

STATE OF MICHIGAN
MICHIGAN GEOLOGICAL AND BIOLOGICAL
SURVEY.

**Publication 27. Geological Series 22
MINERAL RESOURCES OF MICHIGAN**

**WITH
STATISTICAL TABLES OF PRODUCTION
AND VALUE OF MINERAL PRODUCTS**

**FOR
1917 AND PRIOR YEARS**

PREPARED UNDER THE DIRECTION OF
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DIRECTOR MICHIGAN GEOLOGICAL AND
BIOLOGICAL SURVEY

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1917

FORT WAYNE PRINTING COMPANY
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1918

<i>Celestite</i>	39
<i>Feldspar</i>	39
<i>Quartz</i>	39
<i>Trap Rock</i>	39
<i>Slate</i>	39

LETTER OF TRANSMITTAL

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

Gov. Albert E. Sleeper.
Hon. Thomas W. Nadal.
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 27, Geological
Series 22, the seventh of a series of annual statements
of the production and value of the mineral products of
Michigan.

Very respectfully,
R. C. ALLEN,
Director.

Contents

Letter of Transmittal	1
PART I. METALLIC MINERALS	1
<i>Michigan Copper Industry in 1917. Walter E. Hopper..</i>	<i>1</i>
PART II. NON-METALLIC MINERALS	23
<i>Coal</i>	<i>23</i>
<i>Pyrites</i>	<i>23</i>
<i>Salt</i>	<i>24</i>
<i>Bromine and Calcium Chloride</i>	<i>27</i>
<i>Potash</i>	<i>27</i>
<i>Clay</i>	<i>27</i>
<i>Brick and Tile Products</i>	<i>28</i>
<i>Pottery</i>	<i>29</i>
<i>Sandstone</i>	<i>29</i>
<i>Grindstones and Scythestones</i>	<i>30</i>
<i>Sand and Gravel</i>	<i>30</i>
<i>Glass Sand</i>	<i>31</i>
<i>Sand-Lime Brick</i>	<i>32</i>
<i>Limestone</i>	<i>33</i>
<i>Lime</i>	<i>34</i>
<i>Cement</i>	<i>34</i>
<i>Shale</i>	<i>35</i>
<i>Gypsum</i>	<i>35</i>
<i>Mineral Waters</i>	<i>37</i>
<i>Natural Gas</i>	<i>37</i>
<i>Petroleum</i>	<i>38</i>
<i>Marble</i>	<i>38</i>
<i>Graphite</i>	<i>38</i>
<i>Mineral Paints</i>	<i>38</i>

PART I. METALLIC MINERALS

THE MICHIGAN COPPER INDUSTRY IN 1917

GENERAL REVIEW

The smelter production of primary copper in the United States during 1917 was 1,886,120,721 pounds, a decrease of 2.18 per cent from the production of 1916. Of this total 1917 production, the Michigan copper mines produced 268,508,091 pounds, which is only 1,286,440 pounds less than the record production of 269,794,531 pounds in 1916. These figures for Michigan represent the smelter output of ingot and anode copper, or the metal actually recovered from materials treated in 1917 and do not, therefore, correspond exactly with the mine production.

The average price of 2,584,000,000 pounds of copper delivered in 1917, as reported to the United States Geological Survey by selling agencies, was 27.3027 cents a pound. The price received for copper sold by the Michigan mining companies in 1917 varied from 26.238 cents to 29.39 cents per pound. The average price of copper per pound received by Michigan companies in 1916 was 24.6 cents.

The outstanding feature of the Michigan copper industry in 1917 was the constantly rising cost of production. The greatly increased cost of all material and supplies, the high scale of wages and the general scarcity of labor, with the consequent decreased product, materially added to the production costs for the year. All supplies

practically doubled in price in 1917. Coal and powder advanced 100 per cent in cost. Stamp-mill costs are now more than 100 per cent higher than formerly, and at the present time the costs in all departments of operation will average about 75 per cent above normal times.

Further increase in costs was due to the reduced production because of the scarcity and inefficiency of labor. Adventure, Ahmeek, Calumet & Hecla, Cherokee, Franklin, Hancock, Isle Royale, Keweenaw, LaSalle, Michigan, New Arcadian, Quincy and South Lake were the only operating companies which produced more copper in 1917 than in 1916. The Calumet & Hecla's mine production showed a decrease in 1917, but the large increase in production by the Reclamation Plant increased the total production over that of 1916. Production by the Copper Range showed a decrease of about 18 per cent from the record production of the previous year.

In general the output of the mines was largest during the first four months of the year, but after war was declared and the selective draft became effective, the loss of men was felt severely. During the summer months the turnover of labor was extreme. In most of the mines the shortage of labor was considerably reduced before the end of the year. At the Copper Range mines in the third quarter of the year the number of underground men fell off 20 per cent from the number employed in the first quarter, and in the fourth quarter the loss was increased to 24 percent. At the Quincy a total of 2,525 men was hired during the year, of which 805 were secured from other sections, the largest importations of men occurring during the summer months. At the Mass in January the average number of men employed underground was 409. This number gradually decreased until August, when there were only 232, a decrease of over 43 per cent. In December, however, the average number of employees was 372. At the Mohawk the number of men employed in all departments for the entire year averaged 18 per cent under normal. Much of the imported labor was unaccustomed to underground work, required constant attention and training, and thus handicapped the mining operations and decreased the output of ore.

Notwithstanding the inefficiency of the new employees, wages were maintained at a very high average throughout the year. At the Calumet & Hecla and all its subsidiaries the ten per cent premium and 50 cent bonus for each day worked were continued throughout 1917, and notices were posted early in 1918 announcing the continuance of this premium and bonus until July 1, 1918. At practically all the operating mines increase in wages and bonuses were necessary in order to secure the men and maintain production.

On September 21, 1917, a copper price of 23½ cents per pound, f. o. b. New York, to the Government, allies and the public, was fixed by voluntary agreement between the Government and leading copper producers. The price of 23½ cents was to hold for four months, and producers agreed not to reduce wages and to maintain maximum output. On September 28 the copper

producers organized a new Copper Producers' Committee to conduct the copper business of the country under the new conditions, and on October 2, the principal copper consumers formed a committee to confer with the Copper Producers' Committee.

The price received for copper sold by the Michigan mining companies in 1917 varied from 26.238 to 29.39 cents per pound. The fixed price of 23½ cents per pound, however, placed a severe handicap on all operating companies and resulted in the closing down of six or seven mines in the development stage. Operations during the latter part of the year were limited, and work was confined to the more productive areas. At Mass there were practically no earnings during the last six months of the year. Such properties as Centennial, Lake, LaSalle, Mass, Victoria and Winona cannot make a profit and still carry on necessary development at the established Government price of 23½ cents.

The same companies which paid dividends in 1916 paid dividends in 1917. The total amount paid in dividends by the 15 companies in 1917 was \$28,041,026.00, compared with a total of \$28,840,348.59 in 1916. Many of the companies, including Calumet & Hecla, Ahmeek, Allouez, Centennial, Isle Royale, Mass, Osceola and White Pine, showed a net decrease in current assets for the year. Although Copper Range sold its copper at a price nearly 2½ cents per pound higher than in 1916, yet, owing to the reduced production and increased cost, the balance of \$1,022,912.47 added to the surplus from the year's operation was less by more than a million dollars than the amount added in 1916. The income and excess profits taxes and Red Cross payments for the year 1917 amounted to a large sum and helped to decrease current assets.

Adventure, Michigan, North Lake, South Lake and White Pine Extension showed a balance of liabilities at the end of the year, and several other companies showed only a very small balance of assets.

EXPLORATION AND DEVELOPMENT

Scarcity of labor, high wages and high cost of supplies placed a severe handicap on all properties in the exploration and development stage. Throughout the district there was very little exploratory work done in 1917. Some of the larger mines temporarily closed certain of their shafts.

No work of any kind was done at Algomah during 1917.

At the Contact no active work has been done since the completion of diamond drilling in hole No. 21 on June 29, 1916.

At the Cherokee, although results of operations were very encouraging, the mine was closed down about December 25th to await more propitious times.

The Adventure was closed down October 26th. Adventure resumed work in November 1916, and the lodes where opened showed on the whole a satisfactory

copper content. A total of 652,977 pounds was produced during the year. Shortage of labor and high cost of production, however, necessitated the discontinuance of mining operations.

At the Houghton copper mine operations were discontinued the latter part of September.

At the Indiana all work on the property has been stopped until conditions become more favorable.

At the Phoenix mine of the Keweenaw Copper Company a total of 1,410 feet of openings was made, and 380,536 pounds of copper was produced. On December 1st all operations were discontinued and the mine closed down.

The Mayflower-Old Colony began the preliminary work of preparing the property for sinking of a shaft in April. Considerable time was spent in repairing old dwellings, constructing railroad connections and a dam, erecting the necessary buildings for the mine plant and in assembling and installing the necessary equipment. At the end of the year the shaft had reached a depth of about 261 feet.

Exploration and development work was continued throughout the year at the Michigan. Results of operations on the Butler, Ogima and Evergreen lodes were highly encouraging. During the latter part of November shipments to mill were made from the stockpile, and at present regular shipments direct from the stopes are being maintained.

No. 2 shaft Mohawk was closed down temporarily in July.

Naumkeag continued exploratory work throughout the year. The shaft was sunk 156 feet, and 3,284 feet of drifts and crosscuts was driven. Fair copper ground was found for 350 feet on the 400 foot level north. In one or two other places the mineralization was found to be local.

At the New Arcadian development work was reduced to a minimum, and the plan to place the property on at least a limited producing basis was abandoned. Total openings amounted to 1,633 feet and results were satisfactory.

Operations at the New Baltic were continued to a limited extent. The New Arcadian lode and a parallel amygdaloid, about 30 feet above the New Arcadian lode, were explored, and both showed good mineralization.

North Lake carried on exploratory work at the 800 foot level continuously throughout the year. Total openings amounted to 2,034 feet. Several amygdaloid beds carrying copper were cut by the northwest crosscut, but no drifting will be done until the Butler lode is reached.

South Lake continued operations on the north dipping lodes. Production was continuous throughout the year but was incidental to the opening of the lodes. Results insure profitable production when openings have been made and equipment installed for operations on a larger scale.

At the Winona mining operations were carried on as usual for the first nine months of the year. For about six months there was a small margin of profit. Beginning in July, the underground openings ran into much poorer ground, the price of copper was dropping, and when the results of the month's operations were obtained, it was evident that the mine would have to shut down. At that time the fixing of a price for copper by the Government was pending, and it was thought best to await the announcement before stopping operations. Immediately upon the announcement by the Federal Government of a price of 23½ cents, the mine was shut down. Supt. R. R. Seeber recommended a continuance of operations on a somewhat smaller scale and in certain parts of the mine only. It did not seem advisable to the Board of Directors to follow his recommendation. Mr. Seeber, therefore, made application to work the property on tribute, guaranteeing a small minimum payment per pound of copper produced and an additional payment dependent on the price at which the copper was sold exceeding a minimum figure. The mine has been operated on this basis by Mr. Seeber since October 1 with satisfactory results.

All work at the Wyandot mine during 1917 was confined to the further development of No. 8 lode on the 10th level. Two mill tests were run at the Winona mill, one of selected ore and one of unselected ore direct from the openings. Results were very encouraging. The lode is lean, openings are encouraging, but whether the lode can be developed profitably remains yet to be proven. At the end of the fiscal year all operations were suspended, and the mine closed down.

