

STATE OF MICHIGAN  
MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY

**Publication 29. Geological Series 24**  
**MINERAL RESOURCES OF MICHIGAN**  
WITH  
STATISTICAL TABLES OF PRODUCTION  
AND VALUE OF MINERAL PRODUCTS  
FOR  
**1918 AND PRIOR YEARS**

PREPARED UNDER THE DIRECTION OF  
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BIOLOGICAL SURVEY

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BOARD OF GEOLOGICAL AND BIOLOGICAL SURVEY FOR  
1918

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## LETTER OF TRANSMITTAL

*To the Honorable, the Board of Geological and  
Biological Survey of the State of Michigan:*

Gov. Albert E. Sleeper  
Hon. Frank Cody  
Hon. Fred L. Keeler

Gentlemen:—Under authority of act number seven, Public Acts of Michigan, Session of 1911, I have the honor to present herewith Publication 29, Geological Series 24, the eighth of a series of annual statements of the production and value of the mineral products of Michigan.

Very respectfully,  
R. C. ALLEN,  
*Director.*

## PART I. METALLIC MINERALS

### THE MICHIGAN COPPER INDUSTRY IN 1918

L. P. BARRETT

#### GENERAL REVIEW

According to the preliminary report for 1918 on the mineral resources of the United States published by the United States Geological Survey, the smelter production of refined copper for the United States was 1,908,533,595 pounds, an increase of 22,412,874 pounds or 1.17 percent over the production of 1917. The figures for the mine production which always differ slightly from the smelter production, are not yet available. The average price received for all copper sold was 24.7 cents per pound.

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The smelter output for Michigan was 231,096,158 and the mine production, 228,173,863 pounds. Sales of copper totaled 240,714,297 pounds at an average price of 24.38838 cents per pound or \$58,706,317.46. Silver production in 1918 amounted to 473,341.94 ounces which sold for \$1.06518 per ounce or \$504,480.11. The gross sum received from sale of all metal was \$59,210,797.57 or 24.59795 cents per pound copper sold.

The chief features of the copper industry in 1918 were the continuation of mounting costs and the fixing of the sale price of the metal by the United States Government at 23.5 cents per pound for the first half of the year and at 26 cents for the last six months.

We present a table compiled from the reports of the mining companies to the Board of State Tax Commissioners, showing the average costs per ton of twenty-one principal producing companies for the period of the last eight years. This table presents some interesting facts relative to costs in the Michigan copper district. The cost per pound in 1911 excluding exploration, development, construction, and interest charges, was 9.38040 cents and the cost per pound in 1918 excluding charges previously mentioned and also depreciation, depletion, and Federal taxes was 15.87972 cents, an increase of 6.49932 cents or 69.2 percent. Milling, smelting, and refining costs increased from 2.28828 cents per pound in 1911 to 4.34628 cents per pound in 1918, an increase of 89.9 percent. Mining costs per pound in 1911 were 6.06801 cents and in 1918, 9.88072 cents, an increase of 62.8 percent. Selling costs increased from 0.30017 cents to 0.44558 cents or 48.4 percent and general expenses including general offices, State taxes, insurance, and legal expenses advanced from 0.72394 cents in 1911 to 1.20714 cents in 1918, an increase of 66.7 percent. The relatively small increase in cost of mining as compared with the general advance of costs in all commodities is a tribute to the efficiency and management of the Michigan copper mines. This is especially noticeable when it is considered that wages have more than doubled, that the mines are continually getting deeper, and that the grade of ore is practically the same as in 1911.

Until 1917 depreciation and depletion seldom appeared as costs on the books of the mining companies. These charges are now made by practically all mining companies as a direct result of the Federal income and excess profit tax laws. These items are responsible for approximately 1.5 cents per pound increase in costs.

Thirteen companies paid dividends in 1918, totaling \$15,872,269. This is a decrease of \$12,168,757 from dividend payments in 1917.

#### *DETAILS OF MINING COMPANIES*

##### *Adventure Consolidated Copper Company*

Office: 32 Broadway, New York City.

Mine office: Mass, Ontonagon County, Michigan.

President: W. Parsons Todd.

Secretary and Treasurer: W. A. O. Paul.

Superintendent: M. R. Hore.

The Adventure Mine has been closed since October, 1917. The annual report for the year 1918 shows a deficit of \$11,295.33.

##### *Ahmeek Mining Company*

Office: 12 Ashburton Place, Boston, Massachusetts.

Managing office: Calumet, Michigan.

Mine office: Kearsarge, Keweenaw County, Michigan.

President: Rudolphe L. Agassiz.

Vice President and General Manager: James MacNaughton.

Secretary and Treasurer: Clarence R. Bissell.

Superintendent: S. Russell Smith.

Ahmeek mined 1,196,541 tons of rock which yielded 24,851,235 pounds of refined copper, an average of 20.8 pounds refined copper per ton. This is a decrease of 3,068,577 pounds from the production of 1917. The Company had 8,620,222 pounds of copper on hand January 1, 1918 and sold during the year 28,597,173 pounds, leaving a balance of 4,874,284 pounds of copper on hand January 1, 1919.

The total cost of production, exclusive of selling was \$3,552,-829.88 or 14.30 cents per pound copper produced during 1918. The gross receipts from sale of metal was \$6,950,160.69 or an average of 24.30 cents per pound. The total cost of production and delivery of the 28,597,173 pounds of copper delivered in 1918 was \$3,842,019.44 or 13.43 cents per pound. The gain on copper delivered was 10.87 cents per pound or \$3,108,141.25. The net income from all sources was \$3,174,625.32. During the year \$1,600,000 was declared and paid in dividends and \$1,640,000 set aside to meet estimated Federal taxes.

No. 1 shaft is bottomed 43 feet below the 22d level. No sinking was done at this shaft. Openings and stopes show average ground except on the 10th, 11th, 14th and 16th levels south beyond the distributed area; at these points the lode is below average and bumpy.

No. 2 shaft is 165 feet below the 25th level. Openings are of average quality for this part of the mine. Work on the mass copper fissure was limited because of the shortage of labor and lack of compression capacity. Advances were made on the 11th and 16th levels west and stoping done on the 10th, 14th, 16th and 17th levels west and on the 18th level east. The mass copper fissure was encountered on the 20th and 21st levels north of No. 2 shaft with a good showing of copper at both points. One electric pump was installed on the 11th and one on the 21st level. These pumps are handling all of the water at this end of the mine which was formerly handled by eight air pumps.

No further work was done on Kearsarge Conglomerate because of the shortage of labor.

No. 3 shaft is bottomed 322 feet below the 20th level in hanging wall trap. All of the opening and stopes showed average ground.

On July 15 a fire broke out in No. 3 shaft which necessitated the closing down of the north end of the mine and the sealing of both No. 3 and No. 4 shafts. On July 20 an attempt was made to reopen this part of the mine but it was found that the fire was still burning and it was necessary to again seal the shafts. On July 30 the shafts were again opened. Inspection showed that timbers for 180 feet in the 80° portion of the shaft and the concrete sets for 200 feet above the 6th level had been destroyed. Repairs were made as rapidly as possible but it was not until January 17, 1919 that hoisting could be resumed.

No. 4 shaft is 185 feet below the 20th level with two feet of average lode exposed on the hanging wall side. In continuing the drift north on the 15th level the turn of the lode to the east (mentioned in the 1917 report) was found to be local; the lode has again turned west and it has been found necessary to resume drifting on the 14th level. All of the openings and stopes are of average quality for this section of the mine.

Three storage battery locomotives for tramming have been installed at No. 2 shaft, two at No. 3 shaft and five at No. 4 shaft, all of which are giving satisfactory results.

The high rate of wages, abnormal cost of supplies, together with shortage of men and decreased output due to the fire in No. 3 shaft account for increased cost of production over 1917.

The existing system of figuring wages on the old base rates to which was added a premium of 10 percent and a bonus of 50 cents per day was discontinued on May 1 and new base rates were established. These rates were arrived at by adding 15 percent and 50 cents per day to the old base rates. On October 1 there was a second increase in wages of from ten to thirty percent; the larger rate of increase applying to the lower rate of wages.

#### Algoma Mining Company

Office: 60 Congress Street, Boston, Massachusetts.  
Mine office: Lake Mine, Ontonagon County, Michigan.  
President and General Manager: R. M. Edwards.  
Secretary: Albert L. Wyman.  
Treasurer: Henry Tolman.  
Superintendent: Thomas Bennett.

The Algoma Mine was idle during 1918.

#### Allouez Mining Company

Office: 12 Ashburton Place, Boston, Massachusetts.  
Mine office: Allouez, Keweenaw County, Michigan.  
President: Rudolphe L. Agassiz.  
Vice-President and General Manager: James MacNaughton.  
Secretary and Treasurer: George G. Endicott.  
Superintendent: F. W. Ridley.

Total production of the Allouez Mine in 1918 was 514,888 tons of rock yielding 7,071,218 pounds of refined copper, an average of 13.73 pounds per ton. This is a decrease of 1,821,697 pounds from the production of 1917 and a decrease of 1.96 pounds of refined copper per ton. The total cost of production, excluding selling, was \$1,394,950.21 or 19.73 cents per pound. This represents an increase of 6.26 cents per pound over 1917. The company had 1,553,627 pounds of copper on hand December 31, 1917 and sold 7,266,393 pounds during 1918, leaving a balance of 1,358,442 pounds on hand December 31, 1918.

The total cost of copper sold in 1918 was 19.09 cents per pound or \$1,386,882.09 and the gross sum received for copper sold, \$1,779,253.32 or 24.49 cents per pound, leaving a gain on copper sold of 5.40 cents per pound or \$392,371.23. The balance of miscellaneous charges and receipts amounted to \$30,886.74, leaving a net income of \$361,484.49.

During 1918 Allouez paid \$600,000 in dividends.

No. 1 shaft was sunk to a point 72 feet below the 22d level and the skip road completed to that level. The ground passed through continued bad and on this account the progress of the shaft has been somewhat retarded. Drifting on territory tributary to this shaft disclosed average ground except on the 20th level north, which in being holed through to No. 2 shaft opened ground below the average in copper contents. Storage batteries for tramming have been installed on the 19th and 20th levels.

No. 2 shaft was not sunk during 1918. The new openings tributary to this shaft are of average quality. Stopping operations on the 14th, 15th, 16th and 17th levels north yielded a grade of rock somewhat lower than the average. The stopes on the 17th level south yielded rock above the average. A new electric locomotive of the trolley type was installed on the 18th level.

In order to secure better water for boiler feed connection was made with the Ahmeek village water system with satisfactory results. One new boiler was installed.

The fourth unit of Mill No. 2 of the Lake Milling, Smelting and Refining Company at Hubbell went into commission October 22 and since that date all Allouez rock is stamped at this plant.

There were two wage increases, on May 1 and October 1. For details see Ahmeek.

#### Baltic Mining Company (See Copper Range)

#### Calumet and Hecla Mining Company

Office: 12 Ashburton Place, Boston, Massachusetts.  
Mine office: Calumet, Michigan.  
President: Rudolphe L. Agassiz.  
Vice-President and General Manager: James MacNaughton.

Secretary and Treasurer: John F. Perkins.  
Superintendent: John Knox.

The copper product for the year was 67,968,357 pounds divided among the various operations as follows:

|                    | Tons      | Pounds<br>Copper | Pounds<br>per Ton |
|--------------------|-----------|------------------|-------------------|
| Conglomerate lode  | 1,547,603 | 43,329,816       | 28.00             |
| Amygdaloid lode    | 1,328,789 | 15,393,153       | 11.58             |
| Conglomerate sands | 715,007   | 9,245,388        | 12.93             |

The total production costs, excluding selling, were \$14,310,670.54 or 21.05 cents per pound. Mining and milling costs including State taxes for the different operations were as follows: Mine 15.01 cents; reclamation plant 7.20 cents; average for all operations 13.95 cents. Smelting, refining, eastern office and corporation taxes 1.76 cents; depreciation and depletion 5.34 cents.

There were 17,967,381 pounds of copper on hand January 1, 1918. 78,367,245 pounds were sold during 1918, leaving a balance on hand January 1, 1919 of 7,568,490 pounds.

The gross sum received for copper delivered in 1918 was \$19,027,052.27 and the average price per pound was 24.28 cents. The total cost, including selling, of copper delivered in 1918 was \$15,507,297.21 or 19.79 cents per pound. The gain on copper delivered was \$3,519,755.06 or 4.49 cents per pound.

The balance of miscellaneous charges and receipts was \$1,429,441.01 and the net income for 1918, \$4,949,196.07. During the year the Calumet and Hecla Mining Company paid \$5,500,000 in dividends and had a balance of current assets on December 31, 1918 of \$12,565,925.76,

#### *Conglomerate Lode*

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

Calumet No. 5 and 6, 155 feet to boundaries of 60th level.

Calumet No. 4, 7,995 feet, boundary 81st level.

Calumet No. 2, 6,186 feet; permanently bottomed 63d level.

Slope shaft, 1,588 feet below 57th level or 185 feet under 66th level.

Hecla No. 6, 7,874.6 feet; 32.7 feet under 80th level.

Hecla No. 7, 7,977.7 feet; 40 feet under 81st level.

South Hecla No. 8, 6,102 feet; second permanently discontinued at 63d level.

South Hecla No. 9 and No. 10, 8,132.7 feet; 142 feet under 82d level.

Red Jacket Shaft, 4,900 feet; 100 feet under 81st level.

Tamarack No. 3, 5,253 feet; 29.5 feet from 18th level.

Tamarack No. 3, (incline) 616 feet below 18th level; 8 feet below 24th level.

Tamarack No. 5, 5,308.5 feet; 147 feet below the 40th level.

About 81 drills were worked during the year, moving shaft pillars and cleaning up arches and the backs of old stopes. A total of 477,541 tons was from operations,

In the Calumet Branch the 40th level drift north of No. 6 shaft was extended 600 feet opening up a fair grade of rock.

In the Hecla Branch drifts in the lode have been advanced 2,261 feet disclosing rock of average copper content.

In the South Hecla Branch the drifts were in average rock. No. 11 shaft pillars have been all removed and the shaft is abandoned.

Drifts in the Red Jacket shaft branch disclosed 409 feet of fair rock and 905 feet of poor rock, and in the Tamarack Branch 1,411 feet of fair grade rock and 265 feet of poor rock.

Because of the excessive cost of maintaining No. 6 and No. 7 Hecla, No. 9 and No. 10 South Hecla, it was decided to discontinue sinking at these points. In order to reach the ground lower down in this end of the mine, a haulage level (at the elevation of the 80th level) connecting this territory with Red Jacket shaft is being driven in an amygdaloid lode 180 feet under the conglomerate. This haulage level when completed will have a total length of 7,800 feet, 2,826 feet of which have been driven. From this hauling level, sub-shafts will be sunk through which the lower part of the conglomerate can be mined. All of the product obtained from these lower workings will be trammed by power to the Red Jacket shaft.

#### *Osceola Lode*

The operating shafts on the Osceola lode have attained the following depths:

|        |           |
|--------|-----------|
| No. 13 | 3232 feet |
| No. 14 | 2958 feet |
| No. 15 | 3002 feet |
| No. 16 | 3274 feet |
| No. 17 | 2279 feet |
| No. 18 | 1460 feet |

The openings on this lode show about the same grade of rock as last year. The products obtained from the foot-wall stopes were about 22.5 percent of the total product from this branch. Fourteen storage battery locomotives were installed during 1918.

No work was done on the Kearsarge lode, Manitou—Frontenac, or St. Louis Branches during 1918.

### Stamp Mill

At the Stamp Mill the new steam turbine went into commission and the new office building was completed. The size units of the Hecla mill stamping conglomerate rock were remodeled and the slimes made are being treated by flotation replacing the round-table system. The remodeling of No. 1 regrinding plant is completed. It now operates twenty-four large Hardinge mills. During the year the following were obtained from the regrinding plant:

|                                               | From<br>Mines | From Old<br>Sands |
|-----------------------------------------------|---------------|-------------------|
| Tons treated                                  | 530,657       | 715,007           |
| Assay headings                                | .599          | .868              |
| Assay tailings                                | .414          | .568              |
| Pounds refined copper                         | 2,243,022     | 4,776,392         |
| Pounds refined copper (per ton treated)       | 4.23          | 6.68              |
| Cost per pound excluding smelting and selling | 6.75          | 4.33              |

### Leaching Plant

The results during 1918 at the leaching plant were as follows:

|                                                        |           |
|--------------------------------------------------------|-----------|
| Assay headings                                         | .535      |
| Assay tailing                                          | .126      |
| Pounds refined copper                                  | 8,035,156 |
| Pounds refined copper (per ton treated)                | 8.        |
| Cost per pound copper (excluding smelting and selling) | 7.71      |

During 1918 there were two wage increases taking effect May 1 and October 1. These increases are similar to those made elsewhere in Calumet and Hecla group and are fully described under "Ahmeek."

#### Centennial Copper Mining Company (Subsidiary of Calumet Hecla Mining Company)

Office: 12 Ashburton Place, Boston, Mass.  
Mine office: Calumet, Houghton Co, Michigan  
President: Rudolph Agassiz.  
Vice-President and General Manager: James MacNaughton  
Secretary and Treasurer: C. H. Bissell.  
Superintendent: F. W. Ridley.

During 1918 Centennial Produced 159,040 tons of rock which yielded 2,492,857 pounds of refined copper or 15.67 pounds per ton. This is an increase of 490,000 pounds over 1917. Production costs exclusive of selling were \$464,888.49 or 18.65 cents per pound. The company had on hand January 1, 1918, 318,215 pounds of copper and sold during 1918, 2,048,762 pounds leaving a balance on hand December 31, 1918 of 562,310 pounds.

The gross sum received for copper delivered was \$553,373 69. The total production costs on copper sold

were \$429,639.88 leaving a net gain on copper delivered of \$123,733.81. Miscellaneous receipts were \$5,061.05 and the total net income \$128,794.86

During 1918 Centennial Copper Mining Company paid \$100 000 in dividends and closed the year with a balance of current assets of \$430,716.82.

No. 1 shaft was used only for handling men and supplies. No. 2 shaft is bottomed below the 40th level. All hoisting is through this shaft. The rock mined during 1918 was of better quality than that mined during the previous year, but the new openings extending to the north on the 37th, 38th and 39th levels disclosed grounds slightly below the average in quality.

Since the completion of the 4th unit at No. 2 mill of the Lake Milling Smelting and Refining Company at Hubbell, all Centennial rock has been stamped at this plant.

In common with other subsidiaries of the Calumet and Hecla Mining Company there were two wage increases effective May 1 and October 1.

#### Champion Copper Company

Office: 82 Devonshire Street, Boston, Mass.  
Main office: Painsdale, Michigan.  
President: Wm. A. Paine.  
Secretary and Treasurer: F. W. Paine.  
General Manager: Wm. H. Schacht.

The production of the Champion Copper Company was 594,235 tons yielding 21,748,514 pounds of refined copper or 36.59 pounds refined copper per ton. This yield per ton is the highest of any of the Michigan Copper Mining Companies. The gross sum received from sale of copper was \$5,408,068.21 and the total costs were \$2,616,267.83 leaving a net gain of \$2,791,800.38. During 1918 the Champion Copper Company paid \$1,280,000.00 in dividends. The financial statement of the company indicates a balance of assets for December 31, 1918 of \$2,079,762.35.

During the year No. 2 shaft was sunk 95 feet, the total depth is now 2,463 feet and the bottom level, 22d. There was no sinking as Nos. 1, 3 and 4 shafts. The depths of these shafts and the bottom levels are as follows:

|       |                       |
|-------|-----------------------|
| No. 1 | 2,514 ft., 23d level  |
| No. 3 | 2,339 ft., 21st level |
| No. 4 | 2,388 ft., 22d level  |

The total tons of rock hoisted was 618,572 of which 24,337 tons or 3.9 were discarded. The mine showed a decrease of production of 5,801,829 pounds from 1917. This falling off in production was due to the shortage of labor which was a common difficulty in all the Michigan Copper Mines in 1918. The ground opened up in development work was of average quality.

### Cherokee Copper Company

Office: Houghton, Michigan.

Mine office: Winona, Houghton Co., Mich.

President: W. A. Hodgson.

Secretary and Treasurer: Wm. D. Calverly.

The Cherokee Mine was closed during 1918.

### Cliff Mining Company

(Subsidiary of Calumet & Hecla Mining Co.)

Office: 12 Ashburton Place, Boston, Mass.

Operating Office: Calumet, Michigan.

President: Rudolph L. Agassiz.

Vice-President: James McNaughton.

Secretary and Treasurer: C. H. Bissell.

This property has been idle since 1915; the last work consisting of diamond drilling to explore territory lying eastward toward the Eastern Sandstone. The Cliff is the first mine ever opened on native copper and the production in 1845 was 19,903 pounds which was the output of the Lake Superior Region. The last active mining was in 1878. Since that time there have been occasional operations by tributers.

### Contact Copper Company

Office: 70 State Street, Boston, Mass.

Mine office: Houghton, Michigan.

President: Harry F. Fay.

Secretary and Treasurer: C. J. Morrissey.

Superintendent: G. S. Goodale.

This property was idle during 1918.

### Copper Range Company

Office: 682 Devonshire Street, Boston, Mass.

Mine office: Painsdale, Michigan.

President: Wm. A. Paine.

Vice-President: F. W. Denton.

Secretary and Treasurer: F. W. Paine.

General Manager: W. H. Schacht.

The total production of the Copper Range Company was 37,498,197 pounds of copper. The net operating income was \$2,895,615.28 and the dividends paid during the year were \$6.00 per share or \$2,666,394.00. The company closed the year with a balance of assets of \$6,007,528.92. The following comparative statement includes the Baltic, Tri-Mountain Mines and one-half Champion.

|                                          |            |
|------------------------------------------|------------|
| Tons of rock stamped                     | 792,151    |
| Pounds of refined copper produced        | 26,623,940 |
| Pounds of refined copper per ton stamped | 33.61      |
| Total cost per pound                     | 14.46c     |
| Average price received per pound         | 24.76c     |
| Profit per pound                         | 10.30c     |

The same features which caused high cost of production in 1917 were present in still more aggravated form in 1918. The number of men employed was reduced some

fifteen percent compared with the number of men working in 1917 and the wages were further increased twice during the year. This shortage was partly confined to the underground force. The yield of copper per ton of rock was maintained in spite of the shortage of labor as the underground method was not changed but many stopes and other places from which production is made, remained idle.

At the Baltic Mine the shortage was not serious but at the Champion and Trimountain it was responsible for a large drop in output.

#### PRODUCTION

|             |                 |
|-------------|-----------------|
| Champion    | 21,748,514 lbs. |
| Baltic      | 10,406,097 lbs. |
| Trimountain | 5,343,586 lbs.  |
| Total       | 37,498,197 lbs. |

#### Decrease from previous year

|             |                |
|-------------|----------------|
| Champion    | 5,801,829 lbs. |
| Baltic      | 808,764 lbs.   |
| Trimountain | 934,511 lbs.   |
| Total       | 7,545,104 lbs. |

The total cost per pound for the different mines was as follows:—

|                          |        |
|--------------------------|--------|
| Baltic                   | 15.07c |
| Trimountain              | 18.42c |
| Champion                 | 11.92c |
| Average for Copper Range | 14.46c |

Depletion and depreciation charged against 1918 production amounted to \$903,832.41 or 3.4 cents per pound of copper produced. The Federal, income and excess profit taxes paid in 1918 on account of 1917 profits of the Copper Range Company aggregated \$711,-905.45. This was provided for out of the surplus carried over from the 1917 income. The total taxes of all sorts paid in 1918 amount to \$1,489,500.62.

At the Baltic Mine No. 3 shaft was sunk 178 feet and has now reached a total depth of 3,498 feet on the 36th level. No sinking was carried on in No. 2 and 4 shafts. The former is 2,839 feet deep and the bottom level is 29th and the latter is 2,982 feet deep and the bottom level the 31st. During the year 4,222,085 tons were hoisted; 128,484 tons or 30 percent was discarded and 293,601 tons were stamped. The yield of copper per ton stamped being 34.44 pounds. Most of the rock came from the main lode with No. 2 shaft the largest producer. Most of the rock from the West lode came from No. 5 territory.

Hoisting from No. 5 shaft was discontinued in May and rock from No. 5 territory is hoisted through No. 4 shaft. There has been no change in the ground opening to No. 3 and 4 shafts. No. 2 shaft continues in rock of average quality.

At the Trimountain Mine No. 2 shaft was sunk 159 feet to a total depth of 3,125 feet. Its bottom level is the 30th.

No. 3 shaft is still bottomed at 2,563 feet on the 24th level. No. 4 shaft was sunk 154 feet and has now reached 3,007 with its bottom level the 29th.

The tons of rock hoisted during 1918 from the Trimountain Mine were 252,545 of which 51,112 tons or 20 percent were discarded and 201,433 tons sent to the stamping mill. The yield of copper per ton of rock stamped was 26.52 pounds. The openings made during the year were in ground of average quality.

#### Franklin Mining Company

Office: 60 Congress Street, Boston, Mass.

Mine Office: Demmon, Michigan.

President: R. M. Edwards.

Secretary: Albert L. Wyman.

Treasurer: Henry Tolman.

Superintendent: Enoch Henderson.

Franklin produced 2,827,313 pounds of refined copper in 1918. The treasurer's statement shows a total income of \$697,671.84. This includes 377,708 pounds of copper on hand December 31, 1918, inventoried at 20 cents per pound.

