

PRODUCTION AND VALUE
OF
MINERAL PRODUCTS IN MICHIGAN
FOR
1923 AND PRIOR YEARS

STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION.

GEOLOGICAL SURVEY DIVISION

Publication 35
Geological Series 29

MINERAL RESOURCES OF MICHIGAN

WITH

STATISTICAL TABLES OF PRODUCTION
AND VALUE OF MINERAL PRODUCTS

FOR

1923 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 1923

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, Chairman
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 35 Geological Series 29, 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 1923.

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

PART I. METALLIC MINERALS

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THE COPPER INDUSTRY

COPPER INDUSTRY OF MICHIGAN IN 1923

The Michigan copper production in 1923 totaled 137,952,586 pounds. This production was derived from nine operating units; the Ahmeek and Conglomerate Mines and the Torch Lake Reclamation of the Calumet and Hecla Consolidated Copper Company; Baltic and Champion of The Copper Range Company and Isle Royale, Mohawk, Quiney and Wolverine. The Trimountain Mine of The Copper Range Company was closed except for a small production incidental to some development work. Table 1 gives the details of this production, by companies, for the years 1919 to 1923.

The average recovery, per ton of rock treated, amounted to 32.11 pounds per ton and the average price received from the copper totaled 14.95 cents per pound.

The most important event of the year in Michigan copper was the consolidation of The Calumet and Hecla Mining Company, Ahmeek Mining Company, Allouez Mining Company, Centennial Copper Mining Company and The Osceola Consolidated Mining Company, under the heading "Calumet and Hecla Consolidated Copper Company". This re-organization took place and became effective September 1, 1923. In addition to this consolidation, the Mohawk Mining Company acquired the property of the Wolverine and Michigan companies.

GENERAL CONDITIONS OF THE MICHIGAN COPPER DISTRICT

In 1912 Michigan had twenty operating properties, which produced a total of 216,000,000 pounds of copper. Of this total only 5,800,000 pounds or 2.7 per cent was produced at a loss. In 1923 the number of mines had been reduced to ten and the production to 138,000,000 pounds of which 71,000,000 pounds or approximately 54 per cent was produced at an actual loss to the mining company. If all of the mines active in 1912 had continued to 1923 the percentage of copper produced at a loss would of course have been much greater. While it is generally known that conditions in the copper country have been bad for the past five years, the statement given above serves to emphasize this condition.

It is necessary perhaps to point out that this condition is not confined to the single year 1923 but has been operative since the close of the War in 1918. Table III is a compilation of the average cost of producing copper in Michigan during each of the past five years and for the period as a whole. This table shows that the average profit of all producing units in the State during the past five years exclusive of depletion and Federal taxes amounted to slightly over three tenths of a cent per pound. In this computation no costs were included for Calumet and Hecla and subsidiaries during the period these properties were closed in 1921 and 1922. If these costs were included it would be found that the entire Michigan copper production was mined at a loss during the past five years.

EXAMINATION OF THE ECONOMIC FACTORS RESPONSIBLE FOR THIS CONDITION

For the five year period prior to the World War the United States produced and imported in round figures 1,450,000,000 pounds of copper per year. Of this total production approximately one-half was consumed in the United States and the other half exported to foreign countries, principally Europe. At the outbreak of the War in 1914 a temporary curtailment was soon succeeded by an exceptional demand for the red metal and at no time from 1915

to 1918 did production catch up with the consuming requirements. This condition during the War period caused a tremendous expansion in the copper mining industry, an increasing search and rapid development of new mines, while the older properties were equipped for a greater production than ever before. The output of the United States increased from 1,250,000,000 pounds in 1912 to 1,900,000,000 pounds in 1918. In this connection it is significant that the Michigan production showed a relatively small increase in spite of this greatly stimulated demand. In 1912 Michigan production was 216,000,000 pounds, in 1917, 250,000,000 pounds and in 1918 only 228,000,000. During the same period the Arizona production increased from 359,000,000 pounds in 1912 to 769,000,000 pounds in 1918. At the close of the War production fell off rapidly and the average United States production since 1920 is less than the record of the five years preceding the War period. On the other hand the imports of copper have increased. The United States consumption of copper during this period has been in excess of the pre-war record, while the exports have been slightly less. A complete tabulation of the data covering mine production, imports and exports, and the United States consumption is shown in Table IV. It is apparent that the present consumption of new copper in the United States has shown a healthy and normal increase if the exceptional consumption during the World War is discounted. What the World War did result in primarily was the development of a greatly increased capacity for copper production, particularly in the so-called porphyry coppers. It is the competition of the porphyry coppers located in the United States and in foreign countries which has adversely affected the Michigan district.

PORPHYRY COPPERS

In 1912, the production from porphyry coppers was 279,000,000 pounds and in 1922 the output was around 600,000,000 pounds. It is noteworthy for the most part that these porphyry coppers have immense reserves running into hundreds of millions of tons. They are easily mined by the use of open pit steam shovel methods, or relatively shallow underground operations. The average copper content of the porphyry deposits is around 1.75 per cent; the average copper content of the Michigan copper ores is around 1 per cent. In addition the porphyries, like all sulphide coppers, carry appreciable amounts of gold and silver. These subsidiary metals which are obtained as a by-product tend to reduce the cost of operation. In Michigan the only by-product is a very small and almost inconsequential amount of silver. The development of this large group of cheap producers is one of the most important competitive factors with which the Michigan mines have to contend.

FOREIGN COMPETITION

Another important factor entering into the United States competitive field is the rapid increase in foreign competition, particularly from the South American field. The development of the Panama Canal has enabled the South American producers to bring their product into direct competition with the United States.

Table V shows for 1912 and 1922 the production of several of the larger foreign companies, of which costs and statistics are available. It is interesting to note that in 1912 the six companies listed produced 136,000,000 pounds of copper at an average cost of 9 cents per pound. In 1922 this same group produced 388,000,000 pounds of copper at an average cost of 9.56 cents

per pound or an increase in cost of only five tenths of a cent. In 1912 the average cost of production of copper in Michigan was around 10.6 cents and in 1922 the average cost was 12.89 cents. In other words there is a differential in favor of these foreign producers at present of slightly over 3 cents per pound.

PHYSICAL CONDITIONS OF THE MINES

With one or two exceptions, the Michigan copper deposits do not show any indication of termination or diminution of their metallic content with depth. The problem confronting the Michigan producers is entirely one of cost of mining and not related to the geological occurrence of the ore. The long history of mining in the copper country has amply demonstrated that the district is unique for its uniformity of mineralization and continuity with depth. The physical conditions, aside from those resulting from increased depth, remain practically the same. The problem confronting the Michigan producers is, therefore, strictly related to their ability to compete with foreign and western production.

DETAILS OF COMPANY REPORTS

Calumet-Hecla Consolidated Copper Co.

For the eight months previous to the consolidation, there was produced as follows:

| | |
|------------------------|---------------------------|
| Ahmeek Mine..... | 17,811,031 lbs. of copper |
| Conglomerate Mine..... | 24,413,600 lbs. of copper |
| Reclamation..... | 10,634,200 lbs. of copper |

Following the consolidation for the four months of the year, from September 1st the mines produced 21,259,000 pounds of copper and the Reclamation 6,267,000 pounds of copper. The price received for copper delivered during the four months' period from September 1 through December 31 was 13.58 cents per pound.

Reclamation Plant

The following table gives the results obtained during the last four months of the year, as well as the results to date since this operation started:

| | Sept. 1-Dec. 31 1923 | Since starting |
|--|-------------------------|-------------------|
| Tons treated..... | 664,550 | 7,955,518 |
| Assay headings..... | .597 % | .712 % |
| Assay tailings..... | .125 % | .203 % |
| Pounds refined copper..... | 6,267,000 | 82,102,924 |
| Pounds refined copper per ton treated..... | 9.43 | 10.32 |

Of the copper produced during the last four months of 1923, 1,417,000 pounds was from table treatment, 3,974,000 pounds was from leaching, and 876,000 pounds was from flotation.

EARNINGS STATEMENT

September-December, 1923

| Receipts | | |
|---|----------------|----------------|
| Copper Sales | \$2,540,053.73 | |
| Custom Milling, Smelting and Refining | 21,247.84 | |
| Dividends | 21,559.65 | |
| Interest | 77,254.13 | |
| Miscellaneous | 23,371.42 | |
| | | \$2,683,486.77 |
| Disbursements | | |
| Copper on hand September 1, 1923 | \$3,672,555.02 | |
| Production, selling, administration and taxes | 2,931,283.79 | |
| Depreciation and Depletion | 1,319,930.48 | |
| Miscellaneous | 172,709.59 | |
| | \$8,096,478.88 | |
| Less copper on hand end of year | 4,816,494.63 | 3,279,984.25 |
| Loss for period | | \$596,497.48 |

BALANCE SHEET

December 31, 1923

| Assets | | |
|--|-----------------|-----------------|
| Current Assets: | | |
| Cash | \$1,008,358.97 | |
| Liberty Loan Bonds at par | 1,632,850.00 | |
| U. S. Certificates of Indebtedness | 450,000.00 | |
| Notes Receivable | 322,727.85 | |
| Accounts Receivable | 2,678,485.68 | |
| Copper on hand | 4,816,494.63 | |
| Prepaid Charges | 87,228.70 | |
| Supplies at mine (book value) | 4,034,266.94 | \$15,030,412.77 |
| Investments in Other Companies (Book value) | | 2,034,865.33 |
| Capital Assets (book value): | | |
| Real Estate, Stumpage and Timber | \$4,460,034.36 | |
| Mine Lands | \$52,542,942.07 | |
| Less Reserve for Depletion | 877,723.71 | 51,665,218.36 |
| Plant | \$28,414,853.97 | |
| Less Reserve for Depreciation | 12,169,650.19 | 16,245,203.78 |
| Stamp Mill Patents | 40,403.19 | \$72,410,859.69 |
| Total Assets | | \$89,476,137.79 |
| Liabilities | | |
| Current Liabilities: | | |
| Accounts Payable | | \$1,266,818.34 |
| Capital Stock: | | |
| Authorized..... 2,500,000 shares par value \$25.00 per share | \$62,500,000.00 | |
| Less not issued.. 494,498 shares par value \$25.00 per share | 12,362,450.00 | |
| Issued..... 2,005,502 shares par value \$25.00 per share full paid | | \$50,137,550.00 |
| Surplus: | | |
| Paid-in Surplus September 1, 1923 | \$39,671,017.93 | |
| Loss by 1923 operations (4 months) | \$596,497.48 | |
| Dividend paid | 1,002,751.00 | 1,599,248.48 |
| | | 38,071,769.45 |
| Total Liabilities, Capital and Surplus | | \$89,476,137.79 |
| Investments in Other Companies as shown in Balance Sheet include stock holdings of Copper Companies located in Michigan, as follows: | | |
| 28,785 shares Cliff Mining Company, of a total issue of | 60,000 shares | |
| 35,000 shares Isle Royale Copper Company, of a total issue of | 150,000 shares | |
| 152,977 shares LaSalle Copper Company, of a total issue of | 302,977 shares | |
| 50,100 shares Superior Copper Company, of a total issue of | 100,000 shares | |
| 10,000 shares White Pine Copper Company, Preferred, of a total issue of | 10,000 shares | |
| 42,602 shares White Pine Copper Company, Common, of a total issue of | 85,320 shares | |

A. D. NICHOLS,
Treasurer.

Copper Range Company

The 1923 production of all mines was 23,571,360 pounds, of which the Champion produced 18,412,630 pounds and the Baltic and Trimountain 5,851,730 pounds. Of the latter, all except a small percentage came from the Baltic Mine as the Trimountain was idle except for development work. The statements of the operations at the Baltic and Trimountain Mines are as follows:

| Receipts | | |
|--|--------------|--------------|
| 5,158,730 lbs. of copper sold at 14.62 cents per lb. | | \$754,518.30 |
| Interest | | 24,047.51 |
| | | \$778,565.81 |
| Expenditures | | |
| Running expenses at the mines, and property taxes | \$891,712.43 | |
| Smelting, freight, cost of marketing copper and general expense | 109,977.26 | 1,001,689.69 |
| Loss on operations | | \$223,123.88 |
| Trimountain shutdown expense, excluding property taxes of \$41,195.85 deducted above | \$107,320.80 | |
| Depletion and depreciation | 309,289.14 | 416,609.94 |
| Deficit | | \$639,733.82 |
| Construction Charges for 1923 | | \$80,321.98 |

The statement of operations at the Champion is as follows:

| Receipts | | |
|---|----------------|----------------|
| 18,412,630 pounds of copper produced and sold at (including silver) 14.86 cents per lb. | | \$2,736,047.34 |
| Interest | | 55,034.61 |
| | | \$2,791,081.95 |
| Expenditures | | |
| Running expenses at the mine, and property taxes | \$1,636,942.94 | |
| Smelting, freight, cost of marketing copper and general expenses | 415,267.03 | 2,052,209.97 |
| Profit on operations | | \$738,871.98 |
| Depletion and depreciation | | 804,508.69 |
| Deficit | | \$65,636.71 |
| Construction charges for 1923 | | \$9,392.42 |

Consolidated statement of the Copper Range Company for the year ending December 31st, 1923

| | | |
|--|--------------|----------------|
| is as follows: | | |
| 23,571,360 lbs. of copper produced and sold at average of 14.808 cents per pound | | \$3,490,565.64 |
| Interest | | 185,515.87 |
| Atlantic Mining Company income from rents, interest, etc. | | 11,682.48 |
| | | \$3,687,763.99 |
| Mining Expense, smelting, freight, sales department and all other expenses | | 2,797,158.47 |
| Taxes paid by mining companies | | \$890,605.52 |
| | | 307,859.59 |
| | | \$582,745.93 |
| Copper Range Railroad Company | | |
| Operating Income | \$148,807.39 | |
| Less interest on bonds | 114,000.00 | 34,807.39 |
| | | \$617,553.32 |
| Deduct one-half of net mining profit of Champion Copper Company which belongs to the St. Mary's Mineral Land Company | | 369,435.99 |
| Operating Income | | \$248,117.33 |
| Depletion and depreciation for 2½ mines | \$711,543.49 | |
| Trimountain shutdown expense | 107,320.80 | 818,864.29 |
| Deficit | | \$570,746.96 |

MINERAL RESOURCES OF MICHIGAN

CURRENT ASSETS AND TOTAL LIABILITIES

December 31, 1923

(Including Subsidiary Mining Companies)

Assets

| | | |
|-------------------------------------|--------------|----------------|
| Cash | | \$1,059,787.87 |
| United States Liberty Loan Bonds | | 1,793,000.00 |
| U. S. and Short Term Securities | | 1,166,963.35 |
| Copper delivered and not paid for | | 168,738.55 |
| Copper on hand | | 759,256.11 |
| Copper Range Railroad Company bonds | | 870,000.00 |
| Supplies at Mines | \$435,698.00 | |
| Cash at Mines | 27,720.15 | 463,418.15 |
| Accounts receivable | | 273,545.06 |
| Deferred Charges | | 1,529.66 |
| | | \$6,556,238.75 |

Liabilities

| | | |
|-------------------------------|--------------|----------------|
| Current indebtedness at mines | \$151,526.81 | |
| Accounts payable | 68,903.74 | 220,430.55 |
| | | \$6,335,808.20 |
| Less one-half Champion | | 1,320,358.81 |
| Net excess of assets | | \$5,015,449.39 |

The above statement does not include claim for \$92,966.29 filed against the United States Government on account of Railroad Guaranty under the Transportation Act of 1920. The Copper Range Company now holds in its treasury the following:
 97,288 shares Atlantic Mining Company stock.
 50,000 shares Champion Copper Company stock.
 42,443 shares Copper Range R. R. Co., entire stock issued.
 9,200 shares Michigan Smelting Company stock.

Isle Royale Copper Company

Copper product for the year 8,002,244 lbs.

PRODUCTION COSTS

| | | |
|---|-----------------|----------------|
| Mining | 9.87 c. per lb. | \$789,515.82 |
| Smelting and Refining | .91 c. per lb. | 73,012.15 |
| Boston office and mine and corporation taxes | 1.67 c. per lb. | 133,987.73 |
| Depreciation and Depletion | 3.81 c. per lb. | 304,592.96 |
| Production cost of 8,002,244 lbs. at 16.26 c. per lb. | | \$1,301,108.66 |
| On hand January 1, 1923 1,180,980 lbs. at 14.19 c. per lb. | | 167,526.40 |
| | | \$1,468,635.06 |
| Sold in year 6,158,182 lbs. | | 976,784.48 |
| | | \$491,850.58 |
| Less to reduce to market value | | 94,813.82 |
| On Hand December 31, 1923 3,025,042 lbs. at 13.125 c. per lb. | | \$397,036.76 |

EARNINGS STATEMENT

| | | |
|--|-------------|--------------|
| Received for copper sold 6,158,182 lbs. at 14.84 c. per lb. | | \$914,083.35 |
| Cost of Copper Sold: | | |
| Production cost at 15.86 c. \$976,784.48 | | |
| Selling and delivery cost at .47 c. 29,155.42 lbs. at 16.33 c. per lb. | | 1,005,939.90 |
| Loss on copper sold 1.49 c. per lb. | | \$91,856.55 |
| Loss by reduction to market value | | 94,813.82 |
| | | \$186,670.37 |
| Miscellaneous Receipts, Interest, etc. | \$23,545.45 | |
| Miscellaneous Expenses | 15,343.16 | 8,202.29 |
| Loss for year | | \$178,468.08 |

COPPER PRODUCTION IN 1923

CHANGES IN NET CURRENT ASSETS

| | | | |
|---|--------------|------------|----------------|
| Balance of current assets January 1, 1923 | | | \$1,245,365.33 |
| Loss for year | \$178,468.08 | | |
| Less depreciation and depletion reserves | \$304,592.96 | | |
| Less depreciation on plant sold or obsolete | 6,279.86 | 298,313.10 | |
| Net increase in reserves for year | | | \$119,845.02 |
| Capital Assets: | | | |
| Plant increased, new construction | \$2,872.53 | | |
| Plant decreased by sales and obsolescence | 11,089.50 | | |
| Net decrease in capital assets | | | \$8,216.97 |
| Dividends paid: | | | |
| March 15 1923 | \$75,000.00 | | |
| June 15, 1923 | 75,000.00 | | |
| September 15, 1923 | 75,000.00 | 225,000.00 | 216,783.03 |
| Net decrease in current assets | | | 96,938.01 |
| Balance of current assets December 31, 1923 | | | \$1,148,427.32 |

COMPARATIVE RESULTS FOR THE PAST FOUR YEARS

| | 1920 | 1921 | 1922 | 1923 |
|--|------------|-----------|-----------|-----------|
| Tons of rock treated | 591,971 | 116,576 | 246,641 | 308,940 |
| Cost of mining, transportation, stamping and taxes per ton of rock | \$2.73 | \$2.62 | \$2.36 | \$2.88 |
| Pounds of refined copper produced | 10,621,801 | 2,491,000 | 6,639,970 | 8,002,244 |
| Pounds of refined copper per ton of rock treated | 17.94 | 21.37 | 26.92 | 25.90 |

Mohawk Mining Company

The Mohawk Mine, of this company, produced 9,452,539 pounds or an average of 23.32 pounds of copper per ton of rock stamped. The Wolverine Mine, which was purchased by the Mohawk Mining Company, as of August 16, 1923, produced from that date to the end of the year 1,170,335 pounds of copper or an average of 16.82 pounds per ton. Underground work at the Wolverine Mine consisted only of scrambling in the old workings as the virgin ground in this property is practically exhausted to the property lines. The detailed financial statements of the Mohawk Mining Company are as follows:

BALANCE SHEET DECEMBER 31ST, 1923

| Assets | |
|---|-----------------|
| Current Assets: | |
| Cash in Bank and on Hand | \$678,246.35 |
| Accounts Receivable | 161,648.14 |
| Notes Receivable—Timber Accounts | 52,500.00 |
| Copper on hand, at cost | 572,139.18 |
| Supplies at Mines | 315,824.77 |
| Interest Accrued on Securities Owned | 2,229.95 |
| Unexpired Insurance | 1,127.95 |
| | \$1,783,716.34 |
| Investment in Smelting Company and Miscellaneous Securities | 192,997.00 |
| Capital Assets: | |
| Mines and Mine Development: | |
| Mining Properties | \$1,080,644.00 |
| Development of Mines | 2,050,575.26 |
| Ore body enhancement, as of March 1, 1913 | 9,468,508.35 |
| | \$12,599,727.61 |
| Other Real Estate and Undeveloped Mineral Lands | 458,923.40 |
| Buildings, Machinery and Equipment | 3,424,487.24 |
| | 16,483,138.25 |
| | \$18,459,851.59 |

| Liabilities. | | |
|--|----------------|------------------------|
| Current Liabilities: | | |
| Accounts payable | \$142,347.39 | |
| Federal Tax Adjustments, paid in 1924 | 124,266.07 | |
| Notes payable due 1924 | 220,000.00 | |
| Unclaimed dividends | 8,070.50 | |
| Interest Accrued on Notes Payable | 2,983.62 | \$497,667.58 |
| Notes Payable for Purchase of Mineral Lands, Due 1925 and 1926 | | 160,135.00 |
| Reserves for Depletion and Depreciation: | | |
| Depletion of Ore Bodies and Timber | \$6,694,805.18 | |
| Depreciation of Buildings, Machinery and Equipment | 2,483,750.31 | |
| | | 9,178,555.49 |
| Unrealized Appreciation of Ore Bodies at December 31, 1923 | | 4,601,160.53 |
| Capital Stock: | | |
| Authorized—115,000 shares at \$25.00 each | \$2,875,000.00 | |
| Issued—115,000 shares at \$18.00 per share paid | | 2,070,000.00 |
| Surplus, per annexed statement: | | |
| General | \$1,369,513.56 | |
| Capital | 582,819.43 | 1,952,332.99 |
| | | <u>\$18,459,851.59</u> |

SURPLUS ACCOUNT, DECEMBER 31, 1923

| | | |
|---|----------------|-----------------------|
| Balance, December 31, 1922 | \$1,609,589.04 | |
| Profit for the year 1923 before depletion and depreciation | 150,297.73 | |
| Appreciation realized during year 1923 | 166,436.56 | |
| Capital surplus representing premium on stock issued for acquisition of Assets— | | |
| Excess of valuation over amount credited as paid up on shares issued | 582,819.43 | |
| Transfer from Reserve for Contingencies, no longer considered necessary | 52,736.75 | |
| | | <u>\$2,561,879.51</u> |
| Less: | | |
| Depletion during year 1923 | \$204,244.06 | |
| Depreciation for year 1923 | 90,302.46 | |
| Dividends paid during year 1923—Numbers 38 to 40 | 315,000.00 | 609,546.52 |
| Balance December 31, 1923 | | <u>\$1,952,332.99</u> |

**STATEMENT OF INCOME AND PROFIT AND LOSS FOR THE YEAR ENDED DECEMBER 31, 1923

| | | |
|--|-----------------------|---------------------|
| Sales: | | |
| 8,613,745 pounds of copper at 14.2072 cents per pound | | \$1,223,771.77 |
| Cost of Sales: | | |
| Copper on hand January 1, 1923 | \$271,686.69 | |
| Copper purchased from Wolverine Copper Mining Company, August 16, 1923 | 84,981.67 | |
| Operating Expenses at Mines | 1,057,018.33 | |
| Smelting, Freight and New York Expenses | 216,547.29 | |
| Taxes | 75,047.77 | |
| | <u>\$1,705,281.75</u> | |
| Less—Copper on hand December 31, 1923, at cost | 572,139.18 | |
| Net cost of copper sold | | 1,133,142.57 |
| Profit on sales of copper | | <u>\$90,629.20</u> |
| Miscellaneous Income: | | |
| Interest and dividends | \$29,977.67 | |
| Rents Received, etc. | 24,034.46 | |
| Sale of timber | 5,656.40 | 59,668.53 |
| Profit for the year before providing for Depreciation and Depletion | | <u>\$150,297.73</u> |

Quincy Mining Company

The directors submit the following report of the business and operations of the Quincy Mining Company for 1922:

| | | |
|---|----------------|-----------------------|
| The mine yielded 15,402,726 lb. of refined realized copper, for which has been received | | \$2,159,034.88 |
| Profits on silver | | 73,571.34 |
| | | <u>\$2,232,606.22</u> |
| Mining expense | | |
| Opening mine expense | \$1,671,295.16 | |
| Taxes paid in Michigan | 171,189.65 | |
| Capital stock tax | 102,748.33 | |
| Smelting and transportation, etc. | 8,313.00 | |
| | 254,998.46 | 2,208,544.60 |
| | | <u>\$24,061.62</u> |
| Other Receipts | | |
| Total | | 16,009.14 |
| Construction | \$81,883.64 | |
| Accident account | 24,000.00 | 105,883.64 |
| Deficit | | <u>\$65,812.88</u> |
| The statement of assets and liabilities in the last report showed a balance on hand: | | |
| January 1, 1922 | | \$1,611,320.84 |
| Deficit for 1922 | | 65,812.88 |
| | | <u>\$1,545,507.96</u> |

The loss for the year was due entirely to the increased cost of producing copper during the last half of the year through the shortage of underground labor, caving of No. 6 shaft in July, cost of repairs to the shaft, and the higher price for coal due to the coal strike, as operations were conducted at a slight profit during the first half of the year.

