STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION

Publication 34. Geological Series 28.
MINERAL RESOURCES OF MICHIGAN
WITH
STATISTICAL TABLES OF PRODUCTION AND VALUE OF MINERAL PRODUCTS FOR
1922 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 GEOLOGICAL SURVEY DIVISION FOR 1922

Contents

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. Herman Lunden.
Hon. Chas. E. Lawrence.
Hon T. F. Marston.
Hon. Geo. W. Millen.
Hon. Fred Z. Pantlind.
Hon. Howard B. Bloomer.

Gentlemen. Under authority of Act No. 7 Public Acts of Michigan, Session of 1911, I have the honor to present herewith Publication 34 Geological Series 28, the eleventh 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 Geological Survey Division for 1922.

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

PART I. METALLIC MINERALS

THE COPPER INDUSTRY

MICHIGAN COPPER PRODUCTION IN 1922
GENERAL

The total copper production for the year 1922 amounted to 121,386,726 pounds, an increase of 29,124,643 pounds over the preceding year. This production is fully 100,000,000 pounds short of the average pre-war years. Continuous operation was maintained during the year at the Copper Range group, Quincy, Mohawk and Wolverine. On April 1st production was resumed at Ahmeek, Isle Royale and the conglomerate and reclamation branches of the Calumet and Hecla Mining Company. The remaining subsidiaries of the Calumet and Hecla continued idle. Exploration and development was conducted at the Seneca, Gratiot, Mayflower and Arcadian, and at the Seneca Mine 272,182 pounds of

copper were produced from rock hoisted incidental to development work. The Michigan copper mines operated under a labor shortage which was general throughout the district and was due to the attraction offered by higher pay in the automobile industry in the lower part of the State. In the past years there has been always a considerable drift from the mines to the industrial centers but the underground force has in general been satisfactorily maintained by new immigration which was restricted under the present law. The lack of men to operate the mines was a serious handicap and materially increased costs.

Table I shows the production by mines for the years 1911 to 1922 inclusive. Table II shows the United States smelter production by States for the years 1919 to 1922. The smelter production always differs slightly from the mine output, therefore the total production for Michigan for 1922 is not exactly the same as the figure in Table I which represents the compilation from mine production, nevertheless it is close enough to give a true picture of the Michigan proportion of the total production of the country.

MICHIGAN COPPER PRODUCTION BY COMPANIES

TABLE I

PRODUCTION OF PRINCIPAL MICHIGAN COPPER COMPANIES.

	1911	1912	1913*	1914*	1915	1916	1917	1918	1919	1920	1921	1922	1923
Ahmeek	15,196,127	16,455,769	9,220,874	13,684,605	21,800,492	24,142,158	27,919,812	24,851,235	17,223,111	20,489,438	6,255,200	14,885,081	......
Allouez	4,780,494	5,525,455	4,091,129	6,056,548	10,043,459	10,219,290	8,892,915	7,071,218	3,749,984	2,499,239	Idle	Idle	Idle
Calumet and Hecla—													
Conglomerate	58,469,394	51,935,245	32,731,768	37,996,045	51,738,588	51,785,016	50,415,860	43,329,816	32,895,816	34,324,660	9,865,400	29,130,500	......
Amygdaloid	15,661,578	15,692,199	12,051,238	15,695,517	19,291,930	19,564,575	18,003,966	15,393,153	10,880,378	9,164,983	Idle	Idle	......
Reclamation	......	......	......	......	1,582,802	5,412,649	9,075,457	9,245,388	9,089,952	14,138,240	5,301,736	11,362,500	......
Centennial	1,493,834	1,742,338	1,612,262	2,287,130	2,347,500	2,367,400	2,062,857	2,492,857	1,365,148	561,284	Idle	Idle	......
Copper Range—													
Baltic	15,370,449	13,373,961	7,736,126	7,001,945	12,028,947	12,425,804	11,214,861	10,406,097	7,864,653	6,613,918	7,608,847	5,239,586	......
Champion	15,639,426	17,225,508	12,080,594	15,807,206	33,417,599	33,601,136	27,550,343	21,748,514	19,886,917	13,610,324	20,719,307	19,583,806	......
Trimountain	6,120,147	6,980,713	4,990,938	5,048,306	8,302,896	8,720,558	6,278,097	5,343,586	5,274,387	3,532,025	4,341,584	4,116,100	......
Franklyn	820,203	1,710,651	1,021,440	93,283	1,314,969	3,116,566	3,155,574	2,827,313	1,062,879	Idle	Idle	Idle	Idle
Hancock	754,729	......	......	488,678	871,124	2,824,934	4,047,053	3,041,514	Idle	Idle	Idle	Idle	Idle
Isle Royale	7,490,120	8,186,957	4,158,548	6,601,235	9,342,106	12,412,111	13,480,921	15,442,508	13,007,647	10,621,801	2,491,000	6,639,970	......
Lake	......	......	287,200	......	1,581,071	1,489,247	1,461,893	717,403	Idle	Idle	Idle	Idle	Idle
LaSalle	......	Idle	43,906	540,731	782,493	1,380,352	1,919,775	1,832,665	340,719	59,713	......	Idle	......
Mass	1,326,998	2,045,006	1,213,545	2,944,952	4,638,452	4,752,588	3,984,616	3,403,827	1,963,178	Idle	Idle	Idle	Idle
Michigan	327,773	162,950	......	......	......	......	......	1,177,176	1,697,107	1,075,492	......	Idle	......
Mohawk	12,091,056	11,995,598	5,778,235	11,094,859	15,882,914	13,834,034	12,313,887	10,781,041	12,857,392	10,269,824	14,054,235	11,209,396	......
Osceola	18,388,193	18,413,387	11,325,010	14,970,737	19,731,472	19,586,501	16,084,958	15,919,647	10,824,231	7,465,773	Idle	Idle	......
Quincy	22,252,943	20,634,800	12,184,128	15,356,380	22,054,813	21,065,612	22,195,577	19,948,965	19,476,320	19,219,070	16,960,265	15,402,726	......
Superior	3,236,233	3,921,974	2,992,765	3,217,635	3,866,484	3,034,656	2,201,672	1,676,446	563,935	322,871	Idle	Idle	......
Tamarack	7,494,077	7,908,745	4,168,743	1,074,808	3,888,150	Absorbed	in 1916 by	Calumet	and Hecla.				......
Victoria	1,303,331	1,224,911	1,428,693	1,486,242	1,499,635	1,661,832	1,612,640	1,533,536	1,245,590	1,060,829	273,916	Idle	......
White Pine	......	......	......	......	†2,824,145	4,207,449	4,067,529	3,273,680	1,979,268	1,850,787	Idle	Idle	......
Winona	1,275,675	2,307,327	1,448,737	1,352,085	1,722,638	2,167,255	1,494,472	1,576,683	561,238	Idle	Idle	Idle	......
Wolverine‡	9,630,639	9,120,485	8,350,312	3,435,459	7,250,866	6,641,492	5,856,889	4,608,865	4,562,617	3,932,225	3,924,270	3,544,879	......
Development Projects	648,053	228,985	233,915	......	297,612	426,260	745,381	530,730	......	531,384	466,323	272,182	......
Total	219,771,477	216,792,974	139,650,044	166,184,386	258,103,217	266,839,475	256,037,005	228,173,863	178,365,567	161,343,880	92,262,083	121,336,726	......

*Strike year. †Initial production. ‡Production of fiscal year ending July 1st.

UNITED STATES COPPER PRODUCTION BY STATES

TABLE II

PRODUCTION

Copper Produced in the United States from domestic ores, 1919-1922.
(Smelter output, in pounds fine)

	1919	1920	1921	1922
Alaska	56,534,992	66,093,924	76,808,114	59,900,579
Arizona	536,515,368	552,988,731	155,165,656	428,200,634
California	23,548,698	11,822,028	15,906,883	20,440,430
Colorado	4,892,558	4,282,616	6,592,598	3,635,916
Georgia	8,306	3,663	....	8,147
Idaho	3,966,655	1,922,116	1,971,623	3,504,944
Maine	376,186	....	3	....
Michigan	177,594,135	153,483,952	100,918,001	116,283,920
Missouri	588,570	533,368	137,591	1,070,259
Montana	176,289,873	177,743,747	49,471,206	165,341,414
Nevada	64,683,734	55,580,322	15,129,116	20,398,611
New Mexico	60,377,320	52,159,751	18,076,909	29,127,329
North Carolina	3,334	....	....	....
Oregon	2,808,017	2,529,311	274,934	925,954
Pennsylvania	....	618,361	....	888,721
South Carolina	2,297	....	....	....
South Dakota	8,631	2,190	....	....
Tennessee	15,629,454	16,727,803	15,084,294	14,226,232
Texas	2,153	14,217	587	3,889
Utah	143,836,304	110,357,748	45,831,959	79,665,563
Vermont	582,561	....	....	....
Virginia	....	....	....	....
Washington	2,552,134	2,125,586	598,658	309,133
Wyoming	150,051	24,256	9,830	....
Undistributed	15,467,998	47,350	3,608,136	33,066
	1,286,419,329	1,209,061,040	505,586,098	944,024,741

Note—Compiled by United States Geological Survey.

DETAILS OF ACTUAL OPERATIONS

The details of operations of the Michigan copper mines are compiled from the annual reports of the companies to their stockholders.

Ahmeek

Active mining at this property came from ground tributary to Shaft No. 2 and No. 4. At No. 3 Shaft a small amount of development work was carried on during the year but at No. 1 Shaft efforts were confined to pumping, Production from the Mass fissure vein yielded nearly 1,400,000 pounds or a little less than one-tenth of the total copper mined from the Ahmeek. A cross-cut from the end of the 17th level drift on the Mass fissure north of No. 2 Shaft was extended west to intersect the Kearsarge Conglomerate which was 60 feet wide at this point but poor in copper content. The cross-cut will be extended further west to explore the horizon of the Osceola lode.

The details of the year's operations are as follows:

Copper product for the year (April 1-December 31) .... 14,885,081 lbs.

PRODUCTION COSTS

Mining		5.93 c. per lb.	$882,754.50
Smelting and refining		1.66 " " "	247,523.86
Boston office and mine and corporation taxes		.85 " " "	126,348.73
Depreciation and Depletion		4.47 " " "	665,669.97
Production cost of	14,885,081 lbs. at	12.91 " " "	$1,922,297.06
On hand January 1, 1922	9,892,100 " "	14.00 " " "	1,384,894.00
	24,777,181 "	.....	$3,307,191.06
Sold in year	21,870,413 "	.....	2,931,803.68
On hand December 31, 1922	2,906,768 " "	12.91 " " "	$375,387.38

EARNINGS STATEMENT

Received for copper sold	21,870,413 lbs. at	13.66 c. per lb.	$2,986,548.98
Cost of copper sold			
Production cost at 13.41 c. per lb.	$2,931,803.68		
Selling and delivery cost at .50 c. per lb.	108,670.39	at 13.91 " " "	3,040,474.07
Loss on copper sold		.25 " " "	$53,925.09
Maintenance costs (Jan. 1-March 31)			
Mine		$91,268.61	
Boston office and mine and corporation taxes		41,463.94	
Depreciation		7,008.44	139,740.99
			$193,666.08
Miscellaneous Receipts			
Interest, etc.		$75,038.63	
Miscellaneous Expenses		32,924.28	42,114.35
Loss for year			$151,551.73

CHANGES IN NET CURRENT ASSETS

Balance of current assets January 1, 1922		$3,079,475.04
Loss for year	$151,551.73	
Less depreciation and depletion reserves	672,678.41	
	$521,126.68	
Capital Assets increased		
Plant—New construction	12,326.88	
	$508,799.80	
Dividends paid	400,000.00	
Net increase in current assets		108,799.80
Balance of current assets December 31, 1922		$3,188,274.84

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

	1919	1920	1921	1922
Tons of rock treated	756,870	822,192	212,170	439,769
Cost of mining, transportation, stamping and taxes per ton of rock	$2.59	$2.62	$2.40	$2.22
Pounds of refined copper produced	17,223,111	20,489,438	6,255,200	14,885,081
Pounds of refined copper per ton of rock treated	22.8	24.9	29.48	33.85

Total Depth of Shafts
No. 1 shaft 43 feet below the 22d level, 2,799 feet from surface.
No. 2 shaft 226 feet below the 27th level, 3,039 feet from surface.
No. 3 shaft 304 feet below the 24th level, 3,281 feet from surface.
No. 4 shaft 267.5 feet below the 22d level, 3,092 feet from surface.

SUMMARY OF RESULTS

	1919	1920	1921	1922
Rock hoisted	772,357 tons	847,921 tons	217,003 tons	454,168 tons
Rock house discard	15,487 tons	25,729 tons	4,833 tons	14,399 tons
Percentage of discard	2.005	3.034	2.227	3.170

Calumet and Hecla

The conglomerate branch resumed operations on April 1st and the reclamation plant on April 10th. The Osceola Amygdaloid mine remained idle. A total of 1,360 tons of copper rock was recovered from the 81st level exploration on the Kearsarge lode which when milled yielded 12.62 pounds of copper.

The material utilized at the reclamation plant was the most recent of the deposited tailings and much of it had already been reground so that its assay value was lower than the average of the bank.

There was a decided increase in tonnage treated due to fineness of the material and to changes made in the various plants chiefly in the leaching process. The average daily capacity was in excess of 5,000 tons.

At the Tamarack Reclamation Plant construction was resumed in the spring and at the close of the year the main building was erected but no machinery was installed. About 60 per cent of the steel erected in 1922 was remodeled from material taken from the old coal shed. This plant will be equipped with a dredge which will be a duplicate of the one in use at Lake Linden. It is expected that active operations will be commenced in 1924.

Details of the year's operations are as follows:

Copper product for the year (April 1-December 31) ..... 40,493,000 lbs.

PRODUCTION COSTS

Mining		7.42 c. per lb.	$3,005,614.78
Smelting and Refining		1.40 " " "	567,919.34
Boston office and mine and corporation taxes		.93 " " "	378,079.50
Depreciation and Depletion		6.00 " " "	2,424,206.54
Production cost of	40,493,000 lbs. at	15.75 " " "	$6,375,820.16
On hand Jan. 1, 1922	23,864,191 " "	14.00 " " "	3,340,986.74
	64,357,191 "		$9,716,806.90
Sold in year	57,549,859 "		8,644,958.88
	6,807,332 " "	15.75 " " "	$1,071,848.02
Less to reduce to market value			67,766.55
On hand Dec. 31, 1922	6,807,332 " "	14.75 " " "	$1,004,081.47

EARNINGS STATEMENT

Received for copper sold	57,549,859 lbs. at	13.68 c. per lb.	$7,874,156.38
Cost of copper sold			
Production cost at 15.02 c. per lb.	$8,644,958.88		
Selling and delivery cost at .50 c. per lb.	285,015.56	15.52 " " "	8,929,974.44
Loss on copper sold		1.84 " " "	$1,055,818.06
Less by reduction to market value as above			67,766.55
			$1,123,584.61
Maintenance Costs (Jan. 1-March 31)			
Mine		$377,248.65	
Boston office and mine and corporation taxes		125,002.94	
Depreciation		76,917.09	579,168.68
			$1,702,753.29
Miscellaneous receipts			
Dividends from other companies	$425,312.30		
Interest	228,146.96		
Custom Smelting and Refining	172,116.10		
Gain from sale C. E. A. Notes., Lowbell Co. etc	173,384.65	$998,960.01	
Miscellaneous Expenses			
Examinations, depreciation, etc		233,967.57	764,992.44
Loss for year			$937,760.85

CHANGES IN NET CURRENT ASSETS

*Balance of current assets January 1, 1922			$12,902,815.62
Loss for year		$937,760.85	
Less depreciation and depletion reserves		2,501,123.63	
		$1,563,362.78	
Capital Assets increased			
Plant—New construction	$220,377.58		
Less sale	$604.80		
Less sustained depletion	242.98	361.82	
	$220,015.76	$1,563,362.78	$12,902,815.62
*Balance of Current Assets as in Annual Report for 1921			$12,334,157.80
Increase by Federal Adjustments			568,657.82
Revised Balance of Current Assets Jan. 1, 1922, as above			$12,902,815.62
Stumpage and timber lands		$2,323.53	
Copper Canyon Mining Co.		2,300.00	
Copper Mines Information		6.54	
		$224,645.83	
Capital Assets decreased			
Stamp Mill			
Patents	$4,922.22		
Mutual			
W. L. & P. Co. Stock	563.83	5,486.05	
		$219,159.78	
Dividends paid		1,000,000.00	1,219,159.78
Net increase in current assets			344,203.00
Balance of current assets December 31, 1922			$13,247,018.62

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

	1919	1920	1921	1922
Tons of rock treated	1,830,760	1,560,240	261,320	618,800
Mine cost per ton of rock (excluding construction)	$3.85	$4.22	$4.83	$4.07
Pounds of refined copper produced from mine	43,776,194	43,489,643	9,865,400	29,130,500
Pounds of copper per ton of rock	23.91	27.87	37.75	47.08

CONGLOMERATE LODE

The comparative results of operations for the past four years are as follows:

	1919	1920	1921	1922
Tons of rock treated	1,111,080	978,000	261,320	618,800
Mine cost per ton of rock (excluding construction)	$4.87	$5.16	$4.83	$4.07
Pounds of copper produced	32,895,816	34,324,660	9,865,400	29,130,500
Pounds of copper per ton of rock	29.61	35.10	37.75	47.08
Shaft sinking	1,437 feet	1,506 feet	427 feet	371 feet
Drifting	3,375 "	153 "	508 "	1,152 "
Crosscuts and footwall drifts	4,154 "	2,361 "	726 "	354 "

The operating shafts on this lode have attained the following depths.