Mining expenses were \$710,750.55, smelting \$62,224.57, Total, \$806,795. The deficit for the year was \$109,123.16.

The production record for 1918 's as follows:

|                        |           |
|------------------------|-----------|
| Tons rock hoisted      | 296,182   |
| Discard                | 22,218    |
| Tons rock stamped      | 273,964   |
| Pounds copper produced | 2,827,313 |
| Pounds copper per ton  | 10.32     |

Twenty-five percent of the rock produced came from the Pewabic lode and 75 percent from the Allouez conglomerate.

During the year, No. 2 Conglomerate shaft was sunk 253 feet and the total of new openings aggregated 2,149 feet. In general the openings during the year were encouraging, particularly the openings on the Allouez conglomerate of the 18th and 19th levels. The openings on the Pewabic level were also in ground that promises to yield more copper than heretofore encountered in this lode.

A crosscut was driven west from No. 1 shaft on the 37th level and cut the "west lode" at a distance of 227 feet. The lode was then opened by drifts for a distance of 172 feet. In portions of the drift the showing was encouraging but in general the lode was "spotty," narrow and unprofitable.

Because of the excessive cost of labor and supplies, construction was kept as low as possible. An electric coal rig to convey coal from the stock pile to No. 1 boiler house was built in the company's shops and put in service and an experimental regrinding plant consisting of one Hardinge mill, 75 H. P. motor and six Wilfley

tables were set up but were not put into operation on account of a delay in the shipment of some of the electrical equipment.

In general the operations of the company were most adversely affected by conditions due to the War, the most serious factor being the shortage of miners which prevented the mining of sufficient tonnage for economical operation. At no time was the mine operating at better than 66 percent capacity.

#### Hancock Consolidated Mining Company

Office: Hancock, Michigan.

President: John D. Cudahy.

Secretary and Treasurer: John H. Hicock.

Superintendent: Clyde E. Weed.

Hancock produced 227,049 tons of rock which yielded 3,041,514 pounds of refined copper an average of 13.4 pounds per ton.

The treasurer's statement for the year shows receipts from the sale of 3,774,166 pounds of copper, \$917,092.48. Disbursements totaled \$869,540.98 leaving a profit on the year's operation of \$47,551.50. The balance sheet of the company shows a deficit on December 31, 1918, of \$203,066.18.

The Hancock operated through No. 2 shaft of the Hancock and also through No. 7 shaft of the Quincy mine.

Sixty-two and five-tenths percent of the rock hoisted from No. 2 shaft came from No. 4 vein west, which was worked from the 44th to 53rd level. This vein showed about its average mineralization. New openings on this vein aggregated 2,117 feet. No. 1 west vein showed a good mineralization and furnished 13.7 of the product from No. 2 shaft. New openings on this vein totaled 508 feet.

The Pewabic vein continued to maintain a good showing but the hanging wall gives trouble. Seven pounds of No. 2 shaft production came from this vein.

On the 53d level a crosscut was driven 611 feet east and cut two mineralized veins first located by diamond drilling in 1917. The first was narrow and only 75 feet of drifting was done but the second, called No. 3 east, showed some good mineralization and 571 feet of drift were driven while 10.2 percent of rock hoisted came from this vein.

Another east crosscut on the 49th level 428 feet long intersected two amygdaloids, called No. 1 and No. 2 east. No. 1 east produced 5.7 percent of rock tonnage. No. 2 east is very similar to No. 1 but as this was reached toward the end of the year, only a small production, 0.9 percent was obtained. The total new openings tributary to No. 2 shaft were 3,713 feet of drifting, 1,180 feet of crosscutting and 78 feet raising.

No. 7 shaft Quincy underleased to Hancock was operated until May 31, when it was closed on account of labor shortage. A total production of 34,920 tons from

this shaft came from two veins, No. 1 west and the Pewabic. The latter furnishing 78.7 percent.

In common with all the mines, Hancock was troubled by high costs and a shortage of labor. Two wage increases were granted—an increase of 9.3 percent May 1 and 15 percent October 1.

The copper content of rock from No. 2 shaft showed an improvement of 0.8 pound per ton. No construction of importance was carried on.

#### Indiana Mining Company

Office: 60 Congress Street, Boston, Massachusetts.  
Mine office: Lake Mine, Michigan.  
President: R. M. Edwards.  
Secretary: A. L. Wyman.  
Treasurer: Henry Tolman.  
Superintendent: Thomas Bennett.

This property was idle during most of 1918. A small amount of exploratory work was done at No. 2 shaft.

#### Isle Royale Copper Company

Office: 12 Ashburton Place, Boston, Mass.  
Managing Office: Calumet, Michigan.  
Mine Office: Houghton, Michigan.  
President: Rudolph L. Agassiz.  
Vice-President and General Manager: James MacNaughton.  
Secretary and Treasurer: Clarence L. Bissell.  
Superintendent: James Richards.

The Isle Royale Mine produced 974,508 tons of rock which yielded 15,442,508 pounds of refined copper, an average of 15.9 pounds per ton. Isle Royale entered the year with 3,244,274, and 18,686,782 pounds were sold during 1918, leaving a balance on hand December 31, 1918 of 3,922,064 pounds.

The cost of production exclusive of selling, was 16.51 cents or \$2,549,957.31. Selling costs were .49 cents per pound. The total cost of production on copper delivered was 16.80 cents per pound, and the gain on copper delivered during 1918, \$1,130,312.15. Silver sales amounted to \$80,743.43 and the balance of miscellaneous income and charges brought the total net income to \$1,219,404.41.

The Isle Royale Copper Company paid \$375,000 in dividends during 1918. The company closed the year with a balance of assets of \$1,134,332.21.

No sinking was done at No. 1 shaft. The water pocket mentioned in annual report for 1917, was located and drained. Total openings consisted of 1,171 feet of drifting, 208 feet of drift stoping and 51 feet of crosscutting. Drifts indicate 45 percent of ground opened can be stoped.

The bottom of No. 2 lode is in trap between the two lodes 62 feet below the 33d level or 3,650 feet from surface. Openings for year were 47 feet of shaft, making 1,906 feet of drifting, 159 feet of drift stoping and 143

feet of crosscutting. Drifts indicate 55 percent of this ground may be available for stoping.

No. 4 shaft is bottomed in lode of average quality 70 feet below the 19th level or 2,512.5 feet from surface. Openings for the year were 2,576 feet of drift stoping, 227 feet of drifting and 30 feet of crosscutting. About ninety of the openings disclosed copper ground and will be tried for stoping. The old Huron Mine has been completely drained of water. Storage battery locomotives for draining were installed on the 11th, 12th, 13th and 14th levels.

Sinking was resumed at No. 5 shaft in December. The year closed with the bottom of the shaft in foot wall trap, eighty-four feet below the 16th level or 2,118 feet from the surface. The openings for the year included 12 feet of shaft making, 555 feet of drifting, 1,095 feet of drift stoping and 173 feet of crosscutting. About 80 percent of the ground appears to be suitable for stoping. Storage battery locomotives were installed on the 10th, 11th, 12th and 13th levels.

No. 6 shaft is bottomed in the lode 38 feet below the 19th level, or 2,304.5 feet from surface. The openings consisted of 15 feet of shaft sinking, 389 feet of drifting, 413 feet of drift stoping and 30 feet of crosscutting. About 60 percent of new ground appears to be of commercial value. Storage battery locomotives were installed on the 10th, 12th, 13th and 14th levels.

No. 7 shaft is bottomed in foot trap 66 feet below the 9th level or 1,201.5 feet from surface. The year's openings consisted of 10 feet of shaft sinking, 1,618 feet of drifting, and 1,665 feet of drift stoping. About one-half of this appears to be stoping ground.

Two new boilers (making a total of five) were installed at No. 6 boiler house. A 6-inch air line was laid connecting No. 2 and No. 4 compressor plants and a 7-inch air line connecting No. 4 and No. 6 compressor plants, the object being to maintain a more uniform air pressure throughout the mine.

In common with the other subsidiaries of the Calumet and Hecla Mining Company, there were two wage increases on May 1 and on October 1.

#### Keweenaw Copper Company

Office: Calumet State Bank Building, Calumet, Mich.  
President: Thomas F. Cole.  
Secretary and Treasurer: F. W. Taylor.

No mining or exploration was carried on during the year on the property of this company. Equipment and rails of the Mandan Lac La Belle branch of the Keweenaw Central Railroad Company, were disposed of and the proceeds invested in Liberty Bonds—\$200,000.00 of the first issue and \$25,200 of the fourth issue.

#### Lake Copper Company

Office: 85 Devonshire St., Boston, Mass.  
Mine Office: Lake Mine, Ontonagon County, Michigan  
President: William A. Paine.

Secretary and Treasurer: Robert H. Gross.  
Superintendent: C. J. McKie (resigned).

Lake Copper Company produced 717,403 pounds of copper during 1918. The total receipts for the year were \$178,318.15 and expenditures, \$246,006.59, leaving a net loss on the year's operation of \$110,688.08. The books of the company show a surplus of \$220,-836.96 on April 30, 1919.

Mining operations were suspended January 31, 1919, owing to the low price of copper and high cost of labor and supplies.

The result of operations at the Lake shaft on the Lake lode, were disappointing. According to the report of General Manager McKie, the new stopes in this ground showed a steadily decreasing copper content and five or six tons had to be discarded for every ton shipped.

The exploration on the Evergreen which runs in the northern part of the property, was much more satisfactory. During the year the openings on this vein were 121 feet of drifting and 22 feet of raising on 6th level end Butler, 390 feet of crosscutting to the Evergreen lode, 513 feet of drifting on the End Evergreen and 158 feet on the west Evergreen.

Mr. McKie's statement regarding the result of operation on the Evergreen lode is as follows: "This drifting on the Evergreen lode has been very encouraging, especially on the east side. We have started one stope over 200 feet long on this lode. Following are the results of four tests on this Evergreen rock:

December 5, 1918, 246 tons yielding 7,020 pounds copper, or 28.54 pounds per ton.  
January 18, 1919, 574 tons yielding 12,990 pounds copper, or 22.63 pounds per ton.  
October 19, 1918, 451 tons yielding 15,705 pounds copper, or 34.82 pounds per ton.  
January 2, 1919, 492 tons yielding 8,860 pounds, copper, or 18.01 pounds per ton.

"The rock for these tests was not picked underground, but was roughly picked on the surface as it was being loaded and hauled to cars. I consider this Evergreen showing the best we have had on this series so far. There is another lode about 250 feet in the foot of the Evergreen lode. This lode out-crops at the Trissides shaft and has a good surface showing. I think it would be wise to crosscut to this lode whenever the Knowlton shaft is reopened."

#### La Salle Copper Company

Office: 12 Ashburton Place, Boston, Mass.  
Mine office: Calumet, Michigan.  
President: Rudolphe L. Agassiz.  
Vice-President and General Manager: James MacNaughton.  
Secretary and Treasurer: George G. Endicott.  
Superintendent: Ole Hallingby.

The La Salle Copper Company mined 176,423 tons yielding 1,832,665 pounds of refined copper ore, 10.388

pounds per ton. This production exclusive of selling cost was 21.81 cents per pound. La Salle delivered 1,858,328 pounds of copper and closed the year with 347,134 pounds on hand. The total cost per pound on copper delivered was 21.96 cents and the average price mined, 24.35 cents. The gain on copper delivered was \$44,605.81 or 2.39 cents per pound. The balance of miscellaneous charges and receipts, including silver sales, was \$32,450.70 and the net income for the year, \$68,256.61. The financial statement shows a balance of assets on December 31, 1918 of \$401,457.78.

No. 1 shaft supplied 62 percent of the rock hoisted. The quantity of merchantable ground tributary to this shaft is limited and operations are being pushed with the idea of mining out the available ore and abandoning the shaft. On the whole the stopes were lean. The ground between the 9th and 15th levels is exhausted excepting two small areas near the shaft, one above the 14th and one above the 15th level. Limited areas of probable stoping value remain to be tested on the 9th, 16th, and 17th levels.

No. 2 shaft is 2,511 feet deep, the bottom being 133 feet below the 23d level, an advance of 269 feet for the year. Drifting on alternate levels from 17th to 23d developed fair ground north of the shaft. As the north boundary is approached the ground is leaner. On the south side of the shaft the 21st and 23d levels were in fair ground. The 19th level north was stoped in poor ground 900 feet from the shaft. Stopping from the 15th and 17th levels north, furnished 65 percent of the rock output of this shaft.

No work was done on the Osceola lode exploration. The mine showed an unusual cost of production due to the abnormal cost of supplies, shortage of men and high wages. There were two wage increases—one on May 1 and the second on October 1.

#### Mass Consolidated Mining Company

Office: 79 Milk Street, Boston, Mass.  
Mine office: Mass City, Ontonagon County, Michigan.  
President: John W. Linnell.  
Secretary and Treasurer: Wilfred A. Bancroft.  
Superintendent: Elton W. Walker.

The Mass Mine produced 196,456 tons of copper rock yielding 3,403,827 pounds of refined copper or 17.33 pounds per ton. This is a decrease of 480,789 pounds from the record of 1917, but an increase of 1.04 pounds copper per ton stamped.

The cost per pound was 23.82 cents. During the year 2,849,759 pounds of copper were sold for 24.34 cents per pound or \$693,547.87 and the stock on hand December 31, 1918, 554,068 pounds is inventoried at 16 cents per pound or \$88,650.88. Interest and rents bring the total income for year to \$796,638.33. Expenditures for the year totaled \$810,967.81, leaving a loss on the operations of the year of \$14,329.48. The company closed the year with a balance of assets of \$295,773.01.

The development work was somewhat restricted due to high costs and scarcity of labor, but a total of 2,280 feet of new openings was made. These consisted of 575 feet of drifting in territory adjacent to B shaft and 1,368 feet of drifting and 337 feet of cross-cutting in C shaft territory.

Mass copper produced during the year amounted to 29.4 percent of the gross mass and mineral as compared with 29.7 percent in 1917. Production by lodes was as follows: Butler and branches, 127,491 tons; Evergreen, 59,866 tons; and Ogima 9,099 tons.

Construction amounted to \$11,269.24. The Ingersoll Rand compressor mentioned in a previous report, was completed and a permanent concrete foundation built under the compressor and hoist building at the main plant.

The scarcity of labor and increased cost of supplies resulted in increased cost of production. During 1918 the average number of men employed underground was 269 as compared with 320 in 1917. The conditions underground are satisfactory, the copper content of the rock showed an improvement of one pound over 1917.

According to President T. W. Linnell, "The mine has been brought to a point where there remains no question that under normal conditions we can operate to the capacity of our mill and show a good profit therefrom."

#### Mayflower-Old Colony Copper Company

Office: 70 State Street, Boston, Mass.

Mine office: Houghton, Michigan.

President: H. F. Fay.

Secretary and Treasurer: C. T. Morrissey.

Superintendent: George S. Goodale.

During the period January 1, 1918 to March 1, 1919, this company has devoted all efforts toward the sinking of No. 1 shaft. During this period the shafts were sunk from 139 feet to 994 feet. This included all timbering and special construction and the installation of pump stations at 177 and 511 feet. Only a very moderate quantity of water has been encountered and except for short distances the rock was of uniform hard nature.

The character of the ground has necessitated timbering close to the bottom of the shaft, a condition which operates against rapid sinking.

The annual report shows that expenditures for the period were \$95,199.21 and there was a balance on hand December 31, 1918 of \$23,766.49.

#### Michigan Copper Mining Company

Office: 15 William Street, New York City.

Mine office: Rockland, Ontonagon County, Michigan.

President: L. P. Yandell.

Secretary: F. G. Hinmann.

Treasurer: R. E. Graver.

Superintendent: Samuel Brady (Died Sept. 1919.)

The Michigan Mine produced 40,865 tons yielding 1,177,176 pounds of refined copper, an average of

28.56 pounds per ton stamped. The receipts of the company during the year were \$445,782.09. Sales of copper totaled \$290,923.17. There was received from assessments \$153,884 and interest added the balance of \$974.92. Total expenditures were \$290,242.21 to which should be added construction amounting to \$18,729.68 and \$10,000 for purchase of real estate. The balance of receipts over expenditures was \$126,810.20. The deficit of the company has been reduced to \$52,067.97. According to the report of Mr. L. P. Yandell, President of the company, "the character of the ground opened by drifts in the Butler lode has been highly satisfactory throughout the past year. The number of drills at work on January 1, 1918 were six; increased to eighteen at the present date (December 31, 1918). Steady shipments of rock have continued throughout the year increasing month by month with December the record for the year. However, production of copper rock and drifting have both been hampered somewhat by a continuous shortage of labor. The average recovery of 28.56 pounds of refined copper per ton of rock stamped and sold at an average of 24.7 cents is responsible for the mine's ability to pay expenses with the limited production possible in its first year of mining from "E" shaft.

"A study of the underground conditions of the mine at the beginning of 1919 shows a very substantial body of copper rock exposed for stoping by comparison to the amount exposed at the beginning of 1918 and it is believed that production can be doubled in the coming year.

"The same high quality of rock is in sight at this writing that was available for stoping last year. With increased production the cost of our refined copper will be reduced.

"Necessary machinery is on hand and is being installed as fast as required for increased production, and, when the mine has operated continuously producing a tonnage of rock that justifies starting our own mill, custom stamping will stop and operation of our mill commence, effecting an additional economy."

#### Mohawk Mining Company

Office: 15 Williams St., New York, N. Y.

Mine Office: Mohawk, Keweenaw Co., Mich.

President: L. P. Yandell.

Secretary: F. G. Hinmann.

Treasurer: F. E. Graver.

Agent: Theo. Dangler.

Superintendent: W. F. Hartmann.

The Mohawk produced 454,293 tons yielding 10,781,041 pounds of refined copper, an average of 23.73 pounds per ton stamped. This is an increased yield of 2.62 pounds per ton.

The total cost of production was 14.641 cents per pound, or \$1,578,452.10 less copper on hand at cost equals \$1,444,117.32. Sales of 9,775,014 pounds of copper at 24.73 cents amounted to \$2,417,580.50 leaving a gain on copper sold of \$973,463.18. Miscellaneous income

amounted to \$60,226.73. The company had a balance of assets of \$2,208,397.80 on December 31, 1918.

During 1918 No. 4 shaft was sunk 100 feet and its total depth is 2,489 feet. No. 6 shaft was sunk 157 feet to a total depth of 1,451 feet. No. 1 shaft, depth 2,693 feet and No. 5, depth 1,787, were not sunk during the year. The total sinking was 257 feet, drifting 5,639 feet, crosscutting 277 feet, raises 3,080 feet or a total of all openings of 9,253 feet.

Tons rock hoisted amounted to 465,603 of which 11,310 tons or 2.4 percent were discarded and 454,293 tons stamped. Of this product No. 1 shaft produced 6 percent; No. 4 shaft 33 percent; No. 5 shaft 20 percent and No. 6 shaft 41 percent.

The new opening in No. 1 shaft showed no improvement over those of the past three years and it will be necessary to resort to underground selection prior to hoisting. The new opening in Nos. 4, 5 and 6 shafts showed amygdaloid of the same excellent mineralization as in previous years, No. 4 and 5 territory being slightly better than No. 6.

President Yandell sums up the result of operation and general condition at the property as follows: "The smaller rock tonnage handled in 1918 as compared to recent years is due entirely to labor shortage and the increased copper content in the rock handled in 1918 is due to improved mineralization in the workings of the mine. The character of the new ground opened up has been most satisfactory. Our engineers estimate that there remain in the property yet unmined 260,738,612 pounds of copper and it will be noted that to December 31, 1918, 170,235,843 pounds have been taken from the mine.

"The mechanical haulage established in 1918 is now operating effectively and is reducing costs. The improvements being installed at the mill will still further reduce operating costs."

#### Naumkeag Copper Company

Office: 61 Broadway, New York, N. Y.  
Mine office: Houghton, Michigan.  
President: J. Parke Channing.  
Secretary and Treasurer: E. H. Westlake.  
Superintendent: J. H. Reader.

This property is a prospect and has never reached the production stage. During 1918 work on the 400 foot level consisted in driving two crosscuts No. 2 west 450 feet, and No. 2 east 450 feet to the foot wall of the Pewabic beds. This work developed no commercial ground.

The inclined shaft was sunk to a depth of 1,027 feet from the adit level. On the 1,000 foot level 300 feet of drifting and 200 feet of crosscutting was done. The showing on the 1,000 foot level was markedly inferior to that on the adit or even the 400 foot level and it was concluded to abandon work in this part of the mine. The rails, pumps

and cars were removed and the shaft allowed to fill up to the adit level.

Present work on the property will be to relay the tracks in the adit level and explore the south end of the property.

In December 1918, Mr. Sidney S. Lang resigned as superintendent and was succeeded by Mr. J. Harry Reader.

#### New Arcadian Copper Company

Office: Houghton, Michigan.  
President: Robert H. Shields.  
Secretary and Treasurer: W. F. Miller.  
General Manager: Robert H. Shields.

During 1918 the New Arcadian produced 10,195 tons yielding 164,794 pounds of copper or a little more than 16 pounds per ton. Owing to the shortage of labor and supplies the mine was closed down in September, 1918.

Total openings in the mine consist of 5,762 feet of drifting, 4,028 feet of crosscutting and the shaft has been sunk 1,860 feet.

Work during the year included a 520 foot crosscut on the 1,700 foot level to No. 8 conglomerate which was found to be 26 feet wide and carrying some fine copper but nothing of commercial grade. West of the shaft development work has disclosed a fault which displaces the New Arcadian vein 100 feet. On the 1,700 foot level the lode is 47 feet east of the shaft and on the 1,850 foot level the vein was located by a crosscut 62 feet west of the shaft. Drifting on the lode on these levels disclosed good copper ground. According to Mr. H. W. Fesing "Copper has been in evidence on all levels occurring in 'bunches' or 'pockets' some of which are very rich in mineral contents. The New Arcadian vein in all respects is very similar to the vein that is proving commercially valuable at the Isle Royale."

#### New Baltic Copper Company

Office: Houghton, Michigan.  
President: Robert H. Shields.  
Secretary and Treasurer: John Edwards.

A small amount of exploration was carried on at this property during 1918. Operations were suspended in September 1918.

#### North Lake Mining Company

Office: 60 Congress Street, Boston, Massachusetts.  
Mine Office: Lake Mine, Ontonagon County, Michigan.  
President: R. M. Edwards.  
Secretary: A. L. Wyman.  
Treasurer: Henry Tolman.  
Superintendent: Thomas Bennett.

The North Lake is a prospect. Development work has disclosed a number of copper bearing amygdaloids of some promise but sufficient work has not as yet been done to determine if any of the amygdaloids carry enough copper to warrant mining.

### Ojibway Mining Company

Office: 120 Broadway, New York.

Mine Office: Calumet, Michigan.

President: Thos. F. Cole.

Secretary and Treasurer: Frederick R. Kennedy.

General Manager: W. J. Uren.

This property has been idle since 1913.

### Osceola Consolidated Mining Company

Office: 12 Ashburton Place, Boston, Massachusetts.

Mine office: Calumet, Michigan.

President: Eugene V. R. Thayer\*\*.

Secretary and Treasurer: Clarence H. Bissell.

General Manager: James MacNaughton.

Superintendent: F. H. Haller.

Osceola produced 1,194,967 tons yielding 15,919,647 pounds of refined copper or 13.3 pounds per ton. This is a decrease of 165,311 pounds from the production of 1917. The company had 3,701,040 pounds of copper on hand January 1, 1918 and delivered 16,380,996 pounds during the year, leaving a balance of 3,239,691 pounds on hand December 31, 1918.

The total cost of production exclusive of selling was \$2,812,920.66 or 17.67 cents per pound. The total receipts from sale of copper were \$3,997,884.36, an average of 24.41 cents per pound. The cost per pound of copper delivered in 1918 was 17.37 cents and gain on copper delivered was 7.04 cents. The net income of the Osceola Consolidated Mining Company was \$1,203,953.42; dividends paid during the year 1918 amounting to \$961,500.

#### *Osceola Branch*

The product for 1918 from the Osceola Company Mine was 230,517 tons yielding 3,252,233 pounds of refined copper or an average of 14.11 pounds per ton. The cost per ton was \$2.10. The product of copper for the Osceola Branch was nearly 30 percent more than last year and costs were lower in spite of greatly increased wages and labor shortage. The reduction of over two cents a pound on the cost of copper was due to a better grade of rock encountered in the mine, and to the concentration of effort toward labor saving devices and strict economy in the use of new material.

Mine operations were carried on through No. 6 shaft only. The most active and best part of the mine was above the 46th level near the extreme south and west boundaries between 2,000 and 3,500 feet south of No. 6 shaft. In the tunnel beyond the older Workings a great deal of development right up to the LaSalle boundary has been done during the past five years, giving this branch a new lease of life. During 1918 a new level was opened above the 38th for a distance of 500 feet in very good ground. It can be driven one thousand feet before reaching the boundary with a probability of showing copper most of the way. The 39th level drift has been carried to within 100 feet of the boundary in rich ground. The 41st and 43d level drifts have reached a boundary

in fair ground and stoping has been in progress along the boundary on every level from the 39th to the 45th throughout the year.

The 46th level drift was extended south during the latter part of the year in very lean ground. Stopes on the 47th and 48th levels have yielded a good tonnage, but of only fair grade rock. The total of new openings for the year amounted to 1,219 feet. No new construction was carried on at this branch aside from necessary improvements in miners change house and repairs.

