

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION

GEOLOGICAL SURVEY DIVISION

Publication 34
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MINERAL RESOURCES OF MICHIGAN

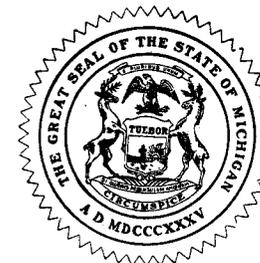
WITH

STATISTICAL TABLES OF PRODUCTION
AND VALUE OF MINERAL PRODUCTS

FOR

1922 AND PRIOR YEARS

PREPARED UNDER THE DIRECTION OF
R. A. SMITH, State Geologist
IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY



PUBLISHED AS A PART OF THE ANNUAL REPORT OF THE GEOLOGICAL
SURVEY DIVISION FOR 1922

LETTER OF TRANSMITTAL.

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

Hon. John Baird, Director.
Hon. W. H. Wallace.
Hon. Herman Lunden.
Hon. Chas. E. Lawrence.
Hon T. F. Marston.
Hon. Geo. W. Millen.
Hon. Fred Z. Pantlind.
Hon. Howard B. Bloomer.

Gentlemen. Under authority of Act No. 7 Public Acts of Michigan, Session of 1911, I have the honor to present herewith Publication 34 Geological Series 28, the eleventh of a series of annual statements of the production and value of the mineral products of Michigan. This publication is a part of the Annual Report of the Geological Survey Division for 1922.

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

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PART I. METALLIC MINERALS

THE COPPER INDUSTRY

MICHIGAN COPPER PRODUCTION IN 1922

GENERAL

The total copper production for the year 1922 amounted to 121,386,726 pounds, an increase of 29,124,643 pounds over the preceding year. This production is fully 100,000,000 pounds short of the average pre-war years. Continuous operation was maintained during the year at the Copper Range group, Quincy, Mohawk and Wolverine. On April 1st production was resumed at Ahmeek, Isle Royale and the conglomerate and reclamation branches of the Calumet and Hecla Mining Company. The remaining subsidiaries of the Calumet and Hecla continued idle. Exploration and development was conducted at the Seneca, Gratiot, Mayflower and Arcadian, and at the Seneca Mine 272,182 pounds of copper were produced from rock hoisted incidental to development work. The Michigan copper mines operated under a labor shortage which was general throughout the district and was due to the attraction offered by higher pay in the automobile industry in the lower part of the State. In the past years there has been always a considerable drift from the mines to the industrial centers but the underground force has in general been satisfactorily maintained by new immigration which was restricted under the present law. The lack of men to operate the mines was a serious handicap and materially increased costs.

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

TABLE I

PRODUCTION OF PRINCIPAL

	1911	1912	1913*	1914*	1915
Ahmeek.....	15,196,127	16,455,769	9,220,874	13,684,605	21,800,492
Allouez.....	4,780,494	5,525,455	4,091,129	6,056,548	10,043,459
Calumet and Hecla—					
Conglomerate.....	58,469,394	51,935,245	32,731,768	37,996,045	51,738,588
Amygdaloid.....	15,661,578	15,692,199	12,051,238	15,695,517	19,291,930
Reclamation.....					1,582,802
Centennial.....	1,493,834	1,742,338	1,612,262	2,287,130	2,347,500
Copper Range—					
Baltic.....	15,370,449	13,373,961	7,736,126	7,001,945	12,028,947
Champion.....	15,639,426	17,225,508	12,080,594	15,807,206	33,417,599
Trimountain.....	6,120,147	6,980,713	4,990,938	5,048,306	8,302,896
Franklyn.....	820,203	1,710,651	1,021,440	93,283	1,314,969
Hancock.....	754,729			488,678	871,124
Isle Royale.....	7,490,120	8,186,957	4,158,548	6,601,235	9,342,106
Lake.....			287,200		1,581,071
LaSalle.....		Idle	43,906	540,731	782,493
Mass.....	1,326,998	2,045,006	1,213,545	2,944,952	4,638,452
Michigan.....	327,773	162,950			
Mohawk.....	12,091,056	11,995,598	5,778,235	11,094,859	15,882,914
Osceola.....	18,388,193	18,413,387	11,325,010	14,970,737	19,731,472
Quincy.....	22,252,943	20,634,800	12,184,128	15,356,380	22,054,813
Superior.....	3,236,233	3,921,974	2,992,765	3,217,635	3,866,484
Tamarack.....	7,494,077	7,908,745	4,168,743	1,074,808	3,888,150
Victoria.....	1,303,331	1,224,911	1,428,693	1,486,242	1,499,695
White Pine.....					12,824,145
Wimona.....	1,275,675	2,307,337	1,448,737	1,352,085	1,722,638
Wolverine.....	9,630,639	9,120,485	8,350,312	3,435,459	7,250,866
Development Projects.....	648,053	228,985	233,915		297,612
Total.....	219,771,477	216,792,974	139,650,044	166,184,386	258,103,217

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

TABLE I

MICHIGAN COPPER COMPANIES.

	1916	1917	1918	1919	1920	1921	1922	1923
	24,142,158	27,919,812	24,851,235	17,223,111	20,489,438	6,255,200	14,885,081	.....
	10,219,290	8,892,915	7,071,218	3,749,984	2,499,239	Idle	Idle	Idle
	51,785,016	50,415,860	43,329,816	32,895,816	34,324,660	9,865,400	29,130,500	.....
	19,564,575	18,003,966	15,393,153	10,880,378	9,164,983	Idle	Idle	.....
	5,412,649	9,075,457	9,245,388	9,089,952	14,138,240	5,301,736	11,362,500	.....
	2,367,400	2,062,857	2,492,857	1,365,148	561,284	Idle	Idle	.....
	12,425,804	11,214,861	10,406,097	7,864,653	6,613,918	7,608,847	5,239,586	.....
	33,601,136	27,550,343	21,748,514	19,886,917	13,610,324	20,719,307	19,583,806	.....
	8,720,558	6,278,097	5,343,586	5,274,387	3,532,025	4,341,584	4,116,100	.....
	3,116,566	3,155,574	2,827,313	1,062,879	Idle	Idle	Idle	Idle
	2,824,934	4,047,053	3,041,514	Idle	Idle	Idle	Idle	Idle
	12,412,111	13,480,921	15,442,508	13,007,647	10,621,801	2,491,000	6,639,970	.....
	1,489,247	1,461,893	717,403	Idle	Idle	Idle	Idle	Idle
	1,380,352	1,919,775	1,832,665	340,719	59,713	.....	Idle	Idle
	4,752,588	3,984,616	3,403,827	1,963,178	Idle	Idle	Idle	Idle
			1,177,176	1,697,107	1,075,492	.....	Idle	Idle
	13,834,034	12,313,887	10,781,041	12,857,392	10,269,824	14,054,235	11,209,396	.....
	19,586,501	16,084,958	15,919,647	10,824,231	7,465,773	Idle	Idle	.....
	21,065,612	22,195,577	19,948,965	19,476,320	19,219,070	16,960,265	15,402,726	.....
	3,034,656	2,201,672	1,676,446	563,935	322,871	Idle	Idle	.....
	Absorbed in 1916 by	Calumet and Hecla.						
	1,661,832	1,612,640	1,533,536	1,245,590	1,060,829	273,916	Idle	.....
	4,207,449	4,067,529	3,273,680	1,979,268	1,850,787	Idle	Idle	.....
	2,167,255	1,494,472	1,576,683	561,238	Idle	Idle	Idle	.....
	6,641,492	5,856,889	4,608,865	4,562,617	3,932,225	3,924,270	3,544,879	.....
	426,260	745,381	530,730	.....	531,384	466,323	272,182	.....
Total.....	266,839,475	256,037,005	228,173,863	178,365,567	161,343,880	92,262,083	121,386,726	.....

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

TABLE II

PRODUCTION

Copper Produced in the United States from domestic ores, 1919-1922.

(Smelter output, in pounds fine)

	1919	1920	1921	1922
Alaska.....	56,534,992	66,093,924	76,808,114	59,900,579
Arizona.....	536,515,368	552,988,731	155,165,656	428,200,634
California.....	23,548,698	11,822,028	15,906,883	20,440,430
Colorado.....	4,892,558	4,282,616	6,592,598	3,635,916
Georgia.....	8,306	3,663		8,147
Idaho.....	3,966,655	1,922,116	1,971,623	3,504,944
Maine.....	376,186		3	
Michigan.....	177,594,135	153,483,952	100,918,001	116,283,920
Missouri.....	588,570	533,368	137,591	1,070,259
Montana.....	176,289,873	177,743,747	49,471,206	165,341,414
Nevada.....	64,683,734	55,580,322	15,129,116	20,398,611
New Mexico.....	60,377,320	52,159,751	18,076,909	29,127,329
North Carolina....	3,334			
Oregon.....	2,808,017	2,529,311	274,934	925,954
Pennsylvania.....		618,361		888,721
South Carolina....	2,297			
South Dakota.....	8,631	2,190		
Tennessee.....	15,629,454	16,727,803	15,084,294	14,226,232
Texas.....	2,153	14,217	587	3,889
Utah.....	143,836,304	110,357,748	45,831,959	79,665,563
Vermont.....	582,561			
Virginia.....				
Washington.....	2,552,134	2,125,586	598,658	369,133
Wyoming.....	150,051	24,256	9,830	
Undistributed.....	15,467,998	47,350	3,608,136	33,066
	1,286,419,329	1,209,061,040	505,586,098	944,024,741

Note—Compiled by United States Geological Survey.

DETAILS OF ACTUAL OPERATIONS

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

Ahmeek

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

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

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

PRODUCTION COSTS

Mining.....	5.93 c. per lb.	\$882,754.50
Smelting and refining.....	1.66 " " "	247,523.86
Boston office and mine and corporation taxes.....	.85 " " "	126,343.73
Depreciation and Depletion.....	4.47 " " "	665,669.97
Production cost of.....	14,885,081 lbs. at 12.91 " " "	\$1,922,297.06
On hand January 1, 1922.....	9,892,100 " " "	1,384,894.00
	24,777,181 " " "	\$3,307,191.06
Sold in year.....	21,870,413 " " "	2,931,803.68
On hand December 31, 1922.....	2,906,768 " " "	\$375,387.38

EARNINGS STATEMENT

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

CHANGES IN NET CURRENT ASSETS

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

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

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

Total Depth of Shafts

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

SUMMARY OF RESULTS

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

Calumet and Hecla

The conglomerate branch resumed operations on April 1st and the reclamation plant on April 10th. The Osceola Amygdaloid mine remained idle.

A total of 1,360 tons of copper rock was recovered from the 81st level exploration on the Kearsarge lode which when milled yielded 12.62 pounds of copper.