Underground conditions continue favorable, with a good showing for copper in the deepest openings, and there was a slight increase in the yield of refined copper per ton of ore hoisted during the year.

The copper was sold at an average of slightly over 14 cents. The recovery of silver was 150,139 fine ounces, all of which was sold to the government under the Pittman Act on the basis of \$1 per oz., netting a profit of \$73,571.34.

During the year the mine produced 674,499 tons of copper ore and mass copper which yielded 22.83 lbs. of refined copper per ton. A total of 1,786,140 lbs. was recovered by the regrind section of the stamp mill.

DEVELOPMENT PROJECTS

Active development operations were carried on at the Seneca, Gratiot, Mayflower and Arcadian Mines but no attempt was made to carry on mining operations at any of the properties mentioned. The largest development project in the district is the Seneca, which is pursuing active development operations on the Kearsage lode on the underlay from the Mohawk Mine.

TABLE I—PRODUCTION OF COPPER BY COMPANIES—1919 TO 1923 INCLUSIVE

| | 1919 | 1920 | 1921 | 1922 | 1923 |
|-----------------------------|-------------|-------------|------------|-------------|-------------|
| Ahmeek | 17,223,111 | 20,489,438 | 6,255,200 | 14,885,081 | †17,811,031 |
| Allouez | 3,749,984 | 2,499,239 | | | |
| Calumet-Hecla (old company) | 52,859,146 | 57,627,883 | 15,167,136 | 40,493,000 | †35,047,800 |
| Calumet-Hecla Consolidated | | | | | =27,526,000 |
| Centennial | 1,365,148 | 561,284 | | | |
| Copper Range Company: | | | | | |
| Baltic | 7,864,653 | 6,613,918 | 7,608,847 | 5,239,586 | 4,877,248 |
| Champion | 19,886,917 | 13,610,324 | 20,719,307 | 19,583,808 | 18,412,630 |
| Trimountain | 5,274,387 | 3,532,025 | 4,341,584 | 4,116,100 | 281,482 |
| Franklin | 1,062,879 | | | | |
| Isle Royale | 13,007,647 | 10,621,801 | 2,491,000 | 6,639,970 | 8,002,244 |
| La Salle | 340,719 | 59,713 | | | |
| Maac | 1,963,178 | | | | |
| Michigan | 1,697,107 | 1,075,492 | | | |
| Mohawk | 12,857,392 | 10,269,824 | 14,054,235 | 11,209,396 | 9,452,539 |
| Osceola | 10,824,231 | 7,465,773 | | | |
| Quincy | 19,476,320 | 19,219,070 | 16,960,265 | 15,402,726 | 13,000,733 |
| Superior | 563,935 | 322,871 | | | |
| Victoria | 1,245,590 | 1,060,829 | 273,916 | | |
| White Pine | 1,979,268 | 1,850,787 | | | |
| Winona | 561,238 | | | | |
| Wolverine | 4,562,617 | 3,932,225 | 3,924,270 | 3,544,879 | 3,544,879 |
| Development Projects | | 531,384 | 466,323 | 272,182 | |
| Total | 178,365,567 | 161,343,880 | 92,262,083 | 121,386,726 | 137,952,586 |

†Seven months prior to consolidation as part of Calumet and Hecla Consolidated Copper Company.

=Five months production of Consolidated Company.

TABLE II

Showing average recovery of copper per ton of rock treated.
Average price received for copper produced and value per ton of rock treated.

| Year. | Pounds copper recovered, per ton treated. | Average price received per pound. | Value per ton. |
|-------|---|-----------------------------------|----------------|
| 1919 | 23.48 | 19.3605 c. | \$4.545 |
| 1920 | 27.35 | 17.8023 c. | 4.869 |
| 1921 | 28.69 | 12.8881 c. | 3.698 |
| 1922 | 34.07 | 13.5462 c. | 4.615 |
| 1923 | 32.11 | 14.9543 c. | 4.802 |

TABLE III

Average Cost per Pound of Producing Copper in Michigan 1919 to 1923 Inclusive. Exclusive of Depletion and Federal Income and Excess Profits Tax.

| Items. | 1919. | 1920. | 1921. | 1922. | 1923. | Average for Five Year Period. |
|------------------------|---------|---------|---------|---------|---------|-------------------------------|
| General Expense | .5937 | .6768 | .4933 | .5866 | .6893 | .6173 |
| State taxes | .8302 | .9321 | .6196 | .7351 | .8030 | .7942 |
| Cost of Mining | 9.9737 | 9.4815 | 7.1913 | 6.1938 | 6.6624 | 8.1487 |
| Milling Smelting | 3.2912 | 4.4098 | 4.1016 | 3.3347 | 3.1596 | 3.6361 |
| Marketing Expense | .5448 | .6321 | .5757 | .5180 | .5365 | .6596 |
| Depreciation | 1.8872 | 1.8452 | 1.3284 | 1.8009 | 1.5278 | 1.7153 |
| Total Gross Cost | 17.1208 | 17.9775 | 14.3099 | 13.1691 | 13.3786 | 15.5702 |
| Silver Credit | .2975 | .2980 | .2822 | .2694 | .1061 | .2520 |
| Net Cost | 16.8233 | 17.6795 | 14.0277 | 12.8997 | 13.2725 | 15.3182 |
| Receipts per lb. | 19.3605 | 17.8023 | 12.8881 | 13.5463 | 14.9543 | 15.6851 |
| Net cost | 16.8233 | 17.6795 | 14.0277 | 12.8997 | 13.2724 | 15.3182 |
| Profit (+) or (-) loss | +2.5372 | +1.2228 | -1.1396 | +1.6465 | +1.6818 | +1.3669 |

Note—The small profit indicated on the weighted 5 year average as against an arithmetic 5 year average is due to the fact that the bulk of high cost copper had to be sold at low prices.

TABLE IV.

Figures Show Pounds of Copper.

| Year. | Mine Production of Copper in U. S. | Imports into United States. | Exports from United States. | U. S. Consumption of new Copper. |
|-------|------------------------------------|-----------------------------|-----------------------------|----------------------------------|
| 1900 | †606,117,166 | 105,176,808 | 348,402,853 | |
| 1901 | †602,072,519 | 137,826,406 | 222,137,911 | |
| 1902 | †659,225,014 | 194,501,757 | 354,668,849 | |
| 1903 | †729,943,131 | 168,707,995 | 310,729,524 | |
| 1904 | †812,537,267 | 181,292,205 | 554,550,030 | |
| 1905 | †888,784,267 | 210,724,685 | 534,907,619 | |
| 1906 | 916,971,387 | 225,843,281 | 454,752,018 | 686,265,987 |
| 1907 | 847,151,015 | 252,620,054 | 508,924,401 | 487,771,625 |
| 1908 | 956,840,578 | 218,705,427 | 661,876,127 | 480,000,000 |
| 1909 | 1,126,521,126 | 321,801,115 | 682,846,726 | 688,500,000 |
| 1910 | 1,088,237,432 | 344,435,771 | 708,316,514 | 732,400,000 |
| 1911 | 1,114,764,197 | 334,607,538 | 786,553,208 | 631,753,279 |
| 1912 | 1,249,094,891 | 410,240,295 | 775,000,658 | 775,978,332 |
| 1913 | 1,235,569,727 | 408,778,954 | 926,241,092 | 812,068,639 |
| 1914 | 1,148,431,437 | 306,350,827 | 840,080,922 | 681,917,955 |
| 1915 | 1,488,071,528 | 315,698,449 | 681,953,301 | 1,043,497,328 |
| 1916 | 2,005,875,312 | 462,335,980 | 784,006,486 | 1,439,755,266 |
| 1917 | 1,895,434,349 | 556,420,297 | 1,125,647,331 | 1,394,829,715 |
| 1918 | 1,910,022,841 | 575,805,115 | 744,243,481 | 1,661,669,576 |
| 1919 | 1,212,334,041 | 429,387,594 | 515,595,019 | 914,471,572 |
| 1920 | 1,224,550,151 | 485,670,691 | 623,158,489 | 1,053,838,538 |
| 1921 | 466,190,853 | 350,472,611 | 628,415,714 | 610,988,744 |
| 1922 | †944,024,741 | 541,013,220 | 742,755,957 | 890,372,627 |

†Smelter production figures.

MINERAL RESOURCES OF MICHIGAN

TABLE V.

Copper Production of Several of Certain Foreign Mines in 1912 and 1922.

| Company. | Copper Produced 1912. | Cost per lb. | Copper Produced 1922. | Cost per lb. |
|-----------------------------|-----------------------|--------------|-----------------------|--------------|
| Braden..... | 7,735,079 | ..... | 93,876,794 | 10.66 |
| Cerro de Pasco..... | 45,272,000 | 9.00 | 73,168,247 | 7.65 |
| Chile..... | ..... | ..... | 134,568,506 | 8.5 |
| Granby..... | 13,231,121 | 11.1 | 31,963,565 | 13.55 |
| Green Cananea..... | 48,157,847 | 10.49 | 10,577,387 | 18.27 |
| Kennecott Alaska..... | 22,366,478 | 5.00 | 44,172,060 | 8.67 |
| Total..... | 136,762,525 | ..... | 388,326,559 | 9.56 |
| Estimated average cost..... | 9.07 c. | ..... | 9.56 c. | ..... |
| Michigan average cost..... | 10.600 c. | ..... | 12.899 c. | ..... |

THE IRON INDUSTRY

MICHIGAN IRON ORE PRODUCTION IN 1923

GENERAL DESCRIPTION.

Shipments of Michigan iron mines for the year, 1923, totalled 13,962,769 tons with an average value of \$3.8858 per ton f. o. b. mine, or a gross value of \$54,256,527.78. The average Lake Erie value, which is the f. o. b. mine value plus transportation costs, amounted to \$5.5142, or a gross value at Lake Erie, of \$76,993,500.81.

The estimated ore reserves as determined for the Board of State Tax Commissioners, January 1, 1924, totalled 191,889,100 tons or a decrease of 3,753,978 tons from the estimate of January 1st, 1923. New discoveries did not keep pace with depletion of ore reserves. This condition has been true since 1921, depletion of ore reserves proceeding at a rate of about four million tons per year. Shipments from Michigan average from twelve to fifteen million tons per annum. It is therefore apparent that we are mining out old deposits faster than new discoveries are coming in.

At the present time there is undoubtedly a surplus in the Lake Superior district as a whole, particularly of high phosphorous ores such as are produced in Iron County, but if the present rate of shipment continues, the surplus ore will be wiped out in a few years and there will be a genuine shortage of ore. Just how long this will take is questionable. Various estimates have been made, varying from a minimum of five, to a maximum of fifteen years.

During 1923, five mines were exhausted and abandoned. These were as follows:

Clifford Mine, Antoine Ore Company, Breitung Township, Dickinson County.

Munro Mine, Munro Iron Mining Company, City of Norway, Dickinson County.

Brotherton Mine, Brotherton Iron Mining Co., City of Wakefield, Gogebic County.

Castile Mine, Castile Mining Company, City of Wakefield, Gogebic County.

Meteor Mine, Castile Mining Company, City of Wakefield, Gogebic County.

The Castile and Meteor properties were abandoned largely because of the failure to discover sufficient ore to warrant profitable operation. It is possible that future discoveries might bring them into the list of producers again. In addition to the mines listed above, the Indiana property located in Breitung Township, Dickinson County, which produced a low grade of siliceous ore was abandoned as unprofitable.

Explorations during the year resulted in the development of two new reserves; one, in Stambaugh Township, Iron County, and the other in Mar-inesco Township, Gogebic County.

The usual statistical information is incorporated in the following tables:

TABLE I.

Production and Shipments of Michigan Iron Mines in 1923.
Compiled by L. P. Barrett from information furnished Board of State Tax Commissioners by Mining Companies.

Dickinson County.

| Mine. | Tons Mined. | Tons Shipped. |
|-------------------|----------------|------------------|
| Aragon..... | 269,168 | 257,738 |
| Chapin..... | 457,275 | 564,251 |
| Loretto..... | 82,238 | 41,570 |
| Penn..... | 165,622 | 383,381 |
| Total..... | 974,303 | 1,246,940 |

Gogebic County.

| Mine. | Tons Mined. | Tons Shipped. |
|-------------------|------------------|------------------|
| Anvil..... | 10,067 | 10,192 |
| Ashland..... | 19,471 | 35,405 |
| Asteroid..... | 122,497 | 107,083 |
| Eureka..... | 277,799 | 280,347 |
| Ironton..... | 348,073 | 369,179 |
| Keweenaw..... | 189,354 | 174,811 |
| Morgan..... | 24,301 | 28,362 |
| Newport..... | 691,301 | 660,947 |
| Norrie Gr..... | 1,449,153 | 1,559,818 |
| Palms..... | 368,927 | 330,066 |
| Plymouth..... | 827,410 | 827,410 |
| Puritan Gr..... | 93,573 | 155,421 |
| Sunday Lake..... | 226,652 | 171,583 |
| Tilden..... | 196,433 | 204,700 |
| Townsite..... | 114,666 | 108,564 |
| Yale..... | 140,822 | 118,824 |
| Wakefield..... | 392,144 | 360,509 |
| Total..... | 5,492,643 | 5,505,721 |

Iron County.

| Mine. | Tons Mined. | Tons Shipped. |
|---------------------|-------------|---------------|
| Balkan..... | 140,567 | 128,244 |
| Baltic-Fogarty..... | 127,440 | 120,536 |
| Bates..... | 95,457 | 49,288 |
| Bengal..... | 248,419 | 157,310 |
| Berkshire..... | 189,790 | 209,512 |
| Bristol..... | 429,836 | 455,025 |
| Buck..... | 6,536 | 4,685 |
| Cardiff..... | 94,403 | 93,459 |
| Carpenter..... | 149,075 | 132,617 |
| Caspian..... | 256,759 | 234,199 |
| Davidson No. 1..... | 117,011 | 104,325 |
| Davidson No. 2..... | 75,924 | 49,400 |
| Davidson No. 3..... | 42,328 | 48,861 |
| Delta..... | 13,087 | 11,508 |
| Dunn-Richards..... | ..... | 17,206 |
| Forbes..... | 84,591 | 119,035 |
| Hiawatha..... | 159,291 | 146,257 |
| Homer..... | 224,265 | 251,355 |
| James..... | 99,629 | 63,143 |
| Judson..... | 80,765 | 69,064 |

Iron County—Concluded.

| | Tons Mined. | Tons Shipped. |
|-------------------|------------------|------------------|
| Spies..... | ..... | 8,839 |
| Monongahela..... | 174,720 | 164,107 |
| Odgers..... | 407,809 | 295,951 |
| Porter..... | 88,611 | 77,699 |
| Riverton Gr..... | 172,608 | 210,596 |
| Rodgers..... | 237,324 | 198,984 |
| Tobin..... | 68,877 | 49,874 |
| Warner..... | 82,343 | 59,917 |
| Zimmerman..... | 71,522 | 51,722 |
| Total..... | 3,938,987 | 3,581,768 |

Marquette Range.

| Mine. | Tons Mined. | Tons Shipped. |
|-----------------------|------------------|------------------|
| Athens..... | 245,545 | 169,477 |
| Austin..... | 82,976 | 67,674 |
| Barnes-Hecker..... | 36,228 | 16,849 |
| Cambria..... | 143,934 | 141,361 |
| Cliffs Shaft..... | 290,615 | 426,533 |
| Francis..... | 110,550 | 5,394 |
| Gwinn..... | ..... | 27,957 |
| Holmes..... | 276,672 | 307,519 |
| Imperial..... | 178,730 | 211,302 |
| Isabella..... | 158,241 | 177,813 |
| Jackson..... | 12,812 | 15,239 |
| Maas..... | 219,240 | 210,477 |
| Mackinaw-Gardner..... | ..... | 10,028 |
| Maitland..... | 98,966 | 98,966 |
| Mary Charlotte..... | 164,907 | 120,319 |
| Morris Lloyd..... | 260,335 | 216,892 |
| Negaunee..... | 364,930 | 336,474 |
| Princeton..... | ..... | 19,227 |
| Republic..... | 104,804 | 149,374 |
| Richmond..... | 271,492 | 271,492 |
| Rolling Mill..... | 193,869 | 177,593 |
| Salisbury..... | ..... | 29,793 |
| Stephenson..... | 247,212 | 69,464 |
| Section 16..... | 315,351 | 369,123 |
| Total..... | 3,777,409 | 3,646,340 |

| County. | Tons Mined. | Tons Shipped. |
|-------------------------|-------------------|-------------------|
| Dickinson..... | 974,303 | 1,246,940 |
| Gogebic..... | 5,492,643 | 5,505,721 |
| Iron..... | 3,938,989 | 3,581,768 |
| Marquette Range..... | 3,777,409 | 3,646,340 |
| Grand Total..... | 14,183,342 | 13,980,769 |

TABLE II.

Comparison of Michigan Iron Ore Shipped with Remainder of Lake Superior District.

| | Tons Shipped. | Per cent of Total. |
|------------|---------------|--------------------|
| Michigan† | 13,980,769 | 23.05 |
| Minnesota= | 45,313,806 | 75.02 |
| Wisconsin= | 1,168,833 | 1.93 |
| Total | 60,463,408 | 100.00 |

†As reported to Board of State Tax Commissioners.

=Figures from Iron Trade Review for Feb. 7, 1924.

TABLE III.

Average Costs, Receipts and Profits of Michigan Iron Mines During 1923. Compiled by L. P. Barrett from reports submitted by Mining Companies to Board of State Tax Commissioners.

| Items. | | |
|--------------------------------------|--------|--------|
| Cost of Mining: | | |
| Labor | 1.1882 | |
| Supplies | .5838 | |
| Total | 1.7720 | 1.7720 |
| Deferred Mining Costs: | | |
| New shafts | .0183 | |
| Development† | .0644 | |
| Total | .0827 | .0827 |
| Taxes except Federal Income Tax: | | |
| State and local general property tax | .2824 | |
| State Corporation | .0039 | |
| Federal Taxes except Income Tax | .0033 | |
| Total | .2896 | .2896 |
| Depreciation | .1097 | .1097 |
| Overhead Expense: | | |
| General superintendence | .0448 | |
| Contingent expense | .0075 | |
| Fire insurance | .0055 | |
| General expense | .0688 | |
| Total | .1266 | .1266 |
| Transportation: | | |
| Rail freight | .7896 | |
| Boat freight | .8369 | |
| Cargo insurance | .0019 | |
| Total | 1.6284 | 1.6284 |
| Analysis and selling expense: | | |
| Analysis | .0042 | |
| Selling commission | .0454 | |
| Total | .0496 | .0496 |

†* cludes stripping.

TABLE IV.

Labor Statistics of Iron Mines.

| | Dickinson Co. | Gogebic Co. | Iron Co. | Marquette Co. | State. |
|----------------------------|---------------|--------------|--------------|---------------|---------------|
| Average No. of men | 1,290 | 4,380 | 2,947 | 3,251 | 11,868 |
| Average No. of days worked | 304 | 293 | 289 | 296 | 295.5 |
| Tons mined | 974,303 | 4,273,089 | 3,830,443 | 3,394,139 | 12,471,974 |
| Tons per man per day | 2.48 | 3.32 | 4.49 | 3.53 | 3.55 |
| Total labor | 1,746,805.00 | 5,951,975.00 | 3,911,251.46 | 4,576,029.00 | 16,186,060.00 |
| Average yearly | 1,353 | 1,358 | 1,324 | 1,405 | 1,362 |
| Average daily | 4.46 | 4.63 | 4.58 | 4.75 | 4.62 |

TABLE V.

Michigan Iron Ore Reserves and Assessed Valuation by Board of State Tax Commissioners. Ore Reserves estimated by L. P. Barrett for Board of State Tax Commissioners.

| | 1923. | | 1924. | |
|------------------|---------------------|---------------|---------------------|---------------|
| | Ore Reserves, Tons. | Total Value. | Ore Reserves, Tons. | Total Value. |
| Dickinson County | 9,348,321 | \$5,994,000 | 8,129,803 | \$5,507,000 |
| Gogebic County | 58,314,512 | 46,496,818 | 54,949,558 | 45,932,758 |
| Iron County | 56,065,508 | 25,624,025 | 58,425,590 | 25,945,145 |
| Marquette Range | 71,914,737 | 35,560,753 | 70,384,149 | 35,987,650 |
| Total | 195,643,078 | \$113,675,596 | 191,889,100 | \$113,372,553 |

PART II. NON-METALLIC MINERALS

SALT

The manufacture of salt is one of Michigan's most stable operations in non-metallic minerals and gives promise of being continued as a successful operation indefinitely. Plants can be located on trunk lines of transportation both by lake and rail so that the fortunate location, together with a practically unlimited supply of very pure mineral salt, which is easily brought to the surface by solution and pumping, give Michigan high rank as a salt producing State. There are six important brine and salt bearing formations,—the Salina, Detroit River (Upper Monroe), Dundee, Berea, Napoleon, and Parma. Of these the Salina is by far the most important as the salt occurs in bedded deposits of great purity and often of great thickness. In the other salt bearing formations quantities of salt are found in brines contained in the rocks but other substances which are also contained in solution render these brines more important at the present time for other uses and the salt produced from them is frequently a by-product from other manufacturing operations. This restriction of salt manufacture to the Salina deposit is of recent date. Formerly salt was produced in important quantities from the Berea, Napoleon, and Parma, but with the beginning of operations in Wayne County (1895) the other sources were soon abandoned or were continued only where waste heat could be utilized, or salt could be produced as a by-product during the recovery of other chemicals.

The Salina formation has never been identified with certainty in outcrop within the State. Rominger* visited and described several outcrops in the vicinity of Point aux Chenes and St. Martin's Bay near St. Ignace but reported no fossils or salt beds, and it is now believed that these are outcrops of the Bass Island formation. A small area around the Straits of Mackinac is the only place where outcrops are supposed to occur and it is known that in this region the salt bearing beds are generally absent. The northernmost record of salt at the Salina horizon was in the St. Ignace well No. 1, where 4 feet of salt was reported. In the No. 2 well two miles north of No. 1 no salt was found. The beds containing salt at St. Ignace have not been determined as Salina. They may belong with the Monroe and without fossil evidence it is not possible with the present data to make a satisfactory correlation. Lithologically they differ from both the typical Bass Island and the typical Salina as they are chiefly red and blue shales. This area is apparently at the border of both the Monroe and Salina basins. Because of the limited area of outcrop, which has never been examined in detail, all of the information accumulated has been from deep borings with the exception of a mining operation at Oakwood, a suburb of Detroit, where rock salt has been recovered by shaft mining. Here the Salina section has been observed and a careful search made for fossils but without finding any trace whatever of organisms. Three deep wells have been drilled since accounts of the Salina were published which throw some light upon its extent and its relation to formations above and below. Two wells drilled by Henry Ford, one at Dearborn, Wayne County, and one at Highland Park, Wayne County, and a well drilled near Chesterfield, Macomb County, by the Macomb County Oil & Gas Syndicate have completely penetrated the Salina. These new records added to some already known in Ontario and Michigan, make it possible to show graphically the relation of the Salina to other beds and the northern and southern terminations of the salt beds. This section shows the salt bearing part of the Salina as a lenticular bed with its deepest part at Chesterfield and its

*Rominger, Carl, Michigan Geological Survey Vol. I, Part 3, p. 30, 1873.

