

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION

Publication 33. Geological Series 27.
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

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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.

PART I. METALLIC MINERALS

THE 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	661,870,127	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	1,349,994,891	410,240,235	775,000,658	775,978,332
1913	1,235,569,727	408,778,954	926,241,092	812,068,839
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	402,335,980	784,006,486	1,429,753,296
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	1,661,659,576
1919	1,310,541,529*	429,387,594	515,595,019	914,471,572
1920	1,309,061,040*	486,070,691	629,158,459	1,033,938,338
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.....	6.68 " " "	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.....	17,069,846 " " "	2,210,473.98
Sold in year.....	23,258,846 " " " 13.42 " " "	\$3,121,282.14
	13,986,746 " " " 13.60 " " "	1,787,676.98
	9,892,100 " " " 13.99 " " "	\$1,383,605.16
Add to bring to market value.....		1,288.84
On hand Dec. 31, 1921.....	9,892,100 " " " 14.00 " " "	\$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.....	\$186,288.71	
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.....	75,519.45	23,184.84
Interest, Silver, etc.....		
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.....	\$ 176,202.98	
†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.....	550,079 "	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.....	\$3,235,288.53	
Increased by Federal adjustments.....	20,389.14	
Revised Balance of Current Assets Dec. 31, 1920, as above.....	\$3,255,677.97	

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.....	24,851,335	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. 1 shaft 43 feet below the 22nd level, 2,799 feet from surface.				
No. 2 " " 27th " " " 3,683 " " "				
No. 3 " 231 " " 24th " " " 3,358 " " "				
No. 4 " 146.5 " " 22nd " " " 2,971 " " "				

SUMMARY OF RESULTS				
Tons of rock hoisted.....	1,204,936	772,357	847,921	217,063
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:

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 " " "	436,587.08
Boston office and mine and corporation taxes.....	.87 " " "	132,108.04
Depreciation and Depletion.....	5.63 " " "	854,385.10
Production cost of.....	15,167,136 lbs. at 19.10 " " "	\$2,897,086.05
On hand Jan. 1, 1921.....	47,058,301 " " " 13.00 " " "	6,117,579.13
Sold in year.....	62,225,437 " " " 14.40 " " "	\$9,014,615.18
	38,361,246 " " " 13.00 " " "	4,986,961.98
	23,864,191 " " " 16.88 " " "	\$4,027,653.20
Less to reduce to market value.....		686,666.40
On hand Dec. 31, 1921.....	23,864,191 " " " 14.00 " " "	\$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 " 13.58 " " "	5,208,896.68
Loss on copper sold.....	.67 " " "	\$ 257,732.26
Loss by reduction to market value as above.....		686,666.40
		\$ 944,398.72
Maintenance Costs.....		
Mine.....	\$869,004.98	
Boston office and mine and corporation taxes.....	403,439.33	
Depreciation.....	280,276.94	1,562,721.25
Miscellaneous Credits.....		
Dividends from other companies.....	\$ 93,151.70	
Interest and silver sales.....	281,069.91	
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.....		\$1,401,259.77
Capital Assets Increased.....		
New construction.....	\$511,925.64	
Obsolescent.....	500.00	
	\$511,425.64	
Copper Canyon Mfg. Co. stock.....	16,387.50	
Copper Mines Information.....	113.62	
Stampage 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	\$1,651,421.89
Less decrease by obsolete Construction.....	170.00	1,084,492.04
Decrease in balance of Current Assets.....		\$ 560,929.85
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 LODGE				
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	34,324,680	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	1,905 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 37th 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.....	7,800.0 " 79 feet under 51st level.
Hecla No. 7.....	8,016.7 " 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		570,000.00
Michigan Smelting Company stock		340,900.00
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	71,955.66	
Accounts receivable		618,722.69
Insurance prepaid		247,412.39
Miscellaneous securities		1,251.85
		47,743.62
		\$7,058,148.13
Liabilities		
Current indebtedness at mines	\$142,497.40	
Accounts payable	19,340.06	
		161,837.46
Less one-half Champion		\$9,896,310.07
		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	
99,500 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
32,669,738 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
Mining expense, exploration, smelting, freight, sales department and all other expenses	\$4,457,395.98
	3,683,752.77
Taxes paid by mining companies	\$773,553.21
	301,679.65
Operating income of Copper Range Railroad Company	\$471,873.56
Less interest on bonds	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		
7,385,419 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	\$990,982.45	
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		\$2,686,295.48
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	
Accounts receivable		232,494.87
Insurance prepaid		330,292.84
		656.58
		\$2,543,268.11
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.....	41,700.30
	\$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
Accounts receivable.....	154,536.85
Insurance prepaid.....	70,556.79
	128.65
	\$1,669,151.40
Liabilities	
Indebtedness at mine.....	\$ 40,122.32
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.....	22,609.75
	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.....	8,607,163 " " "	858,931.19
	4,056,121 " " "	\$715,851.31
Less to reduce market value.....		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 " " "
Loss by reduction to market value as above.....		47,873.96
		147,094.37
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	
Obsolete.....	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	21,243,381 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.
Depletion of ore bodies	11.438 c.
Depreciation of equipment, etc.	3.321 c.
Depreciation of equipment, etc.	.859 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 Profits Taxes	73,972.35	
	<u>\$1,985,998.39</u>	
Less: Copper on hand Dec. 31, 1921, at cost	928,071.88	
Net cost of copper sold		<u>\$1,057,926.51</u>
Profit on sales of copper		<u>\$241,849.66</u>
Miscellaneous Income:		
Dividends and Interest, net	\$ 40,865.12	
Rents received, etc., net	23,180.02	
Deduct: Loss on sale of Liberty Loan bonds	\$ 64,045.14	
	<u>35,623.00</u>	
		<u>28,422.14</u>
Profit for the year, before providing for Depreciation, and Depletion		<u>\$ 270,271.80</u>

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
	<u>\$44,056.02</u>
Less: Items disposed of	<u>6,152.17</u>
	<u>\$37,903.85</u>

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 lights and telephones	62,536.54
Supplies, teaming, etc.	165,501.02
	<u>\$ 742,029.61</u>

SURFACE AND ADMINISTRATION

Superintendence and labor	\$ 20,649.28
Rock houses	34,203.16
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
	<u>\$2,140.93</u>

