless shale, with a few thin, dark bituminous beds. The extent of the easily quarryable areas is uncertain but apparently large. Tests probably will show that this shale is suitable for a variety of purposes. Other exposures of the Antrim shale occur in Charlevoix, Cheboygan, and Alpena counties, notably at East Jordan and along the shore of Lake Michigan at Norwood, Charlevoix County.

Excellent exposures of shale belonging to the Coldwater formation occur at Richmondville, Sanilac County, and along the shore of Lake Huron from Forestville in the same county to Whiterock, Huron County. The Coldwater shale is also exposed or is at shallow depth in a number of places in the vicinity of Coldwater, Union City, Quincy, and Bronson, Branch County. Near Coldwater it is utilized in the manufacture of Portland cement. Exposures of the Bell shale, the base of the Traverse formation, occur near Bell, Presque Isle County. At Rockport, the Bell shale forms the floor of the limestone quarry. The shale is soft, bluish and in places highly calcareous. Probably it will be found to be suitable

for the manufacture of Portland cement though the high lime content probably makes many of the beds unsuitable for high grade clay products. At Charlevoix a bed of shale 10 feet thick underlies the floor of the quarry of the Charlevoix Rock Products Co., Charlevoix County. This shale has been tested and according to reports, is suitable for the manufacture of vitrified products. The burning qualities of the deposits at Ellsworth have not been thoroughly invesigated but the uniform and fine grain character and apparently low lime content make the shale promising for use in vitrified products.

Unfortunately most of the larger and more promising deposits of shale occur in the northern part of the Southern Peninsula relatively distant from large markets or from means of cheap transportation.

CLAY*

The clays** of Michigan are of three general classes, viz: (1) morainic or drift clays, (2) lake clays and, (3) river silts. Deposits of kaolin or china clays are not known in Michigan and the chances for the occurrence of commercial deposits of such clays appear to be small. Deposits of kaolin have been reported at various places in the Northern Peninsula, but these so far as investigated, have proved to be white or calcareous lake clays of the slip variety. The morainic clays, boulder and till clays are always calcareous, some of them being very high in lime, especially in limestone regions. In such regions the clays locally approach the nature of impure marls. The result of recent tests indicate that the occurrence of deposits of relatively low lime surface clays is more common than formerly supposed. The lake clays are generally less calcareous but locally, as in limestone regions, they may contain a large percentage of lime. The river silts are the least calcareous but they are usually gritty. On account of the high content of lime, most of the clays burn white. In many surface beds, however, there is an upper portion relatively free from lime which burns red, and a lower one very high in lime which burns white or cream color. The absence of lime in the upper portion is due to leaching. In such cases, there is usually a zone of lime balls between the leached and unleached portions.

The morainic or drift clays contain pebbles, and boulders (hence the name "boulder clay,") and locally lime concretions. Screening and washing have been resorted to at some plants to separate the clay but the extra expense is generally prohibitive except in districts where good clays are wanting or where the clays possess special burning qualities. The lake clays are comparatively free from pebbles and coarse sand but some contain much very fine grit. These clays are generally suitable for making common brick and tile. There are inexhaustible supplies of such clays in the eastern portion of the Southern Peninsula from Arenac County south to the Ohio boundary. Large areas of pink or reddish lake clays also occur in Chippewa and Ontonagon counties.

The morainic or boulder clays have been developed for the manufacture of common brick and tile at many places in the State but generally on a small scale. The lake clays in the vicinity of Springwells and West Detroit have been developed very extensively for making common brick. With the growth of the city in this direction the land has become so valuable for building purposes that the brick industry is being gradually forced into other localities. Important developments have also been made near Paines and West Saginaw, Saginaw County, and at numerous places in Lenawee, Monroe, and Macomb counties.

*H. Reis, Geol. Surv. Vol. VIII, pt. I, p. 48, Clays and Shales of Michigan.
**See also "Brick and Tile" and "Pottery."

In Ontonagon County some of the clays are of the slip variety and are suitable for glazing pottery. A deposit of slip clay occurs near Harriette, Wexford County.

Most of the surface clays in Michigan are low grade and generally the mining of such clays is merely incidental to the manufacturing of common brick and tile. Nearly all of the clay sold as clay in Michigan is slip clay. It is mined chiefly near Rockland, Ontonagon County, and shipped to potteries in Ohio and other States for glazing. The great distance of the beds from the centers of the pottery industry is a serious obstacle in promoting development. In some years, a small amount of clay is sold for medicinal purposes.

PRODUCTION OF CLAY IN MICHIGAN, 1910–1920

Year.	Slip clay.		Brick clay.		Miscellaneous clay.		Total	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1910	1,363	$3,889	60	$105	1	$400	1,424	$4,394
1911	1,744	5,090	18	32	2	150	1,764	5,272
1912	2,034	6,164	.....	.....	9	9	2,043	6,173
1913	1,710	6,504	.....	.....	.....	.....	1,710	6,504
1914	1,463	4,572	.....	.....	.....	.....	1,463	4,572
1915	1,198	3,805	*	*	*	*	3,142	5,605
1916	.....	10,509	.....	.....	.....	.....	3,454	11,193
1917	2,153	8,824	*	*	.....	.....	5,746	13,627
1918	1,236	4,639	*	*	*	*	2,359	6,373
1919	568	2,123	.....	.....	*	*	568	2,123
1920	505	2,249	.....	.....	4,561	9,046	5,066	11,295
Total	.....	.....	.....	.....	.....	.....	.....	$77,132

*Included in total.

POTTERY

The pottery industry in Michigan has made almost uninterrupted growth since 1899 and since 1908 the growth has been rapid, increasing over 4,054 per cent in 12 years, the main increase being in the past four years. In 1899 the total value of the pottery output was $29,741; in 1908, $62,409; in 1919, $2,096,874, an increase of $120,438 or 6.09 per cent over 1918; and $2,592,625 in 1920, an increase over 1919 of $495,751 or 23.5 per cent. The increases were largely due to the greatly increased output of porcelain electrical and sanitary supplies and porcelain and decorated ware.

The products are chiefly porcelain electrical supplies, sanitary ware decorated and white ware, "white granite" ware and flower pots. Of eight firms, the Jeffrey-Dewitt Company of Detroit manufactures a variety of porcelain products,—sanitary ware, insulators, spark plugs, tumbling jars, crucibles, etc. The Kalamazoo Manufacturing Co., manufactures sanitary ware exclusively. In January 1919 the plant of the Kalamazoo company, which was the largest in the United States, devoted to the manufacture of sanitary ware, was destroyed by fire. But with orders for six months ahead the plant was promptly rebuilt. The Anton Hupprich Co. of Detroit and the Ionia Pottery Co. manufacture flower pots exclusively. The Mt. Clemens Pottery Co. manufactures decorated ware and the Pontiac Clay Pipe Novelty Co., clay pipes and novelty ware.

The clays used for the manufacture of flower pots are obtained from Michigan but those used for porcelain products, pipes, etc., are imported from other States and countries, for no deposits of china or ball clays are found in Michigan.

VALUE OF POTTERY PRODUCTS IN MICHIGAN, 1899–1920

Year.	Rank of State.	No. firms.	Red earthenware. value.	Porcelain electrical supplies. value.	C. C. ware, value.	Miscellaneous. value.**	Total value.	Gain per cent.	Per cent. of total product in U. S.
1899	18	4	$29,641	.....	$100	.....	$29,741	.....	.17
1900	17	4	34,317	.....	.....	.....	34,317	15.4	.17
1901	16	5	42,465	.....	.....	$2,400	44,865	30.2	.20
1902	14	4	44,098	.....	.....	39,000	83,098	87.4	.41
1903	19	4	42,007	.....	.....	6,000	48,007	-42.2	.19
1904	17	4	40,621	.....	.....	3,000	43,621	-9.1	.17
1905	17	5	*	.....	*	7,000	45,961	4.5	.16
1906	17	6	43,510	.....	.....	7,600	51,110	11.2	.16
1907	16	6	54,474	.....	.....	7,100	61,574	18.5	.20
1908	16	6	54,659	.....	.....	7,750	62,409	1.5	.25
1909	13	5	60,939	.....	.....	34,500	95,439	52.9	.31
1910	13	6	94,450	.....	.....	13,300	112,697	18.1	.33
1911	13	6	80,580	*	*	*	130,490	15.8	.38
1912	10	6	99,555	*	.....	*	194,892	49.3	.53
1913	10	5	65,000	*	.....	*	222,133	20.8	.59
1914	9	5	106,452	*	.....	*	265,194	33.0	.75
1915	8	6	112,863	*	.....	*	521,989	96.7	1.40
1916	8	7	133,734	†	†	668,982	792,716	51.8	1.64
1917	8	8	*	*	*	13,722	1,187,981	49.9	2.12
1918	6	8	*	*	*	88,842	1,976,436	66.3	3.00
1919	.....	8	*	*	*	12,708	2,096,874	6.1	.....
1920	.....	8	*	*	*	16,848	2,592,625	23.5	.....
1921	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....

*Included in the total.
†Included under miscellaneous.
**1920 includes art pottery, clay pipes and filter stones.

COAL*

Coal mining began in Michigan as early as 1835 but no records of production are available before 1860, when Michigan was credited with an output of 2,320 tons. Most of the coal in the early days was obtained from veins exposed or at shallow depth in the vicinity of Grand Ledge, Eaton County, Jackson, Jackson County, and Corunna, Shiawassee County. In 1870 production reached 28,150 tons. In 1880, 100,800 tons and for the following two years it exceeded 100,000 tons annually. In 1883, a sharp decline began and in the following year the production fell to only 36,712 tons. It was not until 1897 that the production again exceeded the 100,000 ton mark. In that year, the Saginaw and Bay County fields were opened and the production jumped to 223,592 tons. The industry continued to grow rapidly and, four years later, in 1901, the production reached nearly one and a quarter million tons. The maximum output of 2,035,858 tons was reached in 1907. Following 1907 a rapid decline set in and continued until 1912, when the production was only 1,201,230 tons. Production remained practically stationary until 1917, when it increased to 1,374,805 tons. The gain was due not only to the great demand but to better car service. The shortage of freight cars as well as of labor in 1916 was an important factor in keeping down production. The car situation in 1918 was improved but labor shortage was an important factor in limiting production.

To meet the unprecedented demand caused by the severe winter of 1917-18 and the general tie-up of coal shipments, some new mines were opened and some old ones reopened, in Saginaw and Shiawassee counties. Production reached 1,468,818 tons. In November of 1918, however, Michigan coal was not in demand and the mines operated but half time.

The coal strike of 1919 closed most of the mines and those not affected by the strike order did not operate full time. Partial settlement of the strike caused the mines to be reopened early in July of 1919 and they operated full time until November 1, when all the mines went on strike. During 1919 two new shafts were opened, one two miles east of Corunna in Shiawassee County and the other three miles west of Jackson, Jackson County; and three mines were abandoned, the Robert Gage No. 6 and Wolverine No. 3 in Bay County and the American Sewer Pipe Mine, Grand Ledge, Eaton County; two mines suspended operations, the What Cheer No. 2 in Flint, Genessee County and the Liberty mine six miles north of Owosso, and 3 miles east of the village of Henderson, Shiawassee County.

Production in 1919 decreased to 996,545 tons valued at $3,864,228, a decrease of 372,373 tons or 25.3 per cent in quantity and of $1,850,865 or 32.9 per cent in value There were seven mines operating in Bay

*For a more complete report on the coal industry in Michigan see Publication 19 Geol. Ser. 16, Mineral Resources of Michigan for 1914, pp. 247-270; also Vol. VIII, Pt. 2, Coal, by A. C. Lane.

County, eight in Saginaw County, three in Shiawassee and one each in Calhoun, Eaton, Genessee and Tuscola counties.

In 1920 production increased to 1,489,765, an increase of 493,220 tons or 49.5 per cent. Eighteen mines were operated, four in Bay County, eight in Saginaw County and one each in Calhoun, Clinton, Jackson and Tuscola counties.

The geological map of the State shows that the Coal Basin occupies the center of the Southern Peninsula, but only the eastern and southern parts of the formation have proven coal areas. Michigan coal is all bituminous. There are large proven reserves in Bay, Saginaw, Tuscola and Genessee counties which could be developed if there was a steady demand for Michigan coal.

PRODUCTION OF COAL IN MICHIGAN, 1860–1920, IN SHORT TONS

Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.	Year.	Quantity. Tons.
1860	2,320	1872	33,600	1884	36,712	1896	92,882	1908	1,835,019
1861	3,000	1873	56,000	1885	45,178	1897	223,592	1909	1,784,692
1862	5,000	1874	58,000	1886	60,434	1898	315,722	1910	1,534,967
1863	8,000	1875	62,500	1887	71,461	1899	624,708	1911	1,476,074
1864	12,000	1876	66,000	1888	81,407	1900	849,475	1912	1,164,973
1865	15,000	1877	69,197	1889	67,431	1901	1,241,241	1913	1,138,639
1866	20,000	1878	85,322	1890	74,977	1902	964,718	1914	1,283,030
1867	25,000	1879	82,015	1891	80,307	1903	1,367,619	1915	1,156,138
1868	28,000	1880	100,800	1892	77,990	1904	1,342,840	1916	1,180,360
1869	29,980	1881	112,000	1893	45,979	1905	1,473,211	1917	1,374,805
1870	28,150	1882	135,339	1894	70,022	1906	1,346,338	1918	1,464,818
1871	32,000	1883	71,296	1895	112,322	1907	2,035,858	1919	996,545
								1920	1,489,765

PRODUCTION, COST OF MINING, PROFITS, AND VALUE OF COAL IN MICHIGAN, 1900–1920

YEAR	*Number active mines.	Average number employees per month.	**Average daily wage.	†Total tons of coal mined.	Total cost of coal mined.	Average cost per ton.	***Total tons of coal mined.	***Total value of coal mined.	***Average price received per ton.	‡Average profit per ton.
1900	31	1.676	$2.34	871,388	$1,209,228	$1.387	849,475	$1,259,683	$1.483	$0.096
1901	30	1,847	2.44	1,016,496	1,442,415	1.419	1,241,241	1,753,064	1.412	.007
1902	32	1,616	2.75	899,967	1,284,342	1.427	964,718	1,653,192	1.714	.287
1903	34	3,014	2.91	1,601,984	2,529,027	1.579	1,367,619	2,707,527	1.979	.400
1904	33	2,733	3.01	1,408,375	2,266,098	1.609	1,342,840	2,424,935	1.806	.197
1905	38	2,776	2.96	1,413,307	2,244,434	1.588	1,473,211	2,512,697	1.705	.117
1906	38	2,106	2.40	1,367,385	2,090,489	1.529	1,346,338	2,427,404	1.803	.274
1907	37	2,897	3.24	1,911,201	3,162,837	1.655	2,035,858	3,660,833	1.798	.143
1908	38	3,115	3.02	1,842,778	3,089,759	1.677	1,835,019	3,322,904	1.811	.134
1909	36	2,907	2.93	1,736,573	2,865,083	1.650	1,784,692	3,199,351	1.793	.143
1910	34	2,471	3.07	1,462,276	2,626,342	1.796	1,534,967	2,930,771	1.909	103
1911	32	2,539	3.39	1,389,585	2,623,244	1.887	1,476,074	2,791,461	1.891	.004
1912	26	1,886	3.19	1,160,768	2,170,076	1.869	1,201,230	2,399,451	1.989	.120
1913	24	2,076	3.49	1,138,163	2,250,559	1,977	1,231,786	2,455,227	1.993	.016
1914	23	2,146	3.35	1,153,869	2,285,281	1.99	1,283,030	2,559,786	1.99	.000
1915	20	1,942	3.45	1,069,798	1,929,386	1.77	1,156,138	2,372,797	2.05	.280
1916	18	1,794	3.57	1,076,215	2,049,812	1.90	1,180,360	2,653,182	2.25	.350
1917	22	1,938	4.25	1,393,180	3,148,148	2.27	1,374,805	4,426,314	3.22	.95
1918	25	2,117	5.56	1,520,883	5,195,944	3.41	1,468,818	5,615,097	3.83	.42
1919	22	1,711	6.25	971,603	3,329,815	3.43	996,545	3,864,228	3.87	.44
1920	18	2,064	7.47	1,373,616	5,548,782	4.07	1,489,765	7,346,000	4.93	.86

*Compiled and adapted from reports of State Coal Mine Inspector, Ann. Repts. State Department of Labor.
** For year beginning December 1 and ending November 30.
*** From Mineral Resources of United States, U. S. G. S.
† Does not include coal used for steam and heat.
‡ Not including depreciation, interest on capital invested, etc.

