

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION

GEOLOGICAL SURVEY DIVISION

Publication 33
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MINERAL RESOURCES OF MICHIGAN

WITH

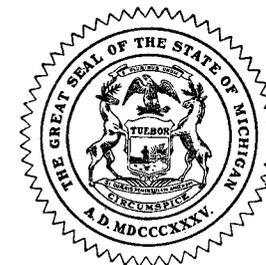
STATISTICAL TABLES OF PRODUCTION
AND VALUE OF MINERAL PRODUCTS

FOR

1921 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
AND BIOLOGICAL SURVEY FOR 1921

LETTER OF TRANSMITTAL

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

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

Gentlemen. Under authority of Act No. 7 Public Acts of Michigan Session of 1911, I have the honor to present herewith Publication 33 Geological Series 27, the tenth 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 and Biological Survey for 1921, publication of which has been delayed by delay in receiving statistics on the clay-using industries from the United States Bureau of the Census.

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

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PART I. METALLIC MINERALS

THE MICHIGAN COPPER INDUSTRY IN 1921

MICHIGAN COPPER INDUSTRY IN 1921

GENERAL STATEMENT

Michigan mines produced 92,262,083 pounds of refined copper in 1921 as against 161,343,880 pounds in 1920. The decrease in production totaled 69,081,797 pounds. The figure given above is the mine production; the smelter output totaled 100,918,001. The smelter production is the basis of statistics of the United States Geological Survey. It always differs slightly from mine production for the reason that mine figures represent copper actually mined during the calendar year, whereas smelter and refinery figures represent quantity of copper produced during the year from ore, part of which was mined at the end of the preceding calendar year.

The great decrease in production in 1921 was due to suspension of operations by the Calumet and Hecla Mining Company and subsidiaries on April first for the balance of the year. Curtailment of production was general by the larger producers throughout the country as can be noted by the following table showing the smelter output of copper in the United States during 1920 and 1921.

	1920	1921
Alaska.....	66,093,924	76,808,114
Arizona.....	552,988,731	155,165,656
California.....	11,822,028	15,906,883
Colorado.....	4,282,616	6,592,598
Georgia.....	3,663	.....
Idaho.....	1,922,116	1,971,623
Maine.....	.....	3
Michigan.....	153,483,952	100,918,001
Missouri.....	533,368	137,591
Montana.....	177,743,747	49,471,206
Nevada.....	55,580,322	15,129,116
New Mexico.....	52,159,751	18,076,909
North Carolina.....	.....	.....
Oregon.....	2,529,311	274,934
Pennsylvania.....	618,361	.....
South Carolina.....	.....	.....
South Dakota.....	2,190	.....
Tennessee.....	16,727,803	15,084,294
Texas.....	14,217	587
Utah.....	110,357,748	45,831,959
Vermont.....	.....	.....
Virginia.....	.....	.....
Washington.....	2,125,586	598,658
Wyoming.....	24,256	9,830
Undistributed.....	47,350	3,608,136
	1,209,061,040	505,586,098

The general suspension of production throughout the country in 1921 arose from the fact that production and importation of copper during

1919 and 1920 greatly exceeded demand with the result that large surplus stocks were built up and the price of copper depressed to an average of 12.5 cents per pound or below cost of operation for all except a few mines.

This special condition in the copper industry came about as a direct result of unusual expansion of production capacity during the War, and as a result the copper mines failed to benefit by the after-War boom of late 1919 and 1920 and the industrial depression of 1921 served to further aggravate an already bad situation.

The abnormal expansion of productive capacity during the War is clearly indicated in the following table which shows the production, imports and consumption of new copper in the United States for the past several years.

YEAR	Mine production of copper in U. S.	Imports into United States	Exports from United States	United States consumption of new copper
1908.....	956,840,578	218,705,487	661,876,127	480,000,000
1909.....	1,126,521,126	321,801,115	682,876,127	688,500,000
1910.....	1,088,237,432	344,435,771	708,316,543	732,400,000
1911.....	1,114,764,197	334,607,538	786,553,208	681,753,279
1912.....	1,249,094,891	410,240,295	775,000,658	775,978,332
1913.....	1,235,569,727	408,778,954	926,241,092	812,068,639
1914.....	1,148,431,437	306,350,827	840,080,922	681,917,955
1915.....	1,488,071,528	315,698,449	681,917,955	1,043,497,328
1916.....	2,005,875,312	462,335,980	784,006,486	1,429,755,266
1917.....	1,895,434,349	556,420,297	1,125,647,336	1,394,829,715
1918.....	1,910,022,841	575,805,115	744,243,481	1,661,669,576
1919.....	1,310,541,529*	429,387,594	515,595,019	914,471,572
1920.....	1,209,061,043*	485,670,691	623,158,489	1,053,838,538
1921.....	466,000,000	350,472,611	609,038,352	610,988,744

*Smelter Production. (It differs but slightly from mine production.)
From statistics United States Geological Survey.

A study of the facts in the above table is conclusive evidence that the productive capacity is much in excess of consumption and there is reason to believe that in spite of a normal increment of increased consumption this condition will still exist for a number of years. Under such conditions the selling price of copper is bound to be low and in direct ratio to the capacity of production of the low cost operations

DETAILS OF COMPANY OPERATIONS OF PRODUCING COMPANIES

Ahmeek Mining Company

Office: 12 Ashburton Place, Boston, Massachusetts.

Mine office: Calumet, Michigan.

This property operated during January, February and March and closed on April first for the balance of the year.

Before the mine closed the cross cut from the 17th level drift on the fissure north of No. 2 shaft was extended 186 feet toward the Kearsarge conglomerate. About 200 feet more will be necessary to intersect and

explore this lode. At No. 1 shaft exploratory drifts were extended south into the faulted area and some medium grade lode was opened up. A small lake overlying the lode south of No. 1 shaft was drained by ditching, eliminating chance of flooding from a possible cave at this point.

The summary of the company's operations as given in their annual report is as follows:

Copper product for the year (Jan. 1—Mar. 31 only).....6,255,200 lbs

PRODUCTION COSTS

Mining.....	7.59 c. per lb.	\$ 474,570.09
Smelting and refining.....	2.02 " " "	126,559.83
Boston office and mine and corporation taxes.....	.68 " " "	42,551.10
Depreciation and Depletion.....	4.27 " " "	267,127.14
Production cost of.....	6,255,200 lbs. at 14.56 " " "	\$ 910,808.16
*On hand Jan. 1, 1921.....	17,003,646 " " "	2,210,473.98
	23,258,846 " " "	\$3,121,282.14
Sold in year.....	13,366,746 " " "	1,737,676.98
	9,892,100 " " "	\$1,383,605.16
Add to bring to market value.....	1,288.84	
On hand Dec. 31, 1921.....	9,892,100 " " "	\$1,384,894.00

EARNINGS STATEMENT

Received for copper sold.....	13,366,746 lbs. at 12.86 c. per lb.	\$1,718,341.58
Cost of copper sold.....		
Production cost at 13.00 c. per lb.....	\$1,737,676.98	
Selling and delivery cost at .57 c. per lb.....	76,008.57	1,813,685.55
Loss on copper sold.....	.71 " " "	\$ 95,343.97
Gain by increase to market value as above.....		1,288.84
Maintenance Costs (Apr. 1—Dec. 31)		
Mine.....	\$186,283.71	
Boston office and mine and corporation taxes.....	132,484.57	
Depreciation.....	21,027.58	339,795.86
Miscellaneous Costs		
Loss by sale of Liberty Loan Bonds, Government copper, etc.	\$ 98,704.29	
Miscellaneous Credits		
Interest, Silver, etc.....	75,519.45	23,184.84
Loss for year.....		\$ 457,035.83
Capital Assets increased		
Plant—New Construction.....	\$6,176.40	
Obsolescent.....	100.00	\$6,076.40
Real Estate.....	1,200.00	
Net increase in Capital Assets.....		7,276.40
Increase in Reserves for Depreciation and Depletion.....	\$288,154.72	\$ 464,312.23
Less decrease by obsolete construction.....	45.42	288,109.30
Decrease in Balance of Current Assets.....		\$ 176,202.93
†Balance of Current Assets December 31, 1920.....		3,255,677.97
" " " " " 31, 1921.....		\$3,079,475.04
*Copper on hand as in Annual Report for 1920.....	17,562,725 lbs.	\$2,283,154.25
Less transferred to copper sold, not delivered, by Federal adjustments.....	559,079 "	72,680.27
Revised copper on hand Dec. 31, 1920, as above.....	17,003,646 "	\$2,210,473.98
†Balance of Current Assets as in Annual Report for 1920.....	\$3,235,288.83	
Increased by Federal adjustments.....	20,389.14	
Revised Balance of Current Assets Dec. 31, 1920, as above.....	\$3,255,677.97	

MINERAL RESOURCES OF MICHIGAN

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

	1918	1919	1920	1921
Tons of rock treated.....	1,196,541	756,870	822,192	212,170
Cost of mining, transportation, stamping and taxes per ton of rock.....	\$2.18	\$2.59	\$2.62	\$3.77
Pounds of refined copper produced.....	24,851,235	17,223,111	20,489,438	6,255,200
Pounds of refined copper per ton of rock treated.....	20.8	22.8	24.9	29.48

Total Depth of Shafts

No.	Shaft	Feet below the 22nd level, 2,799 feet from surface.	27th	24th	22nd
No. 1	43	3,683			
No. 2	70	3,258			
No. 3	281	2,971			
No. 4	146.5				

SUMMARY OF RESULTS

	1918	1919	1920	1921
Tons of rock hoisted.....	1,204,936	772,357	847,921	217,003
Tons of rock house discard.....	8,395	15,487	25,729	4,833
Percentage of discard.....	0.697	2.005	3.034	2.227

†This figure includes all maintenance charges and proportion of mine taxes, from April 1st to December 31st, amounting to \$1.37 per ton.

Arcadian Consolidated Copper Company

Office: Houghton, Michigan

This is a development project and is not on a producing basis. Active exploration during the year consisted of shaft sinking and drifting north and south. One shaft is 1,850 feet deep and the other 1100 feet. About thirty-five men were employed.

Baltic Mining Company
(See Copper Range Company)

Calumet & Hecla Mining Company

Office: 12 Ashburton Place, Boston, Massachusetts.

Mine office. Calumet, Houghton County, Michigan.

The Calumet conglomerate and the regrinding plant at Torch Lake operated until April first and then closed down for the balance of the year. No mining operations were carried on during the year on the Osceola Lode.

At the Red Jacket shaft branch the haulage level was driven 65 feet and the cross cut to intersect the Kearsarge lode was advanced 407 feet to the footwall of what is supposed to be that lode. Drifts in this lode were extended 262 feet north and 210 feet south of the cross cut. In the south drift about 120 feet showed some copper but not of commercial quantity. At the end of the south drift crosscuts east and west for a total distance of 80 feet were negative.

The details of operation during the year as given in the company's annual report are as follows:

MICHIGAN COPPER INDUSTRY IN 1919-1920

Copper product for the year (Jan. 1—Mar. 31 only)..... 15,167,136 lbs

PRODUCTION COSTS

Mining.....	9.72 c. per lb.	\$1,473,607.83
Smelting and refining.....	2.88 " " "	436,937.08
Boston office and mine and corporation taxes.....	.87 " " "	132,106.04
Depreciation and Depletion.....	5.63 " " "	854,385.10
Production cost of.....	15,167,136 lbs. at 19.10 " " "	\$2,897,036.05
On hand Jan. 1, 1921.....	47,058,301 " " "	6,117,579.13
	62,225,437 " " "	\$9,014,615.18
Sold in year.....	38,361,246 " " "	4,986,961.98
	23,864,191 " " "	\$4,027,653.20
Less to reduce to market value.....	686,666.46	
On hand Dec. 31, 1921.....	23,864,191 " " "	\$3,340,986.74

EARNINGS STATEMENT

Received for copper sold.....	38,361,246 lbs. at 12.91 c. per lb.	\$4,951,164.42
Cost of copper sold.....		
Production cost at 13.00 c. per lb.....	\$4,986,961.98	
Selling and delivery cost at .58c. per lb.....	221,934.70	5,208,896.68
Loss on copper sold.....	.67 " " "	\$ 257,732.26
Loss by reduction to market value as above.....		686,666.46
		\$ 944,398.72

Maintenance Costs.....		
Mine.....	\$869,004.98	
Boston office and mine and corporation taxes.....	403,439.33	
Depreciation.....	230,276.94	1,502,721.25
Miscellaneous Credits.....		
Dividends from other companies.....	\$ 93,151.70	
Interest and silver sales.....	281,669.91	
Gain from sales of Calumet Transportation Co. stock, C. E. A., Inc., notes, etc.....	841,947.71	\$1,216,769.32

Miscellaneous Costs.....		
Examination, depreciation, loss on Govt. copper, etc....	260,909.12	955,860.20
Loss for year.....		\$1,491,259.77

Capital Assets.....		
Increased.....		
New construction.....	\$511,926.64	
Obsolescent.....	500.00	
	\$511,426.64	
Copper Canyon Mg. Co. stock.....	16,387.50	
Copper Mines Information.....	113.62	
Stumpage and timber lands.....	11,231.41	\$539,159.17
Decreased.....		
Calumet Trans. Co. stock.....	\$348,511.00	
Mineral and other lands.....	15,000.00	
Copper Export Assn. stock.....	10,000.00	
Mutual W. L. & P. stock.....	563.83	
Stamp mill patents.....	4,922.22	378,997.05

Net increase in Capital Assets..... 160,162.12

Increase in Reserve for Depreciation and Depletion..... \$1,084,662.04

Less decrease by obsolete Construction..... 170.00

Decrease in balance of Current Assets..... \$ 566,929.85

Balance of Current Assets Dec. 31, 1920..... 12,901,087.65

Balance of Current Assets Dec. 31, 1921..... \$12,334,157.80

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

YEAR ENDING DECEMBER 31	1918	1919	1920	1921
Tons of rock treated.....	2,876,392	1,830,760	1,560,240	261,320
Mine cost per ton of rock (excluding construction).....	\$3.07	\$3.85	\$4.22	*\$8.85
Pounds of refined copper produced from mine.....	58,722,969	43,766,194	43,489,643	9,865,400
Pounds of copper per ton of rock.....	20.42	23.91	27.87	37.75

*This figure includes all maintenance charges and proportion of mine taxes, from April 1st to December 31st, amounting to \$4.02 per ton.

CONGLOMERATE LODE

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

YEAR ENDING DECEMBER 31	1918	1919	1920	1921
Tons of rock treated.....	1,547,603	1,111,080	978,000	261,320
Mine cost per ton of rock (excluding construction).....	\$4.09	\$4.87	\$5.16	*\$8.85
Pounds of copper produced.....	43,329,816	32,895,816	34,324,660	9,865,400
Pounds of copper per ton of rock.....	28.00	29.61	35.10	37.75
Shaft sinking.....	33 feet	1,437 feet	1,505 feet	427 feet
Drifting.....	7,149 "	3,375 "	153 "	508 "
Crosscuts and footwall drifts.....	3,659 "	4,154 "	2,361 "	726 "

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.....	3,419.0 " to 35th 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.....	8,016.7 " 79 feet under 81st level.
South Hecla No. 8.....	2,188.0 " to 23d 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.....	29.5 " below the 18th level, 15,223 feet from surface.
Tamarack No. 3 (inclined).....	129.0 " below the 24th level, 737 feet below the 18th level.
Tamarack No. 5.....	147.0 " below the 40th level, 5,308.5 feet from surface.

* This figure includes all maintenance charges and proportion of mine taxes from Apr. 1 to Dec. 31, amounting to \$4.02 per ton.

Champion Copper Company
(See Copper Range Company)

Copper Range Company

Office: 82 Devonshire Street, Boston, Mass.

Mine office: Painesdale, Michigan.

This company owns the Baltic Mine and has a controlling interest in the Trimountain Mining Company, the Atlantic Mining Company and the Copper Range Railroad Company. The Copper Range owns one-half of the stock of the Champion Copper Company, the other half being owned by St. Mary's Mineral Land Company. The Champion Mine is operated by the Copper Range organization.

The financial report of the Copper Range Company for the year 1921 is as follows:

CURRENT ASSETS AND TOTAL LIABILITIES, DECEMBER 31, 1921.
(INCLUDING SUBSIDIARY MINING COMPANIES.)

Assets		
Cash.....		\$299,528.72
United States Liberty Loan Bonds.....		1,979,000.00
Federal Land Bank Bonds.....		54,000.00
Copper delivered and not paid for.....		378,023.12
Copper on hand.....		2,129,499.65
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.....	\$546,767.14	
Cash at mines.....	71,955.55	
		618,722.69
Accounts receivable.....		247,412.39
Insurance prepaid.....		1,251.65
Miscellaneous securities.....		47,743.62
		\$7,058,148.13
Liabilities.		
Current indebtedness at mines.....	\$142,497.40	
Accounts payable.....	19,340.06	161,837.46
		\$6,896,310.67
Less one-half Champion.....		1,220,855.95
Net excess of assets.....		\$5,675,454.72

The Copper Range Company now holds in its treasury the following:

97,231 shares Atlantic Mining Company stock.
99,690 shares Trimountain Mining Company stock.
50,000 shares Champion Copper Company stock.
42,443 shares Copper Range Railroad Company, entire stock issued.

31,753,738 lbs. of copper sold for.....		\$4,205,558.72
916,000 lbs. unsold estimated at 13 c.....		119,080.00
32,699,738 lbs. produced. Average price 13.238 c. per pound.....		\$4,324,638.72
Interest.....		127,395.45
Atlantic Mining Company income from rents, interest, etc.....		5,271.81
		\$4,457,305.98
Mining expense, exploration, smelting, freight, sales department and all other expenses.....		3,683,752.77
		\$773,553.21
Taxes paid by mining companies.....		301,679.65
		\$471,873.56
Operating income of Copper Range Railroad Company.....	\$240,800.84	
Less interest on bonds.....	114,000.00	126,800.84
		\$598,674.40
Deduct one-half of net mining profit of Champion Copper Company which belongs to the St. Marys Mineral Land Company.....		363,489.11
Operating Income.....		\$235,185.29

Baltic Mine

The Baltic Mine was operated during the entire year and produced 7,608,847 pounds of copper at a total cost of 14.15 cents per pound exclusive of depreciation and depletion. The main lode produced two-thirds and Number 2 shaft hoisted 70 per cent of total rock stamped. The top levels north of Number 5 shaft on both main and west lode contributed about one-fifth of the tonnage. The openings at the extreme south end of the lower levels of Number 2 shaft continue in ground of fair quality. Drifting in the bottom of Number 3 shaft on the 39.50 level is being carried on to explore the area at depth.

The statement of receipts and expenditures at this mine is as follows:

Receipts.		
7,395,419 lbs. copper sold for.....		\$967,321.49
213,428 lbs. unsold estimated at 13 c.....		27,745.64
7,608,847 lbs. produced. Average price 13.078c. per lb.....		\$995,067.13
Expenditures		
Running expenses at the mine, and taxes.....	\$960,982.45	
Smelting, freight, cost of marketing copper and general expense.....	115,753.63	1,076,736.08
Deficit.....		\$ 81,668.95
Expended for construction.....		16,534.62
		\$ 98,203.57

Champion Copper Company

The product for the year of the Champion Mine was 531,780 tons, yielding 20,719,307 pounds of copper or an average of 39.018 pounds per ton. This mine was in continuous operation.

The financial statement from the annual report is as follows.