#### *North Kearsarge Branch*

North Kearsarge produced 745,722 tons yielding 9,395,968 pounds of copper or an average of 12.6 pounds per ton. Mining costs were \$1.69 per ton. This branch increased its product nearly ten percent over 1917 producing more copper than in any year since 1911. The grade of rock was only slightly better than last year, being practically the same as the average for the past eight years.

All three shafts were in commission throughout the year with no serious interruptions. No. 1 shaft produced the largest tonnage but during the last quarter the largest production came from No. 4 shaft. This was made possible with fewer men by the highly successful operation of storage battery locomotives on the 15th and 16th levels.

No. 1 shaft was timbered and equipped for three levels below the 35th. Preparations were made for the installation of electric haulage on the 34th and 35th levels of this shaft and the 31st and 32d levels of No. 3 shaft. The total new openings for this branch amounted to 501 ft.

#### *South Kearsarge Branch*

The product for the year amounted to 218,728 tons yielding 3,271,446 pounds of refined copper, an average of 14.96 pounds per ton; the cost per ton for the year was \$1.74. The shortage of labor accounted for the decrease of one-third in South Kearsarge product during 1918. The shortage of men resulted in closing down of No. 2 shaft the end of September and even No. 1 shaft did not have enough men to make a fair showing. The grade of rock stamped was slightly better than 1917.

Footwall mining yielded only a small tonnage this year and only 80,000 tons were secured from shaft pillars. The ground under the bottom level has been mined as far as possible and a hole was made from the Wolverine Mine to take the water when pumping, in South Kearsarge is stopped.

In the early fall the old workings south of No. 2 shaft caved from the 14th level to the surface, but without damage to the shaft or loss of ground for mining. A gradual increased flow of water soon developed however, doubling the pumping expense but otherwise doing no harm.

#### *General*

In common with other subsidiaries of the Calumet and Hecla Mining Company there were two wage increases during the year, the first on May 1 and the second on October 1.

#### Quincy Mining Company

Office: 32 Broadway, New York, New York.  
Mine office: Hancock, Michigan.  
President: William R. Todd.  
Secretary and Treasurer: W. A. O. Paul  
General Manager: Charles L. Lawton.

The product of the mine for 1918 was 1,174,147 tons yielding 19,948,965 pounds of refined copper an average of 16.99 pounds per ton. The total receipts from sale of refined copper were \$4,802,405.99 and from silver \$54,680.06 or a total of \$4,857,085.05; the total cost of production was \$3,733,133.25. The gain from sale of metal amounted to \$1,123,951.90. Miscellaneous receipts were \$81,475.02 and construction and accident accounts amounted to \$342,382.52 leaving a net income for the year of \$863,044.40. Dividends for 1918 amounted to \$935,000.00 and the company closed the year with a balance of assets of \$2,803,123.65. Mining operations were carried on along normal lines. The opening and development work total 24,580 feet and the amount of shaft sinking was 428 feet. In the progress of general mining operations openings on the several branches of the Pewabic lode were made at a great many different points and developed ground that varied but little in the average copper content from that of recent years and yielded about the same percentage of mass and barrel copper.

No. 7 shaft operated for the account of the Hancock Consolidated Mining Company until June 1 when operations of the shaft were suspended. No. 2 shaft produced the largest tonnage of stamp rock which, though of better tenor than that from No. 8 shaft, was lower than that from No. 6, the middle shaft. In No. 2 shaft, however, enough mass copper was found in the ground north of the shaft to make it produce the greatest amount of refined copper. No. 6 shaft produced a good grade of stamp rock throughout the year, although No. 8 shaft produced less refined copper than either of the other two shafts. The prospects for No. 8 shaft for 1919 are much better than they were a year ago for 1918 and in general the physical condition of the mine and the showing for copper at the beginning of the year 1919, compare well with that of one year ago.

A gradual flattening of the lode with depth has increased the difficulty of handling the rock from the flat foot walls of the stopes into the chutes and to the levels below and made it important to design a mechanical power scraper to do this work. The result of many experiments to this end was the perfecting of a power scraper adapted to the underground conditions at the Quincy. Several of these scrapers are now being successfully operated. The company has also experimented with an underground power shovel with encouraging results.

The Quincy Mining Company carried on a considerable construction program during 1918. During the year a new hoisting engine house for No. 2 shaft was practically completed. This engine house is of the latest design of reinforced concrete. The walls have red brick facings, the windows are all prism glass in steel frames; the roof is of concrete with tar felt sheathing and green tar. Other construction included expensive additions to both the stamp mills which are designed to house five 8 foot-Marcy ball mills and two hundred forty additional tables.

#### Seneca Copper Corporation

Office: 11 Broadway, New York, New York.  
Mine office: Calumet, Michigan.  
President: Frederick Lewisohn.  
Secretary: E. J. MacNamara.  
Treasurer: E. C. Westervelt.  
General Manager: W. J. Uren.

Operations at the Seneca consisted in the sinking of a new 3-compartment shaft which will reach the underlay of the Kearsarge lode from the Mohawk Mine.

#### South Lake Mining Company

Office: 60 Congress Street, Boston, Massachusetts.  
Mine office: Lake Mine, Ontonagon County, Michigan.  
President: R. N. Edwards.  
Secretary and Treasurer: Arthur C. Paine.  
Superintendent: T. H. Bennett.

South Lake mined 76,947 tons yielding 365,936 pounds of copper. Owing to the high cost of supplies and materials and labor shortage the mine closed June 30.

The yield per ton was 47.55 pounds. This property is only a prospect but showing on the Evergreen series, particularly the Butler lode, is very encouraging and warrants further development.

#### Superior Copper Company

Office: 12 Ashburton Place, Boston, Massachusetts.  
Mine office: Calumet, Michigan.  
President: Rudolphe L. Agassiz.  
Secretary and Treasurer: George G. Endicott.  
General Manager: James MacNaughton.  
Superintendent: Ocha Potter.

In 1918 Superior produced 120,464 tons yielding 1,676,446 pounds of refined copper or an average of 13.916 pounds per ton.

Superior had on hand January 1, 1918, 603,758 pounds and sold during the year 2,012,590 pounds, leaving a balance on hand December 31, 1918 of 267,614 pounds. The cost of production of the copper mined during the year was 25.06 cents per pound and the cost of the copper delivered was 23.29 cents. The copper delivered was sold for 24.22 cents leaving a gain on copper delivered of \$18,700.38 or .93 cents per pound, the net income for the year. The balance of miscellaneous receipts and charges brought the total net income of the year to \$51,780.31. The company closed the year with a balance of assets \$622,609.11.

No sinking was done at No. 1 shaft during the year and all development was confined to the West lode. The 23d level was extended 389 feet south to a total distance of 1,800 feet from the shaft. Very little copper was found.

The 25th level was drifted for a total of 884 feet disclosing about 100 feet of fair stoping ground. At the present time this drift is in very poor and narrow veins. The 31st level was extended 968 feet disclosing about 400 feet of stoping ground; 350 feet of which is almost continuous and of exceedingly good quality. No work aside from the necessary repairs was done at No. 2 shaft and there was no new construction during the year.

In common with other subsidiaries of the Calumet and Hecla Mining Company, there were two wage increases during the year; the first on May 1 and the second on October 1.

Trimountain Mining Company  
(See Copper Range)

Victoria Copper Mining Company

Office: 60 Congress Street, Boston, Massachusetts.  
President: Fred H. Williams.  
Secretary: Sidney S. Millett.  
Treasurer: James P. Graves.  
Superintendent: George Hooper.

Victoria produced 106,730 tons yielding 1,533,536 pounds of copper, an average of 14.4 pounds per ton. This represents an increase of 2.6 pounds per ton over 1917 and is the highest yield per pound obtained by the Victoria Mining Company during the past eight years.

In common with all other Michigan copper companies, the Victoria had to contend with increasing cost and labor shortage which accounts for the decrease of 30,000 tons over the production of 1917, however, the increased yield of copper resulted in a total product only slightly under the record of 1917.

White Pine Copper Company

Office: 12 Ashburton Place, Boston, Massachusetts.  
Managing office: Calumet, Michigan.  
Mine office: Ontonagon County, Michigan.  
President: Rudolph L. Agassiz.  
Secretary and Treasurer: George G. Endicott.  
General Manager: James MacNaughton,  
Superintendent: Thos. H. Wilcox.

The White Pine Mine produced 194,568 tons yielding 3,273,680 pounds of refined copper, an average of 16.83 pounds per ton. White Pine had 1,026,753 pounds on hand January 1, 1918 and delivered during the year 3,223,377 pounds leaving a balance on hand December 31, 1918 of 1,077,056 pounds. The product for the year was secured at a cost of 24.27 cents per pound and the total cost of copper delivered was 22.48 cents per pound which sold for 24.3 cents per pound leaving a gain on copper delivered of 1.82 cents per pound or 58,743.31 cents; the balance of miscellaneous receipts and charges brought the total net income to \$125,506.93. Dividends paid on preferred stock

amounted to \$4,375 and the company closed the year with a balance of current assets December 31, 1918, of \$402,039.66.

No. 2 shaft was sunk 500.5 feet during the year. Its total depth is now 1,578.5 feet. Of this total depth 581 feet were vertical, 392 feet of curve and 605.5 feet of 45° underlay. At a point 1,300 feet from the surface 60 feet of badly faulted black and lead slate was encountered beyond which the strike and dip change to conform with that existing north of the main fault.

There was no sinking at No. 3 shaft which is 29.5 feet below the 6th level or 1,090 feet from surface. Openings on A. B. third and fourth levels disclosed good copper ground and stoping was started 800 feet east of the shaft on the 4th level (3d lobe) in rich ground. Third level openings west were in poor ground and east disclosed 300 feet showing fair values,

There was no sinking at No. 4 shaft during the year. This shaft is 12.2 feet below the 6th level or 978.4 feet from the surface. Developments were confined to the second 2½ and 3d levels.

At a point midway between the second and 2½ levels a drift slope was driven 80 feet through fair ground. A crosscut on the 2½ level east was driven off 329 feet with a view of cutting the 3d lode east of the fault as shown by diamond drill holes, but because of the very flat dip and broken condition of the ground the work was discontinued without discovering the lode; the 3d level (2d lode) was extended east 650 feet in fair ground.

Surface improvements were confined to building a new hoisting engine house and the installation of a new and larger hoist for No. 2 shaft and the erection of a concrete powder house.

A flotation plant has been installed and is a success. It has materially reduced tailing losses and has lengthened the life of the mine by making available lower grade rock and rock with copper in extremely fine state of subdivision. The tailing losses are still high compared to amygdaloid mines and the question of reducing them is a commercial one depending on the cost of finer grinding as balanced against copper obtained thereby.

There were two wage increases, on May 1 and October 1, respectively,

Winona Copper Company

Office: 60 Congress Street, Boston, Massachusetts.  
Mine office: Winona, Houghton County, Michigan,  
President: Thos. S. Wood.  
Secretary and Treasurer: Arthur C. Paine.  
Superintendent: G. A. Braun.

The Winona Mine was operated for the first four months of the year by Mr. R. R. Seeber, Lessee, during which period copper production was 756,826 pounds. On May 1 the Winona Copper Company assumed and continued operations for the balance of the year.

Copper production for the eight months of company operation was of 819,857 pounds, making a total of 1,576,683 pounds for the mine. The total expenditures amounted to \$284,020.04. The sale of copper netted \$166,228.38 and royalty and miscellaneous receipts brought the total to \$180,270.57. The net loss for the year was \$103,749.47.

Mr. Thomas S. Wood, President of the Winona, describes the general conditions at this mine as follows:

"The Winona Mine, including the King Philip property acquired in 1911, has been opened on the Winona-Isle Royale lode through six shafts, two of which have been abandoned. Although the workings cover a distance of one and one-half miles along the formation, at no point has development work on a large scale been undertaken below the eleventh level.

"The lode is of good width, with a steep pitch favorable to economical mining. The rock is fine grained, hard and traversed by numerous small seams filled with calcite. The masses of copper are comparatively few and small, while the metal in the stamp-rock is mostly in the form of disseminated particles and scales, difficult to recover by ordinary methods at the mill. All these characteristics warrant the belief that a considerable portion of the values once contained in the upper levels has leached downward and will be found lodged at greater depths.

"The Isle Royale Company, the one successful producer operating on the Winona-Isle Royale lode, developed good ground in No. 2 shaft only below the 25th level, although other shafts further south have been more fortunate. This mine showed high costs and deficits until production had been brought above 1,200 tons per day of rock yielding about as much copper as our own.

"Convinced that Winona can become a profitable producer only by following the methods through which Isle Royale has achieved success, your Directors have equipped the hoist at King Philip No. 1 shaft for deeper mining, believing, with many Michigan men, that our south ground gives promise of better copper at depth.

"Improved values must be found and extensive new openings made to furnish an output large enough to insure economical operation. At the mill, which requires few changes to permit the efficient treatment of over 1,250 tons daily, an oil flotation plant for saving the fine copper now lost in the tailings, is in process of installation and will be ready to operate later in the year.

"Because of market conditions, the mine was closed temporarily early in February. During the suspension our new superintendent, who took charge November 15 last at Winona, is working out a plan for consolidating the widely separated power plants of the two original mines, upon an economical basis.

"Winona is not yet a mine but is rather a large prospect with a costly surface equipment and mill, besides houses and timberlands, all together worth much more than the present market price of the stock. Before it can be classed as either a success or a failure, new

explorations must be undertaken at depth on the Winona bed and on the lodes in the Baltic horizon approximately 2,500 feet further east."

#### Wolverine Copper Mining Company

Office: 15 Williams Street, New York, New York.

Mine Office: Calumet, Michigan.

President: L. P. Yandell.

Secretary: F. G. Heumann.

Treasurer: R. E. Graver.

General Manager: Theodore Dengler.

Superintendent: William R. Bolley.

The fiscal year of the Wolverine Copper Mining Company ends June 30. The product for the year ending June 30, 1918 was 4,608,865 pounds and for the year ending June 30, 1919, 4,562,617 pounds. The yield per ton stamped for the former period, was 15.185 pounds and for the latter period 15.306. The total operating costs for 1917-18 were 13.839 cents and for 1918-19, 12.064 cents. The total cost including smelting, marketing, depreciation and depletion for 1917-18 before providing for income and excess profit taxes was \$241,920.36. Dividends for this same period amounted to \$570,000 and the company closed the year with a balance of current assets of \$875,713.81. The net profit for the year 1918-19 was \$10,553.57. Dividends during the year amounted to \$150,000 and the company closed the year with a balance of current assets, \$847,811.95.

During the past two years a production of 7,337 tons has been obtained from the "West vein" through stoping on the fourth, fifth and sixth levels opposite No. 2 shaft. The "West vein" at this part of the mine is 46 feet distant from the Kearsarge lode. It is mineralized along the hanging wall for an average of 415 feet, copper occurring in frequent bunches sufficient in quantity to warrant mining the "West lode" simultaneously with operations on the main lode. The profitable mineralized portion does not appear to extend more than 300 feet laterally.

Approximately 40 percent of the total rock hoisted was obtained from cutting out the Kearsarge lode along the foot-in old and recent slopes throughout the mine.

Early in 1919 South Kearsarge mine which was working bordering the Wolverine on the south, discontinued pumping in the lower levels. To provide for the safety of the Wolverine mine it became necessary to make a raise of 70 feet from the 29th level Wolverine, to the 24th level South Kearsarge. In this raise there were cemented one three inch and one four inch pipe fitted with control valves and pressure gauges on the Wolverine side of the boundary. To handle the water it has been necessary to double the pumping facilities of the Wolverine Mine and to install a 1,400 gallon boiler in No. 3 shaft. As an additional safeguard, concrete dams were built at the 38th and 39th levels south of No. 4 shaft which would serve to prevent any large volume of water going to the bottom of No. 4 shaft. Up to July 1 Wolverine handled 12,600,000 gallons of South Kearsarge water and is now

handling 110,000 gallons per day in addition to its own. Considerable new construction work at the mill is being undertaken jointly with the Mohawk Mining Company. A concrete building 42 x 42 x 18 feet upon a concrete foundation 12 feet high with steel trusses and composition roof and necessary foundations for machinery was constructed adjacent to the mill to accommodate a 1,250 KW 60 cycle, 3 phase 2,200 volt mixed pressure turbine and generator. This turbine will utilize exhaust steam from the stamp heads and is intended to furnish power to drive all the mill machinery in addition to three 7,000-gallon electrically-driven centrifugal pumps which are to be installed at the old pump house thereby eliminating the present boiler pumping plant. At the pump house work on an intake shaft and tunnel under the lake has been started. A shaft 6 x 10 feet outside timbers, has been sunk to a depth of 110 feet below the level of the lake, or a depth of 125 feet below the surface of the ground at the pump house. At a depth of 9 feet below lake level a pump station 12x13 feet was cut and the tunnel proper 6x7 feet inside driven for a distance of 1,420 feet on July 1. This tunnel will be driven 220 feet where a depth of 30 feet of water will be attained.

Wyandot Copper Company

Office: 68 Devonshire Street, Boston, Massachusetts.  
Mine office: Houghton, Michigan.  
President: Ashley Watson.  
Secretary and Treasurer: Charles E. Adams.

This exploration has been idle since March 31, 1918. All work during the year ending March 31, 1918 was confined to further development of No. 8 lode on the 10th level. Drifts were extended northeast and southwest of the winze approximately 300 feet in either direction. Drift stoping was done west of the winze for a distance of 250 feet and a stope was finally started 30 feet west of the winze and 200 feet in length.

IRON ORE INDUSTRY OF MICHIGAN 1918

O. R. HAMILTON

GENERAL REVIEW

Michigan iron mines shipped 17,492,365 tons of ore in 1918, thereby being second in production in the United States. The three leading States of the twenty-six States producing iron ore were, in order, Minnesota, Michigan and Alabama.

Michigan mines making initial shipments in 1918 are the Monongahela in Iron County; The Athens, Bunker Hill, Francis and Maitland in Marquette County. The following shippers were dropped from the list in 1918: The Ravenna and Wickwire mines in Iron County; Queen Group, Stegmiller and Washington in Marquette County; and the Mikado in Gogebic County.

The Iron Trade Review credits the Lake Superior District with a total shipment in 1918 of 62,836,082 tons, of which Michigan shipped 27.8 percent.

Publication 27, Geological Series 22, Michigan Geological and Biological Survey, pages 123 to 131 inclusive, is given over to tables of analyses of Lake Superior iron ore shipments, prepared by W. L. Tinker. The writer submits a table of analyses of 1918 iron ore shipments from Michigan by grades. The variance of percentages from the general trend indicated in Publication 27 is traced back to the unusual demand on the mines during War-time production.

No comparison can be made here between Mr. Tinker's tables and the following statement of the Michigan shipment as the figures given by Mr. Tinker for the Gogebic Range included the shipment from Wisconsin. Likewise the Menominee Range included the ore shipped from Iron County, Michigan, Dickinson County, Michigan, and Florence County, Wisconsin. The Marquette Range takes in Marquette County and Baraga County of Michigan.

The tables of cost and production including 1918 are brought up to date in this volume. Figure No. 1 presents in a graphical manner the salient features of the iron industry for the years 1906 to 1918 inclusive. The total cost to the operator is the sum of "A"—Cost at the mine, "B"—Cost of delivery to Lake Erie ports, and "C"—Royalty. The difference between that sum total and the receipts from the sale of ore is "D"—The profit to the operators. However the item of royalty is generally considered that part of the profit earned by the mines which is shared with the fee owner and is not allowed to the operator by the State Appraiser of Mines when calculating valuation of the mines for purposes of taxation.

| ANALYSES OF 1918 IRON ORE SHIPMENTS FROM MICHIGAN BY GRADES |              |            |             |                   |             |              |             |              |                   |              |
|-------------------------------------------------------------|--------------|------------|-------------|-------------------|-------------|--------------|-------------|--------------|-------------------|--------------|
| Range                                                       | Grade        | Tons.      | Highest     |                   | Lowest      |              | Average**   |              | Average of Totals |              |
|                                                             |              |            | Iron (Nat.) | Phosphorus (Nat.) | Iron (Nat.) | Phos. (Nat.) | Iron (Nat.) | Phos. (Nat.) | Iron (Nat.)       | Phos. (Nat.) |
| Gogebic County                                              | Bessemer     | 2,977,035  | 55.39       | .061              | 38.77       | .034         | 53.14       | .037         | 52.06             | .070         |
|                                                             | Non-Bessemer | 4,000,445  | 55.54       | .070              | 42.48       | .034         | 51.20       | .034         |                   |              |
|                                                             | Unclassified | 102,300    |             |                   |             |              |             |              |                   |              |
|                                                             | Total        | 7,139,980  |             |                   |             |              |             |              |                   |              |
| Iron County                                                 | Bessemer     | None       |             |                   |             |              |             |              |                   |              |
|                                                             | Non-Bessemer | 4,301,912  | 59.93       | .350              | 35.46       | .278         | 50.11       | .421         | 50.11             | .421         |
|                                                             | Unclassified | 8,283      |             |                   |             |              |             |              |                   |              |
|                                                             | Total        | 4,370,195  |             |                   |             |              |             |              |                   |              |
| Dickinson County                                            | Bessemer     | 428,197    | 56.87       | .016              | 37.92       | .016         | 47.47       | .031         | 49.12             | .046         |
|                                                             | Non-Bessemer | 1,180,660  | 55.42       | .060              | 38.00       | .046         | 49.82       | .062         |                   |              |
|                                                             | Unclassified | 113,999    |             |                   |             |              |             |              |                   |              |
|                                                             | Total        | 1,722,796  |             |                   |             |              |             |              |                   |              |
| Marquette and Baraga Counties                               | Bessemer     | 317,708    | 67.28       | .038              | 46.31       | .037         | 56.22       | .042         | 52.50             | .092         |
|                                                             | Non-Bessemer | 3,378,344  | 64.43       | .064              | 37.22       | .066         | 51.23       | .104         |                   |              |
|                                                             | Unclassified | 65,344     |             |                   |             |              |             |              |                   |              |
|                                                             | Total        | 4,259,396  |             |                   |             |              |             |              |                   |              |
| State of Michigan                                           | Bessemer     | 4,222,949  | 67.28       | .038              | 37.92       | .016         | 53.16       | .038         |                   |              |
|                                                             | Non-Bessemer | 12,271,501 | 64.83       | .064              | 35.46       | .278         | 50.73       | .200         | 51.33             | .162         |
|                                                             | Unclassified | 257,924    |             |                   |             |              |             |              |                   |              |
|                                                             | Total        | 17,492,365 |             |                   |             |              |             |              |                   |              |

\*Unclassified as analyses were not available.  
\*\*Averages calculated from total units of iron and phosphorus.

From 1908 to 1914 the cost of production continued remarkably constant, then in 1914 to 1916 came the period of uncertainty due to the World War. However the years 1917 and 1918 express clearly the great confidence industry placed in the Government's supervision of the Steel Market and production was speeded up at a greatly increased cost as the army withdrew workmen from the mines and factories, thereby increasing the cost of labor and supplies while a similar effect was felt in the high rail and boat freights. Let us compare the costs of the normal year 1909 and those of 1918. The figures compared represent average of total costs to all operators.

| <i>Cost of Mining per ton</i>    | 1909      | 1918      |
|----------------------------------|-----------|-----------|
| 1. General office expenses       | \$0.05704 | \$0.11259 |
| 2. Fire Insurance                | .0009     | .00525    |
| 3. Employers Liability Insurance | .00399    | .02976    |
| 4. Taxes                         | .06869    | .15165    |
| 5. Depreciation                  | .12421    | .22317    |
| 6. Mining                        | 1.30734   | 1.98474   |
| 7. Exploration and Development   | .09864    | .02724    |
| 8. Construction                  | .11996    | .24651    |
| 9. Total "Cost at Mine"          | 1.78396   | 2.78091   |

| <i>"Beyond the Mine" Cost per ton</i>  |         |         |
|----------------------------------------|---------|---------|
| 10. Rail freight                       | .34590  | .63736  |
| 11. Boat freight                       | .49555  | .72959  |
| 12. Cargo Insurance                    | .00150  | .00191  |
| 13. Analyses at Lower Lake Ports       | .00239  | .00419  |
| 14. Selling Commissions                | .04023  | .03704  |
| Unclassified                           | .00738  | None    |
| 15. Total "Beyond the Mine" Cost       | .89295  | 1.41009 |
| 16. Total Cost of Delivery             | 2.67691 | 4.19100 |
| 17. Royalty                            | .28448  | .43584  |
| 18. Total Cost of Delivery to Operator | 2.96139 | 4.62684 |

| <i>Profit and Loss</i>                                             |         |         |
|--------------------------------------------------------------------|---------|---------|
| 19. Receipts from Sale of Ore                                      | 3.59276 | 5.12394 |
| 20. Net Profit to Operator                                         | .63137  | .49710  |
| 21. Total profit (Operator's profit plus royalty and depreciation) | 1.04006 | 1.15611 |

\$3.97 a ton, in fact an actual loss of twelve cents a ton on the 1914 volume of business was sustained by the operators if we recognize royalty a part of the cost of production.

It will be noted that the royalty item jumped from \$0.27134 a ton in 1916 to \$0.42668 in 1917 and \$0.43584 in 1918. This increase is due to the large output of certain large mines which pay a much higher royalty than the average of the Michigan producers prior 1917. The other increases shown in the comparative table of costs are directly due to increased cost of labor and supplies.