Calumet Nos. 5 and 6	5,555.0 feet	to 57th level.
Calumet No. 4	9,070.0 "	to 92d level.
Calumet No. 2	3,219.0 "	to 33d level.
Slope Shaft	1,583.0 "	below 57th level or 185 feet under 66th level.
Hecla No. 6	7,890.6 "	48.7 feet under 80th level.
Hecla No. 7	8,175.7 "	238 feet under 81st level.
South Hecla No. 8	1,988.0 "	to 20th level.
South Hecla Nos. 9 and 10	8,134.7 "	42.5 feet under 83d level.
Red Jacket Shaft	4,900.0 "	100 feet under 81st level.
Tamarack No. 3	5,223.0 "	29.5 feet under 18th level.
Tamarack No. 3 (inclined)	737.0 "	below 18th level, 129 feet under 24th level.
Tamarack No. 5	5,308.5 "	147 feet under 40th level.

REGRINDING PLANTS

	From Mine	From Old Sands
Tons treated	340,340	489,150
Assay headings	.755 %	.647 %
Assay tailings	.503 %	.434 %
Pounds refined copper	1,756,000	2,089,000
Pounds refined copper per ton treated	5.16	4.17
Cost per pound, excluding smelting and selling	5.22 c.	8.62 c.

LEACHING PLANT

Tons treated	1,353,654
Assay headings	.488 %
Assay tailings	.108 %
Pounds refined copper	10,455,000
Pounds refined copper per ton treated	7.72
Cost per pound copper, excluding smelting and selling	3.86c.

FLOTATION PLANTS

Tons treated	498,540
Assay headings	.520 %
Assay tailings	.179 %
Pounds refined copper	3,446,000
Pounds refined copper per ton treated	6.95
Cost per pound copper, excluding smelting and selling	2.67 c.

RECLAMATION TOTALS

Tons treated	1,378,250	6,212,418
Assay headings	.532 %	.741 %
Assay tailings	.126 %	.236 %
Pounds refined copper	11,362,500	65,201,724
Pounds refined copper per ton treated	8.24	10.50
Cost per pound copper, excluding smelting and selling	6.28 c.	6.40 c.

Copper Range Company

This company owns the Baltic Mine and one-half the total stock of the Champion Copper Company and practically the entire issue of the Trimountain Mining Company, Atlantic Mining Company and the Copper Range Railroad. The active mines of the group are the Champion, Baltic, and Trimountain. The Atlantic has been idle for years. At the Trimountain Mine production except that incidental to development was suspended in December and coincident with this curtailment the Baltic

stamp mill was closed and all rock treated at the Champion mill.

The financial statement of the Copper Range Comapny for the year 1922 is as follows:

29,029,474 lbs. of copper produced and sold at average of 14.225 cents per pound		$4,129,538.82
Interest		136,298.34
Atlantic Mining Company income from rents, interest, etc		4,585.15
		$4,270,422.31
Mining Expense, smelting, freight, sales department and all other expenses		3,264,322.96
		$1,006,099.35
Taxes paid by mining companies		306,252.55
		699,846.80
Operating Income of Copper Range Railroad Company	$191,094.54	
Less interest on bonds	114,000.00	77,094.54
		$776,941.34
Deduct one-half of net mining profit of Champion Copper Company which belongs to the St. Mary's Mineral Land Company		445,257.58
Operating Income		$331,683.76

CURRENT ASSETS AND TOTAL LIABILITIES DECEMBER 31, 1922

(Including Subsidiary Mining Companies)

Assets

Cash		$2,002,172.51
United States Liberty Loan Bonds		1,703,000.00
Copper delivered and not paid for		316,135.00
Copper on hand		896,538.14
Copper Range Railroad Company bonds		870,000.00
Michigan Smelting Company stock		340,000.00
Balance due from United States Government account Railroad guaranty under the Transportation Act 1920		92,966.29
Supplies at Mines	$523,112.26	
Cash at Mines	88,194.25	611,306.51
Accounts receivable		519,808.79
Insurance Prepaid		1,612.49
U. S. and Short Term Securities		341,119.47
		$7,694,659.20

Liabilities

Current indebtedness at mines	$123,747.34	
Accounts payable	448,329.29	572,076.63
		$7,122,582.57
Less one-half Champion		1,360,619.03
Net excess of assets		$5,761,963.54

The Copper Range Company now holds in its treasury the following:
97,256 shares Atlantic Mining Company stock.
99,600 shares Trimountain Mining Company stock.
50,000 shares Champion Copper Company stock.
42,443 shares Copper Range Railroad Company, entire stock issued.

COMPARATIVE STATEMENT

(Baltic, Trimountain and one-half Champion combined)

	1922	Average for ten years 1913 to 1922 inclusive
Tons of rock stamped	553,513	826,637
Pounds of refined copper produced	19,237,571	25,926,178
Pounds of refined copper per ton stamped	34.75	31.36
Cost of copper per pound	$0.1322	$0.1200
Price received per pound	.1343	.1958
Profit per pound	.00212	.0758
Mining expense, smelting, freight, marketing copper, etc	$2,543,504.91	$3,111,350.00
Net earnings Copper Range Company	331,683.76	1,999,521.04

COST AND PROFITS

(Exclusive of Depreciation and Depletion)

	Production Pounds	Cost Per Pound	Price Received
Baltic	5,329,568	16.76c	13.958c
Trimountain	4,116,100	16.46c	13.958c
Champion (½)	9,791,903	09.93c	14.359c
Copper Range Company	19,237,571	13.22c	14.17c
1921	22,310,084	12.74c	13.19c
1920	16,951,105	17.77c	17.14c
1919	23,082,498	15.02c	18.67c
1918	26,623,940	14.46c	24.757c
1917	31,268,130	12.579c	28.735c

Depletion and depreciation charged against 1922 production amounted to $752,173.07 or 3.91c per pound of copper produced. Depletion and depreciation charges in former years have been as follows:

1921	3.73c per pound
1920	4.16c " "
1919	3.58c " "
1918	3.4c " "
1917	3.2c " "

Baltic Mine

The record of the Baltic Mine for 1922 is as follows:

RECEIPTS

5,329,568 lbs. copper sold at 13.958 c.	$743,925.51

EXPENDITURES

Running expenses at the mine, and taxes	$807,530.47	
Smelting, freight, cost of marketing and general expense	85,964.13	893,503.60
Deficit		$149,578.09
Expended for construction		31,270.63
		$180,848.72

SINKING

	Sunk in 1922	Total Depth	Bottom Level
No. 2 shaft	0 feet	3062 feet	31st
No. 3 shaft	9 "	3839 "	39-50
No. 4 shaft	0 "	2982 "	31st
Total sinking	9 feet		
Total drifting, main vein		3045 feet	
Total drifting, west vein		1552 "	
Total cross-cutting		302 "	
Tons of rock hoisted		237,478	
Tons of rock stamped		165,804	
Tons of waste rock hoisted		71,674 or 30.18 %	
Yield of copper per ton of rock stamped		32.14 pounds	

Of the total stamp rock hoisted, 53 % was produced from the main lode, and 60 % of all rock stamped came from No. 2 shaft.

Champion Copper Company

The statement of operations at this property is as follows:

RECEIPTS

19,583,806 lbs. of copper produced and sold at (including silver) 14.359c. per lb.		$2,811,069.22
Interest		24,116.15
		$2,835,185.37

EXPENDITURES

Running expenses at the mine and taxes	$1,587,249.08	
Smelting, freight, cost of marketing copper and general expenses	357,421.13	1,944,670.21
Net profits		$890,515.16
Surplus December 31, 1921	$2,441,711.90	
Less 1922 Construction	10,988.99	2,430,722.91
		$3,321,238.07
Less capital distribution against depletion ore reserves		600,000.00
Surplus December 31, 1922		$2,721,238.07

CURRENT ASSETS AND TOTAL LIABILITIES

December 31, 1922

Assets

Cash in Boston		$1,460,011.92
Copper on hand		509,744.53
Copper delivered and not paid for		214,971.80
Michigan Smelting Company Stock		110,000.00
U. S. and other securities		223,737.10
Supplies at mine	$247,809.15	
Cash at mine	9,211.19	257,020.34
Accounts Receivable		51,827.56
Insurance prepaid		736.59
		$2,808,049.84

Liabilities

Indebtedness at mine	$69,533.55	
Accounts payable	17,278.22	86,811.77
Excess assets		$2,721,238.07

SINKING

	Sunk in 1922	Total Depth	Bottom Level
No. 1 shaft	139 feet	2920 feet	25th
No. 2 shaft	115 "	2777 "	24th
No. 3 shaft	127 "	2502 "	22d
No. 4 shaft	163 "	2551 "	23d
Total sinking	544 feet		
Total drifting, main vein		4,294 feet	
Total drifting, west vein		906 "	
Total cross-cutting		20 "	
Total raising		648 "	
Tons of rock hoisted		554,457	
Tons of rock stamped		503,593	
Tons of waste rock hoisted		50,864 or 9.17 %	
Yield of copper per ton of rock stamped		38.964 pounds	

Trimountain Mining Company

In common with all other Michigan properties, operations at the mine were handicapped by shortage of miners. The year started out with a force of about two-thirds normal but by summer it was less than one-half normal. This fact was adversely reflected in costs and coupled with the necessity of transfer of copper rock from No. 2 shaft to No. 4 shaft during the construction of a new steel shaft house at No. 2 led the management to discontinue stoping operations on December 1st.

The summary statement of the 1922 operations is as follows:

RECEIPTS

4,116,100 lbs. of copper produced and sold at 14.359c per lb.		$574,544.00
Interest		35,545.54
		$610,089.63

EXPENDITURES

Running expenses at the mine and taxes	$605,376.13	
Smelting, freight, cost of marketing copper and general expenses	72,290.08	677,666.21
Deficit		$67,576.58
Surplus December 31, 1921	$1,442,677.58	
Less Construction	10,741.01	$1,431,936.57
Surplus December 31, 1922		$1,364,359.99

CURRENT ASSETS AND TOTAL LIABILITIES

December 31, 1922

Assets

Cash		$7,408.97
United States Liberty Bonds (par $1,000,000)		993,000.00
Copper on hand		71,538.90
Copper delivered and not paid for		44,258.90
Michigan Smelting Company stock		110,000.00
Supplies at mine	$140,111.61	
Cash at mine	16,810.79	156,922.40
Accounts receivable		80,368.39
Insurance prepaid		267.63
		$1,463,855.19

Liabilities

Indebtedness at mine	$22,473.92	
Copper Range Company	77,021.28	99,495.20
Excess of assets		$1,364,359.99

SINKING

	Sunk in 1922	Total Depth	Bottom Level
No. 2 shaft	98 feet	3577 feet	34th
No. 3 shaft	0 "	2563 "	24th
No. 4 shaft	131 "	3553 "	34th
Total sinking	229 feet		
Total drifting		4,959 feet	
Total cross-cutting		32 "	
Total sub-drifting		68 "	
Total raising		1,016 "	
Tons of rock hoisted		197,521	
Tons of rock stamped		130,913	
Tons of rock hoisted		66,608 or 33.7 %	
Yield of copper per ton of rock stamped		31.44 pounds	

Copper products for the year (April 1-December 31) ..... 6,639,970 lbs.

PRODUCTION COSTS

Mining	7.61 c. per lb.		$505,052.71
Smelting and refining	1.43 " " "		94,920.28
Boston office and mine and corporation taxes	1.53 " " "		101,680.39
Depreciation and Depletion	3.62 " " "		240,251.04
Production cost of	6,639,970 lbs. at	14.19 " " "	$941,904.42
On hand Jan. 1, 1922	4,056,121 " "	14.00 " " "	567,856.94
	10,696,091 "		$1,509,761.36
Sold in year	9,515,111 "		1,342,234.96
On hand Dec. 31, 1922	1,180,980 " "	14.19 " " "	$167,526.40

EARNINGS STATEMENT

Received for copper sold	9,515,111 lbs. at	13.67 c. per lb.	$1,300,526.85
Cost of copper sold			
Production cost at 14.11 c.	$1,342,234.96		
Selling and delivery cost at .49 c.	47,066.24 "	14.60 " " "	1,389,301.20
Loss on copper sold		.93 " " "	$88,774.35
Maintenance cost (Jan.-March)			
Mine	$44,643.80		
Boston office and mine and corporation taxes	33,415.16		
Depreciation	5,069.93		83,128.89
			$171,903.24
Miscellaneous receipts			
Interest, etc.	$17,932.16		
Miscellaneous expenses	17,817.13		115.03
Loss for year			$171,788.21

CHANGES IN NET CURRENT ASSETS

Balance of current assets January 1, 1922			$1,336,557.82
Loss for year	$171,788.21		
Less depreciation and depletion reserves	245,320.97	$73,532.76	
Capital Assets			
Plant increased—New construction	$16,847.87		
The Lake Milling, Smelting and Refining Co.—Decreased	2,122.62		
	$14,725.25		
Dividends paid	150,000.00	164,725.25	
Net decrease in current assets			91,192.49
Balance of current assets December 31, 1922			$1,245,365.33

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

	1919	1920	1921	1922
Tons of rock treated	724,667	591,971	116,576	246,641
Cost of mining, transportation, stamping and taxes per ton of rock	$2.35	$2.73	$2.62	$2.36
Pounds of refined copper produced	13,007,647	10,621,801	2,491,000	6,639,970
Pounds of refined copper per ton of rock treated	17.95	17.94	21.37	26.92

Total Depth of Shafts:
No. 1 shaft 79 feet below the 16th level, 1,614 feet from surface.
No. 2 shaft 62 feet below the 33d level, 3,650 feet from surface.
No. 4 shaft 32 feet below the 23d level, 2,977 feet from surface.
No. 5 shaft 3 feet below the 22d level, 2,793 feet from surface.
No. 6 shaft 106 feet below the 22d level, 2,733 feet from surface.
No. 7 shaft 113 feet below the 9th level, 1,248.5 feet from surface.
"A" shaft 18 feet below the 5th level, 972 feet from surface.