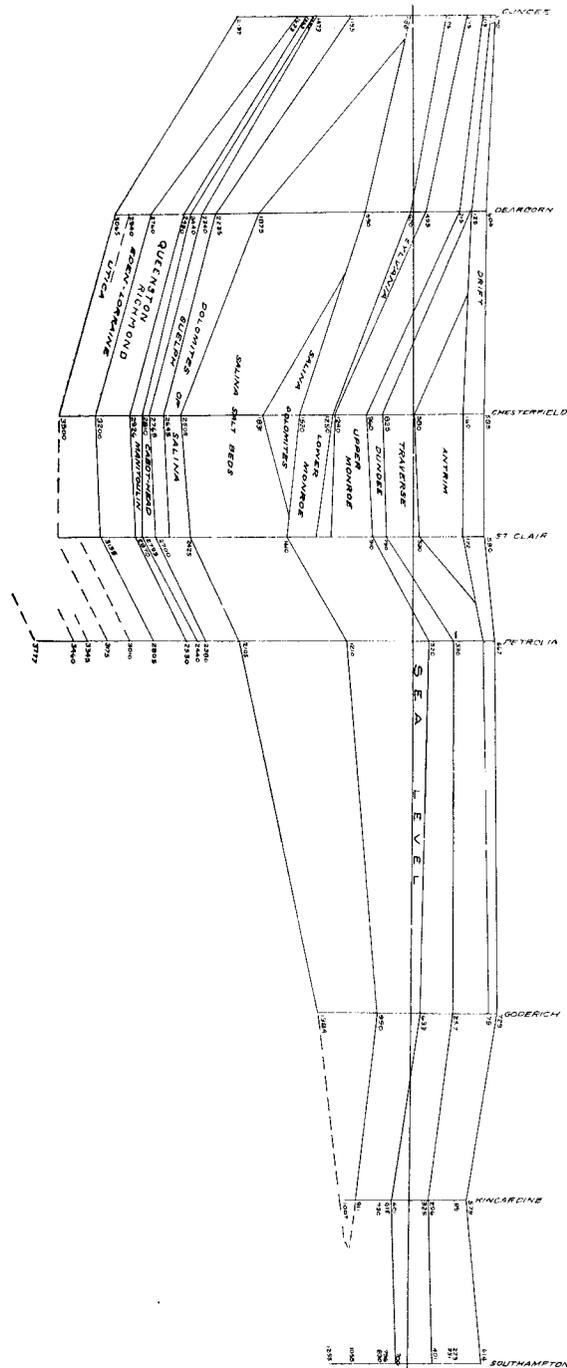


Fig. 1. A cross section from Dundee, Michigan to Southampton, Ontario along the line A-B shown in Fig. 2. Straight lines are used to emphasize the diagrammatic nature of the section.

thickest part near Dearborn. In the Chesterfield well the salt beds were not encountered at the usual horizon but a series of dark colored shales and dolomites was found and penetrated for 311 feet. These dolomites and shales were not found in the Dearborn or St. Clair wells and their position in the lowest part of the basin, together with their lithologic character, which is more like that of the dolomites at the base of the Salina than those of the overlying Bass Island (Lower Monroe) formation, led to their assignment to the Salina. That these dolomites belong to the Salina sedimentary unit seems obvious but like all other correlations made from well records this one implies no exact time relationship. The cross section brings out the fact that the salt bearing part of the Salina is a continuous deposit throughout the basin of its deposition and this is held to be an important observation when applied to the question of the extent of the salt beds. Suggestions have been made that the Michigan deposits were distinct from those of the New York basin and were of a different type, being continental deposits of desert lakes and therefore apt to be found in restricted areas. The broad, regular, and continuous deposit of the Salina as it is shown leads to an opposite conclusion. From its shape and extent it seems reasonable to infer a regular and continuous deposit over the central and northern parts of the Michigan basin. From the prevailing white and gray color of the salt beds, the absence of red excepting in the upper part, the absence of the more soluble salts, and the absence of sands or grits, these beds are held to have had their origin in a large body of water, most probably with a connection with marine waters.

One most important conclusion in regard to the value of the Salina salt beds which follows from the records of recent wells is that potash salts do not occur in appreciable quantities in the Detroit-St. Clair area of Wayne and Macomb Counties. If we accept the inference, made above, of shifting marine conditions with repeated influx of marine waters it is most probable that such salts do not anywhere occur in the Michigan Salina. Prospecting with the intention of recovery of any of the more valuable salts is not warranted by past experience.

While the Salina is thought to be continuous under the greater part of the Southern Peninsula, it is not exploited excepting near the outer margin along the shores of lakes Huron, Michigan, and St. Clair and the Detroit river where the salt beds are not so deep as to make drilling operations unduly hazardous. The salt beds are not found in the southern part where the Salina is represented by shales and shaly dolomites only. The area of productive Salina as it is known at present is bounded on the north by a line connecting Alpena, Onaway, and Manistee and on the south by a line from Muskegon to Trenton. The southern line represents in general a known limit of the salt but the northern line represents only a limit of exploration. The salt beds continue some distance north from Onaway and Alpena. The region which gives greatest promise for new exploration is the Alpena-Onaway area where the salt is thick and comparatively near the surface, having been encountered at 1284 feet at Grand Lake and at 1630 feet at Onaway. The productive area varies greatly as to the amount of salt imbedded in the Salina. Attempts which have been made to correlate salt beds between wells have been fairly successful, and five major salt beds in the Detroit region have been found to occur at similar positions in several of the deep wells. While thick deposits of salt probably occur throughout the Salina basin within the limits described above, it is not at present practicable to exploit them in the central portion of the State because of the great

depth at which they occur. The area under which the Salina is practically out of reach is the portion which has Pennsylvanian and Upper Mississippian rocks at the surface under the drift cover as shown on the geological map.* The territory which offers possibilities for the exploitation of salt deposits in the Salina includes the counties bordering Lake Michigan from Ludington north, those bordering Lake Huron from Oscoda north, those bordering Lake Huron from Grindstone City (Huron County) south, and those along the St. Clair river, Lake St. Clair, and the Detroit river as far south as Trenton in Wayne County.

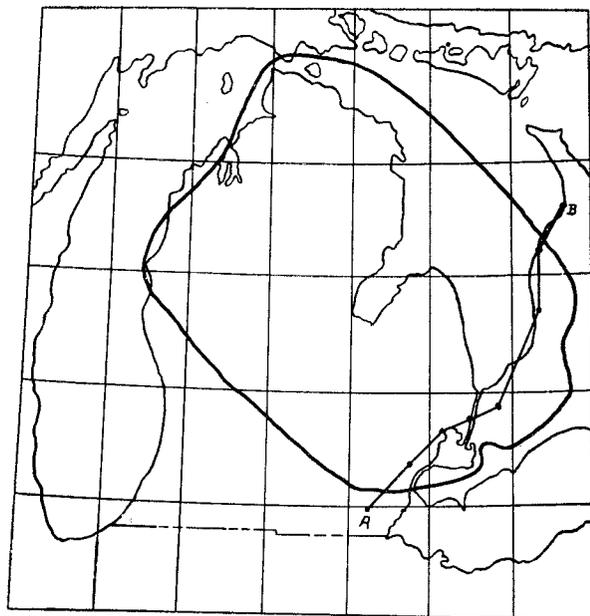


Fig. 2. Limits of the Michigan-Ontario salt basin. In Michigan the central part is untested because of its great depth. Line A-B indicates the direction of the section shown in Fig. 1.

Michigan produced more salt than any other state in 1923. This has been the case since 1880 with the exception of a few years when New York has had a greater production. It is recorded that Michigan was first in salt production from 1880 to 1892, in 1901, from 1905 to 1909, from 1912 to 1921, and in 1922 and 1923.

In 1923 the salt producers in Michigan reported 2,127,412 short tons valued at \$8,684,148. This is but a small increase over the reported production of 1922 which was 2,005,088 short tons valued at \$8,693,604. The low point in production since 1910 was reached in 1921 and the rapid recovery which took place in 1922 has been sustained during 1923.

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

*Mich. Geol. Surv. Pub. 23, 1917.

annually produced nearly one-third of the total output and since 1880 Michigan has produced 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 96.2 per cent of the State output of salt for 1923 came from these two districts, the production being 14,613,300 barrels, valued at \$8,201,024 or 96.2 per cent of the total State production and 94 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; in 1923, 10,457,185 barrels valued at \$2,873,664.

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 1923 was 2,604,607 barrels or 17.1 per cent of the State total, but the valuation of \$4,097,427 represents 47.2 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.

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 1,551,507 barrels of salt valued at \$1,229,933. This is equivalent to 10.2

per cent of the total quantity and 14.2 per cent of the value for the State. Most of the product is packer's salt, i. e., common fine and common coarse.

About fifty years ago Saginaw Valley was the center of the salt industry. The industry was chiefly along Saginaw River. Salt was produced as a by-product of the lumber industry. More than a hundred concerns, chiefly lumber mills, utilized waste material in manufacturing salt from brine, which was obtained from the Marshall sandstone at depths varying from about 650 feet at Saginaw to nearly 1000 feet at Bay City. The production of salt declined with the lumber industry. At present there are only a few concerns along Saginaw River producing salt.

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES
1880-1923††

| 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 | 3,426,989 | ..... | 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 | ..... | 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 | 35,579,672 | ..... | 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 |
| 1923 | 50,933,664 | ..... | 15,195,800 | 29.83 | 1 | 8,684,148 | 1 | 0.571 |
| Total | 1,038,069,125 | ..... | 343,643,530 | ..... | ..... | \$159,712,922 | ..... | ..... |

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

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 1923 bromine production in the United States decreased somewhat, the production reported for the year being 842,352 pounds. Michigan produced the greater part of the United States production. The average price per pound for the United States was \$.17.

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 1923 was 43,596 tons valued at \$642,874, an increase from 1922 of 10,529 tons. The average price per ton dropped from \$17.28 in 1922 to \$14.75 in 1923. Michigan produced the greater 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 the German supply was cut off, the Dow Chemical Company of Midland began the production of metallic magnesium, and, later on, of magnesium alloys.

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.

CEMENT†

The first attempts to manufacture Portland cement in Michigan were made in 1885, when an experimental vertical kiln plant was constructed at Kalamazoo, using marl and clay in the process. The venture was a failure and no second attempt was made to establish the industry in Michigan until 1896. In that 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 the rotary type. 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 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 fuel revolutionized cement manufacture and enabled the industry in the United States to excel that of Europe, and thus inaugurate the present era of concrete construction. The growth of the industry from 1895 to 1907 was phenomenal, the production in 1907 reaching 48,000,000 barrels. The growth was checked by the financial depression of 1907, but it was resumed the following year and continued almost uninterruptedly until 1917, when 92,814,202 barrels were made. The war caused relatively small decreases in production in 1914 and 1916. In 1917 there was a slight increase in production but the restrictions imposed by the Government upon fuel supplies, transportation facilities, labor, and private construction in general caused a marked decrease in output in 1918, production falling to 71,081,663 barrels, the lowest production since 1909. This was somewhat offset by the increased price of cement, \$1.596 per barrel. The total value for the entire country was \$113,153,513. During 1919 production and shipment gained by 13.7 per cent and 20.7 per cent respectively over 1918, production being 80,777,935 barrels and shipments were valued at \$146,734,844 with the average price per barrel at \$1.71. In 1920 production reached the unprecedented figure of 100,023,245 barrels with shipments of 96,311,719 barrels valued at \$194,439,025, an increase of 13 per cent in quantity shipped over 1919, and of 32.5 per cent in value of shipments. The average price for cement in the United States was \$2.02, an increase of \$0.31 or 18 per cent per barrel.

The period between 1899 and 1901 was the "boom" period of the industry, twenty companies being organized 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; thirteen in 1924.

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

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

causing a shortage of Portland cement and an increase in its price. 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 during 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 out-ranked only 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. In 1923 Michigan produced 7,619,792 barrels—an increase of 22 per cent over the production of the preceding year.

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 one-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 of the machinery for the manufacture of cement, including waste heat boilers which supply all the power used in driving the mill. This plant is one of "the best and most efficient wet process" plants and attracted the 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 nothing came of this project.

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 modern plant equipped with waste heat boilers. This began production in 1923. It utilizes "fines" or "waste" stone from limestone quarries.

The Peerless Portland Cement Company, with one plant at Union City, Branch County, is building another at Detroit. The source of raw material is to be refuse from the soda ash plants at Detroit, "fines" or screenings from the limestone quarries in the northern part of the Southern Peninsula, and surface clay in the vicinity of Detroit.

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896-1923.

| Year. | No. of plants in operation. | Michigan Rank. | No. of kilns. | Daily capacity. | Michigan cement made, Bbls. | U. S. cement made, Bbls. | Michigan, per cent made. | Change per cent. | Michigan cement shipped, Bbls. | Michigan cement shipped, Value. | U. S. cement shipped, Value. | Michigan, per cent of value. | Michigan, stock on hand Dec. 31. | Michigan, average price per barrel. | U. S. average price per barrel. |
|-------|-----------------------------|----------------|---------------|-----------------|-----------------------------|--------------------------|--------------------------|------------------|--------------------------------|---------------------------------|------------------------------|------------------------------|----------------------------------|-------------------------------------|---------------------------------|
| 1896 | 1 | 1 | 1 | 4,000 | 4,000 | 1,543,023 | 0.25 | 275.0 | .. | \$7,000 | \$2,244,011 | 0.29 | .. | \$1.75 | \$1.57 |
| 1897 | 2 | 2 | 2 | 12,000 | 12,000 | 2,677,775 | 0.56 | 413.3 | .. | 26,250 | 4,315,891 | 0.6 | .. | 1.75 | 1.61 |
| 1898 | 4 | 4 | 4 | 17,000 | 17,000 | 3,692,284 | 2.11 | 346.2 | .. | 134,750 | 5,970,773 | 2.3 | .. | 1.747 | 1.62 |
| 1899 | 4 | 4 | 4 | 343,566 | 343,566 | 5,632,266 | 6.1 | 93.4 | .. | 513,849 | 8,074,371 | 6.36 | .. | 1.492 | 1.43 |
| 1900 | 6 | 2 | 2 | 604,750 | 604,750 | 8,482,020 | 7.8 | 54.1 | .. | 830,990 | 9,280,525 | 8.9 | .. | 1.25 | 1.09 |
| 1901 | 10 | 3 | 3 | 1,025,718 | 1,025,718 | 12,711,225 | 8.0 | 53.7 | .. | 1,128,290 | 12,532,360 | 9.0 | .. | 1.10 | 0.99 |
| 1902 | 10 | 3 | 3 | 1,377,006 | 1,377,006 | 17,230,644 | 9.1 | 23.9 | .. | 2,074,780 | 20,864,078 | 10.2 | .. | 1.353 | 1.21 |
| 1903 | 13 | 3 | 3 | 1,955,183 | 1,955,183 | 2,342,973 | 8.7 | 14.9 | .. | 2,674,780 | 27,713,319 | 9.7 | .. | 1.367 | 1.24 |
| 1904 | 16 | 3 | 3 | 2,247,160 | 2,247,160 | 26,505,881 | 8.5 | 23.4 | .. | 2,865,656 | 33,355,119 | 10.1 | .. | 1.052 | 0.88 |
| 1905 | 16 | 5 | 5 | 2,773,283 | 2,773,283 | 35,246,812 | 7.9 | 35.5 | .. | 2,921,507 | 33,245,867 | 8.7 | .. | 1.053 | 0.94 |
| 1906 | 14 | 4 | 4 | 3,747,525 | 3,747,525 | 46,463,424 | 8.06 | 19.0 | .. | 4,814,965 | 52,466,186 | 9.2 | .. | 1.284 | 1.13 |
| 1907 | 14 | 4 | 4 | 3,572,668 | 3,572,668 | 48,785,390 | 7.3 | 11.6 | .. | 4,384,731 | 53,992,551 | 8.1 | .. | 1.227 | 1.11 |
| 1908 | 15 | 7 | 7 | 3,892,576 | 3,892,576 | 51,072,612 | 5.6 | 11.7 | .. | 2,556,215 | 43,547,679 | 5.8 | .. | 0.883 | 0.85 |
| 1909 | 12 | 7 | 7 | 3,212,751 | 3,212,751 | 64,991,431 | 4.9 | 11.2 | .. | 2,619,259 | 52,858,354 | 4.9 | .. | 0.815 | 0.813 |
| 1910 | 12 | 8 | 8 | 3,687,719 | 3,687,719 | 76,549,951 | 4.8 | -0.03 | .. | 3,378,940 | 68,205,800 | 4.9 | .. | 0.916 | 0.891 |
| 1911 | 11 | 8 | 8 | 3,686,716 | 3,686,716 | 78,528,637 | 4.69 | 19.79 | .. | 3,024,676 | 66,248,817 | 4.56 | .. | 0.82 | 0.843 |
| 1912 | 11 | 8 | 8 | 3,494,621 | 3,494,621 | 82,438,096 | 4.23 | 2.27 | .. | 3,145,001 | 69,109,800 | 4.55 | .. | 0.861 | 0.813 |
| 1913 | 11 | 8 | 8 | 4,186,236 | 4,186,236 | 92,097,131 | 4.21 | 11.2 | .. | 4,228,879 | 89,106,975 | 4.74 | .. | 1.035 | 1.005 |
| 1914 | 11 | 7 | 7 | 4,285,345 | 4,285,345 | 88,230,170 | 4.85 | 32.00 | .. | 4,064,781 | 80,118,475 | 5.07 | .. | 0.934 | 0.927 |
| 1915 | 11 | 5 | 5 | 4,765,294 | 4,765,294 | 85,914,907 | 5.55 | 3.2 | .. | 4,454,608 | 74,756,674 | 5.95 | .. | 0.942 | 0.86 |
| 1916 | 11 | 6 | 6 | 4,919,023 | 4,919,023 | 91,521,198 | 5.37 | 4.47 | .. | 6,017,911 | 104,258,216 | 5.77 | .. | 1.168 | 1.103 |
| 1917 | 11 | 6 | 6 | 4,688,899 | 4,688,899 | 92,814,202 | 5.03 | 18.1 | .. | 6,122,887 | 122,775,088 | 4.98 | .. | 1.416 | 1.354 |
| 1918 | 10 | 6 | 6 | 3,594,872 | 3,594,872 | 71,081,663 | 5.00 | 11.8 | .. | 6,078,167 | 113,153,513 | 5.37 | .. | 1.680 | 1.596 |
| 1919 | 11 | 4 | 5 | 4,675,244 | 4,675,244 | 80,777,935 | 5.78 | 5.00 | .. | 8,468,196 | 146,734,844 | 5.77 | .. | 1.70 | 1.71 |
| 1920 | 11 | 7 | 5 | 4,891,457 | 4,891,457 | 100,023,245 | 4.89 | 18.1 | .. | 10,939,633 | 194,439,025 | 5.62 | .. | 2.46 | 2.02 |
| 1921 | 12 | 3 | 5 | 5,777,533 | 5,777,533 | 98,293,000 | 5.78 | 22.2 | .. | 10,300,289 | 180,778,415 | 5.69 | .. | 1.815 | 1.80 |
| 1922 | 12 | 3 | 5 | 6,243,805 | 6,243,805 | 115,679,412 | 5.39 | 11.8 | .. | 11,145,573 | 207,170,430 | 5.38 | .. | 1.76 | 1.76 |
| 1923 | 12† | 5 | 5 | 7,619,792 | 7,619,792 | 137,460,238 | 5.54 | .. | .. | 14,038,322 | 257,684,424 | 5.44 | .. | 1.88 | 1.71 |

†Minus sign indicates decrease.
‡Thirteen including branch plants but excluding one plant now under construction.

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 K₂O, amounted to 404 tons valued at \$100,647, of which 196 tons were from industrial wastes and 203 tons from wood ashes. In 1919 the production of potash reckoned as K₂O amounted to but 166 tons (from 666 tons of crude potash) of which 149 tons valued at \$48,581 were sold. This represents a decrease of 238 tons or 58.8 per cent in quantity and of \$52,066 or 51.7 per cent in value. Production was further decreased in 1920 to 56 tons (from 93 tons of crude potash) of which 49 tons were sold for \$18,312, a decrease from 1919 of 110 tons 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, 1922, or 1923.

GYPNUM

Commercial gypsum occurs in the Michigan formation which underlies the Bayport formation of the Upper Mississippian and also in the Salina formation of the Silurian, a much older formation. Only the gypsum of the Michigan formation 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 overburdens 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 Silurian age. 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 1860 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, but in 1923 the total reported was greatly reduced, the figures being withheld from publication because of the small number of producers.

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, 1922, and 1923 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, which was more than compensated by the increased production of 1923.

The production of stucco increased in 1920, decreased in 1921, and increased in 1922 and 1923. Stucco production in 1922 was 72,157 tons valued at \$501,595; in 1923 it was 104,271 tons valued at \$685,992. Plaster board and tile show an increase in quantity and value over 1922.

PRODUCTION OF GYPSUM IN MICHIGAN, 1868-1923

| Year. | Ground into land plaster. Tons. | Calcined sold. Tons. | Sold Crude Tons. | Total mined. Tons. | Gypsum and gypsum products. Total value. | Rank. | |
|--------------|---------------------------------|----------------------|------------------|--------------------|--|-----------|--------|
| | | | | | | Quantity. | Value. |
| Before 1868. | 132,043 | 14,285 | | 146,328 | \$671,022 | | |
| 1868. | 28,837 | 6,244 | | 35,081 | 165,298 | | |
| 1869. | 29,996 | 7,355 | | 37,351 | 178,824 | | |
| 1870. | 31,437 | 8,246 | | 39,683 | 191,718 | | |
| 1871. | 41,126 | 8,694 | | 49,820 | 284,054 | | |
| 1872. | 43,536 | 10,673 | | 54,209 | 259,524 | | |
| 1873. | 44,972 | 14,724 | | 59,696 | 297,678 | | |
| 1874. | 39,126 | 14,723 | | 53,849 | 274,284 | | |
| 1875. | 27,019 | 10,914 | | 37,933 | 195,386 | | |
| 1876. | 39,131 | 11,498 | | 50,629 | 248,504 | | |
| 1877. | 40,000 | 9,819 | | 49,819 | 238,550 | | |
| 1878. | 40,000 | 8,634 | | 48,634 | 229,070 | | |
| 1879. | 43,658 | 9,070 | | 52,728 | 247,192 | | |
| 1880. | 49,570 | 18,920 | | 68,499 | 349,710 | | |
| 1881. | 33,178 | 20,145 | | 53,323 | 298,872 | | |
| 1882. | 37,821 | 24,136 | | 61,957 | 344,374 | | |
| 1883. | 40,082 | 28,410 | | 68,492 | 377,567 | | |
| 1884. | 27,888 | 27,950 | | 55,847 | 335,382 | | |
| 1885. | 28,184 | 25,281 | | 53,465 | 286,892 | | |
| 1886. | 20,373 | 27,370 | | 56,748 | 308,094 | | |
| 1887. | 28,794 | 30,376 | | 59,170 | 329,392 | | |
| 1888. | 22,177 | 35,125 | | 57,302 | 347,531 | | |
| 1889. | 19,823 | 36,800 | | 56,623 | 353,869 | | |
| 1890. | 12,714 | 47,163 | 15,000 | 74,877 | 192,099 | | |
| 1891. | 15,100 | 53,600 | 11,000 | 97,700 | 223,725 | | |
| 1892. | 14,458 | 77,599 | 47,500 | 139,557 | 306,527 | | |
| 1893. | 16,263 | 77,327 | 31,000 | 124,590 | 303,921 | | |
| 1894. | 11,982 | 47,976 | 20,000 | 79,958 | 189,620 | | |
| 1895. | 9,003 | 51,028 | 6,488 | 66,519 | 174,007 | | |
| 1896. | 6,582 | 60,352 | 700 | 67,633 | 146,424 | | |
| 1897. | 7,193 | 71,680 | 16,001 | 94,874 | 193,576 | | |
| 1898. | 13,345 | 77,852 | 1,984 | 93,181 | 204,310 | | |
| 1899. | 17,196 | 88,315 | 39,266 | 144,776 | 283,537 | | |
| 1900. | 10,304 | 86,972 | 33,328 | 129,654 | 285,119 | 2 | 2 |
| 1901. | 9,808 | 120,256 | 46,086 | 185,150 | 267,243 | 1 | 1 |
| 1902. | 13,022 | 158,320 | 68,885 | 240,227 | 459,621 | 1 | 1 |
| 1903. | 18,409 | 198,119 | 52,565 | 269,093 | 700,912 | 1 | 1 |
| 1904. | 18,294 | 185,422 | 34,669 | 238,385 | 541,197 | 1 | 1 |
| 1905. | 20,285 | 203,313 | 24,289 | 247,882 | 634,434 | 1 | 2 |
| 1906. | 30,220 | 208,715 | 27,517 | 341,716 | 753,878 | 1 | 2 |
| 1907. | 15,500 | 197,666 | 36,543 | 317,261 | 681,351 | 3 | 3 |
| 1908. | 11,414 | 192,403 | 40,324 | 327,810 | 401,928 | 1 | 3 |
| 1909. | 11,890 | 344,171 | 45,781 | 394,907 | 1,213,347 | 2 | 1 |
| 1910. | 7,097 | 240,905 | 64,566 | 357,174 | 667,199 | 2 | 2 |
| 1911. | 15,548 | 206,299 | 79,050 | 347,296 | 523,926 | 3 | 4 |
| 1912. | 10,103 | 243,656 | 68,819 | 384,227 | 621,547 | 2 | 3 |
| 1913. | 9,604 | 278,368 | 60,706 | 423,896 | 721,325 | 3 | 3 |
| 1914. | 9,322 | 240,648 | 61,227 | 393,006 | 705,841 | 3 | 3 |
| 1915. | 9,799 | 245,484 | 69,572 | 389,791 | 686,399 | 3 | 4 |
| 1916. | 9,072 | 292,109 | 80,298 | 457,375 | 1,066,599 | 1 | 3 |
| 1917. | 7,090 | 257,588 | 68,155 | 375,803 | 1,568,655 | 3 | 3 |
| 1918. | 5,892 | 207,059 | 46,608 | 286,768 | 1,761,149 | 4 | 4 |
| 1919. | 1,597 | 250,687 | 58,754 | 339,125 | 2,390,367 | 3 | 3 |
| 1920. | 12,092 | 261,499 | 73,842 | 382,212 | 3,521,028 | 3 | 3 |
| 1921. | 26,558 | 240,648 | 110,677 | 408,224 | 3,312,096 | 2 | 2 |
| 1922. | 13,054 | 275,885 | 107,708 | 471,355 | 2,843,117 | 3 | 4 |
| 1923. | † | 341,746 | † | 586,987 | 3,252,993 | 3 | 4 |
| Totals. | | 6,564,430 | | 10,592,216 | \$38,647,624 | | |

†Included in total.