PRODUCTION, COSTS, ETC., OF COAL MINED IN MICHIGAN IN 1919

No. men employed.		Average hours worked per day.	Average days worked per month.	Average daily wages.	Total paid in wages	No. mines using powder.	Kegs of powder used.	Picked coal mined. Tons.	Coal mined by machine. Tons.	Total cost.	Average cost per ton.
December	2,553	7.9	16.1	$6.82	$280,692.87	18	1,130	10,313	99,022	$418,596.12	$3.83
January	2,434	7.9	18.4	6.13	274,622.90	18	1,112	5,662	102,492	375,890.28	3.48
February	2,047	7.9	15.8	6.49	210,519.22	13	833	3,087	79,183	299,035.29	3.64
March	2,003	7.9	15.	6.31	189,929.89	12	760	4,532	74,265	271,790.72	3.45
April	602	8	21.6	5.86	76,415.88	5	305	2,571	27,397	108,052.66	3.61
May	1,556	8	9.7	6.28	94,590.69	10	330	2,530	30,660	153,569.69	4.63
June	1,590	8	17.4	6.51	175,284.40	10	618	3,022	68,227	256,390.46	3.76
July	1,828	8	20.8	6.11	232,721.54	11	1,012	7,741	93,665	318,284.53	3.10
August	1,817	8	22.	6.25	249,813.65	13	1,005	7,284	101,098	334,949.60	3.09
September	2,011	8	22.1	6.37	270,277.84	15	1,090	9,862	104,075	369,111.73	3.24
October	2,050	8	25.1	5.93	305,399.40	15	1,208	8,483	125,989	424,987.10	3.16
November	39	8	10.8	5.32	2,240.98	2	10	203	240	3,156.55	7.12
Aggregate	.....	.....	.....	.....	$2,362,549.26	.....	9,413	65,290	906,313	$3,329,814.73	
Average	1,711	7.9	18.3	$6,25	.....	.....	.....	.....	.....	.....	$3.43

PRODUCTION, COSTS, ETC., OF COAL MINED IN MICHIGAN IN 1920

No. men employed.		Average hours worked per day.	Average days worked per month.	Average daily wages.	Total paid in wages.	No. mines using powder.	Kegs of powder used.	Picked coal mined . Tons.	Coal mined by machine. Tons.	Total cost.	Average cost per ton.
December	2,099	7.5	15.9	$7.15	$238,490.17	16	964	3,535	65,683	$311,796.76	$4.54
January	2,063	7.9	24.6	6.91	350,532.81	14	1,261	7,358	141,129	487,817.07	3.28
February	2,198	7.9	20.4	6.55	293,609.41	14	982	6,172	107,630	412,931.60	3.62
March	2,122	8.	23.	6.83	333,330.31	14	1,022	6,935	121,019	466,355.16	3.64
April	1,875	7.9	20.3	7.41	279,942.69	13	895	5,170	92,279	396,350.96	4.06
May	1,987	8.	16.7	7.76	257,585.39	13	870	6,003	79,749	358,893.17	4.18
June	2,002	8.	23.5	7.29	343,329.55	13	1,093	7,698	113,293	470,855.09	3.89
July	1,904	7.9	24.2	7.44	342,863.80	12	1,052	6,108	115,454	489,381.32	4.02
August	2,040	7.9	22.1	8.05	363,146.27	13	924	6,644	116,469	499,626.74	4.06
September	2,095	7.9	23.2	8.09	393,552.46	15	986	6,553	115,445	538,562.99	4.41
October	2,156	7.9	23.1	8.22	409,227.43	15	1,053	8,209	117,195	577,116.70	4.60
November	2,234	7.9	21.1	7.98	376,326.75	14	1,019	7,878	110,008	539,094.08	4.57
Aggregate	.....	.....	.....	.....	$3,981,937.04	.....	12,121	78,263	1,295,353	$5,548,781.64	.....
Average	2,064	7.9	21.4	7.47	.....	.....	.....	.....	.....	.....	$4.07

PYRITES

In commercial usage the term pyrites is applied to any of the common iron sulphide minerals such as pyrite, marcasite, and pyrrhotite. The term "coal brasses" is also popularly applied to pyrites occurring in coal. Pure pyrite and marcasite are identical in chemical composition and contain about 53 per cent of sulphur and 47 per cent of iron. They differ, however, principally in their manner of crystallization. Both are conspicuous by their yellow or brassy color and high specific gravity. Pyrrhotite when pure contains about 40 per cent of sulphur and 60 per cent of iron.

Pyrites is used mainly for the manufacture of sulphuric acid which in turn is widely used in the manufacture of explosives, commercial fertilizers, chemicals, etc. The enormous expenditure of explosives in the War correspondingly increased the demand for pyrites.

Prior to the War most of the pyrites was imported from Spain but with the increasing shortage of shipping during the progress of the War, this source gradually became more or less completely cut off. Under only the most urgent conditions were ships spared for its importation. To meet the pressing shortage the Federal Government sought to increase domestic production through the more extensive development of operating mines, the reopening of old ones and the discovery of new deposits.

In the summer of 1918 Prof. E. A. Holbrook of the U. S. Bureau of Mines in cooperation with the State Geological Survey made an investigation of the coal brasses of Michigan coal fields. The investigation showed that pyrites occurs in sufficient abundance and in such form in some of the coals as to make its recovery promising from a commercial standpoint, particularly when high prices prevail and the foreign supply cannot fill the domestic demand. Contrary to current opinion the comparatively low sulphur coals are genrally more promising than most of the high sulphur coals. This is because in the low sulphur coals, the pyrites occurs in nodules and masses of considerable size, which may be readily separated from the coal. The pyrites in the high sulphur coals is apt to occur as bands of partings interleaved with the coal and as very thin plates in the fractures. In such conditions, the pyrites is so intimately associated with the coal and breaks up into such minute particles in the processes of concentration that it is difficult to secure a sufficiently pure product for commercial purposes. Moreover, there is a considerable percentage of finely divided pyrites lost in the tailings. Under present market requirements, the concentrate should contain at least 40 per cent of sulphur and a minimum of carbonaceous matter. In the manufacture of sulphuric acid by the chamber process, carbonaceous pyrites may give rise to an excess of carbon dioxide, which dilutes the gases in the chambers and reduces the efficiency of the plant.

The most promising source of pyrites is in the waste piles from the washery of the Consolidated Coal Co. at Saginaw. The pyrites is largely concentrated along the refuse pipe lines and there appears to be several thousand tons of pure lump pyrites which may be readily recovered at a minimum cost. The spoil banks at some of the mines also appear to contain considerable tonnages of pyrites. None of the mines would produce more than a fraction of the amount of pyritic ore necessary to maintain in operation a 50-ton concentrating mill, but it appears probable that the combined output from a number of mines would be sufficient. The pyritic waste from the mines could be shipped to a central concentration plant. Since there is generally much coal in the pyritic waste, it would be very advantageous to combine the concentrating plant with a coal washery. The recovery of both the pyrites and the coal would make it possible to utilize much impure coal which could not be profitably treated for either product alone.

The following are the results of the analyses and tests made under the direction of Prof. Holbrook at the Mining Experiment Station, Urbana, Ill.

ANALYSIS

	Sulphur Per cent.
Pure pyrite lumps. Washery of Consolidated Coal Co., Saginaw	47.2
Band pyrite. Wolverine Mine No. 3 (sample looks good but is light in weight)	38.5
Heavy dark band of shale and pyrite. Wolverine Mine No. 3, cleanest pyrite from band	37.6
Shale refuse	20.7

Separation not very satisfactory.

A sample of refuse was taken from the elevator of the coal washery of the Consolidated Coal Co. at Saginaw and subjected to the following treatment:

TEST

Weight of sample 9.3 pounds

Crushed through ½-inch hole screen

Screened on ⅛-inch screen

Undersize, ⅛ in.—0. Wt. 4.3 lbs.		Oversize, ⅛-in.—½ in. Wt. 5 lbs.	
Panned		Jigged	
Pyrites Wt. 0.9 lbs. Sulphur 19.7%	Tailings and Loss Wt. 3.4 lbs. Sulphur 9.5%	Pyrites Wt. 3.0 lbs. Sulphur 40.6%	Tailings Wt. 2.01 lbs. Sulphur 12.6%

From the above it may be seen that the refuse yielded 3 pounds or over 32 per cent pyrite analyzing 40.6 per cent of sulphur. This according to Prof. Holbrook is very satisfactory. The test indicates that the refuse probably contains about 30 per cent of recoverable pyrite of commercial grade. However with the signing of the Armistice, the War need for pyrites ceased, and the prospective recovery of pyrites from Michigan "coal brasses" did not materialize.

LIMESTONE*

The growth of the limestone industry in Michigan from 1899 to 1903 was relatively slow but in 1904 a rapid growth began which continued until 1919 when the industry declined somewhat but continued to gain during 1920. In 1903 the value of limestone including lime was only $390,473. Ten years later the value, exclusive of lime, was $1,408,703, or more than three and one-half times greater. Large gains were made in each of the succeeding years and in 1918 the total value of limestone products exclusive of lime was $5,186,867, or three and three-fifths times the 1913 value, and over twice the maximum pre-War value of 1916. In 1919, however, production decreased by $1,389,345 or 26.7 per cent to $3,797,522, the decrease being due mainly to a lessened demand for limestone for blast furnace flux, and a very great decrease in sales to alkali works. The industry recovered in 1920, the limestone sold reached a total value of $5,943,229, the largest in the history of the industry. The 1920 value represents an increase of $2,145,707 or 56.5 per cent over 1919 and of $3,553,466 or 148.7 per cent above the pre-War maximum.

The great increases in the annual value of the output for 1913-18 were due not only to greater production but also to constantly increasing prices for the various products. The great increase in 1918 represents the War demand and the War-time inflation of prices for all products. The chief increases for 1918 were in stone for blast furnace flux and for the manufacture of soda ash and allied products occasioned by the enormous War demands on the blast furnaces and chemical industries for iron and steel and chemicals used directly in the prosecution of the War. The output of flux stone in 1918 was 4,289,289 tons valued at $2,892,179. The value of stone sold to alkali plants increased from $438,783 in 1916 to $1,097,291 in 1918. Building and road making for military purposes caused an increase in the output for crushed stone for concrete in 1917 but with the cessation of general building activities production decreased during 1918 to 389,176 tons valued at $261,877. Railroad ballast increased in 1918 to 209,825 tons valued at $125,395. Production of road-making stone continued to decrease from 834,937 tons in 1916 to 591,781 tons in 1918; the value of the stone also decreased from $420,467 to $251,265 in 1918. There was a notable increase in the limestone used as fertilizer, the production increasing to 160,016 tons valued at $150,604.

In 1919 production increased in most of the limestone products whose output was curtailed during the War but decreases were recorded for the war products most urgently needed—flux and limestone for the iron and steel and chemical industries. Flux stone decreased from 4,289,289 tons valued at $2,892,179 in 1918 to 3,585,440 tons valued at $1,857,686, a decrease of 703,849 or 16.4 per cent in quantity and $1,034,493 or 35.7 per cent in value. The value of stone sold to alkali plants decreased from $1,097,251 to $654,632, a decrease of $442,619 or 40.3 per cent. The production and value of limestone used as a fertilizer,—"agstone," increased over 85 per cent but as there were but two producers the exact figures may not be published. The value of limestone sold to paper mills increased from $25,153 in 1918 to $45,706, an increase of $20,553 or 81.7 per cent. Limestone used in road making showed a decrease in quantity of 42,318 tons (7.1 per cent), but an increase in value of $70,512 (28.06 per cent), production and value being respectively 548,463 tons and $321,777. The 1919 resumption in construction activities is shown in the increased production of limestone for concrete which was 508,107 tons valued at $273,085, an increase of 118,931 tons or 30.5 per cent in quantity and of only $11,208 or 4.28 per cent in value.

*For a more complete report of the limestone resources of Michigan see Pub. 21, Geol. Ser. 17, Min. Res. of Mich. for 1915, pp. 103-312.

Formerly it was supposed that Michigan possessed few deposits of limestone, especially adapted for flux and chemical purposes, but in recent years many large deposits of very pure high calcium limestone have been discovered in Presque Isle, Chippewa, Mackinac, and Schoolcraft counties. A large deposit of high calcium limestone has been developed on an extensive scale near Rogers, Presque Isle County. On account of its low silica content this stone is especially adapted for fluxing and chemical purposes and it is successfully invading the markets formerly held by stone from other States.

Most of the high calcium limestone is located in Alpena, Presque Isle, Cheboygan, Emmet, and Charlevoix counties in the northern part of the Southern Peninsula and in Schoolcraft, Mackinac, and Chippewa counties in the Northern Peninsula. Important deposits occur at Sibley, Wayne County, and Bellevue, Eaton County. Undeveloped deposits occur on Heisterman's Island, Saginaw Bay, about three miles northeast of Omer, Arenac County, and about two miles mortheast of Dundee, Monroe County. Small deposits of uncertain commercial importance occur near the mouth of Portage river about six miles north of Jackson, Jackson County. The reserves of high calcium limestone in the northern part of the State are practically inexhaustible.

Enormous deposits of very pure high magnesium limestone or dolomite occur in the Northern Peninsula near the lake shore from Seul Choix Pt., Schoolcraft County, eastward to Point Detour, Chippewa County. This dolomite is adapted for lining open hearth furnaces and for paper making. Extensive areas of impure limestone suitable for concrete, road material, and ballast occur in the vicinity of the high grade limestone areas in the Northern Peninsula. Low grade magnesian limestone or dolomite occurs in abundance in many places in Monroe County, near Bayport, Huron County, and allong the west shore of Green Bay and Little Bay de Noc, Menominee and Delta counties.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899–1920

	Crushed stone.						For blast furnace flux.		To sugar factories.	To alkali works.
	Road making.		Railroad ballast.		Concrete.					
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Value.	Value.
1899								$27,512		
1900								3,200		
1901		$31,605		$18,200		$75,643		13,488		
1902		56,261		40,810		49,430		32,246		
1903		61,342		35,340		48,504		15,502		
1904		58,655		57,100		60,745		62,586		
1905		112,113		43,649		107,396		109,883		
1906		78,437		103,442		61,852		81,517	$224,356	
1907		131,708		46,516		97,762		109,429	22,234	
1908		182,510		33,900		73,200		56,841	32,594	
1909		132,902		42,445		112,829		91,915	25,845	
1910		110,184		42,358		178,318		100,149	69,647	
1911	224,307	113,574	91,713	34,998	306,385	137,285	341,027	186,046	65,141	*
1912	603,553	295,449	54,327	28,368	185,423	97,298	295,941	137,812	36,944	$508,044
1913	532,311	266,316	116,000	48,400	292,616	145,965	1,202,817	494,495	38,215	329,961
1914	505,133	242,839	38,000	20,600	362,209	166,959	1,604,240	565,012	69,477	269,087
1915	482,262	194,970	60,159	19,640	398,948	217,304	2,254,984	763,029	46,143	481,759
1916	834,215	420,467	186,949	57,950	323,479	155,084	3,033,155	1,207,326	41,709	438,783
1917	726,937	344,970	182,375	90,560	418,403	244,648	3,575,178	1,633,965	37,004	787,760
1918	591,781	251,265	*	*	389,176	261,877	4,289,289	2,892,179	*	1,097,251
1919	548,463	321,777	*	*	508,107	273,085	3,585,440	1,857,686		654,632
1920	688,090	460,369	154,050	122,960	884,820	578,039	4,800,400	2,963,095		1,031,251
1921										
Total		$3,876,713				$3,153,133		$13,404,913		$4,690,432

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1889-1920—*Concluded*

Year.	To carbonic acid plants. Value.	To paper mills. Value.	Fertilizer.		Other purposes.**	Number of plants.	Rank of state.	Total
			Tons.	Value.			Value.	Value.
1899					$2,375			$281,769
1900					124,220		12	330,847
1901					101,399		12	429,771
1902					68,164		13	413,148
1903					4,747		14	390,473
1904					5,323		10	501,708
1905					142,790		12	544,754
1906							10	656,269
1907					278,297		11	760,333
1908					253,990		9	669,017
1909					327,571		11	750,589
1910					299,305		9	842,126
1911		$12,558		$3,003	440,857		8	1,005,751
1912		8,150		3,447	13,596		8	1,139,560
1913		10,723		7,048	395,874		7	1,408,703
1914	$53,138	8,307	10,907	11,104	39,523		8	1,457,961
1915	*	8,620		9,746	31,529		7	1,828,766
1916		11,827		11,088	39,896		6	2,389,763
1917	*	24,097	62,027	58,148	97,129		5	3,320,895
1918	*	25,153	160,016	150,604	284,649		3	5,186,867
1919	*	45,706	*	*	678,936	18	5	3,797,522
1920	*	81,718	170,460	191,146	514,651	24	5	5,943,229
1921								
Total		$236,859		$684,689	$4,144,826			$34,049,822

*Included in total.
**Includes rubble and limestone for glass, and sugar factories and, in 1919, railroad ballast and agricultural limestone.

LIME

From 1904 to 1914, the lime industry made little or no growth, the production in those years being respectively 63,601 tons and 66,507 tons. In 1915 the production increased to 81,359 tons but this was 1,749 tons less than the maximum reached in 1909. In 1916 there was only a slight increase, the production being 86,447 tons. But the 1917 production increased 57.2 per cent over 1916 reaching 135,920 tons and the value increased 132 per cent to $892,682. This increase in production and value caused Michigan to advance from thirteenth place to seventh in rank in State production.

In the production of chemical lime, Michigan ranked third in quantity and second in value and produced over 14 per cent of the chemical lime used in the country at 16 per cent of the value. Michigan held sixth place in the amount of lime consumed.

In 1918 Michigan with the rest of the United States showed a decrease in lime production. However, since most of the lime produced in Michigan is chemical lime used in the manufacture of calcium carbide and needed for War industries the percentage decrease was less for Michigan than for any other State, the production being 134,813 tons as compared with 135,920 tons in 1917, a decrease of but 1,107 tons or 0.8 per cent. Michigan succeeded Wisconsin in sixth place. There was a continued increase in value to $1,186,007, an increase of $293,325 or 32.8 per cent over the value for 1917. The total increase over the maximum pre-War value (1916) was 207.7 per cent. The great increase in value in 1917 was due to the increased production and advance in the average selling price per ton. The great increase in value in 1918 was due to the continued advance in price per ton which reached $8.79 as compared with $6.72 in 1917 and $4.45 in 1916.

In 1919, production increased to 145,783 tons valued at $1,381,534, increases of 10,970 tons or 8.1 per cent in quantity and of $195,527 or 16.5 per cent in value. Lime was sold for building, metallurgical, and agricultural purposes and to chemical works, paper mills, sugar factories, tanneries and glass works. Michigan ranked seventeenth in the amount of lime used for building purposes but held first rank in the amount of lime sold to chemical works. Production fell short of consumption by 57,677 tons; 19,711 tons were shipped out of the State and 87,388 tons shipped in, or the State received over four and a half tons for every ton shipped outside the State; in 1917 the proportion was nine to one and in 1918 seven and one-fourth to one. These figures do not take into consideration limestone from Presque Isle County which is shipped to Buffalo, New York, and manufactured into lime near Buffalo. The largest shipments came from Ohio and West Virginia; a few thousand tons were sold in Indiana, Wisconsin and Minnesota.