Of the numerous projects undertaken in 1916 in Ontonagon county, only one, the White Pine Extension, carried on operations in 1917. Nothing was done at the Onodaga, at the Carp Lake mine or at the Algonac and Porcupine Exploration properties. Nothing further developed from the explorations at the Flint steel mine and the Tremont & Devon. The Cass Copper suspended diamond drilling and exploratory work in August.

At the White Pine Extension mining operations were carried on throughout the year. Total openings at the end of 1917 amounted to 5,420 feet, and 13,478 tons of ore had been hoisted. Results of work indicate that only the No. 2 shale can be seriously considered as a mining proposition at the present time. The property must be worked on a large daily tonnage of at least 1,000 tons. This will require sinking of two shafts simultaneously, a large amount of underground opening work and the construction of a modern flotation mill, besides railroad connections. Results show an average of 21.5 to 23 pounds of copper per ton and a width of only 4.8 feet in the lode.

Copper Range expended \$57,364.32 in diamond drilling the lands south of the Champion mine, under option from the St. Mary's Mineral Land Co. No important developments were made, and the drilling will be continued a while longer.

In the latter part of April, the Federal Syndicate Copper Co. was admitted to the State of Michigan and purchased 360 acres of land in Keweenaw County, formerly owned by the Federal Copper Co. The Federal intended to explore the Kearsarge amygdaloid and the Kearsarge conglomerate, and in the fall of 1917 a diamond drill was taken in to the property and set up ready for work. Owing to financial difficulties, however, no drilling was done.

During the year 1917, perhaps the most important and interesting exploratory work was that undertaken in the vicinity of Bear Lake, about seven miles west of Calumet. About the middle of March copper was found in an exploratory pit in section 24. This resulted in the formation of the Bear Lake Pool, and diamond drilling was started in August. Four holes were drilled before the end of the year with encouraging results. The exploratory work will be continued.

In the latter part of 1916, the Longyear-North interests secured options on 1,240 acres in the Bear Lake district and drilled one hole in section 35.

In the fall of 1917, the Federal Syndicate Copper Co., under the name of the Bear Lake Extension, secured options on 2,000 acres adjoining the property of the Bear Lake Pool and the Longyear-North options. Diamond drilling will begin on these lands early 1918.

It is probable, owing to the difficulty of financing three separate explorations, that in the year 1918 the holdings of the Bear Lake Pool and the Longyear options will be consolidated with the Federal Syndicate Copper Company, thus giving a combined acreage of 4 600 acres to be explored by the one organization. Results of the exploratory work in this Bear Lake district will be watched with great interest.

The New Seneca Copper Corporation, organized late in December 1916 to take over the controlling interest in the Seneca Mining Company, began preparatory work towards sinking a shaft to develop the Kearsarge lode in June. During the summer, fall and early winter, practically all the surface buildings were erected and with the completion of railroad connections in December the heavy equipment was ready for installation. Shaft sinking will begin early in 1918, and the progress and the results at the Seneca will be watched with interest.

CONSTRUCTION

Notwithstanding the difficulty in securing delivery of equipment, the shortage of labor, the increased cost of all material and high wages, construction work was continued on a considerable scale throughout the district in 1917. Over \$3,743,976.00 was expended for construction during the year at the various mines and mills. All this work was for improvements towards increased production in the future and for the betterment of the employees. Under the requirements of the Federal Government in regard to income tax returns, it is not permitted to charge construction against income.

Calumet & Hecla expended for construction \$2,274,901.27, including Tamarack Mining Company construction. At the stamp-mills the electric power house is being made thoroughly fire proof, and increased equipment for prevention and control of fire is being installed throughout the mills. A 2,000 ton plant for the treatment of slimes from Nos. 1 and 2 regrinding plants will also be built. The 2,000 ton addition to the leaching plant should be completed by late spring 1918. A new electrically operated coal bridge, capable of handling from vessels 10,000 tons per 24 hours, has been erected and will go into commission at the opening of lake navigation in 1918.

Ahmeek spent \$231,257.42 for construction in 1917. At No. 2 shaft the new steel rockhouse went into commission in April. All of the dwelling houses were provided with stone foundations. Fire protection lines were extended to the 28 new dwellings which were completed early in the year. At the stamp-mill several improvements were made, and an automatic sprinkler system for fire protection is being installed.

Allouez expended \$24,503.11 for construction. A two-boiler addition to No. 1 boiler-house was erected, and considerable work was done on Company dwellings.

At the No. 2 mill, Hubbell, and at the No. 1 mill, Point Mills, of the Lake Milling, Smelting and Refining Company, automatic sprinkler systems for fire protection were installed. At the No. 1 mill work was started on two new stamp units, and at the No. 2 mill a tailings pumping plant is being built.

Isle Royale spent \$316,370.62. At two of the shafts modern fireproof change-houses to accommodate 250 men were erected. These buildings contain offices for mining captains, shift bosses and timekeeper on the main floor, rooms for mine supplies, surface tools, etc., in the basement, toilets, shower-baths and steel lockers. Other items of construction were a combined smithshop, machine shop and warehouse, a new locomotive house containing stalls for six locomotives, a new medical dispensary, 20 new seven-room, two-story dwelling houses with full sized basements and concrete floors, and a twin boarding house, capable of accommodating 39 men. This latter is steam heated, electric lighted, and contains toilets, shower-baths and a large lounging room.

Osceola expended \$96,788.55 for construction, of which amount \$47 314 82 was for new work at the stamp-mill.

White Pine spent \$78,360.76 chiefly towards improvement of living conditions at the location.

Quincy spent \$370,315.25 for construction during 1917. This amount includes the erection of 50 substantial eight-room dwelling houses with full basements, boarding houses for employees, an automatic sprinkler system for better fire protection at the stamp-mills stokers and coal handling plant at stamp-mill boilers, new hoisting plant at No. 2 shaft and numerous other improvements at mine and mill.

Mass expended \$62,775.59 for additions to buildings and \$22,576.87 for additions to equipment.

Franklin spent \$39,510.67 for construction at mine and \$24,570.77 for construction at mill.

Keweenaw spent \$14,866.17; Mayflower-Old Colony, \$22,598.24; Victoria, \$27,090.63.

Mohawk expended \$40,056.73 at the mine for machine shop and for reconstructing hospital and \$50,847.64 at the mill for installing turbine, sprinkler system, water tank and sand conveyor.

MINING AND MILLING

Scarcity of labor was a serious matter during the greater part of the year 1917. Therefore, improvements made in mining were directed toward compensating for a decreased supply of labor. Power haulage was extended underground, and at a number of the mines storage-battery locomotives were installed for this work. At some of the mines it was found advisable to concentrate mining operations. During the latter part of the year, all operations were limited and confined to the more productive areas. The only possible offset to increasing cost of labor and supplies and decreasing copper content of ore is increased production. Hancock and White Pine carried on underground exploration by diamond drill.

At the stamp-mills fine grinding in Hardinge conical mills became standard throughout the district.

At the Calumet & Hecla mills a second steam turbine of 10,000 kilowatt capacity is being installed.

Ahmeck stamp-mill was completed; No. 8 stamp went into commission February 1. At the two oldest units round tables and jigs were replaced by Wilfley tables.

At the Lake Milling, Smelting and Refining Company's No. 1 Point Mills plant work was started on two new stamp units, one for the Isle Royale and one for Hancock. As additional power will be required, the entire plant will be electrified, thereby introducing a decided fuel economy, as the exhaust steam from the stamps will be utilized in a mixed flow pressure turbine which will operate a 2,000 kilowatt electric generator. A 30,000 gallon motor driven centrifugal pump, for furnishing water for the entire mill, will also be installed. No. 6 Chilian mill was replaced by a Hardinge conical mill.

At the No. 2 mill, Hubbell, the first unit of the two stamp addition went into commission October 1st. The second unit is completed except for installing concentrating machinery. Work has been started on a tailing pumping plant, which when completed, will be available for pumping mill tailings farther out into Torch Lake when the present area for launder discharge is exhausted.

At the Quincy mills the bins in No. 1 stamp-mill were remodeled and the capacity doubled. The foundation of No. 4 stamp head was completely rebuilt. A new assay office was erected and equipped at the mills. Taylor

stokers and ash handling apparatus under the Stirling boilers were installed.

At the Victoria mill 15 new concentrating slime tables were installed. Six old concentrating tables were rebuilt with new head motions and rearranged to have ample concentrating machinery for the crushing capacity of the mill.

At the Keweenaw mill plans were made for additional concentrating equipment, consisting of tables, screens, etc., of which four Wilfley tables were installed, replacing the older tables.

At the Calumet & Hecla and White Pine mills experiments with the flotation process were carried on most of the year. Results at the Calumet & Hecla were entirely satisfactory, and two 600-ton Minerals Separation units will be installed at once, with all necessary auxiliary machinery, including Dorr thickeners and Oliver filters. One stamp unit at a time will be converted to the new system. In addition to this, it is proposed to build a 2,000 ton plant for the treatment of slimes from Nos. 1 and 2 regrinding plants, which are now wasted as they are too fine to permit of treatment by leaching.

At the White Pine mill results were sufficiently encouraging to warrant treatment of all tailings by flotation, although only low grade concentrates have been made, and smelting costs will be high. Sufficient Wilfley tables will be removed to make room for a 600-ton flotation unit of the Minerals Separation type. Additional power will be furnished by a triple expansion engine, and two of the pebble mills will be converted into ball mills for finer grinding. An addition to the mill has been built to house two Dorr thickeners.

The two Calumet & Hecla regrinding plants crushed a total of 512,172 tons of coarse tailings during 1917 and produced 2,222,419 pounds of copper, at a cost per pound, excluding smelting and selling of 6.48 cents. In addition, the No. 2 regrinding plant treated 730,543 tons of tailings sands from Torch Lake, producing 4,635,386 pounds of copper, at a cost of 3.5 cents per pound, excluding smelting and selling.

The Calumet & Hecla leaching plant operated continuously throughout the year. The 2,000-ton addition should be completed by late spring 1918. Total recovery was 5,250,331 pounds of which 810,260 pounds was from current mill tailings and 4,440,071 pounds from Torch Lake. The cost per pound, excluding smelting and selling, was 6.41 cents. The total production by the Reclamation plant in 1917 was 9,075,457 pounds, the pounds saved per ton was 12.42, and the cost per pound, excluding smelting and selling, was 5.94 cents.

GENERAL

During 1917 the Calumet & Hecla acquired all of the assets of the Tamarack Mining Company for the sum of \$3,600,000, and the latter company has been dissolved.

The Baltic Mining Company has also been dissolved, and all its assets transferred to the Copper Range Company.

The remaining shares of the Laurium Mining Company stock, not owned by the Calumet & Hecla December 31, 1916, were acquired by the Calumet & Hecla, and dissolution proceedings are in process.

Frederick W. Denton retired from active duty as general manager of the Copper Range mines August 1st, and William H. Schacht was appointed general manager of mining operations. Mr. Denton will continue his connection with the Company as vice-president and managing director, with headquarters in Boston.

J. L. Harris who had been manager of the Hancock since its organization, resigned June 1st, and C. E. Weed, formerly manager of the Lake Copper Co., was appointed to succeed him.

Early in 1917, Ralph Hayden, formerly with the Anaconda, was appointed superintendent of the Quincy stamp-mills.

Many of the employees throughout the district availed themselves of the opportunity to subscribe through their respective companies to both issues of Liberty Loan bonds, paying ten per cent of the purchase price monthly until fully paid.

*DETAILS OF OPERATIONS OF THE MINING COMPANIES IN 1917**

Adventure Consolidated Copper Company

Operations at the Adventure mine in 1917 resulted in a loss. Financial statement shows a balance of assets January 1, 1917, of \$53,783.73 and a balance of liabilities over assets January 1, 1918, of \$11,892.16. Because of the constantly increasing cost of labor and supplies, the low grade of ore and the sudden decline in the price of copper, it was considered useless to continue further efforts to make the mine pay, and mining operations were discontinued October 26th.