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

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

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

Details of the year's operations are as follows:

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

PRODUCTION COSTS

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

EARNINGS STATEMENT

Received for copper sold.....	57,549,859 lbs. at 13.68 c. per lb.	\$7,874,156.38
Cost of copper sold.....		
Production cost at 15.02 c. per lb.....	\$8,644,958.88	
Selling and delivery cost at .50 c. per lb.....	285,015.56	15.52 " " "
Loss on copper sold.....	1.84 " " "	\$1,055,818.06
Loss by reduction to market value as above.....		67,766.55
		\$1,123,584.61

Maintenance Costs (Jan. 1-March 31)

Mine.....	\$377,248.65	
Boston office and mine and corporation taxes.....	125,002.94	
Depreciation.....	76,917.09	579,168.68
		\$1,702,753.29
Miscellaneous receipts.....		
Dividends from other companies.....	\$425,312.30	
Interest.....	228,146.96	
Custom Smelting and Refining.....	172,116.10	
Gain from sale C. E. A. Notes, Lowbell Co. etc.....	173,384.65	\$998,960.01
Miscellaneous Expenses.....		
Examinations, depreciation, etc.....	233,967.57	764,992.44
Loss for year.....		\$937,760.85

CHANGES IN NET CURRENT ASSETS

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

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

	1919	1920	1921	1922
Tons of rock treated.....	1,830,760	1,560,240	261,320	618,800
Mine cost per ton of rock (excluding construction).....	\$3.85	\$4.22	\$4.83	\$4.07
Pounds of refined copper produced from mine.....	43,776.194	43,489,643	9,865,400	29,130,500
Pounds of copper per ton of rock.....	23.91	27.87	37.75	47.08

CONGLOMERATE LODGE

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

	1919	1920	1921	1922
Tons of rock treated.....	1,111,080	978,000	261,320	618,800
Mine cost per ton of rock (excluding construction).....	\$4.87	\$5.16	\$4.83	\$4.07
Pounds of copper produced.....	32,895,816	34,324,660	9,865,400	29,130,500
Pounds of copper per ton of rock.....	29.61	35.10	37.75	47.08
Shaft sinking.....	1,437 feet	1,505 feet	427 feet	371 feet
Drifting.....	3,375 "	153 "	508 "	1,152 "
Crosscuts and footwall drifts.....	4,154 "	2,361 "	726 "	354 "

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

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

REGRINDING PLANTS

	From Mine	From Old Sands
Tons treated.....	340,340	489,150
Assay headings.....	.765 %	.647 %
Assay tailings.....	.503 %	.434 %
Pounds refined copper.....	1,756,000	2,089,000
Pounds refined copper per ton treated.....	5.16	4.17
Cost per pound, excluding smelting and selling.....	5.22 c.	8.62 c.

LEACHING PLANT

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

FLOTATION PLANTS

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

RECLAMATION TOTALS

Tons treated.....	1,378,250	6,212,418
Assay headings.....	.532%	.741%
Assay tailings.....	126%	226%
Pounds refined copper.....	11,362,500	65,201,724
Pounds refined copper per ton treated.....	8.24	10.50
Cost per pound copper, excluding smelting and selling.....	6.28 c.	6.40 c.

Copper Range Company

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

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

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

CURRENT ASSETS AND TOTAL LIABILITIES DECEMBER 31, 1922

(Including Subsidiary Mining Companies)

Assets	
Cash.....	\$2,002,172.51
United States Liberty Loan Bonds.....	1,793,000.00
Copper delivered and not paid for.....	316,135.00
Copper on hand.....	806,538.14
Copper Range Railroad Company bonds.....	870,000.00
Michigan Smelting Company stock.....	340,000.00
Balance due from United States Government account Railroad guaranty under the Transportation Act 1920.....	92,966.29
Supplies at Mines.....	\$523,112.26
Cash at Mines.....	88,194.25
	<u>611,306.51</u>
Accounts receivable.....	519,808.79
Insurance Prepaid.....	1,612.49
U. S. and Short Term Securities.....	341,119.47
	<u>\$7,694,659.20</u>
Liabilities	
Current indebtedness at mines.....	\$123,747.34
Accounts payable.....	448,329.29
	<u>572,076.63</u>
Less one-half Champion.....	\$7,122,582.57
	<u>1,360,619.03</u>
Net excess of assets.....	<u>\$5,761,963.54</u>

The Copper Range Company now holds in its treasury the following:
 97,256 shares Atlantic Mining Company stock.
 99,690 shares Trimountain Mining Company stock.
 50,000 shares Champion Copper Company stock.
 42,443 shares Copper Range Railroad Company, entire stock issued.

COMPARATIVE STATEMENT

(Baltic, Trimountain and one-half Champion combined)

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

COST AND PROFITS

(Exclusive of Depreciation and Depletion)

	Production Pounds	Cost Per Pound	Price Received
Baltic.....	5,329,568	16.76c	13.958c
Trimountain.....	4,116,100	16.46c	13.958c
Champion (1/2).....	9,791,903	09.93c	14.359c
Copper Range Company.....	19,237,571	13.22c	14.17c
1921.....	22,310,084	12.74c	13.19c
1920.....	16,951,105	17.77c	17.14c
1919.....	23,082,498	15.02c	18.67c
1918.....	26,623,940	14.46c	24.757c
1917.....	31,268,130	12.579c	28.735c

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

1921.....	3.73c per pound
1920.....	4.16c " "
1919.....	3.56c " "
1918.....	3.4c " "
1917.....	3.2c " "

Baltic Mine

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

RECEIPTS

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

EXPENDITURES

Running expenses at the mine, and taxes.....	\$807,539.47	
Smelting, freight, cost of marketing and general expense.....	85,964.13	893,503.60
Deficit.....		\$149,578.09
Expended for construction.....		31,270.63
		<u>\$180,848.72</u>

SINKING

	Sunk in 1922	Total Depth	Bottom Level
No. 2 shaft.....	0 feet	3062 feet	31st
No. 3 shaft.....	9 "	3839 "	39.50
No. 4 shaft.....	0 "	2982 "	31st

Total sinking.....	9 feet		
Total drifting, main vein.....		3045 feet	
Total drifting, west vein.....		1552 "	
Total cross-cutting.....		302 "	

Tons of rock hoisted.....	237,478
Tons of rock stamped.....	165,804

Tons of waste rock hoisted.....	71,674 or 30.18 %
Yield of copper per ton of rock stamped.....	32.14 pounds
Of the total stamp rock hoisted, 53 % was produced from the main lode, and 60 % of all rock stamped came from No. 2 shaft.	

Champion Copper Company

The statement of operations at this property is as follows:

RECEIPTS

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

EXPENDITURES

Running expenses at the mine and taxes.....	\$1,587,249.08	
Smelting, freight, cost of marketing copper and general expenses.....	357,421.13	1,944,670.21
Net profit.....		\$890,515.16
Surplus December 31, 1921.....	\$2,441,711.90	
Less 1922 Construction.....	10,988.99	2,430,722.91
		<u>\$3,321,238.07</u>
		600,000.00

Less capital distribution against depletion ore reserves.....		600,000.00
Surplus December 31, 1922.....		<u>\$2,721,238.07</u>

CURRENT ASSETS AND TOTAL LIABILITIES

December 31, 1922

Assets

Cash in Boston.....	\$1,440,011.92
Copper on hand.....	509,744.53
Copper delivered and not paid for.....	214,971.80
Michigan Smelting Company Stock.....	110,000.00
U. S. and other securities.....	223,737.10
Supplies at mine.....	\$247,809.15
Cash at mine.....	9,211.19
	257,020.34
Accounts Receivable.....	51,827.56
Insurance prepaid.....	736.59
	<u>\$2,808,049.84</u>

Liabilities

Indebtedness at mine.....	\$69,538.55	
Accounts payable.....	17,278.22	86,811.77
Excess assets.....		<u>\$2,721,238.07</u>

SINKING

	Sunk in 1922	Total Depth	Bottom Level
No. 1 shaft.....	139 feet	2920 feet	25th
No. 2 shaft.....	115 "	2777 "	24th
No. 3 shaft.....	127 "	2502 "	22d
No. 4 shaft.....	163 "	2551 "	23d

Total sinking.....	544 feet		
Total drifting, main vein.....		4,294 feet	
Total drifting, west vein.....		906 "	
Total cross-cutting.....		20 "	
Total raising.....		648 "	
Tons of rock hoisted.....		554,457	
Tons of rock stamped.....		503,593	

Tons of waste rock hoisted.....	50,864 or 9.17 %
Yield of copper per ton of rock stamped.....	38.964 pounds

Trimountain Mining Company

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

The summary statement of the 1922 operations is as follows:

RECEIPTS

4,116,100 lbs. of copper produced and sold at 14.359c per lb.	\$574,544.09
Interest.....	35,545.54
	<u>\$610,089.63</u>

EXPENDITURES

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

CURRENT ASSETS AND TOTAL LIABILITIES

December 31, 1922

Assets

Cash.....	\$7,498.97
United States Liberty Bonds (par \$1,000,000).....	993,000.00
Copper on hand.....	71,538.90
Copper delivered and not paid for.....	44,258.90
Michigan Smelting Company stock.....	110,000.00
Supplies at mine.....	\$140,111.61
Cash at mine.....	16,810.79
	156,922.40
Accounts receivable.....	80,368.39
Insurance prepaid.....	267.63
	<u>\$1,463,855.19</u>

Liabilities

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

SINKING

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

Isle Royale Copper Company

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

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

PRODUCTION COSTS

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

EARNINGS STATEMENT

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

CHANGES IN NET CURRENT ASSETS

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

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

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

Total Depth of Shafts:

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

SUMMARY OF RESULTS

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

Mohawk Mining Company

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

SUMMARY OF RESULTS FOR THE YEAR

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

MINERAL RESOURCES OF MICHIGAN

PROFIT AND LOSS ACCOUNT

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

CAPITAL INVESTMENTS

During the Year Ending December 31, 1922

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

STATEMENT

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

UNDERGROUND EXPENSE

Mining.....	\$116,410.15
Timbering, tramming and all other labor.....	204,242.99
Hoisting.....	30,349.93
Compressor and drills.....	80,373.68
Power, electric light and telephones.....	46,886.37
Supplies, teaming, etc.....	129,731.90
	\$607,995.02

SURFACE AND ADMINISTRATION

Superintendence and labor.....	\$24,303.16
Rock houses.....	25,503.80
Insurance.....	4,137.49
Industrial accident.....	3,604.86
Incidentals.....	2,604.63
Power, electric light and telephones.....	995.06
Supplies and teaming.....	3,767.85
Employees' insurance.....	7,478.21
	\$72,395.06

TRANSPORTATION

Freight and express.....	\$143,968.90
Labor.....	2,053.26
Supplies, teaming, etc.....	494.97
	146,517.13

STAMP MILL

Labor.....	\$73,431.15
Fuel.....	107,163.44
Sand conveyor.....	7,887.53
Maintaining sprinkler system.....	535.85
Power and electric light.....	832.25
Supplies, teaming, etc.....	28,016.16
	\$217,866.38
Less: Credit for custom stamping, etc.....	30,134.31
	\$187,732.07
	\$1,014,639.28