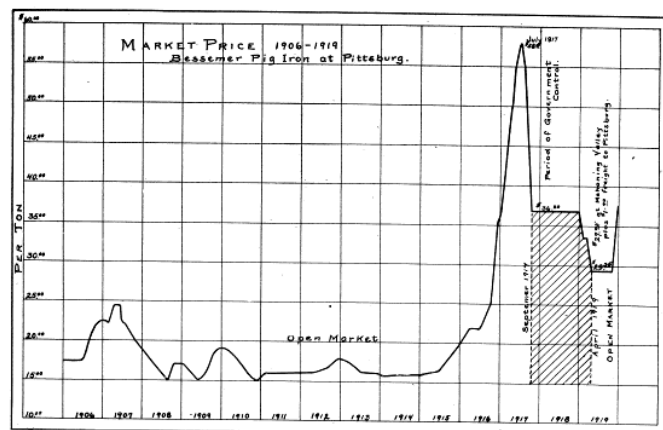


Figure 2. Graphic Record of Bessemer Pig Iron at Pittsburgh.

Figure No. 2 shows the trend of the market for Bessemer pig iron, given here for the benefit of those who wish to follow the iron ore beyond the Lake Erie ports. The curve was plotted from the average market prices of Bessemer pig iron for each month in the years 1906 to 1918 inclusive. Government control extended over the time from September 1917 to April 1919. Bessemer pig iron was chosen as a representative grade for which the standard specifications are:

1. Not more than 0.10 percent of phosphorus.
2. At least 1.00 percent of silicon.
3. Not over 0.05 percent of sulfur.

For this purpose then Bessemer pig iron must be made from Bessemer iron ores which average less than 0.05 percent phosphorus as it requires approximately 1.8 tons of ore to produce one ton of pig iron.

Quoting from the Report of the Commissioner of Corporations on the Steel Industry, Part III, printed in 1913, the average book cost of Bessemer pig iron produced by the furnaces of the Steel Trust 1902 to 1906 inclusive, are given, representing a production of 51,902,699 tons.

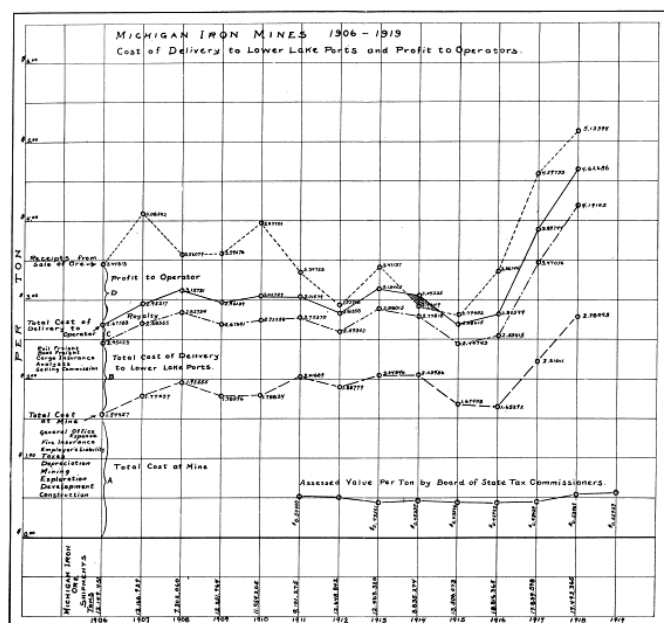


Figure 1. Graphic Record of Cost of Delivery of Michigan Iron Ore at the Lower Lake Ports.

Over the period 1908 to 1914 the fluctuation of costs of production was slight, the difference between the highest figure and the lowest being only thirty-two cents a ton, whereas the market price of iron ore varied from \$2.92 to

#### Average costs per gross ton

|                                                       |                         |
|-------------------------------------------------------|-------------------------|
| Net metallic mixture                                  | \$ 7.30 (\$3.97 ÷ .544) |
| Coke                                                  | 3.89                    |
| Limestone                                             | .43                     |
| Labor                                                 | .77                     |
| Steam                                                 | .12                     |
| Materials in repairs for maintenance                  | .16                     |
| Supplies and tools                                    | .13                     |
| Miscellaneous and general works expense               | .26                     |
| Relining and renewals                                 | .18                     |
| Contingent fund                                       | .02                     |
| Total furnace cost                                    | \$13.26                 |
| Additional cost                                       |                         |
| General and miscellaneous                             | .36                     |
| Depreciation                                          | .39                     |
| Total book cost                                       | \$14.01                 |
| Total cost in 1906 was                                | \$14.50 per gross ton.  |
| For the above the price of gross metallic mixture was | \$4.07                  |
| Price of net metallic mixture was                     | 3.97                    |
| Percent of yield                                      | 54.4                    |
| Pounds of coke used per ton of product                | 2,311                   |
| Price of coke per net                                 | \$3.37                  |

The Steel Corporation's profit on Bessemer pig iron 1902-1906 was \$4.48 a ton, figuring from the book cost of \$13.54 which was reduced to \$11.61 by excluding transfer profits.

A comparison of the data presented by Figure No. 1 and Figure No. 2 indicates that the iron mining business has not received its share of the earnings of the steel business. The raw material is delivered to Lower Lake Ports at a market price relatively lower than that received for the product of the furnaces.

Figure No. 3 anticipates the 1919 shipment which can be only estimated at this time. The Lake Superior shipment for 1919 is not expected to exceed 50,000,000 tons, of which Michigan will ship approximately 13,500,000 tons. Plotting that amount in the production chart, the resulting curve expresses the impetus given the steel industry by War conditions.

## PART II. NON-METALLIC MINERALS

H. M. MARTIN

### NON-METALLIC MINERAL INDUSTRY

#### GENERAL REVIEW

A review of the production of non-metallic minerals in Michigan for 1918 shows an increase in production of all those minerals essential in the economy of the War, and a decrease in production of non-essentials.

The total value of non-metallic production for 1918 was \$35,769,470 as compared with \$30,975,615 in 1917 and \$23,626,879 in 1916. This increase of 12.2 percent over 1917 and 51.3 percent over 1916 represents increased prices since there was in 1918 a decrease in total quantity of production.

In 1916 the chief non-metallic minerals ranked as follows: cement, salt, brick and tile, coal, limestone, sand and gravel, gypsum, pottery, bromine. In 1918 the order was changed to salt, cement, coal, limestone, pottery, gypsum, brick and tile, sand and gravel, bromine. This comparison, however, does not show conclusively the effect of the War upon the industries i. e., bromine still remains in ninth place although its production increased 118.36 percent in quantity and 111 percent in value during 1918 alone and cement which dropped to second place decreased 24.2 percent in production during the same year; brick and tile dropped from third to seventh place. That this industry suffered more than the cement industry was due to the Government demand for cement for military roads and the cantonment at Battle Creek.

Michigan shared in the country-wide depression and stagnation in the building trades which is shown by decreases in both quantity and value in the production of cement, brick and tile, sand-lime brick, sand and gravel and a decrease in the production of gypsum. The total

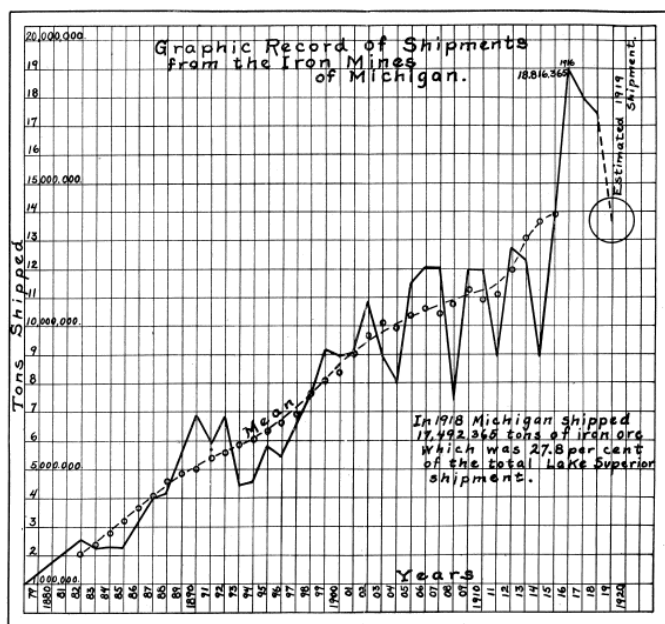


Figure 3. Graphic Record of Shipments Michigan Iron Ore.

The price of Old Range Bessemer Ore delivered at Lake Erie ports in 1906 ranged from \$4.00 to \$4.25 per ton. Average of \$4.15 per ton. Price of net metallic mixture, \$4.05.  $\$4.05 \div .537 = \$7.55$ , the price of net metallic mixture to produce one ton of Bessemer pig iron in 1906.

output of cement in spite of increased prices declined 24.2 percent reaching the lowest level since 1909. The production of brick and tile averaged more than 50 percent less in 1918 than in any year of the past twenty. Michigan retained first rank in the production of sand-lime brick although production decreased 52.9 percent reaching the lowest value since 1911 and the lowest production since 1908; the general deflation in value for the United States was 37.8 percent. Michigan ranked third in the production of gypsum although production decreased 23.69 percent; the value of gypsum decreased in many States but Michigan with New York and Oklahoma records an increase, Michigan's increase being 12.27 percent. With the resumption of imperative building operations these industries will undoubtedly very quickly resume normal conditions.

A comparison of the building operations in Michigan's largest cities Detroit and Grand Rapids, during 1916, 1917 and 1918, is interesting and apropos in this connection. In 1916 Detroit issued 16,489 permits at a total building cost of \$51,068,310; in 1917 this number was reduced to 12,109 permits at a cost of \$39,666,800 but in 1918 only 7,010 permits were issued at a total cost of \$18,226,832. These figures mean that during the War building operations in Detroit decreased 57.5 percent at a total decrease in cost of 64.3 percent. The decline in building operations during 1918 as compared with those of 1917 was 54.1 percent in cost and 42 percent in number of building permits issued. Detroit ranks third after New York and Chicago in cost of building operations. Grand Rapids issued 1,748 permits at a cost of \$3,519,245 in 1916; in 1917 the permits were reduced to 1,351 to cost \$1,817,165 and in 1918 this number was further reduced to 858 at a cost of \$1,199,985. This represents a total War-time reduction of nearly 51 percent in building permits issued and a reduction of 65.9 per cent in building costs compared with 1917 the decrease was 36.5 per cent in building operations and 34 percent in cost.

In spite of the high cost of labor and materials the outlook for the building trades for 1919-1920 is good, not only because of the imperative need of buildings of all kinds but because it is realized that delay in building operations is useless as there is no immediate prospect of costs being lowered. Building operations throughout the State are assuming normal proportions and both costs and operations will show an increase.

Michigan did not however share in the general decrease in the production of lime since practically all of the lime produced in Michigan is used in the chemical rather than in the building industries. The 0.8 percent decrease in production can be ascribed to labor shortage and transportation difficulties.

Limestone records an increase in both production and value; this is due directly to the War, since the greater part of the limestone is used in the chemical industries and as flux in the blast furnaces.

Although Michigan ranked 23 in coal production the State shared to some extent in the general prosperity in the coal industry. The tremendous demand which began in the last quarter of 1916 continued during 1918. Production increased beyond the limit of the railroad capacity for transportation and the demand remained unsatisfied. Prices were under government control after June 1917 and coal prices for the consumer did not reach the high prices of 1916-17, but the price at the mine was higher than ever before in the coal industry of the State.

The production of salt increased but 6.75 percent although the value increased about 32 percent. Labor shortage and the closing of the factories on Mondays by the Fuel Administration early in the year caused some reduction in the salt produced. The demand for salt was good but high costs of materials and shortage of labor made it difficult for producers to fill orders. One operator reported conditions the same as in 1917 but others reported an increase of 50 to 60 percent in operating costs.

Bromine was not exactly in the "War-baby" class but the War rid the industry of the incubus of German competition so that it thrived as did none others of the non-metallic industries. Production increased nearly 213 percent above that of 1916. In that year Michigan produced approximately 70 percent of the total United States production at 72 percent of the total valuation, but in 1918 these percentages had increased to 93.08 percent and 88.2 percent, respectively. The war needs of the Allies, supplemented in 1917-18 by the needs of the United States Army caused the Government to order new wells drilled in Midland County to increase the supply. The signing of the Armistice caused a sudden decrease in the demand from abroad and by the close of 1918 the market had fallen so low that at least one company ceased the manufacture of bromine.

The pottery industry showed increased productions as well as a 66.3 percent increase in value due directly to War demands for porcelain electrical supplies.

In resume: Of the principal non-metallic mineral industries of Michigan for 1918 salt, coal, bromine, limestone and pottery show increase in both production and value; calcium chloride, grindstones, gypsum, and lime show increase in value but decrease in production; and brick and tile, sand-lime brick, cement and sand and gravel show decreases in both production and value.

Michigan ranked first among the States in the production of sand-lime brick bromine, calcium chloride and salt, second in the production of grindstones and third in the production of gypsum.

A detailed account of the non-metallic industry follows:

## **SALT**

During the past nine years the production and value of salt in Michigan has increased annually, the production of 9,452,022 barrels at \$2,231,262 in 1910 increasing to

the maximum of 17,165,179 barrels valued at \$9,048,650 in 1918. In spite of the labor shortage, high cost of fuel, the closing of the factories on Mondays by the Fuel Administration early in the year, and the increased cost in production (cooperage increased and cotton sacking tripled in 1918 as in 1917) the demand remained good and salt production was increased in 1918 by 1,087,043 barrels in quantity and \$2,171,448 in value over 1917, or respectively 6.75 and 31.57 percent. The increase in value is due to the higher average price which was \$0.52 per barrel as "compared with \$0.421 in 1917 and \$0.309 in 1916— an increase of about \$0.22 or 73 percent over the pre-War price. One operator reported no change in operating expenses from those of 1917 but others report operating costs increased 26 to 25 percent in 1917 and 50 to 60 percent in 1918.

From 1880 to 1892 Michigan held first rank in production in the United States. In 1893, New York gained first rank and held it continuously with the exception of the year 1901, until 1905 when Michigan again took the lead and continued first excepting in the two years 1910 and 1911 when New York again led by a narrow margin. With the exception of 1910, Michigan has also held first rank in value since 1908. In the production of rock salt however New York is the largest producer in the United States and Michigan follows Kansas, and Louisiana in fourth place.

From 1880 to 1890 Michigan produced annually from about 42 to over 49 percent of the salt produced in the United States. The percentage declined from 43.69 percent in 1890 to only 22.89 percent in 1896. This was not due to a decline of the industry in Michigan but to the rapid growth of production in New York, Ohio, and other States. Since 1896 Michigan has annually produced nearly one-third of the total output and since 1880 Michigan has produced 27.3 percent or more than one-fourth of the salt used in the United States since records of production have been kept.

Thirty years ago the center of the salt industry was in Saginaw Valley, chiefly along Saginaw River from Saginaw to Bay City. The industry was carried on in connection with the lumber mills and waste steam and fuel from the mills were utilized by more than a hundred lumber concerns in evaporating natural brines which were obtained from the Upper Marshall sandstone at depths varying from about 600 feet in Saginaw to nearly 1,000 feet in Bay City. With the decline of the lumber industry in Saginaw Valley the salt industry became relatively unimportant. In 1917 only 3 percent of the total output of the State was produced in this district. The War revived the industry through the great demand for bromide from abroad which was further increased when the United States entered the War.\* Under present conditions salt is largely manufactured in the Saginaw Valley as a by-product of the bromine industry. The total output of salt for this district in 1918 was only 507,807 barrels or 2.9 percent of the total for the State and was valued at \$422,646, or 4.6 percent of the total State value. This quantity represents an increase of 25,357

barrels over the production for 1917 but falls short of the 1916 production by 53,375 barrels. The maximum production for 1916 represents the great foreign demand, which decreased in 1917 when other sources of bromine production partly met the demand but increased in 1918 with the increased demand for bromine made by the United States government.

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. More than 97 percent of the State output of salt for 1917 came from these two districts.

The salt industry in Wayne County has made a most remarkable growth. Salt was first produced in this county in 1895, the output for that year being 13,077 barrels. In 1906 the production exceeded 1,000,000 barrels and in 1918 it was 10,737,072 barrels, or 62.5 percent of the total for the State. The value was \$2,246,190 or only 24.8 percent of the total.

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 1918 was only 2,694,686 barrels or 15.7 percent of the State output but the value was \$3,427,061 or 37.8 percent of the total value for the State. 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 percent being table and dairy salt.

In the Manistee-Ludington district, salt is made at Manistee, Manistee County, and at Ludington, Mason County. In this district, 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. This district produced 3,266,436 barrels of salt valued at \$92,952,753. This is equivalent to 18.5 percent of the total quantity and 32.6 percent of the value for the State. Most of the product is packer's salt, i. e., common fine and common coarse.

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES.  
1835-1918

| Year. | U. S. Production, Quantity bbls. | Michigan production.                  |                             | Per Cent. of Total Michigan. | Rank Quantity. | Michigan.      |             |             |
|-------|----------------------------------|---------------------------------------|-----------------------------|------------------------------|----------------|----------------|-------------|-------------|
|       |                                  | State Salt In-p. cuts* Quantity bbls. | U. S. G. S.† Quantity bbls. |                              |                | Value Michigan | Rank Value. | Price bbls. |
| 1865  |                                  | 477,200                               |                             |                              |                |                |             |             |
| 1866  |                                  | 407,997                               |                             |                              |                | \$734,395      |             | \$1.80      |
| 1867  |                                  | 474,721                               |                             |                              |                | 840,255        |             | 1.77        |
| 1868  |                                  | 555,690                               |                             |                              |                | 1,028,027      |             | 1.85        |
| 1869  |                                  | 561,288                               |                             |                              |                | 786,839        |             | 1.58        |
| 1870  |                                  | 621,352                               |                             |                              |                | 820,185        |             | 1.32        |
| 1871  |                                  | 728,175                               |                             |                              |                | 1,063,135      |             | 1.46        |
| 1872  |                                  | 724,481                               |                             |                              |                | 1,127,984      |             | 1.37        |
| 1873  |                                  | 821,346                               |                             |                              |                | 1,244,684      |             | 0.81        |
| 1874  |                                  | 1,036,970                             |                             |                              |                | 1,220,094      |             | 1.19        |
| 1875  |                                  | 1,081,856                             |                             |                              |                | 1,190,042      |             | 1.10        |
| 1876  |                                  | 1,482,729                             |                             |                              |                | 1,556,805      |             | 1.05        |
| 1877  |                                  | 1,660,997                             |                             |                              |                | 1,411,847      |             | 0.85        |
| 1878  |                                  | 1,855,884                             |                             |                              |                | 1,577,501      |             | 0.85        |
| 1879  |                                  | 2,058,940                             |                             |                              |                | 2,099,200      |             | 1.02        |
| 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              | 2,302,648      |             | 0.757       |
| 1885  | 7,038,653                        | 3,297,403                             | 3,297,403                   | 46.84                        | 1              | 2,967,663      |             | 0.900       |
| 1886  | 7,707,081                        | 3,667,257                             | 3,667,257                   | 47.58                        | 1              | 2,420,959      |             | 0.661       |
| 1887  | 8,003,062                        | 3,044,309                             | 3,044,309                   | 49.17                        | 1              | 2,201,842      |             | 0.581       |
| 1888  | 8,065,851                        | 3,866,228                             | 3,866,228                   | 47.99                        | 1              | 2,201,743      |             | 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                             | 3,838,637                   | 43.72                        | 1              | 2,302,579      |             | 0.600       |
| 1891  | 9,087,945                        | 3,927,071                             | 3,906,748                   | 39.52                        | 1              | 2,037,289      |             | 0.513       |
| 1892  | 11,098,890                       | 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                             | 7,117,352                   | 36.14                        | 2              | 2,205,024      |             | 0.309       |
| 1900  | 20,869,342                       | 4,738,085                             | 7,210,621                   | 34.55                        | 2              | 2,033,731      |             | 0.282       |
| 1901  | 20,666,661                       | 5,580,101                             | 7,729,041                   | 37.58                        | 1              | 2,437,677      |             | 0.328       |
| 1902  | 23,840,231                       | 4,965,245                             | 8,131,781                   | 34.16                        | 2              | 1,635,823      |             | 0.188       |
| 1903  | 18,968,089                       | 4,387,982                             | 4,297,542                   | 22.65                        | 2              | 1,119,984      |             | 0.260       |
| 1904  | 22,080,002                       | 5,390,812                             | 5,425,904                   | 24.62                        | 2              | 1,579,206      |             | 0.309       |
| 1905  | 25,060,122                       | 5,671,253                             | 9,49,179                    | 35.24                        | 1              | 1,851,332      |             | 0.196       |
| 1906  | 28,172,380                       | 6,44,539                              | 9,936,807                   | 36.31                        | 1              | 2,018,760      |             | 0.203       |
| 1907  | 29,704,128                       | 6,298,463                             | 10,786,630                  | 35.39                        | 1              | 2,231,129      |             | 0.208       |
| 1908  | 28,822,062                       | 6,247,073                             | 10,194,279                  | 35.34                        | 1              | 2,438,303      |             | 0.241       |
| 1909  | 30,107,646                       | 6,055,661                             | 9,966,744                   | 33.16                        | 1              | 2,732,556      |             | 0.274       |
| 1910  | 30,305,656                       | 5,097,276                             | 9,452,022                   | 31.18                        | 2              | 2,231,262      |             | 0.236       |
| 1911  | 31,183,968                       |                                       | 10,320,074                  | 33.10                        | 2              | 2,633,155      |             | 0.255       |
| 1912  | 33,324,808                       |                                       | 10,946,739                  | 32.84                        | 1              | 2,974,429      |             | 0.277       |
| 1913  | 34,393,227                       |                                       | 11,528,800                  | 33.52                        | 1              | 3,293,032      |             | 0.285       |
| 1914  | 34,402,772                       |                                       | 11,670,970                  | 33.92                        | 1              | 3,299,005      |             | 0.283       |
| 1915  | 38,231,406                       |                                       | 12,588,788                  | 32.93                        | 1              | 4,304,731      |             | 0.342       |
| 1916  | 45,440,329                       |                                       | 14,918,278                  | 32.84                        | 1              | 4,612,567      |             | 0.309       |
| 1917  | 49,844,125                       |                                       | 16,978,136                  | 32.25                        | 1              | 6,817,262      |             | 0.421       |
| 1918  | 51,705,317                       |                                       | 17,165,178                  | 33.19                        | 1              | 9,048,650      |             | 0.520       |
| Total |                                  |                                       | 269,967,192                 |                              |                | 114,740,913    |             |             |

\*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.

upper, thick, and apparently persistent bed from 60 to 125 feet in thickness and a lower very thick and continuous bed having a maximum thickness of over 350 feet, though it probably contains partings of dolomite or shale. The average aggregate thickness of the salt beds along Detroit and St. Clair rivers is about 400 feet, but at Royal Oak and Dearborn 609 and 556 feet of salt respectively were penetrated and at the former place the bottom of the Salina apparently was not reached.

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY GRADES, 1906-1918

| Year | Table and dairy |             | Packers          |           |                  |           |
|------|-----------------|-------------|------------------|-----------|------------------|-----------|
|      | Quantity        | Value       | Common fine      |           | Common Course    |           |
|      |                 |             | Quantity         | Value     | Quantity         | Value     |
|      | Barrels         |             | Barrels          |           | Barrels          |           |
| 1906 | 509,905         | \$362,368   | 2,927,478        | \$757,470 | 2,021,287        | \$618,727 |
| 1907 | 657,509         | 392,641     | 3,601,270        | 914,154   | 1,743,840        | 471,378   |
| 1908 | 584,452         | 620,647     | 3,454,062        | 968,617   | 2,020,956        | 610,286   |
| 1909 | 586,370         | 732,907     | 3,530,303        | 1,125,065 | 2,103,719        | 647,878   |
| 1910 | 798,434         | 565,653     | 2,216,181        | 734,828   | 1,992,465        | 596,301   |
| 1911 | 817,486         | 742,702     | 2,362,075        | 698,203   | 2,070,745        | 745,720   |
| 1912 | 905,593         | 920,782     | 2,225,337        | 645,692   | 2,086,492        | 835,673   |
| 1913 | 1,028,008       | 1,037,402   | 2,704,938        | 552,135   | 2,259,164        | 896,521   |
| 1914 | 1,062,344       | 1,023,184   | 2,668,989        | 911,016   | 2,380,378        | 870,715   |
| 1915 | 1,233,117       | 1,420,382   | 3,096,644        | 1,181,337 | 2,263,352        | 1,001,167 |
| 1916 | 1,305,950       | 1,461,085   | 3,109,857        | 1,221,901 | 2,133,690        | 1,064,709 |
| 1917 | 1,388,700       | 2,143,004   | 2,881,000        | 2,106,241 | 1,964,693        | 1,480,660 |
| 1918 | 1,612,207       | 2,500,439   | 3,181,121        | 2,743,657 | 2,514,600        | 2,375,831 |
| Year | Packers         |             | Other rock, etc. |           | Brine and other* |           |
|      | Quantity        | Value       | Quantity         | Value     | Quantity         | Value     |
|      |                 |             |                  |           |                  |           |
|      | Barrels         |             | Barrels          |           | Barrels          |           |
| 1906 | 91,098          | \$33,733    |                  |           | 4,387,043        | \$246,462 |
| 1907 | 119,459         | 48,455      |                  |           | 4,664,552        | 235,729   |
| 1908 | 134,726         | 53,669      |                  |           | 3,991,083        | 205,684   |
| 1909 | 93,357          | 3,983       |                  |           | 3,648,393        | 185,051   |
| 1910 | 92,426          | 43,942      |                  |           | 4,104,934        | 211,317   |
| 1911 | 106,401         | 45,421      | 576,595          | \$181,865 | 4,387,772        | 219,244   |
| 1912 | 223,866         | 84,638      | 703,908          | 250,680   | 4,737,088        | 236,852   |
| 1913 | 50,537          | 25,371      | 737,364          | 244,172   | 4,736,779        | 237,431   |
| 1914 |                 |             | 712,530          | 252,024   | 4,816,735        | 240,086   |
| 1915 |                 |             | 919,735          | 321,354   | 5,073,940        | 380,491   |
| 1916 |                 |             | 1,012,942        | 368,022   | 7,365,927        | 508,850   |
| 1917 |                 |             | 1,304,543        | 568,717   | 8,630,808        | 578,574   |
| 1918 |                 |             | 1,405,671        | 827,348   | 8,451,578        | 541,375   |
| Year | Total           |             |                  |           |                  |           |
|      | Quantity        | Value       |                  |           |                  |           |
|      |                 |             |                  |           |                  |           |
|      | Barrels         |             |                  |           |                  |           |
| 1906 | 9,936,802       | \$2,018,760 |                  |           |                  |           |
| 1907 | 10,786,630      | 2,062,357   |                  |           |                  |           |
| 1908 | 10,194,270      | 2,458,303   |                  |           |                  |           |
| 1909 | 9,968,744       | 2,732,556   |                  |           |                  |           |
| 1910 | 9,452,022       | 2,231,262   |                  |           |                  |           |
| 1911 | 10,320,074      | 2,633,155   |                  |           |                  |           |
| 1912 | 10,946,739      | 2,974,429   |                  |           |                  |           |
| 1913 | 11,528,800      | 3,293,032   |                  |           |                  |           |
| 1914 | 11,670,970      | 3,299,005   |                  |           |                  |           |
| 1915 | 12,588,788      | 4,304,731   |                  |           |                  |           |
| 1916 | 14,918,278      | 4,612,567   |                  |           |                  |           |
| 1917 | 16,978,136      | 6,817,262   |                  |           |                  |           |
| 1918 | 17,165,178      | 9,048,650   |                  |           |                  |           |

\*Brine only after 1910.  
†See common fine and common coarse after 1913.