SUMMARY OF RESULTS

	1919	1920	1921	1922
Rock hoisted	898,346 tons	746,737 tons	149,341 tons	323,667 tons
Rock house discard	173,679 "	154,766 "	32,765 "	77,026 "
Percentage of discard	19.3	20.7	21.9	23.8

Isle Royale Copper Company

Mining operations at this property commenced on April 1st but all efforts were confined to ground tributary to shafts Nos. 4 and 5. The company statement for the year is as follows:

Mohawk Mining Company

Production for 1922 came from Shafts 1, 4, 5 and 6. Shafts 4 and 6 operated continuously but Shaft No. 1 closed June 30th and No. 5 on November 4th. The summary of the year's operation which is unusually full and complete is as follows:

SUMMARY OF RESULTS FOR THE YEAR

Rock hoisted	536,746 tons	
Rock stamped	512,393 tons	
Product of mineral	15,614,600 pounds	
Product of refined copper	11,209,396 pounds	
Yield of rock treated per ton	21.88 pounds	
Cost per ton of rock hoisted	$1.89	
Cost per ton of rock stamped	$1.98	
Total operating cost per pound of refined copper		9.052 c.
Cost of taxes (exclusive of Income and Profit Taxes)		.680 c.
Cost of smelting, freight and marketing product, including Eastern Offices' expenses		1.941 c.
		11.673 c.
Depletion of ore bodies		3.321 c.
Depreciation of equipment, etc.		1.069 c.
Total cost per pound of refined copper		16.063 c.

PROFIT AND LOSS ACCOUNT

Sales:		
15,688,599 pounds of copper at 13.556 cents		$2,126,796.97
Cost of Sales:		
Copper on hand January 1, 1922, at cost	$928,071.88	
Operating expenses at mine as per statement hereafter	1,014,639.28	
Smelting, freight and New York and Boston expenses	217,588.50	
Taxes, exclusive of Income and Profits Taxes	76,249.59	
	$2,236,549.25	
Less: Copper on hand Dec. 31, 1922, at cost	271,686.69	
Net cost of copper sold		$1,964,862.56
Profit on sales of copper		$161,934.41
Miscellaneous Income:		
Dividends and Interest, net	$26,059.49	
Rents received, etc., net	18,486.26	
Sale of Timber	5,000.00	$49,545.75
Profit for the year, before providing for Depreciation, and Depletion		$211,480.16

CAPITAL INVESTMENTS

During the Year Ending December 31, 1922

Electric pumps		$212.31
Water lines and wiring houses		10,978.77
Miscellaneous		367.36
		$11,558.44
Items disposed of		$22,417.03

STATEMENT

Of Working Expenses at the Mohawk Mine for the Year 1922.

UNDERGROUND EXPENSE		
Mining	$116,410.15	
Timbering, trumming and all other labor	204,242.99	
Hoisting	30,340.93	
Compressor and drills	80,373.68	
Power, electric light and telephones	46,886.37	
Supplies, teaming, etc	129,731.90	$607,995.02
SURFACE AND ADMINISTRATION		
Superintendence and labor	$24,303.16	
Rock houses	25,503.80	
Insurance	4,137.49	
Industrial accident	3,604.86	
Incidentals	2,604.63	
Power, electric light and telephones	995.06	
Supplies and teaming	3,767.85	
Employees' insurance	7,478.21	$72,395.06
TRANSPORTATION		
Freight and express	$143,968.90	
Labor	2,053.26	
Supplies, teaming, etc	494.97	146,517.13
STAMP MILL		
Labor	$73,431.15	
Fuel	107,163.44	
Sand conveyor	7,887.53	
Maintaining sprinkler system	535.85	
Power and electric light	832.25	
Supplies, teaming, etc	28,016.16	
	$217,866.38	
Less: Credit for custom stamping, etc	30,134.31	$187,732.07
		$1,014,639.28

BALANCE SHEET, DECEMBER 31ST, 1922

Assets

Investments:		
Miscellaneous stocks and bonds, at cost		$96,592.27
Current Assets:		
Cash in bank and on hand	$1,109,247.63	
Accounts and bills receivable	534,725.54	
Copper on hand, at cost	271,686.69	
Supplies at mine	190,449.97	
		$2,106,109.83
Unexpired insurance		1,672.11
		$2,204,374.21
Capital Assets (Book Value):		
Real Estate	$47,177.92	
Mining property, cost	450,000.00	
Ore body enhancement as of March 1, 1913	7,524,789.85	
Buildings, machinery and plant	2,385,405.32	
Underground openings	1,328,647.03	
Roads and dams	8,024.76	11,744,044.88
		$13,948,419.09

Liabilities

Capital Stock:		
Paid in on 100,000 shares		$1,800,000.00
Current Liabilities:		
Accounts payable	$103,556.36	
Unclaimed dividends	3,077.00	106,633.36
Unrealized appreciation	$4,366,047.22	
Reserve for depreciation	1,687,234.36	
Reserve for depletion	3,978,915.11	10,032,196.69
Reserve for contingencies		400,000.00
Surplus and Realized Appreciation:		
Balance, January 1st	$1,887,571.85	
Add: Profits for the year	211,480.16	
Appreciation realized during the year	304,837.84	
Profit on property disposed of	17,765.22	
	$2,401,655.07	
Deduct: Depreciation for the year	$119,813.20	
Depletion for the year	372,252.83	
Dividends	300,000.00	
	$792,066.03	
Balance, December 31st		1,609,589.04
		$13,948,419.09

Quincy Mining Company

The production of the Quincy Mine during 1922 came from shafts Nos. 2, 6 and 8. The mine operated at an average capacity of between 50 and 60 per cent due to shortage of labor. On July 12 a series of air blasts crushed No. 6 shaft between the 46th and 66th levels which is the section of the shaft that was broken by air blasts in May, 1916. The shaft was repaired and strengthened and hoisting was resumed on October 28th. The management states that examination of the ground and openings along this section of the shaft indicates that the openings are now so crushed and packed together as to carry the weight so that there is slight chance for a repetition of the air blasts in this part of the mine. The territory where these blasts occurred is in ground opened before the practice of leaving protecting shaft pillars was inaugurated. The bottom or lower two thousand feet of all the shafts are protected by pillars and accordingly have never shown especial stress or given serious trouble.

The summary of the year's operation is given by the company as follows:

The product of the mine was 24,806,828 pounds of mineral, yielding 15,402,726 pounds of refined copper for which has been realized		$2,159,034.88
Profit on silver		73,571.34
		$2,232,606.22
Mining expense	$1,671,295.16	
Opening mine expense	171,189.65	
Taxes paid in Michigan	102,748.33	
Capital Stock Tax	8,313.00	
Smelting, transportation, etc	254,998.46	$2,208,544.60
		$24,061.62
Interest receipts	$13,239.14	
Sales of timber	2,680.00	
Sales of Real Estate, Hancock, Michigan	90.00	16,009.14
		$40,070.76
Construction	$81,883.64	
Accident account	24,000.00	105,883.64
		$65,812.88
Deficit		

STATEMENT

of income and expenditures for 1922, with depreciation and depletion included, and cost of construction and sales of real estate excluded, conforming to the requirements of the Federal Government in regard to income tax returns, in which it is not permitted to charge construction against income, but is permissible to deduct from income the depreciation of equipment and depletion of ore reserves.

January 1, 1923.

Receipts		
Sales of copper and silver		$2,232,606.22
Interest		13,239.14
Sales of timber		2,680.00
		$2,248,525.36
Expenses		
All expenses, including accident account and taxes other than Federal Income Tax	$2,232,544.60	
Depreciation of equipment	188,111.71	
Depletion of ore bodies	376,201.39	$2,796,857.70
Net deficit for 1922		$548,332.34

STATEMENT

Of Assets and Liabilities, exclusive of Real Estate, Mine Plant and Supplies in Use

January 1, 1923.

Assets		
Cash, copper and investments		$1,189,240.85
Accounts receivable, New York	$30,028.75	
Accounts receivable, at mine	17,643.90	
Accounts receivable at smelting works	167.98	47,840.63
At mine and smelting works:		
Supplies	$346,669.99	
Timber lands	11,297.16	
Teams and auto trucks	6,595.00	
Construction account	585,912.24	950,474.39
		$2,187,555.87
Liabilities		
Accounts payable in New York	$171,954.48	
Accounts payable at mine	80,937.50	
Accounts payable at smelting works	4,440.22	
Michigan taxes payable January 10, 1923	87,027.74	
Opening mine reserve	91,314.00	
Fire insurance reserve	135,179.29	642,047.91
Accident reserve	71,194.68	
		$1,545,507.96

Wolverine Copper Mining Company

This mine is essentially a scram and mining during the year consisted generally of opening up old levels and mining pillars and blocks of ground considered too lean

in former operations. This work entailed considerable hand picking underground. In addition 27 per cent of the rock hoisted during the year was obtained from vein left in the foot in old stopes throughout the mine.

The summary of results which are full and complete is as follows:

This report represents the fiscal year ending June 30, 1923.

Rock hoisted	250,745 tons
Rock stamped	244,310 tons
Product of mineral	5,431,040 pounds
Product of refined copper	3,544,879 pounds
Yield of rock treated, 14.509 lbs. per ton or	.725 per cent
Cost per ton of rock hoisted	$1.704
Cost per ton of rock stamped	$1.749
Total operating cost per pound of refined copper	12.054 c.
Cost of smelting, freight and marketing product, including Eastern Offices' expenses	1.986 c.
Cost of taxes	.700 c.
	14.740 c.
Depletion of Ore Bodies	4.249 c.
Depreciation of Equipment, etc	.541 c.
Total cost per pound of refined copper	19.530 c.

PROFIT AND LOSS ACCOUNT

For the Year Ending June 30, 1923

Sales:		
4,476,777 pounds of copper at 14.832 cents		$663,987.78
Cost of Sales:		
Copper on hand July 1, 1922	$230,303.25	
Operating expenses at mine, as per statement hereafter	427,306.40	
Smelting, freight and New York and Boston expenses	70,398.60	
Taxes	24,795.94	
	$752,804.19	
Less: Copper on hand June 30, 1923	62,154.86	690,649.33
Loss on sales of copper		$26,661.55
Less:		
Interest, etc., received		1,557.05
Operating loss for the year		$25,104.50

CAPITAL INVESTMENT

During the Year Ending June 30, 1923

Water system at mine	$3,927.85
Water system at mill	232.19
	$4,160.04

BALANCE SHEET

Assets

Investments:		
Miscellaneous stocks and bonds, at cost		$95,154.73
Current Assets:		
Cash in bank and on hand	$101,247.83	
Accounts and bills receivable	264,327.35	
Copper on hand	62,154.86	
Supplies at mine	27,135.56	
Tax refunds due	27,365.59	
		482,231.19
Unexpired insurance		1,360.26
Option on mineral lands		5,000.00
		$583,746.18

Capital Assets (Book Value):		
Real Estate	$181,819.23	
Mining property, cost	550,000.00	
Ore body enhancement as of March 1, 1913	1,943,718.50	
Buildings, machinery and plant	849,703.41	
Underground openings	575,353.22	4,100,594.36
		$4,684,340.54

JUNE 30, 1923

Liabilities

Capital Stock:		
Paid in on 60,000 Shares		$780,000.00
Current Liabilities:		
Accounts payable	$39,934.28	
Unclaimed dividends	4,948.00	
		44,882.28
Unrealized appreciation	$414,858.55	
Reserve for depreciation	705,591.73	
Reserve for depletion	2,493,171.08	
		3,613,621.36
Suspense		27,365.59
Surplus and Realized Appreciation:		
Balance, July 1st, 1922	$304,878.21	
Add:		
Appreciation realized during the year	108,507.82	
	$413,386.03	
Deduct:		
Operating loss for the year	$25,104.50	
Depreciation for the year	19,181.23	
Depletion for the year	150,628.99	
	$194,914.72	
Balance, June 30, 1923		218,471.31
		$4,684,340.54

STATEMENT OF WORKING EXPENSES AT THE WOLVERINE MINE

For the Year Ending June 30, 1923

UNDERGROUND EXPENSES

Mining	$43,398.52
Timbering, tramming and all other labor	113,418.22
Hoisting	30,028.83
Compressor and drills	30,034.42
Electric light and power	996.18
Supplies	12,398.06
	$230,274.23

SURFACE AND ADMINISTRATION

Superintendence and labor	$14,151.88	
Rock house	17,282.56	
Insurance	2,486.36	
Industrial accident	2,665.80	
Incidentals	5,007.19	
Electric light and power	65.90	
Supplies	1,048.35	
	$42,708.04	
Less:		
Amount received for rent and sundry credits	3,082.71	39,625.33

TRANSPORTATION

Freight	$66,415.12	
Labor	1,126.25	
Electric light	6.44	
		67,547.81

STAMP MILL

Labor	$11,703.26	
Fuel	6,247.80	
Sand conveyor	780.60	
Electric light and power	96.70	
Supplies	1,878.14	
Stamping by Mohawk Mining Co	69,201.53	
	$89,908.03	
Less:		
Amount received for steam heat	49.00	89,859.03
		$427,306.40

DEVELOPMENT PROJECTS

In addition to the active mines, exploration and development work was carried on at the Seneca, Gratiot, Mayflower and Arcadian properties. The most extensive project is the Seneca which with adequate financial backing has been following a careful development program since the shaft cut the lode in 1919.

THE IRON INDUSTRY

STATISTICS OF MICHIGAN IRON ORE PRODUCTION for the Year 1922

The total shipments of Michigan iron mines for the year 1922 amounted to 12,433,729 tons; the mine production for the year, 10,360,984 tons, the excess of shipments coming from accumulations of stockpiles in 1921 and

previous years. The total shipments of iron ore in the United States for 1922 amounted to 51,339,031 tons, of which Michigan produced 24.2%. The average value per ton of Michigan iron ore in 1922 was $5.1151 f. o. b. Lower Lake Ports. The value at the mine would be $5.1151 minus cost of transportation which amounted to $1.5956, or $3.5195. The gross value of the 1922 shipments f. o. b. Lake Erie Ports was $63,599,767 and the gross value at the mine was $43,760,509.

In the following tables the data for tons mined is taken from the reports of the mining companies as furnished to the Board of State Tax Commissioners and the data for shipments is compiled from the same sources and checked with the reports of the Lake Superior Iron Ore Association. The figures for past shipments of the various mines are taken from the reports of the Lake Superior Iron Ore Association but in some cases slight modifications have been made in the total individual mines. This is due to the fact that a number of the Ore Association's reports list separately old mines which are now integral parts of present active operations. The data of shipments from other states is that reported by the Lake Superior Iron Ore Association.

Production and former shipments by Districts and Counties.

TABLE I

1922 Production and 1922 and Prior Years Shipment, Gogebic County Iron Mines

Mine.	Tons mined 1922.	Tons shipped 1922.	Grand total shipments all years.
Anvil	29,862	30,558	950,755
Asteroid	3,231	78,414	926,699
Ashland	46,558	76,917	6,618,879
Brotherton	.....	69,033	2,678,800
Castile	.....	24,889	864,076
Colby-Ironton	239,700	267,990	*8,408,416
Eureka	208,799	271,840	2,107,446
Rowenaw	141,344	133,000	1,037,688
Newport-Bonnie	496,207	788,527	17,574,549
Norrie Group	1,129,031	1,385,241	42,066,083
Palms	321,719	472,456	5,477,871
Plymouth	607,876	607,876	4,055,128
Puritan Group	111,250	162,050	2,555,530
Sunday Lake	94,149	190,621	3,137,044
Tilden*	210,735	222,603	*6,832,051
Townsite†	76,250	50,929	†407,513
Wakefield	430,136	430,136	8,320,960
Yale	204,063	263,831	2,049,186
Idle Mines	.....	.....	1,727,020
Total	4,359,910	5,535,911	115,792,698

*Shipments of Tilden mine included with Colby prior to 1891.
†Formerly Norrie Mine part of Norrie Group. Shipments included under Norrie Group prior to 1917.