COPPER PRODUCTION IN 1922

BALANCE SHEET, DECEMBER 31ST, 1922

Assets	
Investments:	
Miscellaneous stocks and bonds, at cost.....	\$96,592.27
Current Assets:	
Cash in bank and on hand.....	\$1,109,247.63
Accounts and bills receivable.....	534,725.54
Copper on hand, at cost.....	271,686.69
Supplies at mine.....	190,449.97
Unexpired insurance.....	\$2,106,109.83
	1,672.11
	\$2,204,374.21
Capital Assets (Book Value):	
Real Estate.....	\$47,177.92
Mining property, cost.....	450,000.00
Ore body enhancement as of March 1, 1913.....	7,524,789.85
Buildings, machinery and plant.....	2,385,405.32
Underground openings.....	1,328,647.03
Roads and dams.....	8,024.76
	11,744,044.88
	\$13,948,419.09
Liabilities	
Capital Stock:	
Paid in on 100,000 shares.....	\$1,800,000.00
Current Liabilities:	
Accounts payable.....	\$103,556.36
Unclaimed dividends.....	3,077.00
	106,633.36
Unrealized appreciation.....	\$4,366,047.22
Reserve for depreciation.....	1,687,234.36
Reserve for depletion.....	3,978,915.11
	10,032,196.69
Reserve for contingencies.....	400,000.00
Surplus and Realized Appreciation:	
Balance, January 1st.....	\$1,867,571.85
Add: Profits for the year.....	211,480.16
Appreciation realized during the year.....	304,837.84
Profit on property disposed of.....	17,765.22
	\$2,401,655.07
Deduct: Depreciation for the year.....	\$119,813.20
Depletion for the year.....	372,252.83
Dividends.....	300,000.00
	\$792,066.03
Balance, December 31st.....	1,609,589.04
	\$13,948,419.09

Quincy Mining Company

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

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

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

STATEMENT

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

			January 1, 1923.
Receipts			
Sales of copper and silver.....		\$2,232,606.22	
Interest.....		13,239.14	
Sales of timber.....		2,680.00	
			\$2,248,525.36
Expenses			
All expenses, including accident account and taxes other than Federal Income Tax.....	\$2,232,544.60		
Depreciation of equipment.....	188,111.71		
Depletion of ore bodies.....	376,201.39	\$2,796,857.70	
Net deficit for 1922.....			\$548,332.34

STATEMENT

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

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

Wolverine Copper Mining Company

This mine is essentially a scram and mining during the year consisted generally of opening up old levels and mining pillars and blocks of ground considered too lean in former operations. This work entailed considerable hand picking underground. In addition 27 per cent of the rock hoisted during the year was obtained from vein left in the foot in old stopes throughout the mine.

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

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

Rock hoisted.....	250,745 tons
Rock stamped.....	244,310 tons
Product of mineral.....	5,431,040 pounds
Product of refined copper.....	3,544,879 pounds
Yield of rock treated, 14,509 lbs. per ton or.....	.725 per cent
Cost per ton of rock hoisted.....	\$1.704
Cost per ton of rock stamped.....	\$1.749
Total operating cost per pound of refined copper.....	12.054 c.
Cost of smelting, freight and marketing product, including Eastern Offices' expenses..	1.986 c.
Cost of taxes.....	.700 c.
	14.740 c.
Depletion of Ore Bodies.....	4.249 c.
Depreciation of Equipment, etc.....	.541 c.
	19.530 c.
Total cost per pound of refined copper.....	19.530 c.

PROFIT AND LOSS ACCOUNT

For the Year Ending June 30, 1923

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

CAPITAL INVESTMENT

During the Year Ending June 30, 1923

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

BALANCE SHEET

Assets

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

MINERAL RESOURCES OF MICHIGAN

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

JUNE 30, 1923

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

STATEMENT OF WORKING EXPENSES AT THE WOLVERINE MINE

For the Year Ending June 30, 1923

UNDERGROUND EXPENSES

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

SURFACE AND ADMINISTRATION

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

TRANSPORTATION

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

COPPER PRODUCTION IN 1922

STAMP MILL

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

DEVELOPMENT PROJECTS

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

THE IRON INDUSTRY

STATISTICS OF MICHIGAN IRON ORE PRODUCTION

for the Year 1922

The total shipments of Michigan iron mines for the year 1922 amounted to 12,433,729 tons; the mine production for the year, 10,360,984 tons, the excess of shipments coming from accumulations of stockpiles in 1921 and previous years. The total shipments of iron ore in the United States for 1922 amounted to 51,339,031 tons, of which Michigan produced 24.2%. The average value per ton of Michigan iron ore in 1922 was \$5.1151 f. o. b. Lower Lake Ports. The value at the mine would be \$5.1151 minus cost of transportation which amounted to \$1.5956, or \$3.5195. The gross value of the 1922 shipments f. o. b. Lake Erie Ports was \$63,599,767 and the gross value at the mine was \$43,760,509.

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

TABLE I

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

Mine.	Tons mined 1922.	Tons shipped 1922.	Grand total shipment all years.
Anvil.....	29,862	30,558	950,755
Asteroid.....	3,231	78,414	926,699
Ashland.....	46,558	76,917	6,615,879
Brotherton.....		69,033	2,678,800
Castile.....		24,889	864,076
Colby-Ironton.....	239,700	267,990	*8,408,416
Eureka.....	208,799	271,840	2,107,446
Keweenaw.....	141,344	133,000	1,037,688
Newport-Bonnie.....	495,207	788,527	17,574,549
Norrie Group.....	1,129,031	1,385,241	42,066,083
Palms.....	321,719	472,456	5,477,871
Plymouth.....	607,876	607,876	4,055,123
Puritan Group.....	111,250	162,050	2,555,539
Sunday Lake.....	94,149	190,621	3,137,044
Tilden*.....	210,735	222,603	*6,832,051
Townsite†.....	76,250	59,929	†407,513
Wakefield.....	430,136	430,136	6,320,960
Yale.....	204,063	263,831	2,049,186
Idle Mines.....			1,727,020
Total.....	4,359,910	5,535,911	115,792,698

*Shipments of Tilden mine included with Colby prior to 1891.

†Formerly Norrie Mine part of Norrie Group. Shipments included under Norrie Group prior to 1917.

TABLE II

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

Mine.	Tons mined 1922.	Tons shipped 1922.	Grand total of shipments.
Aragon.....	209,796	275,464	9,127,179
Chapin*.....	330,676	490,048	24,019,141
Loretto.....	75,022	88,975	2,581,105
Munro.....	35,263	35,263	576,254
Penn Group†.....	177,556	168,186	12,632,890
West Chapin.....		1,270	1,270
Abandoned and Idle Mines.....			15,111,768
Total.....	828,313	1,059,206	64,049,607

*Chapin mine includes Millie Ludington and Hamilton formerly operated as separate mines.

†Penn Group includes following mines: Norway and Cyclops now abandoned, West Vulcan, East Central, Brier Hill, Curry, East Vulcan, active or temporarily idle.

TABLE III

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

Mine.	Tons mined 1922.	Tons shipped 1922.	Total shipments 1922 and prior years.
Balkan	85,493	84,969	1,409,294
Baltic-Fogarty	252,169	264,168	3,082,562
Bates	110,430	112,959	688,989
Bengal	145,029	163,042	1,491,956
Berkshire*	116,265	118,871	800,536
Bristol	51,545	124,146	5,605,343
Buck	8,006	5,660	5,660
Cardiff	50,011	28,982	28,982
Carpenter	165,012	206,837	2,082,652
Caspian	146,030	158,063	4,327,758
Chicagoan		48,774	1,234,339
Davidson Group †	120,965	166,376	1,950,856
Great Western		59,800	2,257,825
Hiawatha	107,018	126,885	2,053,107
Homer	81,880	135,975	1,411,421
Judson	93,161	124,829	763,377
Monongahela	80,570	114,839	429,140
Odgers	102,500	55,481	879,921
Osana-Wauseca	158,957	185,675	1,785,359
Porter	87,662	120,894	592,791
Riverton	140,382	119,916	3,916,161
Rogers	152,438	193,845	701,846
Spies ‡	7,500	35,123	553,497
Tobin	127,100	105,344	3,391,235
Tully		62,129	1,084,587
Warner	47,572	63,152	428,256
Zimmerman	42,031	33,504	1,682,898
Abandoned and Idle mines			16,837,215
Total	2,479,726	3,020,238	61,477,563

*Berkshire including Cottrell.

†Davidson Group includes Davidson Nos. 1, 2 and 3 active or temporarily idle and also Davidson No. 4 or (Waupama) or (Purcell) mined out and abandoned.

‡Spies includes Spies and Virgil.

TABLE IV

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

Mine.	Tons mined 1922.	Tons shipped 1922.	Tons shipped 1922 and prior years.
American-Boston		40,306	1,846,643
Angeline		36,841	9,319,679
Athens	193,259	265,159	597,488
Austin	50,705	5,065	1,315,782
Barnes & Hecker	20,313		
Cliffs Shaft*	131,502	179,496	8,162,772
D. S. S. & A. (Adams)	16,632	16,632	195,384
Francis	98,049	11,437	119,567
Gardner-Mackinaw		40,180	142,453
Gwinn	20,085	26,436	947,166
Holmes	218,066	262,251	740,409
Imperial	118,175	73,083	760,486
Isabella	88,033	109,731	551,997
Jackson	16,101	16,102	4,311,182
Lake		28,581	16,003,988
Maas	209,740	11,997	2,547,956
Mary Charlotte	175,590	172,261	3,875,002
Maitland	13,593	13,593	156,859
Morris Lloyd	221,979	293,916	2,365,797
Negaunee	289,279	337,880	8,730,627
Princeton	74	26,145	2,167,689
Republic	98,173	80,022	7,890,104
Richmond	155,518	155,518	2,440,724
Rolling Mill	107,763	142,801	2,114,175
Salisbury		24,724	4,406,708
Section 16 Group †	237,183	245,694	18,211,376
Stephenson	213,223	202,523	2,458,559
Idle and Abandoned Mines			37,973,920
Total	2,693,035	2,818,374	140,354,492

*Includes Barnum and Iron Cliffs.

†Section 16 Group includes Lake Superior Hard Ore and Section 21 mine now idle and Lake Superior Hematite mined out.