STATEMENT OF OPERATIONS FOR THE YEAR 1921

Receipts.	
20,138,563 lbs. copper (including silver) sold for.....	\$2,686,295.46
580,744 lbs. unsold, estimated at 13c.....	75,496.72
20,719,307 lbs. produced. Average price 13.329c. per lb.....	\$2,761,792.18
Interest.....	24,812.24
	\$2,786,604.42
Expenditures.	
Running expenses at the mine, and taxes.....	\$1,683,237.27
Smelting, freight, cost of marketing copper and general expenses.....	383,411.64
	2,066,648.91
Net Profit.....	\$ 719,955.51
Surplus, December 31, 1920.....	1,721,756.39
Surplus, December 31, 1921.....	\$2,441,711.90

CURRENT ASSETS AND TOTAL LIABILITIES, DECEMBER 31, 1921

Assets	
Cash in Boston.....	\$ 171,927.01
Copper on hand.....	1,319,868.69
Copper delivered and not paid for.....	378,023.12
Michigan Smelting Company stock.....	110,000.00
Supplies at mine.....	\$215,844.40
Cash at mine.....	16,650.47
	232,494.87
Accounts receivable.....	330,292.84
Insurance prepaid.....	656.58
	\$2,543,263.11
Liabilities	
Indebtedness at mine.....	\$85,524.78
Accounts payable.....	16,026.43
	101,551.21
Excess assets.....	\$2,441,711.90

Trimountain Mining Company

The Trimountain Mine operated throughout the year and produced 143,172 tons of stamp rock yielding 4,341,584 pounds of copper or an average of 30.32 pounds per ton. A full development program was carried on during the year, the number of feet exceeding that of the year before. The new opening at the bottom of No. 2 shaft shows improvement over the levels above while the ground opened up at No. 4 shaft is not up to the average of that on levels above a few years ago.

The financial statement of this company is as follows:

STATEMENT OF OPERATIONS FOR THE YEAR 1921

Receipts	
4,219,756 lbs. copper sold for.....	\$551,941.77
121,828 lbs. unsold estimated at 13c.....	15,837.64
4,341,584 lbs. produced. Average price 13.078c. per pound.....	\$567,779.41
Interest.....	41,760.30
	\$609,539.71
Expenditures	
Running expenses at the mine, and taxes.....	\$714,676.89
Smelting, freight, cost of marketing copper and general expenses.....	78,423.32
	793,100.21
Deficit.....	\$ 183,560.50
Surplus December 31, 1920.....	1,626,238.08
Surplus December 31, 1921.....	\$1,442,677.58

CURRENT ASSETS AND TOTAL LIABILITIES, DECEMBER 31, 1921

Assets	
Cash.....	\$ 9,622.73
United States Liberty Bonds (par (\$1,000,000)).....	993,000.00
Copper on hand.....	281,026.30
Copper delivered and not paid for.....	50,277.08
Michigan Smelting Company stock.....	110,000.00
Supplies at mine.....	\$146,108.79
Cash at mine.....	8,428.06
	154,536.85
Accounts receivable.....	70,559.79
Insurance prepaid.....	128.65
	\$1,669,151.40
Liabilities	
Indebtedness at mine.....	\$ 49,122.32
Accounts payable.....	177,351.50
	226,473.82
Excess of assets.....	\$1,442,677.58

Atlantic Mining Company.

Property has been idle for many years. Interest on surplus and rents is more than sufficient to care for current expenses. The financial statement is as follows:

STATEMENT OF RECEIPTS AND EXPENDITURES FOR THE YEAR 1921

Receipts	
Rents, sundry credits, etc., at the mine.....	\$ 6,000.76
Interest.....	10,799.67
	\$16,800.43
Expenditures	
Superintendence and labor.....	\$3,375.58
Supplies.....	1,621.81
General expenses at mine, including taxes and insurance.....	5,047.67
Franchise and Capital Stock Taxes.....	1,422.00
Eastern office expenses.....	61.56
	11,528.62
Gain from year's operation.....	\$ 5,271.81
Insurance received against fire losses.....	\$1,534.78
Sale of second-hand material at mine.....	2,860.61
Timber sales.....	3,346.00
	7,741.39
Surplus December 31, 1920.....	416,511.49
Surplus December 31, 1921.....	\$429,524.69

CURRENT ASSETS AND TOTAL LIABILITIES, DECEMBER 31, 1921

Assets	
Cash on deposit.....	\$287,404.66
Michigan Smelting Company stock.....	40,000.00
Mine supplies.....	\$34,437.41
Mine accounts receivable.....	43,722.72
Mine cash.....	22,890.75
	101,050.88
United States securities.....	966.62
Insurance prepaid.....	265.53
	\$429,687.69
Liabilities	
Accounts payable.....	163.00
Excess of assets.....	\$429,524.69

Isle Royale Copper Company
Office: 12 Ashburton Place, Boston, Mass.
Mine office: Houghton, Michigan.

In common with other subsidiaries of the Calumet & Hecla, the Isle Royale Mine was closed on April first for the balance of the year. Production for the year came principally from No. 4 and 5 shafts with a small amount from No. 1 and No. 6.

Mr. James E. Richards, Superintendent of Isle Royale Mine, died on May 1st. Mr. Richards was connected with the company for twenty-four years, first as Master Mechanic and later as Superintendent.

The general financial and production statement from the annual report is as follows:

Copper product for the year (Jan. 1—March 31 only)..... 2,491,000 lbs

PRODUCTION COSTS

Mining.....	11.22 c. per lb.	\$279,595.17
Smelting and refining.....	4.65 " " "	115,893.33
Boston office and mine and corporation taxes.....	1.24 " " "	30,697.74
Depreciation and depletion.....	3.46 " " "	86,199.34
Production cost of.....	2,491,000 lbs. at 20.57 " " "	\$512,385.58
*On hand Jan. 1, 1921.....	8,172,284 " " "	1,062,396.92
	10,663,284 " " "	\$1,574,782.50
Sold in year.....	6,607,163 " " "	858,931.19
	4,056,121 " " "	\$715,851.31
Less to reduce market value.....	17.65 " " "	147,994.37
On hand Dec. 31, 1921.....	4,056,121 " " "	\$567,856.94

EARNINGS STATEMENT

Received for copper sold.....	6,607,163 lbs. at 12.86 c. per lb.	\$849,593.94
Cost of copper sold		
Production cost at 13.00 c.....	858,931.19	
Selling and delivery cost at 58 c.....	38,536.71	13.58 " " "
		897,467.90
Loss on copper sold.....	.72 " " "	47,873.96
Loss by reduction to market value as above.....		147,994.37
Maintenance Costs (Apr. 1—Dec. 31)		
Mine.....	\$111,987.22	
Boston office and mine and corporation taxes.....	98,514.82	
Depreciation.....	15,227.44	225,729.48
		\$421,597.81
Miscellaneous Credits		
Interest, silver, etc.....	\$ 68,873.01	
Miscellaneous Costs		
Losses by sale of Liberty Loan Bonds, Government copper, etc.....	30,644.65	38,228.36
Loss for year.....		\$383,369.45
Capital Assets		
Increased—Plant New Construction.....	\$7,442.68	
Obsolescent.....	2,459.95	
Net increase in Capital Assets.....		4,982.73
Carried forward.....		\$388,352.18
*Copper on hand as in Annual Report for 1920.....	8,960,848 lbs.	\$1,129,810.24
Less transferred to copper sold, not delivered by Federal adjustments.....	518,564 lbs.	67,413.32
Revised copper on hand Dec. 31, 1920, as above.....	8,172,284 lbs.	\$1,062,396.92

Brought forward.....		\$388,352.18
increase in Reserves for Depreciation and Depletion.....	\$101,426.78	
Less decrease in Reserve for Depreciation by Obsolete construction.....	1,509.23	99,917.55
Decrease in Balance of Current Assets.....		\$ 238,434.63
*Balance of Current Assets December 31, 1920.....		1,624,992.45
Balance of Current Assets December 31, 1921.....		\$1,336,557.82

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

	1918	1919	1920	1921
Tons of rock treated.....	974,508	724,667	591,971	116,576
Cost of mining, transportation, stamping and taxes per ton of rock.....	\$2.14	\$2.35	\$2.73	\$4.25
Pounds of refined copper produced.....	15,442,508	13,007,647	10,621,801	2,491,000
Pounds refined copper per ton of rock treated.....	15.9	17.95	17.94	21.37
*Balance of Current Assets as in Annual Report for 1920.....			\$1,684,195.95	
Decreased by Federal adjustments.....			59,203.50	
Revised Balance of Current Assets Dec. 31, 1920, as above.....			\$1,624,992.45	

†This figure includes all maintenance charges and proportion of mine taxes from April 1st to December 31st, amounting to \$1.63 per ton.

Mayflower-Old Colony Copper Company

Office: 70 State Street, Boston, Mass.
Mine office: Houghton, Michigan.

This is an active exploration in Houghton County. Active development was carried on on the 1400 and 1709 foot levels, and according to company officials a considerable amount of commercial grade ore has been opened up. Explorations to date have indicated rather complex faulting.

Mohawk Mining Company

Office: 15 William Street, New York.
Mine office: Mohawk, Keweenaw County.

The Mohawk Mine was active throughout the year. The statement of results from the company's annual report is as follows:

Rock hoisted.....	703,260 tons
Rock stamped.....	688,273 tons
Product of mineral.....	21,243,386 pounds
Product of refined copper.....	14,054,235 pounds
Yield of rock treated per ton.....	20.42 pounds
Cost per ton of rock hoisted.....	\$1.857
Cost per ton of rock stamped.....	\$1.897
Total operating cost per pound of refined copper.....	9.292 c.
Cost of taxes (exclusive of Income and Profits Taxes).....	.526 c.
Cost of smelting, freight and marketing product, including Eastern Offices' expenses.....	1.620 c.
	11.438 c.
Depletion of ore bodies.....	3.321 c.
Depreciation of equipment, etc.....	.839 c.
Total cost per pound of refined copper.....	15.598 c.

PROFIT AND LOSS ACCOUNT

Sales:		
10,011,572 pounds of copper at 12.98 cents		\$1,299,776.17
Cost of Sales:		
Copper on hand January 1, 1921, at cost	\$ 378,506.67	
Operating expenses at mine as per statement hereafter	1,305,881.67	
Smelting, freight and New York and Boston expenses	227,637.70	
Taxes, exclusive of Income and Profit Taxes	73,972.35	
	\$1,985,998.39	
Less: Copper on hand Dec. 31, 1921, at cost	928,071.88	
Net cost of copper sold		\$1,057,926.51
Profit on sales of copper		\$241,849.66
Miscellaneous Income:		
Dividends and Interest, net	\$ 40,865.12	
Rents received, etc., net	23,180.02	
	\$ 64,045.14	
Deduct: Loss on sale of Liberty Loan bonds	35,623.00	
		28,422.14
Profit for the year, before providing for Depreciation, and Depletion	\$	270,271.80

CAPITAL INVESTMENTS

During the Year Ending December 31, 1921

Electric pumps	\$12,820.81
New stack	10,908.92
Water lines to houses	16,635.03
Miscellaneous	3,691.26
	\$44,056.02
Less: Items disposed of	6,152.17
	\$37,903.85

STATEMENT OF WORKING EXPENSES AT THE MOHAWK MINE
For the Year Ending December 31, 1921

UNDERGROUND EXPENSES		
Mining	\$132,036.45	
Timbering, tramming and all other labor	246,724.85	
Hoisting	41,346.52	
Compressor and drills	103,884.23	
Power, electric light and telephones	62,536.54	
Supplies, teaming, etc.	155,501.02	
		\$ 742,029.61
SURFACE AND ADMINISTRATION		
Superintendence and labor	\$ 20,649.28	
Rock houses	34,263.16	
Insurance	7,098.65	
Industrial accident	4,461.12	
Incidentals	816.90	
Power, electric light and telephones	1,129.00	
Supplies and teaming	4,566.43	
Employees' insurance	9,156.39	
		82,140.93
TRANSPORTATION		
Freight and express	\$207,722.61	
Labor	2,034.51	
Supplies, teaming, etc.	449.76	
		210,206.88
STAMP MILL		
Labor	\$ 78,432.91	
Fuel	150,743.88	
Sand conveyor	12,503.11	
Maintaining sprinkler system	405.51	
Power and electric light	1,079.00	
Supplies, teaming, etc.	29,852.64	
	\$273,017.05	
Less: Credits for custom stamping, etc.	1,512.80	
		271,504.25
		\$1,305,881.67

The lower average yield per ton of copper compared to the three previous years is due principally to increase in operation at No. 1 shaft territory where average recovery has been from four to five pounds less per ton than in the southern part of the mine tributary to Nos. 4, 5 and 6 shafts.

Quincy Mining Company

Office: 32 Broadway, New York.

Mine office: Hancock, Michigan.

The Quincy operated during the entire year. A total of 767,100 tons of stamp rock was mined and the yield of copper was 22.12 pounds per ton. The new regrinding section produced 2,035,000 pounds of copper. Owing to the fact that only four of the five units at No. 1 stamp mill are equipped with regrinding machinery 119,000 tons of stamp rock did not receive this treatment. No. 2 stamp mill was closed on January 4th for the balance of the year. At the smelter the construction of the new furnace was completed and cast its first copper during July.

At the mine the physical conditions are stated to be practically unchanged.

The financial statements in the company's report are as follows:

The product of the mine was 29,021,930 pounds of mineral, yielding 16,960,265 pounds of refined copper for which has been realized	\$2,227,994.47
Profit on silver	60,744.46
	\$2,288,738.93
Mining expense	\$1,813,005.05
Opening mine expense	170,766.77
Taxes paid in Michigan	103,657.14
Capital Stock Tax	10,231.00
Smelting, transportation, etc.	300,397.01
	\$2,398,056.97
Leaves deficit	109,318.04
Interest receipts	6,608.31
Sales of real estate, Hancock, Michigan	5,795.00
	12,403.31
	96,914.73
Construction	147,029.85
Accident account	24,000.00
	171,029.85
Deficit	\$267,944.58

STATEMENT

of income and expenditures for 1921, 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.

Receipts		January 1, 1922.
Sales of copper and silver		\$2,288,738.93
Interest		6,608.31
		\$2,295,347.24
Expenses		
All expenses, including accident account and taxes other than Federal Income Tax	\$2,422,056.97	
Depreciation of equipment	184,453.46	
Depletion of ore bodies	427,025.42	
		\$3,033,535.85
Net deficit for 1921		\$738,188.61

STATEMENT

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

Assets		January 1, 1922.
Cash, copper and investments.....		\$1,657,321.40
Accounts receivable, New York.....	\$ 97,165.85	
" " at mine.....	20,693.09	
" " at smelting works.....	276.77	
		118,135.71
At mine and smelting works		
Supplies.....	\$341,479.73	
Timber lands.....	11,421.11	
Teams and auto trucks.....	7,135.00	
Construction account.....	573,644.61	
		933,680.45
		\$2,709,137.56
Liabilities		
Accounts payable in New York.....	\$624,918.95	
" " at mine.....	97,042.43	
" " at smelting works.....	5,231.60	
Michigan taxes payable January 10, 1922.....	84,466.75	
Opening mine reserve.....	91,314.00	
Fire insurance.....	116,339.05	
Accident.....	78,503.94	
		1,097,816.72
		\$1,611,320.84

Seneca Copper Corporation

Office: 11 Broadway, New York.

Mine office: Calumet, Michigan.

This property is still in the development stage and the only mining was incidental to this work. Fourteen thousand, three hundred ninety-seven tons were stamped at the Baltic mill and yielded 466,323 pounds of copper or an average of 32.388 pounds per ton. Number 1 shaft is now down 52 feet below the 7th level to a total depth of 2,540 feet. New openings for the year totaled 11,085 feet. At the Gratiot Mine of the Gratiot Mining Company a subsidiary of the Seneca, operations were suspended from February 9th to October 10th. During the active period 1,468 feet of new openings were cut. In May the Seneca Copper Corporation agreed to purchase the interest of the Hancock Consolidated Mining Company in the Lake Milling, Smelting & Refining Company. This arrangement assures Seneca ample milling facilities without the necessity of building a railroad and constructing a stamp mill upon the site acquired on the shore of Lake Superior.

Trimountain Mining Company
(See Copper Range Company)

Victoria Copper Mining Company
Office: 60 Congress Street, Boston, Mass.
Mine office: Rockland, Ontonagon County.

The Victoria Mine was active until the latter part of April when operations were suspended for the balance of the year. The only pro-

duction in Ontonagon County came from this mine. The product for the year was 20,400 tons of rock stamped, yielding 273,916 pounds of copper. The financial statement for 1922 is as follows:

STATEMENT OF CASH RECEIPTS AND EXPENDITURES
For the Year Ended December 31, 1921

Receipts	
Cash on hand January 1, 1921.....	\$3,509.92
Sales copper 740,139 lbs.....	95,112.12
Assessment No. 7.....	62,995.00
Sundries.....	10.64
Total Receipts.....	\$161,627.68
Expenditures	
Notes payable.....	\$79,000.00
Interest.....	3,133.04
Freight, smelting, brokerage.....	8,922.75
Office expenses—salaries, rent, etc.....	8,484.46
Legal expenses.....	1,449.99
Taxes paid at Boston.....	718.10
Payment account forfeited stock.....	39.76
Remittances to mine.....	52,060.87
Cash on hand December 31, 1921.....	7,818.71
	\$161,627.68

CURRENT ASSETS AND LIABILITIES
December 31, 1921

Assets	
Cash at Boston.....	\$ 7,818.71
Copper on hand, 1920 and 1921 production.....	93,557.48
Cash at mine.....	844.65
Supplies and stock in store at mine.....	38,054.54
Assessment No. 7 unpaid.....	37,005.00
	\$177,280.38
Liabilities	
Accounts payable.....	\$ 28,042.90
Balance of assets.....	\$149,237.48

Wolverine Copper Mining Company

Office: 15 William St., Boston, Mass.

Mine office: Calumet, Michigan.

The fiscal year of this company ends June 30. During the year ending June 30, 1922, this mine was operated continuously. Approximately 40 per cent of the total tonnage hoisted came from cutting out the footwall in old stopes. The details of production and financial statement are as follows:

SUMMARY OF RESULTS FOR THE YEAR

Rock hoisted.....	296,919 tons
Rock stamped.....	290,419 tons
Product of mineral.....	6,829,590 pounds
Product of refined copper.....	3,924,270 pounds
Yield of rock treated, 13,512 lbs. per ton or.....	.675 per cent
Cost per ton of rock hoisted.....	\$1.561
Cost per ton of rock stamped.....	\$1.585
Total operating cost per pound of refined copper.....	11.812 c.
Cost of smelting, freight and marketing product, including Eastern Offices' expenses.....	1.562 c.
Cost of taxes.....	.627 c.
	14.001
Depletion of ore bodies.....	4.249 c.
Depreciation of Equipment, etc.....	.843 c.
Total cost per pound of refined copper.....	19.093 c.

PROFIT AND LOSS ACCOUNT
For the Year Ending June 30, 1922.