TABLE II

1922 Production and 1922 and Prior Years Shipment, Dickinson County Iron Mines.

Mine.	Tons mined 1922.	Tons shipped 1922.	Grand total of shipments.
Aragon	209,796	275,464	9,127,179
Chapin*	330,676	490,048	24,019,141
Loretto	75,022	88,975	2,581,105
Munro	35,263	35,263	576,264
Penn Group†	177,536	168,186	12,632,890
West Chapin	.....	1,270	1,270
Abandoned and Idle Mines	.....	.....	15,111,788
Total	828,313	1,059,206	64,049,607

*Chapin mine includes Millie Ludington and Hamilton formerly operated as separate mines.
†Penn Group includes following mines: Norway and Cyclops now abandoned, West Vulcan, East Central, Briar Hill, Curry, East Vulcan, active or temporarily idle.

TABLE III

1922 Production and 1922 and Prior Years Shipments Iron County Iron Mines

Mine.	Tons mined 1922.	Tons shipped 1922.	Total shipments 1922 and prior years.
Balkan	85,493	84,969	1,409,204
Baltic-Fogarty	252,169	264,168	3,082,562
Bates	110,430	112,959	688,989
Bengal	145,029	163,042	1,491,956
Berkshire*	116,265	118,871	800,536
Bristol	51,545	124,146	5,605,343
Buck	8,006	5,660	5,660
Cardiff	50,011	28,982	28,982
Carpenter	165,012	206,837	2,082,652
Caspian	146,030	158,063	4,327,758
Chicagoan	.....	48,774	1,234,339
Davidson Group†	120,965	166,376	1,950,856
Great Western	.....	59,800	2,257,825
Hiawatha	107,018	126,885	2,053,107
Homer	81,880	135,975	1,411,421
Judson	93,161	124,829	703,377
Monongahela	80,570	114,939	429,140
Odgers	102,500	55,481	879,921
Osana-Wausecа	158,957	185,675	1,785,359
Porter	87,662	120,894	502,791
Riverton	140,382	119,916	3,916,161
Rogers	152,438	103,845	701,846
Spies‡	7,500	35,123	553,497
Tobin	127,100	105,344	3,391,235
Tully	.....	62,129	1,084,587
Warner	47,572	63,152	428,256
Zimmerman	42,031	33,504	1,682,898
Abandoned and Idle mines	.....	.....	16,837,215
Total	2,479,726	3,020,238	61,477,563

*Berkshire including Cottrell.
†Davidson Group includes Davidson Nos. 1, 2 and 3 active or temporarily idle and also Davidson No. 4 or (Waupama) or (Purcell) mined out and abandoned.
‡Spies includes Spies and Virgil.

TABLE IV

1922 Production and 1922 and Prior Years Shipments of Iron Ore from Marquette and Baraga Counties.

Mine.	Tons mined 1922.	Tons shipped 1922.	Tons shipped 1922 and prior years.
American-Boston	.....	40,306	1,846,643
Angeline	.....	36,841	9,319,679
Athens	193,259	265,159	597,488
Austin	50,705	5,065	1,315,782
Barnes & Hecker	20,313	.....	.....
Cliffs Shaft*	131,502	179,496	8,162,772
D. S. S. & A. (Adams)	16,632	16,632	195,384
Francis	98,049	11,427	119,567
Gardner-Mackinaw	.....	40,180	142,453
Gwinn	20,085	26,436	947,166
Holmes	218,066	262,251	740,409
Imperial	118,175	73,083	760,486
Isabella	88,033	100,731	551,997
Jackson	16,101	16,102	4,311,182
Lake	.....	28,581	16,003,988
Mass	209,740	11,997	2,547,956
Mary Charlotte	175,390	172,261	3,875,002
Maitland	13,593	13,593	156,859
Morris Lloyd	221,979	263,916	2,365,797
Negaunee	289,279	337,880	8,730,627
Princeton	74	26,145	2,167,689
Republic	98,173	80,022	7,890,104
Richmond	155,518	155,518	2,440,724
Rolling Mill	107,763	142,801	2,114,175
Salisbury	.....	24,724	4,406,708
Section 16 Group†	237,183	245,694	18,211,376
Stephenson	213,223	202,523	2,458,559
Idle and Abandoned Mines	.....	.....	37,973,920
Total	2,693,035	2,818,374	140,354,492

*Includes Barnum and Iron Cliffs.
†Section 16 Group includes Lake Superior Hard Ore and Section 21 mine now idle and Lake Superior Hematite mined out.

United States Shipments

TABLE V

1922 Production, and 1922 and Prior Years Shipment of Michigan Iron Ore by Counties.

County.	Tons mined 1922.	Tons shipped 1922.	Tons shipped 1922 and prior years.
Dickinson	828,313	1,059,206	64,049,607
Gogebic	4,359,910	5,535,911	115,792,698
Iron	2,479,726	3,020,238	61,477,563
Marquette and Baraga	2,693,035	2,818,374	140,354,492
Total	10,360,984	12,433,729	381,674,360

TABLE VI

1922 Shipment of Iron Ore in the United States by States.

States.	Tons.
Minnesota	30,772,162
Michigan	12,433,729
Alabama	5,234,568
Wisconsin	795,175
Pennsylvania	780,836
New York	444,381
Wyoming	332,800
Tennessee	156,464
New Mexico	118,038
New Jersey	90,359
Missouri	58,408
Virginia	39,971
Georgia	24,140
Montana	21,726
North Carolina	17,279
California, Colorado, Idaho, Utah, Nevada	18,986
Total	51,339,031

Average Cost of Production

TABLE VII

Stated Average Costs of Producing Iron Ore During 1922, Compiled from Reports of Mining Companies to Board of State Tax Commissioners.

Items.	All active mines.		All active and partial list of inactive properties.*	
Cost of Mining:				
Labor	1.0933		1.0991	
Supplies	.6012		.6058	
Total	1.6949	1.6949	1.7051	1.7051
Other Ore Costs:				
Concentrating and Crushing	.0072		.0072	
Deferred Charges	.0856		.0857	
Total	.0928	.0928	.0929	.0929
Taxes Except Federal Income Tax:				
State and Local General Property Tax	.3678		.3960	
Federal Taxes Except Income Tax	.0051		.0052	
State Corporation Tax	.0982		.0086	
Total	.3811	.3811	.4098	.4098
Depreciation	.1414	.1414	.1416	.1416
Overhead Expense:				
General Superintendence	.0458		.0492	
Contingent Expense	.0109		.0109	
Fire Insurance	.0072		.0076	
General Expense	.0919		.0940	
Total	.1558	.1558	.1617	.1617
Transportation:				
Rail Freight	.8843		.8843	
Boat Freight	.7093		.7093	
Cargo Insurance	.0020		.0020	
Total	1.5956	1.5956	1.5956	1.5956
Analysis and Selling Expense:				
Analysis	.0044		.0044	
Selling Commission	.0385		.0385	
Total	.0429	.0429	.0429	.0429
Total Cost of Mine Operation		4.1045		4.1496
Royalty		.4375		.4414
Cost Adjustment		.0030		.0031
Total Mining Companies Cost		4.5450		4.5941
Receipts from Sale of Ore		5.1151		5.1151
Total Cost of Mine Operation		4.1045		4.1496
Earnings on Mine Operation		1.0106		.9655
Receipts from Sale of Ore		5.1151		5.1151
Total Mining Companies Cost		4.5450		4.5941
Earnings on Mine Operation		.5701		.5210
Interest		.0782		.0793
Net Earnings on Mine Operation		.4919		.4417

*Total assessed value iron mines in 1922 was $113,730,096. The assessed value of the active and idle mines for which costs were presented amounts to $108,850,610. Certain idle reserves return no cost sheets.

Estimated reserves and Assessed Valuation

TABLE VIII

Estimated Ore Reserves and Assessed Valuation Michigan Iron Mines 1922 and 1923.

	1922.			1923.		
	Ore Reserves.	Valuation.	Assessed value per ton.	Ore Reserves.	Valuation.	Assessed value per ton.
Marquette and Baraga	72,953,551	$35,361,552	.4834	72,102,521	$35,560,753	.4932
Gogebic	62,405,146	47,900,266	.7562	58,314,512	46,534,818	.7979
Iron	54,918,070	24,776,948	.4795	57,065,508	25,624,025	.4490
Dickinson	9,467,955	5,908,770	.6346	9,344,407	6,010,300	.6432
	199,744,722	$113,947,536	.5704	196,826,948	$113,730,096	.5778

LOCATION OF ACTIVE IRON MINES AND IDLE RESERVES, MARQUETTE AND BARAGA COUNTIES.

Note: Idle Reserves marked*

Athens:
Parcels in SW ¼ of Sec. 5 and SE ¼ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Athens Mining Company

Austin:
N ½ of the SW ¼ of Sec. 20, T. 45 N.f R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.

Baraga:*
Parcel in SE ¼ of the SE ¼ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Interstate Iron Company.

Barnes and Hecker:
Lot 2 and S ½ of the NE ¼ and S ½ of the NW ¼ of Sec. 2, T. 47 N., R. 28 W., Ely Township.
Cleveland Cliffs Iron Company.

Bunker Hill:*
Parcel in S ½ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Bunker Hill Mining Company.

Cambria:
Lots 7 and 8, Sec. 35; Lots 5, 6 and 7, Sec. 36; S ½ of the SE ¼ Sec. 35. All in T. 48 N., R. 27 W., City of Negaunee.
Republic Iron & Steel Company.

Champion*:
S½ of Sec. 31, T. 48 N., R. 29 W., Champion Township.
Champion Iron Company.

Cliffs Shaft:
N ½ of Sec. 9; S M of the SE ¼ of Sec. 4; SW ¼ of SE ¼ of Sec. 3. Part of N ½ of Sec. 10, T. 47 N., R. 27 W., City of Ishpeming.
Cleveland Cliffs Iron Company.

D. S. S. & A. (Adams):
Parcel of land along old D. S. S. & A. between Maas and Negaunee mines, Sec. 5, 6, T. 47 N., R. 26 W. and Sec. 32, T. 48 N., R. 26 W., City of Negaunee.
Lake Superior Iron Company.

Empire:
E ½ of SW ¼ of Sec. 19, T. 47 N., R. 26 W. Richmond Township.
Empire Mining Company.

Francis:
S ½ of the NW ¼ and SW ¼ of Sec. 27, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.

Gwinn:
NW ¼ of Sec. 28, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.

Hematite No. 1*:
SE ¼ of the SW ¼ and SW ¼ of the SE ¼, and parcel in SE ¼ of the SE ¼ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Interstate Iron Company
Property formerly called Breitung Hematite No. 1.

Holmes:
SW ¼ of the NE ¼ of Sec. 9, T. 47 N., R. 27 W., City of Ishpeming.
Cleveland Cliffs Iron Company.

Imperial:
NW ¼ of Sec. 25, T. 48 N., R. 31 W., Spurr Township.
Ford Motor Company.

Isabella:
SW ¼ of Sec. 29, T. 47 N., R. 26 W., except west 20 rods.
Richmond Township.
Steel & Tube Company of America.

Jackson:
Sec. 1, T. 47 N., R. 27 W., City of Negaunee.
Cleveland Cliffs Iron Company.

Lake Sally*:
Lots 4, 5, 6, 7, 8 and SW ¼ of the SW ¼ and SE ¼ of the SE ¼ of Sec. 14, T. 47 N., R. 27 W., City of Ishpeming.
Jones & Laughlin Ore Company.

Lake Superior Group:
*Hard Ore. N ½ of the SE ¼ of Sec. 9; S ½ of the NW ¼ and the W ½ of the NW ¼ of the SW ¼ of Sec. 10, all in T. 47 N., R. 27 W.
Section 16. SE ¼ of the SE ¼ of Sec. 9, T. 47 N., R. 27 W. and N ½ of the NE ¼ of Sec. 16, T. 47 N., R. 27 W., City of Ishpeming.
*Section 21. W ½ of the NE ¼ and S ½ of the NW ¼ of Sec. 21, T. 27 N., R. 27 W., Tilden Township.
Lake Superior Iron Company.

Lucky Star*:
Parcel in SW ¼ of Sec. 5 and SW ¼ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Lucky Star Mining Company.

Mackinaw-Gardner*:
Mackinaw. N ½ of the SE ¼ and SW ¼ of the SE ¼ of Sec. 35, T. 45 N., R. 25 W.
Gardner. SE ¼ of the SE ¼ of Sec. 35, T. 45 N., R. 25 W. and NW ¼ of the NE ¼ of Sec. 2, T. 44 N., R. 35 W., Forsyth Township.
Cleveland Cliffs Iron Company.

Maitland:
W ½ of the NW ¼ of Sec. 30, T. 47 N., R. 26 W., Richmond Township.
Alexander Maitland, Owner, Negaunee, Michigan.

Mary Charlotte Group:
Breitung No. 2. S ½ of the NW ¼ of Sec. 8, T. 47 N., R. 26 W.
Mary Charlotte. N ½ of the SW ¼ of Sec. 8, T. 47 N., R. 26 W.
Himrod. NE ¼ of the SW ¼ of Sec. 7, T. 47 N., R. 26 W., City of Negaunee.
Marquette Ore Company.

Morris Lloyd Group:
Lloyd. SW ¼ of the NW ¼ and N ½ of the SW ¼ and N ½ of the SE ¼ of Sec. 6, T. 47 N., R. 27 W., Ishpeming Township.
Morris. N ½ of the S ½ and SE ¼ of the NE ¼ of Sec. 1, T. 47 N., R. 28 W., Ely Township.
Cleveland Cliffs Iron Company.

Negaunee:
Parcels in Secs. 5 and 6, T. 47 N., R. 26 W., and Sec. 32, T. 48 N., R. 26 W., City of Negaunee.
Negaunee Mining Company.

Princeton*:
NW ¼ of Sec. 20, T. 45 N., R. 25 W.; S ½ of the SE ¼ of Sec. 18, T. 45 N., R. 25 W.; E ½ of the NE ¼ of Sec. 19, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.

Race Course*:

Parcel in Sec. 6, T. 47 N., R. 26 W. and Sec. 31, T. 48 N., R. 26 W., City of Negaunee.
Lake Superior Iron Company.

Republic:
Entire Section 1, T. 46 N., R. 29 W., except Lot 1, Republic Township.
Cleveland Cliffs Iron Company.

Richmond:
SW ¼ of the SW ¼ of Sec. 28, T. 47 N., R. 26 W., Richmond Township.
Richmond Iron Company.

Rolling Mill:
S ½ of the NE ¼ of Sec. 7, T. 47 N., R. 26 W., City of Negaunee.
Clement K. Quinn & Company.

Stephenson:
S ½ of the SW ¼ of Sec. 20, T. 45 N., R. 25 W., and N ½ of the NW ¼ of Sec. 29, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.

Sundry Parcel No. 1*:
Parcel in southwest corner of SW ¼ of the SW ¼ of Sec. 5, T. 47 N., R. 26 W., .City of Negaunee.
Interstate Iron Company.

LIST AND LOCATION OF ACTIVE IRON MINES AND IDLE RESERVES IN IRON COUNTY.

Note: Idle Reserves marked*

Aronson*:
E ½ of the NW ¼ of the NE ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Republic Iron & Steel Company.

Balkan:
W ½ of the NE ¼ and the NE ¼ of the NW ¼ and Frac. part of the NE ¼ of the SE ¼ of the NW ¼, all in Sec. 13, T. 42 N., R. 33 W., Mastodon Township.
Balkan Mining Company.