Production figures for 1920 show a decrease in quantity but a slight increase in value; the total production was 140,813 tons, or 4,970 tons or 3.4 per cent less than in 1919; the total value was $1,386,760, an increase over 1919 of $5,226 or .37 per cent. Michigan did not share in the general United States increase in the production of lime and dropped in rank from sixth to eighth place. Alabama and Wisconsin taking sixth and seventh places respectively. Michigan produced 3.9 per cent of the total United States production of 3,570,141 tons. Sales of lime for building purposes and to paper mills increased and sales to chemical works, tanneries and for metallurgy decreased. A small quantity of lime was sold to sugar factories and for agricultural purposes. In 1920 Michigan consumed 229,645 tons of lime or 88,832 tons more than were produced; 9,153 tons were shipped outside the State and 97,985 tons shipped in or Michigan received over ten tons for every ton shipped outside the State.

The absence of growth in the lime industry from 1904 to 1914 inclusive was due to several causes, chief of which were: (1) the growing scarcity of suitable wood fuel for burning lime, (2) the substitution of concrete for stone and lime-mortar in building, (3) the rapidly growing use of gypsum wall plasters and plaster substitutes, and (4) the relatively great distance of suitable limestone deposits from markets. Formerly, because of the abundance of cheap wood fuel and the lack of transportation facilities for the transportation of such bulky and unstable product as lime, lime-burning flourished in many communities where limestone was available, even though the stone produced a very inferior lime.

The growth of transportation facilities and the increasing scarcity of cheap wood fuel supplies, together with the cheapness of the product, combined to drive most of the local burners out of business, especially those using inferior or hard burning stone. At present no lime is burned south of Little Traverse and Thunder Bays.

The growth in 1915 and 1916 may be ascribed, though indirectly, to the war in Europe. The great increase in 1917 was due to the entrance of this country into the conflict early in 1917. A large amount of lime is used in the manufacture of many chemical materials used in the War. Very little of the lime produced in Michigan is used for building purposes hence the lime industry in 1918 did not suffer the general depression due to the restriction of building trades, and the small decrease in production may be ascribed to the shortage of labor and of fuel and to the difficulties of transportation.

In 1919 the increase in production was for all uses of lime but particularly for building purposes. The slight decrease of 1920 was due to inability to supply the demand owing to shortage of labor and is shown

in the production of lime for chemical works, for tanneries, and for metallurgy.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904–1920

Year	Total lime burned.		Average price per ton	No. of plants operating.	Rank of State production.
	Quantity Tons	Value.			
1904	63,601	$256,955	$4.04		
1905	48 089	192,844	4.01		
1906	68,133	281,465	4.13	13	
1907	65,822	276,534	4.20	12	16
1908	68,050	282,023	4.14	10	15
1909	83,108	354,135	4.26	12	13
1910	72,345	303,377	4.19	10	14
1911	80,709	352,608	4.37	14	14
1912	74,720	311,448	4.17	11	16
1913	77,088	331,852	4.05	10	14
1914	66,507	287,648	4.33	10	14
1915	81,359	349,979	4.29	10	15
1916	86,447	385,341	4.45	7	13
1917	135,920	892,682	6.72	7	7
1918	134,813	1,186,007	8.79	6	6
1919	145,783	1,381,534	9.48	7	6
1920	140,813	1,386,760	9.85	7	8

SAND-LIME BRICK

The manufacture of sand-lime brick was introduced into the United States in 1901, and the first plant located at Michigan City, Indiana. The industry was a "boom" and within three years nine plants were in operation. Plants were erected all over the country, the producers being under the erroneous impression that sand-lime brick satisfactory for most purposes could be made more cheaply than clay brick. But since proper investigations of the character and supply of raw material, methods of manufacture, competition from clay brick, transportation facilities and market conditions were not made and because the bricks made were of poor quality, many failures resulted and the new industry suffered. The sand-lime brick industry is adapted to those regions where sand is abundant and good brick clay scarce. The superior quality of sand-lime brick now made by many companies is overcoming the early prejudice of contractors and competition from clay-brick is being met successfully.

In Michigan, fortunately most of the early plants were started in widely separated regions, and far from large clay working industries or were located near large cities which furnished a ready market for a limited production. The industry in the State therefore did not suffer from as large a proportion of failures as in some other States and has maintained a relatively steady growth. Michigan quickly attained first rank as a producer of sand-lime brick and with the exception of one year has held that rank since 1904.

The growth of the industry has been in increased production rather than in the number of plants. In 1904, ten plants were in operation and produced only 10,440,000 brick of all grades, valued at $69,765. In 1905 twelve plants produced 26,421,000 bricks, valued at $169,302. After 1905 the number of operating plants fluctuated between ten and thirteen but production and value greatly increased, until the maximum production of 72,004,000 bricks valued at $499,711 was reached in 1916. A sharp decline began in August of 1917 due to the car shortage and, because of War-time conditions was continued during 1918, production dropping to 47,998,000 brick of all classes in 1917 and to 22,564,000 brick in 1918, the lowest production since 1904.

In 1919 the industry rallied and increased 88.6 per cent in quantity and 158 per cent in value. The increase in quantity was from 22,564,000 to 42,570,000 or 20,006,000 brick and in value from $198,633 to $513,094. The increase in quantity was due to the resumption of building operations and the relatively larger increase in value was due to the increased demand and to increased cost of production. The production of 1919 was less than the maximum of 1916 by 29,434,000 brick. Michigan continued the leading State in marketing sand lime brick and produced 29 per cent of the quantity at 30 per cent of the value for the United States.

Although in 1920 the total production of sand lime brick for the United States increased, the production in Michigan decreased to 39,280,000 brick of all classes, a decrease of 3,290,000 brick or 7.7 per cent. The value of $670,744 was an increase of $127,650 or 24.8 and is the highest value recorded. The industry in 1920 was handicapped by the shortage and inefficiency of labor and the difficulties of transportation and in securing raw material. Despite the decreased production Michigan continued in first rank and produced 23 per cent of the total United States production at 26 per cent of the total value.

The production of front and fancy brick has fluctuated greatly. The production of front brick increased from 580,000 in 1904 to about 2,000,000 in 1907, then decreased in 1908 to about 900,000. The maximum production of 3,255,000 was attained in 1910. From 1911 to 1916 the production of front brick did not exceed 1,000,000 annually, falling off in 1916 to 888,000. Evidently front and fancy sand-lime brick as manufactured were not as satisfactory for outside work or could not be produced as cheaply as clay front brick. In 1917, however, the production of front brick increased to 1,019,000 valued at $8,477. Either new methods of moulding, producing a more shapely brick, or better methods of manufacture producing a less easily crumbled brick, accounted for the increased demand. But since 1918 the demand has decreased until there is but one producer hence values may not be published.

Excepting 1906, when New York took first place, Michigan, since 1904, has held first rank among the States both in the number of plants and in the value of the output of sand-lime brick. For a number of years Michigan has produced nearly or more than twice as many sand-lime brick as any other State. The decided setback suffered by the sand-lime brick industry in common with other building industries in 1918 caused many operators to close their plants, so that of eleven firms reporting in 1917, but seven operated in 1918. The increase in building operations caused one plant to be reopened and in 1919 and 1920 eight operators reported production. Plants are located in Detroit, Flint, Grand Rapids, Menominee, Rives Junction, Rochester, Sebawaing, and Saginaw.

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1920

Year.	No. of operating firms reporting.—Mich.	No. of operating firms reporting.—U. S.	Michigan production. Common brick. Quantity. (thousands).	Common brick. Value.	Aver age price per thousand.	Front brick. Quantity. (thousands).	Front brick. Value.	Average price per thousand.	Fancy brick. Quantity. (thousands)	Fancy brick. Value.	Total value Michigan.	Change per cent Michigan.	Total value United States.	Per cent of total production of U. S.	Rank. Production.	Rank. Value
1904	10	57	9,886	$64,034	$6.64	580	$5,234	$9.02	19	$497	$69,765	.....	$463,128	15.6	1	1
1905	12	84	24,841	155,883	6.28	1,577	12,898	8.17	24	526	169,302	142.7	972,064	17.4	1	1
1906	11	87	27,281	162,879	5.97	1,796	12,022	6.69	7	20	174,921	3.3	1,170,005	15.0	1	2
1907	13	94	25,488	158,606	6.22	*2,000	14,284	7.17	.....	.....	172,840	—1.2	1,225,769	14.1	1	1
1908	10	87	21,997	131,827	5.99	*900	6,982	7.76	.....	.....	138,809	—19.7	1,029,699	13.5	1	1
1909	11	74	34,217	207,082	6.05	*1,600	11,144	6.97	.....	.....	218,226	57.2	1,150,580	19.0	1	1
1910	10	76	37,648	218,627	5.81	3,256	22,022	6.76	.....	.....	240,649	10.3	1,169,153	20.5	1	1
1911	10	66	32,889	192,224	5.84	2,726	17,777	6.52	.....	.....	210,001	—12.7	897,664	23.4	1	1
1912	11	71	48,129	307,106	6.38	1,163	9,926	8.27	.....	.....	316,732	—50.8	1,200,228	26.4	1	1
1913	12	68	49,373	315,882	6.40	†	†	.....	†	†	321,245	1.7	1,238,325	25.9	1	1
1914	12	62	41,456	248,113	5.98	†	†	.....	†	†	255,784	—24.4	1,058,512	23.5	1	1
1915	11	56	46,513	281,009	6.04	†	†	.....	†	†	286,948	11.8	1,135,104	25.3	1	1
1916	12	53	71,116	491,866	6.92	888	7,845	8.83	.....	.....	499,711	74.14	1,474,073	33.8	1	1
1917	11	47	46,979	362,246	7.71	1,019	8,477	8.31	.....	.....	370,723	—25.8	1,420,330	26.1	1	1
1918	7	42	22,248	195,636	8.79	†	†	9.48	.....	.....	198,633	—46.4	983,929	22.5	1	1
1919	8	35	42,063	507,010	12.05	†	†	12.00	.....	.....	513,994	+86.7	1,705,163	28.6	1	1
1920	8	37	38,810	632,112	16.80	†	†	18.36	.....	.....	640,744	+26.0	2,490,283	23.1	1	1
1921	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	.....	620,934	$4,632,142	.....	.....	.....	.....	.....	.....	$4,818,127	.....	.....	.....	.....	.....

* Estimated.
† Included in total.

SAND AND GRAVEL

The sand and gravel resources of Michigan are inexhaustible. The most important deposits occur in the form of ridges known as "hog-backs" or eskers, in irregular hills, called kames, in outwash plains, deltas, and beach ridges,—features resulting from water action during the retreat of the Wisconsin or last ice sheet, which covered much of the region north of the Ohio and Missouri rivers. There are enormous deposits of gravel in a series of old beach ridges in Presque Isle and Alpena counties but much of this gravel is composed chiefly of limestone and is of low grade.

Only a small portion of the sand and gravel deposits in the State have been developed. Most of the development has been in the southern half of the Southern Peninsula, particularly in the vicinity of the cities and near railroads, and also in river channels and along the shores of the Great Lakes, where cheap water transportation is available. Large pits are locally developed in building State award roads. The chief producing localities and counties in order of importance are: Detroit and St. Clair rivers, and Kent, Washtenaw, Macomb, Ingham, Livingston, Manistee, Oakland, Berrien, Jackson, Kalamazoo and Calhoun counties.

The composition of gravel varies greatly in different parts of the State. In the localities where the glacial drift is thin, the gravel generally contains a considerable or even a large percentage of pebbles derived from the underlying rocks. Where the drift is thick the gravel is composed chiefly of pebbles which have been carried considerable distances by ice and water, hence the pebbles are usually harder and more resistant rock material. In the limestone regions of Presque Isle and Alpena counties there is a broad belt of gravel ridges along the shore of Lake Huron. The gravel is composed chiefly of limestone largely derived from the underlying beds of limestone. Since many of the beds of limestone in these counties are relatively soft, much of the gravel is inferior grade. The Marshall formation underlies much of Jackson, Calhoun and Kalamazoo and many of the deposits in these counties contain considerable amounts of soft friable sandstone derived from this formation. This tends to make some of the gravel unfit for road building and inferior for use in concrete aggregates. There are also large deposits of gravel in the belt of limestone along the north shore of Lake Michigan and Lake Huron. These deposits contain an abundance of limestone pebbles and, since the beds of limestone in this region are generally hard, it is presumable that the gravel is of better average quality than that in the areas of softer limestones in the northern part of the Southern Peninsula. However, no tests have been made to determine which is the better grade of gravel.

In 1919 the reported production of sand and gravel was 3,772,535 tons, an increase of 935,164 tons or 32.9 per cent over the 1918 production The value of the product was $1,944,143, an increase of $704,269 or 56.8 per cent over the value for the previous year. The increase is accounted for by, the increased demand for building sand and for gravel used in road construction. Gravel production increased from 1,741,681 in 1918 to 2,639,483, an increase of 897,802 or 51.5 per cent; the value of the product increased from $869,316 to $1,378,929, an increase of $509,613 or 58.6 per cent. The increase in production of gravel is accounted for by the increased activity in road building inaugurated by the adoption of the amendment to the State Constitution authorizing the issuance of $50,000,000 bonds for road building purposes.

Production continued to increase in 1920 despite the "discriminating" freight rates, being over two thirds the maximum production of 1913 and nearly equal the production of 1916. Production was 4,386,582 tons valued at $2,867,466, the maximum value yet attained by the sand and gravel industry. The figures show an increase of 614,047 tons or 16.3 per cent in quantity and of $923,323 or 47.4 per cent in value. The increase was due to increased demands for molding, building and paving sands, and for gravel used for railroad ballast. Production of road building gravel decreased although the value of the product increased.

The increase in freight rates caused the opening of local pits by contractors and the expansion of local industries. Producers report also that they "were equipped to ship larger quantities of material than ever before, but could not secure cars, and therefore could not ship sand and gravel material in as large quantities as the demand warranted." The car shortage in 1919 reduced the output of thirty-two plants from 10 per cent to 75 per cent and in 1920 thirty-nine plants report reduction of output from 10 to 90 per cent.

In 1920 there were 57 sand and gravel plants in Michigan, 50 are dry land plants; 6 are wet-class operating in the Detroit, St. Clair and St. Joseph rivers and in Lake St. Clair and Lake Erie; and one operates in a glacial deposit but pumps the sand and gravel through a 15-inch pipeline from an artificial lake.

In 1919 Michigan ranked sixth in quantity and seventh in value among the States and in 1920 ranked eighth in quantity but sixth in value of sand and gravel produced.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1920

Year.	Molding sand.		Building sand.		Engine sand.		Paving sand.		Filter sand.		Other sand.**	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.		Tons.	
1905	19,382	$13,247	263,315	$148,065	.....	.....	.....	.....	.....	.....	50,187	$14,476
1906	61,387	26,108	403,199	127,937	4,000	$400	.....	.....	.....	.....	51,005	12,140
1907	54,172	24,190	451,646	157,150	1,534	153	.....	.....	.....	.....	173,724	12,187
1908	4,584	2,892	474,238	228,395	1,991	319	.....	.....	.....	.....	29,187	6,850
1909	53,226	20,756	1,090,419	327,247	12,415	1,493	.....	.....	.....	.....	295,612	50,953
1910	93,812	24,004	1,151,588	334,346	22,270	2,172	.....	.....	.....	.....	372,880	57,385
1911	68,878	17,901	833,729	247,997	25,392	4,447	152,144	$29,650	.....	.....	114,801	52,005
1912	152,433	40,145	902,556	294,115	18,575	4,774	68,453	16,898	.....	.....	130,624	54,746
1913	50,763	17,493	1,326,016	415,737	4,447	647	533,261	108,328	.....	.....	113,318	20,342
1914	53,400	36,583	1,088,650	360,152	6,357	1,066	320,322	74,866	.....	.....	115,291	107,392
1915	82,666	25,998	843,887	236,956	70,077	2,794	131,466	14,021	.....	.....	111,105	12,248
1916	117,200	31,978	1,234,280	350,138	*	*	154,413	38,068	*	*	228,003	103,722
1917	147,256	52,686	782,305	433,546	4,096	1,103	136,214	49,669	.....	.....	94,227	41,267
1918	116,485	55,255	433,497	174,888	5,174	1,322	237,317	89,430	6,163	$3,048	135,502	28,301
1919	124,006	66,877	539,800	251,733	6,958	2,268	204,045	75,228	.....	.....	190,327	147,247
1920	239,439	179,754	789,495	482,081	5,547	2,943	460,438	254,723	.....	.....	213,851	228,879
1921	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Totals	1,439,089	$635,867	12,608,620	$4,570,473	188,842	$25,901	2,398,073	$750,881	.....	.....	2,419,644	$950,139

* Included under other sand.
** Includes fire, furnace, blast, and filter sand.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1920—*Concluded*

Year.	Railroad ballast.		Gravel.		Total.		Rank.	
	Quantity.	Value.	Quantity.	Value.	Quantity	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1905	.....	.....	76,625	$32,321	414,509	$210,609	10	11
1906	.....	.....	72,598	25,614	597,789	197,699	12	13
1907	.....	.....	329,407	81,182	1,024,641	289,595	10	11
1908	.....	.....	312,262	94,081	842,591	370,365	8	9
1909	.....	.....	695,902	200,523	2,219,757	685,632	8	8
1910	.....	.....	1,197,791	364,841	2,862,738	816,337	7	8
1911	.....	.....	935,072	203,218	2,185,165	565,969	9	10
1912	.....	.....	1,409,180	407,925	2,681,821	818,603	9	8
1913	.....	.....	3,928,874	915,205	6,422,818	1,528,892	4	5
1914	7,565	$781	2,140,359	530,338	3,757,979	1,143,771	8	7
1915	.....	.....	2,457,094	671,970	3,776,726	1,036,739	8	7
1916	.....	.....	2,226,878	726,033	4,407,475	1,295,717	7	7
1917	207,827	21,829	2,292,374	1,011,182	3,814,445	1,641,748	7	6
1918	161,552	18,314	741,681	869,316	2,837,371	1,239,874	8	9
1919	67,916	21,861	2,639,483	1,378,929	3,772,535	1,944,143	6	7
1920	233,816	61,672	2,444,006	1,658,414	4,386,582	2,867,466	8	6
1921	.....	.....	.....	.....	.....	.....	.....	.....
Totals	.....	.....	.....	$9,405,010	46,004,942	$15,993,159	.....	.....