TRANSPORTATION

Freight and express	\$207,722.61
Labor	2,034.51
Supplies, teaming, etc.	449.76
	<u>210,206.88</u>

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
	<u>\$273,017.05</u>
Less: Credits for custom stamping, etc.	<u>1,512.80</u>
	<u>271,504.25</u>
	<u>\$1,305,881.67</u>

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

Mining expense	\$1,813,005.05	
Opening mine expense	170,798.77	
Taxes paid in Michigan	103,657.14	
Capital Stock Tax	10,231.00	
Smelting, transportation, etc.	300,397.01	
	<u>\$2,398,056.97</u>	

Leaves deficit		109,318.04
Interest receipts	6,608.31	
Sales of real estate, Hancock, Michigan	5,785.00	12,403.31
		<u>96,914.73</u>

Construction	147,029.85	
Accident account	24,000.00	
	<u>171,029.85</u>	

Deficit		<u>\$267,944.58</u>
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STATEMENT

of income and expenditures for 1921, with depreciation and depletion included, and cost of construction and sales of real estate included, conforming to the requirements of the Federal Government in regard to income tax returns, in which it is not permitted to charge construction against income, but is permissible to deduct from income the depreciation of equipment and depletion of ore reserves.

January 1, 1922.

Receipts

Sales of copper and silver	\$2,288,738.93
Interest	6,608.31
	<u>\$2,295,347.24</u>

Expenses

All expenses, including accident account and taxes other than Federal Income Tax	\$2,432,056.97
Depreciation of equipment	184,453.46
Depletion of ore bodies	427,025.42
	<u>\$3,043,535.85</u>

Net deficit for 1921	<u>\$738,188.61</u>
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STATEMENT

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

Assets

January 1, 1922.

Cash, copper and investments		\$1,657,321.46
Accounts receivable, New York	\$ 97,185.85	
" " at mine	20,663.09	
" " at smelting works	270.77	
	<u>118,135.71</u>	

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	
	<u>933,680.45</u>	

Liabilities

Accounts payable in New York	\$624,918.96	
" " 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	
	<u>1,097,816.72</u>	
		<u>\$1,611,820.84</u>

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

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 production 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 740,130 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.....	3,123.04	
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 accounts forfeited stock.....	49.74	
Remittances to mine.....	52,000.87	
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.....	230,363.25	
		492,076.38
Loss on sales of copper.....		\$ 45,449.87
Add:		
Interest paid.....	\$ 2,237.98	
Less: Interest, etc., received.....	1,546.75	
		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.....	32,018.05	
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.....	6,309.06	
Electric light and power.....	79.09	
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.....	48,387.02	
Sand conveyor.....	3,950.40	
Electric light and power.....	286.31	
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
Ahmec Mining Co.....	17,223,111	20,489,438	6,255,200
Allouez Mining Co.....	3,749,984	2,409,239	
Arcadian Consolidated Mining Co.....			
Cabnet & 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		
Ile 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	
Mass 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.....	569,935	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

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 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.

*See Bromine.

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES 1880-1921**								
Year	U. S. production quantity bbls.	Michigan production		Per cent of total Michi- gan	Rank quan- tity	Value Michigan	Michigan	
		State Salt Quantity bbls.	U. S. G. S.† Quantity, bbls.				Rank value	Price bbl.
1880	5,901,060	2,676,588	2,485,177	41.69	1	2,271,931	.....	0.75
1881	6,200,000	2,750,299	2,586,317	44.35	1	2,418,171	.....	0.85
1882	6,412,373	3,037,317	3,036,317	47.36	1	2,120,122	.....	0.70
1883	6,192,231	2,894,972	2,894,972	46.74	1	2,344,084	.....	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648	.....	0.757
1885	7,035,653	3,297,403	3,297,403	46.84	1	2,967,003	.....	0.900
1886	7,707,081	3,607,257	3,607,257	47.58	1	2,426,989	.....	0.661
1887	8,003,982	3,944,309	3,944,309	49.17	1	2,291,842	.....	0.581
1888	8,555,881	3,866,228	3,866,228	47.99	1	2,261,743	.....	0.555
1889	8,005,565	3,846,979	3,850,929	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	9,087,945	3,927,671	3,906,748	39.52	1	2,037,259	.....	0.513
1892	11,098,909	3,812,504	3,829,478	32.81	1	2,040,963	.....	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	2	888,837	.....	0.287
1894	12,908,417	3,138,941	3,341,425	26.53	2	1,243,619	.....	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	2	1,048,251	.....	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	2	718,408	.....	0.229
1897	15,973,292	3,622,764	3,993,225	24.99	2	1,243,619	.....	0.313
1898	17,612,634	4,171,916	5,293,564	29.88	2	1,628,081	.....	0.311
1899	19,708,614	4,732,689	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	20,560,061	5,580,101	7,739,641	37.58	1	2,487,077	.....	0.329
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	1,579,306	.....	0.309
1905	26,966,122	5,671,253	9,492,173	35.24	1	1,851,332	.....	0.196
1906	28,172,390	5,644,359	9,936,802	36.31	1	2,018,760	.....	0.203
1907	29,704,128	6,202,468	10,780,479	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	30,107,046†	6,055,661	9,966,744	33.10	1	2,732,556	.....	0.271
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	32,324,808†	.....	10,946,739	32.84	1	2,974,429	.....	0.277
1913	34,398,227†	.....	11,528,800	33.52	1	3,293,082	.....	0.285
1914	34,492,772	.....	11,670,976	33.92	1	3,399,005	.....	0.283
1915	38,231,496†	.....	12,588,788	32.93	1	4,304,731	.....	0.342
1916	45,449,329†	.....	14,518,278	32.84	1	4,612,567	.....	0.369
1917	49,844,125†	.....	16,078,136	32.25	1	6,817,302	.....	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-S.
**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									
	Evaporated		Pressed blocks		Other, rock		Brine and other*		Total
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity Value
1906-10	29,278,297	\$10,302,732	.....	.....	576,695	\$181,865	20,796,907	\$1,083,643	50,336,458 \$11,503,338
1911	2,363,797	2,132,946	.....	.....	779,906	4,287,772	219,244	10,330,974	2,633,155
1912	5,441,268	2,496,753	.....	.....	727,394	244,172	4,756,779	327,431	11,528,800 3,293,032
1913	6,042,657	2,411,429	.....	.....	715,590	419,735	240,066	11,670,976	3,399,005
1914	6,141,711	2,609,800	.....	.....	919,733	321,354	5,073,940	380,491	12,588,788 4,304,731
1915	6,008,155	2,602,890	.....	.....	1,012,942	360,922	7,365,957	500,850	14,918,278 4,612,567
1916	6,549,407	2,729,911	.....	.....	1,204,543	568,717	8,439,800	578,574	16,078,136 6,817,302
1917	6,233,763	2,676,926	.....	.....	1,051,448	483,578	841,575	17,165,178	9,048,650
1918	7,007,923	3,004,713	.....	.....	1,359,634	972,517	9,430,264	666,119	17,800,564 9,456,138
1919	7,031,800	3,004,713	.....	.....	1,359,634	972,517	9,430,264	666,119	17,800,564 9,456,138
1920	6,432,785	3,077,108	.....	.....	1,511,650	1,185,692	9,199,543	549,854	16,163,679 10,698,674
Open pans or grainers Vacuum pans									
Quantity Value	Quantity Value	Quantity Value	Quantity Value	Quantity Value	Quantity Value	Quantity Value	Quantity Value	Quantity Value	Quantity Value
1921	2,349,393	\$3,557,177	2,482,693	\$2,449,417	29,657	\$273,187	1,307,643	\$668,348	3,784,122 \$201,316
1922	.....	.....	.....	.....	.....	.....	.....	.....	10,196,179 \$7,439,445