Sales:		
3,386,972 pounds of copper at 13.187 cents.....		\$446,626.51
Cost of Sales:		
Copper on hand July 1, 1921.....	\$172,956.55	
Operating expenses at mine, as per statement hereafter.....	463,542.14	
Smelting, freight and New York and Boston expenses.....	61,277.51	
Taxes.....	24,603.43	
	\$722,379.63	
Less: Copper on hand June 30, 1922.....	230,303.25	
		492,076.38
Loss on sales of copper.....		\$ 45,449.87
Add:		
Interest paid.....	\$ 2,237.98	
Less: Interest, etc., received.....	1,545.75	
		692.23
Operating loss for the year.....		\$ 46,142.10

CAPITAL INVESTMENTS
During the Year Ending June 30, 1922

Water system at mine.....	\$ 3,328.79
Extension to slime tunnel.....	439.85
	\$ 3,768.64

STATEMENT

Of Working Expenses at the Wolverine Mine for the year ending June 30, 1922

UNDERGROUND EXPENSES	
Mining.....	\$ 38,024.63
Timbering, tramming and all other labor.....	110,645.40
Hoisting.....	28,411.00
Compressor and drills.....	32,018.65
Electric light and power.....	1,108.40
Supplies.....	19,986.02
	230,194.10
SURFACE AND ADMINISTRATION	
Superintendence and labor.....	\$ 12,435.76
Rock house.....	14,345.04
Insurance.....	2,421.43
Industrial accident.....	5,322.07
Incidentals.....	6,309.96
Electric light and power.....	79.69
Supplies.....	1,202.95
	\$ 42,116.90
Less: Amount received for rent and sundry credits.....	1,463.91
	40,652.99
TRANSPORTATION	
Freight.....	\$ 89,512.28
Labor.....	900.84
Electric light.....	7.96
	90,421.08
STAMP MILL	
Labor.....	\$ 37,495.41
Fuel.....	48,387.92
Sand conveyor.....	3,950.40
Electric light and power.....	386.31
Supplies.....	12,305.93
	\$102,525.97
Less: Amount received for steam heat.....	252.00
	102,273.97
	\$463,542.14

Idle Mines

The following mines that were producers in 1919 or 1920 were idle during 1921. Allouez, Centennial, Franklin, Lake, LaSalle, Mass, Michigan, Osceola, Superior, White Pine, and Winona.

MICHIGAN COPPER PRODUCTION BY COMPANIES FROM 1919 TO 1921

	1919	1920	1921
Ahmeek Mining Co.....	17,223,111	20,489,438	6,255,200
Allouez Mining Co.....	3,749,984	2,499,239	
Arcadian Consolidated Mining Co.....			
Calumet & Hecla Mining Co.....	52,859,146	57,627,883	15,167,136
Centennial Copper Mining Co.....	1,365,148	561,284	
Copper Range Company, Baltic Mine.....	7,864,653	6,613,918	7,608,847
Champion Copper Co.....	19,886,917	13,610,324	20,719,307
Franklin Mining Co.....	1,062,879		
Gratiot Mining Co.....		33,704	
Isle Royale Copper Co.....	13,007,647	10,621,801	2,491,000
Lake Copper Co.....	717,403		
La Salle Copper Co.....	340,719	59,713	
Maas Consolidated Mining Co.....	1,963,178		
Michigan Copper Mining Co.....	1,697,107	1,075,492	
Mohawk Mining Co.....	12,857,392	10,269,824	14,054,235
Osceola Consolidated Mining Co.....	10,824,331	7,465,773	
Quincy Mining Co.....	19,476,320	19,219,070	16,960,265
Seneca Copper Corporation.....		497,680	466,323
Superior Copper Co.....	563,935	322,871	
Trimountain Mining Co.....	5,274,387	3,532,025	4,341,584
Victoria Copper Mining Co.....	1,245,590	1,060,829	273,916
White Pine Copper Co.....	1,979,268	1,850,787	
Winona Copper Co.....	561,238		
Wolverine Copper Mining Co.....	4,562,617	3,932,225	3,924,270
Total.....	179,082,970	161,343,880	92,262,083

SUMMARY OF FINANCIAL STATE

	Idle mine expense Maintenance costs	Total production cost and exploration	Expended for construction
Ahmeek		\$910,808.16	\$6,176.40
Algomah	3,835.60		
Allouez	94,358.91		
Arcadian			
Atlantic	11,528.62		
Calumet & Hecla		2,897,036.05	511,926.64
Centennial	53,794.60		
Champion		2,066,648.91	
Cliff	2,706.94		
Copper Range Baltic Mine		1,076,736.08	16,534.62
Franklin	25,635.61		
Indiana			
Isle Royale		512,385.58	7,442.68
Lake			
LaSalle	18,071.89		
Mass	57,638.36		
Mayflower	104,664.96		61.05
Michigan	44,833.46		
Mohawk		1,985,998.39	37,903.85
North Lake	9,461.95		
Osceola	421,291.44		82,651.07
Quincy		1,848,412.36	573,644.61
Seneca			
South Lake	17,953.38		
Superior	17,589.19		
Trimountain		793,100.21	
Victoria			
White Pine	64,164.13		
Winona			
Wolverine		463,542.14	3,768.64

MENTS MICHIGAN COPPER MINES 1921

Sales of copper	Receipts			Dividends paid 1920	Balance of Current Assets (+) Liabilities (-)
	Silver and interest received and misc.	Assessments	Total		
\$1,718,341.58	\$75,519.45		\$1,793,861.03		+ \$3,079,475.04
	9.33				-4,657.76
163,242.27	15,973.31		179,215.58		+ 570,043.12
	16,800.43				+ 429,524.69
4,951,164.42	1,216,769.32		6,167,933.74	\$500,000.00	+ 12,334,157.80
18,108.78	5,707.82		23,816.60		+ 193,140.86
2,761,792.18			2,786,604.42		+ 2,441,711.90
	2,518.92		52,518.03		+ 49,452.93
967,321.49			967,321.49		
849,593.94	68,873.01		918,466.95		+ 1,336,557.82
2,754.64	21,135.37		23,890.01		+ 331,885.71
	11,296.27	\$80,743.00	92,039.27		
	5,131.63	32,326.50	37,458.13		
	7,095.16		7,095.16		- 370,392.97
1,299,776.17	64,045.14		1,363,821.31		+ 2,177,749.92
	57.06				
657,810.65	67,367.99		725,178.64		+ 2,314,003.57
2,227,994.47	67,352.77		2,288,738.93		+ 1,611,320.84
	40,305.27	11,745.50	52,050.77		
31,101.00	18,597.00		49,698.00		+ 388,168.85
551,941.77					+ 1,442,677.58
95,112.12	3,520.58	62,995.00	161,627.68		+ 149,237.48
131,309.13	3,889.01		135,198.14		+ 142,599.44
446,626.51					

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINES 1916-1921
(Compiled from annual reports to stockholders)

	Tons of ore treated	Cost of mining, transportation and stamping per ton	Pounds refined copper produced	Pounds refined copper per cent ton of ore treated	Cost per pound at mine, excluding construction	Other costs per pound*	Total cost per pound	Price received for copper sold
Ahmeek:								
1921	212,170	3.77	6,255,200	29.48	7.59c	6.97c	14.56c	12.86c
1920	822,162	2.62	20,489,438	24.9	10.49	6.15	16.64	18.60
1919	756,870	2.59	17,223,111	22.8	11.39	3.12	14.51	18.97
1918	1,196,541	2.18	24,851,235	20.8	10.52	4.27	14.79	24.80
1917	1,271,275	1.74	27,919,812	22.0	7.91	1.51	9.42	26.84
1916	1,164,010	1.46	24,142,158	20.7	7.04	4.50	11.54	25.72
Allouez:								
1921	131,643	3.528	2,499,239	18.98	18.59	5.87	24.46	12.90
1920	235,312	3.043	3,749,984	15.94	19.10	2.95	22.05	18.65
1919	514,888	2.119	7,071,218	13.73	15.45	4.77	20.92	18.76
1918	566,674	1.869	8,892,915	15.69	11.91	1.93	13.84	24.42
1916	566,960	1.589	10,219,290	18.02	8.82	2.03	10.85	27.35
Copper Range (Baltic Mine):								
1921	195,816		7,608,847	34.15			14.15	12.078
1920	175,357		6,613,918	37.71			18.02	17.11
1919	235,832		7,864,653	33.35				18.968
1918	293,601		10,406,097	34.440			13.769	24.757
1917	325,342		11,214,861	34.47			10.85	28.735
1916	369,287		12,425,804	33.65				25.28
C. & H. (all mine ore):								
1921	261,320	**8.85	9,865,400	37.75	12.60	6.50	19.10	12.91
1920	1,560,240	4.22	43,489,643	27.87	15.42	8.03	23.45	18.76
1919	1,830,760	3.85	43,776,194	23.91	16.10	6.00	22.10	18.81
1918	2,876,392	3.07	58,724,989	20.40	13.95	7.60	21.55	24.28
1917	3,159,570	2.52	68,419,826	21.65	11.66		13.01	28.39
1916	3,166,274	2.03	71,349,591	22.53			11.63	25.48

C. & H. (Conglomerate):									
1921	261,320	**8.85	9,865,400	37.75					
1920	978,000	5.16	34,324,660	35.10					
1919	1,111,080	4.87	32,895,816	29.61					
1918	1,547,603	4.09	43,329,816	28.00					
1917	1,751,621	3.26	50,415,860	28.76					
1916	1,727,794	2.63	51,785,016	29.97			10.75		
C. & H. (Osceola lode):									
1921 (idle)									
1920	582,240	2.62	9,164,983	15.74					
1919	719,680	2.28	10,880,378	15.57					
1918	1,398,789	1.88	15,393,153	11.58					
1917	1,407,949	1.60	18,003,966	12.97					
1916	1,438,480	1.32	19,564,575	13.60			11.84		
Centennial:									
1921									
1920	41,418	4.327	561,284	13.55	31.94	4.79	36.73	12.95	
1919	87,688	3.331	1,365,148	15.57	21.40	3.75	25.15	18.66	
1918	159,040	2.375	2,492,857	15.67	14.52	4.62	19.14	18.84	
1917	148,332	2.331	2,062,857	13.50	17.26	1.41	18.67	26.96	
1916	150,617	1.916	2,367,400	15.72	12.18		13.44	25.02	
Champion:									
1921	531,780		20,719,307	39.018			9.82†	13.329	
1920	321,664		13,610,324	42.419			14.40	17.17	
1919	503,030		19,886,917	39.053			11.77	18.668	
1918	594,235		21,748,514	36.599			11.92	24.757	
1917	776,036	2.42	27,550,343	35.50			10.40	28.735	
1916	936,656	2.42	33,601,136	35.87			7.80	25.28	
Franklin:									
1921 (idle)									
1920 (idle)									
1919	109,565		1,062,879					15	
1918	296,182		2,827,313					24.349	
1917	303,625		3,155,574					26.74	
1916	267,286		3,116,566					25.432	
Hancock:									
1921 (idle)									
1920 (idle)									
1919 (idle)									
1918	227,049		3,041,504	13.40				24.2092	
1917	302,725		4,047,053	13.223				28.229	
1916	203,112		2,824,934	13.908				28.093	

*Includes smelting, refining, corporation taxes, eastern offices, freight, insurance, commissions, etc., on copper delivered.
 **Includes all maintenance charges and proportion of mine taxes, from April 1 to December 31, amounting to \$4.02 per ton.
 †One-half Champion

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINES 1916-1921—Continued

	Tons of ore treated	Cost of mining, transportation and stamping per ton	Pounds refined copper produced	Pounds refined copper per cent ton of ore treated	Cost per pound at mine, excluding construction	Other costs per pound*	Total cost per pound	Price received for copper sold per pound
Isle Royale:								
1921	116,576	*4.25	2,491,000	21.37	15.87	4.70	20.57	12.86
1920	591,971	2.73	10,621,801	17.94	15.20	5.46	20.66	18.61
1919	724,667	2.35	13,007,647	17.95	13.12	3.18	16.30	16.60
1918	974,508	2.14	15,442,508	15.9	13.49	3.51	17.00	24.46
1917	922,162	2.02	13,480,921	14.6	13.80	1.94	15.74	26.87
1916	925,419	1.53	12,412,111	13.4	11.38	4.37	15.75	25.86
Houghton:								
1921 (idle)								
1920 (idle)								
1919 (idle)								
1918 (idle)			179,012	11.45				
1917	15,628.40		204,274	10.55				28.14
1916	19,444.35							
Lake:								
1921 (idle)								
1920 (idle)								
1919 (idle)								
1918	176,423	1.893	717,403					
1917	185,014	1.87	1,461,893	23.13				26.05
1916	144,829	1.79	1,489,247	21.14				29.726
LaSalle:								
1921	3,340		59,713	17.41	112.00	18.62	130.62	13.20
1920	32,995	2.55	340,719	10.326	34.96	6.39	41.35	18.13
1919	176,423	1.893	1,832,665	10.38	18.37	4.03	22.30	24.35
1918	185,014	1.87	1,919,775	10.38	18.03	2.11	20.14	28.45
1917	144,829	1.79	1,380,352	9.53	18.80	2.16	20.96	25.68

MICHIGAN COPPER INDUSTRY IN 1919-1920

Mass:										
1921 (idle)										
1920 (idle)										
1919	123,780		1,963,178	15.86			27.87	21.7		
1918	196,456		3,403,827	17.33			23.82	24.31		
1917	244,671		3,984,616	16.29			19.81	26.32		
1916	287,900		4,752,588	16.51			15.37	26.276		
Michigan:										
1921 (idle)										
1920	46,289		1,075,492	23.23				18.78		
1919	62,373		1,697,107	27.21				17.68		
1918	40,685		1,177,176	28.56				24.7		
Mohawk:										
1921	688,273	3.754	14,054,235	20.42	9.292	6.306	15.598	12.98		
1920	434,988	2.502	10,269,824	23.61	11.244	6.311	17.545	19.08		
1919	560,754	2.049	12,857,392	22.93	8.935	5.048	13.983	17.914		
1918	454,293	2.259	10,781,041	23.73	9.521	5.102	14.641	24.73		
1917	605,202	1.88	12,313,887	20.35	9.25	2.07	11.32	27.94		
1916	664,547	1.54	13,834,034	20.82	7.35	1.17	8.85	25.28		
New Arcadian:										
1921										
1920										
1919										
1918										
1917	10,195		164,794	16.00						
1916	4,900		53,278							
	1,391		32,307							
Osceola:										
1921										
1920	455,982	2.97	7,465,773	16.37	18.14	6.60	24.74	12.83		
1919	739,364	2.21	10,824,331	14.6	13.12	3.42	18.57	18.61		
1918	1,194,967	1.78	15,919,647	13.3	13.35	4.81	18.16	18.65		
1917	1,237,805	1.63	16,084,958	13.0	12.63	4.33	13.86	24.41		
1916	1,284,681	1.36	19,586,501	15.2	8.91	2.78	11.69	27.89		
Quincy:										
1921										
1920	809,263		16,960,930	23.75						
1919	960,393		19,476,320	20.28						
1918	1,174,147		19,948,965	16.99						
1917	1,280,837		22,195,577	17.33						
1916	1,204,026		21,068,612	17.5						
South Lake:										
1921 (idle)										
1920 (idle)										
1919 (idle)										
1918	76,947		365,036							
1917	48,331		523,091							
1916	20,057		283,600	11.03						

*Includes smelting, refining, corporation taxes, eastern offices, freight, insurance, commissions, etc., on copper delivered.
 **Includes all maintenance charges and proportion of mine taxes from April 1 to December 31, amounting to \$1.63 per ton.

MINERAL RESOURCES OF MICHIGAN

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINES 1916-1921—Concluded

	Tons of ore treated	Cost of mining, transportation and stamping per ton	Pounds refined copper produced	Pounds refined copper per cent ton of ore treated	Cost per pound at mine, excluding construction	Other costs per pound*	Total cost per pound	Price received for copper sold
Superior:								
1921	9,549	6.605	322,871	33.81	37.60	7.66	45.26	12.64
1920	27,267	6.605	563,935	20.68	31.94	5.88	37.82	18.26
1919	106,213	2.68	1,676,446	15.78	16.99	8.55	25.54	18.67
1918	129,587	2.50	2,201,672	16.99	14.74	2.14	16.88	24.22
1917	185,315	2.07	3,034,656	16.38	12.62	1.99	14.61	29.39
1916								24.67
Trimountain:								
1921	143,172		4,341,584	30.32			17.20	13.078
1920	116,768		3,532,025	30.24			24.12	17.115
1919	171,995		5,274,387	30.66			19.39	18.668
1918	201,433		5,343,586	20.52			18.42	24.757
1917	264,655		6,278,097	23.72			15.22	28.735
1916	349,504		8,720,558	24.94	9.95	1.15	11.10	25.28
Victoria:								
1921	61,031		1,060,829	17.38				12.88
1920	89,206		1,245,590†					
1919	106,730		1,533,536					
1918	137,286		1,612,640					
1917	146,690		1,661,832					
White Pine:								
1921	93,260	3.797	1,850,787	19.85	19.14	10.35	29.49	12.86
1920	84,008	3.841	1,979,268	23.56	16.30	8.50	24.80	18.69
1919	194,568	2.984	3,273,680	16.83	17.73	7.05	24.78	18.74
1918	212,889	2.365	4,067,529	19.11	12.38	2.61	14.99	24.34
1917	188,890	2.082	4,207,449	22.27	9.35	3.35	12.70	28.30
1916								25.26

Winona:

1921								
1920 (idle)								
1919	39,654		561,238	24.153				18.50
1918	57,837		1,819,857†	14.157				26.00
1917	112,082.55		1,494,472	13.33				29.05
1916	161,828.55		2,617,255	13.39				28.03

Wolverine:**

1920-1921								
1919-1920	290,419	2.146	3,924,270	13.512	11.812	7.281	19.093	13.187
1918-1919	257,294	2.336	3,932,225	15.28	15.238	6.811	22.049	19.11
1917-1918	298,279	2.117	4,562,617	15.306	13.839	6.461	20.300	20.6
1916-1917	303,498	1.914	4,608,865	15.185	12.604	6.323	18.927	24.2
1915-1916	352,845	1.63	5,856,889	16.60	9.28	2.26	11.54	29.15
1914-1915	388,898	1.39	6,641,492	17.07	8.11	1.43	9.54	12.81
	397,614	1.30	7,250,866	18.23	7.13		8.43	14.09

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

†Partly estimated.