SANDSTONE

For many years before the close of the last century the quarrying of sandstone was an important industry in Michigan. There were numerous quarries, though generally small, in Hillsdale, Jackson, Calhoun, Ionia, Eaton and Huron counties. No records, however, were kept until near the close of the century. In 1899, the production was valued at $178,038, the largest recorded, except in 1902, when the value of the output was $188,073. A rapid decline, though intermittent at first, began in 1900, and continued until 1911, when the industry all but ceased, the value of the output being only $12,985. For the past seven years there have been given only one or two producers, hence no figures have been given.

The decline of the sandstone industry in Michigan may be ascribed to (1) the poor quality of much of the sandstone, (2) the substitution of concrete in construction work and (3) the greater use of brick and artificial stone.

Quarries formerly were operated in the sandstone of the Coal Measures near Ionia and at other places in Ionia County, and at Grand Ledge, Eaton County and at many places in the Marshall sandstone in Calhoun Hillsdale, Jackson, and Huron counties. Most of the sandstone in these formations upon exposure to the weather for a few years, alters more or less uniformly or in spots and streaks to an unsightly yellow color. This is due to the fact that the cementing material, especially in the Marshall contains a considerable amount of iron carbonate, which upon exposure to the weather is oxidized to limonite. The sandstone near Ionia, though soft and friable is streaked and mottled with red, orange, and yellow and makes a pleasing appearance in building. Some of the stone when first quarried is reported to be so soft that great care must be used in handling to prevent breakage. After seasoning for some time, the stone becomes sufficiently hard to work and strong enough for ordinary building purposes. The only quarries operating in the Marshall at the present time are at Grindstone City and Eagle Mills, Huron County, where the gritstones near the base of the formation are quarried for grindstones and scythestones. Some rubble and riprap are produced incidentally to the quarrying of gritstone, at Eagle Mills by the Wallace Company of Port Austin.

The only quarry producing sawed and rough building block is near Jacobsville, Houghton County. Extensive quarrying operations have been carried on near Portage Entry for many years but now the Portage Entry Redstone Co. is the only active operator. The sandstone is known as the Jacobsville and is apparently the equivalent of the Lake Superior or Upper Cambrian sandstone. The "redstone" or "brownstone" of the Jacobsville is well cemented, permanent in color, and

pleasing in appearance, but the great distance from markets is a serious obstacle to development.

Formerly much sandstone was quarried for foundations but concrete has largely displaced stone for such purposes because of the cheapness of concrete and the rapidity and the ease of handling. Front and fancy brick are relatively cheap and a variety of artistic effects are possible through their use. Because of this they have largely displaced stone as a building material, except for foundations. Artificial stone is now displacing natural stone for foundations, especially for outside work.

Apparently the sandstone industry will not soon regain its early importance.

In 1919 four plants were operated and production reached a value of $24,413. Uses of sandstone reported were: Rough building stone, rubble, riprap, and road metal. In 1920 there were but two operators hence production values may not be given.

GRINDSTONES AND SCYTHESTONES

The lower part of the Marshall formation which is exposed in flat low-lying benches along the shore of Lake Huron near the end of the "Thumb" contains the "grit" stone from which commercial sandstones are made. The surface material is stripped off and the stone cut by channelling machines into square blocks eight feet or more in thickness. The blocks are split by wedges into slabs which are loaded on cars by derricks and then taken to the mills for sawing into grindstones. The sandstone locally contains thin beds of conglomerate composed of small pebbles of white quartz. From the resemblance of the pebbles to peanuts, the stone is often called "peanut" conglomerate. The pebbles also occur scattered through the sandstone. Much waste stone results from the conglomerate and the scattered pebbles, the latter in places being sufficiently numerous to make the stone unsuitable for use.

The grindstones vary in size from small stones a foot in diameter to those seven feet in diameter having a 14-inch face, and weighing from 1¼ to 2 tons. The broken stone is sawed into various grades of scythestones.

Michigan ranks second in the value of grindstones and scythestones produced, Ohio being first with a total value about six times larger than that of Michigan and West Virginia together, the nearest competitors. There are but two active quarries, both located in Huron County near the end of the "Thumb." The Wallace Company of Port Austin operates a quarry at Eagle Mills and the Cleveland Stone Company operates a quarry at Grindstone City.

Since there are but two producers, the production and value of grindstones and scythestones cannot be given but the total value is included under Miscelllaneous in the Summary table given at the end of this report.

GLASS SAND

Glass sand is extensively quarried near Rockwood, Wayne County, and near Steiner, Monroe County. The glass sand occurs in the Sylvania sandstone, Middle Monroe of the Silurian. The Sylvania underlies a belt which extends west from the mouth of Detroit River, then curves southwest across the southeast corner of Wayne County and through Monroe County and leaves Monroe County near the southwest corner. The belt is from three to five miles wide except in the southwest corner of Monroe County where it narrows to about one-half mile. The thickness of the Sylvania varies exceedingly. Along the Detroit River in Wayne County it is from 70 to 165 feet thick and here as elsewhere contains horizons of sandy dolomite. It thins irregularly to the southwest until near the Ohio line it is only about 35 feet thick.

The sandstone is exposed or is near the surface in three localities, viz.: in the southwestern part of Whiteford township (T. 8 S., R. 6 E.) and in the vicinity of Steiner, Monroe County, and Rockwood, Wayne County. In section 28 of the Whiteford township area, the overburden is locally ten feet or less in depth. It is exposed for a considerable distance in the bed of Raisin River near Steiner in the southwest quarter of section 2, T. 6 S., R. 8 E. At this place the rock is exposed* or covered by a few inches of soil on an area of 8 to 10 acres and on an area of 60 acres the overburden is reported to be nowhere more than two or three feet thick.

There are no natural exposures of the Sylvania in Wayne County but east of Rockwood in section 15, in the vicinity of the pits of the Rockwood Silica Company, the overburden is only from five to eight feet deep. Apparently there is an area of several hundred acres in the vicinity of Rockwood where the overburden does not exceed twenty feet.

Typically the sandstone is a remarkably pure, sparkling, snow-white aggregation of fine incoherent rounded quartz grains, very uniform in size and resembling granulated sugar. Lumps of it may be readily crumbled in the hand and when placed in water disintegrate rapidly. At the pits of the American Silica Co. east of Rockwood, Wayne County, and of the National Silica Co., Ford Plate Glass Co., near Steiner, Monroe County, the sandstone is washed down by a stream of water from a hose. At the Rockwood pit, there is a stratum of hard dolomitic sandstone which requires blasting. The material after being crushed and washed is pumped into bins where it is allowed to drain.

Some years ago the Rockwood Silica Sand Co., drilled a well just east of Rockwood (SE¼ SW¼, Sec. 10) to the depth of 122 feet penetrating 15 feet of clay, 15 feet of dolomite, and 92 feet of glass sand rock without reaching the bottom of it. A six-inch casing was used to rock and below this a four-inch casing, through which steam under a pressure

*W. H. Sherzer, Geology of Monroe County; Mich. Geol. Survey, Vol. VII, pt. 1, p. 54.

of 60 pounds per square inch was injected, forcing out water and sand. About a car-load of sand per day was obtained in this way.

Glass sand pits known as "Toll Pits" were opened many years ago near Steiner, Monroe County. These properties later were taken over by the National Silica Co. which operated them up to 1916 when its plant was burned down. The property was then sold to the Ford Plate Glass Co. of Toledo, Ohio, and a new plant was built. The Whiteford area is undeveloped.

Immediately beneath the drift, the sandstone is more or less colored to a depth varying from a few inches to several feet, by iron from percolating surface water. However, most of the sandstone is very free from iron and the washed product from some horizons contains only about .001 of one per cent of iron. In the quarry of the Rockwood Silica Company near Rockwood, there are numerous masses of celestite, or strontium sulphate, and native sulphur, produced by the reduction of the celestite. The masses of celestite are most numerous near the horizon of the dolomitic sandstone. Washing removes practically all of the small amount of dolomitic cement in the incoherent sandstone and also removes most of the cement from the dolomitic portions. The sand as marketed is stated to contain over 99 per cent of silica.

The following analyses are of the crude unwashed sand from the pits of the National Silica Co. at Steiner, Monroe County, and of the washed product from the pit of the American Silica Co., at Rockwood, Wayne County.

ANALYSES OF GLASS SAND

	Crude Per Cent	*Washed Per Cent
Silica	96.50	99.70
Calcium carbonate	1.50	0.08
Magnesium carbonate	1.04	0.22
Iron oxide	0.00	.....
Sulphuric acid, loss, and undetermined	0.76	.....
Loss on ignition	0.20	.....

The very low percentage of iron makes the sand especially adapted for glass making, particularly for glass of the higher grades, such as plate and optical glass. Large quantities are used in the manufacture of plate glass. Experiments by the United States Bureau of Standards show that the purest grade of the Sylvania sand of Michigan is suitable for making optical glass and now all the sand used by the Government for this purpose comes from this State. It was found that from the deposits near Rockwood it is possible, under careful supervision, to obtain carload lots of glass sand which averaged 0.015 per cent iron oxide, and some analyses as low as 0.004 iron oxide are reported. Glass sand for optical purposes is also obtained at Ottawa, Ill., and Hancock, Maryland, but analyses from the best of these deposits averaged 0.02 per cent iron oxide.

The washed sludge containing the fine grit is used for the ignition surfaces on match boxes. There was but one producer of glass sand,

*J. E. Clark, Analyst.

hence figures on production and value are not given. The Monroe Silica Company is building a new plant near the site of the National Silica Company plant which was burned in 1916. The plant of the Rockwood Silica Company was destroyed by fire July 2, and was not rebuilt during the year.

MINERAL WATERS

Since 1902 there has been a steady decline in the mineral water industry in Michigan, despite annual fluctuations in amount and value of mineral and spring water produced. The principal factors affecting the production are local conditions affecting municipal water supplies, and general business conditions. When a municipal water supply becomes unpalatable or unsafe the vending of mineral waters becomes profitable, only to decline, however, when a filtration plant is installed or a new source of water supply is developed in a town.

The general business depressions of 1906, 1907 and 1914 caused the greatest decrease in production in Michigan. During the past few years the increased demand for soft drinks has for a few firms occasioned a temporary increase in the sale of mineral waters used in the manufacture of "prohibition beers." The production of 8,653,680 gallons valued at $275,763 in 1902 decreased to 884,893 gallons valued at $52,642 in 1913. From 1913 to 1919 production and value steadily increased, and reached a total of 1,570,906 gallons valued at $132,312 an increase over 1918 of 354,024 gallons or 29.1 per cent in quantity and of $2,720 or 2.1 per cent in value. There were ten commercial springs.

In 1920 production decreased 22 per cent in quantity and eight per cent in value, production figures being 1,227,485 gallons valued at $122,010. Michigan ranked ninth among the States in quantity and value of mineral waters sold for all purposes, and ranked seventh in the value of table waters sold. Michigan produced 3 per cent of the total United States production at 2.5 per cent of the total value. There were nine commercial springs in 1920.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900–1920

Year.	Rank.		No. of Springs active.	Total.		Medicinal value.	Table value.	Average price per gal.
	Quantity.	Value.		Quantity. gals.	Value.			
1900	6	4	28	3,398,996	$411,935	.....	.....	$0.121
1901	2	1	28	7,019,168	1,195,614	.....	.....	0.170
1902	1	9	28	8,653,690	275,763	.....	.....	0.032
1903	1	9	19	6,919,107	200,668	.....	.....	0.029
1904	7	13	19	3,385,675	118,422	.....	.....	0.035
1905	4	4	17	2,684,800	277,188	$38,900	$238,288	0.100
1906	13	23	19	902,528	73,357	.....	.....	0.081
1907	8	15	19	1,472,679	127,133	35,091	92,042	0.086
1908	8	16	24	2,004,433	88,910	5,955	82,915	0.044
1909	5	16	19	2,760,604	104,454	6,099	98,355	0.035
1910	9	17	17	1,454,020	69,538	100	69,438	0.048
1911	11	24	23	1,713,401	72,253	12,156	60,097	0.042
1912	12	19	17	1,420,465	75,611	777	74,834	0.053
1913	17	24	20	884,893	52,642	3,605	49,037	0.059
1914	16	20	22	931,343	70,310	12,252	58,058	0.075
1915	16	18	19	913,765	72,111	5,165	67,546	0.080
1916	17	13	18	996,875	108,867	.....	.....	0.109
1917	12	12	11	1,069,164	105,641	500	105,641	0.098
1918	10	8	9	1,216,882	129,592	*	128,809	0.103
1919	7	9	10	1,570,906	132,312	760	132,252	0.080
1920	11	9	9	1,227,485	122,010	1,485	120,525	0.099
1921	.....	.....	.....	.....	.....	.....	.....	.....
Total				52,600,879	3,886,931		1,377,837	0.076

MARBLE

The Kona dolomite in the Marquette iron bearing district, and the Randville dolomite in the Menominee and Crystal Falls districts are locally metamorphosed into dolomitic marble. The marble varies from coarse to fine texture and in color from white to various tones of pink, blue, green, and brown. The marble generally contains so much interbedded slate and quartzite, that few of the deposits offer commercial possibilities. Developments have been attempted but it appears that excessive waste from the interbedded slates and quartzites made operations unprofitable.

An old marble quarry in Sec. 26, T. 42 N., R. 28 W., Dickinson County, was operated by the Metronite Co. of Milwaukee, Wisconsin, until the fall of 1916 when fire destroyed the plant. Operations were resumed again in 1917. The product is ground for paint filler, whiting, etc.

Verde antique marble is now produced by the Michigan Verde Antique Marble Co. some miles north and west of Ishpeming. The marble is in a belt of altered peridotite in which the rock has been altered to serpentine and dolomite. In some places the rock is said to be almost wholly dolomite but generally it is a dolomitic serpentine, the dolomite investing the rock in an intricate system of veins and stringers. The serpentine varies in color from light to dark green with olive tones but the dolomite is generally white. The rock is firm and hard and takes a high polish. The intricate and delicate veins of white dolomite give very beautiful effects in the polished slab. The marble appears equal or superior to

much of the verde antique now on the market; it is said to equal the best from Italian and Grecian quarries and can be provided in larger sections than that formerly imported from Europe.

Developments began in 1914 but lack of transportation facilities, labor shortage, etc., hindered operations. A spur line connecting the quarry with the Chicago and Northwestern railroad was completed and blocks of marble were shipped to Marquette where the company has a stone sawing mill. Marble will be cut and polished at this mill, the electric power being supplied by the city of Marquette. The company shipped broken pieces of green marble to eastern manufacturers of terrazzo, which is used as flooring. Lack of available cars prevented maximum shipments. The broken pieces were blasted from the face of the ledge some years ago and are of little value as marble, but make excellent terrazzo. Fine blocks of verde antique are reported to be in stock, and more shortly to be ready for the finishing plants.

Other projects have been started in the past six years to develop other deposits of marble in this region but the War and post-War business unrest prevented developments. In this locality there are, apparently, several undeveloped deposits of verde antique marble which are under favorable quarrying conditions. The cutting off of foreign sources of marble in 1914 led to the development and appreciation of American marbles; architects and builders are urging the use of American marbles and it is possible that quarrying of marble may become an important industry near Ishpeming.

GRAPHITE

The Northern Graphite Company of L'Anse and the Detroit Graphite Company of Detroit have opened quarries in graphite slate nine miles southeast of L'Anse. The graphite rock, which is reported to contain from 32 to 35 per cent of graphite is ground and used for paint. The production is intermittent, the quarries being operated only as the crude supply becomes depleted, enough being quarried in a year to supply the needs of the companies for several years.

No graphite was produced in 1918, 1919, and 1920.

MINERAL PAINTS

For some years, certain iron ores in Iron County were mined and sold for paint manufacture but production ceased in 1915. The Detroit Graphite Co. manufactures graphite paint from graphitic slate (see graphite) obtained near L'Anse, Baraga County. This company discontinued mining operations in 1917.

CELESTITE

Celestite or strontium sulphate ($SiSO_4$) occurs at several horizons in the Monroe formation in southeastern Michigan. Near Maybee,

Monroe County, it occurs in the Lower Monroe in scattered crystals and masses associated with native sulphur and occurs similarly in the Sylvania sandstone at Rockwood, Wayne County. Near Gibraltar, Wayne County, it occurs in disseminated crystals in Upper Monroe dolomites. In the glass sand pit of the Rockwood Silica Co., the masses are numerous in places and some of them are large. The commercial recovery of the celestite has been but partially investigated. The masses are imbedded in a friable to incoherent sandstone and can be readily separated from it.

FELDSPAR

Deposits of potash feldspar are reported to occur near Republic, and in Sec. 22, T. 47 N., R. 29 W., Marquette County. A pegmatite dike occurs in coarse granite near the south quarter part of Sec. 8, T. 46 N., R. 41 W., Gogebic County.

According to the reports of the Commissioner of Mineral Statistics for 1902 and 1903, the deposit near Republic is of red potash feldspar. A carload from this deposit was shipped to potters in East Liverpool, Ohio, and the material was reported to be satisfactory for the manufacture of porcelain. The following analysis of the material was made by an Ohio chemist.

Silica (SiO_2)	65.25
Alumina (Al_2O_3)	18.60
Iron Oxide (Fe_2O_3)	0.40
Lime ($CaCO_3$)	0.38
Magnesia (MgO)	0.23
Sodium oxide (Na_2O)	1.99
Potassium oxide (K_2O)	13.40

According to the report of the chemist there was but little free quartz in the sample. An attempt was made to develop the deposit in section 22 but apparently without success.