*Brine only after 1916.
†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
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons Value
Bay	a	a	19,879	\$117,619	.....	.....	.....	.....	.....	.....	27,040 \$170,120
Benzie											
Charlevoix											
Emmet											
Grand Haven											
Grand Island											
Grand Rapids											
Leelanau											
Manistee											
Marquette											
Mason											
St. Ignace											
St. Joseph											
St. Lawrence											
St. Louis											
Wayne											
Tons	328,083	\$3,557,177	347,577	\$2,449,417	29,657	\$273,187	1,307,643	\$668,348	3,784,122	\$201,316	.....
Total	2,349,393	3,557,177	2,482,693	2,449,417	29,657	273,187	1,307,643	668,348	3,784,122	201,316	.....

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 bitters or "mother liquors" left after the precipitation of the salt were thrown away. The discovery that the bitters 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 prewar 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.

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

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

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896-1921													
Year	No. of plants in Michigan	No. of plants in U. S.	Daily capacity in Michigan	Michigan cement made, Blks.	U. S. cement made, Blks.	Michigan per cent made	Change per cent cement made	Michigan cement shipped, Blks.	Michigan cement shipped, Value.	U. S. cement shipped, Value.	Michigan per cent of value	Michigan stock in U. S.	Michigan average price per barrel
1896	1	1	1	4,000	1,543,038	0.25			\$7,000	\$2,444,031	0.29		\$1.77
1897	1	1	1	15,000	1,677,775	0.89			15,000	4,818,891	0.31		\$1.74
1898	1	1	1	17,000	1,682,384	1.01			17,000	4,870,773	0.34		\$1.77
1899	1	1	1	343,595	1,652,366	20.78			343,595	8,674,271	3.96		\$1.85
1900	1	1	1	664,719	1,546,512	42.98			664,719	8,080,535	8.25		\$1.89
1901	10	10	10	1,025,718	12,711,225	8.0	54.1	1,128,290	12,532,300	12,532,300	0.9	1,10	\$1.99
1902	10	10	10	1,577,000	17,230,644	9.1	53.7	1,577,000	17,230,644	17,230,644	10.0	1,10	\$1.99
1903	13	13	13	1,855,181	15,342,973	12.1	53.8	1,855,181	15,342,973	15,342,973	10.0	1,10	\$1.99
1904	16	16	16	2,247,160	16,505,881	13.6	14.9	2,247,160	16,505,881	16,505,881	10.0	1,10	\$1.99
1905	16	16	16	2,728,283	16,546,512	16.5	14.9	2,728,283	16,546,512	16,546,512	10.0	1,10	\$1.99
1906	14	14	14	2,747,525	46,463,424	5.9	35.5	2,747,525	46,463,424	46,463,424	5.9	1,204	\$1.13
1907	16	16	16	3,073,658	45,785,390	6.7	4.6	3,073,658	45,785,390	45,785,390	6.7	9,838	\$0.85
1908	15	15	15	2,992,578	51,072,512	5.8	10.9	2,992,578	51,072,512	51,072,512	5.8	9,815	\$0.83
1909	15	15	15	3,112,731	64,991,431	4.8	11.0	3,112,731	64,991,431	64,991,431	4.8	9,815	\$0.83
1910	15	15	15	3,112,731	78,549,951	3.9	11.0	3,112,731	78,549,951	78,549,951	3.9	9,815	\$0.83
1911	11	8	22,400	3,866,716	78,528,637	4.9	0.03	3,866,716	78,528,637	78,528,637	4.9	506,758	\$0.843
1912	11	8	19,450	3,904,621	82,439,096	4.7	0.21	3,904,621	82,439,096	82,439,096	4.7	370,556	\$0.813
1913	11	8	16,000	4,136,285	82,777,131	4.9	0.21	4,136,285	82,777,131	82,777,131	4.9	370,556	\$0.813
1914	11	8	10,100	4,265,245	85,914,907	4.9	0.21	4,265,245	85,914,907	85,914,907	4.9	370,556	\$0.813
1915	11	8	20,800	4,136,285	85,914,907	4.8	0.21	4,136,285	85,914,907	85,914,907	4.8	370,556	\$0.813
1916	11	8	30,650	4,819,029	91,221,198	5.27	3.2	4,819,029	91,221,198	91,221,198	5.27	338,035	\$1.103
1917	11	8	30,550	4,888,999	92,814,297	5.26	4.37	4,888,999	92,814,297	92,814,297	5.26	338,035	\$1.103
1918	10	6	49,450	3,524,872	71,081,663	5.00	24.5	3,524,872	71,081,663	71,081,663	5.00	338,035	\$1.103
1919	11	4	35,300	4,975,475	90,777,525	5.49	5.00	4,975,475	90,777,525	90,777,525	5.49	338,035	\$1.103
1920	7	3	22,700	4,981,457	100,023,245	5.0	0.0	4,981,457	100,023,245	100,023,245	5.0	338,035	\$1.103
1921	11	3	23,000	2,777,533	98,293,000	2.8	18.1	2,777,533	98,293,000	98,293,000	2.8	338,035	\$1.103
1922	11	3	23,000	2,777,533	98,293,000	2.8	18.1	2,777,533	98,293,000	98,293,000	2.8	338,035	\$1.103

*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 K₂O, 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 K₂O 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.