MINERAL RESOURCES OF MICHIGAN

TABLE V

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

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

TABLE VI

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

States.	Tons.
Minnesota.....	30,772,162
Michigan.....	12,433,729
Alabama.....	5,234,568
Wisconsin.....	795,175
Pennsylvania.....	780,836
New York.....	444,381
Wyoming.....	332,800
Tennessee.....	156,464
New Mexico.....	118,038
New Jersey.....	90,359
Missouri.....	58,408
Virginia.....	39,971
Georgia.....	24,149
Montana.....	21,726
North Carolina.....	17,279
California, Colorado, Idaho, Utah, Nevada.....	18,986
Total.....	51,339,031

IRON ORE PRODUCTION IN 1922

TABLE VII

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

Items.	All active mines.	All active and partial list of inactive properties.*
Cost of Mining:		
Labor.....	1.0933	1.0991
Supplies.....	.6012	.6058
Total.....	1.6949	1.7051
Other Ore Costs:		
Concentrating and Crushing.....	.0072	.0072
Deferred Charges.....	.0856	.0857
Total.....	.0928	.0929
Taxes Except Federal Income Tax:		
State and Local General Property Tax.....	.3678	.3960
Federal Taxes Except Income Tax.....	.0051	.0052
State Corporation Tax.....	.0082	.0086
Total.....	.3811	.4098
Depreciation.....	.1414	.1416
Overhead Expense:		
General Superintendence.....	.0458	.0492
Contingent Expense.....	.0109	.0109
Fire Insurance.....	.0072	.0076
General Expense.....	.0919	.0940
Total.....	.1558	.1617
Transportation:		
Rail Freight.....	.8843	.8843
Boat Freight.....	.7093	.7093
Cargo Insurance.....	.0020	.0020
Total.....	1.5956	1.5956
Analysis and Selling Expense:		
Analysis.....	.0044	.0044
Selling Commission.....	.0385	.0385
Total.....	.0429	.0429
Total Cost of Mine Operation.....	4.1045	4.1496
Royalty.....	.4375	.4414
Cost Adjustment.....	.0030	.0031
Total Mining Companies Cost.....	4.5450	4.5941
Receipts from Sale of Ore.....	5.1151	5.1151
Total Cost of Mine Operation.....	4.1045	4.1496
Earnings on Mine Operation.....	1.0106	.9655
Receipts from Sale of Ore.....	5.1151	5.1151
Total Mining Companies Cost.....	4.5450	4.5941
Earnings on Mine Operation.....	.5701	.5210
Interest.....	.0782	.0793
Net Earnings on Mine Operation.....	.4919	.4417

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

TABLE VIII

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

	1922.			1923.		
	Ore Reserves.	Valuation.	Assessed value per ton.	Ore Reserves.	Valuation.	Assessed value per ton.
Marquette and						
Baraga.....	72,953,551	\$35,361,552	.4834	72,102,521	\$35,560,753	.4932
Gogebic.....	62,405,146	47,900,266	.7562	58,314,512	46,534,818	.7979
Iron.....	54,918,070	24,776,948	.4795	57,065,508	25,624,025	.4490
Dickinson.....	9,467,955	5,908,770	.6346	9,344,407	6,010,500	.6432
	199,744,722	\$113,947,536	.5704	196,826,948	\$113,730,096	.5778

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

Note: Idle Reserves marked*

- Athens:
Parcels in SW $\frac{1}{4}$ of Sec. 5 and SE $\frac{1}{4}$ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Athens Mining Company
- Austin:
N $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 20, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.
- Baraga*
Parcel in SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Interstate Iron Company.
- Barnes and Hecker:
Lot 2 and S $\frac{1}{2}$ of the NE $\frac{1}{4}$ and S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 2, T. 47 N., R. 28 W., Ely Township.
Cleveland Cliffs Iron Company.
- Bunker Hill*:
Parcel in S $\frac{1}{2}$ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Bunker Hill Mining Company.
- Cambria:
Lots 7 and 8, Sec. 35; Lots 5, 6 and 7, Sec. 36; S $\frac{1}{2}$ of the SE $\frac{1}{4}$ Sec. 35. All in T. 48 N., R. 27 W., City of Negaunee.
Republic Iron & Steel Company.
- Champion*:
S $\frac{1}{2}$ of Sec. 31, T. 48 N., R. 29 W., Champion Township.
Champion Iron Company.
- Cliffs Shaft:
N $\frac{1}{2}$ of Sec. 9; S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 4; SW $\frac{1}{4}$ of SE $\frac{1}{4}$ of Sec. 3, Part of N $\frac{1}{2}$ of Sec. 10, T. 47 N., R. 27 W., City of Ishpeming.
Cleveland Cliffs Iron Company.
- D. S. S. & A. (Adams):
Parcel of land along old D. S. S. & A. between Maas and Negaunee mines, Sec. 5, 6, T. 47 N., R. 26 W. and Sec. 32, T. 48 N., R. 26 W., City of Negaunee.
Lake Superior Iron Company.
- Empire:
E $\frac{1}{2}$ of SW $\frac{1}{4}$ of Sec. 19, T. 47 N., R. 26 W. Richmond Township.
Empire Mining Company.
- Francis:
S $\frac{1}{2}$ of the NW $\frac{1}{4}$ and SW $\frac{1}{4}$ of Sec. 27, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.
- Gwinn:
NW $\frac{1}{4}$ of Sec. 28, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.
- Hematite No. 1*:
SE $\frac{1}{4}$ of the SW $\frac{1}{4}$ and SW $\frac{1}{4}$ of the SE $\frac{1}{4}$, and parcel in SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Interstate Iron Company
Property formerly called Breitung Hematite No. 1.
- Holmes:
SW $\frac{1}{4}$ of the NE $\frac{1}{4}$ of Sec. 9, T. 47 N., R. 27 W., City of Ishpeming.
Cleveland Cliffs Iron Company.

- Imperial:
NW $\frac{1}{4}$ of Sec. 25, T. 48 N., R. 31 W., Spurr Township.
Ford Motor Company.
- Isabella:
SW $\frac{1}{4}$ of Sec. 29, T. 47 N., R. 26 W., except west 20 rods. Richmond Township.
Steel & Tube Company of America.
- Jackson:
Sec. 1, T. 47 N., R. 27 W., City of Negaunee.
Cleveland Cliffs Iron Company.
- Lake Sally*:
Lots 4, 5, 6, 7, 8 and SW $\frac{1}{4}$ of the SW $\frac{1}{4}$ and SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 14, T. 47 N., R. 27 W., City of Ishpeming.
Jones & Laughlin Ore Company.
- Lake Superior Group:
*Hard Ore. N $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 9; S $\frac{1}{2}$ of the NW $\frac{1}{4}$ and the W $\frac{1}{2}$ of the NW $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Sec. 10, all in T. 47 N., R. 27 W.
Section 16. SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 9, T. 47 N., R. 27 W. and N $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 16, T. 47 N., R. 27 W., City of Ishpeming.
*Section 21. W $\frac{1}{2}$ of the NE $\frac{1}{4}$ and S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 21, T. 27 N., R. 27 W., Tilden Township.
Lake Superior Iron Company.
- Lucky Star*:
Parcel in SW $\frac{1}{4}$ of Sec. 5 and SW $\frac{1}{4}$ of Sec. 6, T. 47 N., R. 26 W., City of Negaunee.
Lucky Star Mining Company.
- Mackinaw-Gardner*:
Mackinaw. N $\frac{1}{2}$ of the SE $\frac{1}{4}$ and SW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 35, T. 45 N., R. 25 W.
Gardner. SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 35, T. 45 N., R. 25 W. and NW $\frac{1}{4}$ of the NE $\frac{1}{4}$ of Sec. 2, T. 44 N., R. 35 W., Forsyth Township.
Cleveland Cliffs Iron Company.
- Maitland:
W $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 30, T. 47 N., R. 26 W., Richmond Township.
Alexander Maitland, Owner, Negaunee, Michigan.
- Mary Charlotte Group:
Breitung No. 2. S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 8, T. 47 N., R. 26 W.
Mary Charlotte. N $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 8, T. 47 N., R. 26 W.
Himrod. NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Sec. 7, T. 47 N., R. 26 W., City of Negaunee.
Marquette Ore Company.
- Morris Lloyd Group:
Lloyd. SW $\frac{1}{4}$ of the NW $\frac{1}{4}$ and N $\frac{1}{2}$ of the SW $\frac{1}{4}$ and N $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 6, T. 47 N., R. 27 W., Ishpeming Township.
Morris. N $\frac{1}{2}$ of the S $\frac{1}{2}$ and SE $\frac{1}{4}$ of the NE $\frac{1}{4}$ of Sec. 1, T. 47 N., R. 28 W., Ely Township.
Cleveland Cliffs Iron Company.
- Negaunee:
Parcels in Secs. 5 and 6, T. 47 N., R. 26 W., and Sec. 32, T. 48 N., R. 26 W., City of Negaunee.
Negaunee Mining Company.
- Princeton*:
NW $\frac{1}{4}$ of Sec. 20, T. 45 N., R. 25 W.; S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 18, T. 45 N., R. 25 W.; E $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 19, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.
- Race Course*:
Parcel in Sec. 6, T. 47 N., R. 26 W. and Sec. 31, T. 48 N., R. 26 W., City of Negaunee.
Lake Superior Iron Company.
- Republic:
Entire Section 1, T. 46 N., R. 29 W., except Lot 1, Republic Township.
Cleveland Cliffs Iron Company.
- Richmond:
SW $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Sec. 28, T. 47 N., R. 26 W., Richmond Township.
Richmond Iron Company.
- Rolling Mill:
S $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 7, T. 47 N., R. 26 W., City of Negaunee.
Clement K. Quinn & Company.
- Stephenson:
S $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 20, T. 45 N., R. 25 W., and N $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 29, T. 45 N., R. 25 W., Forsyth Township.
Cleveland Cliffs Iron Company.
- Sundry Parcel No. 1*:
Parcel in southwest corner of SW $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Sec. 5, T. 47 N., R. 26 W., City of Negaunee.
Interstate Iron Company.

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

Note: Idle Reserves marked*

- Aronson*:
E $\frac{1}{2}$ of the NW $\frac{1}{4}$ of the NE $\frac{1}{4}$ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Republic Iron & Steel Company.