The Adventure resumed mining operations the latter part of November 1916, and shipments of ore to the Winona mill were begun about the middle of December. Production was gradually increased up to the end of the year and by May 1, 1917, amounted to about 300 tons a day. The lodes, where opened, showed on the whole a satisfactory copper content, and results indicated that the mine can be worked profitably. Shortage of labor and high cost of production, with limited openings, however, were too much of a handicap.

During the year 1917, a total of 652,977 pounds of copper was sold for \$198,562.75.

Ahmeek Mining Company

Ahmeek, with four operating shafts, produced 27,919,812 pounds of refined copper in 1917. This is an increase of 3,777,654 pounds over the previous record

production of 24,142,158 pounds in 1916. Of the total production 19,299,590 pounds was delivered and billed in 1917, leaving on hand at the end of the year 8,620,222 pounds.

The cost of production, including mining and mine taxes, smelting, refining, eastern offices and corporation taxes, was 9.05 cents per pound, and the total cost of production and delivery for the 19,299,590 pounds was 9.42 cents per pound. Gross income from 1917 operations was \$3,389,145.92.

The average yield of refined copper per ton of ore treated was 22.0 pounds, a gain of over one pound compared with the yield in 1916.

No. 1 shaft is bottomed 43 feet below the 22d level in foot-wall trap. The shaft entered the shattered zone at about the 20th level and is still in a crushed area, making close timbering necessary and probably involving high maintenance costs in the future. For this reason No. 1 shaft will not be sunk any deeper, and the ore below the 22d level will be hoisted through No. 2 shaft.

All openings and slopes showed ground of average quality, except the stopes on the 10th, 14th and 16th levels south, beyond the disturbed area. At these points the lode is below average quality, the copper occurring in small bunches.

No. 2 shaft is 46 feet below the 25th level. Drifts and stopes mined during the year were of average quality. During the year 628,000 pounds of copper was obtained from the fissure vein north of the shaft. The fissure is now opened up for a total distance of 4,528 feet on the 8th to the 18th levels inclusive, with the exception of the 12th level. Development work on this fissure was somewhat restricted during 1917, owing to shortage of labor and lack of compressor capacity. The new steel rockhouse at No. 2 shaft went into commission in April.

During 1916, a crosscut was driven through the Kearsarge conglomerate, and drifts were run a short distance north and south near the foot of the bed. During 1917, this drifting on the Kearsarge conglomerate was continued north and south of the crosscut for a total distance of 341 feet, but did not develop ground of commercial value. This exploratory work was stopped in April because of shortage of labor but will probably be resumed at some future time.

No. 3 shaft is bottomed 120 feet below the 20th level and is in the hanging-wall trap. Underlying the Fulton fissure is a shear zone, and here the Kearsarge lode has been thrown toward the foot. No work was done on the Fulton fissure on the 15th level because of shortage of labor. Several small masses were taken out in stopes on the 14th level. Although the copper occurs in bunches, all the openings during the year showed ground of average quality for the north end of the property.

The bottom of No. 4 shaft is 173 feet below the 19th level, with about two feet of average lode showing on the hanging wall side of the shaft. All openings showed

ground of average quality for the north end of the property. After passing through the shattered zone on the 14th level, it was found that the lode turns toward the east to such an extent, that at a point about 2,000 feet north of the shaft, there would be only about 69 feet of stopping ground between the level and the Mohawk boundary. It was therefore decided to discontinue drifting on the 14th level, as the ground can be mined through the 15th level. On the 17th level north, the shattered zone, which was encountered on the 14th, 15th and 16th levels, has almost disappeared, being represented by a clay seam about 18 inches wide.

A storage-battery locomotive is in operation on the 18th level of No. 2 shaft. Similar locomotives will be installed on three other levels in No. 2 shaft, on one level of No. 3 shaft and on four levels in No. 4 shaft. At all levels where motor haulage will be used, chutes have been cut to facilitate dumping into the skip.

The stamp-mill has been completed; No. 8 stamp unit went into commission February 1. The round tables and jigs of the oldest units, Nos. 3 and 4 stamps, have been replaced by Wilfley tables.

Ahmeek paid an income tax of \$112,999.28 in 1917 and an excess profits tax of \$869,760.59.

For premiums and bonuses see Calumet & Hecla Mining Co.

Algomah Mining Company

Concerning operations at the Algomah in 1917, President R. M. Edwards states as follows:

"Owing to the very adverse labor situation and high costs, no mining work was undertaken during the year, and it is deemed unwise to resume sinking of the shaft while present conditions continue."

Treasurer's statement shows a surplus on December 31, 1917, of \$16,868.54

Algonac Mineral Development Company

On account of the unsettled financial condition of the country, it was decided to suspend all work at the property.

Allouez Mining Company

Allouez's total production of refined copper in 1917 was 8,892,915 pounds, which is 1,326,375 pounds less than the record production of 1916. Although the total number of tons of ore treated in 1917 was only 286 tons less than the amount treated in 1916, the yield of refined copper per ton of ore treated dropped from 18.02 in 1916 to 15.69 pounds in 1917, hence the noticeable decrease in pounds of refined copper produced. Production cost was 13.47 cents per pound.

No. 1 shaft was sunk 99 feet. The bottom of the shaft is just below the 21st level. Sinking was delayed because of the very bad character of the ground passed through, owing to "crossings." The shaft is in the hanging-wall trap, so that the value of the adjacent lode is not known.

Stopes tributary to this shaft have been of rather low grade.

Total depth of No. 2 shaft is 198 feet below the 21st level, 3,407.5 feet from surface. Stopes tributary to this shaft have yielded ore of fair grade. Five electric locomotives have been put in service and have proved very satisfactory.

For premiums and bonuses see Calumet & Hecla Mining Co.

Baltic Mining Company

On May 29, 1917, the Baltic Mining Company was dissolved, and all its assets have been transferred to the Copper Range Company. The mine will be operated as the Baltic mine of the Copper Range Company.

For details of operations in 1917 see Copper Range Company.

Bear Lake Pool

For many years Mr. George North of Quincy Hill has held the idea that some day copper in commercial quantity would be found in the neighborhood of Bear Lake, east of the Portage Lake Ship Canal and about seven miles west of Calumet. In connection with J. M. Longyear, Jr., of Marquette, Mr. North secured options on 1,240 acres of land in sections 26, 27, 34 and 35, T. 56 R. 34, and late in the year 1916, a diamond drill hole was put down in the N. E. $\frac{1}{4}$ of the N. W. $\frac{1}{4}$ of section 35. This hole was drilled to a depth of 1,000 feet and disclosed nothing but sandstone.

Although no copper was found in this hole drilled in section 35, Mr. North continued his explorations by sinking a test-pit in the S. W. $\frac{1}{4}$ of the S. W. $\frac{1}{4}$ of section 24. On March 17, 1917, Mr. North struck a fairly good showing of copper in this pit and reported the fact to Dr. P. D. MacNaughton, of Calumet, who held an option on the land.

The finding of copper in this test-pit in section 24, resulted in the formation on May 1st of the Bear Lake Pool. Options were secured on 1,360 acres, consisting of all of section 24, the S. E. $\frac{1}{4}$ of section 23, the N. W. $\frac{1}{4}$ the N. E. $\frac{1}{4}$ and the S. E. $\frac{1}{4}$ of section 26 and the W. $\frac{1}{2}$ of the N. W. $\frac{1}{4}$ of section 25, and from May 1 to November 10, efforts were made to secure sufficient money to thoroughly explore the lands. Interests were sold at \$500, and at the end of the year, 27 interests, representing 80 individual people, had been sold.

Diamond drilling was started by the Bear Lake Pool in August 1917. Four holes were drilled before the end of the year. Late in the fall, Mr. John Been was engaged as engineer to superintend the exploration work. The drilling will be continued, and probably more work will be done in the pit originally sunk by Mr. North.

Bear Lake Extension

See Federal Syndicate Copper Company.

Calumet & Hecla Mining Company

The total production of the Calumet & Hecla, from mine and reclamation plant, was 77,495,283 pounds. The production cost of this copper was 12.60 cents per pound. The production from the mine was 68,419,826 pounds and from the reclamation plant 0,075,457 pounds, compared with 71,349,591 pounds and 5,412,649 respectively in 1916. Of the total production, 59,527,902 pounds was delivered and billed in 1917, leaving on hand at the end of the year 17,967,381 pounds. Cross income from 1917 operations was \$13,132,392.83. The 1917 income tax amounted to \$409,188.82, and the 1917 excess profits tax amounted to \$570,285.87

Conglomerate Lode

Production from the conglomerate lode showed a decrease compared with that of 1916 and 1915. The yield per ton of ore treated was also lower in 1917.

There are 10 operating shafts on the conglomerate lode. The work of removing shaft pillars and cleaning up arches and backs of old stopes was continued throughout the year. About 89 drills were used during the year in this work, and a total of 505,682 tons was secured from the operations. About 2,940 feet of drifting was done in Nos. 6 and 7 shafts, Hecla branch and in Nos. 9 and 10 shafts, South Hecla branch. Ground opened in the former shafts was fair; that opened in the latter shafts was fair to poor.

Osceola Lode

There are six shafts operating on this lode. No marked change was found in the grade of ore opened during the year; the average yield of copper per ton of ore treated was 12.79 pounds, which is a slight decrease compared with the average yield of the three previous years.

Total production from the Osceola lode was 18,003,966 pounds, of which about 27 per cent was secured from foot-wall stopes. Shaft openings are so far in advance of drifts that, with the exception of 338 feet at No. 17, no sinking was done during the year.

Kearsarge Lode

No work has been done on the Kearsarge lode since July 1913. There are three shafts on this lode, Nos. 19, 20 and 21. Nos. 19 and 20 are both bottomed at 1,350 feet and were closed down December 1907. No. 21 is 2,291 feet deep and was closed down in July 1913.

Manitou-Frontenac Branch

No work was done on these lands during 1917.

St. Louis Branch

No work has been done at this branch since July 1913. The shaft is 137 feet below the 5th level, or 693 feet from surface.

Stamp-mills

A 50-ton experimental flotation unit was in operation for six months during the year. This experimental work proved so satisfactory that two 600-ton Minerals Separation units, including Don-thickeners and Oliver filters, will be installed at once. One stamp unit at a time will be converted to the new system, beginning with the Hecla mill, and continuing into the Calumet mill, as units can be shut down. In addition it is proposed to build a 2,000-ton plant for the treatment of slimes from Nos. 1 and 2 regrinding plants; these slimes are now wasted, as they are too fine to permit of treatment by leaching. Contracts have been let for remodeling the conglomerate slimes treating machines, and active work of remodeling will be under way in the near future.

Regrinding Plants

Owing to the non-delivery of 15 of the required 24 Hardinge mills, the remodeling of No. 1 plant is almost a year behind schedule. No changes were made in the No. 2 plant. The comparative results for 1917 for the two plants on mill tailings were as follows:

	No. 1	No. 2	Total
Tons coarse tailings crushed	322,811	189,361	512,172
Pounds per ton in material treated	12.74	12.74	12.74
Pounds copper saved per ton	4.11	4.73	4.34
Pounds copper produced	1,326,348	896,071	2,222,419
Cost per pound, excluding smelting and selling	7.10c	5.56c	6.48c

In addition to the above, No. 2 regrinding plant treated 730,543 tons of sands from Torch Lake, producing 4,635,386 pounds of copper, at a cost of 3.5 cents per pound, excluding smelting and selling.