GYP SUM

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.

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							
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	191,716		
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	37,019	10,914		37,933	195,386		
1876	39,131	11,498		50,629	248,004		
1877	40,000	9,819		49,819	238,550		
1878	40,000	8,634		48,634	229,070		
1879	43,658	9,670		53,328	247,192		
1880	46,570	18,420		64,990	349,710		
1881	38,178	20,145		58,323	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		55,838	335,382		
1885	28,184	25,281		53,465	286,892		
1886	20,373	27,370		47,743	308,094		
1887	28,794	30,376		59,170	329,392		
1888	22,177	35,125		57,302	347,531		
1889	19,823	36,820		56,643	353,927		
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	189,020		
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	12,845	77,453	1,984	92,281	204,310		
1899	17,196	88,315	39,266	144,776	283,537		
1900	10,304	86,972	38,328	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	15,294	185,422	34,069	234,791	541,197	1	1
1905	20,258	205,313	24,289	249,860	694,454	1	1
1906	30,220	208,715	27,517	347,716	753,878	1	2
1907	15,500	197,606	36,543	317,251	681,351	3	3
1908	11,414	192,403	40,824	327,801	691,928	1	3
1909	11,890	344,171	45,781	394,907	1,213,347	2	1
1910	7,007	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	422,896	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	686,509	3	4
1916	9,072	292,109	80,298	457,375	1,066,599	3	4
1917	7,090	257,588	68,155	375,893	1,508,455	3	3
1918	5,892	267,059	46,608	289,768	1,761,149	4	4
1919	1,597	250,687	58,764	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...	1,804,577	5,946,799	1,436,195	9,533,874	32,551,514		

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, 1913-1921

Year.	Crude gypsum mined.	Gypsum sold crude.							
		To Portland cement mills.		As land plaster.		For other purposes.		Total sold crude.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1913	423,896	*	*	9,604	\$10,222	10,320	\$9,011	69,706	\$55,969
1914	390,008	*	*	9,322	10,761	*	*	61,227	51,242
1915	389,791	*	*	9,799	9,894	*	*	69,572	65,598
1916	457,375	60,846	\$62,874	9,072	22,903	*	*	80,298	90,973
1917	375,893	40,814	105,621	5,892	23,878	*	*	68,155	116,653
1918	289,768	48,798	138,611	1,597	19,422	*	*	46,008	131,438
1919	339,125	52,705	188,595	12,092	54,650	7	7	58,764	174,110
1920	382,212	74,675	245,695	20,558	98,139	25,458	25,458	73,842	359,968
1921	408,224							110,677	366,155
1922									

Year.	Gypsum sold calcined.							
	As mixed wall plaster.		As stucco.		As boards, tile, etc.		Total sold calcined*	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1913	166,711	\$437,730	95,402	\$202,075			278,368	\$665,356
1914	188,972	475,698	87,790	173,172			249,648	651,599
1915	186,861	420,432	80,172	177,317			245,454	625,073
1916	193,810	569,704	67,465	279,597	33,253	389,901	297,059	1,875,426
1917	147,371	940,511	55,436	384,981	19,158	867,741	337,059	1,829,711
1918	117,902	891,735	52,132	399,743			267,059	1,213,347
1919	153,163	1,460,573	48,639	315,516	46,377	415,075	269,499	3,521,028
1920	183,299	1,499,295	62,458	464,381	60,089	1,365,659	345,499	3,312,096
1921	169,809	1,662,343	37,508	298,538	22,800	807,519	240,648	2,442,911
1922								

*Included in the total are values for sand 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, Corunna, Shiawassee County, near Bay City, Bay County, and Flushing, Genesee County, shales belonging to the coal measures have been utilized for vitrified and front brick, vitrified tile, sewer pipe, conduits, fireproofing, etc.

Important deposits of blue gray shale occur near Ellsworth, Antrim County. The shale is quarried and sold for the manufacture of Portland cement, but no tests have been made to determine the suitability of the shale for clay products. Other deposits of shale occur in this vicinity but are undeveloped. Near East Jordan is a deposit of laminated blue to dark gray to black shale, suitable for brick and cement manufacture. At present a