Baltic-Fogarty Group:
Baltic. W ½ of the NW ¼ of Sec. 7, T. 42 N., R. 34 W.

Fogarty. SE ¼ of the SE ¼ of Sec. 1, T. 42 N., R. 35 W.
Buck (Andrew Young). S ½ of the SW ¼ of Sec. 6, T. 42 N., R. 34 W., Stambaugh Township.
Verona Mining Company.

Bates:
Lots 3 and 4 and S ½ of the NW ¼ of Sec. 19, T. 43 N., R. 34, W., Bates Township.
Bates Iron Company.

Blair:*
NE ¼ of the SW ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
McKinney Steel Company.

Bengal:
N ½ of the SE ¼ of Sec. 36, T. 43 N., R. 35 W., Stambaugh Township.
Verona Mining Company.

Berkshire Group:
Berkshire. NW ¼ of the SW ¼ of Sec. 6, T. 42 N., R. 34 W.
Cottrell. NE ¼ of the SE ¼ of Sec. 1, T. 42 N., R. 34 W.
Corry. NE ¼ of the SW ¼ of Sec. 6, T. 42 N., R. 34 W., Stambaugh Township.
Brule Mining Company.

Bristol:
E ½ of the SE ¼ of Sec. 19, T. 43 N., R. 32 W., City of Crystal Falls.
Bristol Mining Company.

Cardiff:
E ½ of the NE ¼ of Sec. 22, T. 43 N., R. 35 W., Iron River Township.
Wickwire Mining Company.

Carpenter:
N ½ of the SW ¼ of Sec. 31, T. 43 N., R. 32 W., Crystal Falls Township.
Hanna Furnace Company.

Caspian:
NE ¼ of Sec. 1, T. 42 N., R. 35 W., Stambaugh Township.
Verona Mining Company.

Chicagon*:
NE ¼ of Sec. 26, T. 43 N., R. 34 W., Bates Township.
Munro Iron Mining Company.

Davidson Group:
No. 1. NE ¼ of the NW ¼ of Sec. 23, T. 43 N., R 35 W.
No. 2. SW ¼ of the SE ¼ of Sec. 14, T. 43 N., R. 35 W
No. 3. SE ¼ of the SE ¼ of Sec. 14, T. 43 N., R. 35 W., Iron River Township.
Davidson Ore Mining Company.

Delta:
W ½ of the SW ¼ of Sec. 25, T. 43 N., R. 35 W., Iron River Township.
St. Clair Mining Company.

DeGrasse*:
S ½ of the NE ¼ of Sec. 7, T. 42 N., R. 34 W., Stambaugh Township.
Verona Mining Company.

Dunn-Richards:
Dunn. W ½ of the NE ¼ of Sec. 1, T. 42 N., R. 33 W., Mastodon Township.
Richards. SW ¼ of the SE ¼ of Sec. 36, T. 43 N., R. 33 W., Crystal Falls Township.
McKinney Steel Company.

Erickson:*
SW ¼ of Sec. 21, T. 43 N., R. 34 W., Bates Township.
Cleveland Cliffs Iron Company.

Fortune Lake*:
S ½ of the SW ¼ of Sec. 24, T. 43 N., R. 33 W. N ½ of the NW ¼ of Sec. 25, T. 43 N., R. 33 W. NE ¼ of the NE ¼ of Sec. 26, T. 43 N., R. 33 W. SW ¼ of the NE ¼ of Sec. 26, T. 43 N., R. 33 W., Crystal Falls Township.
Fortune Lake Mining Company.

Forbes:
SE ¼ of the SW ¼ of Sec. 14, T. 43 N., R. 35 W., Iron River Township.
Jones & Laughlin Ore Company.

Great Western*:
E ½ of the SW ¼ of Sec. 21, T. 43 N., R. 32 W., City of Crystal Falls.
McKinney Steel Company.

Great Western Extension*:
SW ¼ of the SE ¼ of Sec. 21, T. 43 N., R. 32 W.
McKinney Steel Company.

Hiawatha:
SE ¼ of the SW ¼ and S ½ of the SE ¼ of Sec. 35, T. 43 N., R. 35 W., Stambaugh Township.
Munro Iron Mining Company.

Homer:
W ½ of the NW ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Buffalo Iron Mining Company.

Judson Group:
Judson. SE ¼ of the NW ¼ except five acres and the NE ¼ of the SW ¼ of Sec. 13, T.42 N., R. 33 W.
Carpenter. "40" SW ¼ of the NW ¼ of Sec. 13, T. 42 N., R. 33 W., Mastodon Township.
Balkan Mining Company.

Michaels*:
NW ¼ of the SE ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
McKinney Steel Company.

Minckler*:
W ½ of the NW ¼ of the SE ¼ and the NE ¼ of the SW ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Republic Iron & Steel Company.

Monongahela:
NE ¼ of Sec. 36, T. 43 N., R. 33 W., Crystal Falls Township.
Hanna Furnace Company.

Neely, Crystal Falls*:
Lots 1 and 2, Sec. 21, T. 43 N., R. 32 W., City of Crystal Falls.
Kimberly Iron Company.

Neely, Mastodon Township *:
N ½ of the NE ¼ of Sec. 12, T. 42 N., R. 33 W., Mastodon Township.
Cleveland Cliffs Iron Company.

Odgers:
S ½ of NE ¼ of Sec. 30, T. 43 N., R. 32 W., Crystal Falls Township.
McKinney Steel Company.

Oliver Exploration*:
S ½ of NE ¼ of Sec. 12, T. 42 N., R. 33 W., Mastodon

Township.
Oliver Iron Mining Company.

Osana:
N ½ of the NE ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Mineral Mining Company.

Porter:
E ½ of the NE ¼ of Sec. 22, T. 44 N., R. 33 W., Crystal Falls Township.
Hemlock River Mining Company.

Riverton Group:
Dober. N ½ of the NW ¼ of Sec. 1, T. 42 N., R. 35 W.
Isabella. SW ¼ of the SW ¼ of Sec. 36, T. 43 N., R. 35 W.
Duff. N ½ of the NE ¼ of Sec. 2, T. 43 N., R. 35 W., Stambaugh Township.
Oliver Iron Mining Company.

Rogers:
NE ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
Munro Iron Mining Company.

Ravenna and Prickett*:
W ½ of the SE ¼ of Sec. 19, T. 43 N., R. 32 W. SW ¼ of Sec. 19, T. 43 N., R. 32 W. NE ¼ of the SE ¼ of Sec. 24, T. 43 N., R. 32 W., Crystal Falls Township.
Hanna Furnace Company.

Sherwood*:
SE ¼ of the NE ¼ and the NE ¼ of the SE ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Republic Iron & Steel Company.

Spies Group:
Spies. SE ¼ of the NW ¼ and the NE ¼ of the NW ¼ of Sec. 24, T. 43 N., R. 35 W.
Virgil. SW ¼ of the NW ¼ of Sec. 24, T. 43 N., R. 35 W., Iron River Township.
Cleveland Cliffs Iron Company.

Tobin Group:
Tobin. SW ¼ of Sec. 30.
Genesee. SE ¼ .of Sec. 30; NW ¼ of the NE ¼ of Sec. 31.
Columbia. NW ¼ of Sec. 31, Crystal Falls Township.
McKinney Steel Company.

Tully*:
S ½ of the SE ¼ of Sec. 36, T. 43 N., R. 35 W., Stambaugh Township.
McKinney Steel Company.

Warner:
E ½ of the SE ¼ of Sec. 9, T. 44 N., R. 33 W., Hematite Township.
Hemlock River Mining Company.

Wauseca:
SW ¼ of the NE ¼ and the SE ¼ of the NW ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Mineral Mining Company.

White*:
E ½ of the NW ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
J. A. Monroe et al, Iron River, Michigan.

Wilkinson*:
NE ¼ of the SE ¼ of Sec. 36, T. 43 N., R. 33 W., Crystal Falls Township.
Verona Mining Company.

Zimmerman:
E ½ of the NW ¼ of Sec. 7, T. 42 N., R. 34 W., Stambaugh Township.
Marting Ore Company.

LIST AND LOCATION OF ACTIVE IRON MINES AND IDLE KNOWN ORE RESERVES, GOGEBIC COUNTY.

Note: Idle Reserves marked*

Anvil*:
NE ¼ of Sec. 14, T, 47 N., R. 46 W., Bessemer Township.
Steel & Tube Company of America.

Ashland:
S ½ of the SW ¼ of Sec. 22, T. 47 N., R. 47 W. N ½ of Lot 1, Sec. 27, T. 47 N., R. 47 W. North 10 acres of the NE ¼ of the NW ¼ of Sec. 27, T. 47 N., R. 47 W., City of Ironwood.
Hays Mining Company.

Asteroid:
NE ¼ of Sec. 13, T. 47 N., R. 46 W., Bessemer Township.
The Castile Mining Company.

Brotherton:
N ½ of the SE ¼ and the SE ¼ of NE ¼ of Sec. 9, T. 47 N., R. 45 W., City of Wakefield.
Brotherton Iron Mining Company.
This property was mined out and abandoned in 1922.

Castile:
E ½ of Sec. 10, T. 47 N., R. 45 W., City of Wakefield.
The Castile Mining Company.
This property was abandoned and allowed to fill with water in 1922.

Colby, Ironton Group:
Colby. NE ¼ of Sec. 16, T. 47 N., R. 46 W., City of Bessemer.
Ironton. W ½ of the E ½ of Sec. 17, T. 47 N., R. 46 W., Bessemer Township.
Winona. E ½ of the E ½ of Sec. 17, T. 47 N., R. 46 W., City of Bessemer.
The McKinney Steel Company.

Eureka:
N ½ of the NW ¼ of Sec. 13, and the S ½ of the SW ¼ of Sec. 12, T. 47 N., R. 46 W., Bessemer Township.
The Castile Mining Company.

Keweenaw:
S ½ of the SE ¼ of Sec. 11, T. 47 N., R. 46 W., Bessemer Township.
The Steel & Tube Company of America.

Mikado*:
S ½ of the N ½ of the NW ¼ and the S ½ of the NW ¼ and the NW ¼ of the NE ¼ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Verona Mining Company.

Morgan:
SE ¼ of the SE ¼ of Sec. 11, T. 47 N., R. 45 W., Wakefield Township.
Thomas Furnace Company.

Newport Group:
Newport. NW ¼ of Sec. 24, T. 47 N., R. 47 W., City of Ironwood.
Bonnie. NE ¼ of Sec. 24, T. 47 N., R. 47 W., Erwin

Township.
Steel & Tube Company of America.

Norrie Group:
Aurora. E ½ of the SW ¼ of Sec. 23, T. 47 N., R. 47 W.
East Norrie. W ½ of the SW ¼ of Sec. 23, T. 47 N., R. 47 W.
North Ashland. N ½ of the SW ¼ of Sec. 22, T. 47 N., R. 47 W.
North Norrie. N ½ of the SE ¼ of Sec. 22, T. 47 N., R. 47 W.
North Aurora. S ½ of the NW ¼ of Sec. 23, T. 47 N., R. 47 W.
North Pabst. N ½ of the NE ¼ of Sec. 23, T. 47 N., R. 47 W.
Pabst. S ½ of the NE ¼ of Sec. 23, T. 47 N., R. 47 W.
Vaughn. N ½ of the SE ¼ of Sec. 23, T. 47 N., R. 47 W., City of Ironwood.
Oliver Iron Mining Company.

North Mikado:
Parcels in NW ¼ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Castile Mining Company.

Palms:
NW ¼ of Sec. 14, T. 47 N., R. 46 W., City of Bessemer.
Steel & Tube Company of America.

Pilgrim:
NE ¼ of the NE ¼ and the S ½ of the NE ¼ of Sec. 18, T. 47 N., R. 45 WT, City of Wakefield.
Verona Mining Company.

Plymouth:
NE ¼ of the SW ¼ and the SE ¼ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Plymouth Mining Company.

Puritan Group:
Davis. N ½ of the NW ¼ of Sec. 19, T. 47 N., R. 46 W.
Geneva. SW ¼ of Sec. 18, T. 47 N., R. 46 W.
Royal. SE ¼ of Sec. 18, T. 47 N., R. 46 W.
Puritan. SW ¼ of Sec. 17, T. 47 N., R. 46 W., Bessemer Township.
North Newport: S ½ of Sec. 13, T. 47 N., R. 47 W., Erwin Township.
Oliver Iron Mining Company.

Sunday Lake:
W ½ of Sec. 10, T. 47 N., R. 45 W., City of Wakefield.
Sunday Lake Iron Company.

Tilden:
N ½ of Sec. 15, T. 47 N., R. 46 W., Bessemer City.
The Oliver Iron Mining Company.

Townsite (Formerly Norrie of Norrie Group):
S ½ of the SE ¼ of Sec. 22, T. 47 N., R. 47 W., City of Ironwood.
Townsite Mining Company.

Wakefield:
N ½ of the SW ¼ and the W ½ of the NW ¼ of Sec. 16, and the N ½ and the N ½ of the S ½ of Sec. 17, T. 47 N., R. 45 W., City of Wakefield.
Wakefield Iron Company.

Yale:
S ½ of the NW ¼ of Sec. 16, T. 47 N., R. 46 W., City of Bessemer.
Charcoal Iron Company of America.

LIST AND LOCATION OF IRON MINES IN DICKINSON COUNTY.

Note: Idle Reserves marked*

Aragon:
NE ¼ and the NE ¼ of the NW ¼ of Sec. 8, T. 39 N., R. 29 W. N ½ of the NW ¼ and Frac. part of the SW ¼ of the NW ¼ of Sec. 9, T. 39 N., R. 29 W. Frac. part of the SE ¼ of the SW ¼ and Frac. part of the SW ¼ of the SE ¼ of Sec. 5, T. 39 N., R. 29 W., City of Norway.
Oliver Iron Mining Company.

Chapin:
N ½ of the SE ¼ and the SE ¼ of the SE ¼ of Sec. 25, T. 40 N., R. 31 W. SW ¼ and SW ¼ of the SE ¼ of Sec. 30, T. 40 N., R. 30 W. NW ¼ of the NE ¼ and the NE ¼ of the NW ¼ of Sec. 31, T. 40 N., R. 30 W., City of Iron Mountain.
Oliver Iron Mining Company.
Includes following mines operated at one time separately: Chapin, Ludington, Hamilton, Millie.

Indiana:
N ½ of the NE ¼ of Sec. 27, T. 40 N., R. 30 W., Breitung Township.
The Thomas Furnace Company.

Loretto:
SW ¼ of the NW ¼ and the SW ¼ of Sec. 7, T. 39 N., T. 28 W., Waucedah Township.
Loretto Iron Company.

McKenna*:
NW ¼ of Sec. 2, T. 39 N., R. 30 W., less 10 acres in the NE ¼ of the NW ¼., Breitung Township.
Iron Mountain Furnace & Chemical Company.

Munro:
NW ¼ of the SE ¼ and the NE ¼ of the SW ¼ of Sec. 6, T. 39 N., R. 29 W., City of Norway.
Munro Iron Mining Company.
Property abandoned and lease surrendered at end of 1922.

Penn Group:
Active Mines:
Curry. W ½ of the NE ¼ of Sec. 9, T. 39 N., R. 29 W., SE ¼ of the NE ¼ of Sec. 9; East frac. ½ of the NW ¼ of the SE ¼ of Sec. 9, T. 39 N., R. 29 W.; frac. part of NE ¼ of the SW ¼ of Sec. 9, T. 39 N., R. 29 W., City of Norway.
Brier Hill. S ½ of the NW¼ of Sec. 9, T. 39 N., R. 29 W., except fraction leased to Oliver Iron Mining Company, Norway Township.
East Central. Entire Sec. 10, T. 39 N., R. 29 W.
East Vulcan. SW ¼ of Sec. 11, T. 39 N., R. 29 W.
Operated by Penn Iron Mining Company.