The pegmatite dike in Sec. 8, T. 46 N., R. 41 W., is very coarse. Many of the crystals are from four to six inches long, and some are fourteen inches in length. The feldspar appears to be pink orthoclase. The exposure is very small, being a rock knob 20 to 15 paces across and between 15 and 20 feet high. Exploration would be necessary to determine the extent of the dike. It is probable that other dikes occur in this locality.

TRAP ROCK

There are inexhaustible resources of trap rock in the western half of the Northern Peninsula, chiefly in the iron and copper bearing districts. Trap rock is quarried at Marquette and Negaunee, Marquette County. Large quantities of amygdaloidal trap are produced incidentally to the mining of copper. The trap rock from Marquette County is harder, tougher, and less altered than that from the copper mines. The inferior wearing qualities of the amygdaloidal trap, however, is partially compensated by superior cementing power.

Most of the quarry product and considerable amounts of fieldstone or "hardheads" are crushed for road material and concrete. In some years, a small amount has been sold for riprap. The great distance from markets is a serious obstacle to the development of the trap rock industry of the State. Car and labor shortage is reported to be the chief cause of the decrease in 1918.

PRODUCTION AND VALUE OF TRAP ROCK IN MICHIGAN, 1911–1920.

Year.	No. of producers.	Crushed stone.				Riprap. Rubble. Value.	Total. Value.	Rank. Value.
		Roadmaking		Concrete				
		Quantity.	Value.	Quantity.	Value.			
		Tons.		Tons.				
1911	3	.....	.....	45,250	$38,429	.....	$51,000	8
1912	5	21,805	$18,366	11,355	9,340	$8,500	36,206	8
1913	5	24,920	23,369	*	*	*	92,201	10
1914	5	25,690	24,863	4,448	4,771	.....	34,406	12
1915	6	28,262	29,764	18,775	22,047	*	105,855	12
1916	8	38,193	37,475	9,601	9,715	.....	83,072	12
1917	4	50,420	64,098	*	*	*	70,197	11
1918	4	23,686	32,605	*	*	*	53,269	11
1919	1	.....	.....	.....	.....	.....	36,186	11
1920	4	.....	.....	.....	.....	.....	84,273	10
1921	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	649,965	.....

QUARTZ

Quartz is mined near Ishpeming, Marquette County, and ground for wood filler and paint purposes by the Michigan Quartz Silica Co. of Milwaukee, Wisconsin. Some of the ground product is used in making scouring polishes. According to an analysis submitted by the company the quartz rock is practically pure silica, there being but a trace of impurities. Mills are located at Ishpeming and Milwaukee.

The above company was the only producer in 1918, 1919, and 1920.

SLATE*

In the Northern Peninsula extensive deposits of black slate occur on the northwestern side of the Huron Mountains in Baraga County. The slate is very black, of fine texture, and uniform in quality. It appears to be of superior quality, and suitable for roofing and other purposes for which slate is adapted.

From 1875 to 1878 and 1883 to 1888 a number of slate quarries were operated at and in the vicinity of Arvon. All of the companies failed because of poor methods and means of quarrying, the great distance from markets and lack of cheap transportation facilities.

*See Pub. 16, Min. Res. of Mich. for 1913, pp. 92-95, for a more complete report.

POSSIBILITIES OF OIL AND GAS IN MICHIGAN

W. I. ROBINSON

PETROLEUM

For a number of years prior to 1920 petroleum was produced from a few wells in the Port Huron area. The wells were very small with an initial yield of from three to seven barrels per day, but the yield rapidly decreased to an average of about one-half barrel per day. Most of the wells yielded sufficient gas for motive power in pumping the wells and drilling new ones. This cheap motive power plus the fact that the wells were shallow made operations profitable for the only producer, the G. B. Stock Xylite & Grease Company. The company operated twenty-two wells and used the oil in the manufacture of lubricants. However, in 1919 and 1920 when the company's land became valuable for real estate purposes the wells were abandoned and petroleum production ceased in Michigan.

Despite the abandonment of the only [illegible]

ERRATA

Page 58, line 29 read: "total value was sold as plaster board"

Page 106, line 20 read: "to favor a gradual migration of oil and gas up the dip to the surface or"

Page 106, lines 24-25 read: "would be a considerable flattening of the dip some distance in from the border of the basin"

W. R. Development Company. None of them has proved a steady producer but some encouraging signs and showings of oil have been encountered. The anticipated production is from the Trenton which has been reported to be from 2,000 to 3,000 feet below the surface. According to W. P. Karner, Manager of the company, the last well which was completed in December, 1921, filled to 150 feet from the bottom with petroleum and after shooting about four barrels a day were recovered by pumping. One other well of this group produced small amounts of oil the pumping tests indicating a production of about four barrels a day.

Near Temperance the Bedford-Erie Oil and Gas Company, R. B. Miller President, completed two wells to the Trenton and found a showing of oil.

PETROLEUM

For a number of years prior to 1920 petroleum was produced from a few wells in the Port Huron area. The wells were very small with an initial yield of from three to seven barrels per day, but the yield rapidly decreased to an average of about one-half barrel per day. Most of the wells yielded sufficient gas for motive power in pumping the wells and drilling new ones. This cheap motive power plus the fact that the wells were shallow made operations profitable for the only producer, the G. B. Stock Xylite & Grease Company. The company operated twenty-two wells and used the oil in the manufacture of lubricants. However, in 1919 and 1920 when the company's land became valuable for real estate purposes the wells were abandoned and petroleum production ceased in Michigan.

Despite the abandonment of the only commercial wells and the fact that there is no important production of oil or natural gas in Michigan, there has been a revival of interest in the search for paying quantities of them during the last three years. This has been most noticeable in four regions: The southeastern part of the State which is but a short distance north of production in Ohio, the territory north and west of Port Huron and Mt. Clemens, Seul Choix Point east of Manistique, and Manistee County. There is much in the general structure of the State and in the history of similar enterprises to discourage drilling for oil in any of these areas but with the nation wide campaign for new oil production they will undoubtedly be tested more thoroughly. The results as reported have not been of immediate commercial importance but they will be summarized for the information of property owners and drillers.

1. SOUTHEASTERN MICHIGAN. Five deep wells have been completed in this area by the Deerfield Oil and Gas Company and its successor the W. K. Development Company. None of them has proved a steady producer but some encouraging signs and showings of oil have been encountered. The anticipated production is from the Trenton which has been reported to be from 2,000 to 3,000 feet below the surface. According to W. P. Karner, Manager of the company, the last well which was completed in December, 1921, filled to 150 feet from the bottom with petroleum and after shooting about four barrels a day were recovered by pumping. One other well of this group produced small amounts of oil the pumping tests indicating a production of about four barrels a day.

Near Temperance the Bedford-Erie Oil and Gas Company, R. B. Miller President, completed two wells to the Trenton and found a showing of oil.

Near Blissfield the Blissfield, Riga and Ogden Oil and Gas Company completed one well which, according to the president of the company, Otto Wagner, penetrated 200 feet of Trenton without finding free oil or gas.

At Devil's Lake near Cement City a well is being drilled by the Prospect Hill Development Company of which R. R. Allerdice is president. The Dundee Formation was reached at 1,560 feet, but no free oil was found. This company plans testing deeper formations.

2. Seul Choix Point, Schoolcraft County. A well was completed by the Schoolcraft Development Company reaching the Trenton at 1,020 feet where considerable water was encountered. A second well has penetrated 35 feet of the Trenton and is now drilling at 1,040 feet. No oil signs have been reported. Other wells will be put down to test this area out as the Trenton is a limestone and dolomite "sand" and the factor of porosity as well as structure will influence the concentration of liquids in this formation. That there is a small, well defined anticline at the point has been quite definitely established and the exact nature of its continuation up the dip which may be determined by further drilling will indicate much in regard to the expectation of oil. According to press reports a second company, The Michigan Oil Company, expects to explore in the same general district.

3. Mt. Clemens. A deep well has been completed near Chesterfield, Macomb County, by the Macomb Oil and Gas Syndicate with J. R. Gray in charge. The Trenton was reported at 3,500 feet and small unimportant showings of oil from 2,610 and 2,710 feet. As the surface of the Trenton in southeastern Michigan is very irregular, a number of wells rather closely spaced are needed to determine its attitude. It is probable that more tests will be made in the Mt. Clemens-Port Huron region.

A well is being drilled near Brown City, Sanilac County by the Thumb Oil and Gas Developing Trust under the management of Col. J. C. Gaines. This well will probably be completed to the Dundee Formation.

4. Manistee. Press notices of contemplated drilling in Manistee County indicate that exploration will be resumed in the summer of 1922.

Gas. The only discovery of gas reported was from Clawson, Oakland County, where a water well reached a gas pocket at about 90 feet. The heavy flow of gas blew out the tools; ignited; burned down the farm house adjacent and was finally capped. As far as known this gas is not yet in use. The shallow depth indicates that it comes from the Antrim Formation which occurs in this region under the cover of sand, gravel and clay. Reports of gas wells from this southeastern area are not uncommon but the flow is neither heavy enough nor persistent enough for large commercial exploitation.

OIL AND GAS POSSIBILITIES

The entire State with the exception of the western half of the Upper Peninsula and of the country where Michigan rivers drain to Lake Superior is classed as possible oil and gas territory but production from most of it is extremely improbable; in fact no one should be encouraged to drill within the State with immediate production in mind. Three fundamental conditions are recognized as necessary to regions productive of oil; a rock layer rich in petroleum, openings in the rock which may be either large or small but which must have communicating pores or channels through which the oil may move and finally some enclosing structure which prevents the escape of the oil and gas to the surface or its dissemination through overlying or underlying beds of rock and allows its accumulation until it fills the pores or channels. It will be readily understood that one of the simplest and most effective structures which will meet these requirements and cause an accumulation of oil and at the same time prevent its escape is an arching up of rock layers, the top layer being dense and with few openings of any kind through which oil or gas can move, the lower layers being porous and containing oil and gass and water. Since oil and gas are lighter than water they tend to work upward in such a structure until finally the upper part of the porous rock becomes saturated with oil and gas and the gas works up until it accumulates next to the overlying dense rock. An arching up of rock beds is called an anticline and this is considered as one of the best structures to test by deep drilling if there is any reason to believe that there is an oil bearing rock layer which is porous and has a cover of dense rock within reach of the drill. Such an arching of the rock or anticline may often be determined from shallow-drilling; several of the Michigan anticlines have been first noticed in water wells. In only one case has the presence of an anticline been determined from surface observations within the State because there is a thick cover of sand, gravel and clay which hides nearly all of the surface rocks. The arrangement of hills and valleys depends on the deposition and later wearing away of this cover of loose material and so it would certainly be poor reasoning to say that because there is a high hill in some region we must expect an arching of the rock underneath. The fact is that experience has proved that there is no relation in Michigan between the slopes of the surface and the slope of the hard rocks except in those rare cases where there is no cover of the loose materials and the hard rocks appear at the surface just beneath the soil. One of the most frequent errors which has led in the past to expensive drilling in hopeless territory is this mistaking a hill for an anticline. Drillers who enter our region from the oil fields of the south and southwest should bear in mind that this thick cover of loose materials which is so characteristic of the Lake country is lacking south of the Ohio river.

Of the three fundamental conditions which are noted above as being necessary for important accumulations of oil and gas, two are often characteristic of Michigan rocks; a number of formations have been found to contain petroleum and in several its presence is quite usual; some of them are porous sandstones or dolomites with many communicating openings large enough for the free movement of liquids. The third condition, an impervious roof, is often found but its shape is usually wrong for a container and we must conclude that in most cases where tests have failed in favorable territory the oil and gas have moved up to the surface following a slope of the impervious member or that they have moved out to regions more favorable to their accumulation such as the Ontario fields of Canada or the Toledo field of Ohio.

It is this point of structure which is so discouraging to oil operators in Michigan. The whole territory described above as possible oil territory is underlain by rocks which dip regularly and gently toward the central area in Clare, Gladwin, Isabella and Midland Counties, forming a basin which is the reverse of an anticlinal structure and is one of the least encouraging structures for the accumulation of oil and gas of which it is possible to conceive; but it is one of the structures which is most certain to favor a gradual migration of oil and gas up the dip to the surface of to a neighboring anticline. This large basin reaches to the Lakes and to the south nearly if not quite to the Ohio line. Other conditions which may offer additional chances in spite of this large unfavorable aspect would be a considerable flattening of the dip some distance in from the of the basin forming a terrace or bench or a local dense portion of one of the porous layers which would impede the upward and outward migration of liquids and gases. These conditions have not been reported in any exploration. Again there may be in some places small folds near the border of the basin which would cause a local concentration and the accumulation of small pools. Several folds have been partially outlined by deep drilling, notably one at Saginaw, two in the Port Huron-St. Clair area and one in the western part of Monroe County. One has been demonstrated from surface observations at Seul Choix Point, Schoolcraft County. As a general rule, however, these folds are influenced to such an extent by the shape of the large basin that their axes point in toward its center and although they offer a favorable structure for the accumulation of oil and gas they also offer as easy a channel of escape to the outcrop, or to adjacent areas. A large amount of drilling would be needed to outline these folds and to demonstrate whether or not there are irregularities in the pitch of their axes which are important enough to cause an accumulation of oil and gas. These small folds are not the usual type caused by lateral pressures but are more of the nature of wrinkles in the border of the basin and are primarily due to vertical forces involved in the stress relations of the larger feature. Inthe southeastern part of the State there is an exception to this rule for there the problem is complicated by an older folding involved in the formation of the Cincinnati arch which lies just to the south.

FORMATIONS CONTAINING OIL AND GAS

1. The Saginaw Formation, the Michigan coal bearing series, contains some coals high in volatile matter and in one instance, a drilling at Fowlerville has yielded a showing of oil. As this formation is at the surface, is deeply eroded and is composed of lens shaped beds of small lateral extent, it is not considered to be promising.

2. The Sunbury Formation, a brown shale containing considerable volatile matter, is of too fine a grain to be considered as a producer of free oil or gas in important quantities.

3. The Berea Formation, a grey sandstone containing a pure salt brine and with enough openings to allow a free flow of brine into wells, is bounded above and below by bituminous shales (the Sunbury and Antrim Formations) and has been considered to be one of the most promising gas horizons. It produced some gas at Blackmar, Bay City and Killmaster but in the rather extensive drillings at Saginaw it was found to be of too fine a texture to yield a large flow.

4. The Antrim shales often yield oil and gas signs to the overlying drift, especially in southeastern Michigan where the gas has been found in sufficient quantities to supply single homes for several years and also in the western part of the State. The local nature of these gas reservoirs is revealed by their rapid depletion. Because of the irregular distribution of the drift, prospecting is more a question of trial and error than of intelligent search.

5. The Traverse Formation offered several showings of oil in the Saginaw district and some gas at Port Huron, Osseo, Ypsilanti, Bay City and Alma. It is usually composed of hard limestones and dense shales through which liquids and gases could not penetrate. Locally porous limestones or sand lenses in this formation might yield some oil.

6. The Dundee Formation, a limestone, nearly always has an odor of petroleum and has produced free oil in noteworthy quantities at Allegan, Saginaw and Port Huron. It is a producer of oil in Ontario but no steady production has been obtained from it within the State with the exception of a group of small wells which operated for a number of years near Port Huron. As this formation occurs near the surface in southeastern Michigan testing it is not expensive and a number of wells have been drilled with this intention.

7. The Detroit River Formation (Upper Monroe) yielded free oil at Kalamazoo and East Lake (Manistee) but in small quantities.

8. The Niagaran has produced oil and gas in Ontario but there has never been any indication of oil or gas in Michigan in the few cases where wells have penetrated to its depth.

9. The Richmond has never yielded oil or gas except for oil showings provisionally referred to this formation at Chesterfield.

10. The Lowville and Black River Formations (the Trenton Formation) have yielded oil showings in several points in Monroe County and signs of oil have been noted at their outcrop near Rapid River in the Upper Peninsula.

The Berea, Dundee and Trenton offer possibilities worthy of consideration and one or more of these might furnish oil if a structure could be found which would accumulate and hold it.