PRODUCTION OF GYPSUM IN MICHIGAN, 1913-1923.

| Year. | Crude gypsum mined. | | To Portland cement mills. | | As land plaster. | | For other purposes. | | Total sold crude. | |
|-------|---------------------|------|---------------------------|----------|------------------|----------|---------------------|---------|-------------------|----------|
| | Quantity. | Tons | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | | | | | | | | | | |
| 1913 | 423,896 | | + | | 9,604 | \$10,222 | 10,320 | \$9,011 | 60,706 | \$55,969 |
| 1914 | 393,006 | | + | | 9,322 | 10,761 | | | 61,227 | 51,242 |
| 1915 | 389,791 | | + | | 9,799 | 9,894 | | | 69,572 | 63,236 |
| 1916 | 457,375 | | + | | 9,072 | 16,658 | | | 80,298 | 90,973 |
| 1917 | 375,803 | | | \$92,874 | 7,090 | 22,903 | | | 68,155 | 116,653 |
| 1918 | 376,768 | | | 103,621 | 5,892 | 23,876 | | | 46,608 | 131,438 |
| 1919 | 339,125 | | | 198,911 | 1,897 | 10,422 | | | 58,754 | 174,110 |
| 1920 | 382,212 | | | 248,501 | 12,092 | 54,050 | | | 73,842 | 268,968 |
| 1921 | 408,224 | | | 248,593 | 26,553 | 98,139 | 9,447 | 25,453 | 110,677 | 369,185 |
| 1922 | 471,325 | | | 228,982 | 13,054 | 40,583 | 26,120 | 164,198 | 107,708 | 291,295 |
| 1923 | 586,987 | | | 324,582 | ++ | ++ | ++ | ++ | 135,616 | 355,067 |

Gypsum sold calcined.

| Year. | As mixed wall plaster. | | As stucco. | | As boards, tile, etc. | | Total sold calcined.† | | Total value. | No. mines and quarries. | No. mills. |
|-------|------------------------|-----------|------------|-----------|-----------------------|-----------|-----------------------|-----------|--------------|-------------------------|------------|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | | | |
| | | | | | | | | | | | |
| 1913 | 166,711 | \$437,720 | 95,402 | \$202,675 | 278,368 | \$665,356 | 278,368 | \$665,356 | 7 | x | |
| 1914 | 163,972 | 475,638 | 83,780 | 173,172 | 249,648 | 654,599 | 249,648 | 705,841 | 8 | x | |
| 1915 | 155,861 | 426,432 | 80,172 | 177,317 | 245,484 | 623,073 | 245,484 | 806,309 | 8 | x | |
| 1916 | 193,816 | 668,795 | 87,405 | 279,597 | 292,109 | 975,626 | 292,109 | 1,066,599 | 7 | x | |
| 1917 | 147,371 | 949,511 | 85,426 | 384,961 | 257,588 | 1,452,002 | 257,588 | 1,568,655 | 7 | x | |
| 1918 | 117,902 | 931,725 | 52,132 | 330,761 | 207,059 | 1,629,711 | 207,059 | 1,761,149 | 7 | x | |
| 1919 | 152,162 | 1,460,572 | 48,039 | 315,516 | 46,377 | 415,972 | 250,687 | 2,216,257 | 7 | x | |
| 1920 | 133,289 | 1,499,226 | 48,039 | 446,381 | 60,986 | 1,266,659 | 261,499 | 3,521,028 | 7 | x | |
| 1921 | 169,809 | 1,662,343 | 37,968 | 298,538 | 22,809 | 807,519 | 240,648 | 2,442,911 | 7 | x | |
| 1922 | 160,109 | 1,453,458 | 72,157 | 501,595 | 12,713 | 245,302 | 275,885 | 2,843,117 | 7 | x | |
| 1923 | ++ | ++ | ++ | ++ | ++ | ++ | 341,746 | 2,897,926 | 5 | x | |

†Included in the total are values for sanded plaster, plaster of Paris, Keene's cement, dental plaster, gypsum for plate glass works and for other purposes.
 ††Included in totals.

BRICK AND TILE PRODUCTS

The greatest part of the clay and shale that is produced in Michigan is manufactured at the place where it is found and reaches the market as a finished product such as brick or tile. A discussion of the different kinds of raw materials used in the manufacture of brick and tile will be found below under the headings Clay and Shale. The industry is an important one, but its importance is far less obvious than that of many industries which consume products of the earth because it is scattered in small units throughout the State, and, on account of the great variation in the raw materials used, is not well adapted to a central control either of manufacture or of marketing. The large number of abandoned brick plants which are seen in all parts of the State bear mute testimony of the hazards of the industry especially when it is undertaken without a careful investigation of the raw materials both as to quality and quantity or without sufficient capital to endure through a period of experimentation while the burning qualities of the material are being worked out.

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.

In 1923 the total value of brick and tile products showed a decrease of \$192,292. This decrease was due to a decrease in the amount and value of brick; other items show an increase in amount and value. The average price per thousand decreased from \$14.53 to \$14.36 or 17 cents. The value of drain tile which decreased sharply in 1922 increased again in 1923 by \$168,414, reaching a value of \$337,833. This figure approximates an average figure for drain tile since 1902 and shows that the marked decrease in 1922 was not caused by permanent factors.

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 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, flue lining and wall capping. In 1917 a plant was projected at Williamston, Ingham County, to utilize Coal Measure shales but it did not materialize.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1923.

| 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 | 114,717 | 2,350 | 406 | | 17 | 189 | 1,147,378 |
| 1901 | 215,836,000 | 1,095,254 | 5.07 | 98,472 | 1,880 | 637 | | 14 | 180 | 1,467,169 |
| 1902 | 237,254,000 | 1,331,752 | 5.61 | 96,642 | 3,280 | | | 13 | 182 | 1,660,042 |
| 1903 | 215,791,000 | 1,251,572 | 5.80 | 129,028 | | | \$19,138 | 13 | 178 | 1,662,414 |
| 1904 | 205,196,000 | 1,116,714 | 5.44 | 208,028 | | | 8,080 | 14 | 168 | 1,670,892 |
| 1905 | 211,558,000 | 1,152,502 | 5.45 | 205,463 | | | 3,585 | 14 | 154 | 1,719,746 |
| 1906 | 206,583,000 | 1,178,202 | 5.70 | 284,928 | | | 4,290 | 15 | 142 | 1,703,367 |
| 1907 | 200,817,000 | 1,181,015 | 5.89 | 327,680 | 4,100 | 1,500 | 6,386 | 17 | 136 | 1,786,190 |
| 1908 | 181,049,000 | 994,527 | 5.49 | 364,909 | | 40,100 | | 16 | 132 | 1,666,381 |
| 1909 | 219,820,000 | 1,250,787 | 5.69 | 374,909 | | 66,128 | | 16 | 122 | 1,947,059 |
| 1910 | 232,465,000 | 1,363,316 | 5.86 | 318,265 | | 228,530 | | 15 | 118 | 2,083,525 |
| 1911 | 232,820,000 | 1,301,998 | 5.16 | 312,072 | | 235,459 | | 15 | 111 | 1,953,442 |
| 1912 | 271,189,000 | 1,592,287 | 5.87 | 387,343 | 1,461 | 350,000 | | 13 | 101 | 2,350,606 |
| 1913 | 273,571,000 | 1,626,287 | 5.94 | 425,543 | 3,752 | 234,280 | | 13 | 95 | 2,451,242 |
| 1914 | 269,154,000 | 1,633,216 | 6.07 | 421,944 | 10,850 | 49,735 | | 10 | 90 | 2,434,872 |
| 1915 | 277,399,000 | 1,461,188 | 5.23 | 305,156 | 2,492 | 216,265 | | 11 | 82 | 2,248,068 |
| 1916 | 279,175,000 | 1,856,587 | 6.65 | 538,793 | | 79,996 | | 13 | 73 | 2,270,554 |
| 1917 | 236,612,000 | 1,882,632 | 7.93 | 734,942 | | 73,511 | 4,621 | 12 | 69 | 2,846,264 |
| 1918 | 94,746,000 | 915,590 | 9.63 | 795,398 | 89,147 | 132,844 | | 12 | 61 | 1,708,736 |
| 1919 | 200,352,000 | 2,734,503 | 13.63 | 737,324 | | 200,729 | 6,901 | | | 3,699,929 |
| 1920 | 186,826,000 | 3,062,660 | 16.42 | 690,510 | | 108,394 | 25,486 | | | 3,979,691 |
| 1921 | 193,730,000 | 2,417,809 | 12.47 | 381,507 | | 169,419 | 8,209 | | | 2,915,919 |
| 1922 | 248,608,890 | 3,613,542 | 14.53 | 169,419 | | 609,259 | 5,913 | | | 3,915,310 |
| 1923 | 193,350,663 | 2,773,923 | 14.36 | 337,833 | | 609,259 | | | 33 | 3,723,018 |
| Total | 5,484,369,553 | \$40,585,707 | | \$8,645,494 | | | | | | \$56,821,470 |

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

SHALE

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

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 being contemplated for constructing a plant near East Jordan to utilize the shale beds in that vicinity.

The shale beds at Grand Ledge, Flushing, Jackson, 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 Bedford formation, 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 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, Chestonia, and Boyne City, near Afton, 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. Another bed of shale occurs at the surface about one mile southwest. The burning qualities of the deposits at Ellsworth, Chestonia, and Boyne City 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

Pure clay is a fine grained material usually derived from weathering action on the crystalline rocks but often moved from its place of origin and deposited as a sediment. It is earthy when dry, plastic when wet, and is composed chiefly of hydrous aluminum silicates but with a large variety of other minerals present in small amounts. Its characteristic reaction to heat is to become rock-hard at a red heat, and with higher temperatures to undergo incipient fusion, vitrification, and finally fusion. The nature of clays is greatly affected by the agents of transportation which carry them to basins of deposition and in Michigan there is a great variety of clays because of the varied conditions of transportation and deposition which accompanied the advance and retreat of the ice of the glacial period. All of the clays of the State were so modified that they must be called glacial clays, although some were not deposited directly by the ice but were carried in glacial streams and deposited in the quiet basins of lakes or the flood plains of rivers. The greatest effect on the composition of the glacial clays was by the addition of finely powered sedimentary rocks of Paleozoic age which were ground up by the over-riding glacier ice and worked into the glacial sediments. This caused an addition of considerable material that is more or less soluble and in this State a high percentage of carbonates is especially noticeable. Much of the clay material is found in the terminal and ground moraines as a direct deposit of the ice, and as there has been no sorting of this material by water transportation and deposition there is a mixture of pebbles, boulders, sand, and clay, which is termed *boulder clay*. In places the boulders and pebbles are lacking and the clay was used extensively in pioneer days for brick making. The high content of carbonates, however, results in a brick of very light color and usually with a grayish cast which is not desirable for building brick. The brick has a low crushing strength, so that the brick yards which were started in morainal clays have very largely succumbed to the competition resulting from modern transportation facilities. In some parts of the State these morainal clays can still be utilized to advantage, because of the high freight rates on the imported brick and the ever increasing value of lumber. Brick manufacture from morainal clays is expensive because of the constant care which must be taken to eliminate pebbles, sand, and organic matter, the distribution of which is so irregular that it cannot be determined except by actual opening up of the deposit. These undesirable materials are liable to appear at any time in a face which started in an uncontaminated clay. Fortunately large amounts of the glacial clays were transported by water and deposited in the glacial lakes. These are called *lake clays*. In the process of transportation they lost some of the more soluble constituents such as the carbonates and were sorted when the water stream carrying them entered the quiet waters of the lake, the coarse particles having been quickly dropped near the shore as the current was retarded while the extremely fine particles of clay material were held in suspension for a considerable time and settled to the bottom, slowly forming broad sheets of clay uncontaminated by coarse

sand or pebbles, and without much included organic material. In the shifting of the drainage system which accompanied the changes of the ice front the lake clays were undoubtedly often reworked, and it is reasonable to suppose that with each working over of the material by running water more of the carbonates would be removed by solution. At any rate these lake clays in some places are found to be very low in carbonates and are a commercial clay of a good grade for brick, tile, and coarse pottery manufacture. These clays are usually thin but in places they occur in beds over fifty feet in thickness and sometimes their thickness even exceeds a hundred feet. It has been found that in general the upper layers are more free from carbonates than the lower layers. This is a result not only of the reworking of these clays as noted above, but of a leaching of the uppermost beds which is made possible by openings in the clay caused by the penetration of the clay by plant roots, frost cracks, and similar wedging agencies. The proof of a solution of the carbonates can often be found in a layer containing carbonates in the form of concretions three feet or less from the surface. This layer often marks the lower limit of commercial clay, but in the case of reworked clays, beds of commercial grade may be found at lower levels.

These lake clays are found over broad areas bordering the Great Lakes, their distribution indicating the approximate area of some of the ancient glacial lakes which flooded the land surface during intervals when the outlets were clogged by ice or by glacial debris. The largest areas are in the western part of the Upper Peninsula in the vicinity of Keweenaw Point, in the eastern part in the vicinity of Sault Ste. Marie; in the Lower Peninsula east of Mackinaw City, in the country bordering Saginaw Bay, and in the lowlands along the lake and river shores from the tip of the Thumb District south to the State line. They are not extensively exposed anywhere on the shore of Lake Michigan.

As far as known there are no deposits of kaolin or china clay within the State and discoveries of this kind of clay are not expected because of the disturbance and reworking of residual deposits by the glacial ice. There is a very light colored slip clay that is found in the western part of the glacial lake basins bordering the Lake Superior Basin and is sometimes mistaken for kaolin. This clay, which is mined at Ontonagon, has a low fusion point and is shipped to Ohio and other states for glazing purposes. With the exception of this clay at Ontonagon the clays of Michigan are mined at or near the plants which utilize them so they are not extensively stocked or shipped. The shales of the Saginaw Formation which can be used for brick and tile manufacture when they are free from overburden are discussed under the topic *shales*. The production of clay given in the following table includes only the clay which was marketed in the raw state. When the clay is worked and burned by the same company the production is given as that of the finished product in tables of production for brick and tile and pottery.

PRODUCTION OF CLAY IN MICHIGAN, 1910-1923.

| Year. | Slip clay. | | Brick clay. | | Miscellaneous clay. | | Total. | |
|------------|------------|---------|-------------|--------|---------------------|--------|-----------|----------|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| | Tons | | Tons | | Tons | | Tons | |
| 1910..... | 1,363 | \$3,889 | 60 | \$105 | 1 | \$400 | 1,424 | \$4,394 |
| 1911..... | 1,744 | 5,090 | 18 | 32 | 2 | 150 | 1,764 | 5,272 |
| 1912..... | 2,034 | 6,164 | | | 9 | 9 | 2,043 | 6,173 |
| 1913..... | 1,710 | 6,504 | | | | | 1,710 | 6,504 |
| 1914..... | 1,463 | 4,572 | | | | | 1,463 | 4,572 |
| 1915..... | 1,198 | 3,805 | † | † | † | † | 3,142 | 5,605 |
| 1916..... | | 10,509 | | | | | 3,454 | 193 |
| 1917..... | 2,153 | 8,824 | † | † | | | 5,746 | 13,627 |
| 1918..... | 1,236 | 4,639 | † | † | † | † | 2,359 | 6,373 |
| 1919..... | 568 | 2,123 | | | | | 568 | 2,123 |
| 1920..... | 505 | 2,249 | | | 4,561 | 9,046 | 5,066 | 11,295 |
| 1921..... | 484 | 2,047 | | | 208 | 308 | 692 | 2,355 |
| 1922..... | † | † | † | † | | | 1,653 | 4,852 |
| 1923..... | † | † | | | † | † | 3,617 | 11,903 |
| Total..... | | | | | | | | \$96,242 |

†Included in total.

POTTERY

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

In 1923 the total value of pottery increased by over 110 per cent in spite of the fact that two firms reported no returns, saying that the amount of business done by them was negligible.

Clays used for the manufacture of flower pots are obtained in Michigan. Two firms reported business for 1923. Other articles are manufactured from clays imported from other states and include such varied products as spark plugs, sanitary ware, white ware, saggars, and filter stones. A very little decorative pottery is also made.

VALUE OF POTTERY PRODUCTS IN MICHIGAN, 1899-1923.

| Year. | Rank of State | No. firms. | Red earthen-ware value. | Miscellaneous value.†† | Total value. | Gain per cent. | Per cent of total product in U. S. |
|-------|---------------|------------|-------------------------|------------------------|--------------|----------------|------------------------------------|
| 1899 | 18 | 4 | \$29,641 | ..... | \$29,741 | ..... | 17 |
| 1900 | 17 | 4 | 34,317 | ..... | 34,317 | 15.4 | 17 |
| 1901 | 16 | 5 | 42,465 | ..... | 44,865 | 30.2 | 20 |
| 1902 | 14 | 4 | 44,098 | \$2,400 | 83,098 | 87.4 | 41 |
| 1903 | 19 | 4 | 42,007 | 6,000 | 48,007 | -42.2 | 19 |
| 1904 | 17 | 4 | 40,621 | 3,000 | 43,621 | -9.1 | 17 |
| 1905 | 17 | 5 | 43,510 | 7,000 | 45,961 | 4.5 | 16 |
| 1906 | 17 | 6 | 54,474 | 7,600 | 61,110 | 11.2 | 16 |
| 1907 | 16 | 6 | 54,474 | 7,100 | 61,574 | 18.5 | 20 |
| 1908 | 16 | 6 | 60,939 | 7,750 | 62,409 | 1.5 | 25 |
| 1909 | 18 | 5 | 60,939 | 34,500 | 95,439 | 52.9 | 31 |
| 1910 | 18 | 6 | 94,450 | 13,300 | 112,697 | 18.1 | 33 |
| 1911 | 18 | 6 | 80,580 | ..... | 130,490 | 15.8 | 38 |
| 1912 | 10 | 6 | 99,555 | ..... | 194,892 | 49.3 | 53 |
| 1913 | 10 | 5 | 65,000 | ..... | 222,133 | 20.8 | 59 |
| 1914 | 9 | 9 | 106,452 | ..... | 265,194 | 33.0 | 75 |
| 1915 | 9 | 5 | 112,863 | ..... | 521,989 | 96.7 | 140 |
| 1916 | 8 | 6 | 133,734 | ..... | 792,716 | 51.8 | 164 |
| 1917 | 8 | 7 | ..... | 668,982 | 1,187,981 | 49.9 | 1.64 |
| 1918 | 8 | 8 | ..... | 13,722 | 1,976,436 | 66.3 | 2.12 |
| 1919 | 6 | 8 | ..... | 88,842 | 2,096,874 | 6.1 | 3.00 |
| 1920 | ..... | ..... | ..... | 12,708 | 2,096,874 | ..... | ..... |
| 1921 | ..... | ..... | 138,055 | 16,848 | 2,592,625 | 23.5 | ..... |
| 1922 | ..... | ..... | 38,000 | 1,643,868 | 1,781,923 | -35.1 | ..... |
| 1923 | ..... | 9 | ..... | 1,299,000 | 1,337,000 | -33.3 | ..... |
|  |  |  | ..... | ..... | 1,810,619 | 110.2 | ..... |
| Total |  |  | ..... | ..... | \$16,623,711 | ..... | ..... |

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

COAL

The maximum output of coal, 2,035,858 tons, was reached in 1907. Following 1907 a rapid decline set in and continued until 1912, when production was only 1,201,230 tons. Production remained practically stationary until 1917, when it increased to 1,374,805 tons. The gain was due not only to the great demand but to better car service. The shortage of freight cars as well as of labor in 1916 was an important factor in keeping down production. The car situation in 1918 was improved but labor shortage was an important factor in limiting production.

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

The coal strike of 1919 closed most of the mines and those not affected by the strike order did not operate full time. Partial settlement of the strike caused the mines to be reopened early in July of 1919 and they operated full time until November 1, when all the mines went on strike. During 1919 two new shafts were opened, one two miles east of Corunna in Shiawassee County, and the other three miles west of Jackson, Jackson County; two mines suspended operations, and three were abandoned. Production in 1919 decreased to 996,545 tons valued at \$3,864,228; and in 1920 production increased by 49.5 per cent to 1,489,765 tons valued at \$7,346,000, the highest value attained by Michigan's annual coal output. In 1921 production again declined, 1,141,715 tons being mined, and having a value at \$5,555,000. This was followed in 1922 by a further sharp decline to 929,390 tons mined, valued at \$4,693,376. The price received per ton partly offset the decline from 1921 to 1922. The average price per ton in 1921 was \$4.87 but increased in 1922 to \$5.05. The mining cost decreased from an average of \$4.43 in 1921 to an average of \$3.85 in 1922. The average profit derived from these figures is \$1.20 per ton in 1922 which is the highest reported profit from Michigan coal mines. The cost figures, however, do not include depreciation, interest on investment, etc., hence the profit factor is considerably less than indicated. The year 1923 saw an increase to 1,172,075 tons of coal produced, valued at \$5,545,000 or at an average price of \$4.23 per ton.

†PRODUCTION AND VALUE OF COAL IN MICHIGAN, 1900-1923.

| Year. | Number active mines. | Total tons of coal mined. Excluding that used for steam and heat. | Total tons of coal mined. | Total value of coal mined. | Average price received per ton. |
|-----------|----------------------|---|---------------------------|----------------------------|---------------------------------|
| 1900..... | 31 | 871,388 | 849,475 | \$1,259,683 | \$1.483 |
| 1901..... | 30 | 1,016,496 | 1,241,241 | 1,753,064 | 1.412 |
| 1902..... | 32 | 899,967 | 964,718 | 1,653,192 | 1.714 |
| 1903..... | 34 | 1,601,984 | 1,367,619 | 2,707,527 | 1.979 |
| 1904..... | 33 | 1,408,375 | 1,342,840 | 2,424,935 | 1.806 |
| 1905..... | 38 | 1,413,307 | 1,473,211 | 2,512,697 | 1.705 |
| 1906..... | 38 | 1,367,385 | 1,346,338 | 2,427,404 | 1.803 |
| 1907..... | 37 | 1,911,201 | 2,035,858 | 3,660,833 | 1.798 |
| 1908..... | 38 | 1,842,778 | 1,835,019 | 3,322,904 | 1.811 |
| 1909..... | 36 | 1,736,573 | 1,784,692 | 3,199,351 | 1.793 |
| 1910..... | 34 | 1,462,276 | 1,534,967 | 2,930,771 | 1.909 |
| 1911..... | 32 | 1,389,585 | 1,476,074 | 2,791,461 | 1.891 |
| 1912..... | 26 | 1,160,768 | 1,201,230 | 2,399,451 | 1.989 |
| 1913..... | 24 | 1,138,163 | 1,231,786 | 2,455,227 | 1.993 |
| 1914..... | 23 | 1,153,869 | 1,283,030 | 2,559,786 | 1.99 |
| 1915..... | 20 | 1,069,798 | 1,156,138 | 2,372,797 | 2.05 |
| 1916..... | 18 | 1,076,215 | 1,180,360 | 2,653,182 | 2.25 |
| 1917..... | 22 | 1,393,180 | 1,374,805 | 4,426,314 | 3.22 |
| 1918..... | 25 | 1,520,883 | 1,468,818 | 5,615,097 | 3.83 |
| 1919..... | 22 | 971,603 | 996,545 | 3,864,228 | 3.87 |
| 1920..... | 18 | 1,373,616 | 1,489,765 | 7,346,000 | 4.93 |
| 1921..... | 15 | 1,125,156 | 1,141,715 | 5,555,000 | 4.87 |
| 1922..... | 14 | 822,441 | 929,390 | 4,693,376 | 5.05 |
| 1923..... | 15 | 1,086,198 | 1,172,075 | 5,545,000 | 4.73 |

†From Mineral Resources. U. S. Geological Survey.

| Year. | Quantity. Tons. |
|-------|--------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|--------------------|
| 1860 | 2,320 | 1873 | 56,000 | 1886 | 60,434 | 1899 | 624,708 | 1912 | 1,164,973 |
| 1861 | 3,000 | 1874 | 58,000 | 1887 | 71,461 | 1900 | 849,475 | 1913 | 1,138,639 |
| 1862 | 5,000 | 1875 | 62,500 | 1888 | 81,407 | 1901 | 1,241,241 | 1914 | 1,288,030 |
| 1863 | 8,000 | 1876 | 66,000 | 1889 | 67,431 | 1902 | 964,718 | 1915 | 1,156,138 |
| 1864 | 12,000 | 1877 | 69,197 | 1890 | 74,977 | 1903 | 1,367,619 | 1916 | 1,180,360 |
| 1865 | 15,000 | 1878 | 85,322 | 1891 | 80,307 | 1904 | 1,342,840 | 1917 | 1,374,805 |
| 1866 | 20,000 | 1879 | 82,015 | 1892 | 77,990 | 1905 | 1,473,211 | 1918 | 1,464,818 |
| 1867 | 25,000 | 1880 | 100,800 | 1893 | 45,979 | 1906 | 1,346,338 | 1919 | 996,545 |
| 1868 | 28,000 | 1881 | 112,000 | 1894 | 70,022 | 1907 | 2,035,019 | 1920 | 1,489,765 |
| 1869 | 29,980 | 1882 | 135,339 | 1895 | 112,322 | 1908 | 1,835,019 | 1921 | 1,141,715 |
| 1870 | 28,150 | 1883 | 71,296 | 1896 | 92,882 | 1909 | 1,784,692 | 1922 | 929,390 |
| 1871 | 32,000 | 1884 | 36,712 | 1897 | 223,592 | 1910 | 1,534,967 | 1923 | 1,172,075 |
| 1872 | 33,600 | 1885 | 45,178 | 1898 | 315,722 | 1911 | 1,476,074 | | |

LIMESTONE†

HISTORY

The development of the limestone industry in Michigan began almost with its first settlers, the French. The strategic military points around the Straits of Mackinac and the mouth of St. Marys River were in the vicinity of extensive exposures of limestone rocks. The trails from Toledo to Detroit passed directly across the limestone exposures in Monroe County.