**Wolverine Fiscal year ends June 30.

***Winona Mine during first four months of 1918 by R. R. Seeber, Lessee.

IRON INDUSTRY
STATISTICAL TABLES

DICKINSON COUNTY IRON MINES
Table of Shipments 1917 to 1921

Mine	1917	1918	1919	1920	1921	Grand total of shipments from present active mines
Aragon.....	276,434	305,726	188,098	445,102	146,473	8,852,551
Chapin.....	682,349	705,803	545,050	843,736	281,688	23,047,674
Clifford.....	115,823	118,944	.....	128,489	.....	2,262,056
Indiana.....	46,479	59,220	13,545	11,025	.....	224,949
Loretto.....	193,951	155,891	82,259	122,905	39,953	2,507,402
McKenna.....	.....	.....	.....	.....	.....	.....
Munro.....	46,960	53,031	30,920	45,970	.....	489,953
Penn Group.....	452,710	210,632	160,485	524,192	.....	12,464,845
Pewabic.....	153,256	113,999	.....	.....	.....	9,340,282
Total.....	1,967,962	1,722,796	1,020,357	2,121,419	468,114	59,187,712

GOGEBIC COUNTY IRON MINES
Table of Shipments 1917 to 1921

Mine	1917	1918	1919	1920	1921	Grand total of shipments from present active mines to 1920
Anvil.....	54,027	14,277	4,158	8,406	1,880	870,215
Ashland.....	27,636	41,486	28,083	57,305	6,953	6,434,915
Asteroid.....	93,265	121,152	64,719	197,136	373	847,690
Brotherton.....	84,524	6,904	5,002	36,059	75,351	2,609,768
Castile.....	82,248	73,065	48,596	115,504	.....	838,702
Colby-Ironton Group	598,397	509,358	480,336	669,229	51,167	6,738,596
Eureka.....	191,631	189,696	146,303	265,494	.....	1,705,629
Keweenaw.....	129,498	141,756	122,465	261,033	33,294	856,119
Mikado.....	30,833	.....	995	.....	.....	1,141,619
Newport-Bonnie.....	998,193	1,035,673	872,700	836,700	363,285	17,881,760
Norrie Group.....	1,646,606	1,550,802	1,335,473	1,611,305	1,041,025	40,681,291
Palms.....	475,352	677,415	463,534	595,033	161,867	4,932,697
Plymouth.....	658,284	821,867	498,840	712,806	428,112	3,448,528
Puritan Group.....	410,171	381,624	199,256	270,043	148,925	2,568,519
Sunday Lake.....	198,144	131,426	184,550	225,932	59,436	2,923,209
Tilden.....	108,023	125,137	129,089	150,132	186,569	6,615,727
Townsite.....	25,965	83,428	80,204	107,961	.....	297,558
Wakefield.....	1,116,802	1,130,432	595,944	978,694	.....	5,865,288
Yale.....	73,632	103,490	246,316	337,034	11,395	1,785,481
Total.....	7,003,231	7,138,988	5,506,623	7,435,806	2,542,632	109,043,261

MINERAL RESOURCES OF MICHIGAN

IRON COUNTY IRON MINES
Table of Shipment 1917 to 1921

Mine	1917	1918	1919	1920	1921	Grand total of shipments from present active mines
Balkan	261,014	262,293	159,922	173,094	94,523	1,324,325
Baltic-Fogarty	126,970	166,509	15,405	16,384	126,667	2,818,390
Bates	155,703	98,194	88,988	93,548	35,663	574,713
Bengal	261,350	302,815	229,501	265,035	60,840	1,328,915
Berkshire	57,791	38,439	49,075	159,990	32,104	606,540
Bristol	188,688	245,279	58,138	368,487	9,521	5,413,773
Carpenter	269,178	384,234	396,224	123,409	127,299	1,875,707
Caspian	412,313	345,420	315,328	421,822		4,169,691
Chicago	90,758	109,572	82,656	135,700	83	1,185,563
Chatham	245,744	245,842	51,758	15,624		1,382,276
Cottrell						75,134
Davidson, No. 1	115,132	52,316	152,495	113,832	42,487	873,093
Delta			42,979	8,366		51,345
Davidson, No. 2	108,858	61,462	95,803	96,102		771,897
Davidson, No. 3				11,058		11,058
Davidson, No. 4	16,033	5,070	40,666	51,330	40,667	155,586
Dunn Richards	43,980	56,087	111,116	87,465	80	1,635,626
Forbes				126,581		494,205
Great Western	7,692	63,449	42			1,983,300
Hiawatha	62,847	126,962	86,142	125,031	41,503	1,688,540
Hilltop	19,341	32,164				79,957
Homer	200,566	213,249	208,681	305,392		1,179,850
Judson	60,236	197,091	108,021	49,594	5,689	586,274
Monongahela		25,739	66,013	179,433	12,468	305,573
Michigan						350,301
Odgers	169,668	257,637	100,061	222,336	21,561	824,439
Osana	171,001	158,903	131,635	154,980	10,064	1,472,149
Porter	116,762	65,325	33,067	105,211	57,450	481,066
Riverton Group		100,527	72,875	161,778	115,494	3,796,526
Rogers	117,324	84,193	50,339	94,061		507,998
Ravenna	37,848					296,563
Spies	6,310	48,739	113,434	190,593	15,011	374,087
Tobin	188,590	202,775	97,674	153,544		3,855,435
Tully	121,426	125,087	134,141		72,342	1,022,458
Victoria	16,946					16,946
Virgil		39,918				133,983
Warner	74,814	78,855	77,028	98,785	1,825	365,106
Wauseca		42,187	5,944	15,901		128,988
Youngs	23,197	2,601		8,376		778,276
Zimmerman	230,123	131,248	197,360	170,439		1,649,973
Total	3,978,203	4,370,181	3,353,915	4,303,281	923,341	46,650,805

IRON INDUSTRY—STATISTICAL TABLES

MARQUETTE RANGE IRON MINES
Table of Shipments 1917 to 1921 and Grand Total of Present Active Mines.

Mine	1917	1918	1919	1920	1921	Grand total of shipments from active mines.
Adams	22,560	32,924	15,700			71,184
American Boston	142,488	120,714	71,739	88,639		1,723,389
Argentine	54,673	50,947	36,473	42,800		9,284,791
Athens		23,096	74,500	188,337	46,397	332,329
Austin	44,420	8,533	2,335	3,665	763	1,302,820
Breitung, No. 1	109,962	95,568	52,170	52,412		686,766
Breitung, No. 2	80,073	98,182	19,472	25,771		1,001,711
Cambridg	114,283	143,305	91,008	201,422		3,526,321
Cleveland Cliff Group	933,803	954,542	438,252	651,004	248,488	22,834,775
Empire	38,393	45,947		53,279		529,937
Francis		30,755	26,936	34,200	20,499	112,409
Gwinn	188,070	182,541	66,667	196,932	72,378	933,595
Hematite	19,047	2,269	10,723			7,199,159
Himrod	80,092	65,358	74,553	85,931		430,919
Holmes	53,726	117,957	47,804	195,973	30,222	457,547
Iron Mountain						17,093
Isabella	63,276	84,133	38,805	119,732		438,008
Jackson	47,836	15,879	56,840	69,222	9,734	4,287,748
Lake Superior	293,398	343,439	263,747	299,741	201,030	10,625,844
Maas	313,399	354,410	241,059	379,132		2,552,141
Maitland		19,580	56,506	67,095		142,726
Mary Charlotte	165,461	213,023	156,867	141,318	69,434	3,234,429
Mackinaw Gardner			36,753	49,051	26,448	107,831
Morris Lloyd	316,019	315,563	190,557	200,388	69,025	2,075,051
Negaunee	516,417	490,597	411,296	550,297	145,683	3,255,366
Ohio	108,901	3,229		3,804		769,895
Princeton	150,375	66,244	111,617	153,611	40,923	2,165,600
Queen Group						
Republic	165,182	165,490	69,035	187,749	33,053	7,836,945
Richmond	148,831	144,025	155,984	179,551	84,297	2,284,855
Rolling Mill			116,046	274,012		1,942,675
Stephenson	496,712	75,162	1,965	110,925	27,676	2,213,280
Stegmiller	41,526					418,417
Volunteer	23,806					1,688,725
Washington	12,606			3,853		375,580
Total	4,745,335	4,263,412	2,935,409	4,609,848	1,131,050	101,859,861

LIST OF ACTIVE MICHIGAN IRON MINES

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

LIST OF ACTIVE MICHIGAN IRON MINES—Continued

Name	Location	Owner	Principal Michigan Office	Principal Michigan Official
Caspian	Caspian, Iron Co.	Verona Mining Co.	Caspian	Chas. E. Lawrence, Gen. Supt.
Castile	Ramsay, Gogebic Co.	Castile Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Chapin	Iron Mountain, Dickinson Co.	Oliver Iron Mining Co.	Iron Mountain	O. C. Davidson, Gen. Supt.
Chicagon	Chicagon Mine, Iron Co.	Munro Iron Mining Co.	Iron River	G. L. Woodworth, Mgr.
Clifford	Iron Mountain, Dickinson Co.	Antoine Ore Co.	Negaunee	J. E. Nelson, Gen. Supt.
Cliffs Shaft	Ishpeming, Marquette Co.	Cleveland Cliffs, Iron Co.	Ishpeming	M. M. Duncan, Gen. Mgr.
Colby-Ironton	Bessemer, Gogebic Co.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Dunn-Richards	Crystal Falls, Iron Co.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Davidson Group	Iron River, Iron Co.	Davidson Ore Mining Co.	Iron River	Rudolph Erickson, Gen Supt.
Eureka	Ramsay, Gogebic Co.	Castile Mining Co.	Ironwood	E. W. Hopkins, Range Mgr.
Forbes	Iron River, Iron Co.	Jones & Laughlin Ore Co.	Ishpeming	E. E. Peterson, Supt.
Francis	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Gen. Mgr.
Gardner-Mackinaw	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Gen. Mgr.
Great Western	Crystal Falls, Iron Co.	McKinney Steel Co.	Bessemer	E. D. McNeil, Gen. Supt.
Gwinn	Gwinn, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Gen. Mgr.
Hiawatha	Iron River, Iron Co.	Munro Iron Mining Co.	Iron River	G. L. Woodworth, Manager
Holmes	Ishpeming, Marquette Co.	Cleveland Cliffs Iron Co.	Ishpeming	M. M. Duncan, Gen Mgr.
Homer	Iron River, Iron County	Buffalo Iron Mining Co.	Iron River	E. C. Bowers, Secretary

LIST OF ACTIVE MICHIGAN IRON MINES—Continued

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

LIST OF ACTIVE MICHIGAN IRON MINES—Continued

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

PART II. NON-METALLIC MINERALS

HELEN M. MARTIN

NON-METALLIC MINERAL INDUSTRY

SALT

From 1909 to 1919 the production and value of salt in Michigan increased annually, the maximum production of 17,800,564 barrels valued at \$9,456,138 being reached in 1919. That Michigan showed a gain in 1919 although the total quantity for the United States decreased is due to the fact that the greater part of the salt produced is salt in brine which is used by the chemical industries. In 1920 the total United States production increased slightly but in Michigan production decreased to 16,163,739 barrels and the value increased to \$10,698,674. The salt produced and sold in the United States in 1921 showed a general decrease of 27 per cent in quantity and of 18 per cent in value. Production decreased in Michigan by 6,067,500 barrels or 37 per cent, and value decreased from the maximum value of \$10,698,674 in 1920 to \$7,439,445, a decrease of \$3,259,229 or 30.4 per cent. That the decrease in value was not greater was due to the increased average price, \$.729, received per barrel. The 1921 production was the lowest of any year since 1910. However the average price of \$.729 does not represent the value received per barrel by the entire industry since the manufacturers of evaporated salt for table and dairy purposes report reductions and a steady decline in prices. Some producers reported reductions in operating costs but in general conditions were bad, the trade carried over large stocks and had to contend with high freight rates and a slow market which prevented capacity production. In 1920 the decrease in production was chiefly in production of manufactured salt but in 1921 the production of brine showed the greater decrease.

From 1880 to 1892 Michigan held first rank in production in the United States. In 1893, New York gained first rank and held it continuously with the exception of the year 1901, until 1905 when Michigan again took the lead and continued first excepting in the two years 1910 and 1911 when New York again led by a narrow margin. With the exception of 1910, Michigan has also held first rank in value since 1908. In 1921 New York produced 196,778.5 barrels more than Michigan and so gained first rank in quantity, but as the Michigan production value was \$934,404 greater than that of New York, Michigan continued to hold first rank in value. Michigan holds first place in the quantity and value of evaporated salt produced and marketed. In the production of rock salt, however, New York is the largest producer in the United States and Michigan follows Kansas, and Louisiana, in fourth place.

From 1880 to 1890 Michigan produced annually from about 42 to over 49 per cent of the salt produced in the United States. The percentage declined from 43.69 per cent in 1890 to only 22.89 per cent in 1896. This was not due to a decline of the industry in Michigan but to the rapid growth of production in New York, Ohio, and other States. Since 1896 Michigan has annually produced nearly one-third of the total output and since 1880 Michigan has produced 32.4 per cent or nearly one-third of the salt used in the United States since records of production have been kept.

Thirty-five years ago the center of the salt industry was in the Saginaw Valley, chiefly along Saginaw River from Saginaw to Bay City. The industry was carried on in connection with the lumber mills and waste steam and fuel from the mills were utilized by more than a hundred lumber concerns in evaporating natural brines which were obtained from the Upper Marshall sandstone at depths varying from about 600 feet in Saginaw to nearly 1,000 feet in Bay City. With the decline of the lumber industry in Saginaw Valley the salt industry became relatively unimportant. In 1917 only 3 per cent of the total output of the State was produced in this district. The War revived the industry through the great demand for bromide from abroad which was further increased when the United States entered the War.* During the War the Saginaw Valley district produced salt largely as a by-product of the bromine and chemical industries. The total output of salt for this district in 1921 was only 468,007 barrels or 4.5 per cent of the total for the State and was valued at \$486,525 or 6.5 per cent of the total State value.

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 95.4 per cent of the State output of salt for 1921 came from these two districts, the production being 9,728,114 barrels valued at \$6,952,920 or 95.4 per cent of the total State production and 93.5 per cent of the total value. These figures represent a decrease of 7,533,021 barrels and of \$2,076,661 from the maximum production and value of 1919, and a decrease of 5,244,664 barrels and \$787,403 from the production and value of 1920.

The salt industry in Wayne County made a most remarkable growth from 1895 to 1919. Salt was first produced in this county in 1895, the

*See Bromine.

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 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 1921 Wayne County produced 58.4 per cent of the total salt for Michigan.

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 1921 was 2,183,021.4 barrels or 21.4 per cent of the State total, but the valuation of \$3,463,776 represents 46.5 per cent of the total value for Michigan. The 1921 production was 373,457 barrels or 14.6 per cent less than in 1920 and the value was \$593,720 or 14.6 per cent less than for the previous year. 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 1921 production reached 29,656 tons valued at \$273,187.

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 1,594,571 barrels of salt valued at \$1,436,548. This is equivalent to 15.7 per cent of the total quantity and 19.3 per cent of the value for the State. Production decreased 41 per cent (1,106,165 barrels) from 1920 and 49.5 per cent from the maximum of 1919. The value also decreased, the 1921 value being \$1,745,490 or 54.9 per cent

less than in 1920. Most of the product is packer's salt, i. e., common fine and common coarse.

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

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

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

The depths to the first salt bed in southeastern Michigan varies from a minimum of 730 feet at Detroit to 1,500 and 1,600 feet at Port Huron

and St. Clair, St. Clair County. In northeastern Michigan the depth at Alpena, Alpena County, is about 1,270 feet, at Grand Lake, 1,284 feet, and at Onaway, Presque Isle County, 1,630 feet.

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

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES
1880-1921**

Year	U. S. production quantity bbls.	Michigan production		Per cent of total Michigan	Rank quantity	Michigan	
		State Salt Inspectors* Quantity bbls.	U. S. G. S. † Quantity bbls.			Value Michigan	Rank value Price bbl.
1880	5,961,060	2,676,588	2,485,177	41.69	1	2,271,931	0.75
1881	6,200,000	2,750,299	2,418,171	44.35	1	2,418,171	0.85
1882	6,412,373	3,037,317	3,036,317	47.36	1	2,126,122	0.70
1883	6,192,231	2,894,672	2,894,672	46.74	1	2,344,684	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	1	2,967,663	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	1	2,426,989	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	1	2,291,842	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	1	2,261,743	0.55
1889	8,005,565	3,846,979	3,856,929	48.17	1	2,088,909	0.541
1890	8,776,991	3,838,637	3,838,632	43.72	1	2,302,579	0.600
1891	9,987,945	3,927,671	3,966,748	39.52	1	2,037,289	0.513
1892	11,698,890	3,812,504	3,829,478	32.81	1	2,046,963	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	2	888,837	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	2	1,048,251	0.315
1896	13,850,726	3,366,242	3,164,238	22.89	2	718,408	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	2	1,243,619	0.313
1898	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2	2,205,924	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2	2,033,731	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	1	2,437,677	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	2	1,535,823	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	2	1,119,984	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	2	1,579,206	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1	1,851,332	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	1	2,018,760	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	1	2,231,129	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	1	2,458,303	0.241
1909	30,107,646†	6,055,661	9,966,744	33.10	1	2,732,556	0.274
1910	30,305,656†	5,097,276	9,452,022	31.18	2	2,231,262	0.236
1911	31,183,968†	.....	10,320,074	33.10	2	2,633,155	0.255
1912	33,324,808†	.....	10,946,739	32.84	1	2,974,429	0.277
1913	34,393,227†	.....	11,528,800	33.52	1	3,293,032	0.285
1914	34,402,772†	.....	11,670,976	33.92	1	3,299,005	0.283
1915	38,231,496†	.....	12,588,788	32.93	1	4,304,731	0.342
1916	45,449,329†	.....	14,918,278	32.84	1	4,612,567	0.309
1917	49,844,125†	.....	16,078,136	32.25	1	6,817,202	0.421
1918	51,705,317†	.....	17,165,178	33.19	1	9,048,650	0.520
1919	49,157,686†	.....	17,800,564	36.21	1	9,456,138	0.531
1920	49,745,373†	.....	16,163,679	32.49	1	10,698,674	0.662
1921	35,579,672	.....	10,196,179	28.66	2	7,439,445	0.729
1922	.....	.....	.....	.....	.....	.....	.....
Total.	938,615,111	.....	314,125,673	.....	.....	142,335,170	.....

*Office of State Salt Inspector abolished in 1911.

†In cooperation with the Michigan Geological Survey after 1909.

‡Includes production of Hawaii and Porto Rico 1909-1913, 1915-1916 and of Porto Rico 1914-1917-8.

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

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY METHODS OF MANUFACTURE, 1906-1921

Year	Evaporated		Pressed blocks		Other rock		Brine and other*		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1906	29,278,297	\$10,302,732	.....	.....	.....	.....	20,796,007	\$1,083,643	50,336,468	\$11,503,238
1907	5,355,707	2,232,046	.....	.....	.....	.....	4,387,772	219,244	10,320,074	2,633,155
1908	5,441,288	2,486,785	.....	.....	.....	.....	4,737,038	236,852	10,946,739	2,974,429
1909	6,042,657	2,811,429	.....	.....	.....	.....	4,756,779	237,431	11,528,800	3,299,005
1910	6,141,711	2,806,895	.....	.....	.....	.....	4,816,735	240,086	11,670,976	3,289,005
1911	6,595,113	3,602,886	.....	.....	.....	.....	5,073,940	380,491	12,588,788	4,304,731
1912	6,549,407	3,747,695	.....	.....	.....	.....	7,365,927	506,850	14,918,278	4,612,567
1913	6,233,793	3,759,911	.....	.....	.....	.....	8,639,800	578,574	16,078,136	6,877,202
1914	7,307,928	5,759,927	.....	.....	.....	.....	8,451,578	541,375	17,165,178	9,048,650
1915	7,021,800	8,004,713	.....	.....	.....	.....	9,430,264	660,119	17,800,564	9,456,138
1916	6,452,785	8,677,108	.....	.....	.....	.....	8,199,843	549,824	16,163,678	10,698,674
1917	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1918	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1919	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1920	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921	2,349,893	\$3,557,177	.....	.....	.....	.....	3,784,122	\$201,316	10,196,179	\$7,439,445
1922	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

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

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES, 1921

County	Evaporated in open pans or grainers		Evaporated in vacuum pans		Pressed blocks from evaporated salt		Rock salt		Brine		Total		Bromine		Calcium chloride	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
Bay																
Midland	a	a	19,879	\$117,619							27,040	\$170,129		b		
Manistee	88,354	\$605,804	a	a	a	a	a	a			223,240	\$1,436,548		b		
Mason	38,481	316,396									38,481	316,396				
Saginaw	164,239	2,377,515	113,766	\$33,768	a	a					305,623	3,463,776				
St. Clair	30,768	204,952	82,218	709,916			a	a	529,777	\$291,316	833,073	2,052,596				
Wayne																
Tons	328,985	\$3,557,177	347,577	\$2,449,417	29,656	\$273,187	a	a	529,777	\$291,316	1,427,465	\$7,439,445		b	18,683	\$431,402
Total	2,349,893		2,482,693													

a—Included in total, less than three producers.

b—One producer, value excluded from total.

BROMINE AND CALCIUM CHLORIDE

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

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

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

Bromine dropped in value to 25 cents and 30 cents a pound in 1913. In 1914 when the World War cut off the supplies of German bromine France, Italy and England became largely dependent upon the United States for their supplies. The price of bromine advanced to unprecedented figures, 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 the trenches, was invented and in 1918 the Government ordered new wells driven at Midland to increase the supply of bromine since with the entrance of the United States into the war and the increased use of asphyxiating gases the needs of the United States as well as of the Allies had vastly increased.

Prior to the War the bromine of Michigan was marketed largely as bromides but the increased demand caused the marketing of a large amount of bromide in the crude state—a heavy, reddish brown mobile liquid. Bromine is used in many chemical reactions, in separating gold from platinum and silver, in the manufacturing of disinfectants, dyes and drugs. During the War because of its effect upon the eyes and throat

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

In 1919 the 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 1921 bromine production decreased nearly 36 per cent in quantity and over 75 per cent in value in Michigan. Michigan produced over 93 per cent of the total United States production at 97 per cent total United States value. The average price per pound for the United States was \$0.24 although during the year the price ranged from 50 to 52 cents in February and March and dropped to 23 to 24 cents in December.