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

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

The rock salt occurs in the Salina formation of Silurian age. There are three known rock salt areas, one in southeastern Michigan, a second in Alpena and Presque Isle counties, and a third in Mason and Manistee counties. South of the line from Muskegon through Kalamazoo to Trenton, Wayne County, no rock salt has been found, though wells have penetrated completely through the rock salt bearing formation at many places. The area of rock salt in southeastern Michigan so far known extends from Trenton, Wayne County, northeast along Detroit and St. Clair rivers into western Ontario. The total area known to be underlain by rock salt in southeastern Michigan and western Ontario is several thousand square miles. The rock salt area extends northwest from Detroit River to and beyond Romulus and Dearborn in Wayne County, and Royal Oak in Oakland County but how far the salt area continues in this direction is unknown, since there are no wells northwest of these places deep enough to reach the salt bearing horizons. The aggregate thickness of the salt beds at Royal Oak and Dearborn is greater than to the southeast along Detroit River, thus indicating a considerable extension to the northwest of these places. In southeastern Michigan, the salt beds are very numerous and some of them very thick. There is an

and 5 feet in thickness have been penetrated in some of the wells.

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

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

\*See Bromine page 22.

| PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES, 1918 |                  |             |              |             |                |             |                   |           |           |
|------------------------------------------------------------|------------------|-------------|--------------|-------------|----------------|-------------|-------------------|-----------|-----------|
| County.                                                    | Table and dairy. |             | Packers.     |             |                |             | Other, rock, etc. |           | Brine.    |
|                                                            | Tons.            | Value.      | Common fine. |             | Common coarse. |             | Tons.             | Value.    |           |
|                                                            |                  |             | Tons.        | Value.      | Tons.          | Value.      |                   |           | Tons.     |
| Bay                                                        | a                | a           | a            | a           | 93,670         | \$637,152   | a                 | a         | a         |
| Benzie                                                     | a                | a           | a            | a           | a              | a           | a                 | a         | a         |
| Charlevoix                                                 | a                | a           | a            | a           | a              | a           | a                 | a         | a         |
| Grand Haven                                                | a                | a           | a            | a           | a              | a           | a                 | a         | a         |
| Grand Rapids                                               | 169,769          | \$2,173,425 | 13,041       | \$94,776    | 41,955         | \$266,333   | a                 | a         | a         |
| Leelanau                                                   | 43,921           | 426,714     | 74,434       | 428,938     | 33,135         | 224,745     | a                 | a         | a         |
| Manistee                                                   | a                | a           | a            | a           | a              | a           | a                 | a         | a         |
| St. Clair                                                  | a                | a           | a            | a           | a              | a           | a                 | a         | a         |
| Wayne                                                      | a                | a           | a            | a           | a              | a           | a                 | a         | a         |
| Total—Tons                                                 | 225,709          | \$2,560,439 | 445,337      | \$2,743,637 | 352,044        | \$2,375,831 | 196,794           | \$897,384 | 1,183,221 |
| Bbls.                                                      | 1,612,207        |             | 3,181,121    |             | 2,514,660      |             | 1,405,671         |           | 8,451,579 |

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES, 1918.—Continued

| County.      | Total.     |             | County.           |                | Bromine.  |           | Calcium chloride. |           |
|--------------|------------|-------------|-------------------|----------------|-----------|-----------|-------------------|-----------|
|              | Tons.      | Value.      | Quantity Percent. | Value Percent. | Pounds.   | Value.    | Tons.             | Value.    |
|              |            |             |                   |                |           |           |                   |           |
| Bay          | 296,900    | \$1,855,455 | 12.3              | 20.6           | a         | a         | a                 | a         |
| Benzie       | 169,877    | 1,127,265   | 6.8               | 12.8           | a         | a         | a                 | a         |
| Charlevoix   | 42,952     | 462,678     | 2.6               | 4.0            | a         | a         | a                 | a         |
| Grand Haven  | 877,208    | 3,427,091   | 15.7              | 37.8           | a         | a         | a                 | a         |
| Grand Rapids | 1,508,190  | 2,246,190   | 62.6              | 24.8           | a         | a         | a                 | a         |
| Total—Tons   | 2,405,125  | \$9,048,650 | 100.0             | 100.0          | 1,605,696 | \$855,841 | 20,615            | \$394,200 |
| Bbls.        | 17,165,179 |             |                   |                |           |           |                   |           |

a—Included in total.

BROMINE AND CALCIUM CHLORIDE

The brines of the Marshall sandstone especially near the center of the State contain appreciable quantities of bromine and considerable quantities of chlorides other than sodium chloride or salt. In the early days of the salt industry the bitters or "mother liquors" left after the precipitation of the salt were thrown away. The discovery that the bitters were rich in bromine and calcium chloride led some of the salt companies to install suitable machinery and equipment for the recovery of one or both of these products. Chemical plants were also built for the recovery of bromine and the manufacture of chemicals from the brine. Large quantities of bromine, chiefly in the form of bromides and calcium chloride were produced. Over-production and competition with German bromine forced the price of bromine so low that for a number of years prior to the War the recovery of bromine was abandoned by all of the salt manufacturing concerns. The Dow Chemical Company of Midland however, continued to produce large quantities of bromine and other chemicals derived from the brines.

Bromine dropped in value to 25 cents and to 30 cents a pound in 1913. In 1914 when the World War cut off the supplies of German bromine France, Italy and England became largely dependent upon the United States for their supply. The price of bromine advanced to

unprecedented figures, reaching the peak price of \$6.50 a pound in New York\* in the spring of 1916. The industry was revived in the Saginaw valley. In 1917 there were five producers; in 1918 the Government ordered new wells driven at Midland to increase the supply of bromine since with the entrance of the United States into the War and the increased use of asphyxiating gases the needs of the United States as well as of the Allies had vastly increased.

Prior to the War the bromine of Michigan was marketed largely as bromides but the increased demand caused the marketing of a large amount of bromine in the crude state—a heavy, reddish brown mobile liquid. Bromine is used in many chemical reactions, in separating gold from platinum and silver, in the manufacture of disinfectants, dyes and drugs. During the War because of its effects upon the eyes and throat bromine was extensively used in the manufacture of asphyxiating gases but after the Armistice was signed the large demand for this purpose naturally fell off. A demand increased by the War and one to be continued is for potassium bromide used as a depressant in the treatment of certain nervous diseases. The use of bromine in the form of silver bromide in photography is well known.

In 1918 the quantity of bromine marketed in Michigan was 1,605,696 pounds valued at \$955,841, or 93.08 percent of the total United States production at 88.2 percent of the total United States valuation of \$970,099. The increased production over 1917 was 870,052 pounds or 118.26 percent; the increase in value was \$450,792 or 111 percent. This increase in value is due to the greatly increased production since the price of bromine dropped to \$.53 a pound. The price for the United States remained steady at about \$.75 until the Armistice was signed when the foreign demand fell off and the price dropped to \$.50; if the Government gradually places its reserve stocks of bromine on the market this price will remain fairly stable for some time.

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 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-playgrounds. Since the playground movement is becoming so widespread and since ground treated with calcium chloride presents a hard, dry, dustless surface a few hours after treatment it is advised that greater use be made of the product to provide clean, dust-free playgrounds.

The output of calcium chloride for 1918 was 20,615 tons valued at \$394,200 or \$19.12 a ton, a decrease in output of 2,064 tons or 9.1 per cent, but an increase in value of \$99,507 or 33.7 percent.

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\*It should be remembered that prices quoted in the New York market are much higher than those representing value of the marketed product in large lots f. o. b. at the point of shipment.

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## CEMENT\*

In 1895, less than 1,000,000 barrels of Portland cement were made in the United States. This was only about one-fifth of the maximum pre-War production in Michigan (4,919,123 barrels in 1916.)

Prior to 1895, the kilns used were of the vertical type but in that year rotary kilns, using powdered coal as a fuel were successfully introduced, revolutionizing cement manufacture and enabling the industry in the United States to excel that of Europe, and thus inaugurating 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 has continued almost uninterruptedly up to 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.

The first attempts to manufacture Portland cement in the United States were made in Michigan in 1878 when a vertical kiln plant for manufacturing cement from marl and clay was erected near Kalamazoo. The enterprise failed in 1892, because of the high cost of manufacturing. The Peerless Portland Cement Co., in 1896, erected a vertical kiln plant at Union City, Branch County, and began the successful manufacture of Portland cement from marl and shale. By 1902, the old vertical kilns had been replaced by rotary types. In 1897, the Bronson Portland Cement Co. erected a plant at Bronson, Branch County and next year the Coldwater Cement Co., now the Wolverine Portland Cement Co., built plants at Coldwater and Quincy, also in Branch County.

The period between 1899 and 1901 was the "boom" years of the industry, twenty companies being organized in this period for the manufacture of Portland cement from marl and clay or shale. 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-five different cement plants

have been projected or built in Michigan. Eleven were in operation in 1918. Michigan shared with other States the general decrease in output due to War conditions. Of the ten operating plants one was closed nearly all the year and two others part of the year. Operators reported from 30 percent to 56 percent decrease in production.

The New Egyptian Portland Cement Company in April 1918 was obliged to close its plant near Fenton because of shortage of coal, scarcity of labor and government restrictions. Operation of the plant has now (July, 1919) been resumed by a syndicate which acquired the property from the Security Trust Co., receivers. The new company will manufacture cement from the marl obtained from the company's holdings of 800 acres of marl land.

A new company, the Petoskey Portland Cement Co., has been organized at Petoskey; docks are being built but the plant will probably not be in operation until late in 1920.

The principal raw materials used in Michigan in the manufacture of Portland cement are marl or limestone and clay or shale, though the lime refuse from a soda ash plant near Detroit is also being utilized. The early companies planned to use marl and clay or shale. Because of the greater kiln capacity and lower fuel costs, limestone has been substituted for marl wherever practical. Of eleven plants, six are reported to be using marl and clay and five limestone and shale or clay. The Petoskey Portland Cement Co., intends to use limestone and shale. The plant is to be erected on limestone deposits on Little Traverse Bay about two and one-half miles west of Petoskey. The shale will be obtained from a quarry at Ellsworth in Charlevoix County twenty-seven miles southwest of Petoskey.

When the War caused restrictions in potash imports and the shortage of potash in the United States became acute the attention of Portland cement manufacturers was turned to the recovery of potash from cement dust. Several Michigan companies have the project under consideration and one, the Newaygo Portland Cement Company began the recovery of potash by the Cottrell process in June, 1918.

It has been estimated that nearly one-third of the annual requirements of potash are going to waste in cement dusts; production of potash by recovery from cement dusts may be maintained in the face of competition; use of the dust would rid nearby towns of an ever-present dust nuisance. These facts combined with the steady demand and high price received for potash and the proposed legislation to protect the industry would seem sufficient to cause all the cement producers to install apparatus for potash recovery from cement-furnace dusts and flue gases, and add a valuable by-product to the Portland cement industry.

The following table shows that Michigan produced 3,554,872 barrels of cement in 1918 as compared with 4,688,899 barrels in 1917 a decrease of 1,134,027 barrels or 24.2 percent. The decrease in shipments

beginning in 1916 continued during 1917 and 1918; shipments decreased from 4,313,771 barrels in 1917 to 3,618,088 barrels in 1918 a loss of 695,683 barrels. As before stated decreases were chiefly due to Government restrictions induced by the War. The value of the cement shipped also shows a decrease, the total value in 1918 being \$6,078,167 a decrease of \$44,720 or 0.7 per cent. This disproportionate decrease in value is due to the increase in the average price per barrel—\$1.68, an increase of \$.261 over the average 1917 price per barrel and of \$.493 over the average for 1916—a War-caused increase of 44.6 per cent.

\*See Pub. 24, Geol. Ser. 17, Min. Res. for 1916, for a more detailed report.

PRODUCTION, VALUE, ETC., OF PORTLAND CEMENT IN MICHIGAN AND UNITED STATES, 1896-1918.

| Year | No. of plants in operation | Michigan Rank | No. of kilns | Daily capacity, Bbls. | Michigan, cc. Bbls. made | U. S. Cement Bbls. made | Michigan, per cent made | %Change per cent made | Michigan cement shipped, Bbls. | Michigan cement value, \$1000 | U. S. Cement Value | Michigan, per cent of value | Michigan, stock in hand, Dec. 31 | Michigan, value per barrel | U. S. value per barrel |
|------|----------------------------|---------------|--------------|-----------------------|--------------------------|-------------------------|-------------------------|-----------------------|--------------------------------|-------------------------------|--------------------|-----------------------------|----------------------------------|----------------------------|------------------------|
| 1896 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1897 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1898 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1899 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1900 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1901 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1902 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1903 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1904 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1905 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1906 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1907 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1908 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1909 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1910 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1911 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1912 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1913 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1914 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1915 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1916 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1917 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |
| 1918 | 1                          | 1             | 4            | 1,000                 | 1,000                    | 1,543,023               | 0.35                    | .....                 | 87,000                         | \$2,244,011                   | 0.29               | .....                       | 81,777                           | \$1.45                     | \$1.57                 |

\* Minus sign indicates decrease.

## POTASH

Though Michigan has deposits of rock salt of great extent they are not known to contain potash bearing salts. A small amount of potash is recovered from industrial wastes (cement dust and Steffens water from beet sugar manufacture) and wood ashes. In 1918 the production of potash reckoned as K<sub>2</sub>O, amounted to 404 tons valued at \$100,647, of which 196 tons were from industrial wastes and 206 tons from wood ashes.

When the shortage of potash became acute due to the restrictions in imports caused by the War, attention was turned to the development of all possible domestic sources, particularly to the recovery of potash from former manufacturing wastes. Several Portland cement companies considered the project of recovering potash from cement dust. In June Newago Portland Cement Company began the recovery of potash by the Cottrell process, investigation showing that it was possible to recover about three tons of potash in the manufacture of 2,000 barrels of cement. During a four-month trial mechanical difficulties developed, however, which rendered the recovery of potash unprofitable. It is possible that when the mechanical difficulties are overcome the Newago Portland Cement Company will again open its potash recovery plant.

## GYPSUM

From 1868 to 1889, the annual production of gypsum in Michigan never reached 70,000 tons. The production in 1890, however, attained a maximum of 74,877 tons. The maximum value of gypsum and gypsum products for

the period was attained in 1883, the value being \$377,567. The growth of the industry began in 1890. In 1892 the output reached 139,557 tons but the financial depression throughout the country during 1892-3 disorganized the industry, the production in 1895 decreasing to only 66,519 tons, or less than half that in 1892. From 1896 to 1916 the growth was almost uninterrupted, reaching the maximum production of 457,375 tons in that year, valued at \$1,066,588.

The increased production in 1916 was due to the general activity and prosperity in industrial lines, particularly in the building trades. After the entry of the United States in the War in 1917 building operations, excepting for War purposes, were greatly curtailed. This is reflected in the marked decrease in the production of gypsum and gypsum products for 1917 and 1918, the production falling from 457,375 tons to 375,803 tons in 1917 and to 286,768 tons in 1918, a decrease of 17.8 percent in 1917 and 89,035 tons or 23.69 percent in 1918, a total decrease in production of 170,607 tons or 37.3 percent following the entry of the United States into the War. The percentage decrease for Michigan in 1918 corresponds to the average decrease for the entire United States.

On the other hand, due to the great increase in prices, the value of gypsum and gypsum products marketed increased from \$1,066,599 in 1916 to \$1,568,655 in 1917—a gain of \$502,056 or 56.4 percent, and to \$1,761,149 in 1918 a further gain of \$192,494 or 12.27 percent, producing a total increase of 65.11 percent over pre-War prices, despite the 37.3 percent decrease in production from the maximum (1916) pre-War production.

In the early days of the gypsum industry four-fifths of the raw gypsum was ground into land plaster and from 1869 to 1887 more than half of the gypsum mined was ground into this product. With the more general use of patent fertilizers the demand for land plaster has 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. The Gypsum Industries Association of Chicago, Ill., has launched a campaign to induce greater use of gypsum as land plaster and as a deodorizer and fixative of ammonia in manure about stables. This campaign may have some effect in increasing production of ground gypsum in Michigan since its use will prevent the present wastage of fertilizer value of stable refuse caused by the evaporation and consequent loss of much of the ammonia content. 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. Since 1887, the grinding of land plaster has become relatively insignificant in comparison with the manufacture of building products. In 1918, the value of land plaster was only \$23,876 as compared with \$1,629,711 for calcined products.

The most important of these products is mixed wall plaster; gypsum board and stucco are next in importance. In 1918 wall plaster was valued at \$931,725, or 52.9 percent of the total value of raw and calcined products for the State. Stucco was valued at \$330,761 or 18.7 percent of the total value. The manufacture of gypsum board and tiles is increasing rapidly, the 1918 production exceeding that of 1917 by 73.5 percent in quantity and 401.7 percent in value. The value of the product in 1918 was \$339,901 or 19.3 of the total value of the State, compared with a value of \$67,741 or 4.3 percent of the State total in 1917.

In 1918, five mines, two quarries and eight mills were in operation. Five mines, one quarry and six mills are located at Grand Rapids, Kent County, one quarry and mill at Alabaster, Iosco County, and one mill at Detroit. At least three, and probably four, gypsum beds are worked in Kent County. 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 water troubles which were increasing with the progress of quarrying the quarries have given place to mines. In the western part of Grand Rapids a third bed about 22 feet thick with a parting of shale one foot thick near the center occurs about 60 feet below the surface. At Grandville an upper bed, about 11 feet thick is directly overlain by sand and gravel and is separated below from a 14-foot bed of gypsum by about four feet of hard limestone. These two beds may be equivalent to the 22-foot "split" in West Grand Rapids. The upper bed was formerly quarried but, because of heavy overburden and water, the quarries have been replaced by mines opened in the lower bed. Numerous explorations show that there are several other minable gypsum beds in the Grand Rapids-Grandville district.

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

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

Gypsum beds occur on St. Ignace Peninsula and on St. Martins and other adjacent islands. 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 indicates the presence of seven quarryable beds of gypsum in this district, but locally it is probable that water will be troublesome.

Gypsum was quarried near Pt. Aux Chenes as early as 1850. On account of various troubles chief of which were water and a scourge of smallpox, the quarry was operated only intermittently for a number of years. Finally, when an ice-floe carried away the dock, the quarry was abandoned.

Thick gypsum beds are reported by well drillers in the vicinity of Ionia, Ionia County and Cass City, Tuscola County and beds 6 to 12 feet thick are known to occur at comparatively shallow depths at Bellevue, and Eaton Rapids, Eaton County. In brief, the gypsum deposits of Michigan may be said to be practically inexhaustible.

PRODUCTION OF GYPSUM IN MICHIGAN, 1868-1918

| Year.       | Ground into land plaster. Tons. | Calcined into plaster. Tons. | Sold crude. Tons. | Total mined. Tons. | Gypsum and gypsum products. Total value. | Rank.     |        |
|-------------|---------------------------------|------------------------------|-------------------|--------------------|------------------------------------------|-----------|--------|
|             |                                 |                              |                   |                    |                                          | Quantity. | Value. |
| Before 1868 | 132,043                         | 14,285                       | .....             | 146,328            | \$671,022                                | .....     | .....  |
| 1868        | 28,837                          | 8,244                        | .....             | 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             | 284,024                                  | .....     | .....  |
| 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                       | .....             | 68,490             | 349,710                                  | .....     | .....  |
| 1881        | 33,178                          | 20,145                       | .....             | 53,323             | 298,872                                  | .....     | .....  |
| 1882        | 37,821                          | 24,136                       | .....             | 61,957             | 344,374                                  | .....     | .....  |
| 1883        | 40,082                          | 28,410                       | .....             | 68,492             | 377,567                                  | .....     | .....  |
| 1884        | 27,888                          | 27,950                       | .....             | 55,847             | 335,382                                  | .....     | .....  |
| 1885        | 28,184                          | 25,281                       | .....             | 53,465             | 286,892                                  | .....     | .....  |
| 1886        | 20,373                          | 27,370                       | .....             | 47,743             | 308,094                                  | .....     | .....  |
| 1887        | 28,794                          | 30,376                       | .....             | 59,170             | 329,892                                  | .....     | .....  |
| 1888        | 22,177                          | 35,125                       | .....             | 57,302             | 347,531                                  | .....     | .....  |
| 1889        | 19,835                          | 36,800                       | .....             | 56,635             | 353,809                                  | .....     | .....  |
| 1890        | 12,714                          | 47,163                       | 15,000            | 74,877             | 192,099                                  | .....     | .....  |
| 1891        | 15,100                          | 53,600                       | 11,000            | 97,700             | 223,720                                  | .....     | .....  |
| 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        | 17,106                          | 88,315                       | 39,266            | 144,776            | 283,537                                  | .....     | .....  |
| 1900        | 10,504                          | 86,972                       | 33,328            | 129,804            | 286,119                                  | .....     | .....  |
| 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        | 18,400                          | 198,119                      | 52,503            | 269,022            | 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                          | 192,463                      | 40,324            | 327,810            | 401,928                                  | 1         | 3      |
| 1909        | 11,890                          | 344,171                      | 45,781            | 394,907            | 1,213,347                                | 2         | 1      |
| 1910        | 7,007                           | 249,905                      | 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            | 384,297            | 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            | 686,360                                  | 3         | 4      |
| 1916        | 9,072                           | 292,109                      | 80,298            | 457,375            | 1,006,590                                | 3         | 4      |
| 1917        | 7,090                           | 257,588                      | 68,155            | 375,803            | 1,508,655                                | 3         | 3      |
| 1918        | 5,892                           | 207,059                      | 46,608            | 286,758            | 1,761,149                                | 4         | 4      |
| 1919        | .....                           | .....                        | .....             | .....              | .....                                    | .....     | .....  |
| Totals      | 1,264,330                       | 5,187,965                    | 1,192,922         | 8,404,313          | 23,328,023                               | .....     | .....  |

PRODUCTION OF GYPSUM IN MICHIGAN, 1911-1918

| YEAR | Crude<br>gypsum<br>mined. | Gypsum sold crude.        |          |        |                  |        |                     |           |                   |        |
|------|---------------------------|---------------------------|----------|--------|------------------|--------|---------------------|-----------|-------------------|--------|
|      |                           | To Portland cement mills. |          |        | As land plaster. |        | For other purposes. |           | Total sold crude. |        |
|      |                           | Quantity.                 |          | Value. | Quantity.        |        | Value.              | Quantity. |                   | Value. |
|      |                           | Tons.                     | Tons.    |        | Tons.            | Tons.  |                     | Tons.     | Tons.             |        |
| 1911 | 347,295                   | 63,489                    | \$69,497 | 15,548 | \$15,706         | 13     | 852                 | 79,050    | \$86,255          |        |
| 1912 | 384,297                   | 53,711                    | \$52,420 | 10,103 | 9,375            | 1      | 30                  | 63,819    | \$1,845           |        |
| 1913 | 423,606                   | *                         | *        | 9,604  | 10,222           | 10,320 | 9,011               | 60,706    | \$5,369           |        |
| 1914 | 400,000                   | *                         | *        | 9,322  | 10,761           | *      | *                   | 61,227    | \$1,242           |        |
| 1915 | 389,791                   | *                         | *        | 9,799  | 9,808            | *      | *                   | 69,572    | \$1,236           |        |
| 1916 | 457,375                   | *                         | *        | 9,072  | 9,072            | *      | *                   | 80,298    | \$9,973           |        |
| 1917 | 375,803                   | 66,846                    | \$2,874  | 7,090  | 22,908           | *      | *                   | 68,155    | \$15,633          |        |
| 1918 | 286,758                   | 40,314                    | \$65,621 | 5,892  | 25,876           | *      | *                   | 46,608    | \$11,428          |        |

| Year | Gypsum sold calcined.  |           |                           |          |            |           |                       |          |                       |          |
|------|------------------------|-----------|---------------------------|----------|------------|-----------|-----------------------|----------|-----------------------|----------|
|      | As mixed wall plaster. |           | As plaster of Paris, etc. |          | As stucco. |           | As boards, tile, etc. |          | To plate glass works. |          |
|      | Quantity.              | Value.    | Quantity.                 | Value.   | Quantity.  | Value.    | Quantity.             | Value.   | Quantity.             | Value.   |
|      | Tons.                  | Tons.     | Tons.                     | Tons.    | Tons.      | Tons.     | Tons.                 | Tons.    | Tons.                 | Tons.    |
| 1911 | 146,920                | \$381,362 | 47,989                    | \$68,168 | .....      | .....     | .....                 | .....    | 11,370                | \$19,031 |
| 1912 | 146,920                | 308,076   | 937                       | 3,229    | 82,610     | \$108,134 | .....                 | .....    | 6,214                 | \$8,078  |
| 1913 | 166,713                | 417,720   | .....                     | .....    | 60,402     | 202,673   | .....                 | .....    | .....                 | .....    |
| 1914 | 166,713                | 415,638   | .....                     | .....    | 80,172     | 177,317   | .....                 | .....    | .....                 | .....    |
| 1915 | 185,561                | 429,532   | .....                     | .....    | 83,780     | 173,172   | .....                 | .....    | .....                 | .....    |
| 1916 | 189,849                | 468,705   | 224                       | 1,325    | 87,405     | 279,567   | .....                 | .....    | .....                 | .....    |
| 1917 | 187,371                | 949,511   | .....                     | .....    | 86,230     | 384,561   | 15,118                | \$67,741 | .....                 | .....    |
| 1918 | 117,562                | 931,725   | .....                     | .....    | 52,132     | 330,761   | 33,253                | \$39,901 | .....                 | .....    |

\*Included in total.