REPORTED DISCOVERIES OF OIL IN MICHIGAN

County	Place	Date	Formation	Depth	Owner or Driller	Quantity
Allegan	Allegan	1899	Dundee	1245–1328	Allegan Gas. Oil and Mining Co.	pumped 2 to 5 bbls. daily.
Allegan	Allegan	1912	Dundee	1287	Northern Oil and Gas Co.	2 bbls. daily.
Alcona	Killmaster	1892	Berea	570	?	showing.
Berrien	Niles	1903	Dundee	592	Niles Oil and Gas Co.	showing.
Delta	Rapid River	1904	Trenton	300	Milwaukee Syndicate	showing.
Isabella	Mt. Pleasant	1913	Berea?	2590	W. F. Braun	showing.
Kalamazoo	Kalamazoo	1887	Monroe	1490	Kalamazoo Natural Gas Co.	showing.
Livingston	Fowlerville		Saginaw	157	Henry White	slight flow.
Macomb	Chesterfield	1922	Richmond?	2650–2710	Macomb Gas and Oil Syndicate	showings.
Manistee	East Lake	1885	Monroe	1905	R. G. Peters Lumber Co.	slight flow much gas.
Manistee	East Lake	1885	Antrim	960	R. G. Peters Lumber Co.	showing.
Manistee	East Lake	1908	Monroe	1925	R. G. Peters Lumber Co.	showing.
Manistee	Stronach	?	Dundee	1655	Stronach Lumber Co.	showing.
Manistee	Stronach	?	Antrim	600	Stronach Lumber Co.	showing.
Muskegon	Muskegon	1872	Coldwater	1200	Mason Lumber Co.	slight flow.
Muskegon	Muskegon	?	Coldwater	1200	Ryerson-Hills	slight flow.
Muskegon	Muskegon	1900	Coldwater	1275	Michigan Oil Co.	slight flow.
Monroe	Erie Twp.	1899	Trenton	1555	Potter	slight flow.
Monroe	Strasburg	1907	Trenton	1937–1950	Strasburg Oil & Gas Co	showing.
Monroe	Dundee	1888	Trenton	2133	Dundee Syndicate	showing.
Monroe	Temperance	1920	Trenton	1690	Erie-Bedford Oil and Gas Co.	showing.
Monroe	Deerfield	1921	Trenton	2060	W. K. Development Co.	4 bbls. daily
Monroe	Deerfield	1920	Trenton	2105	Deerfield Oil and Gas Co.	4 bbls. daily.
Saginaw	Saginaw	1912	Traverse	2300–2540	Saginaw Valley Dev. Co. (Wells No. 4-2)	showing.
Saginaw	Saginaw	1912	Dundee	2942–2955	Saginaw Valley Dev. Co. (Wells No. 3,4,5)	first pumpings 2 to 4 bls.daily
St. Clair	Port Huron	1886	Dundee	520–525	C. A. Bailey	showing.
St. Clair	Port Huron	1887	Dundee	515	F. L. Wells	showing.
St. Clair	Port Huron	1898	Dundee	520	G. B. Stock	2 to 3 bbls. daily.
St. Clair	Port Huron	1910	Dundee	500–650	G. B. Stock	10 bbls. daily from 21 wells.
St. Clair	Port Huron	1913	Dundee	?	Mich. Central Oil Co.	about ½ bbl. daily.
St. Clair	Port Huron	1907	Dundee	600?	Eureka Dev. Co.	showing.
St. Clair	Port Huron	?	Dundee	710	(Grand Trunk Jct.)	showing.
St. Clair	Abbotsford	?	Dundee	813	F. A. Beard	slight flow
St. Clair	Fort Gratiot Township	?	Dundee	558–568	Sweitzer	showing.
St. Clair	Fort Gratiot Twp.	?	Dundee	557	Shaw	showing.
St. Clair	Port Huron	1913	Dundee	?	Stock Xylite Grease and Oil Co.	6 to 7 bbls daily from 22 wells.
St. Clair	Port Huron	1914	Dundee	564	Draper Mfg. Co.	⅛bbl. daily

NATURAL GAS*

Although natural gas occurs in Michigan, the amount obtained is so variable, the volume and pressure so low that its production is not an important industry in the State. Most of the gas is produced in Manistee, Alcona, and Montmorency counties, and in the southeastern part of the State in Macomb, Oakland and St. Clair counties.

The gas is obtained both from the bed rock and from the drift. The drift gas is doubtless due to leakage from the underlying bituminous and petroliferous Devonian formations as it is most abundant in belts overlying these formations. Gas given off by springs and shallow wells has occasioned unsuccessful exploration, since these wells are along the exposures of oil and gas bearing formation, therefore, they are along the line or leakage and not in the zone of accumulation. In most cases the wells yield gas sufficient for a few families only, some lasting a score or more of years, but the greater number "play out" in a few weeks or days. Farmers of Oakland and Macomb counties report that the 15 or 20 gas wells which are in use for heating and lighting purposes are rapidly declining in pressure and volume of gas.

The artesian wells around Portage Lake, Manistee County, yield some gas. The most notable yield was from a well driven in 1913 in the drift west of Onekama. In June, 1918, surface gas was struck in a well in Mikado Township, Alcona County. The mineral wells of Mt. Clemens also yield gas which is nearly sufficient for heating the boilers used for pumping. A very limited supply of gas is obtained from small drift wells in Benzie, Monroe, Washtenaw, and Wayne counties.

Many of the oil wells of the Port Huron oil field yielded gas. The May and Gillette wells west of Port Huron are reported to yield from 20,000 to 40,000 feet of gas per day, when allowed to flow freely, with a gas pressure said to vary from 125 to 250 pounds per square inch. Other wells in Port Huron yield gas sufficient for domestic and small industrial purposes.

In 1920 a gas well was reported from Clawson, Oakland County. In drilling a well for water a gas pocket was reached. The flow of gas blew out the tools, ignited and burned down the nearby farmhouse before being capped.

The total production of gas is relatively insignificant the maximum production being 2,422,000 cubic feet in 1914, dwindling to 1,098,000 cubic feet in 1919, valued at $911. The estimated value for 1920 was $500.

The following table shows the production of natural gas for the past seven years.

*See also Petroleum.

PRODUCTION OF NATURAL GAS IN MICHIGAN, 1911-1920

Year	No. of producers.	Domestic.		Industrial.		Other.		Total.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		M cu. ft.		M. cu. ft		M cu. ft.		M cu. ft.	
1911	22	930	$930	.....	.....	800	$400	1,730	$1,330
1912	17	.....	1,020	900	$450	.....	.....	900	1,470
1913	.....	.....	.....	.....	.....	.....	.....	1,805	1,405
1914	.....	.....	.....	.....	.....	.....	.....	2,442	1,442
1915	16	960	960	.....	.....	1,100	550	2,060	1,510
1916	12	598	598	.....	.....	700	350	1,298	948
1917	10	613	613	.....	.....	571	400	1,184	1,013
1918	14	745*	745	.....	.....	428	300	1,173	1,045
1919	15	773	586	.....	.....	325	325	1,098	911
1920	.....	.....	.....	.....	.....	.....	.....	.....	500*
1921	.....	.....	.....	.....	.....	.....	.....	.....	.....

*Estimated.

REPORTED DISCOVERIES OF GAS IN MICHIGAN

County	Place	Date	Formation	Depth	Owner or Driller	Quantity
Alcona	Killmaster	1892	Berea	570	?	showing.
Alcona	Black River	1922	Antrim	118	H. C. McKinnon	showing.
Allegan	Allegan	1900	Dundee	1264	Allegan Gas, Oil & Mining Co.	nearly enough for boiler.
Barry	Assyria	1903	Antrim	1525	G. D. Conner & J. J. Callender	trace.
Bay	Bay City	1898	Antrim	2304,	North American	
			Traverse	2580	Chemical Co.	traces.
				2734		
Benzie	Beulah	?	Antrim	205	C. L. Rowe	?
Berrien	Niles	1865	Dundee?	500 to 700?	?	showing.
Berrien	Niles	1885?	Trenton	1000	?	showing.
Berrien	Niles	1899	Dundee?	518	?	showing.
Berrien	Buchanan	1903	Traverse?	618	Umholtz Oil Co.	showing.
Berrien	Bridgman	1904	Antrim	308	Bridgman Oil and Gas Co.	showing
			Dundee	763		trace.
Charlevoix	Advance	1902	Antrim	?	E. W. Lane	showing.
Clare	Harrison	?	?	?	Hughes Bros.	?
Gratiot	Alma	1889	Traverse	2825	Sanitarium	trace.
Hillsale	Osseo	?	Traverse	1219	C. M. Dewitt	showing.
Hillsdale	Osseo	?	Traverse (Dundee?)	1380	C. M. Dewitt	showing.
Hillsdale	Osseo	?	Dundee	1400	C. M. Dewitt	70 pounds pressure.
Hillsdale	Camden	1907	?	?	C. H. Alvord	trace.
Isabella	Mt. Pleasant	1913	Marshall	1535	W. F. Braun	showings
			Berea?	2590		
Kent	Grand Rapids	?	Antrim	1708	Grand Rapids Artesian Well Co.	trace.
Lenawee	Britton	?	Antrim	90	J. Wiggin	35 pounds pressure.
Lenawee	Palmyra	1904	Antrim	136	S. E. Bailey	showing.
Livingston	Fowlerville	?	Saginaw?	155, 380, 600	Jason-Shumway	showings.
Livingston	Fowlerville	?	Saginaw?	136	Henry White	showing.
Mackinac	St. Ignace	1887	Niagaran	899	Mackinac Lumber Co.	showing.
Macomb	Warren	?	Antrim	69	Franz Elwart	?
Macomb	Warren	?	Antrim	72	Wm. H. Hanekow	?
Macomb	Warren	?	Antrim	90	Wm. L. Hartsig	72 pounds pressure.
Macomb	Warren	?	Antrim	60	Otto Jacob	?
Macomb	Warren	?	Antrim	98	August Mielke	?
Macomb	Warren	?	Antrim	93	A. R. Peters	45 pounds pressure.
Macomb	Warren	?	Antrim	71	Alex. Warren	?
Macomb	Warren	?	Antrim	50	Henry Vohs	?
Macomb	Warren	?	Antrim	68	Max Wolgast	25 pounds pressure.
Macomb	Warren	?	Antrim	?	J. Dobberowsky	25 pounds pressure.
Macomb	Warren	?	Antrim	?	H. Martin	?
Macomb	Warren	?	Antrim	60	Edward Jacob	80 pounds pressure.
Macomb	Warren	?	Antrim	?	Franz Elwart	supplied one house.
Macomb	Warren	?	Antrim	72	A. Smith	supplied one house.
Manistee	Onekama	?	Antrim	437	H. W. Leonard	185 pounds pressure.
Manistee	East Lake	1886	Monroe?	1905	R. G. Peters	large pressure.
Manistee	East Lake	1908	Monroe?	1911	R. G. Peters Salt & Lumber Co.	showing.
Manistee	Stronach	?	Antrim	600	Stronach Lumber Co.	showings.
			Dundee	1655		
Manistee	Portage Lake	1901	Drift	?	?	strong pressure.
Manistee	Portage Lake	1913	Drift	437	H. W. Leonard	185 pounds pressure.
Manistee	Portage Lake	?	Drift	470	Clark	showing.
Manistee	Portage Lake	?	Drift	537	Sands & Smith	showing.
Manistee	Portage Lake	?	Drift	418	A. Lipkowski	showing.
Manistee	Portage Lake	?	Drift	535	H. W. Leonard	showing.
Manistee	Portage Lake	?	Drift	510	Dunham	trace.
Manistee	Portage Lake	?	Drift	318	Showalter	trace.

REPORTED DISCOVERIES OF GAS IN MICHIGAN—*Continued*

County	Place	Date	Formation	Depth	Owner or Driller	Quantity
Manistee	Portage Lake	?	Drift	450	N. & M. Transportation Co.	showing.
Manistee	Portage Lake	?	Drift	399	Prosser	trace.
Monroe	Erie	1899	Trenton	1555	Potter	supplied house.
Monroe	Monroe	?	Trenton	1742	Moore	showing.
Monroe	Dundee	1888	Trenton	2133	Dundee Syndicate	showing.
Monroe	Ida	1893	Unknown		S. Van Akin	showing.
			Bass Island?	480		
Monroe	Strasburg	1907	Trenton	1950 Trenton at 1884	Strasburg Oil & Gas Co.	showing.
Muskegon	Ravenna	?	Coldwater	?	Robt. Jackson	?
Muskegon	Muskegon	1875	Coldwater	1200	Mason Lumber Co.	showing.
Muskegon	Muskegon	?	Coldwater	1200	Ryerson-Hills	seepage ever since completion
Oakland	Royal Oak	?	Antrim	108	Louis Granzow	39 pounds
Oakland	Southfield	?	Berea or Sunbury	105	Frank Grosjean	?
Oakland	Royal Oak	?	Antrim	115	Wm. Hilzinger	39 pounds pressure.
Oakland	Royal Oak	?	Antrim	95	Edwin Landeau	?
Oakland	Royal Oak	?	Antrim	102	Henry Langer	43 pounds pressure.
Oakland	Redford	?	Berea or Sunbury	?	E. McHugh	20 pounds
Oakland	Redford	?	Berea or Sunbury	105	Wm. J. Purdy	weak.
Oakland	Royal Oak	?	Berea	?	E. A. Starr	?
Oakland	Royal Oak	?	Antrim or Berea	116	N. E. Springsteen	?
Oakland	Royal Oak	?	Antrim	108	Frank Parmeter	¼ pound pressure.
Oakland	Pontiac	?	Dundee	1300 1497	Pontiac Natural Gas & Oil Co.	traces.
Oakland	Redford	?	?	116	Wm. Becht	35 pounds pressure.
Roscommon	Roscommon	1914	Marshall and Coldwater	673	Franz Jahncke	trace.
Saginaw	Saginaw	1912	Berea	1830-2141	Saginaw Valley Development Co.	showing.
Saginaw	Blackmar	1870	Berea?	1545	Mr. Blackmar	trace.
St. Clair	Algonac	?	Antrim	300	M. J. and L. J. Harrow	16 pounds pressure.
St. Clair	Port Huron	1886	Dundee	500-572	C. A. Bailey	small.
St. Clair	Grand Trunk Junction Port Huron	?	Antrim	300	?	showing.
St. Clair	Port Huron	1886	Antrim	about 100	C. A. Bailey	small.
St. Clair	Port Huron	1886	Traverse	280-320	C. A. Bailey	small (odorless)
St. Clair	St. Clair	1873	Antrim	113	?	showing.
St. Clair	Port Huron	1887	Dundee	515	F. L. Wells	small.
St. Clair	Port Huron	1887	Traverse	185-290	F. L. Wells	small (odorless)
St. Clair	Port Huron	1898	Dundee	540-600	G. B. Stock	supplied a gas engine
St. Clair	Port Huron	1903	Antrim	?	G. W. Howe	40 pounds pressure.
St. Clair	Port Huron	1910 1916	Dundee	565-620	Michigan Central Oil Company	supplied pumps, drills and two houses.
St. Clair	Port Huron	1907	Antrim	?	E. Heeke	showing.
St. Clair	Port Huron	?	Antrim	110	L. M. Corner	?
St. Clair	Marine City	1903	Antrim	200+	Bath House	25 pounds estimated.
St. Clair	Fort Gratiot Township	?	?	?	F. A. Farr	?
St. Clair	Port Huron	1916	Antrim	190	Morton Salt Co.	good showings.
			Dundee	640		
St. Clair	Port Huron	?	?	?	Mrs. J. Madill	?

REPORTED DISCOVERIES OF GAS IN MICHIGAN—*Continued*

County	Place	Date	Formation	Depth	Owner or Driller	Quantity
St. Clair....	Port Huron...	1913	Dundee.....	487	Reed Wrecking Co...	reached 400 pounds pressure.
St. Clair....	Port Huron...	?	?	?	N. J. McKenzie.....	good flow.
St. Clair....	Kewahdin Beach..... (Port Huron)..	1903	Traverse....	395	Geo. F. Howe.....	supplied several families.
St. Clair....	Marysville....	?	?	?	J. A. Rowe.....	43 pounds pressure.
St. Clair....	Marysville....	?	Dundee.....	588	Church & Co.....	showing.
St. Clair....	St. Clair.....	1873	Antrim.....	113	?	showing.
St. Clair....	Port Huron...	?	?	700	Lawrence Gillett....	?
St. Clair....	Port Huron...	.....	Dundee.....	534	Draper Mfg. Co.....	45 pounds pressure.
St. Clair....	Port Huron...	?	?	610	J. E. Ruff.....	110 pounds pressure.
St. Clair....	Port Huron...	1907	Antrim.....	?	J. Simon.....	showing.
Washtenaw.	Augusta.....	?	Antrim.....	65	H. E. Harman.....	10 pounds pressure.
Washtenaw.	Ann Arbor....	1900	Dundee.....	800	University.....	trace.
Washtenaw.	Madison.....	1905	Antrim.....	612	Madison Oil and Gas	trace.
Washtenaw.	Ypsilanti.....	1904	Detroit River	730	Banner Oil & Gas Co.	trace.
Washtenaw.	Ypsilanti.....	1904	Antrim.....	135	Banner Oil & Gas Co.	trace.
Wayne.....	Detroit.....	?	Antrim.....	65	Irving Becker.....	?
Wayne.....	North Detroit	?	Antrim or... Traverse....	122	Jno. Desgrandchampe	?
Wayne.....	Trenton.....	?	Salina?.....	1310 & 1340	Church & Co.....	traces.
Wayne.....	Wyandotte...	?	Salina.....	1500	Lancy and Churchill.	trace.
Wayne.....	Detroit.....	?	Antrim.....	165	Detroit Natural Gas Co.....	showing.
Wayne.....	Redford.....	?	?	?	L. W. Chaivre.....	supplied one range.
Wayne.....	North Detroit	?	?	100	R. Gersabek.....	showing.
Wayne.....	North Detroit	?	?	?	Edwin Adiska.....	?

OIL SHALES

There are no thick shale formations in the State which would lead to immediate consideration from experimenters who are trying to recover oil from oil bearing shales but so many inquiries are being made in this regard the following summary of shales and coals containing volatile matter may be of interest.

Three Michigan formations have been suggested as possible future sources of volatile products—the Saginaw Formation, a coal bearing horizon of Pennsylvanian age, the Antrim Formation of Devonian age containing blue shale and a heavily bituminous black shale and the Collingwood, also called the Utica Formation of Ordovician age containing brown, gray and black shales—the darker beds high in volatile matter.

2. *The Antrim Formation*

This is the most favorably mentioned formation on account of its uniformity, its occurrence beneath the drift in large areas, its outcrop in portions of Alpena and Charlevoix counties and its occurrence near the larger manufacturing centers of the State. It is a late Devonian formation formed under the same general conditions as the Huron, Chagrin and Cleveland shales of Ohio and the Huron and Port Lambton shales of Ontario. In the southern part of the State three members have been recognized, a lower black shale, a middle blue to gray shale, and an upper black shale. In the northern part of the Lower Peninsula these divisions do not seem to be as definitely represented but there is nearly always a black pyritic shale at the base of the formation which makes a striking color change and is therefore recorded by the driller. The formation as a whole varies from about 150 feet to about 500 feet in thickness but the portion of interest on account of a relatively high volatile content is probably less than a half of the total thickness and its value is further reduced by a frequent intercalation of members of the gray and blue shale. It is common to have the black shale members reported as having thickness of from 20 to 40 feet in the more detailed records although when the record is less carefully taken the dark color of the blue shale when wet leads to an incorrect assumption of greater thicknesses.