Calcium Chloride

Calcium chloride is used in large quantities for the prevention of dust, in refrigerating plants, in protective fire apparatus, in cement mixtures to prevent freezing, as a drying agent in 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. Since the playground movement is becoming so widespread and since ground treated with calcium chloride presents a hard, dry dustless surface a few hours after treatment it is advised that greater use be made of the product to provide clean, dust-free playgrounds.

The output of calcium chloride for 1921 was 18,683 tons valued at \$431,402, a decrease from 1920 of 31,254 pounds or 62.5 per cent in quantity and of \$1,473,611 or 77.3 per cent in value. The average price per ton dropped from \$38.14 in 1920 to \$23.09 in 1921; the average price per ton for the United States was \$21.57. Michigan produced 79 per cent of the total quantity produced in the United States at 84 per cent of the total value for the country.

The greater part of the Michigan production of calcium chloride is highly refined and used as a bleaching agent.

MAGNESIUM

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

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

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

The metal has been used chiefly in the chemical laboratory, in metallurgy as a deoxidizing agent, and in the finely powdered state, as a flash light powder for military and photographic purposes. 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 mechanical strength of iron would satisfy a demand and secure a wide market, and in 1916 established a special research department to extensively investigate the subject. After many experiments an alloy was produced which on account of "its light weight, great tensile strength, machinability, durability, absence of permanent growth on repeated heating and cooling and non-abrasiveness to cast iron make it an ideal piston material."*

This alloy has been named "Dow-Metal"** and "has been developed to a point where it is now recommended to the automobile industry as a casting alloy particularly adapted for use as a piston material."* It has been made into pistons and tested in forty motor plants and in various types of motor cars and Dow-Metal pistons have been used in racing cars.

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

*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. 26, 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 \$.31 or 18 per cent per barrel.

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

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

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

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

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 years, 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 valued at \$10,300,289, an increase in quantity of 1,247,701 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.

The principal raw materials used in Michigan in the manufacture of Portland cement are marl or limestone and clay or shale, though the lime refuse from a soda ash plant near Detroit is also being utilized. The early companies planned to use marl and clay or shale. Because of the greater kiln capacity and lower fuel costs, limestone has been substituted for marl wherever practical. Of eleven plants five are reported

to be using marl and clay, five using limestone and clay or shale, and one using clay and the waste from the 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 on 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 has been organized and it purposes to erect a plant at Coldwater Lake near Mount Pleasant to utilize the marl beds surrounding the lakes in the manufacture of cement.

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

*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, 1896-1921

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	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	1,443,023	0.25	0.56		\$7,000	\$2,244,011	0.29		\$1.75	\$1.57	
1897	2				15,000	3,677,775	0.56	275.0		26,250	4,315,591	2.8		1.75	1.61	
1898	2				77,000	3,692,284	2.11	413.3		134,750	5,970,773	2.8		1.75	1.62	
1899	4	4			343,566	5,652,266	6.1	346.2		513,849	8,074,571	6.36		1.492	1.43	
1900	6	4			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		2,134,596	20,864,078	10.2		1.33	1.21	
1903	13	3			2,342,973	23,342,973	8.7	23.9		2,674,780	27,713,519	9.7		1.33	1.24	
1904	16	4			1,955,183	26,505,881	8.5	14.9		2,865,656	23,355,119	10.1		1.032	0.88	
1905	16	5			2,247,160	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	53,982,551	8.1		1.287	1.11	
1908	15	7			2,892,576	51,072,612	5.6	-19.0		2,556,215	43,547,579	5.8		0.863	0.85	
1909	12	7			3,212,751	64,991,431	4.9	11.6		2,619,259	52,858,354	4.9		0.845	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		3,145,901	69,109,800	4.55	370,526	0.861	0.813	
1913	11	8	83	19,900	4,186,236	92,097,131	4.21	19.79		4,228,879	89,106,975	4.74	573,563	0.921	0.902	
1914	11	7	77	19,100	4,285,345	88,230,170	4.85	2.37		4,418,429	80,118,475	5.07	538,846	0.982	0.927	
1915	11	5	71	20,800	4,765,294	85,914,907	5.55	11.2		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		6,017,911	104,258,216	5.77	338,035	1.168	1.103	
1917	10	6	68	20,550	4,688,899	92,814,202	5.03	-4.47		6,122,887	122,775,088	4.98	491,919	1.419	1.354	
1918	10	6	49	22,160	3,554,872	71,081,663	5.00	-24.2		6,778,167	113,153,513	5.37	635,447	1.630	1.596	
1919	11	4	58	20,425	4,675,244	80,777,935	5.78	32.00		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		10,939,633	194,489,025	5.62	666,389	2.46	2.02	
1921	11	3	53	23,600	5,777,533	98,293,000	5.78	18.1		10,300,289	180,778,415	5.69	700,303	1.815	1.89	
1922																

*Minus sign indicates decrease.

POTASH

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

GYPSUM

The gypsum industry of Michigan dates from 1838. In that year Dr. Douglas Houghton then State Geologist, in selecting a location for a salt well in Grand Rapids discovered that the gypsum deposits of the region are extensive and in his reports to the State Legislature for 1838 and 1840 Dr. Houghton called attention to the extent and character of the beds and the utilization of gypsum for land plaster. About the same time the first Michigan gypsum was calcined and used to make ornamental stucco moldings for a house erected for Louis Campau. The gypsum was ground in an Indian mill and burned in a cauldron kettle. The second moldings made were successful and remained on the house until it was destroyed by fire in 1850. During 1840-45 a small industry developed in the manufacture of inside ornamental moldings, plaster ornaments and flower pots. The first mill for working the gypsum deposits was erected in 1841 and the commercial exploitations of Michigan's almost unlimited resources of gypsum began in the Grand Rapids-Grandville district with the sale of forty tons of plaster at four dollars a ton. Judicious advertising of land plaster among the farmers increased the demand to such an extent that although the mills "ran night and day" and the price reached five dollars and fifty cents a ton, buyers were turned away with their orders unfulfilled. The first shaft for mining gypsum was put down in 1853 by the predecessors of the present Grand Rapids Plaster Company. At the present time five mines and one quarry are operated in the Grand Rapids-Grandville district. The gypsum of the Alabaster district was reported in 1837 by Bela Hubbard who recorded the discovery of gypsum in the mouth of the Au Gres river. Later an outcrop was discovered on

land and quarried with profit. In 1862 a quarry was opened in the beds at Alabaster, the land having been purchased from an old squatter for two dogs and ten dollars. Other quarries were opened in the district and the gypsum sold for land plaster, but all except the Alabaster quarry have been abandoned. This quarry is now operated by the United States Gypsum Company.

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

Commercial gypsum occurs in the formation known as the Grand Rapids Group of the Upper 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 one foot thick near the center occurs about 60 feet below the surface. At Grandville an upper bed, about 11 feet thick is directly overlain by sand and gravel and is separated below from a 14-foot bed of gypsum by about four feet of hard limestone. These two beds may be equivalent to the 22-foot "split" in West Grand Rapids. The upper bed was formerly quarried but, because of heavy overburden and water, the quarries have been replaced by mines opened in the lower bed. Numerous explorations show that there are several other minable gypsum beds in the Grand Rapids-Grandville district.

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

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

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

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

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

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

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

That the gypsum industry recovered from the low production of 1918 and continued to prosper despite the business depression is shown by the continued increase in production of gypsum and value of gypsum products during 1919, 1920 and 1921. The production, however, was less but the values greater for each of the three years than in 1916. In 1921, 408,224 tons of gypsum were mined, an increase of 26,012 tons or 6.8 per cent. Gypsum products were valued at \$3,312,096, a decrease of \$208,932 or 5.9 per cent. The production of 1921 was 87.1 per cent of the 1916 maximum but its value was 211.5 per cent (\$2,245,497) greater than for 1916. This great increase in value is due to increased cost of production, including higher wages, higher cost of supplies and higher freight rates and also to the increased production of gypsum wall board.

The sale of crude gypsum increased from 73,842 tons in 1920 to 110,677 tons in 1921 and values increased from \$268,968 to \$369,185, increases

of 36,835 tons or 49.9 per cent in quantity and of \$100,217 or 37.2 per cent. Portland cement mills purchased 74,672 tons of crude gypsum valued at \$245,593 increases of 41.6 and 25.4 per cent in quantity and value respectively.

In the early days of the gypsum industry four-fifths of the raw gypsum was ground into land plaster and from 1869 to 1887 more than half of the gypsum mined was ground into this product. With the more general use of patent fertilizers the demand for land plaster more or less gradually decreased so that the production in 1918 was only 5,892 tons as compared with the maximum of 49,570 tons in 1880, and in 1919 had further decreased to 1,597 tons. In 1919 the Gypsum Industries Association of Chicago, 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 1921 production represents an increase of 14,466 tons or 119.6 per cent in quantity and the value, \$98,139 of the product was an increase of \$44,089 or 81.6 per cent over that of 1920. Agricultural gypsum represents 23.9 per cent of the quantity and 26.6 per cent of the value of crude gypsum sold in 1921.

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 and 1921 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 was reached, an increase of 33,520 tons or 25.1 per cent; and a maximum value of \$1,662,343, an increase of \$163,117 or 10.9 per cent. The production of stucco, boards, brick and tile increased in 1920 but decreased in 1921. Stucco produced in 1921 was 37,968 tons valued at \$298,538, a decrease of 24,490 tons or 39.2 per cent in quantity and of \$147,843 or 33.1 per cent in value. Plaster board and tile show a considerable decrease in quantity but not a corresponding decrease in value due to the higher average sales price for the product; production was 22,809 tons, a decrease of 38,177 tons or 62.5 per cent and the value was \$807,519 a decrease of \$459,140 or 36.2 per cent. Of the total quantity of gypsum sold calcined in 1921, 70.5 per cent was sold for wall plaster at 69 per cent of the total value for calcined products; 15.7 per cent of the quantity

at 12.2 per cent of the value was sold for stucco and 9.5 per cent of the quantity at 33.5 per cent of the total value was sold for wall boards, whereas in 1920 plaster boards represented 23.3 per cent of the quantity and 38.9 per cent of the value of calcined products and wall plaster 50.9 per cent and 46.1 per cent of quantity and value respectively. The quantity of plaster board produced decreased almost to the 1917 figures, 19,158 tons, although the value for 1921 was almost twelve times that of 1917.

In 1921 Michigan mined 13.3 per cent of the gypsum mined in the United States and produced gypsum products valued at 13.9 per cent of the total value for the country. Of the United States production Michigan produced 25.3 per cent at 19.9 per cent of the value of agricultural gypsum, 15.6 per cent of gypsum sold to Portland cement plants at 15.2 per cent of the total value, and 13.4 per cent of the calcined gypsum sold at 13.9 per cent of the value.

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, 1868-1921

Year.	Ground into land plaster. Tons.	Calcined into plaster. Tons.	Sold crude. Tons.	Total mined. Tons.	Gypsum and gypsum products. Total value.	Rank	
						Quantity.	Value.
Before 1868	132,043	14,285		146,328	\$671,022		
1868	28,837	6,244		35,081	165,298		
1869	29,996	7,355		37,351	178,824		
1870	31,437	8,246		39,683	191,718		
1871	41,126	8,694		49,820	284,054		
1872	43,536	10,673		54,209	259,524		
1873	44,972	14,724		59,696	297,678		
1874	39,126	14,723		53,849	274,284		
1875	27,019	10,914		37,933	195,386		
1876	39,131	11,498		50,629	248,504		
1877	40,000	9,819		49,819	238,550		
1878	40,000	8,634		48,634	229,070		
1879	43,658	9,070		52,728	247,192		
1880	49,570	18,920		68,499	349,710		
1881	33,178	20,145		53,323	298,872		
1882	37,821	24,136		61,957	344,374		
1883	40,082	28,410		68,492	377,567		
1884	27,888	27,950		55,847	335,382		
1885	28,184	25,281		53,465	286,892		
1886	20,373	27,370		47,748	308,094		
1887	28,794	30,376		59,170	329,392		
1888	22,177	35,125		57,302	347,531		
1889	19,823	36,800		56,623	353,869		
1890	12,714	47,163	15,000	74,877	192,099		
1891	15,100	53,600	11,000	97,700	223,725		
1892	14,458	77,599	47,500	139,557	306,527		
1893	16,263	77,327	31,000	124,590	303,921		
1894	11,982	47,976	20,000	79,958	189,620		
1895	9,003	51,028	6,488	66,519	174,007		
1896	6,582	60,352	700	67,633	146,424		
1897	7,193	71,680	16,001	94,874	193,576		
1898	13,345	77,852	1,984	93,181	204,310		
1899	17,196	88,315	39,266	144,776	283,537		
1900	10,304	86,972	33,328	129,654	285,119	2	2
1901	9,808	120,256	46,086	185,150	267,243	1	1
1902	13,022	158,320	68,885	240,227	459,621	1	1
1903	18,409	198,119	52,565	269,093	700,912	1	1
1904	18,294	185,422	34,669	238,385	541,197	1	1
1905	20,285	203,313	24,289	247,882	634,434	1	2
1906	30,220	208,715	27,517	341,716	753,878	1	2
1907	15,500	197,666	36,543	317,261	681,351	3	3
1908	11,414	192,403	40,324	327,810	401,928	1	3
1909	11,890	344,171	45,781	394,907	1,213,347	1	1
1910	7,097	240,905	64,566	357,174	667,199	2	2
1911	15,548	206,299	79,050	347,296	523,926	3	4
1912	10,103	243,656	68,819	384,227	621,547	2	3
1913	9,604	278,368	60,706	423,896	721,325	3	3
1914	9,322	240,648	61,227	393,006	705,841	3	3
1915	9,799	245,484	69,572	389,791	686,309	3	4
1916	9,072	292,109	80,298	457,375	1,066,599	3	4
1917	7,090	257,588	68,155	375,803	1,568,655	3	3
1918	5,892	207,059	46,608	286,768	1,761,149	4	4
1919	1,597	250,687	58,754	339,125	2,390,367	3	3
1920	12,092	261,499	73,842	382,212	3,521,028	3	3
1921	26,558	240,648	110,677	408,224	3,312,096	2	2
1922							
Totals...	1,304,577	5,946,799	1,436,195	9,533,874	32,551,514		

PRODUCTION OF GYPSUM IN MICHIGAN, 1913-1921

YEAR.	Gypsum sold crude.									
	Crude gypsum mined.		To Portland cement mills.		As land plaster.		For other purposes.		Total sold crude.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1913.	Tons		Tons		Tons		Tons		Tons	
1914.	423,806	*	9,604	\$10,222	10,320	\$9,011	60,706	\$55,969	60,706	\$55,969
1915.	383,006	*	9,322	10,761			60,227	51,242	60,227	51,242
1916.	389,791	*	9,799	9,894			69,575	63,236	69,575	63,236
1917.	457,363	*	9,072	16,658			80,298	90,973	80,298	90,973
1918.	375,568		7,090	22,903			80,155	116,653	80,155	116,653
1919.	286,198		5,892	23,876			48,608	131,438	48,608	131,438
1920.	382,212		12,092	54,050			53,745	174,110	53,745	174,110
1921.	408,224		26,558	98,139			73,545	268,968	73,545	268,968
1922.							110,677	369,185	110,677	369,185

Gypsum sold calcined.

YEAR.	Gypsum sold calcined.										
	As mixed wall plaster.		As stucco.		As boards, tile, etc.		Total sold calcined*		Total value.	No. mines and quarries.	No. mills.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.			
1913.	Tons		Tons		Tons		Tons				
1914.	166,711	\$437,720	95,402	\$202,675			278,368	\$665,356	\$721,325	7	8
1915.	163,972	475,638	83,780	173,572			249,648	654,599	705,841	8	8
1916.	155,861	426,482	80,172	177,517			245,484	623,073	686,309	8	8
1917.	193,816	668,795	87,405	279,597			292,109	975,626	1,086,599	7	8
1918.	147,371	949,511	85,426	384,661			257,588	1,452,002	1,568,655	7	8
1919.	117,902	931,725	52,132	330,761			207,059	1,629,711	1,761,149	7	8
1920.	152,162	1,460,572	48,039	315,516			250,687	2,216,257	2,390,367	7	7
1921.	133,289	1,499,226	62,458	446,381			281,499	3,252,060	3,521,028	7	7
1922.	169,809	1,662,343	37,968	298,538			240,648	2,442,911	3,312,096	7	7

*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 varieties and are used for glazing pottery. At Grand Ledge, Eaton County, Jackson, Jackson County, Cornunna, Shiawassee County, near Bay City, Bay County, and Flushing, Genessee County, shales belonging to the coal measures have been utilized for vitrified and front brick, vitrified tile, sewer pipe, conduits, fireproofing, etc.

Important deposits of blue gray shale occur near Ellsworth, 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 shales associated with the coal beds in Saginaw Valley are suitable for front brick and vitrified products.

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

1918 and \$6.65 in 1916. This is an increase in value over 1918 of 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 business in the brick industry as very dull. However, the value of the brick and tile products was greater than ever in the history of the industry. Scarcity of coal and labor and the transportation difficulties are responsible for both the decrease in production and increase in price. Decrease in the production of drain tile is ascribed to "scarcity of labor to lay drains", although the percentage decrease in drain tile production is much less than for other products. The production of common brick was 186,526,000 valued at \$3,062,660, a decrease of 13,826,000 brick or 6.9 per cent in quantity but an increase of \$328,157 or 12 per cent in value. The average price for common brick in 1920 was \$16.42 per thousand. The production 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 increase 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 tile 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.

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

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

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

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1921

Year.	Common brick.		Average price per M.	Vitrified Brick Average price per M.	Drain tile.		Fire-proofing.	Miscellaneous.*		Hollow building tile or blocks Value.	Rank of state.	No. of firms operating.	Total value.
	Quantity.	Value.			Value.	Value.							
1899	200,144,000	\$923,176	\$4.66	\$12.42	\$140,171	\$5,900	\$22,709	13	196	\$1,254,256			
1900	190,892,000	893,250	4.77	12.30	147,747	2,350	406	17	189	1,147,378			
1901	215,826,000	1,093,254	5.07	12.30	98,972	1,880	637	14	180	1,497,169			
1902	237,524,000	1,231,752	5.21	12.50	129,048	3,290	.....	13	182	1,660,942		
1903	245,791,000	1,241,772	5.04	13.25	129,048	.....	.....	14	178	1,662,474	
1904	205,458,000	1,115,704	5.44	13.57	205,448	.....	.....	14	168	1,670,892	
1905	246,582,000	1,176,902	4.75	13.57	314,098	.....	.....	16	154	1,719,746	
1906	200,817,000	1,051,012	5.28	13.96	359,808	.....	.....	16	142	1,793,367	
1907	151,049,000	1,024,327	6.79	12.53	327,630	4,100	1,500	17	136	1,786,190			
1908	249,820,000	1,250,757	5.09	12.84	364,006	.....	40,100	16	132	1,666,381		
1909	232,551,000	1,305,516	5.66	12.82	348,205	.....	66,128	16	122	1,947,059		
1910	252,465,000	1,351,998	5.36	14.00	313,072	.....	.....	15	118	2,083,525	
1911	271,159,000	1,626,287	5.99	13.94	387,945	1,461	228,530	15	111	1,958,442			
1912	273,971,000	1,635,216	5.97	14.71	415,543	3,752	350,000	13	101	2,350,606			
1913	269,154,000	1,461,158	5.43	15.59	421,941	10,850	234,280	10	95	2,451,242			
1914	277,399,000	1,896,857	6.85	14.78	548,795	2,492	49,755	11	90	2,434,872			
1915	279,175,000	1,882,042	6.75	17.16	734,042	.....	216,265	13	82	2,248,068		
1916	236,612,000	1,915,999	8.09	15.23	565,398	89,147	79,996	12	73	2,705,064			
1917	94,746,000	2,734,503	28.94	19.43	737,124	.....	132,844	12	61	2,846,264		
1918	200,352,000	3,062,660	15.30	18.21	690,816	.....	200,729	12	61	3,699,929		
1919	186,526,000	2,417,809	12.99	.....	381,507	.....	108,394	.....	.....	3,979,691
1920	193,730,000	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	5,042,410,000	\$34,196,240	.....	.....	\$8,138,242	.....	.....	.....	.....	\$49,183,142

*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.