PRODUCTION OF GYPSUM IN MICHIGAN, 1911-1918—Continued

| Year | Gypsum sold calcined. |          |                      |           | Total value. | Kettles in mills. |       | Daily output—tons. |           | Shifts run by mills during year. |           | No. mines and No. mills |   |
|------|-----------------------|----------|----------------------|-----------|--------------|-------------------|-------|--------------------|-----------|----------------------------------|-----------|-------------------------|---|
|      | For other purposes.   |          | Total sold calcined. |           |              | No.               | Size. | 24 hrs.            | Total No. | Hrs. in shift.                   | No. mines | No. mills               |   |
|      | Quantity.             | Value.   | Quantity.            | Value.    |              |                   |       |                    |           |                                  |           |                         |   |
|      | Tons.                 | Tons.    | Tons.                | Tons.     |              |                   |       |                    |           |                                  |           |                         |   |
| 1911 | .....                 | .....    | 206,299              | \$458,671 | \$273,020    | 29                | 8x10  | 2,200              | .....     | .....                            | .....     | 8                       | 8 |
| 1912 | 8,303                 | \$10,973 | 243,656              | \$59,702  | \$21,347     | 28                | 8x10  | 2,149              | 1,530     | 11                               | 8         | 8                       | 8 |
| 1913 | .....                 | .....    | 249,648              | \$54,556  | \$21,347     | 28                | 8x10  | 1,785              | 1,368     | 11                               | 7         | 7                       | 7 |
| 1914 | 1,811                 | 5,433    | 249,648              | \$54,556  | \$21,347     | 28                | 8x10  | 1,785              | 1,368     | 11                               | 7         | 7                       | 7 |
| 1915 | .....                 | .....    | 249,648              | \$54,556  | \$21,347     | 28                | 8x10  | 1,785              | 1,368     | 11                               | 7         | 7                       | 7 |
| 1916 | .....                 | .....    | 249,648              | \$54,556  | \$21,347     | 28                | 8x10  | 1,785              | 1,368     | 11                               | 7         | 7                       | 7 |
| 1917 | .....                 | .....    | 249,648              | \$54,556  | \$21,347     | 28                | 8x10  | 1,785              | 1,368     | 11                               | 7         | 7                       | 7 |
| 1918 | .....                 | .....    | 207,059              | \$229,711 | \$1,701,149  | .....             | ..... | .....              | .....     | .....                            | .....     | .....                   | 8 |

\*Included in total.

## BRICK AND TILE PRODUCTS

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

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

Important deposits of blue gray shale occur near Ellsworth, Charlevoix County. The shale is quarried and sold for the manufacture of Portland cement, but no tests have been made to determine the suitability of the shale for clay products. Other deposits of shale occur in this vicinity but are undeveloped. Recently a deposit of high lime clay, possibly weathered shale, has been discovered west of Rogers, Michigan. Other undeveloped deposits of shale occur in Alpena, Cheboygan, Huron, Branch and Ingham counties. Some of the shales associated with the coal beds in Saginaw Valley are suitable for front brick and vitrified products.

**Production.** In 1918 the value of brick and tile products was \$1,708,736, exclusive of pottery,\* or \$1,137,525 less than in 1917. This was a decrease of 39.9 percent as compared with the 5.2 percent increase in 1917 and the-20.3 percent increase in 1916. The quantity of common brick was 94,746,000 or 141,866,000 brick less than in 1917 and 184,429,000 less than the pre-War production of 1916. This represents a decrease of 59.6 percent in quantity during 1918 and a decrease of 66.6 percent from the pre-War maximum of 1916. The value of common brick was \$9157599 or an average price of \$9.65 per thousand as compared with \$7.95 per thousand in 1917 and \$6.65 in 1916. This was an advance in price of nearly 20.3 percent in 1918 and an advance of 45.1 percent above the pre-War figures. The value of drain tile, however, decreased from \$734,042, to \$565,398, a loss of about 23 percent. During 1917 the decrease in manufacture was due largely to a lack of coal which decreases the output, but in 1918 the general

stagnation in the building industries due to the War and the withdrawal of men from the industry in to the Army accounts for the greatly decreased output. One operator reports decreased production due to a decreased demand for drain tile due to the dry season of 1918.

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 made in the State are made in this vicinity. The growth of Detroit in this direction, 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 are 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 1917 another plant was projected at Williamston, Ingham County, but this will not be built until post-War time developments permit profitable operation.

\*See Pottery, value \$1,976,436.

| ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1918 |               |              |                      |              |          |                      |                  |          |                      |             |             |
|---------------------------------------------------------------------|---------------|--------------|----------------------|--------------|----------|----------------------|------------------|----------|----------------------|-------------|-------------|
| Year.                                                               | Common brick. |              |                      | Front brick. |          |                      | Vitrified brick. |          |                      | Drain tile. | Sewer pipe. |
|                                                                     | Quantity.     | Value.       | Average price per M. | Quantity.    | Value.   | Average price per M. | Quantity.        | Value.   | Average price per M. | Value.      | Value.      |
| 1899                                                                | 290,144,000   | \$933,176    | \$4.66               | 4,299,000    | \$58,930 | \$13.73              | *                | *        | *                    | \$140,171   | \$50,390    |
| 1900                                                                | 190,802,000   | 603,559      | 4.77                 | 8,421,000    | 48,411   | 5.75                 | *                | *        | *                    | 112,742     | 57,916      |
| 1901                                                                | 152,506,000   | 1,063,234    | 5.07                 | 9,476,000    | 64,081   | 6.70                 | *                | *        | *                    | 98,572      | *           |
| 1902                                                                | 237,234,000   | 1,081,525    | 5.01                 | 5,084,000    | 46,709   | 7.53                 | *                | *        | *                    | 12,26       | 96,453      |
| 1903                                                                | 216,191,000   | 1,115,572    | 5.16                 | 2,235,000    | 19,000   | 8.54                 | *                | *        | *                    | 18,27       | 129,628     |
| 1904                                                                | 203,186,000   | 1,115,572    | 5.16                 | 1,084,000    | 7,500    | 6.94                 | *                | *        | *                    | 18,28       | 208,068     |
| 1905                                                                | 211,324,000   | 1,178,202    | 5.58                 | 625,000      | 5,000    | 8.05                 | 6,112,000        | \$81,706 | 13.37                | 205,445     | *           |
| 1906                                                                | 208,583,000   | 1,178,202    | 5.58                 | 1,474,000    | 14,103   | 9.61                 | 6,229,000        | \$1,514  | 13.13                | 314,098     | *           |
| 1907                                                                | 219,820,000   | 1,250,747    | 5.69                 | 4,854,000    | 32,116   | 8.12                 | 7,911,000        | 94,681   | 11.96                | 289,868     | *           |
| 1908                                                                | 219,820,000   | 1,250,747    | 5.69                 | 2,896,000    | 19,430   | 10.28                | 6,185,000        | 129,283  | 12.34                | 327,630     | *           |
| 1909                                                                | 232,551,000   | 1,303,316    | 5.60                 | 2,399,000    | 18,634   | 7.84                 | 10,473,000       | 129,283  | 12.34                | 364,006     | *           |
| 1910                                                                | 232,465,000   | 1,301,986    | 5.59                 | 2,498,000    | 27,523   | 12.46                | 6,080,000        | 116,495  | 12.52                | 348,285     | *           |
| 1911                                                                | 271,189,000   | 1,292,283    | 5.07                 | 3,004,000    | 31,372   | 10.44                | 5,597,000        | 78,536   | 14.00                | 312,672     | *           |
| 1912                                                                | 277,309,000   | 1,401,185    | 5.04                 | 2,498,000    | 27,523   | 12.46                | 6,080,000        | 129,283  | 12.34                | 385,945     | *           |
| 1913                                                                | 269,154,000   | 1,633,216    | 6.07                 | 3,004,000    | 31,372   | 10.44                | 5,597,000        | 129,283  | 12.34                | 411,543     | *           |
| 1914                                                                | 277,309,000   | 1,401,185    | 5.04                 | 2,498,000    | 27,523   | 12.46                | 6,080,000        | 129,283  | 12.34                | 348,285     | *           |
| 1915                                                                | 277,309,000   | 1,401,185    | 5.04                 | 2,498,000    | 27,523   | 12.46                | 6,080,000        | 129,283  | 12.34                | 348,285     | *           |
| 1916                                                                | 277,309,000   | 1,401,185    | 5.04                 | 2,498,000    | 27,523   | 12.46                | 6,080,000        | 129,283  | 12.34                | 348,285     | *           |
| 1917                                                                | 277,309,000   | 1,401,185    | 5.04                 | 2,498,000    | 27,523   | 12.46                | 6,080,000        | 129,283  | 12.34                | 348,285     | *           |
| 1918                                                                | 94,746,000    | \$915,759    | \$9.65               | *            | *        | 18.62                | 5,539,000        | 80,915   | 14.50                | 305,156     | *           |
| Totals                                                              | 4,461,802,000 | \$25,981,508 |                      | *            | *        | 24.22                |                  |          | 15.26                | 734,042     | *           |

\* Concealed: less than three producers.

| ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1918.—Continued |                   |        |               |                |                         |                            |                |                         |              |  |  |
|--------------------------------------------------------------------------------|-------------------|--------|---------------|----------------|-------------------------|----------------------------|----------------|-------------------------|--------------|--|--|
| Year                                                                           | Tile (not drain). |        | Fireproofing. | Miscellaneous. | Hollow building blocks. | Per cent of total product. | Rank of state. | No. of firms operating. | Total Value. |  |  |
|                                                                                | Quantity.         | Value. |               |                |                         |                            |                |                         |              |  |  |
| 1899                                                                           |                   |        | 85,000        | \$32,700       |                         | 1.68                       | 13             | 190                     | \$1,234,236  |  |  |
| 1900                                                                           |                   |        | 2,350         | 406            |                         | 1.50                       | 17             | 190                     | 1,147,278    |  |  |
| 1901                                                                           |                   |        | 1,800         | 607            |                         | 1.71                       | 13             | 180                     | 1,497,199    |  |  |
| 1902                                                                           |                   |        | 3,290         |                |                         | 1.69                       | 13             | 192                     | 1,660,042    |  |  |
| 1903                                                                           |                   |        | *             |                | \$19,138                | 1.58                       | 14             | 178                     | 1,602,414    |  |  |
| 1904                                                                           |                   |        | *             |                | 3,553                   | 1.41                       | 14             | 168                     | 1,670,892    |  |  |
| 1905                                                                           |                   |        | *             |                | 4,290                   | 1.38                       | 10             | 142                     | 1,793,967    |  |  |
| 1906                                                                           |                   |        | *             |                | 6,386                   | 1.39                       | 17             | 190                     | 1,746,190    |  |  |
| 1907                                                                           |                   |        | 4,106         | 1,500          |                         | 1.54                       | 16             | 192                     | 1,666,281    |  |  |
| 1908                                                                           |                   |        | 66,129        | 6,386          |                         | 1.44                       | 16             | 122                     | 1,917,059    |  |  |
| 1909                                                                           |                   |        | *             | *              |                         | 1.43                       | 15             | 118                     | 2,083,525    |  |  |
| 1910                                                                           |                   |        | *             | 228,539        |                         | 1.73                       | 13             | 101                     | 2,350,808    |  |  |
| 1911                                                                           |                   |        | 1,401         | 395,459        |                         | 1.73                       | 13             | 86                      | 2,431,242    |  |  |
| 1912                                                                           |                   |        | 3,755         | 550,000        |                         | 1.79                       | 11             | 80                      | 2,434,472    |  |  |
| 1913                                                                           |                   |        | 2,498         | 294,390        |                         | 1.79                       | 11             | 72                      | 2,285,068    |  |  |
| 1914                                                                           |                   |        | 10,850        | 46,755         |                         | 1.48                       | 12             | 60                      | 2,835,554    |  |  |
| 1915                                                                           |                   |        | 2,498         | 216,265        |                         | 1.48                       | 12             | 60                      | 2,708,736    |  |  |
| 1916                                                                           |                   |        | 79,596        |                | 4,621                   | 1.48                       | 12             | 60                      | 2,708,736    |  |  |
| 1917                                                                           |                   |        | 79,596        |                | 4,621                   | 1.48                       | 12             | 60                      | 2,708,736    |  |  |
| 1918                                                                           |                   |        | 79,596        |                | 4,621                   | 1.48                       | 12             | 60                      | 2,708,736    |  |  |
| Totals                                                                         |                   |        |               |                |                         |                            |                |                         | \$35,987,693 |  |  |

\* Concealed: less than three producers.

## SHALE

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

The Michigan Vitrified Brick Company of Bay City formerly mined shale from an abandoned coal mine for

the manufacture of vitrified brick but this company ceased operating in 1916.

For the past several years a project has been 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. Probably it will not be completed until the return of normal business conditions following the War reconstruction period.

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

Excellent exposures of shale belonging to the Coldwater formation occur at Richmondville, Sanilac County, and along the shore of Lake Huron from Forestville in the same county to Whiterock, Huron County. The Coldwater shale is also exposed or is at shallow depth in a number of places in the vicinity of Coldwater, Union City, Quincy, and Bronson, Branch County. Near Coldwater it is utilized in the manufacture of Portland cement. Exposures of the Bell shale, the base of the Traverse formation, occur near Bell, Presque Isle County. At Rockport, the Bell shale forms the floor of the limestone quarry. The shale is soft, bluish and generally highly calcareous. Probably it will be found to be suitable for the manufacture of Portland cement though its generally high lime content probably makes it unsuitable for high grade clay products. At Charlevoix a bed of shale 10 feet thick underlies the floor of the quarry of the Charlevoix Rock Products Co., Charlevoix County. This shale has been tested and according to reports, is suitable for the manufacture of vitrified products. The burning qualities of the deposits at Ellsworth have not been investigated but its uniform fine grained and apparently low lime content makes it very promising for use in vitrified products.

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

## CLAY\*

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

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

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

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

Most of the surface clays in Michigan are low grade and generally the mining of such clays is merely incidental to

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

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

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

| PRODUCTION OF CLAY IN MICHIGAN, 1910-1917. |                |         |                |        |                     |        |                |          |
|--------------------------------------------|----------------|---------|----------------|--------|---------------------|--------|----------------|----------|
| Year.                                      | Slip clay.     |         | Brick clay.    |        | Miscellaneous clay. |        | Total.         |          |
|                                            | Quan-<br>tity. | Value.  | Quan-<br>tity. | Value. | Quan-<br>tity.      | Value. | Quan-<br>tity. | Value.   |
|                                            | Tons.          |         | Tons.          |        | Tons.               |        | Tons.          |          |
| 1910.....                                  | 1,363          | \$3,889 | 60             | \$105  | 1                   | \$400  | 1,424          | \$4,394  |
| 1911.....                                  | 1,744          | 5,050   | 18             | 32     | 2                   | 150    | 1,764          | 5,272    |
| 1912.....                                  | 2,034          | 6,164   |                |        | 9                   |        | 2,043          | 6,173    |
| 1913.....                                  | 1,710          | 6,504   |                |        |                     |        | 1,710          | 6,504    |
| 1914.....                                  | 1,463          | 4,572   |                |        |                     |        | 1,463          | 4,572    |
| 1915.....                                  | 1,198          | 5,805   | *              | *      | *                   | *      | 3,142          | 5,605    |
| 1916.....                                  |                | 10,509  | *              | *      | *                   | *      | 3,454          | 11,193   |
| 1917.....                                  | 2,153          | 8,824   | *              | *      | *                   | *      | 5,746          | 13,627   |
| 1918.....                                  | 1,236          | 4,639   | *              | *      | *                   | *      | 2,359          | 6,373    |
| Total.....                                 |                |         |                |        |                     |        |                | \$63,714 |

\*Included in total.

POTTERY

The pottery industry in Michigan has made almost uninterrupted growth since 1899 and since 1908 the growth has been rapid, increasing over 3,000 percent in ten years, the main increase being during the past three years. In 1899 the total value of the pottery output was \$29,741; in 1908, \$62,409; in 1917, \$1,187,981 and in 1918 \$1,976,436 a gain of 66.3 percent over the value for 1917. The increases were largely due to the greatly increased output of porcelain electrical and sanitary supplies and porcelain and decorated ware.

| VALUE OF POTTERY PRODUCTS IN MICHIGAN, 1899-1918 |                   |            |                                   |                                               |                      |                              |              |                   |                                              |
|--------------------------------------------------|-------------------|------------|-----------------------------------|-----------------------------------------------|----------------------|------------------------------|--------------|-------------------|----------------------------------------------|
| Year                                             | Rank of<br>state. | No. firms. | Red<br>earthen-<br>ware<br>value. | Porcelain<br>electrical<br>supplies<br>value. | C. C. ware<br>value. | Miscel-<br>laneous<br>value. | Total value. | Gain<br>per cent. | Per cent.<br>of total<br>product<br>in U. S. |
| 1899.....                                        | 18                | 4          | \$29,741                          |                                               | \$100                |                              | \$29,741     |                   |                                              |
| 1900.....                                        | 17                | 4          | 34,317                            |                                               |                      |                              | 34,317       | 15.4              | 17                                           |
| 1901.....                                        | 16                | 4          | 42,465                            |                                               |                      |                              | 42,465       | 20.2              | 17                                           |
| 1902.....                                        | 14                | 4          | 44,098                            |                                               |                      |                              | 44,098       | 3.8               | 19                                           |
| 1903.....                                        | 10                | 4          | 47,007                            |                                               |                      |                              | 47,007       | 6.7               | 19                                           |
| 1904.....                                        | 17                | 4          | 40,621                            |                                               |                      |                              | 40,621       | -9.1              | 17                                           |
| 1905.....                                        | 17                | 4          | 45,963                            | *                                             |                      |                              | 45,963       | 4.5               | 16                                           |
| 1906.....                                        | 17                | 6          | 43,310                            |                                               |                      |                              | 43,310       | -5.8              | 16                                           |
| 1907.....                                        | 16                | 6          | 34,474                            |                                               |                      |                              | 34,474       | -18.5             | 15                                           |
| 1908.....                                        | 15                | 6          | 54,659                            |                                               |                      |                              | 54,659       | 29.0              | 16                                           |
| 1909.....                                        | 13                | 6          | 60,509                            |                                               |                      |                              | 60,509       | 9.9               | 17                                           |
| 1910.....                                        | 13                | 6          | 94,430                            |                                               | *                    |                              | 94,430       | 22.8              | 18                                           |
| 1911.....                                        | 13                | 6          | 90,595                            |                                               | *                    |                              | 90,595       | -4.2              | 18                                           |
| 1912.....                                        | 10                | 6          | 99,353                            |                                               | *                    |                              | 99,353       | 9.6               | 19                                           |
| 1913.....                                        | 10                | 6          | 65,000                            |                                               | *                    |                              | 65,000       | -20.8             | 19                                           |
| 1914.....                                        | 8                 | 6          | 169,482                           |                                               | *                    |                              | 169,482      | 19.8              | 22                                           |
| 1915.....                                        | 8                 | 6          | 112,882                           |                                               | *                    |                              | 112,882      | -29.7             | 19                                           |
| 1916.....                                        | 8                 | 6          | 138,734                           |                                               | *                    |                              | 138,734      | 23.8              | 20                                           |
| 1917.....                                        | 8                 | 6          |                                   | *                                             | *                    |                              | 1,187,981    | 66.3              | 21                                           |
| 1918.....                                        | 6                 | 8          |                                   | *                                             | *                    |                              | 1,976,436    | 66.3              | 22                                           |
| Total.....                                       |                   |            |                                   |                                               |                      |                              | 4,997,670    |                   |                                              |

\* Included in the total.  
† Included under miscellaneous.

The products are chiefly procelain electrical supplies, sanitary ware, decorated and white ware, "white granite" ware, and flower pots. Of eight firms the Jeffery-DeWitt Co., of Detroit manufacture a variety of porcelain products,—sanitary ware, insulators, spark plugs, tumbling jars, crucibles, etc. The Kalamazoo Manufacturing Co., manufactures sanitary ware exclusively. T he Anton Hupprich Co. of Detroit and the Ionia Pottery Co. manufacture flower pots exclusively. The Mt. Clemens Pottery Co. manufactures decorated ware and the Pontiac Clay Pipe Novelty Co., clay pipes and novelty ware.

The clays used for the manufacture of flower pots are obtained from Michigan but those used for porcelain

products, pipes, etc., are imported from other States and countries, for no deposits of china or ball clays are found in Michigan.

COAL\*

Coal mining began in Michigan as early as 1835 but no records of production are available before 1860, when Michigan was credited with an output of 2,320 tons. Most of the coal in the early days was obtained from veins exposed or at shallow depth in the vicinity of Grand Ledge, Eaton County, Jackson, Jackson County, and Corunna, Shiawassee County. Ten years later the production reached 28,150 tons, in 1880, 100,800 tons, and for the following two years it exceeded 100,000 tons annually. In 1883, a sharp decline began and in the following year the production fell to only 36,712 tons. It was not until 1897 that the production again exceeded the 100,000 ton mark. In that year, the Saginaw and Bay County fields were opened and the production jumped to 223,592 tons. The industry continued to grow rapidly and four years later, in 1901, the production reached nearly one and a quarter million tons. The maximum output of 2,035,858 tons was reached in 1907. Following 1907 a rapid decline set in and continued until the production for 1912 was only 1,201,230 tons. Production remained practically stationary until 1917, when it increased from 1,180,360 tons in 1916 to 1,374,805 tons, a gain of 193,445 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.

During 1918 production was increased to 1,468,818 tons valued at \$5,615,097, a gain of 288,458 tons or 24.4 percent in quantity, and of \$1,188,783 or 26.8 percent in value.

To meet the unprecedented demand caused by the severe winter of 1917-18 and the general tie-up of coal shipments, some new mines were opened and some old ones reopened, the most important being the New Robert Gage No. 3, Robert Gage No. 8, Uncle Henry No. 2, Riverside No. 2, Middleton, and a new mine east of Owosso operated by a Detroit company. During the year four old mines were abandoned. There were eleven mines worked in Saginaw County, seven in Bay County, three in Shiawassee County, and one each in Tuscola, Genessee, Calhoun, and Eaton counties.

There are large proven reserves of coal in Bay, Saginaw, Tuscola, and Genessee counties, which, if machinery and labor were available for development, would greatly relieve the present scarcity of coal in Michigan. During 1918, there was not sufficient labor to maintain the operating mines up to maximum capacity, much less to open and operate new mines. The signing of the Armistice gave promise of improvement in the labor situation, but the slow return of the miners and the

threatened strike of coal miners make prognostications of future coal developments uncertain.