West Chapin:
N ½ of the SW ¼ and the NE ¼ of the NW ¼ of Sec. 31, T. 40 N., R. 30 W., City of Iron Mountain.
West Chapin Mines Company.

PART II. NON-METALLIC MINERALS

SALT

Michigan led all other States in salt production for 1922. This was due to a rapid recovery from adverse conditions in the Middle Western States as well as to a development of adverse weather and trade conditions in the East. New York, the closest competitor for first place in salt production, although subject to these adverse conditions showed an increase over 1921 production of 35 per cent with an increase in value of 9 per cent, while Michigan showed an increase in production over 1921 of 40 per cent, and an increase in value of 17 per cent. The total salt production of the United States showed an increase over 1921 of 36 per cent and an increase in value of 12 per cent.

With the exception of a few years when New York has had a greater production, Michigan has been the greatest salt producing State since 1880. It is recorded as first in production from 1880 to 1892, in 1901, from 1905 to 1909, from 1912 to 1921, and in 1922. This leading place in the salt industry was achieved by the development of large deposits of mineral salt in the Salina formation, which is known to underlie large areas in the Southern Peninsula, following the period of greatest activity in lumbering when salt was often produced from formations other than the Salina and in much smaller quantities. Exploration for Salina salt has been largely confined to the borders of the State where these comparatively deep seated rocks are nearest the surface, and where markets or trunk lines of transportation are within easy reach.

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. That Michigan showed a gain in 1919 although the total quantity for the United States decreased, was due to the fact that the greater part of the salt produced is salt in brine which is used by the chemical industries.

The salt sold in the United States in 1922 showed a general increase of 36 per cent in quantity, but only 12 per cent in value. Production in Michigan increased by 577,623 tons (4,125,879 barrels) or 40 per cent while the value increased by $1,254,159, or 17 per cent. The low point in the production since 1910 was reached in 1921 and the returns for 1922 indicate a substantial gain with the figures approximating the production for the year 1916.

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 32.4 per cent or nearly one-third of the salt used in the United States since records of production have been kept.

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. Over 95.2 per cent of the State output of salt for 1922 came from these two districts, the production being 13,644,736 barrels valued at $8,086,559 or 95.2 per cent of the total State production and 93 per cent of the total value.

The salt industry in Wayne County made a most remarkable growth from 1895 to 1919. Salt was first produced in this country in 1895, the output for that year being 13,077 barrels. In 1906 the production exceeded 1,000,000 barrels and in 1919 a maximum of 11,539,258 barrels, or 64.8 per cent of the total for the State, was reached. The value was $2,324,164 or only 24.5 per cent of the total. The industry began to decline in 1920, production being 9,713,564.3 barrels valued at $2,510,789, a decrease of 1,925,694 barrels or 16.6 per cent in production but an increase of $186,625 or 8 per cent in value. Production continued to decrease in 1921, being only 5,950,521.4 barrels valued at.$2,052,596, a decrease of 3,763,043 barrels or 38.7 per cent in quantity (a decrease of 48.4 per cent from the maximum of 1919) and of $458,193 or 17.1 per cent in value. In 1922 Wayne County produced 9,363,564 barrels valued at $2,437,710.

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 1922 was 2,575,371 barrels or 17.9 per cent of the State total, but the valuation of $3,972,261 represents 45.7 per cent of the total value for Michigan. 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. In 1922 production reached 37,350 tons valued at $368,515.

In the Manistee-Ludington district, salt is made at Manistee, Manistee County, and at Ludington, Mason County. 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. The district produced 1,705,800 barrels of salt valued at $1,676,588. This is equivalent to 11.9 per cent of the total quantity and 19.2 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 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.

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES
1880-1922**

Year.	U. S. production quantity bbls.	Michigan production. State Salt Inspectors* Quantity. bbls.	Michigan production. U. S. G. S.† Quantity. bbls.	Per cent of total Michigan.	Rank quantity.	Value Michigan.	Michigan. Rank value.	Michigan. 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	2,420,989	.....	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	1	2,291,842	.....	0.581
1888	8,055,881	3,886,228	3,886,228	47.99	.....	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	39.53	1	2,037,289	.....	0.523
1892	11,698,890	3,812,504	3,829,478	32.81	1	2,046,963	.....	0.287
1893	11,897,208	3,514,485	3,057,898	25.70	2	888,837	.....	0.375
1894	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619	.....	0.315
1895	13,699,649	3,529,362	3,343,395	24.46	2	1,048,251	.....	0.229
1896	13,850,726	3,336,242	3,164,238	22.89	2	718,408	.....	0.313
1897	15,973,202	3,622,764	3,993,225	24.99	2	1,243,619	.....	0.311
1898	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081	.....	0.309
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	8,121,781	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	9,938,802	36.31	1	2,018,760	2	0.203
1907	29,704,128	6,208,403	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	36.21	1	9,456,138	1	0.531
1920	49,745,373‡	.....	16,163,679	32.49	2	10,698,674	1	0.662
1921	35,579,072	.....	10,196,179	28.66	2	7,439,445	1	0.729
1922	48,520,350‡	.....	14,322,057	29.52	1	8,693,604	1	0.607
Total.	987,135,461	.....	328,447,730	.....	.....	151,028,774	.....	.....

*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 and 1922.
**For State total 1865–1879 see Pub. 29, G. S. 24, Michigan Geological Survey.

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY METHODS OF MANUFACTURE, 1906-1922.

	Evaporated. Quantity.	Evaporated. Value.	Pressed blocks. Quantity Tons.	Pressed blocks. Value.	Other rock. Quantity. Bbls.	Other rock. Value.	Brine and other.* Quantity. Bbls.	Brine and other.* Value.	Total. Quantity. Bbls.	Total. Value.
1906–1910	29,278,297	$10,302,732	.....	.....	576,695	$181,965	20,796,007	$1,083,643	50,336,468	$11,503,338
1911	5,355,707	2,235,046	.....	.....	763,908	250,680	4,357,772	219,344	10,320,074	2,633,155
1912	5,441,288	2,486,785	.....	.....	727,304	244,173	4,737,938	236,832	10,946,739	2,974,429
1913	6,042,657	2,811,429	.....	.....	712,320	252,024	4,756,779	337,431	11,528,800	3,293,032
1914	6,141,711	2,806,895	.....	.....	919,735	321,354	4,816,735	240,096	11,670,976	3,299,005
1915	6,595,113	3,602,886	.....	.....	1,012,942	368,022	5,073,940	380,401	12,588,788	4,304,731
1916	6,549,407	3,747,695	.....	.....	1,204,543	368,717	7,965,927	506,520	14,918,278	4,612,567
1917	6,393,793	5,729,911	.....	.....	1,405,671	927,348	8,639,800	578,474	16,078,136	6,877,202
1918	7,307,928	7,677,927	.....	.....	1,350,634	972,517	8,451,578	541,375	17,165,178	9,048,650
1919	7,621,809	8,094,713	.....	.....	1,511,050	1,186,682	9,430,264	660,119	17,800,564	9,456,138
1920	6,482,785	8,677,108	.....	.....	.....	.....	8,199,843	549,824	16,163,678	10,698,674

	Open pans or grainers. Quantity. Bbls.	Open pans or grainers. Value.	Vacuum pans. Quantity. Bbls.	Vacuum pans. Value.						
1921	2,349,893	$3,557,177	2,482,693	$2,449,417	29,657	$273,187	1,367,643	$868,348	3,784,122	$201,316	10,196,179	$7,439,445
1922	2,987,236	4,643,626	2,786,443	2,471,455	**	**	**	**	6,600,543	430,154	14,322,057	8,693,604

*Brine only after 1910.
†1919 computed from census return and subject to revisions and corrections.
**Included in total.

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 depth 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.

BROMINE AND CALCIUM CHLORIDE

The brines of the Napoleon and Lower Marshall formations contain considerable quantities of magnesium bromide, together with various chlorides. These substances were extracted first by the salt companies, but later chemical plants were built for the purpose. The brines are generally heavier and more complex near the center of the Michigan basin and the industry has been developed especially at Midland where the Dow Chemical Company has successfully produced bromine and other chemicals. The brines contain , an especially large amount of bromine.

Owing to German competition before the war, little bromine was produced in this country, but from 1918 to 1921 the amount was about 50 per cent greater. During 1921 the production was again reduced to about the amount which was produced annually before the war. The average price for bromine sold in the United States has shown a marked tendency to a steady decline and has dropped from $1.31 per pound in 1916 to $.15 in 1922.

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 Michigan's production 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, the average price for 1916 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 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 bromine in the crude state—a heavy, reddish brown, mobile liquid. Bromine is used in many chemical reactions, in separating gold from 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 ashpyxiating gases but after the Armistice was signed the large demands 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 maximum quantity of bromine was marketed in Michigan, i. e., 1,736,633 pounds valued at $1,179,834 or 93.6 per cent of the total United States production at 95.5 per cent of the total United States valuation of $1,234,969. Although the war-need for bromine passed in 1918 the chemical and photographic demand continued to keep production and price up.

In 1922 bromine production in the United States increased 41 per cent in quantity but decreased 13 per cent in value. Michigan produced the greater part of the United States production. The average price per pound for the United States was $0.15.

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 chemical 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.

The United States output of calcium-magnesium chloride for 1922 was 33,067 tons valued at $571,326, an increase from 1921 of 9,395 tons or 50.28 per cent in quantity and of $60,603 or 11.8 per cent in value. The average price per ton dropped from $21.57 in 1921 to $17.28 in 1922. Michigan produced the greatest part of the total quantity produced in the United States.

The above figures refer to the direct production, of calcium chloride from raw mineral material and there is a large additional output from chemical plants which produce it in various manufacturing operations.

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 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. Prior to the experiments of the Dow chemists 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 chemical 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, absence of permanent growth on repeated heating and cooling and non-abrasiveness to cast iron makes 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 many motor plants and in various types of motor cars.

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

**For a more complete discussion of the properties of Dow Metal see Pub. 32, Geol. Sec. 36, Min. Res. of Mich. 1920, pp. 46-48.

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 $0.31 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.

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-eight different cement plants have been projected or built in Michigan. Eleven plants were in operation in 1921 and 1922 and another began production in 1923.

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.

The demand was heavy the first ten months of 1920, but fell off the last two. The difficulties in obtaining either coal or cars for transportation of raw materials and the finished product forced 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. Stocks held at the end of 1920 were greater than at the close of any previous year, being 666,389 barrels as compared with 219,699 barrels at the end of 1919. Prosperity in the cement industry continued during 1921 and Michigan produced 5,777,533 barrels of cement, an increase of 886,076 barrels or 18.1 per cent. Shipments reached 5,680,156 barrels or 27.9 per cent but a decrease in value of $639,344 or 5.8 per cent. The decrease in value is due to the decreased price received per barrel, $1.81, which is $0.65 or 26 per cent less than the maximum price per barrel of 1920. Stocks on hand at the end of 1921 were greater than ever before, being 760,503 as compared with 666,389, an increase of 94,114 barrels or 14.1 per cent. This increase in production caused Michigan to advance in rank from seventh to third place, being ranked by Pennsylvania and California.

During 1922 there was a further increase in production in Michigan and in the United States. Michigan produced 6,243,805 barrels, an increase of 466,272 barrels or 11.8 per cent over the production for 1921. Shipments of Michigan cement were valued at $11,145,573, an increase over 1921 of $845,284. The total amount of cement made in the United States was reported as 115,679,412 barrels, an increase over 1921 of 17,386,412 barrels. The value of cement shipped in the United States was $207,170,430, an increase over 1921 of $26,392,015.

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 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 whenever 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 plant of the Michigan Alkali Company. All plants use coal as fuel, nine manufacture cement by the wet process and two by the dry process.

In 1920 the Petoskey Portland Cement Company erected a plant on the limestone deposits of Little Traverse Bay about two and a half miles west of Petoskey to manufacture cement from limestone of the company's holdings on Little Traverse Bay, and shale from a quarry at Ellsworth in Antrim 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 was organized and it purposed to erect a plant at Coldwater Lake near Mount Pleasant to utilize the marl beds surrounding the lakes in the manufacture of cement, but construction has not been started.

In December 1921 the Aetna Portland Cement Company which has a plant at Fenton, purchased 33 acres of land on the Saginaw River near Bay City and erected one unit of a plant which began production in 1923. It utilizes "fines" or "waste" stone from limestone quarries.

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

*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.

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896-1922.

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	2,342,973	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		3,024,676	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	3,651,094	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	4,228,879	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	2.27	4,218,429	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	4,727,768	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	22,160	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	666,389	2.46	2.02
1921	11	3	53	23,600	5,777,533	98,293,000	5.78	18.1	5,680,156	10,300,289	180,778,415	5.69	760,503	1.815	1.89
1922	12	5	60	25,550	6,243,805	115,679,412	5.39	11.8	6,349,751	11,145,573	207,170,430	5.38	759,703	1.76	1.76

*Minus sign indicates decrease.

POTASH

Though Michigan has deposits of rock salt of great extent they are not known to contain important amounts of 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 per cent 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. There was no potash produced in Michigan in 1921 or 1922.

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 unfilled. 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 Mississippian 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 about 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 trade. 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 the early days of the 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, Illinois, 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 1,597 tons in 1919 to 12,092 in 1920 and 26,558 tons in 1921. The 1922 production was 13,054 tons valued at $40,583.

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 follow in second and third place.

The character of the building activity inaugurated in 1919 and continuing through 1920, 1921, and 1922, is reflected in the production of gypsum products. In 1920 the production of mixed wall plaster decreased 14.1 per cent from the production of 1919, but in 1921 a production of 169,809 tons was reached, and in 1922 a production of 160,109 tons shows only a small decline. The production of stucco increased in 1920, decreased in 1921, and increased in 1922. Stucco production in 1922 was 72,157 tons valued at $501,595. Plaster board and tile show a considerable decrease in quantity and value. Production was 12,713 tons and the value was $245,302.

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, 1868-1922

Year.	Ground into land plaster. Tons.	Calcined sold. Tons.	Sold crude. Tons.	Total mined. Tons.	Gypsum and gypsum products. Total value.	Rank. Quantity.	Rank. Value.
Before 1868	132,043	14,285	.....	146,328	$671,022	.....	.....
1868	28,837	6,244	.....	35,081	165,208	.....	.....
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	250,524	.....	.....
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	77,500	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	6,382	60,352	700	67,433	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	34,668	238,385	541,167	1	1
1905	20,285	203,313	24,289	247,887	634,434	1	2
1906	30,220	208,715	27,517	341,736	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	394,507	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	347,286	523,926	3	4
1912	10,103	243,656	68,819	384,227	621,547	2	3
1913	9,604	278,368	60,706	423,806	721,325	3	3
1914	9,322	240,648	61,227	303,006	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	7,030	257,588	68,155	375,803	1,568,655	3	3
1918	5,892	207,059	46,008	286,768	1,761,149	4	4
1919	1,597	230,687	58,754	339,125	2,360,967	3	3
1920	12,092	261,499	73,842	382,212	3,521,028	3	3
1921	26,558	240,648	110,677	408,224	3,312,096	2	2
1922	13,054	275,885	107,708	471,355	2,843,117	.....	.....
Totals	1,317,631	6,222,684	1,543,903	10,085,229	35,394,631	.....	.....