- Balkan:**
W ½ of the NE ¼ and the NE ¼ of the NW ¼ and Frac. part of the NE ¼ of the SE ¼ of the NW ¼, all in Sec. 13, T. 42 N., R. 33 W., Mastodon Township.
Balkan Mining Company.
- Baltic-Fogarty Group:**
Baltic. W ½ of the NW ¼ of Sec. 7, T. 42 N., R. 34 W.
Fogarty. SE ¼ of the SE ¼ of Sec. 1, T. 42 N., R. 35 W.
Buck (Andrew Young). S ½ of the SW ¼ of Sec. 6, T. 42 N., R. 34 W., Stambaugh Township.
Verona Mining Company.
- Bates:**
Lots 3 and 4 and S ½ of the NW ¼ of Sec. 19, T. 43 N., R. 34 W., Bates Township.
Bates Iron Company.
- Blair*:**
NE ¼ of the SW ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
McKinney Steel Company.
- Bengal:**
N ½ of the SE ¼ of Sec. 36, T. 43 N., R. 35 W., Stambaugh Township.
Verona Mining Company.
- Berkshire Group:**
Berkshire. NW ¼ of the SW ¼ of Sec. 6, T. 42 N., R. 34 W.
Cottrell. NE ¼ of the SE ¼ of Sec. 1, T. 42 N., R. 34 W.
Corry. NE ¼ of the SW ¼ of Sec. 6, T. 42 N., R. 34 W., Stambaugh Township.
Brule Mining Company.
- Bristol:**
E ½ of the SE ¼ of Sec. 19, T. 43 N., R. 32 W., City of Crystal Falls.
Bristol Mining Company.
- Cardiff:**
E ½ of the NE ¼ of Sec. 22, T. 43 N., R. 35 W., Iron River Township.
Wickwire Mining Company.
- Carpenter:**
N ½ of the SW ¼ of Sec. 31, T. 43 N., R. 32 W., Crystal Falls Township.
Hanna Furnace Company.
- Caspian:**
NE ¼ of Sec. 1, T. 42 N., R. 35 W., Stambaugh Township.
Verona Mining Company.
- Chicagon*:**
NE ¼ of Sec. 26, T. 43 N., R. 34 W., Bates Township.
Munro Iron Mining Company.
- Davidson Group:**
No. 1. NE ¼ of the NW ¼ of Sec. 23, T. 43 N., R. 35 W.
No. 2. SW ¼ of the SE ¼ of Sec. 14, T. 43 N., R. 35 W.
No. 3. SE ¼ of the SE ¼ of Sec. 14, T. 43 N., R. 35 W., Iron River Township.
Davidson Ore Mining Company.
- Delta:**
W ½ of the SW ¼ of Sec. 25, T. 43 N., R. 35 W., Iron River Township.
St. Clair Mining Company.
- DeGrasse*:**
S ½ of the NE ¼ of Sec. 7, T. 42 N., R. 34 W., Stambaugh Township.
Verona Mining Company.
- Dunn-Richards:**
Dunn. W ½ of the NE ¼ of Sec. 1, T. 42 N., R. 33 W., Mastodon Township.
Richards. SW ¼ of the SE ¼ of Sec. 36, T. 43 N., R. 33 W., Crystal Falls Township.
McKinney Steel Company.
- Erickson*:**
SW ¼ of Sec. 21, T. 43 N., R. 34 W., Bates Township.
Cleveland Cliffs Iron Company.
- Fortune Lake*:**
S ½ of the SW ¼ of Sec. 24, T. 43 N., R. 33 W. N ½ of the NW ¼ of Sec. 25, T. 43 N., R. 33 W. NE ¼ of the NE ¼ of Sec. 26, T. 43 N., R. 33 W. SW ¼ of the NE ¼ of Sec. 26, T. 43 N., R. 33 W., Crystal Falls Township.
Fortune Lake Mining Company.
- Forbes:**
SE ¼ of the SW ¼ of Sec. 14, T. 43 N., R. 35 W., Iron River Township.
Jones & Laughlin Ore Company.
- Great Western*:**
E ½ of the SW ¼ of Sec. 21, T. 43 N., R. 32 W., City of Crystal Falls.
McKinney Steel Company.
- Great Western Extension*:**
SW ¼ of the SE ¼ of Sec. 21, T. 43 N., R. 32 W.
McKinney Steel Company.
- Hiawatha:**
SE ¼ of the SW ¼ and S ½ of the SE ¼ of Sec. 35, T. 43 N., R. 35 W., Stambaugh Township.
Munro Iron Mining Company.
- Homer:**
W ½ of the NW ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Buffalo Iron Mining Company.

- Judson Group:**
Judson. SE ¼ of the NW ¼ except five acres and the NE ¼ of the SW ¼ of Sec. 13, T. 42 N., R. 33 W.
Carpenter. "40" SW ¼ of the NW ¼ of Sec. 13, T. 42 N., R. 33 W., Mastodon Township.
Balkan Mining Company.
- Michaels*:**
NW ¼ of the SE ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
McKinney Steel Company.
- Minckler*:**
W ½ of the NW ¼ of the SE ¼ and the NE ¼ of the SW ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Republic Iron & Steel Company.
- Monongahela:**
NE ¼ of Sec. 36, T. 43 N., R. 33 W., Crystal Falls Township.
Hanna Furnace Company.
- Neely, Crystal Falls*:**
Lots 1 and 2, Sec. 21, T. 43 N., R. 32 W., City of Crystal Falls.
Kimberly Iron Company.
- Neely, Mastodon Township*:**
N ½ of the NE ¼ of Sec. 12, T. 42 N., R. 33 W., Mastodon Township.
Cleveland Cliffs Iron Company.
- Ogders:**
S ½ of NE ¼ of Sec. 30, T. 43 N., R. 32 W., Crystal Falls Township.
McKinney Steel Company.
- Oliver Exploration*:**
S ½ of NE ¼ of Sec. 12, T. 42 N., R. 33 W., Mastodon Township.
Oliver Iron Mining Company.
- Osana:**
N ¼ of the NE ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Mineral Mining Company.
- Porter:**
E ½ of the NE ¼ of Sec. 22, T. 44 N., R. 33 W., Crystal Falls Township.
Hemlock River Mining Company.
- Riverton Group:**
Dober. N ½ of the NW ¼ of Sec. 1, T. 42 N., R. 35 W.
Isabella. SW ¼ of the SW ¼ of Sec. 36, T. 43 N., R. 35 W.
Duff. N ½ of the NE ¼ of Sec. 2, T. 43 N., R. 35 W., Stambaugh Township.
Oliver Iron Mining Company.
- Rogers:**
NE ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
Munro Iron Mining Company.
- Ravenna and Prickett*:**
W ½ of the SE ¼ of Sec. 19, T. 43 N., R. 32 W. SW ¼ of Sec. 19, T. 43 N., R. 32 W. NE ¼ of the SE ¼ of Sec. 24, T. 43 N., R. 32 W., Crystal Falls Township.
Hanna Furnace Company.
- Sherwood*:**
SE ¼ of the NE ¼ and the NE ¼ of the SE ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Republic Iron & Steel Company.
- Spies Group:**
Spies. SE ¼ of the NW ¼ and the NE ¼ of the NW ¼ of Sec. 24, T. 43 N., R. 35 W.
Virgil. SW ¼ of the NW ¼ of Sec. 24, T. 43 N., R. 35 W., Iron River Township.
Cleveland Cliffs Iron Company.
- Tobin Group:**
Tobin. SW ¼ of Sec. 30.
Genesee. SE ¼ of Sec. 30; NW ¼ of the NE ¼ of Sec. 31.
Columbia. NW ¼ of Sec. 31, Crystal Falls Township.
McKinney Steel Company.
- Tully*:**
S ½ of the SE ¼ of Sec. 36, T. 43 N., R. 35 W., Stambaugh Township.
McKinney Steel Company.
- Warner:**
E ½ of the SE ¼ of Sec. 9, T. 44 N., R. 33 W., Hematite Township.
Hemlock River Mining Company.
- Wauseca:**
SW ¼ of the NE ¼ and the SE ¼ of the NW ¼ of Sec. 23, T. 43 N., R. 35 W., Iron River Township.
Mineral Mining Company.
- White*:**
E ½ of the NW ¼ of Sec. 29, T. 43 N., R. 34 W., Bates Township.
J. A. Monroe et al, Iron River, Michigan.
- Wilkinson*:**
NE ¼ of the SE ¼ of Sec. 36, T. 43 N., R. 33 W., Crystal Falls Township.
Verona Mining Company.
- Zimmerman:**
E ½ of the NW ¼ of Sec. 7, T. 42 N., R. 34 W., Stambaugh Township.
Marting Ore Company.

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

Note: Idle Reserves marked*

- Anvil*:**
NE $\frac{1}{4}$ of Sec. 14, T. 47 N., R. 46 W., Bessemer Township.
Steel & Tube Company of America.
- Ashland:**
S $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 22, T. 47 N., R. 47 W. N $\frac{1}{2}$ of Lot 1, Sec. 27, T. 47 N., R. 47 W.
North 10 acres of the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Sec. 27, T. 47 N., R. 47 W., City of Ironwood.
Hays Mining Company.
- Asteroid:**
NE $\frac{1}{4}$ of Sec. 13, T. 47 N., R. 46 W., Bessemer Township.
The Castile Mining Company.
- Brotherton:**
N $\frac{1}{2}$ of the SE $\frac{1}{4}$ and the SE $\frac{1}{4}$ of NE $\frac{1}{4}$ of Sec. 9, T. 47 N., R. 45 W., City of Wakefield.
Brotherton Iron Mining Company.
This property was mined out and abandoned in 1922.
- Castile:**
E $\frac{1}{2}$ of Sec. 10, T. 47 N., R. 45 W., City of Wakefield.
The Castile Mining Company.
This property was abandoned and allowed to fill with water in 1922.
- Colby, Ironton Group:**
Colby. NE $\frac{1}{4}$ of Sec. 16, T. 47 N., R. 46 W., City of Bessemer.
Ironton. W $\frac{1}{2}$ of the E $\frac{1}{2}$ of Sec. 17, T. 47 N., R. 46 W., Bessemer Township.
Winona. E $\frac{1}{2}$ of the E $\frac{1}{2}$ of Sec. 17, T. 47 N., R. 46 W., City of Bessemer.
The McKinney Steel Company.
- Eureka:**
N $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 13, and the S $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 12, T. 47 N., R. 46 W., Bessemer Township.
The Castile Mining Company.
- Keweenaw:**
S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 11, T. 47 N., R. 46 W., Bessemer Township.
The Steel & Tube Company of America.
- Mikado*:**
S $\frac{1}{2}$ of the N $\frac{1}{2}$ of the NW $\frac{1}{4}$ and the S $\frac{1}{2}$ of the NW $\frac{1}{4}$ and the NW $\frac{1}{4}$ of the NE $\frac{1}{4}$ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Verona Mining Company.
- Morgan:**
SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 11, T. 47 N., R. 45 W., Wakefield Township.
Thomas Furnace Company.
- Newport Group:**
Newport. NW $\frac{1}{4}$ of Sec. 24, T. 47 N., R. 47 W., City of Ironwood.
Bonnie. NE $\frac{1}{4}$ of Sec. 24, T. 47 N., R. 47 W., Erwin Township.
Steel & Tube Company of America.
- Norrie Group:**
Aurora. E $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 23, T. 47 N., R. 47 W.
East Norrie. W $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 23, T. 47 N., R. 47 W.
North Ashland. N $\frac{1}{2}$ of the SW $\frac{1}{4}$ of Sec. 22, T. 47 N., R. 47 W.
North Norrie. N $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 22, T. 47 N., R. 47 W.
North Aurora. S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 23, T. 47 N., R. 47 W.
North Pabst. N $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 23, T. 47 N., R. 47 W.
Pabst. S $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 23, T. 47 N., R. 47 W.
Vaughn. N $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 23, T. 47 N., R. 47 W., City of Ironwood.
Oliver Iron Mining Company.
- North Mikado:**
Parcels in NW $\frac{1}{4}$ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Castile Mining Company.
- Palms:**
NW $\frac{1}{4}$ of Sec. 14, T. 47 N., R. 46 W., City of Bessemer.
Steel & Tube Company of America.
- Pilgrim:**
NE $\frac{1}{4}$ of the NE $\frac{1}{4}$ and the S $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Verona Mining Company.
- Plymouth:**
NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ and the SE $\frac{1}{4}$ of Sec. 18, T. 47 N., R. 45 W., City of Wakefield.
Plymouth Mining Company.
- Puritan Group:**
Davis. N $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 19, T. 47 N., R. 46 W.
Geneva. SW $\frac{1}{4}$ of Sec. 18, T. 47 N., R. 46 W.
Royal. SE $\frac{1}{4}$ of Sec. 18, T. 47 N., R. 46 W.
Puritan. SW $\frac{1}{4}$ of Sec. 17, T. 47 N., R. 46 W., Bessemer Township.
North Newport. S $\frac{1}{2}$ of Sec. 13, T. 47 N., R. 47 W., Erwin Township.
Oliver Iron Mining Company.
- Sunday Lake:**
W $\frac{1}{2}$ of Sec. 10, T. 47 N., R. 45 W., City of Wakefield.
Sunday Lake Iron Company.