Leaching Plant

The leaching plant operated continuously throughout the year with very satisfactory results. The 2,000 ton addition is well underway; the first of the new tanks will go into commission in February, and all work should be completed by late spring 1918. The results of the leaching plant for 1917 were as follows:

Tons treated	643,911
Assay headings	.571
Assay tailings	.148%
Pounds refined copper	5,250,331
Pounds copper per ton treated	8.15
Cost per pound of copper, excluding smelting and selling	6.41c

Of this copper 810,260 pounds were from current mill tailings and 4,440,071 pounds from Torch Lake.

Reclamation Plant

Production from this plant was continuous and uniform throughout the year. The operations of the plant include pumping the sands from Torch Lake to a shore-plant, classifying the sands, elevating the coarse sands into

the regrinding plant, regrinding and washing these coarse sands, pumping the tailings of this plant to the leaching plant where they are leached, and the disposal of the waste material after being leached. Results for 1917 were as follows:

Tons tailings treated	730,543
Pounds per ton material treated	17.06
Pounds copper saved per ton treated	12.42
Pounds copper produced	9,075,457
Cost per pound of copper, excluding smelting and selling	5.94c

General

A new electrically operated coal-bridge, capable of handling from vessels 10,000 tons per 24 hours, has been erected at No. 2 coal dock.

During the year 1917 the Calumet & Hecla acquired all of the assets of the Tamarack Mining Company for the sum of \$3,600,000, and the latter company has been dissolved.

The remaining shares of Laurium Mining Company stock, not owned by the Calumet & Hecla December 31, 1916, were also acquired, and dissolution proceedings are in process.

The ten per cent premium and fifty cent bonus for each day worked were continued throughout 1917 and will remain in force until July 1, 1918. This statement of premiums and bonuses also applies to the following Calumet & Hecla subsidiaries: Ahmeek, Allouez, Centennial, Isle Royale, LaSalle, Osceola, Superior and White Pine.

Carp Lake Mine

No work was done at the Carp Lake mine during 1917.

Cass Copper Company

Exploratory work at the Cass was discontinued in August 1917. Eight holes, totalling 10,000 feet, have been drilled. Management slates results of exploration were satisfactory, and reason given for stopping work was "drilling completed."

Centennial Copper Mining Company

Results of operations at the Centennial during 1917 showed a marked decrease in total production and in the yield of refined copper per ton of ore treated. Production costs showed a decided increase to 18.35 cents per pound, and there was a very noticeable increase in the percentage of discard of rock hoisted.

Centennial has two shafts; No. 1 is bottomed at the 37th level, 4,000.5 feet from surface; No. 2 shaft is 300 feet below the 38th level, 4,537 feet from surface.

No active mining operations were carried on tributary to No. 1 shaft in 1917.

A No. 2 shaft sinking was continued. Openings, totalling 1,409 feet, disclosed ground poor to fair in quality.

For premiums and bonuses see Calumet & Hecla Mining Co.

Champion Copper Company

Champion again in 1917 led all the producing mines in the district in the yield of refined copper per ton of ore treated, with an average yield of 35.50 pounds. Champion's cost per pound, however, increased from 7.80 cents in 1916 to 10.40 cents in 1917.

Champion is one of the three producing Copper Range mines. The total production of the three mines in 1917 was 45,043,301 pounds, of which Champion produced 27,550,343 pounds. This is a decrease of 6,050,793 pounds from the record production of 1916. Total tonnage hoisted was 814,284 tons, of which 38,248 tons, or 4.7 per cent, was discarded as waste rock. The ground developed by the openings made during the year was of average quality.

Cherokee Copper Company

Exploratory work was continued at the Cherokee throughout the year 1917. About the middle of December, the Directors decided that, in view of the general unfavorable conditions, it would be better to suspend all operations at the mine and to await more propitious times. Results of the work to the end of the year 1917 may be summarized as follows:

The shaft is bottomed at a depth of 450 feet. Drifts were driven northeast and southwest at 110, 220, 320 and 420 feet; total footage of drifts is 653 feet.

Copper of commercial value was found in the shaft from the surface to a depth of 300 feet. The copper follows the foot-wall, and the mineralized area varies from two to five feet in width. From the shaft and the drifts on the 1st, 2nd and 3rd levels, 93 tons of selected ore was obtained, which yielded 7,472 pounds of refined copper.

Above the No. 3 station a fault plane crosses the shaft. The fault was first encountered in the west drift on the No. 2 level; it dips to the east at an angle of about 45° and again appears in the east drift on the 3rd level. The extent of the broken and disturbed ground due to this minor faulting is at present unknown.

When work is resumed, the shaft will probably be sunk to the 6th level, and a drift run to the east, with the hope of finding the mineralized part of the lode, lost at the 3rd level.

Captain John Broan, of Houghton, made a detailed examination of the mine on December 24th. Mr. Broan reported as follows:

"First level East, shows 38 feet of good commercial copper ground.

"First level West, shows 22 feet of good commercial copper ground.

"Second level East, shows 30 feet of good commercial copper ground.

"At this point the drift shows 22 feet of poor ground followed by 3 feet of good copper ground at the breast of drift.

"Second level West good copper ground shows to fault line. At this point the drift went through about 20 feet of poor ground. The face of this drift is showing good commercial copper.

"Third level East, length of drift 90 feet for 35 feet showing a little copper.

"Third level West, 41 feet in poor ground, with about 3 feet good copper ground.

"Fourth level East, 54 feet, some places showing a little copper.

"Fourth level West, 85 feet, showing some copper. East of clay slip about 52 feet from shaft.

"The showing down to where the fault line was struck in the shaft is very good. This fault line has a dip to the east of about 45 degrees and it is reasonable to expect that a continuation of that copper will be found farther east which can be tested by drifting the bottom levels through the broken ground to a front east of the fault line. The showing at the 2nd level west, I considered very important as that drift is breasted in good copper ground, west of the broken ground.

"It is rather unfortunate that the shaft should come down into such broken ground, but that ought not to discourage the stockholders, as some of the best mines of the Copper Country meet with similar conditions, and though having very often to drift hundreds of feet, are well rewarded for it. I think the showing to date warrants further development when conditions are favorable."

Contact Copper Company

Since the completion of diamond drilling in hole No. 21 on June 29, 1916, no further active work has been done at the Contact. At the time of the suspension of the exploratory work, the plans for investigation of the mineralized bed (No. 8 Wyandot amygdaloid) were but partly carried out. As mentioned in the report on the Copper Industry in 1910, in order to protect the Company's cash resources, further work on the property was suspended, pending results at the Wyandot to the south.

During 1917 additional sales of machinery and supplies were made from the equipment long held in storage. The treasurer's report shows a balance of \$12,006.97.

Copper Range Company

The net income of Copper Range for 1917 amounted to \$4,960,824.97, \$12.60 per share. Dividends paid during the year-totalled \$3,943,912.50, \$10.00 per share. Although the copper produced was sold at an average price of 28.735 cents per pound, the highest price ever received by the Company and two and one-half cents per pound higher than in 1916, yet, owing to the reduced production and increased cost, the balance of \$1,022,912.47, added to the surplus from the year's

operations, was less by more than a million dollars than the amount added in 1916.

The total production of copper from the Baltic, the Trimountain and one-half of the Champion was 31,268,130 pounds, a decrease from the 1916 production of 6,678,800 pounds.

The reduced production was due to the scarcity and inefficiency of labor. The loss of men was not felt severely until after the draft went into effect. In the third quarter of the year the number of underground men fell off 20 per cent from the number employed in the first quarter, and in the fourth quarter the loss was increased to 24 per cent. Wages were high; coal and other supplies are now costing double the price of normal times. Stamp-mill costs are now more than 100 per cent higher than formerly, and at the present time the cost in all departments of the operation will average about 75 per cent above normal times.

The outstanding feature of the year's operations was the remarkable average yield of 32.97 pounds of copper per ton of ore treated.

During 1917 Copper Range expended \$57,364.32 in diamond drill exploration of lands lying south of the Champion and under option from the St. Mary's Mineral Land Company. President Paine states that no important developments have been made and that the drilling will be continued a while longer.

Copper Range has purchased from Messrs. T. F. Cole and F. W. Nichols surface and mineral rights of certain scattered lands, amounting to 5,050 acres, in Houghton and Ontonagon counties. There has also been purchased the mineral rights on an additional 2,000 acres. The price paid was approximately \$50,000.

Frederick W. Denton, who has been connected with the Copper Range mines since 1900, most of the time as general manager, retired from active duty as manager August 1, and William H. Schacht, who had been Mr. Denton's assistant for seven years, was appointed general manager of mining operations. Mr. Denton will continue his connection with the Company as vice-president and managing director, with headquarters in Boston.

The Baltic Mine

During 1917 the Baltic Mining Company was dissolved, and all its assets transferred to the Copper Range Company. The mine will henceforth be operated as the Baltic mine of the Copper Range Company.

Results of operations at the Baltic mine during 1917 were as follows:

Net profit for the year amounted to \$1,678,323.39. The average yield of refined copper per ton of ore stamped was 34.47 pounds, the highest in the history of the mine. Of the total tonnage of material hoisted, 119,265 tons, or 27 per cent, was discarded as waste rock. Total production for the year was 11,214,861 pounds.

No. 2 shaft was the chief producer from the main lode. All shafts are now producing from the West lode, with No. 5 the chief producer. Ground opened was of fair quality.

Federal Syndicate Copper Company

The Federal Syndicate Copper Company was incorporated under the laws of South Dakota, October 12, 1916, and was admitted to the State of Michigan April 27, 1917.

The Company purchased 360 acres of land, formerly owned by the Federal Copper Company, consisting of the N. W. $\frac{1}{4}$ and all but the S. E. $\frac{1}{4}$ of the S. W. $\frac{1}{4}$ of section 33, T. 58 R. 31, and the W. $\frac{1}{2}$ of the N. W. $\frac{1}{4}$ of section 4, T. 57 R. 31, Keweenaw County. The property carries the Kearsarge amygdaloid, and the northwesterly dip of this bed at an angle of about 30 degrees gives an underlay on the Federal lands of about 292.5 acres of possible copper-bearing ground.

The Federal intended to explore the Kearsarge amygdaloid and the Kearsarge conglomerate, and in the fall of 1917 a diamond drill was taken in to the property and set up ready for work. The Company was unable to secure 160 acres of land lying to the east, and about December 1, 1917, the drill was taken out, no drilling having been done.

On November 20, 1917, the Federal, under the name of the Bear Lake Extension, secured options on 2,000 acres of land southwest of Calumet, consisting of the S. W. $\frac{1}{4}$ of section 27, the W. $\frac{1}{2}$ of section 34, T. 56 R. 34 and all of section 3, the N. W. $\frac{1}{4}$ of section 10 and the N. $\frac{1}{2}$ and the W. $\frac{1}{2}$ of the S. W. $\frac{1}{4}$ of section 2, T. 55 R. 34, Houghton County. These lands adjoin the Longyear options of 1,240 acres in sections 34, 35, 27 and 26, T. 56 R. 34 and the property of the Bear Lake Pool, consisting of 1,360 acres in sections 23, 24, 25 and 26, T. 56 R. 34. No diamond drilling was done during 1917 on these lands, known as the Bear Lake Extension, but exploration will probably be started in February by drilling a hole in section 3. It is probable, owing to the difficulty of financing three separate explorations on adjoining lands, that the holdings of the Bear Lake Pool and the Longyear options will be consolidated with the Federal Syndicate Copper Company, thus giving a combined acreage of 4,600 acres to be explored by the one organization.