company is being formed to consider the development of the East Jordan deposits. Recently a deposit of high lime clay, possibly weathered shale, has been discovered west of Rogers, Michigan. Other undeveloped deposits of shale occur in Alpena, Cheboygan, Huron, Branch and Ingham counties. Some of the 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. Value.	Fire-proofing. Value.	Miscellaneous.* Value.	Hollow building tile or blocks. Value.	Rank of state.	No. of firms operating.	Total value.
	Quantity.	Value.									
1899	200,144,000	\$933,176	\$4.66		\$140,171	\$5,900	\$22,709		13	196	\$1,254,256
1900	190,502,000	\$60,559	4.77	\$12.42	114,747	2,300	805		17	189	1,147,178
1901	215,826,000	1,005,254	5.07	12.30	98,972	1,880	637		14	180	1,497,669
1902	237,254,000	1,331,752	5.63	13.26	90,545	2,200	837		13	182	1,690,343
1903	215,791,000	1,251,072	5.80	13.27	129,028	2,000	837	\$118,138	14	178	1,662,614
1904	265,196,000	1,116,714	6.44	13.28	208,088	2,000	837	5,000	14	168	1,670,592
1905	211,558,000	1,152,005	5.45	13.37	203,445	*	837	5,000	16	154	1,719,746
1906	268,582,000	1,174,307	5.70	13.38	314,093	2,000	837	5,000	16	142	1,793,607
1907	260,817,000	1,181,015	5.48	11.96	239,868	2,000	837	5,000	17	136	1,796,180
1908	181,049,000	594,525	5.49	12.43	327,630	4,100	837	5,000	18	132	1,666,381
1909	219,820,000	1,200,787	5.69	12.84	364,006	*	837	5,000	16	122	1,947,099
1910	252,511,000	1,303,210	5.18	12.82	348,301	4,100	837	5,000	15	118	2,083,535
1911	226,066,000	1,301,094	5.76	14.00	313,072	*	228,330	5,000	16	111	2,000,442
1912	271,189,000	1,502,283	5.37	13.92	387,740	1,461	837	5,000	13	103	2,336,006
1913	271,189,000	1,502,283	5.37	13.92	387,740	1,461	837	5,000	13	90	2,336,006
1914	269,154,000	1,633,216	6.07	15.59	421,941	3,753	234,280	5,000	*	10	2,434,572
1915	277,699,000	1,851,188	5.25	14.96	505,156	10,850	40,705	5,000	*	11	2,703,056
1916	279,175,000	1,856,087	6.65	14.78	548,705	2,402	218,265	5,000	*	13	2,703,056
1917	289,612,000	1,882,042	7.80	19.16	734,442	70,996	4,002	5,000	12	69	3,000,264
1918	94,746,000	915,699	9.65	15.23	585,398	89,142	78,511	4,601	61	61	1,708,798
1919	186,526,000	3,062,660	16.42	18.16	737,124	*	25,486	4,901	69	69	3,899,399
1920	186,526,000	3,062,660	16.42	18.21	690,816	*	25,486	4,901	61	61	3,899,399
1921	193,730,000	2,417,809	12.47		381,507		8,209	5,209		61	2,915,919
Total	5,042,410,000	\$34,106,240			\$5,138,242						\$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.

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.

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

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

PRODUCTION OF CLAY IN MICHIGAN, 1910-1921

Year.	Slip clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quan- tity.	Value.	Quan- tity.	Value.	Quan- tity.	Value.	Quan- tity.	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		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	8,834					5,746	13,627
1918.	1,236	4,639					2,359	6,373
1919.	508	2,123					568	2,123
1920.	505	2,349			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 earthenware value.	Miscellaneous value.**	Total value.	Gain per cent.	Per cent of total products in U. S.
1899.	18	4	\$29,741		\$29,741	17	
1900.	17	4	34,312		34,312	17	
1901.	16	5	42,465	82,400	124,865	30.2	.20
1902.	16	4	44,098	39,000	83,098	37.4	.11
1903.	19	4	42,007	6,000	48,007	-42.2	.19
1904.	17	7	40,921	9,000	49,921	9.1	.17
1905.	17	5		7,000	42,921	-4.5	.16
1906.	17	6	43,510		43,510	11.2	.16
1907.	16	6	54,474	7,100	61,574	18.5	.20
1908.	16	6	54,856	7,549	62,405	1.5	.25
1909.	13	5	60,939	34,500	95,439	52.9	.31
1910.	13	6	94,450	13,500	107,950	18.1	.33
1911.	13	6	80,580		130,490	15.8	.38
1912.	10	9	99,555		194,867	40.8	.38
1913.	10	5	65,000		222,153	20.8	.59
1914.	9	5	108,452		265,184	33.9	.75
1915.	8	6	112,865		321,989	20.7	1.40
1916.	8	6	158,794	668,982	827,776	51.8	1.64
1917.	8	8		13,722	1,187,981	49.9	2.22
1918.	8	8		88,842	1,976,486	66.3	2.82
1919.	8	8		12,708	2,096,874	6.1	
1920.	8	8		16,848	2,592,625	23.5	
1921.					1,781,923	-35.1	
Total.			138,055	1,643,868	1,781,923		

*Included in the total.

**1908 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 decreased from 86 cents in 1920 to 44 cents in 1921. The average daily wage has with slight fluctuations in 1905, 1906, 1909, 1912, steadily increased from \$2.34 per day in 1900 to \$7.96 per day in 1921. Michigan ranked twenty-first in value and twenty-second in quantity of coal produced by the "soft" coal mining States and produced less than .3 per cent of the bituminous coal mined in the United States at less than .5 per cent of the total value, but the average value per ton, \$4.87, was exceeded only in Alaska and North Carolina, the average value per ton for the United States being \$2.89.

operated the entire year. In November the Reed mine at Grand Ledge, Eaton County, was opened.

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

*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.

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

YEAR.	Quantity. Tons.	YEAR.	Quantity. Tons.	YEAR.	Quantity. Tons.	YEAR.	Quantity. Tons.	YEAR.	Quantity. Tons.
1860	2,320	1872	33,600	1884	26,712	1896	92,882	1908	1,835,019
1861	2,000	1873	56,000	1885	45,176	1897	223,052	1909	1,784,082
1862	2,000	1874	56,000	1886	45,176	1898	312,722	1910	1,534,967
1863	9,000	1875	62,500	1887	71,461	1899	624,708	1911	1,476,974
1864	12,000	1876	69,107	1888	67,421	1900	1,349,470	1912	1,684,973
1865	15,000	1877	83,323	1889	67,421	1901	1,349,470	1913	1,538,939
1866	20,000	1878	92,015	1890	80,307	1902	1,307,519	1914	2,263,030
1867	25,000	1879	109,840	1891	80,307	1903	1,307,519	1915	1,156,138
1868	28,000	1880	115,000	1892	1,322,840	1904	1,470,511	1916	1,000,000
1869	29,980	1881	115,000	1893	45,979	1905	1,470,511	1917	1,464,818
1870	29,100	1882	115,000	1894	70,000	1906	2,030,528	1918	5,186,867
1871	32,100	1883	71,296	1895	112,322	1907	2,030,528	1919	3,797,522
								1920	5,943,229
								1921	3,387,722