\*For a more complete report on the coal industry in Michigan see Publication 19, Geol. Ser. 16, Mineral Resources of Michigan for 1914, pp. 247-270 ; also Vol. VIII, Pt 2, Coal, by A. C. Lane.

| PRODUCTION OF COAL IN MICHIGAN, 1860-1918, IN SHORT TONS |                    |       |                    |       |                    |       |                    |       |                    |       |                    |       |
|----------------------------------------------------------|--------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|--------------------|-------|
| Year.                                                    | Quantity.<br>Tons. | Year. | Quantity.<br>Tons. | Year. | Quantity.<br>Tons. | Year. | Quantity.<br>Tons. | Year. | Quantity.<br>Tons. | Year. | Quantity.<br>Tons. | Year. |
| 1860                                                     | 2,320              | 1872  | 33,600             | 1884  | 36,712             | 1906  | 92,882             | 1908  | 1,835,019          |       |                    |       |
| 1861                                                     | 3,000              | 1873  | 56,000             | 1885  | 42,176             | 1907  | 231,092            | 1909  | 1,784,092          |       |                    |       |
| 1862                                                     | 5,000              | 1874  | 28,000             | 1886  | 69,434             | 1908  | 815,722            | 1910  | 1,734,061          |       |                    |       |
| 1863                                                     | 15,000             | 1875  | 62,500             | 1887  | 71,461             | 1909  | 824,178            | 1911  | 1,734,061          |       |                    |       |
| 1864                                                     | 18,000             | 1876  | 66,000             | 1888  | 81,407             | 1910  | 849,475            | 1912  | 1,734,061          |       |                    |       |
| 1865                                                     | 20,000             | 1877  | 69,197             | 1889  | 87,531             | 1911  | 1,241,241          | 1913  | 1,734,061          |       |                    |       |
| 1866                                                     | 20,000             | 1878  | 85,222             | 1890  | 74,977             | 1912  | 964,718            | 1914  | 1,734,061          |       |                    |       |
| 1867                                                     | 22,000             | 1879  | 82,018             | 1891  | 80,307             | 1913  | 1,367,419          | 1915  | 1,734,061          |       |                    |       |
| 1868                                                     | 23,000             | 1880  | 100,800            | 1892  | 77,990             | 1914  | 1,342,849          | 1916  | 1,734,061          |       |                    |       |
| 1869                                                     | 24,000             | 1881  | 112,000            | 1893  | 45,479             | 1915  | 1,472,211          | 1917  | 1,734,061          |       |                    |       |
| 1870                                                     | 25,000             | 1882  | 125,239            | 1894  | 70,822             | 1916  | 1,446,388          | 1918  | 1,734,061          |       |                    |       |
| 1871                                                     | 26,000             | 1883  | 71,296             | 1895  | 112,422            | 1917  | 2,086,808          |       |                    |       |                    |       |

| PRODUCTION, COST OF MINING, PROFITS, AND VALUE OF COAL IN MICHIGAN, 1900-1918 |                         |                                          |                           |                                 |                                  |                             |                             |                                     |                                       |                               |  |  |
|-------------------------------------------------------------------------------|-------------------------|------------------------------------------|---------------------------|---------------------------------|----------------------------------|-----------------------------|-----------------------------|-------------------------------------|---------------------------------------|-------------------------------|--|--|
| Year.                                                                         | Number active<br>mines. | Average<br>hours<br>worked<br>per month. | Average<br>daily<br>wage. | Total<br>tons of<br>coal mined. | Total<br>cost of<br>total mined. | Average<br>cost<br>per ton. | Profit<br>of coal<br>mined. | Total<br>value<br>of coal<br>mined. | Value<br>of coal<br>mined<br>per ton. | Average<br>profit<br>per ton. |  |  |
| 1900                                                                          | 31                      | 170                                      | \$2.44                    | 871,388                         | \$1,209,228                      | \$1.387                     | \$49,475                    | \$1,258,703                         | \$1.445                               | \$89.006                      |  |  |
| 1901                                                                          | 31                      | 184                                      | 2.47                      | 1,016,498                       | 1,442,415                        | 1.419                       | 1,119                       | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1902                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1903                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1904                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1905                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1906                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1907                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1908                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1909                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1910                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1911                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1912                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1913                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1914                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1915                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1916                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1917                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |
| 1918                                                                          | 32                      | 191                                      | 2.51                      | 1,001,984                       | 1,427,027                        | 1.427                       | 1,001,984                   | 1,734,061                           | 1.714                                 | 287                           |  |  |

\* Compiled and adapted from reports of State Coal Mine Inspector, Ann. Repts. State Department of Labor.  
\*\* For year beginning December 1 and ending November 30.  
\*\*\* From Mineral Resources of United States, U. S. G. S.  
\* Does not include coal used for domestic consumption.  
† Not including depreciation, interest on capital invested, etc.

PYRITES

In commercial usage the term pyrites is applied to any of the common iron sulphide minerals such as pyrite, marcasite, and pyrrhotite. The term "coal brasses" is also popularly applied to pyrites occurring in coal. Pure pyrite and marcasite are identical in chemical composition and contain about 53 percent of sulphur and 47 percent of iron. They differ, however, principally in their manner of crystallization. Both are conspicuous by their yellow or brassy color and high specific gravity. Pyrrhotite when pure contains about 40 percent of sulphur and 60 percent of iron.

Pyrites is used mainly for the manufacture of sulphuric acid which in turn is widely used in the manufacture of explosives, commercial fertilizers, chemicals, etc. The enormous expenditure of explosives in the War correspondingly increased the demand for pyrites.

Prior to the War most of the pyrites was imported from Spain but with the increasing shortage of shipping during the progress of the War, this source gradually became more or less completely cut off. Under only the most urgent conditions were ships spared for its importation. To meet the pressing shortage the Federal Government sought to increase domestic production through the more extensive development of operating mines, the reopening of old ones and the discovery of new deposits.

In the summer of 1918 Prof. E. A. Holbrook of the U. S. Bureau of Mines in cooperation with the State Geological Survey made an investigation of the coal brasses of Michigan coal fields. The investigation showed that pyrites occurs in sufficient abundance and in such form in some of the coals as to make its recovery promising from a commercial standpoint, especially under present high prices. Contrary to current opinion the comparatively low sulphur coals are generally more promising than most of the high sulphur coals. This is because in the low sulphur coals, the pyrites occurs in nodules and masses of considerable size, which may be readily separated from the coal. The pyrites in the high sulphur coals is apt to occur as bands of partings interleaved with the coal and as very thin plates in the fractures. In such conditions, the pyrite is so intimately associated with the coal and the pyrite breaks up into such minute particles in the processes of concentration that it is difficult to secure a sufficiently pure product for commercial purposes. Moreover, there is a considerable percentage of finely divided pyrites lost in the tailings. Under present market requirements, the concentrate should contain at least 40 percent of sulphur and a minimum of carbonaceous matter. In the manufacture of sulphuric acid by the chamber process, carbonaceous pyrites may give rise to an excess of carbon dioxide, which dilutes the gases in the chambers and reduces the efficiency of the plant.

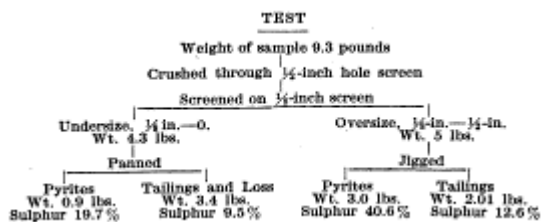
The most promising source of pyrites is in the waste piles from the washery of the Consolidated Coal Co. at Saginaw. The pyrites is largely concentrated along the refuse pipe lines and there appears to be several thousand tons of pure lump pyrites which may be readily recovered at a minimum cost. The spoil banks at some of the mines also appear to contain considerable tonnages of pyrites. None of the mines would produce more than a fraction of the amount of pyritic ore necessary to maintain in operation a 50-ton concentrating mill, but it appears probable that the combined output from a number of mines would be sufficient. The pyritic waste from the mines could be shipped to a central concentration plant. Since there is generally much coal in the pyritic waste, it would be very advantageous to combine the concentrating plant with a coal washery. The recovery of both the pyrites and the coal would make it possible to utilize much impure coal which could not be profitably treated for either product alone.

The following are the results of the analyses and tests made under the direction of Prof. Holbrook at the Mining Experiment Station, Urbana, Ill.

|                                                                                      | Sulphur<br>Percent. |
|--------------------------------------------------------------------------------------|---------------------|
| Pure pyrite lumps. Washery of Consolidated Coal Col, Saginaw                         | 47.2                |
| Band pyrite. Wolverine Mine No. 3 (sample looks good but is light in weight)         | 38.5                |
| Heavy dark band of shale and pyrite. Wolverine Mine No. 3, cleanest pyrite from band | 37.6                |

Separation not very satisfactory.

A sample of refuse was taken from the elevator of the coal washery of the Consolidated Coal Co. at Saginaw and subjected to the following treatment.



From the above it may be seen that the refuse yielded 3 pounds or over 32 percent of pyrite analyzing 40.6 per cent of sulphur. This according to Prof. Holbrook is very satisfactory. The test indicates that the refuse probably contains about 30 percent of recoverable pyrite of commercial grade. However with the signing of the Armistice, the War need for pyrites ceased; there was prospect of an early release of ships for the foreign trade and the prospective recovery of pyrites from Michigan "coal brasses" did not materialize.

## LIMESTONE\*

The growth of the limestone industry in Michigan from 1899 to 1903 was relatively slow but in 1904 a rapid growth began which has continued to the present.

During the past six years the growth has been accelerated. In 1903 the value of limestone including lime was only \$390,473. Ten years later the value, exclusive of lime was \$1,408,703, or more than three and one-half-times greater. Large gains were made in each of the succeeding years and in 1917 four years later the total value of limestone products exclusive of lime was \$3,320,895 or about two and one-third times that in 1913. The increase over that of 1916 was \$931,132 or 38.96 percent. This value was further increased in 1918 to \$5,186,867 an increase of \$1,865,972 or 56.18 percent.

The great increases in the annual value of the output for 1913-17 were due not only to greater production but also to constantly increasing prices for the various products. The great increase in 1918 represents the War demand and the War-time inflation of prices for all products. The chief increases for 1918 were in stone for blast furnace flux and for the manufacture of soda ash and allied products occasioned by the enormous War demands on the blast furnaces and chemical industries for iron and steel and chemicals used directly in the prosecution of the War. The output of flux stone in 1918 was 4,289,289 tons valued at \$2,892,179 a gain of 14 percent in quantity and 77 percent in value over the 1917 production and a gain of 41 percent in quantity and 139.5 percent in value over pre-War figures of 1916. The value of stone sold to alkali plants increased from

\$438,783 in 1916 to \$787,760 in 1917 to \$1,097,291 in 1918 an increase of 39.2 percent over 1917 and of 150.0 percent over 1916, an increase due directly to War demands. Building and road making for military purposes caused an increase in the output for crushed stone for concrete in 1917 but with the cessation of general building activities production decreased during 1918 from 418,403 tons valued at \$244,648 to 389,176 tons valued at \$261,877, a decrease in quantity of 29,227 tons or 6.9 percent but an increase in value of 7 percent over 1917 and of 68.8 percent in value over 1916. Railroad ballast which decreased in 1917 shows an increase from 182,375 tons valued at \$90,560 in 1917 to 209,825 tons valued at \$125,395 in 1918 or 15 percent in quantity and 38.4 percent in value. This value is an increase of 116.4 percent over that of 1916. Production of road-making stone continued to decrease from 834,937 tons in 1916 to 726,937 tons in 1917 to 591,781 tons in 1918; the value of the stone also decreased from \$420,467 in 1916 to \$344,970 in 1917 to \$251,265 in 1918. There was a notable increase also in the limestone used as fertilizer the production increasing from 62,027 tons valued at \$58,148 in 1917 to 160,016 tons valued at \$150,604 in 1918 or an increase of 157.9 percent in quantity and of 159 percent in value.

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

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

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

places in Monroe County, near Bayport, Huron County, and along the west shore of Green Bay and Little Bay de Noc, Menominee and Delta counties.

\*For a more complete report of the limestone resources of Michigan see Pub. 21, Geol. Ser. 17, Min. Res. Of Mich. for 1915, pp. 103-312.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1918

| Year. | Rough building.<br>Value. | Rubble.<br>Value. | Ripecap.<br>Value. | Crushed stone. |             |
|-------|---------------------------|-------------------|--------------------|----------------|-------------|
|       |                           |                   |                    | Road making.   |             |
|       |                           |                   |                    | Tons.          | Value.      |
| 1899  | \$30,299                  |                   | \$1,111            |                |             |
| 1900  | 32,362                    |                   | 799                |                |             |
| 1901  | 47,785                    | \$5,008           | *                  |                | \$31,605    |
| 1902  | 58,707                    | 8,101             | 5,740              |                | 56,201      |
| 1903  | 36,528                    | 7,110             | 800                |                | 61,342      |
| 1904  | 32,941                    | 2,800             | 2,405              |                | 58,655      |
| 1905  | 17,071                    | 744               | 1,568              |                | 112,113     |
| 1906  | 9,565                     | 4,654             | 1,204              |                | 78,437      |
| 1907  | 15,120                    | 1,433             | 1,234              |                | 131,708     |
| 1908  | 7,276                     | 15,907            | 1,574              |                | 182,510     |
| 1909  | 4,450                     | 1,572             | 3,615              |                | 132,902     |
| 1910  | 3,522                     | 2,205             | 908                |                | 110,164     |
| 1911  | 7,526                     | 165               | 380                | 224,307        | 113,574     |
| 1912  | 9,967                     | 380               | 75                 | 603,553        | 295,449     |
| 1913  | 8,274                     | 3,511             | 610                | 532,311        | 266,316     |
| 1914  | 3,537                     | 1,651             | 6,727              | 505,133        | 242,839     |
| 1915  | 4,262                     | 743               | 104                | 482,202        | 194,970     |
| 1916  | 5,633                     | *                 | *                  | 834,215        | 420,467     |
| 1917  | *                         | *                 | *                  | 726,937        | 344,970     |
| 1918  | *                         | *                 | *                  | 591,781        | 251,265     |
| Total |                           |                   |                    |                | \$3,094,567 |

\* Included in total for year.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1918.—Continued.

| Year. | Crushed stone.    |          |           |             | For blast furnace flux. |             |           | To sugar factories. | To shali works. |
|-------|-------------------|----------|-----------|-------------|-------------------------|-------------|-----------|---------------------|-----------------|
|       | Railroad ballast. |          | Concrete. |             | Tons.                   | Value.      |           |                     |                 |
|       | Tons.             | Value.   | Tons.     | Value.      |                         |             |           |                     |                 |
| 1899  |                   |          |           |             |                         | \$27,512    |           |                     |                 |
| 1900  |                   |          |           |             |                         | 3,000       |           |                     |                 |
| 1901  |                   | \$18,200 |           | \$75,643    |                         | 13,488      |           |                     |                 |
| 1902  | 49,910            |          |           | 49,920      |                         | 42,246      |           |                     |                 |
| 1903  | 35,340            |          |           | 48,204      |                         | 15,502      |           |                     |                 |
| 1904  | 57,000            |          |           | 60,145      |                         | 62,586      |           |                     |                 |
| 1905  | 43,640            |          |           | 107,396     |                         | 109,883     |           |                     |                 |
| 1906  | 103,142           |          |           | 61,552      |                         | 81,517      | \$224,336 |                     |                 |
| 1907  | 46,516            |          |           | 97,702      |                         | 300,429     | 22,234    |                     |                 |
| 1908  | 33,500            |          |           | 73,200      |                         | 50,541      | 37,584    |                     |                 |
| 1909  | 42,445            |          |           | 112,829     |                         | 91,915      | 23,845    |                     |                 |
| 1910  | 97,328            |          |           | 175,118     |                         | 109,149     | 69,697    |                     |                 |
| 1911  | 95,713            |          | 106,385   | 137,285     | 341,027                 | 186,046     | 65,141    |                     |                 |
| 1912  | 28,308            |          | 125,427   | 97,208      | 295,941                 | 133,042     | 69,697    | \$508,044           |                 |
| 1913  | 116,000           |          | 48,400    | 145,965     | 1,302,817               | 484,495     | 38,215    | 329,061             |                 |
| 1914  | 39,000            |          | 200,000   | 168,959     | 1,061,140               | 365,012     | 69,677    | 266,087             |                 |
| 1915  | 60,116            |          | 398,948   | 217,304     | 2,234,984               | 703,029     | 46,163    | 481,750             |                 |
| 1916  | 186,539           |          | 37,300    | 315,479     | 1,355,084               | 1,307,330   | 1,769     | 438,183             |                 |
| 1917  | 182,375           |          | 90,500    | 418,403     | 244,848                 | 3,375,178   | 1,633,965 | 787,700             |                 |
| 1918  | *                 |          | 859,176   | 261,877     | 4,280,280               | 2,862,179   | 37,004    | 1,097,251           |                 |
| Total |                   |          |           | \$2,302,009 |                         | \$8,584,182 |           |                     | \$3,094,549     |

\*Included in total.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES,\*1899-1918.—Continued

| Year.  | To carbonic acid plants.<br>Value. | To paper mills.<br>Value. | Fertilizer. |            | Other purposes. | Bank of state.<br>Value. | Total.<br>Value. |
|--------|------------------------------------|---------------------------|-------------|------------|-----------------|--------------------------|------------------|
|        |                                    |                           | Tons.       | Value.     |                 |                          |                  |
| 1899   |                                    |                           |             |            | \$2,375         |                          | 8781,769         |
| 1900   |                                    |                           |             |            | 124,220         | 12                       | 330,847          |
| 1901   |                                    |                           |             |            | 68,164          | 12                       | 429,771          |
| 1902   |                                    |                           |             |            | 13,527          | 13                       | 415,158          |
| 1903   |                                    |                           |             |            | 15,323          | 14                       | 415,158          |
| 1904   |                                    |                           |             |            | 142,000         | 10                       | 501,708          |
| 1905   |                                    |                           |             |            | 278,507         | 12                       | 514,724          |
| 1906   |                                    |                           |             |            | 253,999         | 10                       | 626,269          |
| 1907   |                                    |                           |             |            | 327,571         | 9                        | 669,017          |
| 1908   |                                    |                           |             |            | 296,305         | 11                       | 700,825          |
| 1909   |                                    |                           |             |            | 448,857         | 8                        | 842,136          |
| 1910   |                                    |                           |             |            | 3,447           | 13                       | 1,065,751        |
| 1911   |                                    |                           |             |            | 11,104          | 13                       | 1,129,560        |
| 1912   |                                    |                           |             |            | 36,874          | 8                        | 1,408,703        |
| 1913   |                                    |                           |             |            | 30,523          | 8                        | 1,427,961        |
| 1914   |                                    |                           |             |            | 31,529          | 8                        | 1,428,766        |
| 1915   |                                    |                           |             |            | 39,800          | 0                        | 2,380,763        |
| 1916   |                                    |                           |             |            | 1,129           | 0                        | 3,320,905        |
| 1917   |                                    |                           |             |            | 284,610         | 6                        | 3,186,867        |
| 1918   |                                    |                           |             |            | 284,610         | 0                        |                  |
| Total. |                                    |                           | \$109,435   | \$ 254,138 | \$2,051,234     |                          | \$3,309,078      |

\*Included in total.

ranked third in quantity and second in value, Virginia being the largest producer and Pennsylvania second. Michigan produced over 14 percent of the chemical lime used in the country at 16 percent of the value. Michigan held sixth place in the amount of lime consumed. Production fell short of consumption by 89,068 tons; 11,702 tons were shipped out of the State and 100,770 tons shipped in, or the State received nine tons for every ton shipped outside the State. These figures do not take into consideration limestone from Presque Isle County which is shipped to Buffalo, New York, and manufactured into lime near Buffalo. The largest shipments came from Ohio and West Virginia; a few thousand tons were sold in Indiana, Wisconsin and Minnesota.

In 1918 Michigan with the rest of the United States showed a decrease in lime production. However, since most of the lime produced in Michigan is chemical lime used in the manufacture of calcium carbide and needed for War industries the percentage decrease was less for Michigan than for any other State, the production being 134,813 tons as compared with 135,920 tons in 1917, a decrease of but 1,107 tons or 0.8 percent. Michigan succeeded Wisconsin in sixth rank. There was a continued increase in value to \$1,186,007, an increase of \$293,325 or 32.8 percent over the value of \$892,682 for 1917. The total increase over the maximum pre-War value (1916) was 207.7 percent. The great increase in value in 1917 was due to the increased production and advance in the average selling price per ton. The great increase in value in 1918 was due to the continued advance in price per ton which reached \$8.79 as compared with \$6.72 in 1917 and \$4.45 in 1916.

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

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

The growth in 1915 and 1916 may be ascribed, though indirectly, to the war in Europe. The great increase in 1917 was due to the entrance of this country into the conflict early in 1917. A large amount of lime is used in the manufacture of many chemical materials used in the War. Very little of the lime produced in Michigan is used

## LIME

From 1904 to 1914, the lime industry made little or no growth, the production in these 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. The next year there was only a slight increase, the production being 86,447 tons but in 1917 there was a large increase, the production being 135,920 tons or 57.2 percent greater than in 1914. The value increased from \$385,341 in 1916 to \$892,682 in 1917 an increase of \$507,341 or about 132 per cent. This increased production and value caused Michigan to jump from thirteenth place to seventh in rank in State production, Pennsylvania, Ohio, Virginia, West Virginia, Missouri and Wisconsin ranking Michigan. In the production of chemical lime, Michigan

for building purposes hence the lime industry in 1918 did not suffer the general depression due to the restriction of building trades, and the small decrease in production may be ascribed to the shortage of labor and of fuel and to the difficulties of transportation.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1918

| Year. | Total lime burned. |           | Average price per ton | No. of plants operating. | Rank of state production. |
|-------|--------------------|-----------|-----------------------|--------------------------|---------------------------|
|       | Quantity. Tons.    | Value.    |                       |                          |                           |
| 1904. | 63,601             | \$256,055 | \$4 04                |                          |                           |
| 1905. | 48,089             | 192,844   | 4 01                  |                          |                           |
| 1906. | 68,134             | 281,465   | 4 13                  | 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             | 308,377   | 4 19                  | 10                       | 14                        |
| 1911. | 80,709             | 352,608   | 4 37                  | 14                       | 14                        |
| 1912. | 74,720             | 311,448   | 4 17                  | 11                       | 16                        |
| 1913. | 77,088             | 331,852   | 4 05                  | 10                       | 14                        |
| 1914. | 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                        | 7                         |
| 1917. | 135,920            | 892,682   | 6 72                  | 7                        | 7                         |
| 1918. | 134,813            | 1,186,007 | 8 79                  | 6                        | 6                         |

## SAND-LIME BRICK

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

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

The growth of the industry has been in increased production rather than in the number of plants. In 1904, ten plants were in operation and produced only 10,440,000 brick of all grades, valued at \$69,765. In 1905 twelve plants produced 26,421,000 bricks value 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. Somewhat normal conditions were maintained

during the first half of 1917 but after the car shortage became acute in August 1917 and prevented shipment sand lime brick production suffered a sharp decline, which, due to Government restrictions in building operations, increased transportation difficulties, scarcity and high cost of labor, and the shortage of coal, continued during 1918. Production decreased 46.4 percent in value and 52.9 percent in quantity in 1918, there being a production of but 22,564,000 brick of all classes valued at \$198,633 as compared with 47,998,000 brick in 1917 valued at \$370,723. Thus the production for 1918 was but 31.3 percent of the maximum pre-War production.

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

Excepting 1906, when New York took first place, Michigan, since 1904 has held first rank among the States both in the number of plants and in the value of the output of sand-lime brick. For a number of years Michigan has produced nearly or more than twice as many sand-lime brick as any other State. In 1918 Michigan produced 23 percent of the sand-lime brick made in the United States, valued at 22 percent of the total value of the production for the entire country. The decided setback suffered by the sand-lime brick industry in common with other building industries in 1918 caused many operators to close their plants, so that of eleven firms reporting in 1917, but seven were operating in 1918 and in October one of these ceased operating. Plants are located in Detroit, Grand Rapids, Rives Junction, Rochester, Saginaw and Sibley.