PRODUCTION OF GYPSUM IN MICHIGAN, 1913-1922

Year.	Crude gypsum mined. Quantity.	Gypsum sold crude. To Portland cement mills. Quantity.	To Portland cement mills. Value.	As land plaster. Quantity.	As land plaster. Value.	For other purposes. Quantity.	For other purposes. Value.	Total sold crude. Quantity.	Total sold crude. Value.
	Tons	Tons		Tons		Tons		Tons	
1913	423,806	*	*	9,604	$10,222	10,320	$9,011	60,706	$55,969
1914	303,006	*	*	9,322	10,761	.....	.....	61,227	51,242
1915	389,791	*	*	9,799	9,894	*	*	69,572	63,236
1916	457,375	.....	.....	9,072	16,668	.....	.....	80,298	90,978
1917	375,803	60,846	$92,874	7,090	22,903	*	*	68,155	116,653
1918	286,768	40,314	103,621	5,892	29,876	*	*	46,008	131,438
1919	339,125	48,708	138,611	1,597	10,422	*	*	58,754	174,110
1920	382,212	52,705	148,591	12,092	54,050	*	*	73,842	268,968
1921	408,224	74,672	245,593	26,558	98,139	9,447	25,453	110,677	369,185
1922	471,355	85,275	228,982	13,054	40,583	26,120	164,198	107,708	291,295

Year.	Gypsum sold calcined. As mixed wall plaster. Quantity.	As mixed wall plaster. Value.	As stucco. Quantity.	As stucco. Value.	As boards, tile, etc. Quantity.	As boards, tile, etc. Value.	Total sold calcined.* Quantity.	Total sold calcined.* Value.	Total value.	No. mines and quarries.	No. mills.
	Tons		Tons		Tons		Tons				
1913	166,711	$437,720	95,402	$202,675	.....	.....	278,368	$865,356	$721,325	7	8
1914	163,972	475,688	83,736	173,172	.....	.....	249,648	654,599	705,841	8	8
1915	155,861	416,432	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	19,138	867,741	257,588	1,452,002	1,568,655	7	8
1918	117,902	931,725	52,132	320,761	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	230,687	2,216,257	2,360,967	7	8
1920	133,289	1,499,226	62,458	446,381	60,986	1,266,659	261,499	3,252,999	3,521,028	7	8
1921	169,809	1,662,343	57,968	298,538	22,909	807,519	240,648	2,442,911	3,312,096	7	8
1922	160,109	1,453,458	72,157	501,595	12,713	245,302	275,885	2,851,822	2,843,117	7	8

*Included in the total are values for sanded plaster, plaster of Paris, Keene's cement, dental plaster, 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 variety and are used for glazing pottery. At Grand Ledge, Eaton County, Jackson, Jackson County, Corunna, Shiawassee County; near Bay City, Bay County; and Flushing, Genesee 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, Antrim 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 shale 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 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 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 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; others reported better sales but inability to meet demands due to coal and labor scarcity; and others report businesss 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 value of drain tile decreased from 68,967 tons valued at $737,124 in 1919 to 69,225 tons valued at $690,816 in 1920.

In 1921 the total value of brick and tile products decreased by $1,063,772 or 26.7 per cent from $3,979,691 in 1920 to $2,915,919 in 1921. Common brick showed a slight decrease in quantity (3.6 per cent), production being 193,730,000 brick valued at $2,417,809, a decrease in value of $644,851 or 21.05 per cent. The decrease in value is due to the decrease in average price per thousand, from $16.42 (in 1920) to $12.47. The value of drain title decreased 44.7 per cent from $690,816 to $381,507; hollow building tile shows the greatest decrease in value, the decrease being from $25,486 in 1920 to $8,209 in 1921, a decrease of 67.7 per cent; production of vitrified brick was not reported.

In 1922 the total value of brick and tile products increased by $999,391, or 34.3 per cent, thus recovering from the decrease in 1921 to a total value of $3,915,310, which was but little less than the maximum value of $3,979,691 reported in 1920. The production of common brick, which for 1922 includes a small amount of face brick, showed a gain of 54,878,890 brick or 28.3 per cent over the 1921 production, and an increase in value of $1,195,733, or an increase over the 1921 value of 49.5 per cent. The average price per thousand increased from $12.47 in 1921 to $14.53 in 1922. The value of drain tile showed a large decrease, from $381,507 in 1921 to $169,419 in 1922, or a decrease of 44.4 per cent, continuing a steady decline which began in 1919.

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 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 Measure 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, 1899-1922

Year.	Common brick.†		Average price per M.	Vitrified Brick	Drain tile.	Fire-proofing.	Miscellaneous.*	Hollow building tile or blocks	Rank of state.	No. of firms operating.	Total value.
	Quantity.	Value.		Average price per M.	Value.	Value.	Value.	Value.			
1899	200,144,000	$933,176	$4.66	.....	$140,171	$5,900	$22,709	.....	13	196	$1,254,256
1900	180,892,000	863,250	4.77	$12.42	114,747	2,350	406	.....	17	189	1,147,378
1901	215,826,000	1,095,254	5.07	12.30	98,972	1,890	637	.....	14	180	1,497,169
1902	237,254,000	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	129,029	.....	.....	$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	206,583,000	1,178,202	5.70	13.13	314,098	.....	.....	4,250	16	142	1,703,367
1907	200,817,000	1,181,015	5.88	11.96	289,868	.....	1,000	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	1,466,381
1909	219,820,000	1,250,787	5.69	12.34	364,006	*	66,128	.....	16	122	1,947,059
1910	232,551,000	1,360,216	5.86	12.82	348,205	*	*	.....	15	118	2,015,525
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	*	13	101	2,466,606
1913	273,571,000	1,626,287	5.94	14.71	415,543	*	350,000	*	13	95	2,451,242
1914	209,154,000	1,433,216	6.67	15.59	421,941	3,752	254,280	*	10	90	2,334,872
1915	277,399,000	1,491,183	5.23	14.50	303,156	10,850	49,755	*	11	82	2,248,068
1916	279,175,000	1,856,587	6.65	14.78	348,785	2,492	216,265	.....	13	74	2,703,054
1917	236,612,000	1,882,042	7.95	17.16	734,042	.....	79,996	4,521	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	89,147	132,844	6,901	.....	.....	3,699,929
1920	186,526,000	3,062,660	16.42	18.21	690,816	*	200,729	25,486	.....	.....	3,979,691
1921	193,730,000	2,417,809	12.47	.....	381,567	.....	108,394	8,209	.....	.....	2,915,919
1922	748,608,890	3,613,542	14.53	.....	169,419	.....	126,436	5,913	.....	.....	3,915,310
Total	5,291,018,890	$37,809,782			$8,307,661						$53,098,452

*For 1919 includes also vitrified brick, sewer pipe, faience tile; in 1920 includes also face brick, faience tile, sewer pipe; and in 1921 includes faience tile, sewer pipe and other.
†For 1922 includes face brick.

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 south 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 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 quarry able 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 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 Antrim, Charlevoix, Cheboygan, and Alpena Counties, notably at East Jordan and Chestonia, near Afton, near Walloon Lake, and Central Lake, along the shore of Lake Michigan, south of Norwood, and at Paxton.

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 White Rock, 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 and Rogers, and some miles northeast of Posen, 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 some 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 Company, 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, and Chestonia have been thoroughly investigated and the results are promising. Tests have also been made on most of the other deposits. The results are to appear in a forthcoming report on the clay and shale resources of the State.

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.

PRODUCTION OF CLAY IN MICHIGAN, 1910-1922

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	.....	10,599	.....	.....	.....	.....	3,454	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
1921	484	2,047	.....	.....	208	308	692	2,355
1922	*	.....	*	*	.....	.....	1,653	4,852
Total	.....	.....	.....	.....	.....	.....	.....	$4,339

*Included in total.

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.

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.

During the past two years an investigation of the clay and shale resources has been made in co-operation with the University of Michigan. The results are to appear in a forthcoming report.

*H. Reis, Geol. Surv. Vol. VIII, pt. I, p. 48, Clays and Shales of Michigan.

†See also "Brick and Tile" and "Pottery."

POTTERY

The pottery industry in Michigan has made almost uninterrupted growth since 1899, and after 1908 the growth was rapid, increasing over 4,054 per cent in 12 years, the main increase being in the period 1916-1920. In 1899 the total value of the pottery output was $29,741; in 1908, $62,409; in 1919, $2,096,874; and $2,592,625 in 1920. The increases were largely due to the greatly increased output of porcelain electrical and sanitary supplies and porcelain and decorated ware. In 1921 production decreased to $1,781,923, a decrease of $810,702 or 25.1 per cent, and in 1922 there was a decrease to $1,337,000 or 33.3 per cent.

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 Company 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 Company of Detroit and the Ionia Pottery Company manufacture flower pots exclusively. The Mt. Clemens Pottery Company manufactures decorated ware, and the Pontiac Clay Pipe Novelty Company, 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, 1899-1922

Year.	Rank of State.	No. firms.	Red earthenware value.	Miscellaneous value.**	Total value.	Gain per cent.	Per cent of total product in U. S.
1899	18	4	$29,641	.....	$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	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	1.3	.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	89,580	*	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	658,982	792,716	51.8	1.64
1917	8	8	*	13,722	1,187,984	49.9	2.12
1918	6	8	*	88,842	1,976,136	66.3	3.00
1919	.....	8	*	12,708	2,096,874	6.1	.....
1920	.....	8	*	16,848	2,592,625	23.5	.....
1921	.....	.....	138,055	1,643,868	1,781,923	—35.1	.....
1922	.....	.....	38,000	1,299,000	1,337,000	—33.3	.....
Total	.....	.....	.....	.....	.....	.....	.....

*Included in the total.
**1920 includes art pottery, clay pipes and filter stones, 1921 and 1922 includes white ware, sanitary ware, porcelain electric supplies, and other miscellaneous ware.

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 production was only 1,201,230 tons. Production remained practically stationary until 1917, when it increased to 1,374,8,05 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; two mines suspended operations, and three were abandoned. Production in 1919 decreased to 996,545 tons valued at $3,864,228; and in 1920 production increased by 49.5 per cent to 1,489,765 tons valued at $7,346,000, the highest value attained by Michigan's annual coal output. In 1921 production again declined, 1,141,715 tons were mined, valued at $5,555,000, followed in 1922 by a further sharp decline to 929,390 tons mined, valued at $4,693,376. The price received per ton partly offset the decline from 1921 to 1922. The average price per ton in 1921 was $4.87 but increased in 1922 to $5.05. The mining cost decreased from an average of $4.43 in 1921 to an average of $3.85 in 1922. The average profit derived from these figures is $1.20 per ton in 1922 which is the highest reported profit from Michigan coal mines. The cost figures however do not include depreciation, interest on investment, etc., hence the profit factor is considerably less than indicated.

*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.

PRODUCTION OF COAL IN MICHIGAN, 1860-1922, 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
								1921	1,141,715
								1922	929,390

PRODUCTION, COST OF MINING, PROFITS, AND VALUE OF COAL IN MICHIGAN, 1900-1922

Year.	*Number active mines.	Average number employes 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. 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	2,711	6.25	971,603	3,329,815	4.43	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
1921	15	1,911	7.96	1,125,156	4,982,258	4.43	1,141,715	5,555,000	4.87	.44
1922	14	2,166	....	822,441	3,165,207	3.85	929,390	4,693,376	5.05	1.20

*Compiled and adapted, Ann. Rept. State Department of Labor and Industry.
**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.

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 began to fluctuate, declining somewhat in 1919, increasing by over 36 per cent in 1920, but declining with the slump in the steel industry in 1921. 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 war demands and war-time inflation of prices forced the total value of limestone products exclusive of lime to $5,186,867. In 1919, however, production decreased 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 56.5 per cent over 1919 and of 148.7 per cent above the pre-war maximum.

In 1921 a restriction in the production of steel resulted in a greatly reduced production of limestone so that its value for that year decreased by 43 per cent from the figure for 1920. In 1922 this condition improved, the total value of limestone was $4,533,998, indicating a gain over 1921 of 25.3 per cent. This gain is not entirely due to increased consumption of the blast furnaces but includes increases in limestone produced for crushed stone used in railroad ballast and concrete, for use in alkali works and paper mills, and for use as fertilizer.

The only marked decrease was in limestone used by the sugar factories.

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, Cheboygan, Alpena, Chippewa, Mackinac, and Schoolcraft Counties. Large deposits of high calcium limestone has been developed on an extensive scale near Rogers, Presque Isle County, and Rockport and Alpena, Alpena County. On account of its low silica content, the stone at Rogers and Rockport 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 at Bellevue, Eaton County. Undeveloped deposits occur on Heisterman's Island, Saginaw Bay; about three miles northeast of Omer, Arenac County; and about two miles northeast of Dundee, Monroe County. Deposits of uncertain commercial importance occur near the mouth of Portage River about six miles north of Jackson, and at Parma, Jackson County.

The reserves of high calcium limestone in the northern part of the State are practically inexhaustible.

Enormous deposits of very pure magnesian 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 along the west shore of Green Bay and Little Bay de Noc, Menominee and Delta Counties.

*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.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1922

Year.	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.	Tons.	Value.	Tons.	Value.
1899								$27,512				
1900								3,200				
1901		$91,605		$18,200		$75,643		13,433				
1902		56,261		40,810		49,430		32,246				
1903		61,342		35,340		48,304		15,302				
1904		58,655		57,100		60,745		62,586				
1905		112,113		63,649		107,396		109,883				
1906		78,437		103,442		61,852		91,017		$224,356		
1907		131,708		46,516		97,762		109,429		22,234		
1908		132,510		33,900		73,200		96,841		32,594		
1909		132,902		42,445		112,829		91,915		25,845		
1910		110,184		42,358		178,318		109,149		69,647		
1911	224,307	113,574	91,713	34,998	306,385	137,285	341,027	186,046		63,141		*
1912	603,553	295,449	54,327	29,368	185,423	97,298	265,941	137,812		36,944		$508,044
1913	532,311	266,316	116,000	48,400	252,616	145,965	1,202,817	494,495		38,216		329,961
1914	505,123	242,339	39,000	20,600	362,209	166,959	1,604,240	565,012		40,477		269,087
1915	482,262	194,970	60,139	19,640	398,948	217,304	2,254,984	763,029		46,143		481,759
1916	534,215	420,467	186,949	57,950	423,479	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	332,777	*	*	508,107	273,085	3,583,440	1,837,681		*		654,632
1920	688,090	460,369	154,050	122,960	884,820	578,039	4,800,400	2,963,955		*		1,031,254
1921			37,090	28,752	1,265,690	889,937	2,422,950	1,275,860				543,994
1922			38,300	33,024	1,024,110	662,781	4,812,850	2,300,692	62,070	124,678	1,127,780	842,131
*										75,961		
Total		$3,876,713		$949,012		$4,705,851		$17,071,465		$909,948		$6,076,557

*Included under concrete after 1920.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1922—Concluded

Year.	To paper mills.		Fertilizer.		Other purposes.†		Number of plants.	Rank of state.	Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.		Value.	Tons.	Value.
1899						$2,375				$281,769
1900						124,220		12		330,847
1901		$12,558		$3,003		101,399		12		429,771
1902		8,150		3,447		68,164		13		413,148
1903		10,723		7,048		4,747		14		390,473
1904		8,307	10,907	11,104		5,323		10		501,708
1905		8,629		9,746		142,700		12		544,754
1906		11,827		11,088				10		656,269
1907		24,097	62,027	58,148		378,297		11		760,333
1908		25,153	160,016	150,604		253,990		9		669,017
1909		45,706	*			327,571		11		750,389
1910		81,718	170,460	191,146		299,305		9		842,126
1911		77,859	285,960	201,251		440,857		8		1,065,731
1912		79,438	218,360	211,192	259,440	13,596		8		1,139,560
1913						395,874		7		1,408,703
1914						39,523		8		1,457,961
1915						31,529		7		1,838,766
1916						39,936		6		2,389,763
1917						97,129		5		3,320,895
1918						284,649		3		5,196,867
1919						678,936	18	5		3,797,522
1920						514,651	24	5		5,943,229
1921						245,400	24	6		3,387,722
1922	50,520	79,438				235,895			7,646,550	4,533,998
Total		$394,147		$1,097,132		$4,626,121				$41,971,542

*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 production decreased slightly, 0.8 per cent, but increased in value. Production in 1919 increased 8.1 per cent in quantity and 16.5 per cent in value, and decreased somewhat in quantity but increased in value in 1920, reaching the maximum value of $1,386,760 in the latter year.