YEAR.	*Number active mines.	Average output per month.	Average daily output.	Total tons of coal mined.	Total cost of coal mined.	Average cost per ton.	**Value of coal mined.	**Value of coal mined.	Average price received per ton.	Average profit per ton.
1900	31	1,676	\$2.34	871,388	\$1,209,228	\$1.387	840,475	\$1,259,683	\$1.483	\$0.096
1901	30	1,847	2.48	1,016,496	1,447,415	1.423	1,241,241	1,733,064	1.412	.067
1902	32	1,616	2.15	1,009,967	1,284,342	1.272	1,064,718	1,635,192	1.714	.442
1903	33	2,014	2.91	1,061,994	2,329,027	2.193	1,307,610	2,707,527	2.079	.400
1904	33	2,733	3.91	1,408,375	2,266,068	1.609	1,842,840	2,424,050	1.806	.197
1905	38	2,776	2.96	1,413,307	2,244,434	1.588	1,473,211	2,512,697	1.705	.117
1906	38	2,106	2.40	1,307,385	2,090,480	1.592	1,346,338	2,427,404	1.803	.274
1907	37	2,007	2.44	1,011,291	1,162,827	1.150	1,064,718	1,635,192	1.714	.442
1908	38	2,115	2.62	1,242,778	1,080,750	0.870	1,535,019	1,322,904	1.511	.134
1909	36	2,007	2.51	1,295,573	2,865,083	2.212	1,784,694	1,990,351	1.788	.064
1910	34	2,471	3.07	1,462,276	2,626,342	1.796	1,534,967	2,930,771	1.909	.103
1911	32	2,086	2.44	1,242,840	2,024,444	1.629	1,474,075	2,660,833	1.807	.174
1912	32	1,616	2.15	1,009,967	1,284,342	1.272	1,064,718	1,635,192	1.714	.442
1913	34	2,086	2.44	1,242,840	2,024,444	1.629	1,474,075	2,660,833	1.807	.174
1914	24	1,616	2.15	1,009,967	1,284,342	1.272	1,064,718	1,635,192	1.714	.442
1915	20	1,847	2.48	1,016,496	1,447,415	1.423	1,241,241	1,733,064	1.412	.067
1916	18	1,794	2.32	919,812	1,418,148	1.542	1,192,360	2,455,142	2.055	.513
1917	22	1,988	2.45	1,309,180	1,148,148	0.878	1,474,075	1,635,192	1.714	.442
1918	24	2,117	2.56	1,309,853	1,148,148	0.878	1,474,075	1,635,192	1.714	.442
1919	22	1,711	2.05	971,603	1,229,815	1.266	990,545	1,364,228	1.37	.44
1920	18	2,064	2.47	1,373,616	1,448,782	1.055	1,489,765	2,345,000	1.57	.50
1921	15	1,911	2.06	1,135,156	1,482,258	1.305	1,141,715	1,482,258	1.305	.00

No. Men Employed.	Average hours worked per month.	Average daily wage.	Average total paid in wages.	Total paid in wages.	No. mines using powder.	Kinds of powder used.	Picked coal mined tons.	Cost mined by machine. Tons.	Total cost.	Average cost per ton.	
December	2,247	7.9	24.5	\$8.05	\$443,353.55	14	1,158	9,943	130,071	653,166.32	4.47
January	2,179	7.9	16.9	8.18	397,076.00	14	1,083	8,144	113,939	581,666.32	4.47
February	2,549	7.9	17.6	8.11	325,313.19	14	958	8,144	113,939	489,644.79	4.84
March	1,761	8.0	16.9	8.20	258,261.00	12	730	4,155	71,022	387,554.57	5.25
April	1,744	8.0	15.2	8.20	286,127.20	11	740	2,051	62,700	313,909.47	4.84
May	1,615	8.0	18.8	7.70	230,909.60	10	640	648	73,900	329,417.19	4.22
June	1,609	8.0	19.9	7.70	230,909.60	10	640	648	73,900	329,417.19	4.22
August	1,797	7.9	20.3	7.76	202,545.91	10	763	2,101	96,407	394,062.53	4.30
September	2,128	7.9	20.3	7.81	202,545.91	10	763	2,101	96,407	394,062.53	4.30
October	2,128	7.9	20.5	8.04	351,163.42	13	921	1,869	111,539	461,909.32	4.19
November	2,199	7.9	19.5	7.81	335,082.15	13	955	3,676	105,831	467,055.25	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	19.5	7.96							4.43

During 1921 four mines were operated in Bay County excepting in May, June, July and September when the What Cheer No. 1 and Wolverine No. 2 were closed, and in August when the Wolverine No. 2 was not operated. One mine was operated in Calhoun County near Albion during January and February. In Clinton County the Russell Mine was not operated during April, May and June. In Saginaw County eight mines were operated nearly all the year, the Bliss mine being closed in September, the Uncle Henry No. 2 in March, April, May and June, and the Robert Gage No. 3 during July and August. The Akron mine in Tuscola County was

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.

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

Year.	To paper mills Value.	Fertilizer		Other purposes.**	Number of plants.	Rank of state. Value.	Total Value.
		Tons.	Value.				
1899				82,372		12	\$281,760
1900				124,220		12	330,857
1901				101,899		12	429,771
1902				66,594		13	412,148
1903				8,747		14	386,473
1904				8,585		10	501,708
1905				142,700		12	444,754
1906				278,297		10	626,360
1907				332,908		11	760,333
1908				327,571		9	699,017
1909				399,365		11	740,589
1910				440,857		8	842,126
1911				448,857		8	1,083,751
1912	\$12,558		\$3,003	447,126		8	1,130,569
1913	8,150		2,447	393,874		7	1,005,703
1914	10,725		7,048	399,874		7	1,005,703
1915	8,307	10,007	11,094	39,506		4	1,457,961
1916	8,630		0,746	31,329		7	1,828,766
1917	11,857		11,688	97,129		6	2,389,753
1918	24,097	62,027	58,148	284,649		5	3,330,805
1919	25,153	100,016	106,604	678,836		5	3,186,867
1920	45,706			678,836	18	5	3,797,522
1921	81,718	170,460	191,146	514,651	24	5	5,163,270
1922	77,850	280,960	201,251	245,400		6	3,857,722
Total	\$314,709		\$885,940	\$4,306,226			\$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