- Tilden:**
N $\frac{1}{2}$ of Sec. 15, T. 47 N., R. 46 W., Bessemer City.
The Oliver Iron Mining Company.
- Townsite (Formerly Norrie of Norrie Group):**
S $\frac{1}{2}$ of the SE $\frac{1}{4}$ of Sec. 22, T. 47 N., R. 47 W., City of Ironwood.
Townsite Mining Company.
- Wakefield:**
N $\frac{1}{2}$ of the SW $\frac{1}{4}$ and the W $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 16, and the N $\frac{1}{2}$ and the N $\frac{1}{2}$ of the S $\frac{1}{2}$ of Sec. 17, T. 47 N., R. 45 W., City of Wakefield.
Wakefield Iron Company.
- Yale:**
S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 16, T. 47 N., R. 46 W., City of Bessemer.
Charcoal Iron Company of America.

LIST AND LOCATION OF IRON MINES IN DICKINSON COUNTY.

Note: Idle Reserves marked*

- Aragon:**
NE $\frac{1}{4}$ and the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Sec. 8, T. 39 N., R. 29 W. N $\frac{1}{2}$ of the NW $\frac{1}{4}$ and Frac. part of the SW $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Sec. 9, T. 39 N., R. 29 W. Frac. part of the SE $\frac{1}{4}$ of the SW $\frac{1}{4}$ and Frac. part of the SW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 5, T. 39 N., R. 29 W., City of Norway.
Oliver Iron Mining Company.
- Chapin:**
N $\frac{1}{2}$ of the SE $\frac{1}{4}$ and the SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 25, T. 40 N., R. 31 W. SW $\frac{1}{4}$ and SW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 30, T. 40 N., R. 30 W. NW $\frac{1}{4}$ of the NE $\frac{1}{4}$ and the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Sec. 31, T. 40 N., R. 30 W., City of Iron Mountain.
Oliver Iron Mining Company.
Includes following mines operated at one time separately: Chapin, Ludington, Hamilton, Millie.
- Indiana:**
N $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 27, T. 40 N., R. 30 W., Breitung Township.
The Thomas Furnace Company.
- Loretto:**
SW $\frac{1}{4}$ of the NW $\frac{1}{4}$ and the SW $\frac{1}{4}$ of Sec. 7, T. 39 N., R. 28 W., Waucedah Township.
Loretto Iron Company.
- McKenna*:**
NW $\frac{1}{4}$ of Sec. 2, T. 39 N., R. 30 W., less 10 acres in the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$, Breitung Township.
Iron Mountain Furnace & Chemical Company.
- Munro:**
NW $\frac{1}{4}$ of the SE $\frac{1}{4}$ and the NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Sec. 6, T. 39 N., R. 29 W., City of Norway.
Munro Iron Mining Company.
Property abandoned and lease surrendered at end of 1922.
- Penn Group:**
Active Mines
Curry. W $\frac{1}{2}$ of the NE $\frac{1}{4}$ of Sec. 9, T. 39 N., R. 29 W., SE $\frac{1}{4}$ of the NE $\frac{1}{4}$ of Sec. 9; East frac. $\frac{1}{2}$ of the NW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of Sec. 9, T. 39 N., R. 29 W.; frac. part of NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of Sec. 9, T. 39 N., R. 29 W., City of Norway.
Brier Hill. S $\frac{1}{2}$ of the NW $\frac{1}{4}$ of Sec. 9, T. 39 N., R. 29 W., except fraction leased to Oliver Iron Mining Company, Norway Township.
East Central. Entire Sec. 10, T. 39 N., R. 29 W.
East Vulcan. SW $\frac{1}{4}$ of Sec. 11, T. 39 N., R. 29 W.
Operated by Penn Iron Mining Company.
- West Chapin:**
N $\frac{1}{2}$ of the SW $\frac{1}{4}$ and the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Sec. 31, T. 40 N., R. 30 W., City of Iron Mountain.
West Chapin Mines Company.

PART II. NON-METALLIC MINERALS

NON-METALLIC MINERALS

SALT

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

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

From 1909 to 1919 the production and value of salt in Michigan increased annually, the maximum production of 17,800,564 barrels valued at \$9,456,138 being reached in 1919. That Michigan showed a gain in 1919 although the total quantity for the United States decreased, was due to the fact that the greater part of the salt produced is salt in brine which is used by the chemical industries.

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

From 1880 to 1890 Michigan produced annually from about 42 to over 49 per cent of the salt produced in the United States. The percentage declined from 43.69 per cent in 1890 to only 22.89 per cent in 1896. This was not due to a decline of the industry in Michigan but to the rapid growth of production in New York, Ohio, and other States. Since 1896 Michigan has

annually produced nearly one-third of the total output and since 1880 Michigan has produced 32.4 per cent or nearly one-third of the salt used in the United States since records of production have been kept.

At present the chief salt producing districts are in eastern Michigan along the Detroit-St. Clair rivers and in Western Michigan at Ludington and Manistee. In these districts, artificial brines are used for the manufacture of salt. The brine is obtained by forcing water through casings down to rock salt beds and then back to the surface. Rock salt is mined by the Detroit Rock Salt Co., at Oakwood, a suburb on the west side of Detroit. The salt is obtained from a 20 foot bed at a depth of about 1,040 feet. The salt is crushed, screened, and sized, and sold for pickling, curing fish, meats, and hides, for the manufacture of ice cream, and for general refrigeration purposes. Over 95.2 per cent of the State output of salt for 1922 came from these two districts, the production being 13,644,736 barrels valued at \$8,086,559 or 95.2 per cent of the total State production and 93 per cent of the total value.

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

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

In St. Clair County the chief salt producing centers are Port Huron and St. Clair. The output of St. Clair County in 1922 was 2,575,371 barrels or 17.9 per cent of the State total, but the valuation of \$3,972,261 represents 45.7 per cent of the total value for Michigan. The exceptionally high value for this county is due to the fact that much of the salt produced is of the better grades, practically 50 per cent being table and dairy salt.

During 1917 pressed blocks of salt were placed on the market as a substitute for the large lumps of rock salt formerly used in field and stable to salt

cattle. The blocks are made by hydraulic press, and dispose of the refined salt spilled around the machines in the evaporating and packing departments. Although the profit from the industry is not great, the demand for the pressed block has increased so that production increased more than 85 per cent in the four years 1917-1920. In 1922 production reached 37,350 tons valued at \$368,515.

In the Manistee-Ludington district, salt is made at Manistee, Manistee County, and at Ludington, Mason County. The salt industry is still largely carried on in connection with the lumber industry, waste steam and waste fuel being utilized for evaporating artificial brines. The district produced 1,705,800 barrels of salt valued at \$1,676,588. This is equivalent to 11.9 per cent of the total quantity and 19.2 per cent of the value for the State. Most of the product is packer's salt, i. e., common fine and common coarse.

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

In Alpena and Presque Isle Counties, the salt area although undoubtedly very large is of unknown extent. Rock salt was struck at Onaway, Grand Lake, and Alpena in great quantities, and the greatest aggregate thickness of rock salt yet penetrated in Michigan or in Ontario, Canada, is at Onaway,

Presque Isle County. A test hole drilled for oil at Onaway penetrated over 800 feet of rock salt in a section of 1,200 feet. The lowest bed is 225 feet in thickness, and perhaps is to be correlated with the thick bed in the Detroit River region. At Grand Lake salt beds aggregating over 300 feet in thickness were penetrated in a deep well without reaching the bottom of the rock salt formation.

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

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

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

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

Year.	U. S. production quantity bbls.	Michigan production.		Per cent of total Michigan.	Rank quantity.	Value Michigan.	Michigan.	
		State Salt Inspectors* Quantity. bbls.	U. S. G. S.† Quantity. bbls.				Rank value.	Price bbl.
1880	5,961,060	2,676,588	2,485,177	41.69	1	2,271,931	.....	0.75
1881	6,200,000	2,750,299	.....	44.35	1	2,418,171	.....	0.85
1882	6,412,373	3,037,317	3,036,317	47.36	1	2,126,122	.....	0.70
1883	6,192,231	2,894,672	2,894,672	46.74	1	2,344,684	.....	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648	.....	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	1	2,967,663	.....	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	1	2,426,989	.....	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	1	2,291,842	.....	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	1	2,261,743	.....	0.585
1889	8,005,565	3,846,979	3,856,929	48.17	1	2,088,909	.....	0.541
1890	8,776,991	3,838,637	3,838,632	43.72	1	2,302,579	.....	0.600
1891	9,987,945	3,927,671	3,966,748	39.52	1	2,037,289	.....	0.513
1892	11,698,890	3,812,504	3,829,478	32.81	1	2,046,963	.....	0.523
1893	11,897,208	3,514,485	3,057,898	25.70	2	888,837	.....	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619	.....	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	2	1,048,251	.....	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	2	718,408	.....	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	2	1,243,619	.....	0.313
1898	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081	.....	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2	2,205,924	.....	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2	2,033,731	2	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	1	2,437,677	1	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	2	1,535,823	2	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	2	1,119,984	2	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	2	1,579,206	2	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1	1,851,332	2	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	1	2,018,760	2	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	1	2,231,129	2	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	1	2,458,303	1	0.241
1909	30,107,646†	6,055,661	9,966,744	33.10	1	2,732,556	1	0.274
1910	30,305,656†	5,097,276	9,452,022	31.18	2	2,231,262	2	0.236
1911	31,183,968†	.....	10,320,074	33.10	2	2,633,155	1	0.255
1912	33,324,808†	.....	10,946,739	32.84	1	2,974,429	1	0.277
1913	34,393,227†	.....	11,528,800	33.52	1	3,293,032	1	0.285
1914	34,402,772†	.....	11,670,976	33.92	1	3,299,005	1	0.283
1915	38,231,496†	.....	12,588,788	32.93	1	4,304,731	1	0.342
1916	45,449,329†	.....	14,918,278	32.84	1	4,612,567	1	0.309
1917	49,844,125†	.....	16,078,136	32.25	1	6,817,202	1	0.421
1918	51,705,317†	.....	17,165,178	33.19	1	9,048,650	1	0.520
1919	49,157,686†	.....	17,800,564	36.21	1	9,456,138	1	0.531
1920	49,745,373†	.....	16,163,679	32.49	1	10,698,674	1	0.662
1921	33,579,672	.....	10,196,179	28.66	2	7,439,445	1	0.729
1922	48,520,350†	.....	14,322,057	29.52	1	8,693,604	1	0.607
Total.	987,135,461	.....	328,447,730	.....	.....	151,028,774	.....	.....