Quarrying limestone and burning lime for the construction of fortifications and buildings were logical industries in these localities. The slow settlement and development of the State, the limited markets, and poor interior transportation facilities tended, however, to retard the early development of the limestone industry except in a few favored localities. By 1850 burning lime and quarrying of building stone were flourishing industries in Monroe County. The chief centers were in the vicinities of Monroe and Dundee, especially along Plum Creek and near the mouth of Macon River. Detroit was the principal market but Monroe lime, which enjoyed a reputation for good quality, was shipped to many other parts of the State. Other small centers of lime burning were in the vicinity of Bellevue, Eaton County; and Jackson, Jackson County. The great distance of the deposits in the northern part of the State from markets prevented their early development, but here and there quarries were operated for burning lime or producing building stone chiefly for local needs. Later with the settlement of the State and with improvement in lake and railroad transportation facilities lime burning became a thriving industry around Thunder and Little Traverse bays, where there are extensive deposits of limestone. Large quarries were opened on Drummond Island to furnish block stone for use in building the first locks of the present group at Sault Ste. Marie.

Wood was used in burning lime. With the exhaustion of cheap wood fuel and competition from lime from northern Ohio, the lime burning industry in Monroe County gradually died out. The industry in the other centers also died out with the gradual exhaustion of cheap wood fuel supplies. At the present time there are no commercial lime kilns south of the Little Traverse Bay region. The lime burning industry is now confined to the northern portions of the State where there are still supplies of wood fuel, chiefly wastes from timber industries. The industry, however, has declined even in this part of the State, chiefly because of the growing scarcity of cheap wood fuel and competition from Portland cement and from gypsum building materials.

The production of limestone block for building purposes never became an important industry. This was due chiefly to the variable character and quality of the limestone beds, which made it difficult to produce a uniform product without excessive quarry waste.

The real growth of the limestone industry in Michigan followed the rapid growth of the cement industry, which occurred between 1899 and 1903. The growth of the limestone industry lagged behind that of the cement industry in Michigan because in the early days marl was used rather than limestone in the manufacture of cement. Gradually limestone was substituted for marl until only a few cement plants in Michigan now use marl. A large amount of limestone is used in the manufacture of cement, and in

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

concrete aggregates. The industry received another impetus from the discovery near cheap water transportation of large deposits of pure limestone especially adapted for blast furnace flux and other purposes requiring a pure limestone. A third impetus came from the initiation of a state-wide program of road building requiring large quantities of both cement and crushed stone. A steady growth in the chemical industries using large quantities of limestone products has also helped to increase the growth of the limestone industry.

In 1901 Michigan was twelfth among the states in value of its limestone output, but by 1910 it had climbed to ninth place, and in 1920 to fourth place. It fell back, however, to seventh place in 1923, not because of a decline in production but because of higher average prices obtained in rival states. In quantity it was second in 1920 and a close third in 1923.

CHARACTER AND OCCURRENCE

Most of the commercially important limestone deposits of Michigan occur in two belts, one extending around the northern part of the Southern Peninsula from Little Traverse Bay eastward to Thunder Bay, and the other in the Northern Peninsula extending from Menominee eastward along the north shores of Lake Michigan and Lake Huron into Ontario. A large amount of siliceous and slaty magnesian limestone, partially marbled, occurs in the iron bearing districts of the western part of the Northern Peninsula, but these limestones appear to be of limited economic importance. South of the Little Traverse and Thunder Bay belt, deposits of limestone are relatively few and scattered, and only three or four are of any considerable commercial importance.

In Charlevoix, Emmet, Cheboygan, Presque Isle, and Alpena Counties of the Southern Peninsula, and in Menominee, Delta, Schoolcraft, Luce, Mackinac, and Chippewa Counties of the Northern Peninsula there are many exposures of pure limestone, and hundreds of exposures of pure dolomite, of commercial quality. The few commercially important deposits of limestone south of the Little Traverse-Thunder Bay belt are in Arenac, Huron, Wayne, Monroe, and Eaton Counties. There are several exposures of limestone in the vicinity of Jackson, but the deposits appear to be patchy and very thin and of little commercial importance.

The limestones in the Northern Peninsula are largely dolomite or high magnesian limestone, but there is one series of beds which is chiefly pure limestone. The exposures of magnesian limestones of the Northern Peninsula occupy a belt generally 10 to 15 miles wide along the northern shores of Lake Michigan and Lake Huron, from Green Bay to Marblehead, Drummond Island. The exposures of pure limestone are unfortunately inland, forming a narrow belt immediately north of the belt of high magnesian limestone deposits. The inland position of the deposits of pure limestone make them of much less economic importance than they would be were they near lake transportation.

The limestones of the Little Traverse-Thunder Bay belt are generally low in magnesia, though here and there high magnesian beds occur. Shales and shaly and siliceous limestones are associated with the pure limestones, especially at certain horizons. Many of the larger deposits of limestone are near lake transportation. The pure limestones are suitable for most purposes requiring high calcium limestone and most of the siliceous and argillaceous limestones are adapted for use in the manufacture of Portland cement.

The predominance and extent of low magnesian limestones, and the proximity of many of the deposits to lake transportation give great economic importance to this belt. These two factors account for the great development of the limestone industry in this part of the State and undoubtedly will continue to make this the principal limestone producing district in Michigan for an indefinitely long period.

DEVELOPMENT AND USE

The chief developments in the Southern Peninsula are near Rogers, Presque Isle County; Alpena and Rockport, Alpena County; Petoskey, Emmet County; Afton, Cheboygan County; Bayport, Huron County; and Sibley, Wayne County; in the Northern Peninsula, near Trout Lake and Ozark, Mackinac County; Blancy and Manistique, Schoolcraft County; and Escanaba, Delta County. Important quarry operations were formerly carried on at Charlevoix, Charlevoix County. Recently a large quarry at Hendricks, Mackinac County, was closed indefinitely.

Most of the important deposits near water have been developed or acquired by present operating companies or by limestone using concerns. Important undeveloped deposits near water transportation occur near Norwood and Charlevoix, Charlevoix County; Mackinaw City, Cheboygan County; and at El Cajon Beach about seven miles northeast of Alpena, Alpena County; on Adams Point and near Twin Lakes and Rogers, Presque Isle County.

The inland limestone deposits of the Little Traverse-Thunder Bay belt are very large and numerous, but the only important inland quarry is at Afton, Cheboygan County. Very extensive undeveloped deposits of pure limestone also occur in this vicinity and also at Rogers, Presque Isle County. The interior deposits of undeveloped limestone in Alpena and Presque Isle Counties are practically inexhaustible. South of the Little Traverse-Thunder Bay belt undeveloped deposits of pure limestone occur near Omer, Arenac County; on Heisterman's Island, Huron County; and near Dundee, Monroe County.

Practically inexhaustible deposits of very pure high magnesian limestone or dolomite occur near the lake shore between Seul Choix Point, Schoolcraft County, and Drummond Island, Chippewa County. These dolomites, because of their purity and porosity, are especially adapted for paper manufacture by the sulphite process. They are also suitable for lining furnaces. The only development of this stone is at Ozark, Mackinac County. The limestone in Monroe County is largely impure dolomite, suitable chiefly for concrete, road material, and ballast.

The limestone in the vicinity of Rogers and Twin Lakes, Presque Isle County, averages very high in calcium, low in magnesia, and exceptionally low in silica and alumina. This makes it especially adapted for flux in smelting iron and other ores, for which it is extensively used. The limestone produced elsewhere is generally considerably higher in silica; therefore is not so well adapted for fluxing purposes. More than half of the total production of limestone in the State is sold for flux. A large part of the remainder of the output is used in the alkali industries, the manufacture of Portland cement, calcium carbide, the clarification of sugar, etc. Siliceous and shaly limestones and "fines" or screenings are used extensively in the manufacture of Portland cement. A large tonnage of the harder varieties of limestone are utilized for road building and concrete construction especially in localities deficient in good sand and gravel.

| Year. | To paper mills. | | Fertilizer. | | Other purposes. † | | Number of plants. | Rank of state. | Total. | |
|-------|-----------------|-----------|-------------|-------------|-------------------|--------|-------------------|----------------|--------|--------------|
| | Tons. | Value. | Tons. | Value. | Tons. | Value. | | | Tons. | Value. |
| 1899 | | | | | | | | | | \$281,769 |
| 1900 | | | | | | | | | | 330,847 |
| 1901 | | | | | | | | | | 429,771 |
| 1902 | | | | | | | | 12 | | 413,148 |
| 1903 | | | | | | | | 13 | | 390,473 |
| 1904 | | | | | | | | 14 | | 501,708 |
| 1905 | | | | | | | | 10 | | 544,754 |
| 1906 | | | | | | | | 12 | | 656,269 |
| 1907 | | | | | | | | 10 | | 760,333 |
| 1908 | | | | | | | | 11 | | 669,017 |
| 1909 | | | | | | | | 9 | | 750,589 |
| 1910 | | | | | | | | 11 | | 842,126 |
| 1911 | | \$12,558 | | \$2,003 | | | | 9 | | 1,005,751 |
| 1912 | | 8,150 | | 7,447 | | | | 8 | | 1,130,560 |
| 1913 | | 10,723 | | 7,048 | | | | 8 | | 1,457,961 |
| 1914 | | 8,307 | | 11,088 | | | | 7 | | 1,828,766 |
| 1915 | | 11,827 | | 9,744 | | | | 8 | | 2,389,763 |
| 1916 | | 8,620 | | 11,088 | | | | 7 | | 3,320,895 |
| 1917 | | 24,097 | | 58,148 | | | | 5 | | 5,186,867 |
| 1918 | | 25,153 | | 150,604 | | | | 5 | | 3,707,522 |
| 1919 | | 45,706 | | 160,016 | | | | 6 | | 4,533,998 |
| 1920 | | 81,718 | | 170,460 | | | | 5 | | 5,848,649 |
| 1921 | | 77,850 | | 285,960 | | | | 5 | | |
| 1922 | | 79,438 | | 218,360 | | | | 6 | | |
| 1923 | | 147,909 | | 164,790 | | | | 6 | | |
| | | 50,520 | | 191,146 | | | | 18 | | |
| | | 110,300 | | 201,251 | | | | 24 | | |
| | | | | 235,895 | | | | 24 | | |
| | | | | 108,554 | | | | 7,646,550 | | |
| | | | | | | | | 10,589,070 | | |
| Total | | \$542,056 | | \$1,205,686 | | | | | | \$47,820,191 |
| | | | | | | | | | | \$4,979,187 |

†Included in total.

‡Includes rubble and limestone for glass, and sugar factories and, when not given separately, railroad ballast, marl, and agricultural limestone.

LIME

From 1904 to 1914 the lime industry made little or no growth, the production in those years being respectively 63,601 tons and 66,507 tons. In 1915 the production increased to 81,359 tons but this was 1,749 tons less than the maximum reached in 1909. In 1916 there was only a slight increase, the production being 86,447 tons. But the 1917 production increased 57.2 per cent over 1916, reaching 135,920 tons and the value increased 132 per cent to \$892,682. This increase in production and value caused Michigan to advance from thirteenth place to seventh in rank in state production. In the production of chemical lime Michigan ranked third in quantity and second in value and produced over 14 per cent of the chemical lime used in the country at 16 per cent of the value. Michigan held sixth place in the amount of lime consumed.

In 1918 production decreased slightly, 0.8 per cent, but increased in value. Production in 1919 increased 8.1 per cent in quantity and 16.5 per cent in value, but decreased somewhat in quantity and increased in value in 1920, reaching the maximum value of \$1,386,760 in the latter year.

The business depression of 1921 plus high cost of coal and high freight rates which closed markets for lime, caused Michigan to suffer more than any other State from the general decrease in lime production. The average decrease for the United States was 29.1 per cent, ranging from a decrease of 9.4 per cent in Massachusetts to 65.8 per cent in Michigan. Michigan's production was 48,164 tons valued at \$445,386, decreases of 92,649 tons (65.8 per cent) in quantity and of \$941,374 or 67.8 per cent in value. The production was the lowest since 1905 and Michigan dropped in rank from eighth to fifteenth place. Lime burned was sold for building, chemical, tanning, metallurgical, and fertilizer purposes, and to paper mills, sugar factories, and dealers. The greatest decreases were in the sale of lime for chemical and metallurgical purposes and to paper mills. In 1920 of the 28 kilns operating eighteen burned wood, one coal, and nine coke, but in 1921 wood was burned in the twenty-three kilns operating. Conditions were not much improved in 1922. A production of 53,635 tons valued at \$484,945 was reported, an average price of \$9.04. This was an increase over 1921 of 11.3 per cent in quantity and 11.2 per cent in value. In 1923, 59,629 tons were produced, valued at \$612,369, an average price of \$10.27 per ton.

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

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

The growth in 1915 and 1916 may be ascribed, though indirectly, to the war in Europe. The great increase in 1917 was due to the entrance of this

country in the conflict early in 1917. A large amount of lime is used in the manufacture of many chemical materials used in the war. Very little of the lime produced in Michigan is used for building purposes, hence the lime industry in 1918 did not suffer the general depression due to the restriction of building trades, and the small decrease in production may be ascribed to the shortage of labor and fuel and to the difficulties of transportation.

In 1919 the increase in production was for all uses of lime but particularly for building purposes. The slight decrease of 1920 was due to inability to supply the demand owing to shortage of labor and is shown in the production of lime for chemical works, for tanneries, and for metallurgy; and as stated above, the great decrease for 1921 was due to the closing of markets for the lime industry, and the general depression throughout the United States. The continuance of this condition permitted but little increase in production and value of lime in 1922 or 1923.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1923

| Year. | Total lime | | Average price per ton. | No. of plants operating. | Rank of State production. |
|-------|-----------------|-----------|------------------------|--------------------------|---------------------------|
| | Quantity. Tons. | Value. | | | |
| 1904 | 63,601 | \$256,955 | \$4.04 | | |
| 1905 | 48,089 | 192,844 | 4.01 | | |
| 1906 | 68,133 | 281,465 | 4.13 | 13 | |
| 1907 | 65,822 | 276,534 | 4.20 | 12 | 16 |
| 1908 | 68,050 | 282,023 | 4.14 | 10 | 15 |
| 1909 | 83,108 | 354,135 | 4.26 | 12 | 13 |
| 1910 | 72,345 | 303,377 | 4.19 | 10 | 14 |
| 1911 | 80,709 | 352,608 | 4.37 | 14 | 14 |
| 1912 | 74,720 | 311,448 | 4.17 | 11 | 16 |
| 1913 | 77,088 | 331,852 | 4.05 | 10 | 14 |
| 1914 | 66,507 | 287,648 | 4.33 | 10 | 14 |
| 1915 | 81,359 | 349,979 | 4.29 | 10 | 15 |
| 1916 | 86,447 | 385,341 | 4.45 | 7 | 13 |
| 1917 | 135,920 | 892,682 | 6.72 | 7 | 7 |
| 1918 | 134,813 | 1,186,007 | 8.79 | 6 | 6 |
| 1919 | 145,783 | 1,381,534 | 9.48 | 7 | 6 |
| 1920 | 140,813 | 1,386,760 | 9.85 | 7 | 8 |
| 1921 | 48,164 | 445,386 | 9.24 | 6 | 15 |
| 1922 | 53,635 | 484,945 | 9.04 | 7 | 16 |
| 1923 | 59,629 | 612,369 | 10.27 | 7 | 18 |

SAND LIME BRICK

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

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

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

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

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

Since statistics for sand-lime brick were collected by the Bureau of the Census there has been considerable delay in securing production figures and

details of the industry. In 1921 a production of 33,658,000 bricks of all classes valued at \$403,929 is reported. The production value shows a decrease of \$236,815 or 36.9 per cent when compared with the 1920 reports. In 1922 a production of 46,558,000 at \$557,647 shows a gain of 38 per cent in value over the 1921 figure. In 1923, 64,650,000 valued at \$777,693 show a gain of 39 per cent.

The production of front and fancy brick has fluctuated greatly. The production of front brick increased from 580,000 in 1904 to about 2,000,000 in 1907, then decreased in 1908 to about 900,000. The maximum production of front brick did not exceed 1,000,000 annually, falling off in 1916 to 888,000. Evidently front and fancy sand-lime brick as manufactured were not as satisfactory for outside work or could not be produced as cheaply as clay front brick. In 1917, however, the production of front brick increased to 1,019,000 valued at \$8,477. Either new methods of molding, producing a more shapely brick, or better methods of manufacture, producing a less easily crumbled brick, accounted for the increased demand, but the output quickly declined and at present no bricks other than common bricks are made by the sand-lime process.

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

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1923

| Year | No. of operating firms—Mich. | | No. of operating firms—U. S. | | Common brick. | | Front brick. | | Fancy brick. | | Total value Michigan. | Change per cent Michigan. | Total value United States. | Per cent of total production U. S. | Rank. | |
|-------|------------------------------|---------|------------------------------|-------------------|---------------|-----------------------------|-------------------|--------|-------------------|--------|-----------------------|---------------------------|----------------------------|------------------------------------|-------------|--------|
| | Quantity (thous.) | Value. | Average price per thousand. | Quantity (thous.) | Value. | Average price per thousand. | Quantity (thous.) | Value. | Quantity (thous.) | Value. | | | | | Production. | Value. |
| 1904 | 10 | 9,886 | \$6.04 | 580 | \$5,234 | \$9.02 | 19 | \$497 | \$69,765 | 142.7 | \$463,128 | 15.6 | 1 | 1 | | |
| 1905 | 12 | 24,841 | 6.28 | 1,577 | 12,898 | 8.17 | 24 | 526 | 169,302 | 3.3 | 972,064 | 17.4 | 1 | 1 | | |
| 1906 | 11 | 27,281 | 5.97 | 1,736 | 12,022 | 6.69 | 7 | 20 | 174,921 | 3.3 | 1,170,005 | 15.0 | 1 | 1 | | |
| 1907 | 13 | 25,488 | 6.22 | 2,000 | 14,284 | 7.17 | .. | .. | 172,840 | -1.2 | 1,225,769 | 14.1 | 1 | 1 | | |
| 1908 | 10 | 21,997 | 5.99 | 1,900 | 6,982 | 7.76 | .. | .. | 138,809 | -19.7 | 1,029,699 | 13.5 | 1 | 1 | | |
| 1909 | 11 | 34,217 | 6.05 | 1,600 | 11,144 | 6.97 | .. | .. | 218,226 | 57.2 | 1,169,580 | 19.0 | 1 | 1 | | |
| 1910 | 10 | 37,648 | 5.81 | 3,256 | 22,022 | 6.76 | .. | .. | 240,649 | 10.3 | 1,169,580 | 20.5 | 1 | 1 | | |
| 1911 | 10 | 32,889 | 5.84 | 2,726 | 17,777 | 6.52 | .. | .. | 210,001 | -12.7 | 897,664 | 23.4 | 1 | 1 | | |
| 1912 | 11 | 48,129 | 6.38 | 1,163 | 9,926 | 8.27 | .. | .. | 316,732 | 50.8 | 1,200,228 | 26.4 | 1 | 1 | | |
| 1913 | 12 | 49,373 | 6.40 | .. | .. | .. | .. | .. | 321,245 | 1.7 | 1,238,325 | 25.9 | 1 | 1 | | |
| 1914 | 12 | 41,456 | 5.98 | .. | .. | .. | .. | .. | 255,784 | -24.4 | 1,038,512 | 23.5 | 1 | 1 | | |
| 1915 | 11 | 46,513 | 6.04 | .. | .. | .. | .. | .. | 286,948 | 11.8 | 1,135,104 | 25.3 | 1 | 1 | | |
| 1916 | 12 | 71,116 | 6.92 | 888 | 7,845 | 8.83 | .. | .. | 499,711 | 74.14 | 1,474,073 | 33.8 | 1 | 1 | | |
| 1917 | 11 | 46,979 | 7.71 | 1,019 | 8,477 | 8.31 | .. | .. | 370,723 | -25.8 | 1,420,830 | 26.1 | 1 | 1 | | |
| 1918 | 42 | 22,248 | 8.79 | .. | .. | 9.48 | .. | .. | 198,633 | -46.4 | 883,929 | 22.5 | 1 | 1 | | |
| 1919 | 8 | 42,063 | 12.05 | .. | .. | 18.36 | .. | .. | 513,044 | +8.67 | 1,705,163 | 28.6 | 1 | 1 | | |
| 1920 | 8 | 38,810 | 16.80 | .. | .. | .. | .. | .. | 640,744 | +26.0 | 2,490,283 | 23.1 | 1 | 1 | | |
| 1921 | 8 | *33,658 | 11.97 | .. | .. | .. | .. | .. | 408,929 | +36.9 | .. | .. | .. | .. | .. | |
| 1922 | 9 | *46,558 | 12.03 | .. | .. | .. | .. | .. | 557,647 | +38.0 | .. | .. | .. | .. | .. | |
| 1923 | 9 | 64,650 | .. | .. | .. | .. | .. | .. | 777,693 | +39.4 | .. | .. | .. | .. | .. | |
| Total | .. | 765,800 | .. | .. | \$5,967,482 | .. | .. | .. | \$6,557,396 | .. | .. | .. | .. | .. | .. | |

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

SAND AND GRAVEL

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

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

The composition of gravel varies greatly in different parts of the State. In the localities where the glacial drift is thin, the gravel generally contains a considerable or even a large percentage of pebbles derived from the underlying rocks. Where the drift is thick the gravel is composed chiefly of pebbles which have been carried considerable distances by ice and water, hence the pebbles are usually harder and more resistant rock material. In the limestone regions of Presque Isle and Alpena counties there is a broad belt of gravel ridges along the shore of Lake Huron. The gravel is composed chiefly of limestone pebbles largely derived from the underlying beds of limestone. Since many of the beds of limestone in these counties are relatively soft, much of the gravel is of inferior grade. The Marshall formation underlies much of Jackson, Calhoun, and Kalamazoo, and many of the deposits in these counties contain considerable amounts of soft friable sandstone derived from this formation. This tends to make some of the gravel unfit for road building and inferior for use in concrete aggregates. There are also large deposits of gravel in the belt of limestone along the north shore of Lake Michigan and Lake Huron. These deposits contain an abundance of limestone pebbles and, since the beds of limestone in this region are generally hard, it is presumable that the gravel is of better average quality than that in the areas of softer limestone in the northern part of the Southern Peninsula. However, few tests have been made to determine the better grades of gravel in these areas and belts.