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

	Crushed stone.						For blast furnace flux.		To sugar factories.		To alkali works.
	Road making.*		Railroad ballast.		Concrete.						
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Value.	Value.	
1899											
1900											
1901		\$31,605		\$18,200		\$75,643		827,512		3,200	
1902		36,351		40,810		85,254		13,488		13,488	
1903		61,342		25,340		49,430		32,246		32,246	
1904		68,645		25,340		49,430		13,488		13,488	
1905		112,113		43,649		107,380		62,586		62,586	
1906		77,487		101,442		108,853		108,853	\$224,356		
1907		151,708		46,516		97,762		108,459		22,254	
1908		132,902		32,900		71,500		175,314		23,845	
1909		112,154		42,445		112,829		106,140		23,845	
1910		112,154		42,445		112,829		106,140		23,845	
1911	224,307	113,574	91,713	34,998	306,385	137,285	341,027	130,046	65,141		*
1912	665,553	201,449	54,327	20,368	183,423	97,298	292,961	137,912	30,944	\$508,044	
1913	532,311	305,316	116,000	48,400	292,610	145,965	1,302,817	494,405	38,315	329,961	
1914	505,123	347,359	38,000	19,600	367,309	169,050	1,604,240	565,012	69,477	369,097	
1915	482,202	194,070	60,139	19,640	368,948	217,304	2,254,984	703,029	46,143	481,759	
1916	634,215	430,487	136,349	37,965	325,479	135,084	3,035,155	1,207,326	41,700	439,758	
1917	726,037	344,070	182,375	90,360	418,603	244,638	3,575,178	1,633,965		787,700	
1918	591,731	251,295	*	*	389,176	81,877	4,260,360	1,811,979		1,097,251	
1919	548,403	323,777			468,107	273,085	3,385,440	1,827,686		654,832	
1920	688,000	405,369			884,820	278,029	4,900,400	2,963,065		1,031,251	
1921			37,090	28,752	1,955,690	889,937	2,422,950	1,375,860	134,678	543,994	
1922											
Total		\$3,876,713			\$4,043,070		\$14,680,773		\$5,234,426		

*Included under concrete after 1920.

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	281,495	4.13	13	
1907.....	65,822	276,534	4.20	12	16
1908.....	68,959	282,023	4.14	10	15
1909.....	83,108	354,135	4.26	12	13
1910.....	72,845	308,377	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.....	96,507	287,048	4.33	10	14
1915.....	81,359	349,979	4.29	10	15
1916.....	86,447	385,341	4.45	7	13
1917.....	135,020	892,082	6.62	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.

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

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

Michigan production.															Rank.	
Year.	No. of plants in Michigan.	No. of plants in U. S.	Common brick.		Average price per thousand (U. S. cents).	Front brick.		Average price per thousand (U. S. cents).	Fancy brick.		Total value Michigan.	Change per cent Michigan.	Total value United States.	Per cent of total production of U. S.	Pro-duction.	Value.
			Quan-ity (thous-ands).	Value.		Quan-ity (thous-ands).	Value.		Quan-ity (thous-ands).	Value.						
1904	10	57	9,890	\$64,034	6.54	280	\$5,234	89.02	19	\$497	869,765	8463,128	15.6	1	1	
1905	12	84	24,841	155,883	6.28	1,277	12,898	8.17	23	426	169,862	1,672,004	17.6	1	1	
1906	11	87	37,751	182,479	5.97	1,796	12,492	5.17	7	20	174,921	1,170,005	15.0	1	2	
1907	13	94	25,488	158,096	6.22	*2,000	14,284	5.17			174,921	1,170,005	15.0	1	2	
1908	10	87	21,957	131,877	5.99	*900	6,982	7.68			188,800	-19.7	1,629,609	14.9	1	1
1909	11	74	34,317	207,082	6.05	*1,600	11,144	6.97			218,299	-10.9	1,650,880	15.0	1	1
1910	10	86	32,889	192,234	5.84	2,726	17,777	6.52			218,299	-12.1	1,600,758	14.9	1	1
1911	11	71	45,129	307,106	6.81	9,920	8.27				218,299	-10.2	897,964	15.0	1	1
1912	12	68	49,373	345,882	6.40	†					218,299	-50.8	1,000,125	14.9	1	1
1913	12	62	41,486	248,112	5.98	†					218,299	-1.7	1,238,225	25.3	1	1
1914	11	56	46,313	281,069	6.04	†					218,299	1.1	1,185,041	25.3	1	1
1915	12	53	71,110	481,066	6.78	8,83					280,195	71	1,135,014	25.3	1	1
1916	11	47	46,979	369,246	7.71	1,019	8,477	8.13			199,711	74.14	1,484,072	25.3	1	1
1917	7	42	25,248	185,806	8.79	9.48					70,723	-28.1	1,420,380	26.1	1	1
1918	8	35	42,043	367,010	12.05	†					68,633	-40.6	1,483,072	26.1	1	1
1919	9	37	38,810	632,117	16.80	†					513,094	+88.7	1,705,163	26.1	1	1
1920	†	†	*93,038	†	†	†					74,744	-26.0	2,490,253	23.1	1	1
1921	†	†	†	†	†	†					403,929	-36.9	†	†	†	†
Total	†	†	654,592	\$4,632,142	†	†					85,222,056	†	†	†	†	†

*Eliminated.
†Included in total.
**Includes common and front brick.

SAND AND GRAVEL

The sand and gravel resources of Michigan are inexhaustible. The most important deposits occur in the form of ridges known as "hogbacks" or eskers, in irregular hills, called kames, in out wash plains, deltas,

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.