SHALE

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

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

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

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

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

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

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

CLAY*

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

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

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

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

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

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

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

In 1921 the general business depression had a marked effect on the clay industry, the output decreased 86 per cent in quantity and 79 per cent in value as compared with the production and value for 1920.

PRODUCTION OF CLAY IN MICHIGAN, 1910-1921

Year.	Slip clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons		Tons		Tons		Tons	
1910.....	1,363	\$3,889	60	\$105	1	\$400	1,424	\$4,394
1911.....	1,744	5,090	18	32	2	150	1,764	5,272
1912.....	2,034	6,164	.....	.....	9	9	2,043	6,173
1913.....	1,710	6,504	.....	.....	.....	.....	1,710	6,504
1914.....	1,463	4,572	.....	.....	.....	.....	1,463	4,572
1915.....	1,198	3,805	*	*	*	*	3,142	5,605
1916.....	.....	10,509	.....	.....	.....	.....	3,454	11,193
1917.....	2,153	8,824	*	*	.....	.....	5,746	13,627
1918.....	1,236	4,639	*	*	.....	*	2,359	6,373
1919.....	568	2,123	.....	.....	.....	*	568	2,123
1920.....	505	2,249	.....	.....	4,561	9,046	5,066	11,295
1921.....	484	2,047	.....	.....	208	308	692	2,355
1922.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	.....	.....	.....	.....	.....	.....	.....	\$79,487

*Included in total.

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.

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

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

VALUE OF POTTERY PRODUCTS IN MICHIGAN, 1899-1920

YEAR.	Rank of State.	No. firms.	Red earthen-ware 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	.....	34,517	15.4	17
1901.	16	5	42,465	\$2,400	44,865	30.2	20
1902.	14	4	44,098	39,000	83,098	87.4	41
1903.	19	4	42,007	6,000	48,007	-42.2	19
1904.	17	4	40,621	3,000	43,621	-9.1	17
1905.	17	5	.....*	7,000	45,961	4.5	16
1906.	17	6	43,510	7,600	51,110	11.2	16
1907.	16	6	54,474	7,100	61,574	18.5	20
1908.	16	6	54,659	7,750	62,409	1.5	25
1909.	13	5	60,939	34,500	95,439	52.9	31
1910.	13	6	94,450	13,300	112,697	18.1	33
1911.	18	6	80,580	.....*	130,490	15.8	38
1912.	10	6	99,555	.....*	194,892	49.3	53
1913.	10	5	65,000	.....*	222,133	20.8	59
1914.	9	5	106,452	.....*	265,194	33.0	75
1915.	8	6	112,863	668,982	521,989	96.7	1.40
1916.	8	7	133,734	13,722	732,716	51.8	1.64
1917.	8	8	.....*	88,842	1,187,981	49.9	2.12
1918.	8	8	.....*	12,708	1,976,436	66.3	3.00
1919.	6	8	.....*	16,848	2,096,574	6.1	.....
1920.	.....	.....	.....*	1,643,868	2,592,625	23.5	.....
1921.	.....	.....	138,055	1,643,868	1,781,923	-35.1	.....
Total.	.....	.....	.....	.....	.....	.....	.....

*Included in the total.
 **1920 includes art pottery, clay pipes and filter stones, 1921 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 1,374,805 tons. The gain was due not only to the great demand but to better car service. The shortage of freight cars as well as of labor in 1916 was an important factor in keeping down production. The car situation in 1918 was improved but labor shortage was an important factor in limiting production.

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

The coal strike of 1919 closed most of the mines and those not affected by the strike order did not operate full time. Partial settlement of the strike caused the mines to be reopened early in July of 1919 and they operated full time until November 1, when all the mines went on strike. During 1919 two new shafts were opened, one two miles east of Corunna in Shiawassee County and the other three miles west of Jackson, Jackson County; 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 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, a decline of 348,050 tons or 23.3 per cent in quantity and of \$1,791,000 or 24.3 per cent in value. The average price per ton dropped from \$4.93 in 1920 to \$4.87 in 1921 and the average profit per ton de-

*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.

MINERAL RESOURCES OF MICHIGAN

PRODUCTION, COST OF MINING, PROFITS, AND VALUE OF COAL IN MICHIGAN, 1900-1921

YEAR.	*Number active mines.	Average number employees per month.	**Average daily wage.	†Total tons of coal mined.	Total cost of coal mined.	Average cost per ton.	***Total tons of coal mined.	***Total value of coal mined.	***Average price received per ton.	†Average profit. 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	0.007
1902	32	1,616	2.75	899,967	1,284,342	1.427	1,964,718	1,653,192	1.714	0.287
1903	34	3,014	2.91	1,601,984	2,529,027	1.579	1,367,619	2,707,527	1.979	0.400
1904	33	2,733	3.01	1,408,375	2,266,098	1.609	1,342,840	2,424,935	1.806	0.197
1905	38	2,776	2.96	1,413,307	2,244,434	1.588	1,473,211	2,512,697	1.705	0.117
1906	38	2,106	2.40	1,367,385	2,090,489	1.529	1,346,338	2,427,404	1.803	0.274
1907	37	2,897	3.24	1,911,201	3,162,837	1.655	2,035,858	3,660,833	1.798	0.143
1908	38	3,115	3.02	1,842,778	3,089,759	1.677	1,835,019	3,322,904	1.811	0.134
1909	36	2,907	2.93	1,736,573	2,865,083	1.650	1,784,692	3,199,351	1.793	0.143
1910	34	2,471	3.07	1,462,276	2,626,342	1.796	1,534,967	2,930,771	1.909	0.103
1911	32	2,530	3.30	1,389,585	2,623,244	1.887	1,476,074	2,791,461	1.891	0.004
1912	26	1,886	3.19	1,160,768	2,170,076	1.869	1,201,230	2,399,451	1.989	0.120
1913	24	2,076	3.49	1,138,163	2,240,559	1.977	1,231,786	2,455,227	1.993	0.016
1914	23	2,146	3.35	1,153,869	2,285,281	1.99	1,283,030	2,559,786	1.99	0.000
1915	20	1,942	3.45	1,069,798	1,929,386	1.77	1,156,138	2,372,797	2.05	0.280
1916	18	1,704	3.57	1,076,215	2,049,812	1.90	1,180,368	2,653,182	2.25	0.350
1917	22	1,938	4.25	1,393,180	2,148,148	2.27	1,374,805	4,426,314	3.22	0.95
1918	25	2,117	5.56	1,520,883	3,189,944	3.41	1,468,818	5,615,097	3.83	0.42
1919	22	1,711	6.25	971,603	3,329,815	3.43	996,545	3,864,228	4.92	0.44
1920	18	2,064	7.47	1,373,616	3,548,782	4.07	1,489,765	7,346,000	4.92	0.86
1921	15	1,911	7.96	1,125,156	4,982,258	4.43	1,141,715	5,555,000	4.87	0.44
1922										

*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.

PRODUCTION, COSTS, ETC., OF COAL MINED IN MICHIGAN IN 1921

No. Men Employed.	Average hours worked per day.	Average days worked per month.	Average daily wage.	Total paid in wages.	No. mines using powder.	Kegs of powder used.	Picked coal mined tons.	Coal mined by machine. Tons.	Total cost.	Average cost per ton.
December	2,247	7.9	\$8.05	\$443,353.55	14	1,158	9,943	130,071	615,303.84	4.47
January	2,277	7.9	8.18	397,576.20	14	1,083	8,144	113,939	558,166.32	4.57
February	2,249	17.6	8.11	322,346.90	14	958	5,929	95,259	489,645.79	4.84
March	1,844	7.9	8.24	258,261.09	12	735	4,155	71,622	397,524.57	5.25
April	1,761	8.0	8.20	220,167.85	11	740	2,051	62,700	315,909.47	4.88
May	1,622	7.9	7.99	215,856.52	10	640	2,776	68,645	300,335.99	4.33
June	1,515	16.6	7.79	233,909.66	10	645	648	75,930	323,417.10	4.32
July	1,629	19.8	7.59	229,820.30	10	608	330	72,156	311,693.84	4.30
August	1,797	18.5	7.76	292,545.91	10	763	2,101	95,407	394,062.55	4.04
September	1,665	7.9	7.61	260,281.62	10	647	2,123	81,598	347,236.62	4.19
October	2,128	7.9	8.04	351,163.42	13	921	1,869	111,239	461,909.32	4.08
November	2,199	7.9	7.81	335,082.85	13	955	3,576	105,831	467,053.25	4.27
Aggregate	22,933			3,560,365.87	142	9,853	40,759	1,084,397	4,982,258.66	
Average	1,911	8	7.96							4.43

NON-METALLIC MINERALS

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 the practical closing of the steel plants and the high freight rates caused a greatly reduced production valued at \$3,387,722, a reduction in value of \$2,555,507 or nearly 43 per cent.

In 1921 production decreased in all limestone products except "ag-stone," limestone used as fertilizer. Under judicious advertising of the product the demand for limestone to be used as a fertilizer has steadily increased from 10,907 tons valued at \$11,104 in 1914 to 285,960 tons valued at \$201,251 in 1921. The 1921 production represents an increase over 1920 of 115,500 tons or 67.8 per cent, but not a corresponding increase in value, the 1921 value being \$201,251, an increase of only \$10,105 or 5.2 per cent. Flux stone decreased from 4,800,400 tons valued at \$2,963,095 in 1920 to 2,422,950 tons, valued at \$1,275,860, decrease of 2,377,450 tons or 49.3 per cent in quantity and of \$1,687,235 or 56.9 per cent in value. The value of stone sold to alkali plants decreased from \$1,031,251 in 1920 to \$543,994, a decrease of \$487,257 or 47.2 per cent. Limestone sold to paper mills decreased slightly in value from \$81,718 in 1920 to \$77,850, a decrease of \$3,868 or 4.7 per cent, but the value of limestone sold to sugar factories increased to \$124,678. During 1921 production of crushed stone, for road making, railroad ballast and concrete decreased from 1,726,960 tons valued at \$1,161,368 to 1,302,780 tons valued at \$918,689, decreases of 424,180 tons or 24.5 per cent in quantity and of \$242,679 or 20.8 per cent in value.

Formerly it was supposed that Michigan possessed few deposits of limestone, especially adapted for flux and chemical purposes, but in recent

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

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

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

MINERAL RESOURCES OF MICHIGAN

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1921

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.				
1899										
1900										
1901		\$31,605		\$18,200				\$27,512		
1902		56,261		40,810				3,200		
1903		61,342		48,480				13,488		
1904		58,655		57,700				32,246		
1905		112,113		43,649				15,502		
1906		78,437		103,649				62,886		
1907		131,708		163,442				109,883		
1908		182,510		35,900				81,517		
1909		182,902		42,558				109,429		
1910		110,184		52,358				56,841		
1911	224,307	113,574	91,713	54,398	306,385			91,915		
1912	603,583	295,443	51,827	28,368	185,423	178,818		100,149		
1913	532,311	266,316	14,827	48,400	292,616	137,285		186,046		
1914	505,133	242,839	18,000	20,600	362,209	97,298		137,812		
1915	482,262	194,970	38,000	19,640	398,948	145,965		494,495		
1916	834,215	420,467	69,159	19,640	323,479	169,869		565,012		
1917	726,937	340,970	189,349	37,950	418,403	217,304		763,029		
1918	591,781	254,260	182,372*	90,560	389,175	155,084		1,207,326		
1919	548,463	221,777	*	*	508,107	244,648		1,633,965		
1920	688,090	460,369	154,050	122,960	884,820	261,877		2,892,179		
1921			37,090	28,752	1,265,690	578,085		1,857,686		
1922						889,937		2,963,095		
Total		\$3,876,713		\$4,043,070		\$4,043,070		\$14,680,773		\$5,234,426

*Included under concrete after 1920.

NON-METALLIC MINERALS

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1889-1921—Concluded

Year	To paper mills Value.	Fertilizer		Other purposes.**	Number of plants.	Rank of state.	Total Value.
		Tons.	Value.				
1899				\$2,375		12	\$281,769
1900				124,220		12	330,647
1901				101,899		12	429,771
1902				68,164		13	413,148
1903				4,747		14	390,473
1904				5,523		10	501,708
1905				142,790		12	534,754
1906				278,297		10	656,269
1907				253,990		11	700,333
1908				327,571		9	669,017
1909				299,305		11	730,589
1910				440,857		9	842,126
1911	\$12,558		\$3,003			8	1,005,751
1912	8,150		3,447			8	1,139,560
1913	10,723		7,048			7	1,408,703
1914	8,307		11,104			8	1,457,961
1915	8,620	10,907	9,746	39,523		7	1,828,766
1916	11,827		11,088	39,896		6	2,389,763
1917	24,097		58,148	97,129		5	3,320,895
1918	25,153		150,604	284,649		3	5,186,867
1919	45,706		160,016	678,936	18	3	3,797,522
1920	81,718		170,460	514,651	24	5	5,943,229
1921	77,850		285,960	245,400	24	6	3,387,722
1922							
Total	\$314,709		\$885,940	\$4,390,226			\$37,437,544

*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 operated.

The absence of growth in the lime industry from 1904 to 1914 inclusive was due to several causes, chief of which were: (1) the growing scarcity of suitable wood fuel for burning lime, (2) the substitution of concrete for stone and lime-mortar in building, (3) the rapidly growing use of gypsum wall plasters and plaster substitutes, and (4) the relatively great distance of suitable limestone deposits from markets. Formerly, because of the abundance of cheap wood fuel and the lack of transportation facilities for the transportation of such 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 into the conflict early in 1917. A large amount of lime is used in the manufacture of many chemical materials used in the War. Very little of the lime produced in Michigan is used for building purposes hence the lime industry in 1918 did not suffer the general depression due to the restriction of building trades, and the small decrease in production may be ascribed to the shortage of labor and of fuel and to the difficulties of transportation.

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

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1921

Year.	Total lime burned		Average price per ton.	No. of plants operating.	Rank of State production.
	Quantity. tons.	Value.			
1904.....	63,601	\$256,955	\$4.04		
1905.....	48,089	192,844	4.01		
1906.....	68,133	281,465	4.13	13	
1907.....	65,822	276,534	4.20	12	16
1908.....	68,050	282,023	4.14	10	15
1909.....	83,108	354,135	4.26	12	13
1910.....	72,345	303,377	4.19	10	14
1911.....	80,709	352,608	4.37	14	14
1912.....	74,720	311,448	4.17	11	16
1913.....	77,088	331,852	4.05	10	14
1914.....	66,507	287,648	4.33	10	14
1915.....	81,359	349,979	4.29	10	15
1916.....	86,447	385,341	4.45	7	13
1917.....	135,920	892,682	6.72	7	7
1918.....	134,813	1,186,007	8.79	6	6
1919.....	145,783	1,381,534	9.48	7	6
1920.....	140,813	1,386,760	9.85	7	8
1921.....	48,164	445,386	9.24	6	15
1922.....					

SAND-LIME BRICK

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

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

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

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

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

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 brick 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.

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

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

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1921

Year.	No. of operating firms		Common brick.		Average price per thousand.	Front brick.		Average price per thousand.	Fancy brick.		Total value Michigan.	Change per cent Michigan.	Total value United States.	Per cent of total production U. S.	Rank.	
	Mich.	U. S.	Quantity (thou-sands).	Value.	Quantity (thou-sands).	Value.	Quantity (thou-sands).	Value.	Production.	Value.						
1904	10	57	9,886	\$64,034	\$6.64	580	\$5,234	\$9.02	19	\$497	\$69,765	142.7	\$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	3.3	972,064	17.4	1	1
1906	11	87	27,281	162,879	5.97	1,796	12,022	6.69	24	20	174,921	3.3	1,170,005	15.0	1	1
1907	13	94	25,485	158,606	6.22	*2,000	14,284	7.17	7	.....	172,840	-1.2	1,225,769	14.1	1	1
1908	10	87	21,987	131,827	5.99	*900	6,982	7.76	.....	.....	138,809	-19.7	1,029,699	13.5	1	1
1909	10	74	24,217	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	70	32,689	192,224	5.84	2,726	17,777	6.52	.....	.....	210,001	-12.7	1,897,664	23.4	1	1
1912	11	66	48,329	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	23.9	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	362,248	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	1,883,929	22.5	1	1
1919	8	35	42,063	507,010	12.05	.....	.....	12.00	.....	.....	513,094	+26.0	1,705,163	28.6	1	1
1920	8	37	38,810	632,112	16.80	.....	.....	18.36	.....	.....	640,744	+36.9	2,490,283	23.1	1	1
1921	.....	.....	*33,658	.....	.....	.....	.....	.....	.....	.....	403,929	.....	.....	.....	1	1
Total	.....	.....	654,592	\$4,632,142	.....	.....	.....	.....	.....	.....	\$5,222,056	.....	.....	.....	.....	.....

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

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

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

Since 1918 sand and gravel have increased annually in production and value in spite of the "discriminating" freight rates. In 1919 production was 3,772,535 tons valued at \$1,944,143 and in 1920, 4,386,522 tons at \$2,867,466 were produced. The 1921 reports total 5,515,253 tons valued at \$2,916,917, an increase of 1,128,671 tons or 25.7 per cent in quantity and of \$49,451 or 1.7 per cent in value. Decreased production was reported for molding and engine sand and increases for building, paving and road building sand and building gravel. Building gravel reached the highest production and value ever reported in Michigan. Despite the high freight rates practically all the large operators report improved conditions and increased demands. But many of the smaller operators report pits temporarily closed. During 1921 freight rates were reduced in Michigan but not as much as the 1920 increases. The continued activity in the building and road making industries account for Michigan's increase.

Production of molding sand decreased from the 1920 maximum of 239,439 tons valued at \$179,754 to 96,554 tons valued at \$25,576, decreases of 142,885 tons or 59.6 per cent in quantity and of \$154,178 or 85.7 per cent; engine sand decreased from 5,547 valued at \$2,943 to 3,508 tons valued at \$1,201, decreases of 36.7 per cent in quantity and of 59.2 per cent in value. Building sand increased from 789,495 tons to 823,791 or 4.3 per cent in quantity but decreased from \$482,081 to \$416,959 or 13.5 per cent in value; paving sand increased by 293,573 tons or 63.7 per cent from 460,438 tons in 1920 to 754,011 tons in 1921; railroad ballast increased in quantity by 6.7 per cent to 249,588 tons but decreased in value by 3.1 per cent to \$59,752. Gravel sold for road building increased by 972,875 tons or 39.8 per cent from 2,444,006 tons in 1920 to 3,416,881 valued at \$1,959,610, an increase in value of \$301,206 or 18.1 per cent.

In 1921 over two hundred producers reported sand and gravel production in Michigan; there were 57 sand and gravel plants, 50 are dry land plants; 6 are wet-class operating in the Detroit, St. Clair and St. Joseph rivers and in Lake St. Clair and Lake Erie; and one operates in a glacial deposit but pumps the sand and gravel through a 15-inch pipeline from an artificial lake.

In 1920 Michigan ranked eighth in quantity and sixth in value among the States producing sand and gravel.