Flint Steel

In the 1916 report on the Copper Industry, it was stated that during the latter part of 1916 the old Flint Steel mine was unwatered for the purpose of examining and exploring the old workings. It was hoped that a thorough examination would result in some activity at the property.

Mr. Samuel Brady states that nothing was done at the property during 1917, and that the mine has been allowed to fill with water again.

Franklin Mining Company

Franklin produced 3,155,574 pounds of refined copper in 1917. Practically all of the ore came from the Allouez conglomerate tributary to No. 1 shaft. The working of a limited number of stopes with an increased number of machines in each, instead of working numerous places with two drills in each place, proved practical and worked to advantage. This plan of stoping was made possible by mechanical haulage, which also greatly increased the output per man and very materially reduced the cost per ton.

Results obtained during the year were such as to encourage the belief that, with two or more shafts operating and with normal conditions as to material and labor, the Allouez conglomerate may be worked at a profit.

The 27th level north on the conglomerate was driven 540 feet to explore new territory, but results were unfavorable. On the 30th level of the Pewabic amygdaloid the north drift disclosed 700 feet of the best ore ever found in the amygdaloid workings. It is expected that the same grade of ore will be encountered in the extensions of the drifts north on the lower levels. A crosscut to test the west lode on the 37th level had advanced 51 feet January 1, 1918, with a total distance of about 230 feet to drive in order to reach the lode. No. 2 conglomerate shaft was opened and rebuilt from the 4th level to the bottom at the 17th level. Sinking is now underway.

Hancock Consolidated Mining Company

With two operating shafts, Hancock produced during 1917 a total of 4,005,882 pounds of refined copper, at an average yield of 13.223 pounds per ton of ore treated. Total production showed an increase of 1,180,948 pounds over the production in 1916.

A large amount of development work was done during the year. This work was confined chiefly to exploring the known lodes and opening ground for future stoping.

Electric haulage was installed on the main haulage levels during the year. Six electric locomotives, four of the battery type and two of the trolley type, are now in operation. This electric haulage offset to some extent the scarcity and inefficiency of trammers during the summer and fall. Production was not, however, increased as much as was expected.

No. 2 Shaft

During 1917 about 74 per cent of the ore from this shaft came from the No. 4 "vein." Development work on this lode showed fair mineralization. A little stoping was done on No. 3 west "vein" on the 53rd level, with fair results.

A small amount of drifting and stoping on the No. 2 west "vein" showed the bed to be very narrow and bunchy, with a very poor hanging-wall. About 8.9 per cent of the ore from this shaft came from this lode.

The Pewabic "vein" and the No. 1 west "vein" furnished about 17 per cent of the ore from this shaft. Both lodes showed very good mineralization during the year.

About 1,200 feet of diamond drilling was done underground, and some very important results were obtained.

No. 7 Shaft

Stoping and development work were carried on in this shaft on the Pewabic and No. 1 West lodes. About 95 per cent of the ore stamped came from the Pewabic lode and the rest from the No. 1 West.

During the first eight months of the year, a fairly good yield of copper per ton was obtained, but during the last four months of the year, the average yield dropped considerably. Mr. C. E. Weed, superintendent, states that "this was due to a poor bar of ground about 200 feet wide which seems to extend almost vertically all through that part of the mine." He further states that "south of this bar we are again getting into good ground so that our production from this shaft should increase again rapidly."

Mr. John L. Harris, who had been manager of the Company since its organization, resigned June 1, and Mr. C. E. Weed, formerly superintendent at the Lake mine, was appointed to succeed him.

Houghton Copper Company

During the first nine months of the year, Houghton Copper produced a small amount of ore, and at the same time preparations were being made for a somewhat larger output. It was hoped that this increased tonnage would make possible a further exploration of the property at a little greater depth.

The total production for the year was 179,012 pounds. The yield of copper per ton of ore stamped was 11.45 pounds. The bulk of the production for the year came from the 620 foot level, both north and south of the shaft. On the 820 foot level some good ore was cut south of the winze, and preparations for stoping were made. On the 1,220 foot level fair ground was cut on the Superior lode for a considerable distance north of the winze.

In the latter part of September, operations were discontinued. The fixing of the price of copper by the Government at 23½ cents made it necessary to shut down the mine.

Since it was believed by the directors that the showing in the property warranted further exploration, arrangements were made with the adjoining Superior Copper Company to extend the 19th level of the Superior mine into Houghton Copper territory. Preparations for drifting were begun October 1. The drift is on the West lode. President Paine states that "the undertaking of any further work will depend largely on what is exposed by this drift."

Indiana Mining Company

During the year 1917, all work at the Indiana was confined to the No. 2 exploratory shaft. This shaft was started in the S. W. ¼ of section 21 late in 1916. During 1917, the shaft was sunk 186 feet to a total depth of 310 feet. At the 300 foot level crosscuts were driven for a total distance across the formations of 1,496 feet, 769 feet to the southeast and 727 feet to the northwest.

President Edwards states that "this exploration is supposed to be in the horizon of the main system of Ontonagon County lodes, but, as no conglomerate was encountered, the geological position of the crosscut has not been definitely established."

Several amygdaloid beds carrying a little copper and one narrow seam carrying heavy copper were cut by the crosscut. Although these beds cannot be considered of commercial value where opened by the crosscut, they are worthy of further exploration by drifting.

Owing to the constant increase in cost of all material and labor, it was decided to suspend all work on the property for the present or until conditions become more favorable.

Isle Royale Copper Company

Operations at the Isle Royale during 1917 resulted in an increase of over one million pounds of refined copper over the production in 1916. The yield of copper per ton of ore treated also increased from 13.4 pounds in 1916 to 14.6 pounds in 1917. Production cost per pound was 15.35 cents. Mining operations were carried on in six shafts.

At No. 1 shaft no sinking was done during the year. Drifts driven during 1917 indicate that about 38 per cent of the ground opened may be available for stoping.

On January 31st miners on the 9th level north blasted into unmapped workings of the old Grand Portage mine which were filled with water. The water rushed down No. 1 shaft, filling it to the back of the 14th level plat and filled No. 2 shaft to a point midway between the 28th and 29th levels. Two men were lost by drowning.

Drifting on the 9th and 12th levels north was stopped because of the proximity to the old Sheldon-Columbia mine which is full of water.

At the No. 2 shaft sinking was continued on a vertical curve to reach the West lode. All drifting during 1917 was in the West lode; about 60 per cent of the ground opened showed copper.

At the No. 4 shaft all work was done on the Isle Royale lode. About 90 per cent of the openings disclosed ground of commercial value. Driving of the crosscut on the 6th level, 200 feet north of the shaft, was continued. Amygdaloid beds were cut at points 334 feet and 411 feet from the Isle Royale lode. (The crosscut is in the foot.) A limited amount of drifting on each of these beds disclosed no copper, and the work was discontinued.

At the No. 5 shaft about 85 per cent of the ground opened in 1917 appears to be of commercial value.

No. 6 shaft was sunk to a point 23 feet below the 19th level. The shaft is in the lode, and the ground at the bottom is of average quality. About 70 per cent of the ground opened during the year appears to be of commercial value.

At the No. 7 shaft sinking and drifting were continued. About 65 per cent of the ground opened seems to be of commercial value.

In shafts Nos. 4, 5 and 6 preparations were made for the installation of storage-battery locomotives for tramping, on three levels in each shaft.

For premiums and bonuses see Calumet & Hecla Mining Co.

Keweenaw Copper Company

All work during the year 1917 was conducted on the property of the Phoenix Consolidated Copper Co.

No sinking was done during 1917 at No. 1 shaft. Total openings for the year amounted to 1,410 feet. Ground opened varied from poor to good. Stopping was done on the 3rd, 4th, 5th, 6th, 8th and 10th levels east and west, also on the 7th and 12th levels east. General Manager Uren states that "as stopping was continued it was found that the gray part of vein was not of sufficient value as a whole to mine alone, and as the stopes first opened on the red part showed good values, during latter part of year more work was done on the red part of vein which showed better ground than the gray part."

A crosscut north on the 7th level on the old Phoenix fissure showed no copper, but to the south the crosscut showed some copper, and near the end of the crosscut some fair copper ground, containing small mass copper, was found.

For exploratory purposes, 53 diamond drill holes, aggregating 3,063 feet, were drilled.

Total production during 1917 was 380,536 pounds of refined copper. Although at the mill four Wilfley tables were installed to replace older tables, the mill loss was 5.586 pounds of copper per ton of ore stamped. The number of pounds of copper in ore per ton stamped was 14.834, and the recovery per ton stamped was 9.248 pounds.

Scarcity of underground labor during the year made it impossible to maintain an adequate force, and this fact, together with the increasing cost of labor and supplies, resulted in the suspension of all operations for the present on December 1.

Lake Copper Company

The production of the Lake mine during the year ending April 30, 1918, was 1,461,893 pounds of refined copper. This amount is only 27,354 pounds less than the production of the year ending April 30, 1917. The fixed price of 23½ cents for copper, which became effective in

September, 1917, however, caused a decrease of about \$70,000 in the amount received from the sale of the year's production compared with the previous year. At the same time the increased cost at the mine, due to high scale of wages and higher prices for supplies, resulted in a further loss of over \$77,000 compared with the operations of the previous year. Scarcity of mine, labor was a serious handicap to operations, and taxes in Ontonagon County continued to be a heavy burden.

Work at the Lake shaft during the year consisted of stopping ground already developed. A total of 711 feet of drifting, 86 feet of crosscutting and 488 feet of raising was done at this shaft during the year. Drifting on the 9th level south and the 10th level north opened up some good stopping ground which continued up only a short distance. Drifting on the 11th level north failed to locate the lode. Crosscuts in the foot on the 6th and 7th levels north opened a small bunch of rich stopping ground which continued up to the 3rd level.

At the Knowlton shaft the work consisted of stopping on the Knowlton lode and drifting on the Butler lode. Stopping has been done from the 2d to the 6th levels inclusive on the Knowlton lode on the east side and also on the 6th level on the west side. Stopes on the 4th and 6th levels on this lode show very rich ground over a width of three or four feet. The 2d and 3rd levels show good copper ground. During the year 110 feet of raising and 84 feet of drifting were done on the Knowlton lode.

On the Butler lode the west drift was advanced 435 feet to a point near the South Lake boundary and was stopped. A stope started on this side is showing fair copper ground. The east drift on the Butler lode was advanced 899 feet during the year; some stretches of good stopping ground are exposed.

The crosscut from which the Knowlton and Butler lodes have been developed will be continued to the Evergreen lode, which should be reached early in August.

The yield of refined copper per ton of ore stamped showed an increase of about two pounds; the yield in 1917 was 23.13 pounds, and the yield in 1916 was 21.14 pounds.

Lake Milling, Smelting and Refining Company

No. 1 Mill, Point Mills

At this plant work has been started on two new stamp units, one for the Isle Royale Copper Company and one for the Hancock Consolidated Mining Company.

As additional power will be required, contracts have been let to electrify the entire plant, thereby introducing a decided fuel economy, as the exhaust steam from the stamps will be utilized in a mixed-flow pressure turbine which will operate a 2,000 kilowatt electric generator.

A 30,000 gallon motor driven centrifugal pump for furnishing water for the entire mill will also be installed. The pump intake will be located at the extreme west end of the property, making the area in front of the mill

available for sand room when the present pump is out of commission.

No. 6 Chilian mill was replaced by a Hardinge conical mill, and the roof over No. 1 and No. 2 stamp units was raised to give necessary head room for compounding these stamps when desired.

No. 2 Mill, Hubbell.