Sand and gravel have been produced in greater quantities each year since 1918. In 1919 production was 3,772,535 tons valued at \$1,994,143, and in 1920, 4,386,522 tons valued at \$2,867,466 were produced. In 1921, reports total 5,515,253 tons valued at \$2,916,917 and this was followed by a further increase in 1922 to a total production of 5,962,916 tons valued at \$3,222,043, while in 1923 a much greater increase was indicated by the report of a total production of 9,601,562 tons valued at \$5,096,071. From the tables it will be seen that there was a marked increase in all of the important kinds of sand and gravel production.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1905-1923

| Year. | Molding sand. | | Building sand. | | Engine sand. | | Paving sand. | | Filter sand. | | Other sand. † | |
|------------|----------------|-----------|-----------------|-------------|---------------|----------|--------------|-------------|--------------|--------|---------------|-------------|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| 1905. | Tons 19,382 | \$13,247 | Tons 263,315 | \$148,065 | Tons 4,000 | \$400 | Tons | | Tons | | Tons | \$14,476 |
| 1906. | 61,387 | 26,108 | 403,199 | 127,937 | 1,384 | 138 | | | | | 50,187 | 12,140 |
| 1907. | 54,172 | 24,180 | 451,646 | 137,150 | 1,391 | 139 | | | | | 51,005 | 12,187 |
| 1908. | 4,584 | 2,892 | 474,238 | 228,395 | 1,391 | 319 | | | | | 173,724 | 6,850 |
| 1909. | 53,226 | 20,756 | 1,090,419 | 327,247 | 12,415 | 1,493 | | | | | 295,187 | 57,983 |
| 1910. | 93,812 | 24,004 | 834,346 | 354,346 | 22,270 | 2,172 | | | | | 372,880 | 57,385 |
| 1911. | 68,878 | 17,901 | 833,729 | 247,997 | 25,392 | 4,447 | \$29,650 | | | | 114,800 | 52,005 |
| 1912. | 152,433 | 40,145 | 902,556 | 294,115 | 18,575 | 4,774 | 182,144 | | | | 130,624 | 54,746 |
| 1913. | 53,400 | 17,493 | 1,326,016 | 415,737 | 4,447 | 647 | 533,361 | | | | 113,318 | 20,392 |
| 1914. | 82,666 | 36,583 | 1,088,650 | 360,152 | 6,357 | 1,066 | 108,328 | | | | 111,105 | 107,392 |
| 1915. | 117,200 | 25,998 | 843,887 | 256,956 | 70,077 | 2,794 | 131,466 | | | | 228,003 | 12,792 |
| 1916. | 147,256 | 31,978 | 1,234,280 | 350,138 | 4,096 | 1,103 | 38,068 | | | | 64,227 | 41,267 |
| 1917. | 116,485 | 52,686 | 782,305 | 433,546 | 5,174 | 3,322 | 139,514 | | | | 135,502 | 48,201 |
| 1918. | 124,006 | 55,255 | 433,497 | 174,888 | 6,958 | 2,268 | 237,517 | | | | 190,327 | 142,217 |
| 1919. | 239,439 | 66,877 | 539,800 | 251,733 | 5,547 | 2,943 | 204,045 | | | | 213,851 | 28,870 |
| 1920. | 342,439 | 179,754 | 789,495 | 482,081 | 3,508 | 1,201 | 460,438 | 6,163 | \$3,048 | | 137,505 | 28,552 |
| 1921. | 96,554 | 25,576 | 823,791 | 416,432 | † | † | 754,011 | | | | 131,887 | 35,434 |
| 1922. | 147,546 | 40,865 | 558,764 | 445,970 | 1,915 | 790 | 731,933 | | | | 272,514 | 164,160 |
| 1923. | 342,936 | 84,965 | 1,743,825 | 1,143,971 | | | 1,069,859 | | | | | |
| Totals.... | 2,028,124 | \$787,270 | 16,040,000 | \$6,577,373 | 194,265 | \$27,892 | 4,953,276 | \$1,935,235 | | | 2,891,550 | \$1,302,275 |

†Included under other sand.
‡Includes furnace, filter, polishing, and glass sand.

| Year. | Railroad ballast. | | Gravel. | | Total sand and Gravel. | | Rank. | |
|--------|-------------------|---------|------------|--------------|------------------------|--------------|-----------|--------|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| 1905 | Tons. | | Tons. | \$32,321 | Tons. | \$210,609 | Tons. | 11 |
| 1906 | | | 76,625 | 25,614 | 414,509 | 197,699 | 12 | |
| 1907 | | | 72,598 | 51,182 | 597,789 | 289,595 | 10 | |
| 1908 | | | 329,407 | 64,081 | 1,024,641 | 370,365 | 8 | |
| 1909 | | | 312,262 | 200,323 | 842,591 | 685,632 | 7 | |
| 1910 | | | 695,902 | 364,841 | 2,219,757 | 816,337 | 8 | |
| 1911 | | | 1,197,791 | 203,218 | 2,862,738 | 565,969 | 10 | |
| 1912 | | | 1,935,073 | 407,925 | 2,185,165 | 818,603 | 8 | |
| 1913 | | | 1,409,180 | 607,925 | 2,681,821 | 1,143,771 | 5 | |
| 1914 | | | 3,928,874 | 530,358 | 6,422,818 | 1,528,892 | 7 | |
| 1915 | | \$781 | 2,140,359 | 650,358 | 3,757,979 | 1,036,739 | 6 | |
| 1916 | 7,565 | | 2,457,094 | 771,970 | 3,776,726 | 1,295,717 | 7 | |
| 1917 | | | 2,226,873 | 726,033 | 4,407,475 | 1,641,748 | 8 | |
| 1918 | 207,827 | 21,829 | 2,292,374 | 1,011,182 | 3,814,445 | 1,239,874 | 9 | |
| 1919 | 161,552 | 18,314 | 2,741,681 | 809,316 | 2,837,371 | 1,944,143 | 7 | |
| 1920 | 67,916 | 21,861 | 2,630,483 | 1,378,929 | 3,772,585 | 2,867,466 | 6 | |
| 1921 | 233,816 | 61,672 | 2,444,006 | 1,058,414 | 4,386,582 | 2,916,917 | | |
| 1922 | 249,588 | 59,752 | 3,416,081 | 1,059,610 | 5,515,253 | 3,222,043 | | |
| 1923 | 484,112 | 208,311 | 3,507,567 | 1,392,232 | 5,962,916 | 5,096,071 | | |
| | 1,078,343 | 257,564 | 5,087,170 | 2,914,107 | 9,601,562 | | | |
| Totals | | | 35,911,204 | \$16,270,959 | 67,084,673 | \$27,228,289 | | |

GLASS SAND

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

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

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

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

Some years ago the Rockwood Silica Sand Company drilled a well just east of Rockwood (SE¼ SW¼ Sec. 10) to the depth of 122 feet penetrating 15 feet of clay, 15 feet of dolomite, and 92 feet of glass sand rock without reaching the bottom of it. A six inch casing was used to rock and below this a four inch casing through which steam under pressure of 60 pounds per square inch was injected, forcing out water and sand. About a car load of sand per day was obtained in this way.

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

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

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

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

ANALYSES OF GLASS SAND

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

The very low percentage of iron makes the sand especially adapted for glass making, particularly for glass of the higher grades, such as plate and optical glass. Large quantities are used in the manufacture of plate glass. Experiments by the United States Bureau of Standards show that the purest grade of the Sylvania sand of Michigan is suitable for making optical glass and now all the sand used by the Government for this purpose comes from this State. It was found that from the deposits near Rockwood it is possible under careful supervision to obtain carload lots of glass sand which average 0.015 per cent iron oxide, and some analyses running as low as 0.001 per cent in iron are reported. Glass sand for optical purposes is also obtained at Ottawa, Ill., and Hancock, Maryland, but analyses from the best of these deposits averaged 0.02 per cent iron oxide.

The washed sludge containing the fine grit is used for the ignition surfaces on match boxes.

†J. E. Clark, Analyst.

SANDSTONE

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

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

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

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

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

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

In 1919 four plants were operated and production reached a value of \$24,413. Uses of sandstone reported were: rough building stone, rubble, riprap, and road metal. In 1920 there were but two operators; hence pro-

duction values may not be given. In 1921 sandstone for rough building material and road metal was produced to the value of \$49,270.

In 1923 sandstone produced for building stone, rough blocks, rubble, and riprap totalled 19,030 tons valued at \$36,963.

GRINDSTONES AND SCYTHESTONES

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

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

Until after the war Michigan ranked third in the value of grindstones and scythestones produced, Ohio being first with a total value about six times larger than that of Michigan and West Virginia together, the nearest competitors. There were but two active quarries, both located in Huron County near the end of the "Thumb," but these ceased operations during the war. The Wallace Company of Port Austin formerly operated a quarry at Eagle Mills and the Cleveland Stone Company a quarry at Grindstone City. The latter resumed operations in 1923 but the former has permanently abandoned its quarry operations. The 1923 production was 1,253 tons valued at \$38,212.

MINERAL WATERS

From 1902 to 1906 there was a steady decline in the mineral water industry of Michigan, despite annual fluctuations in amount and value of mineral and spring water produced, but from 1906 to the present time there has been little change. The principal factors affecting the production are local conditions affecting municipal water supplies, and general business conditions. When a municipal water supply becomes unpalatable or unsafe the vending of mineral waters becomes profitable, only to decline, however, when a filtration plant is installed or a new source of water supply is developed in a town.

The general business depressions of 1906, 1907, and 1914 caused the greatest decrease in production in Michigan. During the past few years the increased demand for soft drinks has for a few firms occasioned a temporary increase in the sale of mineral waters used in the manufacture of "prohibition beers." The production of 8,653,680 gallons valued at \$275,763 in 1902 decreased to 884,893 gallons valued at \$52,642 in 1913. From 1913 to 1919 production and value steadily increased and reached a total of 1,570,906 gallons valued at \$132,312. There were ten commercial springs. In 1921 production and value of mineral waters increased from 1,227,485 gallons valued at \$122,010 to 1,344,900 gallons valued at \$154,405, an increase of 117,415 gallons or 9.5 per cent in quantity and of \$32,395 or 26.2 per cent in value. There were nine commercial springs in 1921. In 1922 with nine producing springs, Michigan again was ninth in the production of mineral waters although there was a decline from the 1921 production of 1,344,900 gallons at \$154,405 to 1,229,802 gallons at \$150,237, or a decrease of 8.5 per cent in quantity and of 2.7 per cent in value. In 1923 Michigan produced 1,478,135 gallons valued at \$164,968, an increase of 20% in quantity and 10% in value.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900-1923

| Year. | Rank. | | No. of springs active. | Total. | | Medicinal value. | Table value. | Average price per gal. |
|------------|-----------|--------|------------------------|----------------|-------------|------------------|--------------|------------------------|
| | Quantity. | Value. | | Quantity gals. | Value. | | | |
| 1900..... | 6 | 4 | 28 | 3,398,996 | \$411,935 | | | \$0.121 |
| 1901..... | 2 | 1 | 28 | 7,019,168 | 1,195,614 | | | 0.170 |
| 1902..... | 1 | 9 | 28 | 8,653,690 | 275,763 | | | 0.032 |
| 1903..... | 1 | 9 | 19 | 6,919,107 | 209,668 | | | 0.029 |
| 1904..... | 7 | 13 | 19 | 3,385,675 | 118,422 | | | 0.035 |
| 1905..... | 4 | 4 | 17 | 2,684,800 | 277,188 | \$38,900 | \$238,288 | 0.100 |
| 1906..... | 13 | 23 | 19 | 902,528 | 73,357 | | | 0.081 |
| 1907..... | 8 | 15 | 19 | 1,472,679 | 127,133 | | | 0.086 |
| 1908..... | 8 | 16 | 24 | 2,004,433 | 88,910 | 35,091 | 92,042 | 0.044 |
| 1909..... | 5 | 16 | 19 | 2,760,604 | 104,454 | 5,955 | 82,915 | 0.035 |
| 1910..... | 9 | 17 | 17 | 1,454,020 | 69,538 | 6,099 | 98,255 | 0.048 |
| 1911..... | 11 | 24 | 23 | 1,713,401 | 72,253 | 100 | 69,438 | 0.042 |
| 1912..... | 12 | 19 | 17 | 1,420,465 | 75,611 | 12,156 | 60,097 | 0.053 |
| 1913..... | 17 | 24 | 20 | 884,893 | 52,642 | 777 | 74,834 | 0.059 |
| 1914..... | 16 | 20 | 22 | 931,343 | 70,310 | 3,605 | 49,037 | 0.075 |
| 1915..... | 16 | 18 | 19 | 913,765 | 72,111 | 12,252 | 58,058 | 0.080 |
| 1916..... | 17 | 13 | 18 | 996,875 | 108,867 | 5,165 | 67,546 | 0.109 |
| 1917..... | 12 | 12 | 11 | 1,069,164 | 105,641 | | | 0.098 |
| 1918..... | 10 | 8 | 9 | 1,216,882 | 129,592 | 500 | 105,641 | 0.103 |
| 1919..... | 7 | 9 | 10 | 1,570,906 | 132,312 | 1 | 128,809 | 0.080 |
| 1920..... | 11 | 9 | 9 | 1,227,485 | 122,010 | 760 | 132,252 | 0.099 |
| 1921..... | 6 | 7 | 9 | 1,344,900 | 154,405 | 1,485 | 120,525 | 0.114 |
| 1922..... | 8 | 8 | 9 | 1,229,802 | 150,237 | | | 0.122 |
| 1923..... | 7 | 6 | 10 | 1,478,135 | 164,969 | | | 0.11 |
| Total..... | | | | 56,653,716 | \$4,356,541 | | | 0.077 |

MARBLE

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

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

Verde Antique marble has been produced in commercial quantities by the Michigan Verde Antique Marble Company some miles north and west of Ishpeming. The marble is in a bed of altered peridotite in which the rock has been altered to serpentine and dolomite. In some places the rock is said to be almost wholly dolomite but generally it is a dolomitic serpentine, the dolomite investing the rock in an intricate system of veins and stringers. The serpentine varies in color from light to dark green with olive tones but the dolomite is generally white. The rock is firm and hard and takes a high polish. The intricate and delicate veins of white dolomite give very beautiful effects in the polished slab. The marble appears equal or superior to much of the verde antique now on the market; it is said to equal the best from Italian and Grecian quarries and can be provided in larger sections than that formerly imported from Europe.

Developments began in 1914 but lack of transportation facilities, labor shortage, etc., hindered operations. A spur line connecting the quarry with the Chicago and Northwestern railroad was completed and blocks of marble were shipped to Marquette where the company has a stone sawing mill. Marble will be cut and polished at this mill, the electric power being supplied by the city of Marquette. In 1920 and 1921 the company shipped broken pieces of green marble to eastern manufacturers of terrazzo which is used as flooring. Lack of available cars prevented maximum shipments. The broken pieces were blasted from the face of the ledge some years ago and are of little value as marble, but make excellent terrazzo. Further shipments were made in 1923. Fine blocks of verde antique are reported to be in stock and ready for the finishing plants.

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

GRAPHITE

The Northern Graphite Company of L'Anse and the Detroit Graphite Company of Detroit have opened quarries in graphitic slate nine miles southeast of L'Anse. The graphite rock, which is reported to contain from

32 to 35 per cent of graphite, is ground and used for paint. The production is intermittent, the quarries being operated only as the crude supply becomes depleted, enough being quarried in a year to supply the needs of the companies for several years.

No graphite was produced in 1918, 1919, 1920, 1921, or 1922, but production was again reported in 1923.

MINERAL PAINTS

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

CELESTITE

Celestite or strontium sulphate (SrSO_4) occurs at several horizons in the Monroe formation in southeastern Michigan. Near Maybee, Monroe County, it occurs in the Bass Island (Lower Monroe) in scattered crystals and masses associated with native sulphur and occurs similarly in the Sylvania sandstone at Rockwood, Wayne County. Near Gibraltar, Wayne County, it occurs in disseminated crystals in Detroit River (Upper Monroe) dolomites. In the glass sand pit of the Rockwood Silica Company the masses are numerous in places and some of them are large. The commercial recovery of the celestite has been but partially investigated. The masses are imbedded in a friable to incoherent sandstone and can be readily separated from it.

FELDSPAR

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

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

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

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

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

TRAP ROCK

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

Most of the quarry product and considerable amounts of fieldstone or "hardheads" are crushed for road material and concrete. In some years a small amount has been sold for riprap. The great distance from markets is a serious obstacle to the development of the trap rock industry of the State. Car and labor shortage is reported to be the chief cause of the decrease in 1918. The utilization of trap rock for roofing granules in 1921 caused the value of the stock produced to increase from \$84,273 in 1920 to \$173,620, an increase of \$89,347 or 106 per cent.

PRODUCTION AND VALUE OF TRAP ROCK OR BASALT IN MICHIGAN, 1911-1923

| Year. | No. of producers. | Crushed stone. | | | | Total tons. | Total value. | Rank value. |
|-------|-------------------|----------------|----------|----------------|----------|-------------|--------------|-------------|
| | | Roadmaking. | | Concrete, etc. | | | | |
| | | Quantity. | Value. | Quantity. | Value. | | | |
| | | Tons | | Tons | | | | |
| 1911. | 3 | | | 45,250 | \$38,429 | | 8 | |
| 1912. | 5 | 21,805 | \$18,366 | 11,355 | 9,340 | \$51,000 | 8 | |
| 1913. | 5 | 24,920 | 23,369 | † | † | 36,206 | 10 | |
| 1914. | 5 | 25,690 | 24,863 | 4,448 | 4,771 | 92,201 | 12 | |
| 1915. | 6 | 28,262 | 29,764 | 18,775 | 22,047 | 34,406 | 12 | |
| 1916. | 8 | 38,193 | 37,475 | 9,601 | 9,715 | 105,855 | 12 | |
| 1917. | 4 | 50,420 | 64,098 | † | † | 83,072 | 11 | |
| 1918. | 4 | 23,686 | 32,605 | † | † | 70,197 | 11 | |
| 1919. | 1 | | | | | 53,269 | 11 | |
| 1920. | 4 | | | | | 36,186 | 10 | |
| 1921. | 6 | 17,640 | 22,174 | | 151,446 | 84,273 | 12 | |
| 1922. | | 57,730 | 102,884 | † | † | 173,620 | | |
| 1923. | 12 | † | † | † | † | 94,560 | | |
| | | | | | | 109,810 | | |
| | | | | | | \$1,620,897 | | |

*Included in total.

QUARTZ

Quartz is mined near Ishpeming, Marquette County, and ground for wood filler and paint purposes. Some of the ground product is used in making scouring polish. According to an analysis submitted by the company the quartz rock is practically pure silica, there being but a trace of impurities. The value of quartz sold in 1923 was \$31,580.

SLATE†

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

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

PETROLEUM AND NATURAL GAS

Very little information regarding explorations for oil has been received during the current year. The Manistee Oil and Gas Company has drilled a second well but only a part of the log has been reported. The Jackson County Oil and Gas Company, which obtained a showing of oil in a well near Deerfield last year, has not obtained production from that well or drilled any others. J. C. Gaines reported that a well had been begun by him near Port Huron but no further details have been furnished. In Section 7, T. 14 N., R. 3 W. a showing of oil was reported from 1100 feet by the Dow Chemical Company. Details of this drilling are not available.

Reports of gas from the drift overlying the Antrim formation were made by Ruggles and Rademacher, Manistee, who found a flow of gas at 800 feet in a well on the west shore of Manistee Lake; by William Felty of Mount Clemens who struck a flow of gas in a water well at 135 feet; and by H. K. Gustin, who reported a strong flow of gas from a well on the farm of Mr. Wilder, one mile west of Hillman, Montmorency County.

Records of five deep wells reported during the year are given on the following pages:

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

MINERAL RESOURCES OF MICHIGAN

LANSING (INGHAM COUNTY)

MUNICIPAL TEST WELL

Location: Sec. 23, T. 4 N., R. 2 W. At waterworks, junction of S. Francis St. and Pere Marquette R. R.
Elevation: 820 feet above sea level.
Drilled in 1924 as a deep test for water by Wm. Cater, contractor, Chicago.

| | Thickness feet | Depth feet |
|---|-------------------|---------------|
| Pleistocene: | | |
| Sand and gravel | 25 | 25 |
| Boulder clay | 10 | 35 |
| No record | 30 | 65 |
| Pennsylvanian: | | |
| Woodville Formation: | | |
| Gypsum, noted by Mr. Gilchrist, engineer; thickness small and undetermined. | | |
| Saginaw Formation: | | |
| Gray sandstone with a few flakes of coal; considerable mica; some pyrite | 15 | 80 |
| Fine grained very light gray sandstone with mica and a few flakes of coal, shading below to a darker gray very fine grained sandstone with pyrite | 180 | 260 |
| Gray laminated shale | 15 | 275 |
| Fine grained gray sandstone (from above) and gray shale | 5 | 280 |
| Gray shale | 30 | 310 |
| Very fine grained gray sandstone with pyrite | 10 | 320 |
| Grayish black shale with pyrite | 5 | 325 |
| Dark gray shale | 55 | 380 |
| Mississippian: | | |
| Michigan Formation: | | |
| Fine grained white sandstone with flakes of black shale, pyrite, and olive green "soapstone" and dolomite and small amounts of gypsum | 80 | 460 |
| No record | 15 | 475 |
| Same but with larger amounts of gypsum, some pink, and selenite | 15 | 490 |
| Dark gray shale, small amounts of gypsum | 15 | 505 |
| Gypsum, some dark gray shale | 15 | 520 |
| Dark gray shale | 10 | 530 |
| No record | 20 | 550 |
| Gypsum and dark gray shale, some dolomite | 25 | 575 |
| Dark gray shale; some dolomite | 10 | 585 |
| Dark gray shale and sandstone with oolitic coating of cement | 5 | 590 |
| Dark gray shale small amounts of gypsum | 10 | 600 |

NON-METALLIC MINERALS

MUSKEGON (MUSKEGON COUNTY)

BRUNSWICK, BALKE, AND COLLENDER WELL

Location: Sec. 20, T. 10 N., R. 16 W. About 4 blocks northeast from the Occidental Hotel.
Elevation: About 634 feet above sea level.
Drilled by Wm. Cater, Chicago, as test for water in 1924.
Partial log and scattered samples from Mr. Cater.

| | Thickness feet | Depth feet |
|---|-------------------|---------------|
| Pleistocene: | | |
| Sand (no samples) | 100 | 100 |
| Clay (no samples) | 170 | 270 |
| Mississippian: | | |
| Lower Marshall Formation: | | |
| Light gray sandstone, fine grained, many green grains and some particles of selenite. Some granitic fragments indicate an admixture of drift. | 3 | 273 |
| Lower Marshall, Coldwater, and Bedford Formations (Undivided): | | |
| No record | 382 | 655 |
| Gray calcareous shale with small fragmentary fossils, pyrite, gypsum, and quartz | 5 | 660 |
| Gray shale with fine grains of calcite and dolomite (lime sand) and a few much larger grains of quartz | 50 | 710 |
| Same but more calcareous | 105 | 815 |
| No record | 115 | 930 |
| Red highly calcareous shale with a few very small grains of a green mineral and of quartz. Considerable gypsum | 10 | 940 |
| Red and green somewhat calcareous shale with a few grains of quartz | 5 | 945 |
| No record | 25 | 970 |
| Gray calcareous shale | 20 | 990 |
| Gray-green calcareous shale | 5 | 995 |
| Gray calcareous shale | 5 | 1000 |

POWERS (MENOMINEE COUNTY)

DELTA-MENOMINEE SANATORIUM WELL

Location: Section 16, T. 38 N., R. 26 W.
Elevation: 856 feet above sea level.
Drilled in 1924 for water. Samples furnished by J. W. Towey.

| | Thickness feet | Depth feet |
|---|-------------------|---------------|
| Pleistocene: | | |
| No record | 80 | 80 |
| Ordovician: | | |
| Beekmantown Formation: | | |
| White crystalline dolomite with some quartz grains† | 20 | 100 |
| Light gray earthy dolomite with small amounts of quartz and shale | 10 | 110 |
| Gray earthy dolomite with reddish tinge; some quartz grains | 5 | 115 |
| Light buff dolomitic sandstone | 55 | 170 |
| Gray sandy dolomite | 10 | 180 |
| Cambrian: | | |
| Lake Superior Formation: | | |
| Reddish sandstone, shaly, ferruginous, and dolomitic | 42 | 222 |

†Small scattered grains of a bright green mineral appear in nearly all of the samples.

MINERAL RESOURCES OF MICHIGAN

MANISTEE (MANISTEE COUNTY)

MICHIGAN OIL & DEVELOPMENT COMPANY NO. 2

Location: Sec. 31, T. 22 N., R. 16 W. To the north across the river from East Lake.