Crushed stone used for railway ballast and road metal showed a slight increase, production being 1,381,250 tons valued at \$1,025,463. Crushed stone for the most part is produced from the larger cobbles and boulders found in the gravel pits, although some limestone is included. Figures are not complete since much of the stone is produced for use in local road work from "side of the road" pits which are abandoned after a short time and no record of production kept.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1921

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.
1905	Tons 19,382	\$13,247	Tons 263,315	\$148,065	Tons 4,000	\$400	Tons		Tons		Tons	\$14,476
1906	61,387	26,108	403,199	127,937	4,000	400					50,187	12,140
1907	54,172	24,190	451,646	157,150	1,534	153					51,065	12,187
1908	4,584	2,892	474,238	228,395	1,991	319					173,724	6,850
1909	53,226	20,756	1,090,419	327,247	12,415	1,493					295,612	50,953
1910	93,812	24,004	1,151,588	334,346	22,270	2,172					372,880	57,383
1911	68,878	17,901	833,729	247,997	25,392	4,447					114,801	52,005
1912	152,433	40,145	902,556	294,115	18,575	4,774	152,144	\$29,650			130,624	54,746
1913	50,763	17,493	1,326,016	415,737	4,447	647	68,453	16,898			113,318	20,342
1914	53,400	36,583	1,088,650	360,152	6,357	1,066	533,261	108,328			115,291	107,392
1915	82,666	25,998	843,887	236,956	6,357	1,066	320,322	74,866			111,105	12,248
1916	117,200	31,978	1,234,280	350,138	70,077	2,794	131,466	14,021			228,003	103,722
1917	147,256	52,686	782,305	433,546	4,096	1,103	154,413	38,068			94,227	41,267
1918	116,485	55,255	433,497	174,888	5,174	1,322	136,214	49,669			135,502	28,301
1919	124,006	66,877	539,800	251,733	6,958	2,268	237,317	89,430			190,327	147,247
1920	239,439	179,754	789,495	482,081	5,547	2,943	204,045	75,228			213,851	28,879
1921	96,554	25,576	823,791	416,432	3,508	1,201	460,438	254,723			137,505	35,552
1922							754,011	311,341				
Totals	1,537,643	\$661,443	13,432,411	\$4,987,432	192,350	\$27,102	3,152,084	\$1,062,222			2,557,149	\$985,691

* Included under other sand.

** Includes fire, furnace, blast and filter sand.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1921—Concluded.

Year.	Railroad ballast.		Gravel.		Total.		Rank.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1905	Tons.		Tons.	\$32,321	Tons.	\$210,609	Tons.	
1906	76,625		76,625	25,614	414,509	107,609	10	11
1907	72,598		72,598	81,182	597,789	197,609	12	13
1908	329,407		329,407	94,081	1,024,641	280,592	18	11
1909	312,262		312,262	200,523	843,591	370,365	8	9
1910	695,902		695,902	364,841	2,219,757	682,632	8	8
1911	1,197,791		1,197,791	203,218	2,869,758	816,337	7	8
1912	935,072		935,072	407,925	2,187,165	568,909	9	10
1913	1,409,180		1,409,180	915,205	2,681,391	808,603	9	8
1914	3,928,874		3,928,874	530,338	6,423,818	1,528,922	4	5
1915	2,140,359	\$781	2,140,359	671,970	3,757,970	1,036,771	8	5
1916	2,457,094		2,457,094	796,033	3,776,726	1,295,717	8	7
1917	2,226,373		2,226,373	1,011,182	4,407,475	1,241,748	7	7
1918	207,827	21,829	207,827	869,316	3,814,445	1,239,874	8	6
1919	161,552	18,314	161,552	1,378,929	2,837,375	1,639,874	8	9
1920	67,916	21,861	67,916	1,658,414	2,772,521	2,844,143	8	7
1921	233,816	61,672	233,816	1,959,610	4,366,582	2,867,466	6	6
1922	249,588	59,752	249,588		5,515,233	2,916,917		
Totals				\$11,364,620	51,520,195	\$18,910,176		

GLASS SAND

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

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

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

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

Some years ago the Rockwood Silica Sand Co., drilled a well just east of Rockwood (SE $\frac{1}{4}$ SW $\frac{1}{4}$, Sec. 10) to the depth of 122 feet penetrating 15 feet of clay, 15 feet of dolomite, and 92 feet of glass sand rock without reaching the bottom of it. A six-inch casing was used to rock and below this a four-inch casing, through which steam under a pressure

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

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

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

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

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

ANALYSES OF GLASS SAND

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

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

The washed sludge containing the fine grit is used for the ignition surfaces on match boxes. The Rockwood Silica Company was the only producer in 1921 hence statistics of production may not be published, but is included in the total for sand and gravel.

*J. E. Clark, Analyst.

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) the poor quality of much of the sandstone, (2) the substitution of concrete in construction work and (3) the greater use of brick and artificial stone.

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

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

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

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

In 1919 four plants were operated and production reached a value of \$24,413. Uses of sandstone reported were. Rough building stone, rubble, riprap, and road metal. In 1920 there were but two operators hence production values may not be given. In 1921 sandstone for rough building material and road metal was produced to the value of \$49,270.

GRINDSTONES AND SCYTHESTONES

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

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

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

Since there are but two producers, the production and value of grindstones and scythe-stones may not be given but the total value is included under Miscellaneous in the Summary table given at the end of this report.

MINERAL WATERS

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

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

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

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900-1921

Year.	Rank.		No. of springs active.	Total.		Medicinal value.	Table value.	Average price per gal.
	Quantity.	Value.		Quantity gals.	Value.			
1900.....	6	4	28	3,398,996	\$411,935			\$0.121
1901.....	2	1	28	7,019,168	1,195,614			0.170
1902.....	1	9	28	8,653,690	275,763			0.032
1903.....	1	9	19	6,919,107	200,668			0.029
1904.....	7	13	19	3,385,675	118,422			0.035
1905.....	4	4	17	2,684,800	277,188	\$38,900	\$238,288	0.100
1906.....	13	23	19	902,528	73,357			0.081
1907.....	8	15	19	1,472,679	127,133	35,091	92,042	0.086
1908.....	5	16	24	2,004,433	88,910	5,955	82,915	0.044
1909.....	8	16	19	2,760,604	104,454	6,099	98,355	0.035
1910.....	9	17	23	1,454,020	69,538	100	69,438	0.048
1911.....	11	24	23	1,713,401	72,253	12,156	60,097	0.042
1912.....	12	19	17	1,420,465	75,611	777	74,834	0.053
1913.....	17	24	20	884,893	52,642	3,605	49,037	0.059
1914.....	16	20	22	931,343	70,310	12,252	58,058	0.075
1915.....	16	18	19	913,765	72,111	5,165	67,546	0.080
1916.....	17	13	18	996,875	108,867			0.109
1917.....	12	12	11	1,069,164	105,641	500	105,641	0.098
1918.....	10	8	9	1,216,882	129,592	*	128,809	0.103
1919.....	7	9	10	1,570,906	132,312	760	132,252	0.080
1920.....	11	9	9	1,227,485	122,010	1,485	120,525	0.099
1921.....			9	1,344,900	154,405			0.114
1922.....								
Total.....				\$53,945,779	\$4,041,336			0.085

MARBLE

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

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

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

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

Developments began in 1914 but lack of transportation facilities, labor shortage, etc., hindered operations. A spur line connecting the quarry with the Chicago and Northwestern railroad was completed and blocks of marble were shipped to Marquette where the company has a stone sawing mill. Marble will be cut and polished at this mill, the electric power being supplied by the city of Marquette. 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 and 1921.

MINERAL PAINTS

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

CELESTITE

Celestite or strontium sulphate (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 Co., the masses are numerous in places and some of them are large. The commercial recovery of the celestite has been but partially investigated. The masses are imbedded in a friable to incoherent sandstone and can be readily separated from it.

FELDSPAR

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

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

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

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

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

TRAP ROCK

There are inexhaustible resources of trap rock in the western half of the Northern Peninsula, chiefly in the iron and copper bearing districts. Trap rock is quarried at Marquette and Negaunee, Marquette County.

Large quantities of amygdaloidal trap are produced incidentally to the mining of copper. The trap rock from Marquette County is harder, tougher, and less altered than that from the copper mines. The inferior wearing qualities of the amygdaloidal trap, however, is partially compensated by superior cementing power.

Most of the quarry product and considerable amounts of fieldstone or "hardheads" are crushed for road material and concrete. In some years, a small amount has been sold for riprap. The great distance from markets is a serious obstacle to the development of the trap rock industry of the State. Car and labor shortage is reported to be the chief cause of the decrease in 1918. 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 IN MICHIGAN, 1911-1921

Year.	No. of producers.	Crushed stone.				Roofing granules.	Total Value.	Rank Value.
		Roadmaking.		Concrete.				
		Quantity.	Value.	Quantity.	Value.			
		Tons		Tons				
1911	3			45,250	\$38,429		\$51,000	8
1912	5	21,805	\$18,366	11,355	9,340		36,206	8
1913	5	24,920	23,369	*	*		92,201	10
1914	5	25,690	24,863	4,448	4,771		34,406	12
1915	6	28,262	29,764	18,775	22,047		105,855	12
1916	8	38,193	37,475	9,601	9,715		83,072	12
1917	4	50,420	64,098	*	*		70,197	11
1918	4	23,686	32,605	*	*		53,269	11
1919	1						36,186	11
1920	4						84,273	10
1921	6	17,640	22,174			\$151,446	173,620	12
1922								
							\$823,585	

QUARTZ

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

The above company was the only producer in 1918, 1919, 1920, and 1921.

SLATE*

In the Northern Peninsula extensive deposits of black slate occur on the northwestern side of the Huron Mountains in Baraga County. The

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

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.

NATURAL GAS AND PETROLEUM

During 1921 drilling for oil and gas continued in southeastern Michigan with some small success, and exploration continued in other parts of the State, notably in the vicinity of Manistee, on Seul Choix Point and in the southern Thumb district. The wells of the producing district about Port Huron were abandoned on account of the increase in land values for building purposes.

There were eight small wells producing natural gas, all in the southeastern district. Production was sufficient in each case for domestic purposes only. The estimated value was \$300.00.

A bulletin discussing in detail the oil and gas possibilities in Michigan may be obtained gratis by a request to the Michigan Geological Survey.

SUMMARY TABLE OF THE PRODUCTION AND VALUE

Mineral Products.	1917		1918
	Quantity.	Value.	Quantity.
Brick and tile products, number of brick	239,670,000	\$2,846,264	98,747,000
Brick, sand-lime, number of brick	47,998,000	370,723	22,564,000
Bromine; pounds	735,654	405,059	1,605,696
Calcium chloride; tons	22,679	294,693	20,615
Cement, Portland; bbls. made, value cement shipped	4,688,899	6,122,887	3,554,872
Clay, tons	5,746	13,627	2,359
Coal, tons	1,374,805	14,426,314	1,464,818
Coke, tons; value sales			
Copper, lbs	268,508,091	**75,622,256	226,224,305
Glass sand	(c)	(c)	(c)
Graphite			
Grindstones, tons		(a)	
Gypsum, tons mined; value gypsum products sold	375,803	1,568,655	286,768
*Iron ore, shipments long tons, value f. o. b. mine	17,694,731	59,029,600	17,495,377
Iron, pig, long tons made; value pig iron shipped	509,460	b18,300,501	489,816
Lime, tons made	135,920	892,682	134,813
Limestone		3,320,895	
Mineral paints			
Mineral and spring waters, gallons sold	1,069,164	105,641	1,248,082
Natural gas, M. cu. ft.	1,184	1,013	1,173
Petroleum		(a)	
Pottery		1,187,981	
Potash (Pure K ₂ O) tons produced; value potash sold		275,215	404
Precious stones		(a)	
Quartz		(a)	
Salt, bbls	16,078,136	6,877,202	17,165,178
Sand and Gravel, tons	3,814,445	1,641,748	2,837,371
Sandstone		(a)	
Silver, fine oz. Troy	759,068	499,300	473,342
Stone, crushed			
Traprock		70,197	
Miscellaneous		159,406	
Total		\$165,731,363	

* Figures from State Tax Commission.

** Estimated at \$ 228164 per pound, the average price received for copper sold.

† Estimated at \$3.50 per ton.

a. Included under miscellaneous.

b. Excluded from total; covered by iron ore.

c. Included under sand and gravel.

d. Copper sales.

e. Estimated.

f. No production.

OF MINERAL PRODUCTS IN MICHIGAN, 1917-1921

1918	1919		1920		1921	
	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.
\$1,708,736	200,359,000	\$3,699,929	187,415,000	\$3,979,691	193,730,000	\$2,417,309
198,633	42,063,000	513,094	38,810,000	640,744	33,658,000	403,929
855,841	1,736,633	1,179,834	1,046,165	692,100		(a)
394,200	21,668	256,091	49,937	1,905,013	18,683	431,402
6,078,167	4,675,244	8,468,196	4,891,457	10,939,633	5,777,533	10,300,289
6,373	568	2,123	5,066	11,295		2,355
5,615,097	996,545	3,864,228	1,489,765	7,346,000	1,141,715	5,555,000
55,120,307	179,082,970	33,696,537	161,343,880	29,220,990	100,918,001	16,873,992
(c)	(c)	(c)	(c)	(c)	(c)	(c)
(f)	(f)	(f)	(f)	(f)	(f)	(f)
(a)	(a)	(a)	(a)	(a)	(a)	(a)
1,761,149	339,125	2,390,367	382,212	3,521,028	408,224	3,312,096
64,977,830	12,816,304	47,945,800	18,470,354	83,319,770	5,230,669	19,970,694
b17,823,684	416,277	b13,418,185	513,920	b16,812,062	243,433	b5,955,205
1,186,007	145,783	1,381,534	140,813	1,386,760	48,164	445,386
5,186,867		3,797,522		5,943,229		3,387,722
129,592	1,570,906	132,312	1,227,485	122,010	1,344,900	154,405
1,045	1,098	911		e500	400	300
(a)	(a)	(a)	(a)	(a)	(a)	(a)
1,976,436		2,096,874		2,592,625		1,781,923
100,647	166	48,581	56	18,312		(f)
(a)	(a)	(a)	(a)	(a)	(a)	(a)
(a)	(a)	(a)	(a)	(a)	(a)	(a)
9,048,650	17,800,564	9,456,138	16,163,679	10,698,674	10,196,179	7,439,445
1,242,794	3,772,535	1,944,143	4,386,582	2,867,466	5,515,253	2,916,917
(a)	19,640	24,413		(a)		(a)
504,480	425,610	477,054	510,601	518,326	310,727	310,727
53,269		36,186		84,273	1,381,250	1,025,463
247,204		60,242		161,822		173,620
						292,880
\$156,393,324		\$121,482,109		\$181,702,225		\$81,872,995

APPENDIX

DIRECTORY OF THE PRODUCERS OF NON-METALLIC
MINERALS IN MICHIGAN, 1921

BRICK AND TILE MANUFACTURERS, 1922

Operator.	Office.	Works.
<i>Allegan County:</i>		
Allegan Brick Co.....	Allegan.....	Allegan.
Zeeland Brick Co.....	Zeeland.....	Zeeland.
<i>Barry County:</i>		
Leonard Bros. Co.....	Delton.....	Delton.
<i>Berrien County:</i>		
Manner Brick Co.....	Benton Harbor.....	Benton Harbor.
<i>Cheboygan County:</i>		
Cheboygan Tile & Brick Co.....	Cheboygan.....	Inverness Twp.
<i>Chippewa County:</i>		
Rudyard Brick Works.....	Rudyard.....	Rudyard.
Thornton Brick Yard.....	Rudyard.....	Rudyard.
<i>Eaton County:</i>		
American Sewer Pipe Co.....	Broad St., Akron, Ohio.....	Grand Ledge.
Briggs Co.....	Lansing.....	Grand Ledge.
Grand Ledge Clay Products Co.....	Grand Ledge.....	Grand Ledge.
<i>Emmet County:</i>		
De Arment, C. A.....	Petoskey.....	Petoskey.
<i>Genesee County:</i>		
Scholl, L. J. & C. E.....	Clio.....	Clio.
Sharp, Frank.....	R. D. No. 1, Linden.....	South Mundy.
Atlas Clay Products Co., Inc.....	Redford.....	Redford.
<i>Gratiot County:</i>		
Ashley Tile Co.....	Ashley.....	Ashley.
Stevenson & Sons, David.....	Ashley.....	Ashley.
North Star Tile Co.....	North Star.....	North Star.
St. Louis Tile Co.....	St. Louis.....	St. Louis.
Riverside Brick & Tile Co.....	Sumner.....	Sumner.
C. D. Peet.....	North Star.....	Sickles.
<i>Ingham County:</i>		
Clippert-Spaulling Co.....	Lansing.....	Lansing.
Michigan State Brick & Tile Plant.....	Jackson.....	Onondaga.
<i>Ionia County:</i>		
Michigan Porcelain Tile Works.....	Ionia.....	Berlin Twp.
<i>Jackson County:</i>		
American Vitrified Products Co.....	Akron, Ohio.....	Jackson.
<i>Kent County:</i>		
Grand Rapids Brick Co.....	Mich. Ave and Fuller St., Grand Rapids.....	Grand Rapids.
Sparta Clay Mfg. Co.....	Sparta.....	Sparta.
<i>Lenawee County:</i>		
Britton Pressed Brick Co.....	Ann Arbor.....	Britton.
American Brick & Tile Co.....	Morenci.....	Morenci.
Comfort, Albert A.....	R. D., Tecumseh.....	Tecumseh.
Fairbanks, M. F.....	Morenci.....	Seneca.
<i>Macomb County:</i>		
A. Dordsloff, A. Buswitzsky and L. Churnsot.....	Detroit.....	Warren.
<i>Manistee County:</i>		
Ernest Klein.....	Onekama.....	Onekama.
<i>Mecosta County:</i>		
Wm. F. Nehmer.....	Big Rapids.....	Big Rapids.
<i>Midland County:</i>		
Narnburger & Fish.....	Coleman.....	Coleman.
<i>Monroe County:</i>		
Maybee Brick & Tile Co.....	Maybee.....	Maybee.
Angerer Clay Products Co.....	Scofield.....	Scofield.
Meyer Bros.....	Azalia.....	Azalia.

BRICK AND TILE MANUFACTURERS—*Continued*

Operator.	Office.	Mine.
<i>Muskegon County:</i> Muskegon Brick & Tile Co.....	Muskegon.....	Holton.
<i>Newaygo County:</i> Grant Tile Mfg. Co.....	R. D. Grant.....	Grant.
<i>Ottawa County:</i> Zeeland Brick Co.....	Zeeland.....	Zeeland.
<i>Saginaw County:</i> Day, Thomas..... Saginaw Plate Glass Co..... Miller City Tile Co..... Saginaw Clay Products.....	R. D. No. 3, Saginaw..... Saginaw..... Saginaw..... Saginaw.....	Saginaw. Saginaw. Paines. Paines.
<i>St. Clair County:</i> St. Clair Brick Co..... Shriner Brick Co.....	Detroit..... Marine City.....	St. Clair. Marine City.
<i>Sanilac County:</i> Croswell Brick & Tile Co..... Huron Clay Products Co.....	Croswell..... Croswell.....	Croswell. Croswell.
<i>Shiawassee County:</i> New Corunna Brick Co.....	Corunna.....	Caledonia Twp.
<i>Van Buren County:</i> Olliney, A. C.....	Hartford.....	Hartford
<i>Wayne County:</i> Daniel Brick Co., Jacob..... Haggerty, John S..... McDonald & Son, John C..... Bunte Bros. Tile Co..... Clippert & Bro. Brick Co., Geo. H..... Clippert, Wm..... Mercier, Bryan, Larkins Brick Co..... Porath Bros..... Springwells Brick Co..... Pewabic Pottery & Tile Co..... Lonyo Bros..... Walker & Frank Co..... Warren Brick & Tile Co..... Alliance Brick Co.....	291 Clippert Ave., Detroit..... 1815 Dime Sav. Bldg., Detroit..... 707 Hammond Bldg., Detroit. Flat Rock..... 1960 Michigan Ave., Detroit.. 1960 Michigan Ave., Detroit.. Michigan Ave. and Lonyo Road, Detroit..... 306 Free Press Bldg., Detroit.. 1009 Hammond Bldg., Detroit.. 2161 Jefferson Ave., Detroit.. 1603 Campbell Ave., Detroit.. Detroit..... Detroit..... Detroit..... Detroit..... Detroit.....	Detroit. Detroit. Springwells. Flat Rock. Springwells. Springwells. Springwells. Springwells. Detroit. Detroit. Detroit. Detroit. Detroit. Detroit. Detroit.