The business depression of 1921 plus high price of coal and the high freight rates which closed markets for lime, caused Michigan to suffer more than any other State from the general decrease in lime production. The average decrease for the United States was 29.1 per cent, ranging from a decrease of 9.4 per cent in Massachusetts to 65.8 per cent in Michigan. Michigan's production was 48,164 tons valued at $445,386, decreases of 92,649 tons (65.8 per cent) in quantity and of $941,374 or 67.8 per cent in value. The production was the lowest since 1905 and Michigan dropped in rank from* eighth to fifteenth place. Lime burned was sold for building, chemical, tanning, metallurgical, and fertilizer purposes, and to paper mills, sugar factories, and dealers. The greatest decreases were in the sale of lime for chemical and metallurgical purposes and to paper mills. In 1920 of the 28 kilns operating eighteen burned wood, one coal and nine coke, but in 1921 wood was burned in the twenty-three kilns operating. Conditions were not much improved in 1922. A production of 53,635 tons valued at $484,945 was reported, an average price of $9.04. This was an increase over 1921 of 11.3 per cent in quantity and 11.2 per cent in value.

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 buildings, (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 a 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 in 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; and as stated above, the great decrease for 1921 was due to the closing of markets for the lime industry and the general depression throughout the United States. The continuance of this condition permitted but little increase in production and value of lime in 1922.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1922

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	16
1907	65,822	276,534	4.20	12	15
1908	68,050	282,023	4.14	10	13
1909	83,108	354,135	4.26	12	
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	4.46	7	13
1917	135,920	892,682	6.72	7	7
1918	134,813	1,186,097	8.79	6	6
1919	145,783	1,381,534	9.48	7	6
1920	140,813	1,386,760	9.85	7	8
1921	48,164	445,386	9.24	6	15
1922	53,635	484,945	9.04	7	16

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 convinced 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 brick made was 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 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 bricks 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 bricks of all classes in 1917 and to 22,564,000 bricks 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 bricks 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 bricks. 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 bricks of all classes, a decrease of 3,290,000 bricks or 7.7 per cent. The value of $670,744 was an increase of $127,650 or 24.8 per cent and is the highest value

recorded. The industry in 1920 was handicapped by the shortage and inefficiency of labor and 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.

Since statistics for sand-lime brick were collected by the Bureau of the Census there has been considerable delay in securing production figures and details of the industry. In 1921 a production of 33,658,000 bricks of all classes valued at $403,929 is reported. The production value shows a decrease of $236,815 or 36.9 per cent when compared with the 1920 reports. In 1922 a production of 46,558,000 at $557,647 shows a gain of 38 per cent in value over the 1921 figure.

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 bricks as any other State. The decided set back 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, Sebewaing, and Saginaw.

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1922

Year.	No. of operating firms reporting—Mich.	No. of operating firms reporting—U. S.	Michigan production. Common brick. Quantity (thousands).	Common brick. Value.	Average 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	1,225,760	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	883,929	22.5	1	1
1919...	8	35	42,063	507,010	12.05	†	†	12.00	...	...	513,094	+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...	...	...	‡33,658	...	...	...	...	...	...	...	403,929	−36.9	...	...	...	...
1922...	8	...	‡46,558	557,647	11.97	...	...	...	...	...	557,647	+38.0	...	...	...	...
Total..	...	...	701,150	$5,189,789	...	...	...	...	...	...	$5,779,703	...	...	...	...	...

*Estimated.
†Included in total.
‡Includes common and front brick.

SAND AND GRAVEL

The sand and gravel resources of Michigan are inexhaustible. The most important deposits occur in the form of ridges known as "hogbacks," 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 has 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 pebbles 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 limestone in the northern part of the Southern Peninsula. However, no tests have been made to determine the better grades of gravel in these areas and belts.

Sand and gravel have been produced in greater quantities each year since 1918. In 1919 production was 3,772,535 tons valued at $1,994,143, and in 1920 4,386,522 tons at $2,867,466 were produced. In 1921 reports total 5,515,253 tons valued at $2,916,917 and

this was followed by a further increase in 1922 to a total production of 5,962,916 tons valued at $3,222,043, an increase over 1921 of 8.1 per cent in quantity and 10.46 per cent in value.

The production of molding sand increased from 96,554 tons in 1921 to 147,546 tons in 1922, or 52.8 per cent, and the 1922 value was greater by $15,286, or 59.7 per cent. Building sand increased from 823,791 tons at $416,432 in 1921 to 858,764 tons at $445,970 in 1922, an increase of 4.2 per cent in quantity and 7.1 per cent in value. Paving sand decreased from 754,011 tons in 1921 to 731,933 tons in 1922, but the value increased from $311,341 in 1921 to $342,499 in 1922, making a decrease of 2.9 per cent in quantity but an increase of one per cent in value. Railroad ballast increased from 249,588 tons at $59,752 in 1921 to 484,112 tons at $208,311 in 1922, an increase of 93.9 per cent in quantity and 248.6 per cent in value. Gravel for road building increased from 3,416,881 tons at $1,959,610 in 1921 to 3,507,567 tons at $1,992,232 in 1922, an increase of 2.65 per cent in quantity and of 1.66 per cent in value.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1922

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	24,100	451,646	157,150	1,534	153					173,724	12,187
1908	4,584	2,802	454,238	228,395	1,991	319					29,187	6,850
1909	53,226	20,756	1,090,419	327,247	12,415	1,493					295,613	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	992,556	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	39,342
1914	53,490	36,583	1,088,650	360,152	6,357	1,066	320,322	74,866			115,291	107,393
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	350,133	*	*	154,413	35,068	*	*	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	116,488	55,255	433,497	171,888	5,174	1,322	237,317	89,630	6,163	$3,048	135,502	28,301
1919	124,006	66,877	539,860	251,733	6,958	2,268	204,045	75,228	*	*	190,327	147,247
1920	230,439	179,754	789,495	482,081	5,547	2,943	460,436	204,723			213,851	28,879
1921	96,554	25,576	823,791	416,432	3,508	1,201	754,011	311,341			137,305	35,552
1922	147,546	40,862	858,764	445,970	*	*	731,933	342,499			61,887	152,424
Totals	1,685,188	$702,305	14,291,175	$5,433,402	192,350	$37,102	3,884,017	$1,404,721			2,619,036	$1,138,115

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

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1922.—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			72,508	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	842,991	370,365	8	9
1909			695,902	200,523	2,219,757	585,632	8	8
1910			1,197,791	364,841	2,862,738	816,337	7	8
1911			935,073	203,218	2,185,165	565,969	9	10
1912			1,409,189	407,925	2,681,821	818,603	9	8
1913			3,928,874	915,305	6,422,818	1,528,892	4	5
1914	7,563	$781	2,189,359	530,338	3,757,979	1,148,771	8	7
1915			2,457,094	674,970	3,776,726	1,036,739	8	7
1916			2,226,574	726,033	4,467,475	1,295,747	7	7
1917	207,827	21,829	2,299,374	1,011,182	3,814,445	1,641,748	7	6
1918	161,552	18,314	741,681	869,316	2,537,371	1,239,874	8	6
1919	67,996	21,861	2,689,483	1,378,929	3,772,535	1,944,143	6	7
1920	233,516	61,672	2,444,006	1,958,414	4,386,582	2,867,466	8	6
1921	249,588	59,752	3,416,881	1,959,610	5,515,253	2,916,917		
1922	484,112	208,311	3,507,567	1,992,232	5,962,916	3,222,043		
Totals				$13,356,852	57,483,111	$22,132,219		

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,

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 Rockford, 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 hands and when placed in water disintegrate rapidly. At the pits of the American Silica Company east of Rockwood, Wayne County, and of the National Silica Company, Ford Plate Glass Company, 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 Company 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 pressure 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 Company, which operated them up to 1916 when its plant was burned down. The property was then sold to the Ford Plate Glass Company of Toledo, 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 Company at Steiner, Monroe County, and of the washed product from the pit of the American Silica Company 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	--

*J. E. Clark, Analyst.

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 average 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. The Rockwood Silica Company was the only producer in 1922.

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

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.

The decline of the sandstone industry in Michigan may be ascribed to 1 (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 quarry operating in the Marshall at the present time is at Grindstone City, Huron County, where the gritstones near the base of the formation are quarried for grindstones and scythestones. Formerly some rubble and riprap were 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 Company 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. In 1921 sandstone for rough building material and road metal was produced to the value of $49,270.

In 1922 sandstone produced for building stone, rough blocks, rubble, and riprap totalled 7,220 tons valued at $6,280.

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 for 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.

Until after the war Michigan ranked third 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 were but two active quarries, both located in Huron County near the end of the "Thumb." But these ceased operations during the war. The Wallace Company of Port Austin formerly operated a quarry at Eagle Mills and the Cleveland Stone Company a quarry at Grindstone City. The latter resumed operations in 1923 but the former probably has permanently abandoned its quarry operations.

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 wafers 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. There were ten commercial springs.

In 1920 production decreased 22 per cent in quantity and 8 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. In 1921 production and value of mineral waters increased from 1,227,485 gallons valued at $122,010 to 1,344,900 gallons valued at $154,405, an increase of 117,415 gallons or 9.5 per cent in quantity and of $32,395 or 26.2 per cent in value. There were nine commercial springs in 1921. In 1922 with nine producing springs Michigan again was ninth in the production of mineral waters although there was a decline from the 1921 production of 1,344,900 gallons at $154,405 to 1,229,802 gallons at $150,237, or a decrease of 8.5 per cent in quantity and of 2.7 per cent in value.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900-1922

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	3,385,075	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	75,411	777	74,634	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	6	7	9	1,344,900	154,405	.....	.....	0.114
1922	8	8	9	1,229,802	50,237	.....	.....	0.122
Total	.....	.....	.....	55,175,581	$4,191,573	.....	.....	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 Company 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 has been produced in commercial quantities by the Michigan Verde Antique Marble Company some miles north and west of Ishpeming. The marble is in a bed 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. In 1920 and 1921 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, 1920, 1921, or 1922.

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 Company manufactures graphite paint from graphitic slate (see graphite) obtained near L'Anse, Baraga County. This company discontinued mining operations in 1917.

CELESTITE

Celestite or stronium sulphate ($SrSO_4$) 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 Company 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. The utilization of trap rock for roofing granules in 1921 caused the value of the rock produced to increase from $84,273 in 1920 to $173,620, an increase of $89,347 or 106 per cent.

PRODUCTION AND VALUE OF TRAP ROCK OR BASALT IN MICHIGAN, 1911-1922

Year.	No. of producers.	Crushed stone.				Total tons.	Total value.	Rank value.
		Roadmaking.		Concrete, etc.				
		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	.....	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	18,275	22,047	.....	105,855	12
1916	8	38,193	37,475	9,601	9,715	.....	83,072	13
1917	4	50,430	64,068	*	*	.....	70,197	11
1918	4	23,686	32,605	*	*	.....	53,269	11
1919	1	.....	.....	.....	.....	.....	36,186	11
1920	4	.....	.....	.....	.....	.....	84,273	10
1921	6	17,640	22,174	.....	151,446	.....	173,620	12
1922	.....	57,730	102,884	*	*	94,560	376,788	.....
.....	.....	.....	.....	.....	.....	.....	$1,200,373	.....

*Included in total.

QUARTZ

Quartz is mined near Ishpeming, Marquette County, and ground for wood filler and paint purposes by the Michigan Quartz Silica Company of Milwaukee, Wisconsin. Some of the ground product is used in making scouring polish. 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.

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.

PETROLEUM

The usual amount of exploration for petroleum and natural gas has been completed during the year. These explorations are by small companies who are content with one or two test wells. Those interested in the companies are most often a group of property owners in the vicinity of the test well. No encouraging showings of oil or gas have been reported with the exception of the Deerfield well in Lenawee County which is mentioned below.

Since the last published notice* a second well has been completed by the Schoolcraft Development Company at Seul Choix Point, Schoolcraft County, Benjamin Gerow, Manistique, in charge. This well was continued far beyond the known oil bearing formations and penetrated the upper part of the Cambrian sandstone. No important oil showings were reported and with this test the company has abandoned operations. At Devil's Lake near Cement City the Prospect Hill Development Company, with R. R. Allerdyce in charge, has stopped operations. Very meager accounts of this well have been furnished by the company but the test was apparently completed in the upper part of the Dundee at 1,612 feet. The Thumb Oil & Gas Development Trust, J. C. Gaines in charge, completed a well near Burnside, Lapeer County, and furnished a complete set of samples which will serve as a standard of reference for the sub-surface geology of the Thumb district. No important showings of oil were obtained and the well was completed in the upper part of the Detroit River (Upper Monroe) formation at 2,627 feet. Press notices indicate that a well will be drilled near Manistee during the summer of 1924. A well completed near Deerfield, Lenawee County, by the W. K. Development Company has continued to furnish about four barrels of oil at each pumping although it has not been pumped regularly. One additional well near the producing location has been drilled by the Jackson County Oil and Gas Company, George Chrisman in charge. This well penetrated the oil

horizon and obtained a showing of oil but has not been completed. The same company completed a well at Napoleon, Jackson County, at 1,876 feet, in the Detroit River (Upper Monroe) formation without obtaining any important showing of oil or gas. The Bay City Freezer, Paul W. Peterson in charge, drilled a well in the northeastern part of Bay City and furnished a set of samples which has served as a check on the drilling already done in the vicinity. This well was completed in the Lower Marshall at 1,003 feet. It was not drilled with the hope of finding oil or gas but gives an additional point of reference in regard to the underground structure. Two other deep wells furnished important information, one at Sault Ste. Marie drilled by William Cater for the Cadillac Lumber and Chemical Company reached a depth of nearly 1,000 feet without penetrating the Cambrian formation in which it started, while one at Bay View drilled by A. Purcell for Charles Ditto penetrated the Traverse and Bell formations and was bottomed in the Dundee formation at 497 feet.

Rock samples from these wells which have been sent in by the various companies are on exhibition at the offices of this survey and are available at all times to anyone who is interested in deep drilling projects. The following records of samples submitted during the last two years and their correlation with formations in neighboring wells will offer some suggestions as to depths and drilling conditions.

The names of formations and also of the larger time-divisions as used in these records must be considered as tentative in most cases but because of the confusion which would be introduced by the use of a great number of query signs or other indications of uncertainty these have been quite generally omitted.

*Pub. 32, Mich. Geol. Surv. p. 103, 1922.

NATURAL GAS

The production of natural gas reported for 1922 was 700,000 cubic feet valued at $350.00.

The production of natural gas is confined to the extreme southeastern part of the State, and a small area near Manistee in the northwestern part, where it is developed from shallow wells in the drift. Its development is usually accidental when a water well penetrates a gas pocket. The behavior of the small wells thus completed is erratic and they are subject to a rapid decline. The source of the gas is believed to be the Antrim formation which underlies the drift in each reported well. This formation is known to contain considerable quantities of bituminous matter included in the shale and in peculiar concretions of bituminous limestone which are often seen in outcrop as large spheroidal masses sometimes three or four feet through. These masses weathered from the shale mass have given the name of Kettle Point to an Ontario locality where the half buried concretions resemble overturned kettles. There is little hope of developing production within this formation because of its dense shaly texture. The accumulations under the capping of drift clay are probably due to a fractured condition of the formation and a favorable combination of the angle of dip, which is in this case somewhat greater than normal, and the angle of the plane of erosion.