Elevation: 583 feet above sea level.

| | Thickness feet | Depth feet |
|---|-------------------|---------------|
| Pleistocene: | | |
| No record | 600 | 600 |
| Mississippian: | | |
| Berea Formation: | | |
| Black shale and very fine grained sandstone. Some grains of coarse sand | 7 | 607 |
| Mississippian: | | |
| Bedford Formation: | | |
| Light gray shale at top shading to dark gray at bottom | 253 | 860 |
| Devonian: | | |
| Antrim Formation: | | |
| Black shale | 50 | 910 |
| Traverse Formation: | | |
| Dark gray limestone, some gypsum | 35 | 945 |
| No record | 15 | 960 |
| Gray, brown, and white limestone, some gypsum | 15 | 975 |
| Brown limestone, gypsum, petroleum | 125 | 1100 |
| Oil sand, a brown and white limestone with selenite crystals. Probably a fifth of this sample was gypsum | | 1100 |
| Brown, gray, and white limestone, with selenite (samples at 1158, 1220, 1335, 1345, 1440, 1465, and 1470) | 370 | 1470 |

NON-METALLIC MINERALS

EAST LANSING (INGHAM COUNTY)

MUNICIPAL WELL

Location: Near center of Section 18, T. 4 N., R. 1 W. Near water tower between Orchard and Kedzie Streets.

Elevation: 860 feet above sea level.

Drilled as test for water by Wm. Purcell, contractor, Jackson.

Samples from Mr. Purcell.

| | Thickness feet | Depth feet |
|--|-------------------|---------------|
| Pleistocene: | | |
| Brown sand | 55 | 55 |
| Gravel | 5 | 60 |
| Pennsylvanian: | | |
| Saginaw Formation: | | |
| Gray shale with mica | 35 | 95 |
| Fine grained white sandstone with mica | 235 | 330 |
| Gray shale | 30 | 360 |
| White sandstone coarser than the upper sand | 20 | 380 |
| White sandstone, grayish black shale; pyrite | 5 | 385 |
| Grayish black shale | 20 | 405 |
| Gray shale | 5 | 410 |
| Grayish black shale | 15 | 425 |

SUMMARY TABLE OF THE PRODUCTION AND VALUE

| Mineral Products. | 1919. | | 1920. |
|---|-------------|----------------|-------------|
| | Quantity. | Value. | Quantity. |
| Brick and tile products, number of brick | 200,359,000 | \$3,699,929 | 187,415,000 |
| Brick, sand-lime, number of brick | 42,063,000 | 513,094 | 38,810,000 |
| Bromine, pounds | 1,736,633 | 1,179,834 | 1,046,165 |
| Calcium chloride, tons | 21,668 | 256,091 | 49,937 |
| Cement, Portland; bbls. made, value cement shipped | 4,675,244 | 8,468,196 | 4,891,457 |
| Clay, tons | 568 | 2,123 | 5,066 |
| Coal, tons | 996,545 | 3,864,228 | 1,489,765 |
| Coke, tons; value sales | | | 1,485,833 |
| Copper, lbs. | 179,082,970 | 33,696,537 | 161,343,880 |
| Glass sand | (c) | (c) | (c) |
| Graphite | (f) | (f) | (f) |
| Grindstones, tons | (a) | (a) | (a) |
| Gypsum, tons mined; value gypsum products sold | 339,125 | 2,390,367 | 382,212 |
| Iron ore, shipments long tons, value f. o. b. mine | 12,816,304 | 47,945,800 | 18,470,354 |
| Iron, pig, long tons made; value pig iron shipped | 416,277 | (b) 13,418,185 | 513,920 |
| Lime, tons made | 145,783 | 1,381,534 | 140,813 |
| Limestone | | 3,797,522 | |
| Mineral paints | | | |
| Mineral and spring waters, gallons sold | 1,570,906 | 132,312 | 1,227,485 |
| Natural gas, M. cu. ft. | 1,098 | 911 | |
| Petroleum | | (a) | |
| Pottery | | 2,096,874 | |
| Potash (Pure K ₂ O) tons produced; value potash sold | 166 | 48,581 | 56 |
| Precious stones | | (a) | |
| Quartz | | (a) | |
| Salt, bbls. | 17,800,564 | 9,456,138 | 16,163,679 |
| Sand and gravel, tons | 3,772,535 | 1,944,143 | 4,386,582 |
| Sandstone | 19,640 | 24,413 | |
| Silver, fine oz. Troy | 425,610 | 477,054 | 510,601 |
| Stone, crushed | | | |
| Traprock | | 36,186 | |
| Miscellaneous | | 60,242 | |
| Total | | \$121,482,109 | |

- † Figures from State Tax Commission.
‡ Estimated at \$.135 per pound, the average price.
‡‡ Estimated at 14.9543 cents per pound, the average price.
a. Included under miscellaneous.
b. Excluded from total; covered by iron ore.
c. Included under sand and gravel.
d. Copper sales.
e. Estimated.
f. No production.
g. Included in limestone.

OF MINERAL PRODUCTS IN MICHIGAN, 1919-1923.

| 1920. | 1921. | | 1922. | | 1923. | |
|----------------|-------------|--------------|-------------|----------------|-------------|----------------|
| | Value. | Quantity. | Value. | Quantity. | Value. | Quantity. |
| \$3,979,691 | 193,730,000 | \$2,417,309 | 748,608,890 | \$3,915,318 | 193,350,663 | \$3,723,018 |
| 640,744 | 33,658,000 | 403,929 | 45,558 | 557,647 | 64,650,000 | 777,693 |
| 692,100 | | (a) | | (a) | | (a) |
| 1,905,013 | 18,683 | 431,402 | | (a) | 32,669 | 578,462 |
| 10,939,633 | 5,777,533 | 10,300,289 | 6,243,805 | 11,145,573 | 7,619,792 | 14,038,322 |
| 11,295 | | 2,355 | 1,653 | 4,852 | 3,617 | 11,903 |
| 7,346,000 | 1,141,715 | 5,555,000 | 929,390 | 4,693,000 | 1,172,075 | 5,545,000 |
| 15,731,994 | 835,973 | 4,704,141 | 1,142,059 | 9,229,083 | 1,648,773 | 14,389,742 |
| 29,220,990 | 100,918,001 | 16,873,992 | 121,386,726 | 116,387,208 | 137,952,586 | 120,062,984 |
| (c) | | (c) | | (c) | | (c) |
| (f) | | (f) | | (f) | | (f) |
| (a) | | (a) | | (f) | 1,253 | 38,212 |
| 3,521,028 | 408,224 | 3,312,096 | 471,355 | 2,843,117 | 586,987 | 3,252,993 |
| 83,319,770 | 5,230,669 | 19,970,694 | 12,433,729 | 43,760,509 | 13,962,769 | 54,256,527 |
| (b) 16,812,062 | 243,433 | b5,955,205 | 595,647 | (b) 14,791,041 | 717,279 | (b) 18,327,808 |
| 1,386,760 | 48,164 | 445,386 | 53,635 | 484,945 | 59,629 | 612,369 |
| 5,943,229 | | 3,387,722 | | 4,533,998 | 10,589,070 | 5,848,649 |
| 122,010 | 1,344,900 | (f) | | (f) | | (f) |
| (e) 500 | 400 | 154,405 | 1,229,802 | 150,237 | 1,478,135 | 164,968 |
| | | 300 | 700 | 350 | 700 | 320 |
| | | (f) | | (f) | | (f) |
| 2,592,625 | | 1,781,923 | | 1,337,000 | | 2,810,619 |
| 18,312 | | (f) | | (f) | | (f) |
| (a) | | (f) | | (f) | | (f) |
| (a) | | (a) | | (a) | | (a) |
| 10,698,674 | 10,196,179 | 7,439,445 | 14,322,057 | 8,693,604 | 15,195,800 | 8,684,148 |
| 2,867,466 | 5,515,253 | 2,916,917 | 5,962,916 | 3,222,043 | 9,601,562 | 5,096,071 |
| (a) | | (a) | | (a) | 19,030 | 36,963 |
| 518,326 | 310,727 | 310,727 | 361,912 | 361,912 | 253,705 | 208,038 |
| | 1,381,250 | 1,025,463 | | (g) | (g) | (g) |
| 84,273 | | 173,620 | 94,560 | 376,778 | 109,810 | 420,524 |
| 161,822 | | 292,880 | | 627,860 | | 200,590 |
| \$181,702,225 | | \$81,872,995 | | \$112,325,034 | | \$140,758,121 |

APPENDIX

DIRECTORY OF THE PRODUCERS OF NON-METALLIC
MINERALS IN MICHIGAN, 1923

BRICK AND TILE MANUFACTURERS, 1923

| | Office. | Works. |
|--|---------------------------------|--------------------------|
| <i>Allegan County</i> | | |
| Allegan Brick Works (Fish & Fish)..... | Allegan..... | Allegan. |
| Veneklasen Clay Products Co..... | Hamilton..... | Hamilton. |
| <i>Barry County</i> | | |
| Leonard Bros. & Co..... | Delton..... | Delton. |
| <i>Chippewa County</i> | | |
| Thornton Bros. Brick Co..... | Grand Rapids..... | Rudyard. |
| <i>Eaton County</i> | | |
| Grand Ledge Clay Product Co..... | Grand Ledge..... | Grand Ledge. |
| <i>Emmet County</i> | | |
| C. A. DeArment Brick Works..... | Petoskey..... | Petoskey. |
| <i>Gratiot County</i> | | |
| Ashley Tile Company..... | Ashley..... | Ashley. |
| North Star Tile Co..... | North Star..... | North Star. |
| Riverside Brick & Tile Yard..... | Summer..... | Summer. |
| <i>Ingham County</i> | | |
| The Briggs Co..... | Lansing..... | Lansing and Grand Ledge. |
| <i>Jackson County</i> | | |
| Michigan State Industries..... | Jackson..... | Onondaga. |
| American Vitrified Products Co..... | Akron, Ohio, (15 Broad St.).. | Jackson and Grand Ledge. |
| <i>Lenawee County</i> | | |
| Albert A. Comfort..... | Tecumseh..... | Tecumseh. |
| <i>Macomb County</i> | | |
| The Trombley Brick Co..... | Detroit, (10546 Gratiot Ave.).. | Detroit. |
| <i>Manistee County</i> | | |
| Jos. Kujawski..... | Manistee..... | Manistee. |
| <i>Mecosta County</i> | | |
| Wm. F. Nehmer..... | Big Rapids..... | Big Rapids. |
| <i>Saginaw County</i> | | |
| Miller City Tile Co..... | Saginaw..... | Paines Station. |
| National Plate Glass Co..... | Detroit..... | Saginaw. |
| <i>Sanilac County</i> | | |
| Croswell Brick Co..... | Croswell..... | Croswell. |
| <i>Shiawassee County</i> | | |
| New Corunna Brick Co..... | Corunna..... | Corunna. |
| <i>Van Buren County</i> | | |
| Hartford Brick & Tile Co..... | Hartford..... | Hartford. |
| <i>Wayne County</i> | | |
| Anton Hupprich..... | Detroit, 4645 51st St..... | Detroit. |
| Jacob Daniel Brick Co..... | Detroit, 290 Atkinson Ave.... | Springwells. |
| John McDonald..... | Detroit, 504 Dime Bk. Bldg.. | Detroit. |
| John S. Haggerty..... | Detroit, 1815 Dime Bk. Bldg.. | Detroit. |
| Pewabic Pottery & Tile Co..... | Detroit, 10125 Jefferson Ave.. | Detroit. |
| Bunte Bros. Tile Co..... | Flat Rock..... | Flat Rock. |
| Clippert Brick Co..... | Detroit, Dewey and Southern | Springwells. |
| Wm. Clippert Brick Co..... | Detroit, Western Ave. and | |
| | M. C. R. R..... | Detroit. |
| Porath Brothers..... | Detroit, 305 Free Press Bldg.. | Detroit. |
| Walker & Frank..... | Detroit, 8810 Dix Ave..... | Detroit. |
| Mercier-Bryan-Larkins Co..... | Detroit, Michigan Ave. and | |
| | Lonyo Road..... | Detroit. |
| Egle Brothers Mfg. Co..... | Detroit, 169 Sylvester St..... | Detroit. |

SAND LIME BRICK PRODUCERS, 1923

| | Office. | Works. |
|---|---|-----------------|
| <i>Genesee County:</i> Flint Sandstone Brick Co..... | Flint..... | Flint. |
| <i>Huron County</i> Sebewaing Sandstone Brick Co..... | Sebewaing..... | Sebewaing. |
| <i>Jackson County</i> Jackson-Lansing Brick Company..... | Rives Junction..... | Rives Junction. |
| <i>Kent County</i> Grande Brick Co..... | Grand Rapids, 1456 Sunny- side Ave..... | Grand Rapids. |
| <i>Menominee County</i> Menominee Brick Co..... | Menominee..... | Menominee. |
| <i>Oakland County</i> Rochester Brick & Sand Co..... | Detroit, 400 Penobscot Bldg. | Rochester. |
| <i>Saginaw County</i> Saginaw Brick Co..... | Saginaw, 321 N. Hamilton St. | Saginaw. |
| <i>Wayne County</i> Michigan Pressed Brick Company..... | Detroit, Cor. Lawton Ave. at M. C. Railroad..... | Detroit. |
| Sand Lime Products..... | Detroit, Foot of Jean St..... | Detroit. |

CEMENT PRODUCERS, 1923

| Operator. | Office. | Works. |
|---|-----------------------------------|---------------------|
| Huron Portland Cement Company..... | 1525 Ford Building, Detroit..... | Alpena. |
| Alpha Portland Cement Co..... | 140 S. Dearborn St., Chicago..... | Bellevue. |
| Peninsular Portland Cement Co..... | Cooley Block, Jackson..... | Cement City. |
| Michigan Portland Cement Co..... | Chelsea..... | Four Mile Lake. |
| Wolverine Portland Cement Co..... | Coldwater..... | Coldwater & Quincy. |
| Aetna Portland Cement Co..... | 412 Union Trust Bldg., Detroit | Fenton. |
| Newaygo Portland Cement Co..... | Grand Rapids..... | Newaygo. |
| Peerless Portland Cement Co..... | Union City..... | Union City. |
| Wyandotte Portland Cement Co..... | 1525 Ford Bldg., Detroit..... | Wyandotte. |
| New Egyptian Portland Cement Co..... | Fenton..... | Fenton. |
| Petoskey Portland Cement Co..... | Petoskey..... | Petoskey. |
| <i>New Plants</i> Aetna Portland Cement Co. (operating) | Fenton..... | Bay City. |
| New Egyptian Portland Cement Co. (under construction)..... | Port Huron..... | Port Huron. |
| Peerless Portland Cement Co. (under construction)..... | Detroit..... | Detroit. |

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

| Name of Mine. | County. | Manager. | Address. | Superintendent. | Address. |
|---|--------------|-------------------|-----------------|-----------------|-------------|
| Robert Gage Coal Co. Beaver No. 7 | Bay | Chas. Coryell | Bay City | Wm. A. Jones | Bay City. |
| Beaver Mine | Bay | Chas. Coryell | Bay City | Wm. A. Jones | Bay City. |
| Wolverine Coal Mining Co. No. 2 | Bay | R. M. Randall | Saginaw | Alex Liddle | Bay City. |
| What Cheer Coal Mining Co. No. 1 | Bay | A. N. Fancher | Bay City | Alex Jeffreys | Bay City. |
| Peoples Coal Mining Co. | Calhoun | W. A. Knapp | Albion | W. C. Sellers | Bay City. |
| Russell Mine | Calhoun | | | | Albion. |
| Reed Mine | Eaton | | | | |
| Robert Gage Coal Co. No. 3 | Saginaw | Chas. Coryell | Bay City | Wm. A. Jones | Bay City. |
| Robert Gage Coal Co. No. 8 | Saginaw | Chas. Coryell | Bay City | Wm. A. Jones | Bay City. |
| Buss Coal Mining Co. | Saginaw | C. E. Linton | Saginaw | J. T. Phillips | Saginaw. |
| Banner Coal Mining Co. | Saginaw | Wm. B. Carmichael | Saginaw | Richard Jenkins | Swan Creek. |
| Community Coal Co. | Saginaw | Alex Jeffreys | Swan Creek | | Swan Creek. |
| Consolidated Coal Co. { Riverside No. 2 | Saginaw | R. M. Randall | Bay City | Wm. Pollis | Swan Creek. |
| { Shiawassee | Saginaw | R. M. Randall | Saginaw | Alex Liddle | Bay City. |
| Uncle Henry No. 2 | Saginaw | R. M. Randall | Saginaw | Alex Liddle | Bay City. |
| Owosso Coal Mining Company | Saginaw | | Saginaw | Alex Liddle | Bay City. |
| Akron Coal Mining Co. No. 2 | 6-Mile Creek | Chas. Handy | Owosso | Alex Liddle | Bay City. |
| | Tuscola | | Bay City, W. S. | Chas. Ferrod | Akron. |

CLAY MINERS, 1923

| | Office. | Works. |
|---|--|-------------------------------------|
| <i>Allegan County</i> Allegan Brick Works..... | Allegan..... | Allegan. |
| <i>Barry County</i> Leonard Bros. Co..... | Delton..... | Delton. |
| <i>Ontonagon County</i> Thos. Edmond Estate..... F. A. Jeffs..... Robinson Clay Products Co..... | Rockland..... Rockland..... Akron, Ohio, 1010 E. Market St..... | Rockland. Rockland. Rockland. |
| <i>Wayne County</i> Clippert Brick Co..... | Detroit, 1960 Michigan Ave. | Springwells. |

COKE PRODUCERS, 1923

| Operator. | Address. | Location of Plant. | No. of ovens. | County. |
|--------------------------|---------------------|--------------------|---------------|-----------|
| Consumers Power Co..... | Zilwaukee..... | Zilwaukee..... | 19 | Saginaw. |
| Michigan Alkali Co..... | Wyandotte..... | Plant No. 2..... | 30 | Wayne. |
| Sement-Solvay Co..... | Syracuse, N. Y..... | Detroit..... | 175 | Wayne. |
| Ford Motor Co..... | Detroit..... | River Rouge..... | 120 | Wayne. |
| Battle Creek Gas Co..... | Battle Creek..... | Battle Creek..... | 11 | Calhoun.. |

GRAPHITE PRODUCERS, 1923

| Operator. | Office. | Quarry. |
|--------------------------|-------------------------------|---------|
| Detroit Graphite Co..... | 10, 12th Street, Detroit..... | L'Anse. |

GRINDSTONE AND SCYTHESTONE PRODUCERS, 1923

| Operator. | Office. | Quarry. |
|--|----------------------|-------------------------------------|
| <i>Huron County</i> Cleveland Stone Co..... | Cleveland, Ohio..... | Grindstone City and Port Austin. |

PRODUCERS OF GYPSUM PRODUCTS, 1923

| Operator. | Office. | Name of Plant. | Location of mine. |
|---------------------------------------|---|-----------------|-------------------|
| United States Gypsum Co..... | Chicago, Ill..... | Alabaster..... | Alabaster. |
| United States Gypsum Co..... | Chicago, Ill..... | Midland..... | Grand Rapids. |
| Alabastine (Michigan Gypsum Co.)..... | Grand Rapids..... | ..... | Grand Rapids. |
| Grand Rapids Plaster Co..... | Grand Rapids, 427 Mich. Trust Bldg.. | Grandville..... | Grandville. |
| Beaver Products Co..... | Grand Rapids..... | ..... | Grand Rapids. |
| Certainfeed Products Co..... | Grand Rapids..... | ..... | Grand Rapids. |

LIMESTONE AND LIME PRODUCERS, 1923

| Operator. | Office. | Quarry. |
|--|---|---|
| <i>Alpena County</i> Michigan Alkali Co..... Kelly Island Lime and Transport Co..... | Wyandotte..... Cleveland..... | Rockport. |
| <i>Cheboygan County</i> Campbell Stone Co. (also lime)..... | Indian River..... | Afton. |
| <i>Chippewa County</i> Scott Quarry Co..... | Sault Ste. Marie..... | Trout Lake. |
| <i>Delta County</i> Delta Contracting Co..... Bichler Bros..... | Escanaba..... Gladstone..... | Escanaba (Hyde) Pine Ridge. |
| <i>Dickinson County</i> Metronite Co., The..... McKenna Bros..... | Milwaukee, Wis..... Quinnesec..... | Felch. Quinnesec. |
| <i>Emmet County</i> Antrim Lime Co. (also lime)..... Northern Lime Co. (also lime)..... Petoskey Portland Cement..... | 912 Mich. Trust Bldg., Grand Rapids..... Petoskey..... Petoskey..... | Petoskey. Petoskey. Petoskey. |
| <i>Huron County</i> Wallace Stone Co..... | Bayport..... | 3 mile E. of Bayport. |
| <i>Mackinac County</i> Ozark Stone Quarry..... Union Carbide Co..... Fiborn Limestone Co..... | Ozark..... 42nd St. Bldg., New York City Sault Ste. Marie, Ont., Canada | Ozark. Hendricks Quarry. Fiborn Quarry. |
| <i>Monroe County</i> The France Stone Co..... Morris, Sam W..... | 1800 Second National Bank Bldg., Toledo, Ohio..... Monroe..... | Monroe. Monroe. |
| <i>Presque Isle County</i> Michigan Limestone & Chemical Co..... | 55 Liberty St., New York, or Rogers City, Mich..... | Calcite. |
| <i>Schoolcraft County</i> The White Marble Lime Co..... | Manistique..... | Blaney, Manistique, and Marblehead. |
| <i>Wayne County</i> Solvay Process Co..... Dunbar & Sullivan Dredging Co..... | Syracuse, N. Y..... Detroit or River Rouge..... | Trenton and Sibley. Mouth of Detroit River. |

MINERAL AND SPRING WATER PRODUCERS, 1923

| Operator. | Office. | Spring. |
|----------------------------------|--------------------------------------|----------------------------|
| Eastman Springs Beverage Co..... | Benton Harbor..... | Eastmans. |
| Artic Spring Water Co..... | Grand Rapids, 412 Ottawa Avenue..... | Artic. |
| Ogemaw Spring Water Co..... | Malthy..... | Ogemaw. |
| Ponce de Leon Co..... | Grand Rapids..... | Ponce de Leon. |
| Sharkey, Chas..... | Mt. Clemens..... | Victory. |
| Magnetic Spring Water Co..... | Saginaw, W. S..... | Andrew's Magnetic Mineral. |
| Charbeneau, Jno. H..... | Mt. Clemens..... | Maple Leaf Springs. |
| Preussel, Frank W..... | 47 Crocker Ave., Mt. Clemens | Panacea. |
| Silver Springs Water Co..... | Detroit..... | Northville. |
| John Gerick..... | Denton (Wayne Co.)..... | John Gerick. |

PIG IRON PRODUCERS, 1923

| Operator. | Office. | Name of Furnace. | Location of Furnace. |
|-----------------------------------|----------------------|---------------------|----------------------|
| Mitchell-Diggins Iron Co..... | Cadillac..... | Cadillac..... | Cadillac. |
| East Jordan Furnace Co..... | East Jordan..... | East Jordan..... | East Jordan. |
| Cleveland Cliffs Iron Co..... | Cleveland, Ohio..... | Pioneer No. 1..... | Gladstone. |
| Cleveland Cliffs Iron Co..... | Cleveland, Ohio..... | Pioneer No. 2..... | Near Marquette. |
| Antrim Iron Co..... | Antrim..... | Antim..... | Mancelona. |
| Charcoal Iron Co. of America..... | Detroit..... | Boyne City..... | Boyne City. |
| Charcoal Iron Co. of America..... | Detroit..... | Manistique..... | Manistique. |
| Charcoal Iron Co. of America..... | Detroit..... | Newberry..... | Newberry. |
| Ford Motor Co..... | Dearborn..... | Henry & Benson..... | Springwells. |
| Delta Chemical & Iron Co..... | Escanaba..... | Delta..... | Wells. |
| Hanna Furnace Co..... | Detroit..... | A & B..... | Detroit. |

POTTERY PRODUCERS

| Operator. | Office. | Works. |
|--|--|-----------------|
| <i>Kalamazoo County</i> Kalamazoo Sanitary Mfg. Co..... | Factory and Alcot Streets, Kalamazoo..... | Kalamazoo. |
| <i>Maccmb County</i> Mt. Clemens Pottery Co..... | Mt. Clemens..... | Mt. Clemens. |
| <i>Menroe County</i> South Rockwood Pottery Co..... | South Rockwood..... | South Rockwood. |
| <i>Wayne County</i> Becker Bros. Flower Pot Co..... | Detroit, 4645 51st St..... | Detroit. |
| Champion Porcelain Co..... | Detroit, 3154 Leuschner St..... | Detroit. |
| Hygeia Filter Co..... | Detroit, 3422 Denton Ave..... | Detroit. |
| Meaker Spark Plug Co..... | Detroit, 1366 Antietam Ave..... | Detroit. |
| Pewabic Pottery & Tile Co..... | Detroit, 10125 Jefferson Ave..... | Detroit. |