SAND-LIME BRICK PRODUCERS, 1921

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

CEMENT PRODUCERS, 1921

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

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

Name of mine.	County.	Manager.	Address.	Superintendent.	Address.
Robert Gage Coal Co. No. 7	Bay	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Reaver Coal Company	Bay	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Wolverine Coal Mining Company No. 2	Bay	R. M. Randall	Saginaw	Alex Liddle	Bay City
What Cheer Coal Mining Company No. 1	Bay	A. N. Fancher	Bay City	Alex Jeffreys	Bay City
R. S. K. Coal Mining Co.	Calhoun	W. A. Knapp	Albion	W. C. Sellars	Albion
Russell Mine	Clinton				
Reed Mine	Eaton				
Robert Gage Coal Company No. 3	Saginaw	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Robert Gage Coal Company No. 8	Saginaw	Chas. Coryell	Bay City	Wm. A. Jones	Bay City
Bliss Coal Mining Company	Saginaw	C. E. Linton	Saginaw	J. T. Phillips	Saginaw
Banner Coal Mining Company	Saginaw	Wm. B. Carmichael	(Saginaw)	Richard Jenkins	Swan Creek
Community Coal Company	Saginaw	Alex Jeffreys	Bay City	Wm. Folis	Swan Creek
Consolidated Riverside Coal Company No. 2	Saginaw	R. M. Randall	Saginaw	Alex Liddle	Bay City
Coal Co. Shawassee Coal Company	Saginaw	R. M. Randall	Saginaw	Alex Liddle	Bay City
Uncle Henry Coal Co. No. 2	Saginaw	R. M. Randall	Saginaw	Alex Liddle	Bay City
Akron Coal Mining Co. No. 2	Tuscola	Chas. Handy	Bay City (W. S.)	Chas. Period	Akron

CLAY MINERS, 1921

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

COKE PRODUCERS, 1921

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

GRAPHITE PRODUCERS, 1917*

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

*No graphite produced in 1919, 1920, 1921.

GRINDSTONE AND SCYTHESTONE PRODUCERS, 1921

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

PRODUCERS OF GYPSUM PRODUCTS, 1921

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

LIMESTONE AND LIME PRODUCERS, 1921

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

MINERAL AND SPRING WATER PRODUCERS, 1921

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

PIG IRON PRODUCERS, 1921

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

POTTERY PRODUCERS, 1921

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

QUARTZ PRODUCERS, 1921

Operator.	Office.	Mine.
<i>Marquette County:</i> Michigan Quartz Silica Co.	Milwaukee, Wis.	Ishpeming.

SALT PRODUCERS, 1921

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

SANDSTONE PRODUCERS, 1921

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

SAND AND GRAVEL PRODUCERS REPORTING IN 1921

Operator.	Office.	Pit.
<i>Alcona County:</i>		
Federal Sand & Gravel Co.....	302 1/2 Federal Ave., Saginaw..	Greenbush.
<i>Allegan County:</i>		
F. Buhler.....	Zeeland, R. F. D. No. 3.....	Burnips Corners.
F. W. Sutter.....	Byron Center.....	Burnips Corners.
Howard Van Keuren.....	Allegan.....	Monterey.
A. J. Powell.....	Plainwell.....	Plainwell.
Philetus Purdy.....	Fennville.....	Saugatuck.
Murrey Acklin.....	South Haven R. F. D. No. 4.....	South Haven.
<i>Alpena County:</i>		
Federal Sand & Gravel Co.....	302 1/2 Federal Ave., Saginaw..	Lachine.
Alpena Towing Co.....	Alpena.....	Alpena.
<i>Antrim County:</i>		
H. B. Sage.....	Central Lake.....	Central Lake.
James B. Gaylord.....	Mancelona.....	Mancelona.
Floyd E. Moore.....	Central Lake.....	Eastport.
<i>Barry County:</i>		
Chas. Woolston.....	Hastings, R. F. D. No. 2.....	Hastings.
Penock, Arthur.....	Nashville.....	Nashville.
E. Leibhauser.....	Nashville.....	Nashville.
P. O. Dunham.....	Nashville, R. F. D. No. 4.....	Maple Grove.
<i>Bay County:</i>		
Whitney, Geo. A.....	Bentley.....	Bentley.
A. J. Schabel, Jr.....	Munger.....	Munger.
<i>Benzie County:</i>		
John Dean.....	Bendon.....	Bendon.
Wm. Huddleston.....	Bendon, R. F. D. No. 1.....	Bendon.
Hubble Sand Co.....		
<i>Berrien County:</i>		
Ireland & Lester.....	Benton Harbor.....	Benton Harbor.
W. Harmount.....	Berrien Springs.....	Oronoka.
Frank Brewer.....	Galien, R. F. D. No. 1.....	Galien.
C. Andrews.....	Galien.....	Galien.
Broderick Bros.....	Riverside.....	Riverside.
Anton Thar.....	Coloma.....	Riverside.
Kerlikowske Bros.....	St. Joseph.....	Riverside.
Case, E. F. & Son.....	Watervliet.....	Watervliet.
<i>Branch County:</i>		
J. F. Werner.....	Bronson.....	Matteson Lake.
Barnes, Mrs. Olive A.....	Montgomery.....	Kinderhook.
Daniel Haley.....	Ray, Ind., R. F. D. No. 2.....	Ray.
Mack L. Roe.....	Bronson.....	Bronson.
<i>Calhoun County:</i>		
A. H. Marsh.....	Union City.....	Union City.
Van Sickles, Elmer I.....	Albion.....	Albion.
Willard A. Young.....	Albion.....	Albion.
Brownlee Park Gravel & Material Co.	Battle Creek.....	Battle Creek.
Geo. W. Greble.....	Marshall St., Battle Creek.....	Battle Creek.
Michigan Ry. Co.....	Jackson.....	Near Albion.
A. C. Behling.....	Albion.....	Albion.
Ralph Look.....	Eckford.....	Eckford.
Michigan Railway Co.....	Jackson.....	Marshall.
<i>Cass County:</i>		
Crandall, Fred.....	Cassopolis.....	Cassopolis.
<i>Charlevoix County:</i>		
Ward, E. B.....	Charlevoix.....	Charlevoix.
<i>Chippewa County:</i>		
Taylor, F. H.....	Pickford.....	Pickford.
Rye Bros.....	409 Maple St., Sault Ste. Marie.....	Sault Ste. Marie.
Mrs. J. Hudson.....	Pickford.....	Pickford.
<i>Clinton County:</i>		
Noah, Wilhelm.....	Bath, R. D. 25.....	Bath.
S. B. Gleason.....	Ovid.....	Ovid.

SAND AND GRAVEL PRODUCERS REPORTING IN 1921—Continued

Operator.	Office.	Pit.
<i>Genesee County:</i>		
Flint Sandstone Brick Co.	Flint	Flint
McVannell Gravel Co.	Flint	Swartz Creek.
Ernest A. Johnson	Swartz Creek	Grand Blanc.
Wm. P. Goodrich	Grand Blanc, R. D. 2	Goodrich.
Martin C. Stine	Goodrich	Goodrich.
Alfred Reid	Flint, R. D. 1	Flint.
Elige Bowles	Linden	Linden.
Genesee Gravel Co.	1409 Ford Bldg., Detroit	Mt. Morris.
Ford Sales Co.	Flint	Otisville.
Bayer Brice Gravel Co.	Flint	Flint.
Otisville Gravel Co.	Saginaw	Otisville.
<i>Gratiot County:</i>		
Emery A. Church, R. D. 4	Alma	Pine River.
A. Ray Colthorp	Breckenridge	Breckenridge.
Jos. Dexter	Shepherd R. D. 2	Summerton.
Elsa J. Every	Sumner	Sumner.
A. E. Tomlinson	Sumner	Sumner.
W. L. Wiles	Sumner	Carson City.
<i>Hillsdale County:</i>		
Charles Coler	Camden	Camden.
Nelson Wolcott	Hillsdale	Hillsdale.
<i>Huron County:</i>		
Garey, Conley Co.	Saginaw	Port Austin.
<i>Ingham County:</i>		
Burwell Sand & Gravel Co.	Lansing	Lansing.
F. M. Stockman	Lansing	Lansing.
Hoyt Woodman	Lansing	Lansing.
Hugh Campbell & Son	Bay City	Mason.
Charles Couch	Mason	Mason.
J. S. Hazel	Mason, R. 1	Eden.
A. E. Sheltraw	Saginaw W. S.	Mason.
Michigan Railway Co.	Jackson	Mason.
<i>Ionia County:</i>		
Hazelitt, J. I.	Star Rout, Ionia	Palo.
Miller, Henry	East Main St., Ionia	Ionia.
Forest P. Trowbridge	Ionia, R. F. D. No. 1	Ionia.
Glick, Cephas	Lowell, R. F. D. No. 3	Saranac.
S. L. McIntyre	Ionia	Ionia.
<i>Jackson County:</i>		
Alfred B. Cooper	Horton	Horton.
Wm. Blake	Jackson, R. F. D. No. 6	Jackson.
<i>Kalamazoo County:</i>		
Michael Owens	Kalamazoo	Kalamazoo.
Buurma, Sam. H.	Kalamazoo	Kalamazoo.
Kalamazoo, Greenville Gravel Co.	Kalamazoo	Kalamazoo.
Haas, Casper H.	Kalamazoo	Kalamazoo.
Nelson Concrete Culvert Co.	Portage St., Kalamazoo	Kalamazoo.
Quick, Isaac	Kalamazoo	Kalamazoo.
Kalamazoo Co. Road Comm.	Kalamazoo	Kalamazoo.
<i>Kent County:</i>		
Michigan Ry. Co.	Jackson	Granville.
Richard J. Slater	Ada, R. F. D. No. 1	Cascade.
M. J. Kriger	Kent City	Kent.
Grand Rapids Gravel Co.	Grand Rapids	Grandville Road.
Harrison Land Co. Lim.	Grand Rapids	Grand Rapids.
Walker Ave. Gravel Pit	Grand Rapids	Grand Rapids.
Valley City Stone & Gravel Co.	Grand Rapids	Grand Rapids.
Fred Geer	Kent City	Kent City.
Jos. Deiss	Sparta, R. F. D. No. 1	Englishville.
Overholt, R., & Son	Byron Center	Dutton.
Percy H. Read	Alpine	Alpine.
<i>Lapeer County:</i>		
Broecker, August W.	Goodrich, R. F. D. No. 2	Hadley.
Fred Miteen	Goodrich, R. F. D. No. 1	Sec. 18, Hadley.
John F. Smith	Goodrich	Hadley
M. Caley	Hunters Creek	Hunters Creek

SAND AND GRAVEL PRODUCERS REPORTING IN 1921—Continued

Operator.	Office.	Pit.
<i>Lenawee County:</i>		
Evans, Geo. M.	Morenci	Morenci.
Gillispie Estate	Tecumseh	Tecumseh.
Tecumseh Gravel Co.	Tecumseh	Tecumseh.
Frank E. Lowe	Hudson	Hudson.
<i>Livingston County:</i>		
Detroit Greenville Gravel Co.	Greenville, Ohio	Brighton.
Ohio & Michigan Sand & Gravel Co.	1025 Nicholas Bldg., Toledo, Ohio	Chilson.
Henry Farnham	Benton, R. F. D. No. 3	Linden.
Grand River Washed Sand & Gravel Co.	Ann Arbor	
<i>Macomb County:</i>		
Detroit Gravel & Ballast Co.	808 Detroit Savings Bank Bldg.	Armada.
Lakeside Ice & Coal Co.	Mt. Clemens	Mt. Clemens.
Wacker, H. Jacob	Mt. Clemens	Mt. Clemens.
Detroit Sand & Gravel Co.	34 McGraw Bldg., Detroit	Utica.
Peters Bros.	Mt. Clemens	Clinton River.
Cadillac Builders Supply Co.	Campau Bldg., Detroit	St. Clair Lake.
<i>Manistee County:</i>		
Hubbell Sand Co.	Manistee	Manistee.
Farr & Co., M. A.	140 S. Dearborn St., Chicago	Onkama.
Szymanski, Geo.	Freesoil	Freesoil.
<i>Marquette County:</i>		
Champion Sand & Gravel Co.	Marquette	Champion.
<i>Mason County:</i>		
Hubbell Sand Co.	Nabustee	Ludington.
Mason Co. Sand & Gravel Pit	Scottsville, R. F. D. No. 4	Amber.
Tobey, Wm. A.	Freesoil	Freesoil.
C. C. Dodge & Son	Walhalla	Walhalla.
H. E. Dunbar	Tallman	Tallman.
<i>Mecosta County:</i>		
Midland Gravel Co.	Midland	Millbrook.
<i>Menominee County:</i>		
Board of County Road Commissioners	Menominee	Various places.
John A. Schoen	Wilson	Wilson.
<i>Montcalm County:</i>		
Belknap Cement Products Co.	Greenville	Greenville.
Frank H. Stark	Pierson	Pierson.
E. O. Williams	Edmore	Edmore.
<i>Muskegon County:</i>		
Muskegon County Road Commissioner	Court House, Muskegon	Slocum.
Valley, Edw. F.	Twin Lakes, R. F. D. No. 1	Twin Lakes.
Michigan Materials Co.	704 Union Bank Bldg., Muskegon	Grand Haven.
<i>Oakland County:</i>		
Dodge Bros.	Detroit	Rochester.
Porath, Julius	34 McGraw Bldg., Detroit	Oxford.
United Fuel & Supply Co.	Free Press Bldg., Detroit	Oxford.
Park & Son, A. H.	Birmingham, R. F. D. No. 2	Birmingham.
Hinway Parkes	Atkins	Atkins.
W. R. Thompson Co.	100 Beaubien St., Detroit	Goodison.
Standard Gravel Co.	Pontiac	New Hudson.
Mrs. M. Campbell	Holly, R. F. D. No. 2	Holly.
Detroit-Oxford Gravel & Stone Co.	Oxford	Oxford.
Ward Sand & Gravel Co.	Penobscot Bldg., Detroit	Oxford.
Boise Bros.	Pontiac, R. F. D. No. 7	Pontiac.
Rockwell, C. L.	Pontiac	Pontiac.
Rochester Sand & Brick Co.	1001 Smith Bldg., Detroit	Rochester.
Slater Construction Co.	Pontiac	New Hudson.
<i>Oceana County:</i>		
Aldrich, A. O.	Hart	Crystal Valley.
Newfield Twp.	Hesperia	Hesperia.
Wherle, Frank	Rothbury	Rothbury.
<i>Osceola County:</i>		
Federal Sand & Gravel Co.	302 1/2 Federal Ave., Saginaw	Evart.
Crescent Gravel Co.	Reed City	Hersey.
Hersey Gravel Co.	Hersey	Hersey.

SAND AND GRAVEL PRODUCERS REPORTING IN 1921—*Concluded*

Operator.	Office.	Pit.
<i>Ottawa County</i>		
Holdrop, Jno.	Ferrysburg.	Ferrysburg.
Bunce, C. W.	Ravenna.	Ravenna.
Van Weelden & Co., I.	609 Fulton St., Grand Haven.	Grand Haven
Michigan Materials Co.	Muskegon.	Dredge, Bass River
<i>Saginaw County:</i>		
Valley Sand Co.	336 Howard St., Saginaw	Saginaw River.
H. C. Buckhardt	Bridgeport.	Bridgeport.
Bridgeport Sand & Coal Co.	Saginaw	Orville.
<i>St. Clair County:</i>		
Superior Sand & Gravel Co.	726 Dime Bank Bldg., Detroit.	St. Clair River.
Westrick & Son, C. A.	119 Water St., Marine City.	Marine City.
Reynolds & Bailey	Port Huron	Port Huron.
Chapman, Jas.	Memphis.	Riley.
Chester & Frank Kinney	Port Huron, R. F. D. No. 1.	Wadhams.
Thompson Tug Co.	Port Huron.	Port Huron.
Thompson Co., W. R.	Detroit.	Marysville.
<i>Sanilac County:</i>		
Handy Bros. Mining Co.	Bay City.	Decker.
Geo. Carney	Sandusky, R. F. D. No. 2.	Watertown.
Dawson & Son, Wm.	Sandusky	Marlette Twp.
<i>Shiawassee County:</i>		
Martenis, Burt.	Bancroft.	Bancroft.
Clark, Geo.	Byron, R. F. D. No. 2.	Byron.
Graham, John	Byron, R. F. D. No. 1.	Byron.
Allen Hathaway	Byron.	Byron.
Darling, E. R.	Carland.	Carland.
John C. Frishke	Owosso.	Owosso.
A. A. Schultz.	Laingsburg.	Laingsburg.
<i>Tuscola County:</i>		
Cass City Sand & Gravel Co.	Cass City.	Cass City.
Tuscola Sand & Gravel Co.	Cass City.	Cass City.
Tom Hile	Caro, R. R. No. 2.	Near Caro.
Gilbert Baker	Kingston.	Kingston.
Benson Whittaker	Kingston.	Kingston.
<i>Van Buren County:</i>		
Hopping, A. D.	Bangor.	Bangor.
John Sherburn	Decatur, R. F. D. No. 2.	Decatur.
Leonard Dade	Hartford.	Hartford.
<i>Washtenaw County:</i>		
Washtenaw County Road Commissioner	Ann Arbor.	Various places.
Eddie, Geo.	Ann Arbor, R. F. D. No. 8.	Ann Arbor.
Feigel, Fred.	Ann Arbor, R. F. D. No. 3.	Ann Arbor.
Wm. Shiller	Ann Arbor.	Ann Arbor.
Cadillac Sand & Gravel Co.	1452 Penobscot Bldg., Detroit	Ann Arbor.
Finkbeiner Bros.	Ann Arbor.	Ann Arbor.
<i>Wayne County:</i>		
F. D. Gleason Coal Co.	Detroit.	
Michigan Pressed Brick Co.	Detroit.	Goodison.
Ontario Gravel Co.	28 Sandwich St., Windsor, Ont.	St. Clair Flats.
Rockwood Silica Co.	Rockwood.	Rockwood.
Cameron Steamship Co.	39 Buhl Block, Detroit.	1 1/2 miles east of Rockwood.
Birmingham Sand & Gravel Co.	Detroit.	Detroit.
W. J. Jacques Co.	Detroit.	Detroit.

TRAP ROCK PRODUCERS, 1921

Operator	Office	Quarry
<i>Dickinson County:</i>		
County Road Commissioner	Iron Mountain.	Mine rock from stockpile.
<i>Marquette County:</i>		
City of Negaunee.	Negaunee.	Negaunee.
Olivine Co.	Marquette.	Marquette.
Beaver Granulith Co.	Negaunee.	Negaunee.
City of Ishpeming.	Ishpeming.	Ishpeming.
Advance Industrial Supply Co.	Chicago, Ill.	Marquette.
<i>Ontonagon County:</i>		
Blumgren, J. E.	Norway.	Bergeland.
<i>Iron County:</i>		
Iron Co. Road Commr.	Crystal Falls.	N. W. of N. E. Sec. 7 43-32.

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