Year.	Molding sand.		Building sand.		Engine sand.		Paving sand.		Filter sand.		Other sand.**	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.		Tons.	
1905.	19,382	\$13,247	263,315	\$148,065							50,187	\$14,476
1906.	61,387	26,108	403,199	127,937	4,000	8400					31,005	12,140
1907.	54,172	34,100	451,646	157,159	1,534	135					173,724	12,187
1908.	4,684	2,892	474,238	228,306	1,991	819					29,487	6,850
1909.	26,206	10,736	527,159	267,962	4,447	1,201					395,519	50,653
1910.	93,812	24,004	1,151,588	334,840	22,270	5,172	152,144	\$29,650			372,869	57,265
1911.	68,878	17,401	1,038,419	247,097	6,447	607	533,291	108,328			114,801	32,065
1912.	152,433	40,145	902,556	294,115	18,575	4,774	68,453	18,508			130,624	54,746
1913.	50,763	17,401	1,226,016	415,737	6,447	607	533,291	108,328			113,318	29,847
1914.	53,400	36,583	1,688,640	360,152	6,357	1,066	230,322	74,666			115,291	107,292
1915.	82,605	35,908	843,887	236,908	70,072	2,794	131,466	44,821			111,105	12,548
1916.	117,200	31,678	1,234,280	350,138			154,413	38,068			228,003	163,727
1917.	147,256	52,488	932,580	433,540	4,099	1,103	782,214	89,660			94,227	41,267
1918.	116,485	55,255	433,497	174,888	5,174	1,322	237,317	89,430	6,163	\$3,048	135,502	28,301
1919.	124,006	66,577	539,900	231,723	6,558	1,205	264,045	79,228			190,227	147,747
1920.	239,439	179,754	789,495	482,081	5,547	2,943	469,438	254,725			213,841	28,879
1921.	96,554	55,576	823,791	416,432	3,608	1,201	734,011	311,841			197,605	30,552
1922.												
Totals.	1,537,643	\$601,443	13,432,411	\$4,987,432	192,350	827,102	3,152,084	\$1,062,232			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--Continued.									
Year.	Railroad ballast.		Gravel.		Total.		Rank.		
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Tons.		Tons.		Tons.		Tons.		
1905.			76,025	832,321	414,509	\$210,699	10	11	
1906.			72,598	25,614	597,769	197,699	12	12	
1907.			329,407	51,182	1,024,641	298,565	8	11	
1908.			312,903	94,081	842,591	379,365	10	11	
1909.			695,902	200,023	2,219,757	682,632	8	8	
1910.			1,197,191	364,841	2,862,788	816,357	7	7	
1911.			955,075	203,218	2,183,185	562,969	9	10	
1912.			1,028,199	497,025	2,061,871	1,028,803	8	8	
1913.			915,925	161,802	1,877,727	518,603	10	10	
1914.	7,565	\$781	2,140,359	510,265	6,422,818	1,028,803	4	5	
1915.			1,028,199	200,308	2,737,079	1,143,711	7	7	
1916.			2,326,678	725,030	3,776,726	1,006,739	6	7	
1917.	397,827	21,429	2,997,2	1,011,182	4,497,475	1,260,717	5	6	
1918.	161,252	18,314	741,681	869,316	2,837,377	1,041,744	7	6	
1919.	87,919	21,861	2,409,619	378,959	2,722,361	1,084,143	8	8	
1920.	233,816	61,672	2,444,006	1,658,414	4,386,582	2,907,400	6	6	
1921.	249,588	59,752	3,410,881	1,959,610	5,515,253	2,916,917	.....	.....	
1922.									
Totals.				\$11,364,620	51,520,195	\$18,910,170			

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.

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 Rock-wood Silica Company, the overburden is only from five to eight feet deep. Apparently there is an area of several hundred acres in the vicinity of Rockwood where the overburden does not exceed twenty feet.

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

Some years ago the Rockwood Silica Sand Co., drilled a well just east of Rockwood (SE¼ SW¼ Sec. 10) to the depth of 122 feet penetrating 15 feet of clay, 15 feet of

dolomite, and 92 feet of glass sand rock without reaching the bottom of it. A six-inch casing was used to rock and below this a four-inch casing, through which steam under a pressure 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	--
*J. E. Clark, Analyst.		

The very low percentage of iron makes the sand especially adapted for glass making, particularly for glass of the higher grades, such as plate and optical glass. Large quantities are used in the manufacture of plate glass. Experiments by the United States Bureau of Standards show that the purest grade of the Sylvania sand of Michigan is suitable for making optical glass and now all the sand used by the Government for this purpose comes from this State. It was found that from the deposits near Rockwood it is possible, under careful supervision, to obtain carload lots of glass sand which

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.

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

SANDSTONE

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

The decline of the sandstone industry in Michigan may be ascribed to (1) 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 scythestones.

Michigan ranks third in the value of grindstones and scythestones produced, Ohio being first with a total value about six times larger than that of Michigan and West Virginia together, the nearest competitors. There

are but two active quarries, both located in Huron County near the end of the "Thumb." The Wallace Company of Port Austin operates a quarry at Eagle Mills and the Cleveland Stone Company operates a quarry at Grindstone City.

Since there are but two producers, the production and value of grindstones and scythestones 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.

* 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	\$411,835			\$0.121
1901	2	1	28	7,019,168	1,195,614			0.170
1902	1	9	28	8,653,680	275,763			0.032
1903	1	9	19	6,919,107	200,608			0.029
1904	7	13	19	3,385,675	118,422			0.035
1905	4	4	17	2,084,800	277,188	\$38,900	\$238,288	0.190
1906	13	23	19	902,528	73,357			0.081
1907	8	15	19	1,472,679	127,133	35,091	92,042	0.086
1908	8	16	24	2,004,433	88,910	5,955	82,915	0.044
1909	5	16	19	2,700,604	104,454	6,099	98,355	0.035
1910	9	17	17	1,454,020	69,538	100	69,438	0.048
1911	11	24	23	1,713,401	72,253	12,156	60,097	0.042
1912	12	19	17	1,420,465	75,611		777	74,834
1913	17	24	20	884,893	52,642	3,605	49,037	0.059
1914	16	20	22	931,343	70,810	12,252	58,558	0.075
1915	16	18	19	913,765	72,111	5,165	67,546	0.080
1916	17	13	18	996,875	108,807			0.109
1917	12	12	11	1,069,164	105,641	800	105,641	0.098
1918	10	8	9	1,210,882	129,502		128,800	0.103
1919	10	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

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.

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 inter-bedded 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 ₂ O ₃)	18.60
Iron Oxide (Fe ₂ O ₃)	0.40
Lime (CaCO ₃)	0.38
Magnesia (MgO)	0.23
Sodium oxide (Na ₂ O)	1.99
Potassium oxide (K ₂ O)	13.40

According to the report of the chemist there was but little free quart 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.

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	\$15,366	11,355	9,340		36,206	8
1913	5	24,920	23,369		*		92,201	10
1914	5	25,090	24,863	4,448	4,771		34,406	12
1915	6	28,262	29,764	18,775	22,047		105,855	12
1916	8	35,193	37,475	9,601	9,715		83,072	12
1917	4	50,420	64,098		*		70,197	11
1918	4	23,686	32,605		*		58,269	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	

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.

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 slate is very black, of fine texture, and uniform in quality. It appears to be of superior quality, and suitable for roofing and other purposes for which slate is adapted.

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

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

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.