*Office of State Salt Inspector abolished in 1911.

†In cooperation with the Michigan Geological Survey after 1909.

‡Includes production of Hawaii and Porto Rico 1909-1913, 1915-1916 and of Porto Rico 1914-1917-8 and 1922.

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

	Evaporated.		Pressed blocks.		Other rock.		Brine and other.*		Total.	
	Quantity.	Value.	Quantity Tons.	Value.	Quantity Bbls.	Value.	Quantity Bbls.	Value.	Quantity Bbls.	Value.
1906-										
1910	29,278,297	\$10,302,732			576,695	\$181,865	20,796,007	\$1,083,643	50,336,468	\$11,503,238
1911	5,355,707	2,232,046			653,908	250,680	4,337,772	219,244	10,320,074	2,632,155
1912	5,441,288	2,486,785			727,364	244,172	4,737,038	236,852	10,946,730	2,974,429
1913	6,042,657	2,811,429			712,530	252,024	4,756,779	237,431	11,528,800	3,293,032
1914	6,141,711	2,806,895			919,735	321,354	5,073,940	240,086	11,670,978	3,302,032
1915	6,595,113	3,602,886			1,012,942	368,022	7,365,927	380,491	12,588,788	4,302,795
1916	6,549,407	3,747,695			1,204,543	568,717	8,639,800	506,850	14,318,278	4,812,567
1917	6,233,793	7,679,911			1,405,671	827,348	8,451,578	578,574	16,078,138	6,872,502
1918	7,307,928	8,004,713			1,350,634	972,517	9,430,264	660,119	17,800,562	9,948,050
1919†	7,021,800	8,004,713			1,511,050	1,186,682	8,199,843	549,824	17,800,562	9,948,050
1920	6,452,785	8,677,108							16,163,673	10,698,674
	Open pans or grainers.	Vacuum pans.								
	Quantity. Bbls.	Value.								
	Quantity. Bbls.	Value.								
1921	2,349,893	\$3,557,177	2,482,693	\$2,449,417					10,196,179	\$7,439,445
1922	2,987,250	4,543,626	2,786,443	2,471,455					14,322,057	8,698,604
			29,657	\$273,187	1,367,643	\$868,348	3,784,122	\$201,316		
			**	**	**	**	6,600,543	430,154		

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

BROMINE AND CALCIUM CHLORIDE

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

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

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

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

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

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

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

In 1919 the maximum quantity of bromine was marketed in Michigan, i. e., 1,736,633 pounds valued at \$1,179,834 or 93.6 per cent of the total United States production at 95.5 per cent of the total United States valuation of \$1,234,969. Although the war-need for bromine passed in 1918 the chemical and photographic demand continued to keep production and price up.

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

Calcium Chloride

Calcium chloride is used in large quantities for the prevention of dust, in refrigerating plants, in protective fire apparatus, in cement mixtures, to prevent freezing, as a drying agent in chemical processes, as a bleaching agent, as a preservative of wood, and for many other purposes. Because of its strong affinity for water a sprinkling of a solution of calcium chloride will keep a road moist and therefore dustless for several weeks under favorable conditions. It is thus extensively used in the place of crude oil for sprinkling streets; and could be used to great advantage on the hundreds of dusty summer play-grounds.

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

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

MAGNESIUM

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

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

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

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

The Dow Company realized that an alloy combining the lightness of magnesium with the chemical strength of iron would satisfy a demand and secure a wide market, and in 1916 established a special research department to extensively investigate the subject. After many experiments an alloy was produced which on account of "its light weight, great tensile strength, machinability, durability, absence of permanent growth on repeated heating and cooling and non-abrasiveness to cast iron makes it an ideal piston material."*

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

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

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

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

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

decreases in production in 1914 and 1916. In 1917 there was a slight increase in production but the restrictions imposed by the Government upon fuel supplies, transportation facilities, labor, and private construction in general caused a marked decrease in output in 1918, production falling to 71,081,663 barrels, the lowest production since 1909. This was somewhat offset by the increased price of cement, \$1.596 per barrel. The total value for the entire country was \$113,153,513. During 1919 production and shipment gained by 13.7 per cent and 20.7 per cent respectively over 1918, production being 80,777,935 barrels and shipments were valued at \$146,734,844 with the average price per barrel at \$1.71. In 1920 production reached the unprecedented figure of 100,023,245 barrels with shipments of 96,311,719 barrels valued at \$194,439,025, an increase of 13 per cent in quantity shipped over 1919, and of 32.5 per cent in value of shipments. The average price for cement in the United States was \$2.02, an increase of \$0.31 or 18 per cent per barrel.

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

The period between 1899 and 1901 was the "boom" years of the industry, twenty companies being organized in this period for the manufacture of Portland cement from marl and clay or shale. In 1900 Michigan with six plants attained third rank with Pennsylvania and New Jersey holding first and second rank respectively. Extensive investigations of marl and clay deposits and elaborate plans were made by many of the companies. Only ten reached the productive stage and but five of these are still in operation. Since 1896, thirty-eight different cement plants have been projected or built in Michigan. Eleven plants were in operation in 1921 and 1922 and another began production in 1923.

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

The demand was heavy the first ten months of 1920, but fell off the last two. The difficulties in obtaining either coal or cars for transportation of

raw materials and the finished product forced Michigan cement to \$2.46 per barrel (compared with \$1.70 in 1919), a price greater than ever received in Michigan and greater than received in any other State in 1920. The average factory price per barrel in the United States was \$2.02. Stocks held at the end of 1920 were greater than at the close of any previous year, being 666,389 barrels as compared with 219,699 barrels at the end of 1919. Prosperity in the cement industry continued during 1921 and Michigan produced 5,777,533 barrels of cement, an increase of 886,076 barrels or 18.1 per cent. Shipments reached 5,680,156 barrels or 27.9 per cent but a decrease in value of \$639,344 or 5.8 per cent. The decrease in value is due to the decreased price received per barrel, \$1.81, which is \$0.65 or 26 per cent less than the maximum price per barrel of 1920. Stocks on hand at the end of 1921 were greater than ever before, being 760,503 as compared with 666,389, an increase of 94,114 barrels or 14.1 per cent. This increase in production caused Michigan to advance in rank from seventh to third place, being ranked by Pennsylvania and California.

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

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

In 1920 the Petoskey Portland Cement Company erected a plant on the limestone deposits of Little Traverse Bay about two and a half miles west of Petoskey to manufacture cement from limestone of the company's holdings on Little Traverse Bay, and shale from a quarry at Ellsworth in Antrim County, twenty-seven miles southwest of Petoskey. The plant began operating March 21, 1921, with a capacity of 2,500 barrels a day. The mill building contains all the machinery for the manufacture of cement, including waste heat boilers which supply all the energy used in driving the mill. This

*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.

plant is pronounced "the best and most efficient wet process plant" and is attracting attention of all American as well as foreign cement manufacturers.*

The National Portland Cement Company was organized and it purposed to erect a plant at Coldwater Lake near Mount Pleasant to utilize the marl beds surrounding the lakes in the manufacture of cement, but construction has not been started.

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

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

Year.	No. of plants in operation.	Michigan Rank.	No. of kilns. Rotary.	Daily capacity. Bbls.	Michigan, cement made, Bbls.	U. S. cement made, Bbls.	Michigan, per cent made	*Change per cent cement made.	Michigan cement shipped, Bbls.	Michigan cement shipped, Value.	U. S. cement shipped, Value.	Michigan, per cent of value.	Michigan, stock on hand Dec. 31. Bbls.	Michigan, average price per barrel.	U. S. average price per barrel.
1896	1	1	1	4,000	1,543,023	1,543,023	0.25	275.0	.....	\$7,000	\$2,244,011	0.29	.....	\$1.75	\$1.57
1897	2	2	2	15,000	2,677,775	3,692,284	0.56	413.3	.....	26,250	4,315,891	2.3	.....	1.77	1.62
1898	2	2	2	77,000	3,692,284	3,692,284	2.11	346.2	.....	134,750	5,970,773	9.7	.....	1.77	1.62
1899	4	2	4	343,566	5,652,266	8,482,020	6.1	93.4	.....	513,849	8,074,371	6.36	.....	1.492	1.43
1900	6	2	4	664,750	8,482,020	8,482,020	7.8	.....	.....	830,990	9,280,525	8.9	.....	1.25	1.09
1901	10	3	3	1,025,718	12,711,225	12,711,225	8.0	54.1	.....	1,128,290	12,532,360	9.0	.....	1.10	0.99
1902	10	3	3	1,577,006	17,230,644	17,230,644	9.1	53.7	.....	2,134,396	20,864,078	10.2	.....	1.353	1.21
1903	13	3	3	1,955,183	2,342,973	2,342,973	8.7	23.9	.....	2,674,780	27,713,319	9.7	.....	1.367	1.22
1904	16	4	4	2,247,160	26,505,881	26,505,881	8.5	14.9	.....	2,365,656	23,355,119	10.1	.....	1.032	0.88
1905	16	5	5	2,773,283	35,246,812	35,246,812	7.9	23.4	.....	2,921,507	33,245,867	8.7	.....	1.033	0.84
1906	14	4	4	3,747,525	46,463,424	46,463,424	8.06	35.5	.....	4,814,965	52,466,186	9.2	.....	1.284	1.13
1907	14	4	4	3,572,668	48,785,390	48,785,390	7.3	-4.6	.....	4,384,731	53,992,551	8.1	.....	1.227	1.11
1908	15	7	7	2,892,576	51,072,612	51,072,612	5.6	-19.0	.....	2,556,215	43,547,679	5.8	.....	0.883	0.85
1909	12	7	7	3,212,751	64,991,431	64,991,431	4.9	11.6	.....	2,619,259	52,858,354	4.9	.....	0.815	0.813
1910	12	8	8	3,687,719	76,549,951	76,549,951	4.8	11.7	.....	3,378,940	68,205,800	4.9	.....	0.916	0.891
1911	11	8	96	3,686,716	78,528,637	78,528,637	4.69	-0.03	.....	3,024,676	66,248,817	4.56	506,758	0.82	0.843
1912	11	8	92	3,494,621	82,438,096	82,438,096	4.23	-5.21	3,651,094	3,145,001	69,109,800	4.55	370,956	0.861	0.813
1913	11	8	83	4,186,236	92,097,131	92,097,131	4.21	19.79	4,228,879	4,228,879	89,106,975	4.74	473,563	0.835	1.005
1914	11	7	77	4,285,345	88,230,170	88,230,170	4.85	2.27	4,218,429	4,064,781	80,118,475	5.07	538,846	0.964	0.927
1915	11	5	71	4,765,294	85,914,907	85,914,907	5.55	11.2	4,727,768	4,454,608	74,756,674	5.95	569,919	0.942	0.86
1916	11	6	68	4,919,023	91,521,198	91,521,198	5.37	3.2	5,151,818	6,017,911	104,258,216	5.77	338,035	1.168	1.103
1917	11	6	68	4,688,899	92,814,202	92,814,202	5.03	-4.47	4,313,771	6,122,887	122,775,088	4.98	701,919	1.419	1.334
1918	10	6	49	3,554,872	71,081,663	71,081,663	5.00	-24.2	3,618,088	6,078,167	113,153,513	5.37	635,447	1.680	1.596
1919	11	4	58	4,675,244	80,777,935	80,777,935	5.78	32.00	4,990,308	8,468,196	146,734,844	5.77	219,641	1.70	1.71
1920	11	7	58	4,891,457	100,023,245	100,023,245	4.89	5.00	4,442,455	10,939,633	194,439,025	5.62	666,389	2.46	2.02
1921	11	3	53	5,777,533	98,293,000	98,293,000	5.78	18.1	5,680,156	10,300,289	180,778,415	5.69	760,503	1.815	1.89
1922	12	5	60	6,243,805	115,679,412	115,679,412	5.39	11.8	6,349,751	11,145,573	207,170,430	5.38	759,703	1.76	1.76

*Minus sign indicates decrease.