At this mill the first unit of the two stamp addition went into commission October 1 and is at present stamping Allouez ore. The second unit is completed, with the exception of concentrating machinery.

Work has been started on a tailings pumping plant, located near the outer edge of the sand bank, which, when completed, will be available for pumping mill tailings further out into Torch Lake when the present area for launder discharge is exhausted. This plant is being built jointly by the Osceola Consolidated Mining Company, the Lake Milling, Smelting and Refining Company and the Calumet & Hecla Mining Company.

LaSalle Copper Company

Results of operations at LaSalle during 1917 showed a larger tonnage of ore treated than in 1916, an increase of almost a pound in the yield of refined copper per ton of ore treated, and a noticeable increase in the pounds of refined copper produced. Production and delivery cost of copper delivered was 20.14 cents per pound, so that the gain on copper delivered was only 8.31 cents per pound. The average yield of refined copper per ton of ore treated was still low, being 10.38 pounds.

At the No. 1 shaft the stopes continued lean, with occasional limited areas of fair quality. No. 1 shaft supplied 70 per cent of the total product of the mine for the year.

At the No. 2 shaft sinking was resumed late in April, after the installation of the larger hoist. The shaft was sunk 163 feet in foot-wall trap, but throughout this distance there was exposed from two to four feet of the foot side of the lode, which showed fair mineralization.

The 17th and 19th level drifts north of the shaft showed fair stoping ground, although both became leaner as the Osceola boundary was approached. In the drifts to the south, fair copper ground continued 700 feet from the shaft on the 17th level and 800 feet on the 19th level. Beyond these points the 17th level was driven 600 feet and the 19th level 100 feet, with practically no copper being disclosed. At the end of the year the 21st level was in good ground at a distance of 140 feet on each side of the shaft. Stopping was continued throughout the year on the 15th and 17th levels in fair ground, which supplied about 72 per cent of the total product from this shaft.

Osceola Lode Exploration

The exploration of the Osceola lode in LaSalle territory was continued until the end of November, when it was stopped on account of difficulties of operation. The 42nd

level south of the Osceola No. 6 shaft was extended 466 feet, to a point 1,158 feet south of the Osceola boundary, or 4,443 feet from the No. 6 Osceola shaft. The ground was found to be poorer than that previously opened, much of it being of no value. The 45th level was driven 713 feet into LaSalle territory, to a point 3,593 feet from No. 6 Osceola shaft. This work opened fair to good ground, corresponding with that in the openings directly above.

LaSalle ore was stamped at the No. 1 mill of the Lake Milling, Smelting and Refining Company, and there was no lack of stamping facilities at any time during the year.

For premiums and bonuses see Calumet & Hecla Mining Co.

Longyear-Michigan Exploration Company

This company holds options on 1,240 acres of land in sections 26, 27, 34 and 35, T. 56 R. 34, Houghton County.

In the latter part of the year 1916, a diamond drill hole was put down in the N. E. $\frac{1}{4}$ of the N. W. $\frac{1}{4}$ of section 35. The hole was drilled through sandstone to a depth of 1,000 feet and disclosed no copper.

See Federal Syndicate Copper Company.

Mass Consolidated Mining Company

Scarcity of labor throughout the year was responsible for the marked decrease in production at the Mass. In January the average number of men employed underground was 409. This number gradually decreased until in August there were only 232 men, a decrease of over 43 per cent. During the latter part of the year the number increased slowly, and in December the average number of employees was 372. Conditions underground continued very satisfactory throughout the year, and had it been possible to obtain sufficient labor, results would have been very much better.

The main Butler lode and branches produced 163,310 tons of ore, the Evergreen lode 74,733 tons, and the Ogima lode 6,628 tons, making a total of 244,671 tons from all lodes. Total production of refined copper was 3,984,616 pounds. The cost per pound was 19.81 cents.

Considerable more development work was done in 1917 than in 1916, so that the reserves were appreciably increased. Considerable work was done on the Evergreen lode on a number of levels, and the lode has shown good values where opened on all the levels. Superintendent E. W. Walker states as follows:

"The Evergreen lode was first opened on the 5th level at 'C' shaft, in 1916. With the new openings on this lode at the 3rd, 7th and 9th levels and the character of the rock exposed by drifting and stoping, it seems reasonable to assume that a new mine has been opened at this end of the property which can be operated through our present 'C' shaft. Crosscuts to this lode will be driven on the lower levels as required."

A large quantity of mass copper was obtained from the Evergreen lode during the year, accounting in part for the large proportion of mass copper produced, which amounted to 29.7 per cent of the gross mass and "mineral."

The mineralization of the Butler lode, as shown in the drifts and the bottom of C shaft, was very good.

As soon as labor conditions permit, work will be started on a new shaft at about 1,800 feet west of C shaft.

Three dividends of \$1.00 each were paid during the year, amounting to \$291,915.

Mayflower Mining Company

See Mayflower-Old Colony Copper Company.

Mayflower-Old Colony Copper Company

The new Mayflower-Old Colony Copper Company is a consolidation of the Mayflower Mining Company and the Old Colony Copper Company. The consolidation was made for the purpose of exploring and developing, by means of a shaft, the mineralized formation disclosed by the extensive diamond drill campaigns, previously conducted on both properties.

The preliminary work of preparing the location for a shaft was undertaken in April 1917. The site of the shaft is about 300 feet west and 250 feet south of the quarter post between sections 8 and 17, T. 56 R. 32, on the line formerly dividing the properties of the two companies.

Considerable time was spent in repairing old dwellings, constructing railroad connections and a dam, in erecting the necessary buildings for the mine plant and in assembling and installing the necessary equipment.

In sinking for the shaft, the overburden was found to be 13½ feet deep. The shaft, below the concrete collar, is 20 feet by 8 feet 10 inches. It is constructed for two skip-roads and one ladder-way, and is being sunk on a dip of 80 degrees. At the end of the year it had reached a depth of about 261 feet.

Michigan Copper Mining Company

Operations at the Michigan mine during 1917 were continued according to the plans undertaken in 1916.

The triple compartment E shaft was sunk to a point below the 8th level, and on several of the drifts south from the shaft at the different levels, the Butler, Ogima and Evergreen lodes were explored. These lodes seem to indicate a general mineralization of the territory commanded by the shaft and thus far have proved of commercial value. Results for the year were very satisfactory and most encouraging.

Development work was pushed on the 6th level, especially on the Ogima lode east and west and upon the Evergreen lode east of the main crosscut, where work on this level has been largely concentrated. Results were very encouraging.

Crosscuts have been completed as far as the Ogima lode upon the 5th, 7th and 8th levels, and also upon the 6th level as far as the Evergreen lode. Drifting upon the Ogima on the 5th and 7th levels has not yet exposed mineralization equal to that found on the same lode on the 6th level, but better results are expected when the work becomes more extended.

Upon the Butler, or most northerly one of the three lodes thus far opened, the rich shoot of ore opened in 1916 to the east of the shaft on the 5th level, after having been traced through from the 6th level, was enlarged in extent, and, by crosscutting a short distance to the north from the east drift on the 4th level, its presence there was proved, carrying the same high values as upon the lower levels. These bunches or patches of rich ground, two of which have thus far been opened, seem to be associated very intimately with the strong shear lines characterizing the locality of the shaft.

About 75 feet of work on the Butler lode at the 2nd level west of E shaft has disclosed there very favorable conditions, and, at the present time, a considerable quantity of rich stamp material and mass copper is now being obtained at this point.

During the year, 188 feet of new ground was opened by drifting east on the Evergreen lode on the 6th level. This work disclosed a very wide and strong lode, carrying stamp material and mass copper in satisfactory quantities, especially in and near the characteristic cross fractures. In some places the lode was found to be from 10 to 18 feet wide, with copper still showing in the hanging. Since production was started, stoping upon this lode has presented many surprises in regard to the richness and width of the copper-bearing ground.

Shipments of ore to a custom mill from the stockpile of about 6,000 tons were begun November 22. These stockpile shipments were continued until February 12, 1918, when they were replaced by shipments of ore direct from the stopes on the Butler, Ogima and Evergreen lodes on the 5th and 6th levels. A total of 4,876 tons of stockpile ore was shipped and treated; results showed better than 25 pounds of ingot copper per ton of ore stamped. A total of 2,777 tons of ore, taken from the stopes now being opened in the mine, showed a somewhat higher yield of refined copper than the stockpile ore.

The future outlook of the Michigan continues most promising, and at nearly all points where openings have been made, the copper-bearing ground continues to prove to be of somewhat exceptional richness.

Mohawk Mining Company

Mohawk's total production for 1917 amounted to 12,313,887 pounds of refined copper. Mass copper produced totaled 574,000 pounds, and the average yield per ton of all ore stamped was 20.35 pounds. The total cost per pound of refined copper produced and marketed was 11.32 cents.

No. 1 shaft contributed 20 per cent, No. 2 shaft 3 per cent, No. 4 shaft 21 per cent, No. 5 shaft 23 per cent, and No. 6 shaft 33 per cent of the total tons of ore stamped.

New openings in No. 1 shaft, as a whole, did not show any improvement in mineralization and indicate the necessity of picking out a large amount of poor material underground. Since labor for this work was scarce, mining operations were confined as much as possible to the better blocks of ground in the upper levels.

Operations at No. 2 shaft were carried on largely in ground which would not be accessible from No. 1 shaft. Scarcity of labor prevented the completion of the work toward eliminating entirely hoisting from No. 2 shaft, and the shaft was closed down temporarily in July.

The exploration crosscuts on the 21st level, at a point 670 feet south of No. 2 shaft, were extended but were discontinued early in the year. The crosscut west, or in the hanging, had reached a distance of 791 feet, and the crosscut east a distance of 1,112 feet. About 16 amygdaloids were intersected by the crosscuts, but none indicated mineralization worth further exploration.

The new openings in Nos. 4, 5 and 6 shafts showed the lode to be of excellent quality, and an improvement in mineralization was noted in general throughout all the new openings. The drifts in Nos. 4 and 5 shafts continued to show a slightly better average in copper than those in No. 6 shaft.

Stopping on the mass fissure vein, encountered on the 8th level south of No. 6 shaft, was carried up to the 7th level. Considerable mass copper was recovered, and the main lode was found to be greatly enriched in its vicinity. The fissure was drifted upon for a distance of 213 feet and 32 feet into the hanging on the 7th and 9th levels respectively, but the heavy mineralization did not extend to any great distance beyond the hanging wall of the main lode. There is sufficient copper in evidence in the fissure at the ends of the present drifts to warrant the extension of these drifts and possibly others on lower levels, as soon as sufficient labor is available.

Naumkeag Copper Company

Operations at the Naumkeag were continued during 1917, and a total of 3,440 feet of work was done during the year.

The bed upon which shaft "A" was sunk, and the 250 feet of drifting done on the same bed, showed only a little copper, less in amount than the mineralization indicated by the diamond drill holes which originally cut this particular bed.

On the 400 foot level 1,806 feet of drifting was done on the Pewabic lode, 830 feet of crosscutting and about 170 feet of drifting on another bed. Two crosscuts were driven at a point about 900 feet north of the shaft, one to the east and one to the west, each about 250 feet long. The west crosscut will be extended about 200 feet to cut No. 15 conglomerate. In this crosscut No. 2 to the west

a bed was cut, carrying small masses of copper up to 200 pounds in weight, but drifting showed the mineralization to be local.

The best copper-bearing ground on the 400 foot level was disclosed from a point 750 feet north of the shaft to 1,100 feet north of the shaft, all showing fair copper ground.