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1918

| Year.  | No. of operating plants producing sand-lime brick. | Michigan production.     |         |                         |                          |              |                         |                          |        |                            |            | Total value produced in Michigan. | Change from previous year, per cent. | Total value of production of U. S. | Per cent of total production of U. S. | Rank. |
|--------|----------------------------------------------------|--------------------------|---------|-------------------------|--------------------------|--------------|-------------------------|--------------------------|--------|----------------------------|------------|-----------------------------------|--------------------------------------|------------------------------------|---------------------------------------|-------|
|        |                                                    | Common brick.            |         | Front brick.            |                          | Fancy brick. |                         | Total Michigan.          |        | Change from previous year. |            |                                   |                                      |                                    |                                       |       |
|        |                                                    | Quantity (thous. units). | Value.  | Average price per unit. | Quantity (thous. units). | Value.       | Average price per unit. | Quantity (thous. units). | Value. | Quantity (thous. units).   | Value.     |                                   |                                      |                                    |                                       |       |
|        |                                                    |                          |         |                         |                          |              |                         |                          |        |                            |            |                                   |                                      |                                    |                                       |       |
| 1904   | 10                                                 | 57                       | 9,886   | 80,034                  | 80 04                    | 580          | 85,216                  | 80 02                    | 19     | 8197                       | 809,765    | 142 5                             | 8491,128                             | 15 6                               | 1                                     |       |
| 1905   | 12                                                 | 84                       | 26,421  | 169,302                 | 6 28                     | 1,577        | 12,911                  | 8 17                     | 24     | 825                        | 169,302    | 100 00                            | 972,000                              | 12 4                               | 1                                     |       |
| 1906   | 10                                                 | 87                       | 27,281  | 162,879                 | 5 97                     | 1,790        | 12,022                  | 6 69                     | 2      | 174,921                    | 174,921    | 3 3                               | 1,179,003                            | 15 0                               | 1                                     |       |
| 1907   | 13                                                 | 98                       | 35,438  | 198,005                 | 6 22                     | 2,039        | 14,519                  | 6 97                     | 23     | 122,849                    | 198,005    | 1 2                               | 1,251,569                            | 14 1                               | 1                                     |       |
| 1908   | 10                                                 | 87                       | 21,007  | 131,827                 | 5 03                     | 938          | 6,942                   | 7 76                     | 17     | 155,539                    | 131,827    | 1 0                               | 1,029,009                            | 13 5                               | 1                                     |       |
| 1909   | 11                                                 | 74                       | 34,517  | 157,052                 | 6 03                     | 1,039        | 11,141                  | 6 97                     | 17     | 158,224                    | 157,052    | 1 0                               | 1,139,559                            | 13 6                               | 1                                     |       |
| 1910   | 10                                                 | 76                       | 37,648  | 218,627                 | 5 81                     | 3,255        | 22,022                  | 6 78                     | 20     | 243,849                    | 218,627    | 1 0                               | 1,169,153                            | 23 5                               | 1                                     |       |
| 1911   | 10                                                 | 60                       | 32,500  | 162,234                 | 5 84                     | 2,725        | 17,771                  | 6 50                     | 17     | 210,000                    | 162,234    | 1 0                               | 1,137,004                            | 25 4                               | 1                                     |       |
| 1912   | 11                                                 | 71                       | 38,129  | 167,106                 | 6 28                     | 1,101        | 9,605                   | 8 27                     | 1      | 316,732                    | 167,106    | 1 0                               | 1,209,223                            | 25 4                               | 1                                     |       |
| 1913   | 12                                                 | 65                       | 49,273  | 215,873                 | 6 43                     | 1,000        | 7,000                   | 8 31                     | 1      | 321,245                    | 215,873    | 1 0                               | 1,238,225                            | 25 4                               | 1                                     |       |
| 1914   | 11                                                 | 56                       | 46,513  | 281,000                 | 6 04                     | 1            | 1                       | 7                        | 1      | 255,781                    | 281,000    | 1 0                               | 1,038,512                            | 23 5                               | 1                                     |       |
| 1915   | 12                                                 | 62                       | 49,150  | 281,873                 | 5 96                     | 1            | 1                       | 7                        | 1      | 282,848                    | 281,873    | 1 0                               | 1,135,101                            | 25 4                               | 1                                     |       |
| 1916   | 11                                                 | 71                       | 71,190  | 491,956                 | 6 92                     | 880          | 7,440                   | 8 38                     | 1      | 499,711                    | 491,956    | 1 0                               | 1,474,073                            | 31 3                               | 1                                     |       |
| 1917   | 7                                                  | 42                       | 40,979  | 362,248                 | 7 71                     | 1,019        | 8,477                   | 8 31                     | 1      | 370,723                    | 362,248    | 1 0                               | 1,423,300                            | 25 4                               | 1                                     |       |
| 1918   | 7                                                  | 42                       | 22,564  | 198,633                 | 8 79                     | 1            | 1                       | 9 48                     | 1      | 198,633                    | 198,633    | 1 0                               | 883,523                              | 22 5                               | 1                                     |       |
| Total. |                                                    |                          | 549,003 | 3,491,020               | 80 46                    |              |                         |                          |        |                            | 83,664,283 |                                   |                                      |                                    |                                       |       |

\*—Estimated. †—Included in total.

## SAND AND GRAVEL

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

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

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

In 1918 the reported production of sand and gravel in Michigan was 2,837,376 tons or 977,074 tons less than in 1917. The value of the product was \$1,239,874 or \$401,874 less than in 1917. Most of the loss in tonnage was due to the great decrease in building sand produced

which was only 433,497 tons in 1918 compared with 782,305 tons in 1917 and the maximum production of 1,234,280 tons in 1916. The amount of gravel produced for road making decreased from 2,292,374 tons produced in 1917 to 1,741,687 tons in 1918 a decrease of 550,693 tons. The production of paving and filter sand increased during the year.

The effect of the War upon the sand and gravel industry is seen in the reduced production. Some operators reported an increased demand for sand and gravel but inability to supply the demand on account of car shortage, increase of freight rates, and lack of labor. Others reported their pits closed for the War period. In some cases notably where Government building and road making were in progress operators report increased production, in others that if it were not for the Government demands the pits would remain idle.

The increased activity in road building due to the road building campaign inaugurated by the adoption of the amendment to the State Constitution authorizing the issuance of \$50,000,000 bonds for road building purposes, is sufficient to encourage operators of sand and gravel pits producing road metal to prepare for active operations beginning in 1919.

| PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1908-1918 |               |         |                |           |              |        |              |         |              |                |
|----------------------------------------------------------------|---------------|---------|----------------|-----------|--------------|--------|--------------|---------|--------------|----------------|
| Year.                                                          | Molding sand. |         | Building sand. |           | Engine sand. |        | Paving sand. |         | Filter sand. | Other sand. ** |
|                                                                | Quantity.     | Value.  | Quantity.      | Value.    | Quantity.    | Value. | Quantity.    | Value.  | Quantity.    | Value.         |
|                                                                | Tons.         |         | Tons.          |           | Tons.        |        | Tons.        |         | Tons.        |                |
| 1908.                                                          | 19,382        | 19,247  | 369,315        | 148,965   |              |        |              |         |              |                |
| 1909.                                                          | 61,387        | 28,108  | 469,199        | 127,937   | 4,000        | \$400  |              |         | 59,187       | \$14,476       |
| 1910.                                                          | 54,172        | 24,199  | 431,646        | 157,158   | 1,364        | 136    |              |         | 51,985       | 12,149         |
| 1911.                                                          | 4,584         | 2,892   | 474,238        | 228,393   | 1,961        | 196    |              |         | 173,724      | 17,157         |
| 1912.                                                          | 38,226        | 30,736  | 1,099,419      | 327,247   | 12,415       | 1,241  |              |         | 29,187       | 6,500          |
| 1913.                                                          | 93,812        | 24,004  | 1,151,288      | 334,346   | 22,270       | 2,227  |              |         | 205,612      | 50,653         |
| 1914.                                                          | 68,748        | 17,001  | 859,759        | 417,997   | 18,075       | 1,807  | 152,144      | 29,656  | 372,864      | 27,500         |
| 1915.                                                          | 152,433       | 49,145  | 967,546        | 294,115   | 4,774        | 477    | 48,826       | 16,308  | 114,801      | 52,005         |
| 1916.                                                          | 56,748        | 17,403  | 1,235,916      | 412,737   | 4,447        | 444    | 538,291      | 109,226 | 130,024      | 54,445         |
| 1917.                                                          | 53,490        | 36,581  | 1,088,659      | 360,152   | 6,357        | 635    | 320,322      | 14,866  | 113,318      | 20,242         |
| 1918.                                                          | 82,066        | 21,986  | 843,877        | 236,656   | 70,077       | 7,007  | 2,794        | 4       | 115,291      | 107,292        |
| 1919.                                                          | 172,491       | 51,975  | 1,234,280      | 350,136   | 4,000        | 400    | 154,413      | 38,061  | 111,103      | 102,248        |
| 1917.                                                          | 147,256       | 52,056  | 782,305        | 459,446   | 5,174        | 517    | 287,317      | 89,430  | 228,003      | 168,222        |
| 1918.                                                          | 116,480       | 55,205  | 433,497        | 174,888   |              |        |              |         | 94,227       | 41,297         |
| Totals.                                                        | 1,075,644     | 389,236 | 11,279,325     | 3,836,609 | 176,337      | 17,633 | 1,738,590    | 420,930 | 2,015,466    | 574,013        |

\*Included under other sand.  
\*\*Includes fire, furnace, blast, filter sand.

| PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN* 1908-1918—Continued. |                   |        |            |           |            |            |                  |
|---------------------------------------------------------------------------|-------------------|--------|------------|-----------|------------|------------|------------------|
| Year.                                                                     | Railroad ballast. |        | Gravel.    |           | Total.     |            | Rank.            |
|                                                                           | Quantity.         | Value. | Quantity.  | Value.    | Quantity.  | Value.     | Quantity. Value. |
|                                                                           | Tons.             |        | Tons.      |           | Tons.      |            | Tons. Value.     |
| 1908.                                                                     |                   |        | 76,625     | \$32,331  | 414,599    | 219,699    | 10 11            |
| 1909.                                                                     |                   |        | 72,808     | 25,614    | 597,789    | 197,699    | 12 13            |
| 1910.                                                                     |                   |        | 369,407    | 81,182    | 1,034,641  | 389,509    | 10 10            |
| 1911.                                                                     |                   |        | 315,203    | 94,081    | 842,591    | 370,365    | 8 9              |
| 1912.                                                                     |                   |        | 695,902    | 306,528   | 2,215,727  | 685,835    | 8 8              |
| 1913.                                                                     |                   |        | 1,107,791  | 364,541   | 2,862,735  | 819,437    | 8 8              |
| 1914.                                                                     |                   |        | 1,009,190  | 305,218   | 2,182,735  | 545,809    | 9 9              |
| 1915.                                                                     |                   |        | 3,458,072  | 467,925   | 6,422,818  | 1,618,603  | 4 5              |
| 1916.                                                                     |                   |        | 3,458,072  | 467,925   | 6,422,818  | 1,618,603  | 4 5              |
| 1917.                                                                     |                   |        | 2,587,064  | 671,979   | 3,776,736  | 1,030,759  | 7 7              |
| 1918.                                                                     |                   |        | 2,587,064  | 671,979   | 3,776,736  | 1,030,759  | 7 7              |
| 1919.                                                                     |                   |        | 2,587,064  | 671,979   | 3,776,736  | 1,030,759  | 7 7              |
| Totals.                                                                   |                   |        | 19,810,097 | 6,367,667 | 37,846,825 | 11,191,550 |                  |

## 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. For the past five years there have been only one or two producers, hence no figures have been given.

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 buildings. 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 sometime, the stone becomes sufficiently hard to work and strong enough for ordinary building purposes. The only quarries operating in the Marshall at the present time are at Grindstone City and Eagle Mills, Huron County, where the grit stones near the base of the formation are quarried for grindstones and scythestones. Some rubble and riprap are produced incidentally to the quarrying of gritstone at Eagle Mills by the Wallace Company of Port Austin.

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

Formerly much sandstone was quarried for foundations but concrete has largely displaced stone for such purposes because of the cheapness of concrete and the rapidity and the ease of handling. Front and fancy brick are relatively cheap and a variety of aristic 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.

## **GRINDSTONES AND SCYTHESTONES**

Of the various mineral activities the production of grindstones seems at first thought to offer little contribution to War activities. Yet this industry during

1918 contributed practically its entire output directly or indirectly to the prosecution of the War. The manufacture of cutlery, hardware and tools, which were used either directly as War material or in the manufacture of War materials used a large part of the grindstone output. Large numbers of grindstones were used for dressing or sharpening tools in the industrial plants that made the many articles required by military operations.

The War time production of grindstones for the entire United States increased over 11 percent but the value of the product in 1918 was increased 98 percent over that of 1916. Michigan, followed in third place by West Virginia, ranks a far second in the production of grindstones, Ohio being first with 85 percent of the entire total for the United States. Although the production for the entire country increased during 1917-1918, the labor situation and shipping conditions in Michigan caused a decrease of about 17 percent from pre-War production although the value increased a little over 47 percent.

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

The "grit" or "grindstone" occurs in the lower part of the Marshall formation which is exposed in flat low-lying benches near the shore of Lake Huron. The surface material is stripped off and the stone cut by channelling machines into square blocks eight feet or more in thickness. The blocks are split by wedges into slabs which are loaded onto 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 presence of 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.

Since there are but two producers, the production and value of grindstones and scythestones cannot be given but the total value is included under Miscellaneous in the Summary Table given at the end of this report.

## **GLASS SAND**

Glass sand is extensively quarried near Rockwood, Wayne County, and near Steiner, Monroe County. The glass sand occurs in the Sylvania sandstone, Middle Monroe of the Silurian. The Sylvania underlies a belt which extends west from the mouth of Detroit River, then curves southwest across the southeast corner of Wayne

County and through Monroe County and leaves Monroe County near the southwest corner. The belt is from three to five miles wide except in the southwest corner of Monroe County where it narrows to about one-half mile. The thickness of the Sylvania varies exceedingly. Along the Detroit River in Wayne County it is from 70 to 165 feet thick and here as elsewhere contains horizons of sandy dolomite. It thins irregularly to the southwest until near the Ohio line it is only about 35 feet thick.

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

There are no natural exposures of the Sylvania in Wayne County but east of Rockwood in section 16, 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 Co. east of Rockwood, Wayne County, and of the National Silica Co. near Steiner, Monroe County, the sandstone is washed down by a stream of water from a hose. At the Rockwood pit, there is a stratum of hard dolomitic sandstone which requires blasting. The material after being crushed and washed is pumped into bins where it is allowed to drain.

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

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

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

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

ANALYSIS OF GLASS SAND

|                                      | Crude<br>Per Cent | *Mashed<br>Per Cent |
|--------------------------------------|-------------------|---------------------|
| Silica                               | 96.50             | 99.70               |
| Calcium carbonate                    | 1.50              | 0.08                |
| Magnesium carbonate                  | 1.04              | 0.22                |
| Iron oxide                           | 0.00              | --                  |
| Sulphuric acid loss and undetermined | 0.76              | --                  |
| Loss on ignition                     | 0.20              | --                  |

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

The washed sludge containing the fine grit is used for the ignition surfaces on match boxes. There was but one producer of glass sand, hence figures on production and value are not given. The Monroe Silica Company is building a new plant near the site of the National Silica Company plant which was burned in 1916. The plant of the Rockwood Silica Company was destroyed by fire July 2, and was not rebuilt during the year.

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

## MINERAL WATERS

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

The general business depressions of 1906, 1907 and 1914 caused the greatest decrease in production in Michigan. During the past year 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. Since 1913 production has increased 37 percent in quantity and 146 percent in value, being 1,216,882 gallons valued at \$129,592 in 1918, the gain in value being due to the greater average price per gallon. In 1917 the gain in production was 7 percent over that of 1916 but the average price per gallon decreased to 9.8 cents. In 1918 the gain in production was 147,718 gallons valued at \$129,592 representing an increase of nearly 14 percent in production and 13 percent in value. The increase in value is due in part to the increased average price per gallon—10.3 cents as compared with 9.8 cents per gallon in 1917.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1902-1918

| 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                     | 8,653,680       | 275,763     |                  |              | 0.032                  |
| 1903   | 1         | 9      | 19                     | 6,919,107       | 200,668     |                  |              | 0.029                  |
| 1904   | 7         | 13     | 19                     | 3,385,675       | 118,422     |                  |              | 0.035                  |
| 1905   | 4         | 4      | 17                     | 2,684,800       | 277,188     | \$38,900         | \$238,288    | 0.100                  |
| 1906   | 13        | 23     | 19                     | 902,528         | 73,357      | 35,091           | 92,042       | 0.081                  |
| 1907   | 8         | 15     | 19                     | 1,472,679       | 127,133     | 5,995            | 82,915       | 0.044                  |
| 1908   | 8         | 16     | 24                     | 2,004,433       | 88,910      | 6,069            | 98,355       | 0.035                  |
| 1909   | 5         | 16     | 19                     | 2,760,604       | 104,454     | 100              | 69,438       | 0.048                  |
| 1910   | 9         | 17     | 17                     | 1,454,020       | 69,538      | 12,156           | 80,097       | 0.042                  |
| 1911   | 11        | 24     | 23                     | 1,713,401       | 72,253      | 777              | 74,834       | 0.053                  |
| 1912   | 12        | 19     | 17                     | 1,420,465       | 75,611      | 3,603            | 49,037       | 0.059                  |
| 1913   | 17        | 24     | 20                     | 884,893         | 52,642      | 12,252           | 58,058       | 0.075                  |
| 1914   | 16        | 20     | 22                     | 931,343         | 70,310      | 5,165            | 67,546       | 0.080                  |
| 1915   | 16        | 18     | 19                     | 913,765         | 72,111      |                  |              | 0.109                  |
| 1916   | 17        | 12     | 18                     | 906,875         | 108,867     | 500              | 105,641      | 0.098                  |
| 1917   | 12        | 12     | 11                     | 1,069,164       | 106,641     | *                | 128,800      | 0.103                  |
| 1918   | 10        | 8      | 9                      | 1,216,882       | 129,592     |                  |              |                        |
| Total. |           |        |                        | 49,802,488      | \$3,632,600 |                  | \$1,125,060  | \$0.074                |

\*Consolidated, less than three producers.

formations as it is most abundant in belts overlying these formations. Gas given off by springs and shallow wells has occasioned unsuccessful exploration, since these wells are along the exposures of oil and gas bearing formations, therefore, they are along the line of leakage and not in the zone of accumulation. In most cases the wells yield gas sufficient for a few families only, some lasting a score or more of years, but the greater number "play out" in a few weeks or days. Farmers of Oakland and Macomb counties report that the 25 or 30 gas wells which are in use for heating and lighting purposes are rapidly declining in pressure and volume of gas.

The artesian wells around Portage Lake, Manistee County, yield some gas. The most notable yield was from a well driven in 1913 in the drift west of Onekama. In June, 1918, surface gas was struck in a well in Mikado Township, Alcona County. The mineral wells of Mt. Clemens also yield gas which is nearly sufficient for heating the boilers used for pumping. A very limited supply of gas is obtained from small drift wells in Benzie, Monroe, Washtenaw, and Wayne counties.

Many of the oil wells of the Port Huron oil field yield gas. The May and Gillette wells west of Port Huron are reported to yield from 20,000 to 40,000 feet of gas per day, when allowed to flow freely, with a gas pressure said to vary from 125 to 250 pounds per square inch. A project for utilizing the excess gas for lighting a small suburb of Port Huron seems to have been abandoned. Other wells in Port Huron yield gas sufficient for domestic and small industrial purposes.

The total production of gas is relatively insignificant, the maximum production being 2,422,000 cubic feet in 1914, dwindling to 1,173,000 cubic feet in 1918, the average annual value being less than \$1,500.

The following table shows the production of natural gas for the past seven years.

PRODUCTION OF NATURAL GAS IN MICHIGAN, 1911-1918

| Year | No. of producers. | Domestic. |        | Industrial. |        | Other.    |        | Total.    |         |
|------|-------------------|-----------|--------|-------------|--------|-----------|--------|-----------|---------|
|      |                   | Quantity. | Value. | Quantity.   | Value. | Quantity. | Value. | Quantity. | Value.  |
|      |                   | M cu. ft. |        | M cu. ft.   |        | M cu. ft. |        | M cu. ft. |         |
| 1911 | 22                | 930       | \$930  |             |        | 800       | \$400  | 1,730     | \$1,330 |
| 1912 | 17                |           | 1,020  | 900         | \$450  |           |        | 900       | 1,470   |
| 1913 |                   |           |        |             |        |           |        | 1,805     | 1,405   |
| 1914 |                   |           |        |             |        |           |        | 2,442     | 1,442   |
| 1915 | 16                | 960       | 960    |             |        | 1,100     | 550    | 2,060     | 1,510   |
| 1916 | 12                | 598       | 598    |             |        | 700       | 350    | 1,298     | 948     |
| 1917 | 10                | 619       | 619    |             |        | 400       |        | 1,019     | 1,013   |
| 1918 | 14                | 745*      | 745    |             |        | 428       | 300    | 1,173     | 1,045   |

\*Estimated.

## NATURAL GAS

Although natural gas occurs in Michigan, the amount obtained is so variable, the volume and pressure so low, that its production is not an important industry in the State. Most of the gas is produced in Manistee, Alcona, and Montmorency counties, and in the southeastern part of the State in Macomb, Oakland and St. Clair counties.

The gas is obtained both from the bed rock and from the drift. The drift gas is doubtless due to leakage from the underlying bituminous and petroliferous Devonian

## PETROLEUM\*

Michigan has no large oil producing field but small quantities of oil have been found at many places, principally at Port Huron, Allegan and Saginaw. The most notable producing area is that of Port Huron in which are two groups of wells and several scattered wells. The wells are very small with an initial yield of from three to seven barrels per day, it is said, but the yield rapidly decreases to an average of about one-half barrel a day. Most of the wells yield gas, and many yield

the gas in such quantities that it is sufficient for motive power in pumping the wells and drilling new ones. This cheap motive power added to the fact that the wells are shallow make operation profitable. The G. B. Stock Xylite Grease and Oil Company operates a group of twenty-two wells and uses the oil in the manufacture of lubricants for which it is adapted. At group of eleven wells was drilled on the Henry May and Lawrence Gillette farms near the "Oxbow" bend of the Black River about two miles west of Port Huron. The average yield of these wells when pumped is said to be similar to that of the Stock Wells. Since some of the wells yield significant quantities of gas, more than sufficient to furnish power for operating the wells and drilling new ones, it is possible to make the operation of this group profitable. But as yet the wells of the May and Gillette farms have not been put on a producing basis.

There was but one operator reporting a production in 1918, hence figures of production and value are omitted.

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\*Pub. 14, Geol. Ser. 11. Occurrence of Oil and Gas in Michigan 1912. See Pub. 19, Geol. Ser. 16, Mineral Resources of Michigan for 1914 for a more complete discussion of the Port Huron field.

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## MARBLE

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

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

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

Developments began four years ago but lack of transportation facilities, labor shortage, etc., hindered operations. A considerable amount of stone was quarried and stocked pending the completion of a railroad spur to the quarry. The spur connecting the quarry with the Chicago and Northwestern railroad has been completed and blocks of marble will be shipped to Marquette where the company has purchased a stone sawing mill. Marble will be cut and polished at this mill, the electric power being supplied by the city of Marquette. The company is now (July 1919) shipping broken pieces of green marble to eastern manufacturers of terrazzo, which is used as flooring. Lack of available cars prevents 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. There are reported fine blocks of verde antique in stock, and more shortly to be ready for the finishing plants.

Other projects have been started in the past four years to develop other deposits of marble in this region but the War 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 building operations are rapidly being resumed, hence it is possible that with the return of normal labor and business conditions the quarrying of marble may become an important industry near Ishpeming.

## GRAPHITE

The Northern Graphite Company of L'Anse and the Detroit Graphite Company of Detroit have opened quarries in graphite slate nine miles southeast of L'Anse. The graphite rock, which is reported to contain from 32 to 35 percent 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.

## MINERAL PAINTS

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

## CELESTITE

Celestite or strontium sulphate (81804) occurs at several horizons in the Monroe formation in southeastern Michigan. Near Maybee, Monroe County, it occurs in

the Lower Monroe in scattered crystals and masses associated with native sulphur and occurs similarly in the Sylvania sandstone at Rockwood, Wayne County. Near Gibraltar, Wayne County, it occurs in disseminated crystals in Upper Monroe dolomites. In the glass sand pit of the Rockwood Silica Co., the masses are numerous in places and some of them are large. The commercial recovery of the celestite has been but partially investigated. The masses are imbedded in a friable to incoherent sandstone and can be readily separated from it.

FELDSPAR

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

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

|                                              |       |
|----------------------------------------------|-------|
| Silica (SiO <sub>2</sub> )                   | 65.25 |
| Alumina (Al <sub>2</sub> O <sub>3</sub> )    | 18.60 |
| Iron oxide (Fe <sub>2</sub> O <sub>3</sub> ) | 0.40  |
| Lime (CaCO <sub>3</sub> )                    | 0.38  |
| Magnesia (MgO)                               | 0.23  |
| Sodium oxide (Na <sub>2</sub> O)             | 1.99  |
| Potassium oxide (K <sub>2</sub> O)           | 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.

QUARTZ

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

The above company was the only producer in 1918.

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 tougher, and less 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 field-stone 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.

PRODUCTION AND VALUE OF TRAP ROCK IN MICHIGAN, 1911-1918.

| Year.       | No. of<br>producers. | Crushed stone. |          |                |          | Riprap.<br>Rubble.<br>Value. | Total.<br>Value. | Rank.<br>Value. |
|-------------|----------------------|----------------|----------|----------------|----------|------------------------------|------------------|-----------------|
|             |                      | Roadmaking     |          | Concrete       |          |                              |                  |                 |
|             |                      | Quan-<br>tity. | Value.   | Quan-<br>tity. | Value.   |                              |                  |                 |
|             |                      | Tons.          |          | Tons.          |          |                              |                  |                 |
| 1911 .....  | 3                    |                |          | 45,250         | \$38,429 |                              | \$51,000         | 8               |
| 1912 .....  | 5                    | 21,805         | \$18,366 | 11,355         | 9,340    | \$8,500                      | 36,206           | 8               |
| 1913 .....  | 5                    | 24,920         | 23,369   | "              | "        | "                            | 92,301           | 10              |
| 1914 .....  | 5                    | 25,690         | 24,863   | 4,448          | 4,771    | "                            | 34,406           | 12              |
| 1915 .....  | 6                    | 28,262         | 29,764   | 18,775         | 22,047   | "                            | 105,855          | 12              |
| 1916 .....  | 8                    | 38,193         | 37,475   | 9,601          | 9,715    | "                            | 83,672           |                 |
| 1917 .....  | 4                    | 50,420         | 64,098   | "              | "        | "                            | 70,197           |                 |
| 1918 .....  | 4                    | 23,686         | 32,605   | "              | "        | "                            | 33,269           |                 |
| Total ..... |                      |                |          |                |          |                              | \$529,506        |                 |

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 Arbon. All of the companies failed because of poor methods and means of quarrying, the great distance from markets and lack of cheap transportation facilities.

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



Figure 4. Map Showing Location of Mineral Industries of Michigan.



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