Few analyses have been attempted but those which have been made show that this formation is not of a grade which will lead to early development. The following analyses were made by the United States Bureau of Mines Experiment Station at Denver, Colorado.

	Yield of oil Gals. per ton	Nitrogen per cent
Sample No. 1, Paxton shale quarry, Alpena Co.....	9.4	0.54
Sample No. 2, Outcrop, Norwood, Charlevoix Co.....	4.8	0.36
Sample No. 3, Outcrop, Walloon Lake Junction, Charlevoix Co.....	3.9	0.35

An analysis was made of a sample of Antrim shale taken from between 1,575 feet and 1,700 feet in the Assyria well at Assyria, Barry County.

(Analysis made in the Lansing High School Laboratory.)

Moisture	6.595 per cent
Volatile Carbon	6.025 per cent
Fixed Carbon	3.95 per cent
Ash	83.435 per cent
	99.985 per cent

A sample from near Alpena was analyzed by W. H. Johnson of Alpena for volatile content.

Volatile content (Water between 5 and 10 per cent)	17.96
Fixed Carbon	6.49
Ash	75.55
	100.00

Although the Antrim shale occurs as the highest rock member in the southwestern and southeastern portions of the State in the more easily accessible and most thickly populated districts, it is here buried under a cover of drift which varies from 90 feet to 200 feet and would therefore be recoverable only by mining. In the northern part of the State it is quite generally overlain by drift but also outcrops in portions of Alpena and Charlevoix counties. It also occurs deeply buried under other formations in nearly the whole of the Lower Peninsula but as the depths at which it is found vary from a few hundreds to a few thousands of feet it is now completely removed from mining operations except in the areas mentioned above where it is the highest rock layer and is covered only by the drift.

2. *The Collingwood Formation* (Also called Utica)

Recovery of oil from this shale was attempted on a commercial scale at Collingwood, Ontario, in 1859. Seven to eight gallons per ton were obtained by a distillation of crushed shale lasting two and one-half hours. Slightly larger amounts were added by longer distillation but the shorter period was regarded as being more economical. The cost was said to be fourteen cents per gallon and although no data are at hand regarding the profits to the manufacturer, production was continued for some time until petroleum was obtained from wells in Ontario.

The Collingwood has been reached by the drill in southeastern Michigan but at depths (over a thousand feet) which place it beyond reach of mining operations. In the Upper Peninsula it occurs in outcrop in the valley of Whitefish River north of the town of Rapid River and has been traced, mainly by inference, eastward through Schoolcraft, Luce and Chippewa counties. There is considerable drift covering the outcrop in this area but as far as known from the few well records available it is usually thin,—rarely over fifty feet although in places over a hundred

feet thick. The thickness of the Collingwood seems to be quite uniformly from fifty to seventy-five feet. The smaller figure is more usual. It is dense shale, black when wet and dark brown when dry, weathering in places to gray and blue shades, formed under the same general conditions as the Collingwood of Ontario. No intercalation of beds of other materials is known although a lower layer is sometimes noted as being of a darker color than the upper part.

The following analyses show the general nature of this shale. They are taken from a report on the geology of Wisconsin.

1. Brownish black fine grained rock from Cape Smith, Lake Huron.

	Per cent
Clay and sand	38.45
Carbon	6.83
Hydrogen	0.74
Oxygen	3.20
Carbonate of lime	45.02
Carbonate of magnesia	2.09
Alumina and iron oxide	2.16

2. Blackish brown, fine grained, of earthy texture and of laminated structure. From an island to the north of Maple Cape, Lake Huron.

Clay and sand	34.60
Carbon	6.63
Hydrogen	0.77
Oxygen	2.96
Carbonate of lime	49.31
Carbonate of magnesia	2.53
Alumina and oxide of iron	2.09

3. *The Saginaw Formation*

This formation is the Michigan representative of the Coal Measures of the Pennsylvanian period and is characteristically formed of lenses of very diversified materials,—white shales, sandstones, black shales and coals, and more rarely blue shales, black band iron ore and limestone. It underlies the drift in all of the central part of the Lower Peninsula occasionally outcropping near the outer edge of this area, notably near Jackson, Saginaw and Grand Ledge.

There are a number of thin beds of shale and coal which undoubtedly contain a large percentage of volatile matter. Most of them are too thin to work as coal seams and they are very irregular in thickness as well as in lateral extent. One rock bed often varies as much as twenty feet in thickness in one mine. Lane has mentioned fourteen horizons of coal, all within a 400 foot section and most of them too thin to work.

That this series is, in places, petroliferous is demonstrated by the discovery of an oil showing in a well near Fowlerville where it was reported from a blue shale at a depth of from 136 to 166 feet. A dark sandstone reported from 157 feet may have been the real source of the oil. Nothing has been developed commercially nor has been attempted since this one reported occurrence.

Analyses mentioned by Smith (Publication 14, Michigan Geological Survey) have been made of two Michigan coals showing their volatile content.

		Per cent
1.	Bone Coal Saginaw Valley	
	Moisture	8.08
	Volatile	30.74
	Fixed carbon	49.29
	Ash	11.89
1.	Cannel Coal, Arenac County	
	Moisture	11.35
	Volatile	35.80
	Fixed carbon	41.10
	Ash	11.87

APPENDIX

DIRECTORY OF THE PRODUCERS OF NON-METALLIC MINERALS IN MICHIGAN, 1920

Operator.	Office	Works
Allegan County:		
Allegan Brick Works (Fish & Fish)	Allegan	Allegan.
Zeeland Brick Co	Zeeland	Zeeland.
Barry County:		
Leonard Brick Co	Delton	Delton.
Berrien County:		
Manner Brick Co	Benton Harbor	Benton Harbor
Chippewa County:		
Rudyard Brick Works	Rudyard	Rudyard.
Eaton County:		
American Sewer Pipe Co	Broad St., Akron, Ohio	Grand Ledge.
Briggs Co	Lansing	Grand Ledge.
Grand Ledge Clay Products Co	Grand Ledge	Grand Ledge.
Emmet County:		
De Arment, C. A	Petoskey	Petoskey.
Genesee County:		
Scholl, L. J. & C. E	Clio	Clio.
McCann, Fred'k W	Gaines	Gaines.
Sharp, Frank	R. D. No. 1, Linden	South Mundy.
Gratiot County:		
Ashley Tile Co	Ashley	Ashley.
Stevenson & Sons, David	Ashley	Ashley.
North Star Tile Co	North Satr	North Star.
St. Louis Tile Co	St. Louis	St. Louis
Riverside Brick & Tile Co	Sumner	Summer.
C. D. Peet	North Star	Sickles.
Jackson County:		
Warden Michigan State Prison	Jackson	Jackson.
American Sewer Pipe Co	Akron, Ohio	Jackson.
Kent County:		
Grand Rapids Brick Co	Mich. Ave. and Fuller St., Grand Rapids	Grand Rapids.
Sparta Tile & Brick Co	Sparta	Sparta.
Lenawee County:		
Britton Pressed Brick Co	Ann Arbor	Britton.
American Brick & Tile Co	Morenci	Morenci.
Comfort, Albert A	R. D., Tecumseh	Tecumseh.
Fairbanks M. F	Morenci	Seneca.
Midland County:		
Rilett J. W	Coleman	Coleman.
Monroe County:		
Maybee Brick & Tile Co	Maybee	Maybee.
Angerer Clay Products Co	Scofield	Scofield.
Muskegon County:		
Muskegon Brick & Tile Co	Muskegon	Holton.
Newaygo County:		
Grant Tile Mfg. Co	R. D.. Grant	Grant.
Ottawa County:		
Zeeland Brick Co.	Zeeland	Zeeland
Saginaw County:		
Parker-Lohmann Brick & Tile Co	R. D. No. 10, Saginaw, W. S	Saginaw, W. S.
Day, Thomas	R. D. No. 3, Saginaw	Saginaw.
Saginaw Plate Glass Co,	Saginaw	Saginaw.
Miller City Tile Co	Saginaw,	Paines.
St. Clair County:		
St. Clair Brick Co	Detroit,	St. Clair.

BRICK AND TILE MANUFACTURERS—*Continued*

Operator.	Office.	Mine.
Sanilac County:		
Croswell Brick & Tile Co	Croswell	Croswell.
Van Buren County:		
Olliney, A. C		
Wayne County:		
Daniel Brick Co. Jacob	291 Clippert Ave., Detroit	Detroit.
Haggerty, John S	1815 Dime Sav. Bk. Bldg., Detroit	Detroit.
McDonald & Son John C	707 Hammond Bldg., Detroit	Springwells.
Bunte Bros Tile Co	Flat Rock	Flat Rock.
Clippert & Bro. Brick Co., Geo H	1960 Michigan Ave., Detroit	Springwells.
Clippert, Wm	1960 Michigan Ave., Detroit	Springwells.
Mercier, Bryan, Larkins Brick Co	Michigan Ave. and Lonyo Road, Detroit	Springwells.
Porath Bros	306 Free Press Bldg., Detroit	Springwells.
Springwells Brick Co	1009 Hammond Bldg., Detroit	Springwells.
Pewabic Pottery & Tile Co	2161 Jefferson Ave., Detroit	Detroit.
Lonyo Bros	1603 Campbell Ave., Detroit	Detroit.
Walker & Frank Co	Detroit	Detroit.

SAND-LIME BRICK PRODUCERS, 1920

Operator.	Office.	Works.
Genesee County:		
Flint Sandstone Brick Co	Flint	Flint.
Huron County:		
Sebewaing Sandstone Brick Co	Sebewaing	Sebewaing.
Jackson County:		
Jackson-Lansing Brick Co	Rives Junction	Rives Junction.
Kalamazoo County:		
South Michigan Brick Co	Kalamazoo	Kalamazoo.
Kent County:		
Grande Brick Co	Kalamazoo Ave., Grand Rapids	Grand Rapids.
Menominee County:		
Menominee Brick Co	Menominee	Menominee.
Oakland County:		
Rochester Brick & Sand Co	Rochester	Rochester.
Saginaw County:		
Saginaw Brick Co	321 N. Hamilton St., Saginaw	Saginaw.
Wayne County:		
Michigan Pressed Brick Co	Cor. Lawton Ave., and M. C. R. R. Detroit	Detroit.
Fairview Brick Co	Foot of Jean St., Detroit	Detroit.

CEMENT PRODUCERS, 1920

Operator.	Office.	Works.
Huron Portland Cement Co	1525 Ford Bldg., Detroit	Alpena.
Alpha Portland Cement Co	Bellevue	Bellevue.
Peninsular Portland Cement Co	Cooley Block, Jackson	Cement City.
Michigan Portland Cement Co	Chelsea	Four Mile Lake.
Wolverine Portland Cement Co	Coldwater	Coldwater and Quincy.
Aetna Portland Cement Co	412 Union Trust Bldg, Detroit	Fenton.
Newago Portland Cement Co	Grand Rapids	Newago.
Peerless Portland Cement Co	Union City	Union City.
Wyandotte Portland Cement Co	1525 Ford Bldg., Detroit	Wyandotte.
New Egyptian Portland Cement Co	Fenton	Fenton.
Petoskey Portland Cement Co	Petoskey	Petoskey.

LIST OF MICHIGAN COAL MINES, LOCATION BY COUNTY, NAMES OF MANAGERS AND SUPERINTENDENTS

Name of mine.	County.	Manager.	Address.	Superintendent.	Address.
Robert Gage Coal Co. No. 7	Bay	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Beaver Coal Company	Bay	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Wolverine Coal Mining Company No. 2	Bay	R. M. Randall	Saginaw	Alex Liddle	Bay City
Sun Coal Company	Bay	Wm. Cameron	Bay City	O. S. Callahan	Bay City
What Cheer Coal Mining Company No. 1	Bay	A. N. Fancher	Bay City	Alex Jeffreys	Bay City
B. S. K. Coal Mining Co	Calhoun	W. A. Knapp	Albion	W. C. Sellars	Albion
Robert Gage Coal Company No. 3	Saginaw	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Robert Gage Coal Company No. 8	Saginaw	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Bliss Coal Mining Company	Saginaw	C. E. Linton	Saginaw	J. T. Phillips	Saginaw
Banner Coal Mining Company	Saginaw	Wm. B. Carmichael	Saginaw Swan Creek	Richard Jenkins	Swan Creek Saginaw
Community Coal Company	Saginaw	Alex Jeffreys	Bay City	Wm. Follis	Bay City
Riverside Coal Company No. 2	Saginaw	R. M. Randall	Saginaw	Alex Liddle	Bay City
Shiawassee Coal Company	Saginaw	R. M. Randall	Saginaw	Alex Liddle	Bay City
Uncle Henry Coal Co. No. 2	Saginaw	R. M. Randall	Saginaw	Alex Liddle	Bay City
Middleton Mining Co	Shiawassee	Isaac Middleton	Corunna		
Corunna Coal Mining Co	Shiawassee	Harry Cohoney	Corunna		
Akron Coal Mining Co. No. 2	Tuscola	Chas. Handy	Bay City (W. S.)	Chas. Period	Akron

Hon. A. K. Smith, State Coal Mine Inspector, Bay City, Michigan.

CLAY MINERS, 1920

Operator.	Office.	Mine.
Allegan County:		
Allegan Brick Works	Allegan	Allegan
Barry County:		
Leonard, Wm.	Delton	Delton.
Ontonagon County:		
Robinson Clay Products Co.	1010 E. Market St., Akron, Ohio.	Rockland.
Jeffs, F. A.	Rockland	Rockland.
Wayne County:		
Geo. H. Clippert & Bro. Brick Co.	Detroit	Springwells.

COKE PRODUCERS, 1920

Operator.	Address.	Location of plant.	No. of ovens.	County.
Michigan Alkali Co.	Wyandotte	Plant No. 2	30	Wayne.
Semet-Solvay Co	Syracuse, N. Y.	Detroit	175	Wayne.

NATURAL GAS PRODUCERS, 1920

Operator.	Address.
Benzie County:	
Gordon & Conklin Son	Beulah.
Oakland County:	
McClelland, James	Redford.
Springsteen, N. E.	Royal Oak.
St. Clair County:	
Haas, H. G.	Port Huron, 1615 Griswold St.
Stevens, H. Leroy	Port Huron
Mason, F. H.	Port Huron, 2478 Military St.
Howe, Geo. W.	Port Huron, 4008 Military St.
Wayne County:	
Bicht, Wm. F.	Redford.
Chaivre, Louis W	Detroit, 21 Linsdale Ave.

GRAPHITE PRODUCERS, 1917*

Name.	Address	Quarry.
Detroit Graphite Co	10, 12th St., Detroit	L'Anse.
Northern Graphite Co.	L'Anse	L'Anse

GRINDSTONE AND SCYTHESTONE PRODUCERS, 1920

Operator.	Office.	Quarry.
Huron County:		
Cleveland Stone Co.	Cleveland, Ohio	Grindstone City.
The Wallace Co.	Port Austin	Eagle Mills.
Cleveland Stone Co.	Cleveland, Ohio	Port Austin.

*No graphite produced in 1919, 1920.

PRODUCERS OF GYPSUM PRODUCTS, 1920

Operator.	Office.	Name of plant.	Location of mine.
United States Gypsum Co	Chicago, Ill	Alabaster	Alabaster.
United States Gypsum Co	Chicago, Ill	Midland	Grand Rapids.
Acme Cement Plaster Co.	St. Louis, Mo.	Mill No. 5	Beverly.
Alabastine (Michigan Gypsum-Co.	Grand Rapids		Grand Rapids.
American Cement Plaster Co	Lawrence, Kas	Grand Rapids.	Grand Rapids.
	427 Mich Trust	Eagle Mill	Grand Rapids.
Grand Rapids Plaster Co.	Bldg., Gd. Rapids	Grandville	Grandville.

LIMESTONE AND LIME PRODUCERS, 1920

Operator.	Office.	Quarry.
Alger County:		
County Road Commrs	Munising	Eben.
Alpena County:		
Michigan Alkali Co	Wyandotte	Wyandotte.
Great Lakes Stone and Lime Co	Alpena	Rockport.
Charlevoix County:		
Northern Lime Co (lime)	Petoskey	Bay Shore.
Cheboygan County:		
Campbell Stone Co (also lime)	Indian River	Afton.
Cheboygan Limestone Products Co.	Mackinaw City	Mill Creek.
Ross Stone Co	Afton	Afton.
Chippewa County:		
Scott Quarry Co	Sault Ste. Marie	Trout Lake.
Delta County:		
Delta Contracting Co.	Escanaba	Escanaba (Hyde)
Bichler Bros	Gladstone	Pine Ridge
Berkman, Andrew J,	Gladstone, R. F. D. No. 1	Gladstone, R. F. D. No. 1, Escanaba Twp.
Dickinson County:		
Metronite Co., The	Milwaukee, Wis.	Felch.
Emmet County:		
Antrim Lime Co. (also lime)	912 Mich. Trust Bldg., Grand Rapids	Petoskey.
Northern Lime Co. (also lime)	Petoskey	Petoskey.
Petoskey Crushed Stone Co.	Petoskey	Petoskey.
Huron County:		
Wallace Stone Co.	Bayport	3 mi E. of Bayport.
Mackinac County:		
Ozark Stone Quarry	Ozark	Ozark.
Union Carbide Co	42nd St. Bldg., New York, N. Y.	Hendricks Quarry.
Filborn Limestone Co.	Sault Ste. Marie, Ontario, Can	Filborn Quarry.
Menominee County:		
Menominee Co. Road Commrs.	Menominee	
Spencer, Henry	Menominee	Menominee
Monroe County:		
The France Stone Co	1800 Second National Bank Building, Toledo, Ohio	Monroe.
Morris, Sam W	Monroe	Monroe, S. part of City.
Augerer & Gutman	Hammond Bldg., Detroit	Schofield.
Presque Isle County:		
Michigan Limestone and Chemical Co	55 Liberty St., New York, or Rogers City, Mich.	Calcite.
Schoolcraft County:		
The White Marble Lime Co (Also Lime)	Manistique	Blaney, Manistique and Marblehead.
Delta Contracting Co.	Escanaba	Manistique.
Wayne County:		
Solvay Process Co.	Syracuse, N. Y.	Trenton and Sibley
Dunbar Stone Co.	Detroit or River Rouge	Mouth of Detroit River.