New Arcadian Copper Company

Because of the unusual rise in the price of material and the high cost and great demand for labor, the plan to place the New Arcadian on at least a limited producing basis in 1917 was abandoned, and operations were reduced to a minimum.

From the stockpile, which had accumulated during development work, there was shipped, taking the run of the pile, some 4,900 tons of ore which yielded 53,278 pounds of refined copper.

The shaft was sunk 392 feet during the year and is now bottomed at 1,860 feet, stations having been cut at the 1,700 foot and 1,850 foot levels. On the 1,500 foot level, drifting, both north and south, was carried on to a limited extent (443 feet) in ground of fair mineralization. A crosscut was also extended west on the 1,500 foot level 175 feet to the Old Arcadian vein, on which 80 feet of drifting was done in badly faulted ground.

On the 1,700 foot level, a crosscut is being extended east to cut the No. 8 conglomerate, which was found to be mineralized where exposed on the 900 foot level. The crosscut has been driven 320 feet and should cut the No. 8 conglomerate within the next 100 feet.

At a distance of 47 feet east in this crosscut on the 1,700 foot level, a well mineralized bed, 10 feet in thickness, was passed through, which, from its general appearance, is believed to be the New Arcadian lode. H. W. Fesing, mining engineer at the mine, states as follows:

"As this vein was encountered much sooner than expected, a decided change in dip was the only explanation, which is apparently borne out by the fact that a vein well charged with copper in similar appearance was exposed in sinking the shaft below the 1,700 foot level, from 1,730 feet to 1,760 feet.

"In cutting the station at the 1,850 foot level, a very marked fault, running about north and south and with a hade of about 85 degrees to the east, was encountered, thus accounting in part, at least, for the decided change in dip of the vein noticed at and below the 1,700 foot level.

"Crosscutting both east and west on the 1,850 foot level was undertaken, with the result that an amygdaloid about 18 feet in thickness and very heavily charged with copper, was encountered in the west crosscut at a distance of 47 feet. From its physical and mineral bearing characteristics, this is undoubtedly the New Arcadian vein, which heretofore has always been found

from 100 feet to 150 feet east of the shaft, on all levels above the 1,700 foot."

New Baltic Copper Company

On account of the abnormal conditions, due to the war, and especially because of the great increase in cost of labor, fuel and supplies, operations at the New Baltic in 1917 were somewhat limited. Exploration and development work, however, were continued throughout the year.

At a depth of 270 feet, which corresponds with the 250 foot level of the New Arcadian mine, a station was cut, and active exploration was undertaken at this point. From the appearance and general character of the lode exposed in sinking the shaft, it was thought that the bed in which the shaft is sunk was the New Arcadian lode. Further work, however, demonstrated that this is not the New Arcadian lode but a parallel lode about 30 feet above or west of the New Arcadian lode. The New Arcadian lode where cut was found to be very heavily charged with copper of commercial grade and showed a thickness of from 6 to 12 feet, averaging about 8 feet.

Drifts were run north and south on the New Arcadian lode for a total distance of 420 feet, of which 270 feet were south and 150 feet north of the shaft. While more or less copper was in evidence all the way, the chief values seem to be concentrated in a shoot about 200 feet in length, 40 feet of which is north and 160 feet south of the shaft. The richest ground opened is in the vicinity of the shaft.

In order to further test the ground, a few small raises were put up both north and south of the shaft, with the result that a considerable quantity of "barrel work," in addition to stamp material, was obtained.

As a result of the development work, it was deemed advisable to extend the shaft; sinking was resumed about March 1, 1918.

Soon after sinking was resumed, copper again appeared in the foot of the shaft, which is carrying three or four feet of the hanging of the lode. On the next lower level, further work will be done on the hanging-wall lode, as well as on the New Arcadian lode to the east.

North Lake Mining Company

Exploratory work was carried on continuously throughout the year 1917 on the 800 foot level. On January 1, 1918, the face of the northwest crosscut was 1,695 feet from the shaft, and the face of the southeast crosscut was 1,410 feet from the shaft, making a total distance of 3,105 feet across the formation that has been explored by the 800 foot level crosscut. The foot-wall of No. 6 conglomerate is at the shaft on the 800 foot level, consequently the total length of the northwest and southeast crosscuts represents the horizontal distance that has been explored above and below the foot-wall of No. 6 conglomerate.

The amygdaloid which showed fair copper values, where cut by the southeast crosscut at 679 to 728 feet from the

shaft, was drifted on east and west for a total distance of 384 feet. Some good ore was taken out, but the average was low grade.

Several amygdaloid beds carrying copper were cut by the northwest crosscut, but no drifting was done to determine their value, as it was thought advisable not to interrupt the crosscutting until the Butler lode is reached.

The next amygdaloid to be cut by the southeast crosscut should be the one that showed very good copper values where encountered in the diamond drill holes, and the northwest crosscut should reach the Butler lode within the next 200 feet.

Old Colony Copper Company

See Mayflower-Old Colony Copper Company.

Onondaga Copper Company

Onondaga has not done any exploratory work since August 1916, and it is not probable that diamond drilling will be resumed until conditions are more normal.

The Company has about \$30,000 on hand.

Osceola Consolidated Mining Company

The total production of Osceola for 1917 was 16,084,958 pounds, compared with 19,586,501 pounds in 1916. Besides this marked decrease in total production, the yield of refined copper per ton of ore treated also dropped from 15.2 pounds in 1916 to 13.0 pounds in 1917. Operations at all three branches, however, resulted in a substantial profit for the year.

Osceola Branch

The total production from the Osceola branch was about 25 per cent less than that of 1916. A very low grade of ore was encountered in the workings during the middle of the year, and the average yield of copper per ton of ore treated in 1917 was 12.38 pounds.

No. 3 shaft and surface plant remained idle all the year. No. 5 shaft was kept in repair as a safety outlet, and mining operations were carried on in No. 6 shaft only. The most active and the most productive part of the mine was that above the 46th level and nearest to the extreme south and west boundaries.

The 42d level was driven into LaSalle territory to a point 1,158 feet beyond the LaSalle boundary line and was stopped in May. The 45th level, also in LaSalle territory, was stopped in November, at a point 713 feet beyond the boundary line.

New openings were kept ahead of immediate requirements, with the view of getting the extreme south workings properly opened for a retreating stoping system. This aim will have been accomplished by the early part of 1918, so that during the greater portion of 1918, it will be possible to reduce development work considerably and concentrate on stoping.

North Kearsarge Branch

With the exception of the year 1916, North Kearsarge produced more copper and made a larger profit in 1917 than in any other year since 1911. The grade of ore treated was low, 12.54 pounds per ton of ore treated, which contributed to higher costs per pound of copper recovered.

All three shafts were in operation throughout the year, with only slight interruptions. No. 1 shaft was sunk below the 38th level, but on drifting has been done below the 35th level. In No. 3 shaft most of the product in 1917 was taken from the upper levels. At No. 4 shaft all levels were worked to as great an extent as the scarcity of laborers would permit.

To partly offset the scarcity of labor, power haulage will be installed. Three storage-battery locomotives with five ton tram cars will be put in operation in No. 4 shaft. If they prove successful, similar equipment will be provided for No. 1 and No. 3 shafts.

If nothing unforeseen occurs to prevent, this branch should make a further increase in tonnage during 1918, as it is expected that a considerable number of men can be transferred from the South Kearsarge branch when no longer needed there.

South Kearsarge Branch

Production at South Kearsarge in 1917 was 4,900,781 pounds, nearly one-third less than that of 1916. Operations were very seriously hindered by snow storms in the early months of the year, and trammers were very scarce during the summer and fall. Nearly half the tonnage came from foot-wall work and from the backs of old slopes, and was nearly all low grade material. The branch, however, made a substantial profit in 1917.

Less than 100,000 tons was mined from shaft pillars, leaving about 500,000 tons available in the mine. As soon as the ground under the bottom level of No. 1 shaft along the Wolverine boundary had been mined, it will be possible to mine shaft pillars more rapidly.

For premiums and bonuses see Calumet & Hecla Mining Co.

Quincy Mining Company

The production of the Quincy mine during the year 1917 was 1,280,837 tons of ore, which yielded 17.33 pounds of copper per ton. Total production of refined copper was 22,195,577 pounds. The proportion of mass copper to stamp material continued about the same as for the year 1916. The output was largest during the first four months, before the declaration of war and before the selective draft became effective, both of which decreased the underground working force.

Openings throughout the mine in 1917 totaled 26,900 feet; the shafts were sunk a total of 499 feet. The openings on the various branches of the Pewabic lode were made at a great many different points and developed ground of average mineralization, with the usual quantity of mass copper.

No. 7 shaft was used only for the operations of the Hancock and for the bailing of a small quantity of water.

No. 2 shaft was sunk 179 feet and produced 452,290 tons of stamp material. In all the drifts and openings on the several branches developed, especially on the bottom levels, fair grade ore was found, some portions showing well in "barrel work" and mass copper. On the 65th level on the west branch considerable new ground was opened. The 73rd, 74th, 75th, 76th and 77th levels are opened on the main branches and average fair in copper.

No. 6 shaft was sunk 125 feet and produced 428,250 tons of stamp material, of a slightly better grade than in 1916, and with a little greater percentage of mass copper. The drifts on the lode averaged fair in copper. Some sections are rich in mass copper, with a general average about the same as in the previous two years. All the bottom levels show a satisfactory grade of ore, with openings on only one of the branches.

No. 8 shaft was sunk 195 feet and produced 400,296 tons of fair to low grade stamp material. The lower levels in this shaft are showing the best mineralization.

There are many very long levels in the mine that make hand tramming expensive. For this work electric locomotives, hauling tram cars in trains of four cars each, have been in use for about 15 years. There are now 25 locomotives in operation in the mine.

In order to maintain the hoisting capacity of the shafts as they become deeper, the capacity of the skips was increased early in the year by an addition to the top, thus avoiding the necessity of changing any of the loading or dumping devices in the shafts or rock-houses. The average weight of ore loaded per skip is seven and one-quarter tons.

The No. 2 and No. 8 hoisting engines are gradually approaching the limit of their capacity in depth for hoisting. Therefore, early in 1917, a large new modern compound condensing hoist was ordered of the Nordberg Manufacturing Company for No. 2 shaft, with a hoisting capacity of ten tons load from a depth of 10,000 feet. It is expected that the hoist when completed will reduce the cost of hoisting with increasing depth below the present cost of hoisting at the lesser depth.

The Quincy & Torch Lake Railroad handled 1,390,000 tons of ore, 90,000 tons of coal and 2,200,000 feet of stull timber during the year.

The stamp-mills operated satisfactorily throughout the year. Early in 1917, Mr. Ralph Hayden, formerly with the Anaconda, was appointed superintendent of the stamp-mills.

Seneca Copper Corporation

The Seneca Copper Corporation was incorporated December 26, 1916, and was organized to take over the shares of the Seneca Mining Company owned by the Calumet & Hecla Mining Company. The Company now

owns 11,960 shares of the 20,000 shares of the Seneca Mining Company.

The eastern office of the Company is in New York City. The officers are Frederick Lewisohn, president; Walter Lewisohn, vice-president and treasurer, and E. J. Macnamara, secretary. The directors are Hamilton Fish, Jr., T. F. Cole, F. de C. Sullivan, P. A. Clarke and W. F. Bartholomew.

The property of the Seneca Mining Company, the controlling interest of which is held by the Seneca Copper Corporation, consists of 1,880 acres, lying north of the Mohawk and the Ahmeek and northwest of the Gratiot. This large tract carries the Ashbed, the Allouez-Pewabic bed, the Allouez, Calumet and Kearsarge conglomerates and the Osceola and Kearsarge amygdaloids.