NON-METALLIC MINERALS

POTASH

Though Michigan has deposits of rock salt of great extent they are not known to contain important amounts of potash bearing salts. A small amount of potash is recovered from industrial wastes (cement dust and Steffens water from beet sugar manufacture) and wood ashes. In 1918 the production of potash reckoned as K_2O , amounted to 404 tons valued at \$100,647, of which 196 tons were from industrial wastes and 206 tons from wood ashes. In 1919 the production of potash reckoned as K_2O amounted to but 166 tons (from 666 tons of crude potash) of which 149 tons valued at \$48,581 were sold. This represents a decrease of 238 tons or 58.8 per cent in quantity and of \$52,066 or 51.7 per cent in value. Production was further decreased in 1920 to 56 tons (from 93 tons of crude potash) of which 49 tons were sold for \$18,312, a decrease from 1919 of 110 tons or 66.2 per cent in quantity and \$30,269 or 62.3 per cent in value. Eighteen plants reported production of potash in 1919. There were seven producers in 1920. There was no potash produced in Michigan in 1921 or 1922.

GYPSUM

The gypsum industry of Michigan dates from 1838. In that year Dr. Douglas Houghton, then State Geologist, in selecting a location for a salt well in Grand Rapids discovered that the gypsum deposits of the region are extensive and in his reports to the State Legislature for 1838 and 1840 Dr. Houghton called attention to the extent and character of the beds and the utilization of gypsum for land plaster. About the same time the first Michigan gypsum was calcined and used to make ornamental stucco moldings for a house erected for Louis Campau. The gypsum was ground in an Indian mill and burned in a cauldron kettle. The second moldings made were successful and remained on the house until it was destroyed by fire in 1850. During 1840-45 a small industry developed in the manufacture of inside ornamental moldings, plaster ornaments and flower pots. The first mill for working the gypsum deposits was erected in 1841 and the commercial exploitations of Michigan's almost unlimited resources of gypsum began in the Grand Rapids-Grandville district with the sale of forty tons of plaster at four dollars a ton. Judicious advertising of land plaster among the farmers increased the demand to such an extent that although the mills "ran night and day" and the price reached five dollars and fifty cents a ton, buyers were turned away with their orders unfilled. The first shaft for mining gypsum was put down in 1853 by the predecessors of the present Grand Rapids Plaster Company. At the present time five mines and one quarry are operated in the Grand Rapids-Grandville district. The gypsum of the Alabaster district was reported in 1837 by Bela Hubbard who recorded the discovery of gypsum in the mouth of the Au Gres River. Later an outcrop was discovered on land and quarried with profit. In 1862 a quarry was

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

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

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

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

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

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

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

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

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

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

In the early days of the industry four-fifths of the raw gypsum was ground into land plaster, and from 1869 to 1887 more than half of the gypsum mined was ground into this product. With the more general use of patent fertilizers the demand for land plaster more or less gradually decreased, so that the production in 1918 was only 5,892 tons as compared with the maximum of 49,570 tons in 1880 and in 1919 had further decreased to 1,597 tons. In 1919 the Gypsum Industries Association of Chicago, Illinois, launched a campaign to induce greater use of gypsum as land plaster, as a deodorizer and fixative of ammonia in manure about stables, as a soil stimulant, and as a specific for black alkali. That the campaign was effective is shown by the fact that the production of agricultural gypsum for the United States increased from 40,000 to 107,000 tons. In Michigan the increase was from the minimum production of 1,597 tons in 1919 to 12,092 in 1920 and 26,558 tons in 1921. The 1922 production was 13,054 tons valued at \$40,583.

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

The most important of these products are mixed wall plaster; gypsum board, block and tile, and stucco follow in second and third place.

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

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

BRICK AND TILE PRODUCTS

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

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

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

In 1919 the brick and tile industry recovered somewhat from the war-induced slump of 1918. The total value of clay products exclusive of pottery (see Pottery) was \$3,699,929, an increase of 116.5 per cent over the 1918 production. The quantity of common brick produced was 200,352,000, or 105,606,000 brick more than in 1918 but falling short of the maximum of 1916 by 78,823,000; this represents an increase of 111.4 per cent over 1918. The value of common brick was \$2,734,503 or an average of \$13.64 a thousand as compared with \$9.65 in 1918 and \$6.65 in 1916. This is an increase in value over 1918 of 198.6 per cent and an advance in average price per ton of \$3.99. Drain tile also advanced in value from \$565,398 in 1918 to \$737,124 in 1919, an increase of \$171,726 or 30.3 per cent.

The rise in production was not maintained during 1920. Only one producer reported 100 per cent normal business; others reported better sales but inability to meet demands due to coal and labor scarcity; and others report 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 decrease in quantity (3.6 per cent), production being 193,730,000 brick valued at \$2,417,809, a decrease in value of \$644,851 or 21.05 per cent. The decrease in value is due to the decrease in average price per thousand, from \$16.42 (in 1920) to \$12.47. The value of drain 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.

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

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

Drain tile is next in importance to common brick. Sewer pipe is made in large quantities at Grand Ledge, Eaton County; and at Jackson, Jackson

County. Grand Ledge is also the chief center for the manufacture of vitrified drain tile. The manufacture of face or front brick in Michigan is in its infancy, there being but two plants in operation, one at Saginaw and the other at Grand Ledge. In 1920 only the Grand Ledge plant reported the production of face brick.

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

NON-METALLIC MINERALS

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1922

Year.	Common brick. †		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	180,892,000	863,250	4.77	114,747	2,350	406		17	189	1,147,378
1901	212,836,000	1,095,254	5.07	98,972	1,880	637		14	180	1,497,169
1902	237,254,000	1,231,752	5.61	96,645	3,280			13	182	1,660,942
1903	217,791,000	1,231,752	5.80	129,028			\$19,138	14	178	1,662,414
1904	205,196,000	1,116,714	5.44	208,038			8,080	14	168	1,670,892
1905	211,558,000	1,152,505	5.45	205,445	*		3,585	16	154	1,719,746
1906	206,583,000	1,178,202	5.70	314,098			4,200	16	142	1,793,367
1907	200,817,000	1,181,015	5.88	289,868	4,100	1,500	6,386	17	136	1,786,190
1908	181,049,000	1,064,525	5.86	327,630	*	40,100		16	132	1,666,381
1909	229,820,000	1,240,787	5.60	364,008		66,128		16	122	1,947,059
1910	232,351,000	1,263,916	5.86	313,072				15	115	2,083,525
1911	272,465,000	1,303,908	5.16	387,945	*	228,530		15	111	2,195,342
1912	271,559,000	1,592,387	5.84	415,543	1,461	359,459		13	101	2,350,606
1913	273,571,000	1,626,216	5.94	421,941	3,752	350,000		13	95	2,451,242
1914	269,194,000	1,638,716	6.07	305,156	10,850	234,280		10	90	2,434,872
1915	277,329,000	1,809,387	6.53	543,793	2,492	49,755		11	82	2,248,068
1916	279,175,000	1,899,387	6.82	733,042		216,955		13	73	2,705,054
1917	236,912,000	1,882,942	7.95	565,208		73,996	4,621	12	69	2,846,264
1918	94,746,000	273,389	3.65	737,124	89,147	132,814	6,901		61	3,699,929
1919	200,352,000	2,734,503	13.64	690,874	*	200,730	25,486			3,979,691
1920	186,528,000	3,002,600	16.42	381,507		108,394	8,209			3,915,919
1921	193,730,000	2,417,809	12.47	169,419			5,913			3,915,310
1922	748,608,890	3,613,542	14.53			126,436				
Total	5,291,018,890	\$37,809,782		\$8,307,661						\$53,098,452

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

SHALE

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

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

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

The shale beds at Grand Ledge, Jackson, Flushing, and Corunna belong to the Coal Measures. The beds vary from soft white, or light gray shale to compact, dark or black bituminous shale. Probably further tests will show that some of the beds are suitable for other products than those now made. The beds at Paxton belong to the lower portion of the Antrim Formation of the Upper Devonian. The extent of the easily 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 shale and huge balls of iron carbonate and dolomite. The shale beds at Ellsworth belong to the upper part of the Antrim and are largely of soft blue gritless shale, with a few thin, dark, bituminous beds. The extent of the easily quarryable areas is uncertain but apparently large. Tests probably will show that this shale is suitable for a variety of purposes. Other exposures of the Antrim shale occur in Antrim, Charlevoix, Cheboygan, and Alpena Counties, notably at East Jordan and Chestonia, near Afton, near Walloon Lake, and Central Lake, along the shore of Lake Michigan, south of Norwood, and at Paxton.

Excellent exposures of shale belonging to the Coldwater formation occur at Richmondville, Sanilac County, and along the shore of Lake Huron from Forestville in the same county to White Rock, Huron County. The Coldwater shale is also exposed or is at shallow depth in a number of places in the vicinity of Coldwater, Union City, Quincy, and Bronson, Branch County. Near Coldwater it is utilized in the manufacture of Portland cement. Exposures of the Bell shale, the base of the Traverse formation, occur near Bell and Rogers, and some miles northeast of Posen, Presque Isle County. At Rockport the Bell shale forms the floor of the limestone quarry. The

shale is soft, bluish, and in places highly calcareous. Probably it will be found to be suitable for the manufacture of Portland cement, though the high lime content probably makes some of the beds unsuitable for high grade clay products. At Charlevoix a bed of shale 10 feet thick underlies the floor of the quarry of the Charlevoix Rock Products Company, Charlevoix County. This shale has been tested and according to reports is suitable for the manufacture of vitrified products. The burning qualities of the deposits at Ellsworth, and Chestonia have been thoroughly investigated and the results are promising. Tests have also been made on most of the other deposits. The results are to appear in a forthcoming report on the clay and shale resources of the State.

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

CLAY*

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

The morainic or drift clays contain pebbles, and boulders, (hence the name "boulder clay"), and locally lime concretions. Screening and washing have been resorted to at some plants to separate the clay but the extra expense is generally prohibitive except in districts where good clays are wanting or where the clays possess special burning qualities. The lake clays are comparatively free from pebbles and coarse sand but some contain much very fine

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