MINERAL AND SPRING WATER PRODUCERS, 1920

Operator.	Office.	Spring.
Eastman Springs Beverage Co	Benton Harbor	Eastmans.
Artic Spring Water Co	412 Ottawa Ave., Grand Rapids	Arctic.
Ogemaw Spring Water Co	Bay City	Ogemaw.
Ponce de Leon Co	Grand Rapids	Ponce de Leon.
Shorkey, Chas	Mt. Clemens	Victory.
Magnetic Spring Water Co	Saginaw, W. S	Andrew's Magnetic Mineral.
Charbeneau, Jno. H	Mt. Clemens	Maple Leaf Springs.
Preussel, Frank W	47 Crocker Ave., Mt Clemens	Panacea.
Silver Springs Water Co	Detroit	Northville.
Deep Springs Co	Northville	Deep Springs.

PIG IRON PRODUCERS, 1920

Operator.	Office.	Name of furnace.	Location of furnace.
Mitchell-Diggins Iron Co	Cadillac	Cadillac	Cadillac.
Detroit Furnace Co	1069 Jefferson Ave., Detroit	Detroit	Detroit.
Detroit Iron & Steel Co	149 Jefferson Ave., Detroit	A & B	Detroit.
East Jordan Furnace Co	East Jordan		East Jordon.
Cleveland Cliffs Iron Co	Cleveland, Ohio	Pioneer No 1	Gladstone.
Cleveland Cliffs Iron Co	Cleveland, Ohio	Pioneer No 2	Near Marquette
Antrim Iron Co	Antrim	Antrim	Antrim.
Stephenson Charcoal Iron Co		Stephenson	Wells.
Charcoal Iron Co of America	Detroit	Boyne City	Boyne City.
Charcoal Iron Co. of America	Detroit	Manistique	Manistique.
Charcoal Iron Co. of America	Detroit	Newberry	Newberry.
Ford Blast Furnace Co	Dearborn	Ford Blast	Dearborn.

POTTERY PRODUCERS, 1920

Operator.	Office.	Works.
Ionia County:		
Ionia Pottery Co	Ionia	Ionia.
Kalamazoo County:		
Kalamazoo Sanitary Mfg. Co	Kalamazoo	Kalamazoo.
Macomb County:		
Mt. Clemens Pottery Co	Mt. Clemens	Mt. Clemens
Oakland County:		
Pontiac Clay Pipe & Novelty Co	Pontiac	Pontiac.
Wayne County:		
Jeffery-Dewitt Co	Detroit	Detroit.
Hupprich, Anton	2161 Michigan Ave., Detroit	Detroit.
Pewabic Pottery & Tile Co	2161 Jefferson St., Detroit	Detroit.
Hygeia Filter Co	338 Denton Ave., Detroit	Detroit.

QUARTZ PRODUCERS, 1920

Operator.	Office.	Mine.
Marquette County:		
Michigan Quartz Silica Co	Milwaukee, Wis	Ishpeming.

SALT PRODUCERS, 1920

Operator.	Office.	Works.
Bay County:		
Hine Lumber Co	Sta. A., Bay City	W. Bay City.
Biglow-Cooper Co	Bay City	Bay City.
Manistee County:		
The Buckley & Douglass Lumber Co	381 River St., Manistee	Manistee.
Sands Salt & Lumber Co., Louis	Manistee	Manistee.
Mason County:		
Morton Salt Co	Ludington	Ludington.
Stearns Salt & Lumber Co	Ludington	Ludington.
Midland County:		
The Dow Chemical Co (bromine)	Midland	Midland.
Saginaw County:		
Mershon, Eddy, Parker & Co	Saginaw	Carrolton.
Bliss & Van Auken Lumber Co	Saginaw, W. S.	Saginaw.
Eastman Salt Products Co	Saginaw, W. S	Saginaw.
Estate of Edward Germain	Holland Ave., near Genesee St. Saginaw, E. S	Saginaw.
National Plate Glass Co	Saginaw, W. S	Saginaw, W. S
Strable Lumber & Salt Co	Saginaw	Saginaw.
Saginaw Chemical Co	Saginaw	Saginaw.
St. Clair County:		
Michigan Salt Works	Marine City	Marine City.
Morton Salt Co	717 Ry. Ex., Chicago, Ill	Port Huron.
Diamond Crystal Salt Co	St. Clair	St. Clair.
Wayne County:		
Inland Delray Salt Co	Detroit	Delray.
Solvay Process Co	Detroit	Delray.
Detroit Rock Salt Co	Scranton, Pa	Detroit.
Mulkey Salt Co	610 Equity Bldg., Detroit	Oakwood.
Worcester Salt Co	168 Duane St., New York, N. Y	Ecorse.
Michigan Alkali Co	Wyandotte	Wyandotte.
Pennsylvania Salt Mfg. Co	115 Chestnut St., Philadelphia Pa	Wyandotte.

SANDSTONE PRODUCERS, 1920

Operator.	Office.	Quarry.
Huron County:		
Cleveland Stone Co	Cleveland, Ohio	Grindstone.
Marquette County:		
Marquette Trap Rock Co	Marquette	Marquette.

SAND AND GRAVEL PRODUCERS REPORTING IN 1920

Operator.	Office.	Pit.
Alcona County:		
Federal Sand & Gravel Co.	302½ Federal Ave. Saginaw	Greenbush
Allegan County:		
F. Buhler	Zeeland, R. F. D. No. 3.	Burnips Corners.
F. W. Sutter	Byron Center	Burnips Corners.
Alpena County:		
Federal Sand & Gravel Co.	302½ Federal Ave. Saginaw	Lachine.
Alpena Towing Co	Alpena	Alpena.
Levi Smith	Alpena, R. F. D. No. 2	Alpena.
Antrim County:		
H. B. Sage	Central Lake	Central Lake
James B. Gaylord	Mancelona	Mancelona.
Barry County:		
Chas. Woolston	Hastings, R. F. D. No. 2.	Hastings.
Penock, Arthur	Nashville.	Nashville.
E. Leibhauser	Nashville	Nashville.
C. G. Hinckley	Hastings	Hastings.
Dunham, P. O.	Nashville, R. F. D. No. 4	Maple Grove.
Bay County:		
Whitney, Geo. A	Bentley	Bentley
Amidon, E.	Bendon	Bendon.
Schabel, A. J. Jr	Munger	Munger.
Dean. John	Bendon	Bendon.
Benzie County:		
Huddleston, Wm	Bendon, R. F. D. No. 1	Bendon.
Berrien County:		
Ireland & Lester	Benton Harbor	Benton Harbor.
Harmount, W.	Berrien Springs	Oronoka.
Breger, Frank	Galien, R. F. D. No. 1.	Galien.
Andrew. C.	Galien	Galien.
Broderick Bros.	Riverside	Riverside.
Thar, Anton	Coloma,	Riverside.
Kerlikowske Bros.	St. Joseph	Riverside.
Case, E. F. & Son	Watervaliet	Watervaliet.
Branch County:		
Werner, J. F.	Bronson	Matteson Lake.
Barnes, Mrs. Olive A	Montgomery	Kinderhook.
Haley, Daniel	Ray, Ind. R. F. D. No. 2	Ray.
Calhoun County:		
Marsh, A. H.	Union City	Union City.
Van Sickles, Elmer I.	Albion	Albion.
Young, Williard A	Albion	Albion.
Brownlee Park Gravel & Material Co	Battle Creek	Battle Creek.
Greble, Geo. W	Marshall St., Battle Creek	Battle Creek.
Michigan Ry. Co.	Jackson	Near Albion.
Cass County:		
Crandall. Fred	Cassopolis	Cassopolis.
Charlevoix County:		
Ward, E. B.	Charlevoix	Charlevoix.
Chippewa County:		
Taylor, F. H.	Pickford	Pickford.
Rye Bros.	409 Maple St., Sault Ste. Marie	Sault Ste. Marie.
Clinton County:		
Wilhelm. Noah	Bath, R. D. 25	Bath.
Ingham County:		
Gohr Bros. Contracting Co	Lansing	Lansing.
Burwell Sand & Gravel Co.	Lansing	Lansing.
Stockman, F. M.	Lansing, R. F. D.	Lansing.
Couch, Chas.	Mason	Mason.
Potts, Walter	Mason	Eden.
Woodman. Hoyt	Lansing	Lansing.
Sheltraw. A. E.	Saginaw, W. S	Mason.

SAND AND GRAVEL PRODUCERS REPORTING IN 1920—*Continued*

Operator.	Office.	Pit.
Ionia County:		
Hazelitt, J. I.	Star Rout, Ionia	Palo.
Miller, Henry	East Main St. Ionia	Ionia.
Trowbridge, Forest, P.	Ionia, R. F. D. No. 1	Ionia.
Glick, Cephas	Lowell, R. F. D. No. 3.	Saranac.
Jackson County:		
Cooper, Alfred B	Horton	Horton.
Blake. Wm	Jackson, R. F. D. No. 6.	Jackson.
Kalamazoo County:		
Balch, U. K	Kalamazoo	Kalamazoo.
Buurma. Sam. H	Kalamazoo	Kalamazoo.
Kalamazoo Greenville Gravel Co.	Kalamazoo	Kalamazoo
Haas, Casper H	Kalamazoo	Kalamazoo.
Nelson Concrete Culver Co.	Portage St., Kalamazoo	Kalamazoo.
Quick, Isaac	Kalamazoo	Kalamazoo.
Kent County:		
Michigan Ry. Co	Jackson	Granville.
Slater, Richard J	Ada, R. F. D. No. 1	Cascade.
Grand Rapids Gravel Co	Grand Rapids	Grandville Road.
Harrison Land Co. Lim	Grabd Rapids	Grand Rapids.
Walker Ave. Gravel Pit	Grand Rapids	Grand Rapids.
Valley City Stone & Gravel Co	Grand Rapids	Grand Rapids.
Greers, Fred	Kent City	Kent City
Deiss, Jos	Sparta, R. F. D. No. 1.	Englishville
Oerholt, Rufus	Byron Center	Dutton.
Lapeer County:		
Broecker, August W.	Goodrich, R. F. D. No. 2.	Hadley.
Miteen, Fred	Goodrich, R. F. D. No. 1.	Sec. 18, Hadley
Smith, John F.	Goodrich	Hadley.
Lenawee County:		
Lockwood, Mrs. S. P.	Hudson, R. F. D. No. 5.	Hudson.
Evans, Geo. M.	Morenci	Morenci.
Gillispie Estate	Tecumseh	Tecumseh.
Tecumseh Gravel Co.	Tecumseh	Tecumseh.
Livingston County:		
Detroit Greenville Gravel Co.	Greenville, Ohio	Brighton.
Ohio & Michigan Sand & Gravel Co	1025 Nicholas Bldg. Toledo Ohio	Chilson.
Farnham, Henry	Benton, R. F. D. No. 3.	Linden.
Macomb County:		
Detroit Gravel & Ballast Co.	808 Detroit Savings Bank Bldg	Armada.
Lakeside Ice & Coal Co.	Mt. Clemens	Mt. Clemens.
Wacker, H. Jacob	Mt. Clemens	Mt. Clemens.
Detroit Sand & Gravel Co.	34 McGraw Bldg., Detroit	Utica.
Manistee County:		
Hubbell Sand Co.	Manistee	Manistee.
Farr & Co. M. A	140 S. Dearborn St. Chicago	Onekama
Szymanski, Geo	Freesoil	Freesoil.
Marquette County:		
Champion Sand & Gravel Co.	Marquette	Champion.
Mason County:		
Hubbell Sand Co.	Nabustee	Ludington.
Mason Co. Sand & Gravel Pit.	Scottsville, R. F. D. No. 4	Amber.
Tobey, Wm. A.	Freesoil	Freesoil.
Dodge, C. C. & Son	Walhalla	Walhalla.
Dunbar, H. E.	Tallman	Tallman.
Menominee County:		
Board of County Road Commissioners	Menominee	Various places.
Montcalm County:		
Belknap Cement Products Co.	Greenville	Greenville.
Christiansen, Niels	Greenville	Greenville.
Stark, Frank H.	Pierson	Pierson.
Williams, E. O	Edmore	Edmore.

SAND AND GRAVEL PRODUCERS REPORTING IN 1920—*Continued*

Operator.	Office.	Pit.
Muskegon County:		
Muskegon County Road Commissioner	Court House, Muskegon	Slocum.
Valley, Edw. F.	Twin Lakes, R. F. D. No. 1	Twin Lakes.
Michigan Material Co	704 Union Bank Bldg.	Grand Haven.
Oakland County:		
Dodge Bros	Detroit	Rochester.
Porath, Julius	34 McGraw Bldg., Detroit	Oxford.
United Fuel & Supply Co	Freepress Bldg., Detroit	Oxford.
Park & Son, A. H	Birmingham, R. F. D. 2	Birmingham.
Calvert, J. & Sons	5 McGraw Bldg., Detroit	Clarkston.
Whiticam, R.	Atkins	Atkins.
Thompson, W. R. Co	100 Beaubien St., Detroit	Goodison.
Standard Gravel Co	Pontiac	New Hudson.
Campbell, Mrs. M	Holly, R. F. D. No. 2	Holly.
Detroit-Oxford Gravel & Stone Co	Oxford	Oxford.
Ward Sand & Gravel Co	Penobscot Bldg, Detroit	Oxford.
Boise Bros	Pontiac, R. F. D. No. 7	Pontiac.
Rockwell, C. L.	Pontiac	Pontiac.
Stroupe, R. T.	Pontiac, R. F. D. No. 7	Pontiac.
Rochester Sand & Brick Co	1001 Smith Bldg., Detroit	Rochester.
Oceana County:		
Aldrich, A. O	Hart	Crystal Valley.
Newfield Twp	Hesperia	Hesperia.
Wherle, Frank	Rothbury	Rothbury.
Osceola County:		
Federal Sand & Gravel Co	302½ Federal Ave., Saginaw	Evart.
Crescent Gravel Co	Reed City	Hersey.
Hersey Gravel Co	Hersey	Hersey.
Ottawa County:		
Holdtrop, Jno	Ferrysburg	Ferrysburg.
Bunce, C. W.	Ravenna	Ravenna.
Van Weelden & Co., I	609 Fulton St., Grand Haven	Grand Haven.
Saginaw County:		
Moiles & Donely	336 Howard St., Saginaw	Saginaw River.
St. Clair County:		
Superior Sand & Gravel Co	726 Dime Bank Bldg., Detroit	St. Clair River.
Westrick & Son, C. A.	119 Water St., Marine City	Marine City.
Reynolds & Bailey	Port Huron	Port Huron.
Baker, Wm. H	Memphis	Memphis.
Chapman, Jas	Memphis	Riley.
Recor, L.	Marine City	St. Clair.
Kinney, Chester & Frank	Port Huron, R. F. D. No. 1	Wadhams.
Thompson Tug Co	Port Huron	Port Huron.
Thompson Co., W. R	Detroit	Marysville.
Sanilac County:		
Handy Bros. Mining Co	Bay City	Decker.
Mills, Henry	Palms, R. F. D. No. 1	Near Palms.
Carney, Chas	Sandusky, R. F.D. No. 2	Watertown.
Dawson & Son, Wm	Sandusky	Marlette Twp.
Shiawassee County		
Martenis, Burt	Bancroft	Bancroft.
Clark, Geo	Byron, R. F. D. No. 2	Byron.
Graham, John	Byron, R. F. D. No. 1	Byron.
Hathaway, Allen	Byron	Byron.
Darling, E. R.	Carland	Carland.
Frishke, John C	Owosso	Owosso.
Tuscola County		
Cass City Sand & Gravel Co	Cass City	Cass City.
Tuscola Sand & Gravel Co	Cass City	Cass City.

SAND AND GRAVEL PRODUCERS REPORTING IN 1920—*Continued*

Operator.	Office.	Pit.
Van Buren County		
Hopping, A. D	Bangor	Bangor.
Sherburn, John	Decatur, R. F. D. No. 2,	Decatur.
Doyle, Stephen A	Hartford	Hartford.
Dade, Leonard	Hartford	Hartford.
Wright, J. E	Bangor	Bangor.
Washtenaw County		
Washtenaw County Road Commissioner	Ann Arbor	Various places.
Eddie, Geo	Ann Arbor, R. F. D. No. 8	Ann Arbor.
Fiegel, Fred	Ann Arbor, R. F. D. No. 3	Ann Arbor.
Shiller, Wm	Ann Arbor	Ann Arbor.
Michigan Central R. R. Co	Ann Arbor	Ann Arbor.
Graves, Mrs. Margaret	Ann Arbor	Saline.
Cadillac Sand & Gravel Co	1452 Penobscot Bldg., Detroit	Ann Arbor.
Wayne County:		
F. D. Gleason Coal Co	Detroit	
Michigan Pressed Brick Co	Detroit	Goodison.
Ontario Gravel Co	228 Sandwich St., Windsor, Ont	St. Clair Flats.
Rockwood Silica Co	Rockwood	Rockwood.
Cameron Steamship Co	39 Buhl Block, Detroit	1½ miles east of Rockwood.
Thompson, W. R	Detroit, 606 Kresge Bldg.	Detroit.

TRAP ROCK PRODUCERS, 1920

Operator.	Office.	Quarry.
Houghton County:		
Winona Copper Co	Winona	Winona.
Marquette County:		
City of Negaunee	Negaunee	Neguaunee.
Marquette Trap Rock Co	Marquette	Marquette.
Ontonagon County:		
Blumgren, J. E	Norway	Bergeland.
Iron County:		
Iron Co. Road Commr	Crystall Falls	N. W. of N. E. Sec. 7 43-32.

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