QUARTZ PRODUCERS, 1923

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

SALT PRODUCERS, 1923

| Operator. | Office. | Works. |
|--|--|--------------|
| <i>Bay County</i> Hine Lumber Co..... | Sta. A., Bay City..... | W. Bay City. |
| <i>Manistee County</i> Louis Sands Salt & Lumber Co..... | Manistee..... | Manistee. |
| Ruggles & Rademacher..... | Manistee..... | Manistee. |
| <i>Masn County</i> Morton Salt Co..... | Ludington..... | Ludington. |
| <i>Midland County</i> The Dow Chemical Co. (bromine)..... | Midland..... | Midland. |
| <i>Saginaw County</i> Mershon, Eddy, Parker & Co..... | Saginaw..... | Saginaw. |
| Bliss & VanAuken Lbr. Co..... | Saginaw, W. S..... | Saginaw. |
| Saginaw Salt Products Co..... | Saginaw, W. S..... | Saginaw. |
| Estate of Edward Germain..... | Saginaw, W. S., Holland Ave. near Genesee Street..... | Saginaw. |
| National Plate Glass Co..... | Saginaw..... | Saginaw. |
| Strable Lumber & Salt Co..... | Saginaw..... | Saginaw. |
| Saginaw Chemical Co..... | Saginaw..... | Saginaw. |
| <i>St. Clair County</i> Michigan Salt Works..... | Marine City..... | Marine City. |
| Morton Salt Co..... | Chicago, Ill., 717 Railway Exch..... | Port Huron. |
| Diamond Crystal Salt Co..... | St. Clair..... | St. Clair. |
| <i>Wayne County</i> Inland Delray Salt Co..... | Detroit..... | Detroit. |
| Solvay Process Co..... | Detroit..... | Delray. |
| Detroit Rock Salt Co..... | Scranton, Pa..... | Detroit. |
| Mulkey Salt Co..... | Detroit, 610 Equity Bldg..... | Oakwood. |
| Worcester Salt Co..... | New York City, 168 Duane Street..... | Ecorse. |
| Michigan Alkali Co..... | Wyandotte..... | Wyandotte. |
| Pennsylvania Salt Mfg. Co..... | Philadelphia, Pa., 115 Chestnut St..... | Wyandotte. |

SANDSTONE PRODUCERS, 1923

| Operator. | Office. | Quarry. |
|--|----------------------|----------------|
| <i>Dickinson County</i> Anton Meinch..... | Iron Mountain..... | Iron Mountain. |
| Hofelz and Eisele..... | Iron Mountain..... | Iron Mountain. |
| <i>Huron County</i> Cleveland Stone Co..... | Cleveland, Ohio..... | Grindstone. |
| The Wallace Company..... | Port Austin..... | Eagle Mills. |
| <i>Marquette County</i> Marquette Trap Rock Co..... | Marquette..... | Marquette. |

SAND AND GRAVEL PRODUCERS IN 1923.

| Operator. | Office. | Pit. |
|------------------------------------|------------------------------|------------------|
| <i>Alcona County</i> | | |
| Federal Sand & Gravel Co. | Saginaw, 301½ Federal Ave. | Greenbush. |
| <i>Allegan County</i> | | |
| F. Buhler | Zeeland, R. F. D. No. 3 | Burnips Corners. |
| Fred W. Sutter | Byron Center | Burnips Corners. |
| Howard Van Keuren | Allegan | Monterey. |
| A. J. Powell | Plainwell | Plainwell. |
| W. G. Fry | South Haven, R. F. D. No. 6 | Saugatuck. |
| Murray Acklin | | |
| <i>Alpena County</i> | | |
| Alpena Gravel Co. | Alpena | Alpena. |
| Alpena Towing Co. | Alpena | Alpena. |
| Levi Smith | Alpena | Alpena. |
| Federal Sand & Gravel Co. | Alpena | Lachine. |
| <i>Antrim County</i> | | |
| Floyd H. Moore | Central Lake, R. F. D. No. 1 | Central Lake. |
| James B. Gaylord | Mancelona | Mancelona. |
| <i>Barry County</i> | | |
| Chas Woolston | Hastings | Hastings. |
| S. J. Palmiter | Bellevue, R. F. D., No. 4 | Nashville. |
| Arthur Penock | Nashville | Nashville. |
| P. O. Dunham | Nashville, R. F. D. No. 4 | Maple Grove. |
| Hastings Gravel & Construction Co. | | |
| <i>Bay County</i> | | |
| Geo. A. Whitney | Bentley | Bentley. |
| A. J. Schable, Jr. | Munger | Munger. |
| <i>Benzie County</i> | | |
| E. Amidon | Bendon | Bendon. |
| John Dean | Bendon | Bendon. |
| Wm. Huddleston | Bendon, R. F. D., No. 1 | Bendon. |
| Hubbell Sand Co. | Manistee | Elberta. |
| Wm. Ferrens | | |
| <i>Berrien County</i> | | |
| Ireland & Lester | Benton Harbor | Benton Harbor. |
| Albert Noack | Coloma, R. F. D. No. 3 | Coloma. |
| Frank Brewer | Galien | Galien. |
| Christ Andrews | Galien | Galien. |
| F. D. Noggle & Son | Galien | Galien. |
| Broderick Bros. | Benton Harbor | Riverside. |
| Anton Thar | Coloma | Riverside. |
| F. J. Thar | Coloma, R. F. D. No. 3 | Riverside. |
| Kerklikowske Bros | St. Joseph | Riverside. |
| E. F. Chase & Son | Watervliet | Watervliet. |
| <i>Branch County</i> | | |
| Mack L. Roe | Bronson, R. F. D. No. 4 | Bronson. |
| J. F. Werner | Bronson | Bronson. |
| Mrs. Olive A. Barnes | Montgomery | Fremont. |
| Daniel Haley | Ray, Ind | Near Ray, Ind. |
| Andrew Marsh | Union City, R. F. D., No. 5 | Union City. |
| Clifford A. Bishop | | |
| D. H. Rogers | | |
| <i>Calhoun County</i> | | |
| A. C. Behling | Albion | Albion. |
| Floyd Van Sickle | Albion | Albion. |
| Willard A. Young | Albion | Albion. |
| Brownlee Park Gravel & Mat. Co. | Battle Creek, R. 1, Box 83 | Brownlee Park. |
| George W. Greble | Battle Creek | Iron City. |
| Ralph Cook | Eckford | Marshall. |
| Michigan Railway Co. | Jackson | Marshall. |
| <i>Cass County</i> | | |
| Fred Crandall | | |
| <i>Charlevoix County</i> | | |
| Edw. Ward Estate | Charlevoix | Charlevoix. |
| John Martin | | |

SAND AND GRAVEL PRODUCERS IN 1923.—Continued.

| Operator. | Office. | Pit. |
|---|--|----------------------|
| <i>Chippewa County</i> | | |
| William Gough | Pickford | Pickford. |
| Mrs. Jennie Hudson | Pickford | Pickford. |
| F. H. Taylor | Pickford | Pickford. |
| Rye Bros | Sault Ste. Marie, 409 Maple St. | Sault Ste. Marie. |
| <i>Clinton County</i> | | |
| A. A. Schultz | Laingsburg | Laingsburg. |
| S. B. Gleason | Ovid | Ovid. |
| Elmer Stowell | Ovid | Ovid. |
| George Parmenter | Shepardsville | Shepardsville. |
| <i>Crawford County</i> | | |
| Federal Sand & Gravel Co. | | Roscommon. (near) |
| <i>Delta County</i> | | |
| Chicago & N. W. Railroad Co. | | Escanaba. |
| Delta County Highway Commissioner | Escanaba | Escanaba. |
| Biehler Bros. | | |
| Gogebic & Lake Superior | | |
| <i>Dickinson County</i> | | |
| Chicago & Northwestern R. R. Co. | | Antoine. |
| Chicago, Milwaukee & St. Paul R. R. Co. | | Iron Mountain. |
| <i>Eaton County</i> | | |
| Ralph W. Ballentine | Lansing, 309 W. Lapeer | Dimondale. |
| <i>Genesee County</i> | | |
| Nelson Carpenter | Byron | Byron. |
| Morehouse Bros. | Fenton | Fenton. |
| Flint Sandstone Brick Co. | Flint | Flint. |
| Ford Sales Co. | Flint | Flint. |
| E. A. Johnson | Swartz Creek | Flint. |
| Ford Goodrich | Grand Blanc | Goodrich. |
| Martin Stine | Grand Blanc | Goodrich. |
| Alfred Reid | Goodrich | Grand Blanc. |
| E. Bowles | Flint | Linden. |
| Nitz Bros. | Linden | Linden. |
| Geo. Sandson | Linden | Linden. |
| Bayer-Brice Gravel Co. | Linden | Linden. |
| | Flint, 701 Genesee Co. Sav. Bk. Bldg. | Mt. Morris. |
| Genesee Gravel Co. | Detroit, 1409 Ford Bldg | Mt. Morris. |
| City of Flint Gravel Co. | Flint, City Hall | Otisville. |
| Otisville Gravel Co., Lewis Kuehl | Saginaw | Otisville. |
| <i>Gogebic County</i> | | |
| Chicago & N. W. R. R. Co. | | Blenners. |
| <i>Gratiot County</i> | | |
| Emery Church | Alma | Alma. |
| A. Ray Colthorp | Breckenridge, Box 303 | Breckenridge. |
| James Dexter | Shepherd | Summerton. (near) |
| Elmon J. Evey | Sumner | Sumner. |
| A. E. Tomlin | Sumner | Sumner. |
| Wm. Wiles | Sumner, R. F. D. No. 2 | Sumner. |
| Willis Plank | | |
| <i>Hillsdale County</i> | | |
| Chas. Coler | Camden | Camden. |
| New York Central R. R. Co. | Cleveland, Ohio | Jonesville. |
| L. W. Thompson | Waldron | Waldron. |
| Nelson Wolcott | Hillsdale | Hillsdale. |
| <i>Huron County</i> | | |
| Garey, Conley Co. | Saginaw, 405 Bearinger Bldg. | Port Austin. |
| Port Crescent Sand & Gravel Co. | | |
| <i>Ingham County</i> | | |
| Central Michigan Gravel Co. | Lansing | Lansing. |
| Heller Bros. | Lansing | Lansing. |
| Frank Leonard & Co. | Charlotte | Lansing. |
| F. M. Stockman | Lansing | Lansing. |
| Hoyt Woodman | Lansing | Lansing. |
| Hugh Campbell & Son | Bay City, 1516 6th St. | Mason. |
| Charles Couch | Mason | Mason. |
| J. Hazel | Mason | Mason. |
| William Hazelton | Mason | Mason. |

SAND AND GRAVEL PRODUCERS IN 1923.—Continued.

| Operator. | Office. | Pit. |
|---|--|---|
| <i>Ingham County—Continued</i> | | |
| A. E. Sheltraw Michigan Railway Co. | Saginaw | Mason. Mason and Haslett. |
| Lansing Sand & Gravel Co. F. P. Leonard Michigan Central R. R. Co. | | |
| <i>Ionia County</i> | | |
| Fred W. Green | Ionia | Ionia. |
| J. I. Hazelitt | Ionia, R. F. D. | Ionia. |
| E. J. Elvert | Muir | Muir. |
| Glick's Gravel Co. | Lowell, R. F. D. No. 3 | Saranac. |
| Goode Bros | Caledonia | Saranac. |
| S. L. McIntyre | Lowell, R. F. D. No. 3 | Saranac. |
| <i>Iron County</i> | | |
| Chicago Mil. & St. Paul R. R. Co. | | Crystal Falls. |
| <i>Jackson County</i> | | |
| Alfred Cooper | Horton | Horton. |
| Wm. Blake | Jackson, R. F. D. No. 6. | Jackson. |
| Jackson Gravel Co. | Jackson | Jackson. |
| <i>Kalamazoo County</i> | | |
| Michigan Railway County Wm. A. Balch County Road Commissioner Kalamazoo-Greenville Gravel Co. Peter Molhock Casper Haas Nelson Concrete Culvert Co. Isaac Quick John Rysenga | Kalamazoo, 1425 Forbes St. Kalamazoo Kalamazoo Kalamazoo Kalamazoo Kalamazoo, 824 Parker St. Kalamazoo, 432 Drexel Blk | Augusta. Kalamazoo. Kalamazoo. Kalamazoo. Kalamazoo. Kalamazoo. Kalamazoo. |
| <i>Kent County</i> | | |
| Kent County Road Commissioner Percy Reed G. P. Scharl (County Pit) Mr. Neuman Richard J. Slater Rufus Overholt & Son Battjes Fuel & Mat. Co. G. W. Bunker Co. Grand Rapids Gravel Co. Harrison Land Co., Ltd. Michigan Railway Co. Valley City Stone & Gravel Co. Walker Ave. Gravel Pit Wyoming Sand & Gravel Co. John N. Coalter Fred Geers M. Kreggers High Ridge Gravel Co. Jos. Deiss Belmont Sand & Gravel Co. Township of Paris Pere Marquette Railroad Co. | Grand Rapids. Alpine. Caledonia. Ada, R. F. D. No. 1. Byron Center Grand Rapids Grand Rapids Gd. Rapids, 329 Mich Trust Bldg. Gd. Rapids, Cor. Pine and 4th Gd. Rapids, 135 E. Fulton St. Gd. Rapids, 1518 Walker Ave. Grand Rapids, R. R. No. 8 Kent City Kent City Kent City Rockford Sparta, R. F. D. 2 | Grand Rapids. Alpine. Caledonia. Cascade. Dutton. Grand Rapids. Grand Rapids. Grand Rapids. Grand Rapids. Grand Rapids. Grand Rapids. Grand Rapids. Grand Rapids. Kent City. Kent City. Kent City. Rockford. Sparta. |
| <i>Lapeer County</i> | | |
| Aug. W. Broecker Fred Miteen John F. Smith M. Caley Clayton Michael Willis Van Alstine | Goodrich Goodrich Goodrich Hunters Creek | Hadley. Hadley. Hadley. Hunters Creek. |
| <i>Lenawee County</i> | | |
| Frank Lowe Geo. Evans R. P. Gillespie Estate Lenawee Sand & Gravel Co. Tecumseh Gravel Co. Puritan Sand & Gravel Co. | Hudson N. Morenci Tecumseh Tecumseh Tecumseh | Hudson. N. Morenci. Clinton. Tecumseh. Tecumseh. |
| <i>Livingston County</i> | | |
| Detroit Greenville Gravel Co. Grand River Washed Sand & Gravel Co. Ohio & Mich. Sand & Gravel Co. Chas. R. Horton | Ann Arbor Toledo, Ohio, 1021 Nicholas Bldg. Detroit, 7054 Burwell Ave. | Brighton. Brighton. Chilson. Hamburg. |

SAND AND GRAVEL PRODUCERS REPORTING IN 1923—Continued

| Operator. | Office. | Pit. |
|---|---|--|
| <i>Macomb County</i> | | |
| Detroit Gravel & Ballast Co. Cadillac Builders Supply Co. | Detroit, 808 Det. Savings Bank Bldg. Detroit, 26 Campau Bldg. | Armada. Dredged from the lake. Mt. Clemens. Mt. Clemens. Mt. Clemens. Rochester. Utica. |
| Peters Bros. Lake Side Ice & Coal Co. H. Jacob Wacker Frank Yates Detroit Sand & Gravel Co. | Mt. Clemens. Mt. Clemens Mt. Clemens, 111 Rose St. Rochester Detroit, 35 McGraw Bldg. | |
| <i>Manistee County</i> | | |
| Hubbell Sand Co. George Szymanski M. A. Farr & Co. Manistee Sand Company | Manistee, R. F. D. No. 2 Chicago, Ill., 140 S. Dearborn St. | Manistee. Manistee. Onokama. |
| <i>Marquette County</i> | | |
| Champion Gravel Co. Lake Superior & Ishpeming | Marquette | Champion. |
| <i>Mason County</i> | | |
| Marion N. Fitch William A. Tobey Hubbell Sand Co. C. C. Dodge & Son H. B. Dunbar | Scottsville, R. F. D. No. 4. Free Soil Walhalla Tallman | Amber. Free Soil. Ludington. Walhalla. Tallman. |
| <i>Meecosta County</i> | | |
| Midland Gravel Co. | Midland | Millbrook. |
| <i>Menominee County</i> | | |
| Board of County Road Commissioners F. C. Nowack Co. John A. Schoen The Donner Company | Menominee 1316 Main Street Powers, R. F. D. No. 1. | Various Places. Menominee. Wilson. |
| <i>Montcalm County</i> | | |
| Belknap Cement Products Co. H. Anderson Alexander Kenny Frank H. Stark James Tuttle | Greenville Greenville Pierson Pierson Edmore | Greenville. Greenville. Pierson. Pierson. Edmore. |
| <i>Muskegon County</i> | | |
| Muskegon County Highway Dept. | Muskegon | Casnovia. |
| <i>Oakland County</i> | | |
| Dodge Bros. Julius Porath United Fuel & Supply Co. A. H. Park & Son J. Calverts Sons Charles Munzel Warner R. Thompson & Co. Standard Gravel Co. Detroit-Oxford Gravel & Stone Co. Ward Sand & Gravel Co. Boice Bros. Fred Parker C. L. Rockwell Rochester Sand & Brick Co. M. D. Ward Fuller Becker Co. | Detroit Detroit, 35 McGraw Bldg. Detroit, Free Press Bldg. Birmingham, R. F. D. No. 2. Detroit, McGraw Bldg. Farmington Detroit, 604 Kerr Bldg. Pontiac Oxford Detroit, Penobscot Bldg. Pontiac, 974 Orchard Lake Ave. Pontiac, R. F. D. No. 6. Pontiac, 180 Franklin Rd. Detroit. | Oxford and Rochester. Oxford. Oxford. Birmingham. Clarkston. Farmington. Goodison. New Hudson. Oxford. Oxford. Pontiac. Pontiac. Pontiac. Rochester. |
| <i>Oceana County</i> | | |
| A. O. Aldrich Twp. Board of Newfield Frank Wherle | Hart Hesperia Muskegon, 191 Grand Ave. | Crystal Valley. Hesperia. Rothbury. |
| <i>Osceola County</i> | | |
| Pere Marquette R. R. Co. Federal Sand & Gravel Co. Crescent Gravel Co. Hersey Gravel Co. | Reed City Hersey | Evart. Hersey. Hersey. |
| <i>Ogemaw County</i> | | |
| John Finerty | West Branch | West Branch. |

SAND AND GRAVEL PRODUCERS REPORTING IN 1923—Continued

| Operator. | Office. | Pit. |
|---|-----------------------------------|------------------|
| <i>Ottawa County</i> | | |
| John Holtrop | Ferrysburg | Ferrysburg. |
| Construction Materials Co. | Muskegon | Grand Haven. |
| I. Van Welden & Co. | Grand Haven, 609 Fulton St. | Grand Haven. |
| C. W. Bunce | Ravenna | Harrisburg. |
| Wallinger Bros. | | |
| D. J. Scharpshorn | | |
| Tom Johnson Gravel Co. | | |
| <i>Presque Isle County</i> | | |
| Alpena Gravel Co. | | |
| <i>Saginaw County</i> | | |
| H. C. Buckhardt | Bridgeport | Bridgeport. |
| Bridgeport Sand & Coal Co. | Saginaw | Orville. |
| Valley Sand Co. | Bay City, 612 Webster St. | Saginaw River. |
| Saginaw Brick Co. | | |
| <i>St. Clair County</i> | | |
| Superior Sand & Gravel Co. | Detroit, 926 Dime Bank Bldg. | Marine City. |
| C. A. Westrick & Son | Marine City | Marine City. |
| Reynolds & Bailey | Marysville | Marysville. |
| Mrs. Helena Baker | Memphis | Memphis. |
| Jas. Chapman | Memphis | Memphis. |
| Michigan Moulding Sand Co. (W. B. Sicker) | | |
| Warner R. Thompson Co. | Port Huron, 1928 Seventh St. | Port Huron. |
| L. Recor | Marine City | Port Huron. |
| Frank & Chester Kinney | Port Huron, R. F. D. No. 1 | St. Clair River. |
| McLouth Estate | | Wadham. |
| Thompson Tug Co. | Port Huron | Port Huron. |
| <i>Sanilac County</i> | | |
| Handy Bros. Mining Co. | Bay City | Decker. |
| George Carney | Sandusky, R. F. D. | Sandusky. |
| William Dawson | Sandusky | Sandusky. |
| <i>Shiawassee County</i> | | |
| Bert Martens | Bancroft | Bancroft. |
| George Clark | Byron, R. F. D. No. 2 | Byron. |
| William Dyer | Bancroft | Byron. |
| John Graham | Highland Park, 88 Geneva Ave. | Byron. |
| Allen Hathaway | Byron | Byron. |
| E. R. Darling | Carland | Carland. |
| John Frischke | Owosso | Owosso. |
| F. Hoyes | | |
| <i>Tuscola County</i> | | |
| Tom Hile | Caro, R. F. D. No. 2 | Caro. |
| Cass City Sand & Gravel Co. | Cass City | Cass City. |
| Tuscola Sand & Gravel Co. | Cass City | Cass City. |
| Gilbert Baker | Kingston | Kingston. |
| Lewis DeGrow | Kingston | Kingston. |
| Benson Whittaker | Kingston, R. F. D. No. 2 | Kingston. |
| A. C. Hess | | |
| <i>Van Buren County</i> | | |
| James Dowhens | Breedsville | Breedsville. |
| John Sherburn | Decatur | Decatur. |
| Dade & Bennett | Hartford | Hartford. |
| J. E. Wright | Lawrence | Lawrence. |
| Bennett & Parks | | |
| <i>Washtenaw County</i> | | |
| Board of County Road Commissioners | Ann Arbor, Box 124 | Ann Arbor. |
| Geo. Eddie | Ann Arbor, R. F. D. No. 8 | Ann Arbor. |
| Fred Fiegel | Ann Arbor, R. F. D. No. 3 | Ann Arbor. |
| William Schiller | Ann Arbor, R. F. D. No. 3 | Ann Arbor. |
| Mich. Central R. R. Co. | Detroit | Osborn Pit. |
| Fenkbeiner Bros. | Saline, R. F. D. | Saline. |
| Cadillac Sand & Gravel Co. | Toledo, Ohio, 1021 Nicholas Bldg. | Ypsilanti. |
| Ann Arbor Sand & Gravel Co. | | |

SAND AND GRAVEL PRODUCERS REPORTING IN 1923—Concluded

| Operator. | Office. | Pit. |
|-------------------------------|---------------------------------------|---------------------|
| <i>Wayne County</i> | | |
| Birmingham Sand & Gravel Co. | Detroit, 2690 E. Atwater St. | Detroit. |
| Cameron Steamship Co. | Detroit, Foot of Chene | River near Detroit. |
| F. D. Gleason Coal Co. | Detroit | Detroit. |
| W. J. Jaques Co. | Detroit, 1222 Parkview Ave. | Detroit. |
| Ontario Gravel Freighting Co. | W. Windsor, Ontario, 228 Sandwich St. | Detroit. |
| Michigan Pressed Brick Co. | Detroit, 4500 Lawton | Goodison. |
| Rockwood Silica Co. | Rockwood | Rockwood. |

TRAP ROCK (BASALT) PRODUCERS, 1923

| Operator. | Office. | Quarry. |
|-----------------------------------|----------------|------------------------------|
| <i>Dickinson County</i> | | |
| McKenna Bros. | Quinnesec | Quinnesec. |
| <i>Iron County</i> | | |
| Iron Co. Road Commissioners | Crystal Falls | N. W. of N. E. Sec. 7, 43-32 |
| W. S. Peters | Wakefield | Wakefield. |
| <i>Oakland County</i> | | |
| Standard Gravel Co. | Pontiac | Pontiac. |
| <i>Ontonagon County</i> | | |
| Blumgren, J. E. Estate | Norway | Bergland. |
| <i>Marquette County</i> | | |
| City of Negaunee | Negaunee | Negaunee. |
| Olivine Co. | Marquette | Marquette. |
| Beaver Granulith Co. | Negaunee | Negaunee. |
| City of Ishpeming | Ishpeming | Ishpeming. |
| Advance Industrial Supply Co. | Chicago, Ill. | Marquette. |
| City of Marquette | Marquette | Marquette. |
| Marquette Co. Road Commissioners | Marquette | Marquette. |
| Garvey Weyenberg Construction Co. | Appleton, Wis. | Marquette. |

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