In June 1917 work preparatory to sinking of a shaft was begun, to develop the Kearsarge lode. The site selected for the shaft is in the southeastern corner of the property, adjoining Ahmeek and Mohawk, in the southeast corner of the N. E. $\frac{1}{4}$ of the N. E. $\frac{1}{4}$ of section 28. The shaft, which will consist of three compartments, will be sunk vertically from surface and at depth will curve to conform to the dip of the Kearsarge lode which outcrops in the S. E. $\frac{1}{4}$ of the N. W. $\frac{1}{4}$ of section 23.

During the summer, fall and early winter preparatory work was carried on under numerous difficulties. By December 1st practically all the surface buildings had been erected, and, with the completion of the spur connecting the mine with the Keweenaw Central; machinery and other equipment was ready for installation. Shaft sinking will probably begin early in 1918.

South Lake Mining Company

Openings at the South Lake during the year 1917 totaled 2,520 feet. Since shipments began in May 1916, there had been sent to the mill up to December 31, 1917, a total of 68,388 tons of ore, which produced 754,443 pounds of refined copper, at an average yield of 11.03 pounds per ton. The average yield per ton can no doubt be increased by proper selection of ore. Recovery for December 1917 was 14.5 pounds per ton and for January 1918 it was 16 pounds of refined copper per ton. Adding the average production from mass copper of three pounds per ton, the average yield of refined copper per ton for December 1917 and January 1918 would be increased to 17½ and 19 pounds respectively. If this average can be maintained, profitable production is assured when openings have been made and equipment installed for operations on a larger scale.

The east drift on the South No. 3 lode at the 600 foot level was extended and holed through to the Lake mine. This work proved that the No. 3 lode is the extension of the lode drifted upon by the Lake. Some good copper ground was opened along this drift, but, on account of the long tram; stoping is not advisable until some system of mechanical haulage can be installed. With the

exception of this drift, all work during 1917 was on the north dipping lodes. Although production was continuous, it must be considered as incidental to the opening of the lodes. Opening work must be pushed further before sufficient selection can be made to insure profitable production.

The Butler lode was opened on the surface level by a crosscut into the bluff from the collar of the shaft, on the 300 foot level and on the 600 foot level. It shows better mineralization than any of the other lodes, the higher yield per ton mentioned above for December and January being due to larger proportion of ore from the Butler lode.

South Lake has entered into a contract to purchase at \$90,000 the 166 acres of land to the north of the present property. To furnish funds for this purpose and to pay floating indebtedness, an issue of capital stock was offered to the stockholders at \$2.00 per share. The acquisition of this property will enable South Lake to proceed with plans for more economical operation by means of an incline shaft on the Butler lode. It also gives control of a large area, carrying the Knowlton lode, which can be developed from the Butler shaft.

Superior Copper Company

Results at the Superior in 1917 showed a total production of 2,201,672 pounds of, refined copper, an average yield per ton of ore treated of 16.99 pounds, and a production cost of 16.54 cents per pound. Gross income from 1917 operations was \$214,094.62.

Owing to the many difficulties encountered, which made sinking very slow and expensive, it was decided to discontinue sinking No. 1 shaft at the 31st level instead of at the 33rd level as planned. All development work during 1917 was confined to the west lode. Extension of the 21st level south opened about 200 feet of stoping ground, and, after drifting about 50 feet into barren ground, this level was discontinued. The 23rd level was extended 1,005 feet south to a point about 1,450 feet from the shaft.

The shoot of copper, opened on the levels above in this shaft, was found on the 23rd level, and, while 200 or 300 feet of it was of stoping quality, results were somewhat disappointing. The drift is being continued in lean ground.

On the 31st level, at which point extensive explorations will be made, drifting was carried on for a distance of about 700 feet to the south, but nothing of value was disclosed.

No work was undertaken at No. 2 shaft during the year 1917. There remains approximately 150,000 tons of ore to be sloped, but the future of the mine depends upon developments on the 23rd and 31st levels south of No. 1 shaft.

For premiums and bonuses see Calumet & Hecla Mining Co.

Tamarack Mining Company

In 1917 the Calumet & Hecla Mining Company acquired all of the assets of the Tamarack for the sum of \$3,600,000, and the Tamarack Mining Company has been dissolved.

Trimountain Mining Company

Trimountain's production for 1917 showed a decrease of 2,442,461 pounds from the record production of 1916. The yield per ton dropped to 23.72, and the cost per pound increased to 15.22 cents. Net profits for the year amounted to \$848,241.06.

All openings made during the year 1917 were in ground of average quality.

The Trimountain Mining Company was ordered dissolved by the Circuit Court for the County of Houghton, Michigan, in January 1916. The dissolution ordered was appealed by dissenting stockholders, representing three-tenths of one per cent of the capital stock. In March 1918 the Supreme Court of Michigan reversed the decision of the Circuit Court, so that henceforth the Trimountain Mining Company will continue to be operated as a separate corporation.

Victoria Copper Mining Company

The production of refined copper for the year 1917 was 1,612,640 pounds, or 49,192 pounds less than the record production of 1916. This decrease was due to limited stoping ground at the first of the year, but chiefly to the great scarcity and inefficiency of labor. The shaft and hoisting capacity is now sufficient for double the year's production. Operations for the year 1917, including expenditures of \$28,176.95 for construction and development of water power, showed a profit of \$70,224.91.

More development work was done during 1917 than in 1916, but not as much as was hoped would be done, because of the unusual labor conditions. Reserves, however, are well ahead of stoping requirements.

During the latter part of the year there was a slight improvement in the copper yield per ton of ore stamped, but this required a greater amount of underground sorting.

Both the No. 2 shaft and the second compartment of the same shaft were completed to 50 feet below the 27th level, the stations cut and the drifts started. In the fall of the year a drift was driven east approximately 100 feet from the 19th level north crosscut, presumably on the Butler lode. Some copper was found but not of commercial value.

At the stamp-mill an addition was built, and 15 new concentrating slime tables were installed. Six old concentrating tables were rebuilt with new head motions and rearranged to have ample concentrating machinery for the crushing capacity of the mill. The mill is now in a position to handle a larger tonnage.

White Pine Copper Company

Production of the White Pine for the year 1917 was 4,067,529 pounds, compared with 4,207,449 pounds in 1916. The yield of refined copper per ton of ore treated was 19.11 pounds, compared with 22.27 pounds in 1916 and 24.76 pounds in 1915. Gross income from 1917 operations was \$442,085.78.

No. 2 shaft was sunk 755 feet during 1917. The upper part of the shaft is vertical, but at a depth of 581 feet from surface, a curve was started toward the south and continued for 392 feet. The lower end of this curve is 146 feet south of the vertical part of the shaft. At this lower end, which is 973 feet from surface, a tangent to the curve was started, and the shaft bottomed at a depth of 1,078 feet from surface at the end of the year.

During the sinking of the No. 2 shaft, the gray sandstone was cut at 800 and at 900 feet from surface. Drifts were started at these two points towards the southwest. On the 800 foot level the ground opened seems to consist of large blocks broken from the lode by faulting. On the 900 foot level a more even and better mineralized lode was disclosed. This level was extended in the lode for 39 feet, disclosing ore of fair quality. The 900 foot level is now being extended to the west and east. All of the ground encountered by the No. 2 shaft is badly faulted, and it will be necessary to continue the shaft some distance further before settled ground may be found.

No. 3 shaft was not sunk during the year. Two levels, "A" and "B," were started in the lode from the shaft at 100 feet and 50 feet respectively above the first level. "A" level was driven west 255 feet and east 170 feet, and "B" level west 398 feet and east 150 feet, all in ground of average quality. Drifting on the 3d lode showed good ground on the 3d level west, faulted ground carrying only fair copper values on the 4th level west and east, and ground of poor quality on the 5th and 6th levels.

No sinking was done in No. 4 shaft during 1917. Development work was confined to the upper levels, as the two lower levels, the 5th and 6th, were stopped in close proximity to the main fault. The first level was extended east 430 feet through ground of poor quality. On the 2d level east and on the 2½ level east the third lode showed fair ground. The 4th level was extended east 678 feet in the first lode; the lode was faulted, narrow, and carried only fair copper values.

Approximately 1,000 feet of diamond drilling was done on the 4th level east to explore the 2d and 3d lodes. In general the ten holes drilled showed the 2d lode to be of fair quality and the 3d lode poor.

Experiments with the flotation process were carried on at the stamp-mill most of the year. Results were sufficiently encouraging to warrant treatment of all tailings by this process, although only low grade concentrates were obtained and smelting costs will be high. Sufficient Wilfley tables will be removed to make room for a 600 ton flotation unit of the Minerals

Separation type. Additional power will be furnished by a triple expansion engine and two of the pebble mills will be converted into ball mills for finer grinding. An addition to the mill was built to house two Dorr thickeners. The adoption of the flotation process will result in greater metallurgical efficiency but increased milling costs. It is hoped that the new changes will result in making available as ore, large tonnages of slate and 2d lode material now too low in copper content to mine at a profit.

For premiums and bonuses see Calumet & Hecla Mining Co.

White Pine Extension Copper Company

Exploration and development work were continued throughout the year 1917. Results were interesting and furnish valuable information as to the future prospects of the property.

The shaft was sunk 196 feet to a total of 438 feet. Drifting was carried on to north and south on the 2d and 4th levels, for a total distance of 3,344 feet.

As the drifting on No. 2 shale, the main lode, advanced, samples were taken across the entire width at the breast of the drift at intervals of from five to ten feet, as near as possible with due regard to irregularities in width of lode, caused by slight faulting. Drifting averaged 4.8 feet in width, including an average of 0.9 feet in width of barren brown shale along the hanging which broke with the lode. All assay reports include this barren shale. The results of sampling showed an average of 21½ pounds of copper per ton as a mean average for all drifting. There is considerable variation in mineralization, a number of returns showing 40 pounds copper per ton and a few as high as 48 to 60 pounds per ton.

Starting from about 700 feet north of the shaft on the 2d level and at 350 feet north of the shaft on the 4th level, an appreciable decrease in mineralization of the No. 2 shale, or main lode, was noted. This indicates an area averaging only 13½ pounds per ton, in which drifts were driven 558 feet on the 2d level and 330 feet on the 4th level, with no apparent improvement in mineralization at the north end of the drifts. Eliminating this poor area, there is -to the south a total of 3,121 feet of drifting, 2,131 feet on the 2d level and 990 feet on the 4th level, which averages 23.5 pounds of copper per ton, as compared with an average of 21.5 pounds of copper for all drifting.

At intervals of 100 feet along the drift on No. 2 shale short crosscuts were driven into the hanging to test No. 1 shale, and at every 200 feet crosscuts were driven into the foot to test No. 3 sandstone. Samples were taken on both of these beds in the same manner as previously described for No. 2 shale.

A total of 23 observations on No. 1 shale on the 2d level and 11 on the 4th level gave returns varying from 6 pounds to 20 pounds per ton, an average of 12 pounds of copper per ton for an average width of 5.7 feet.

A total of 10 observations in crosscuts on No. 3 sandstone on the 2d level gave returns varying from nothing to 28 pounds per ton and a width varying from 1.6 to 3.0 feet. In the crosscut at the shaft and also in the crosscut 100 feet north and 100 feet south, the average width was found to be 1.6 feet, with 60 pounds of copper per ton. A drift of 40 feet on the 2d level showed a width of two feet but no copper. This No. 3 sandstone has shown no mineralization on the 4th level and in some crosscuts cannot be identified.

To ascertain whether both No. 1 and No. 2 shales can be stoped without breaking the intervening six foot layer of barren sandstone, stopes were made on the 2d level at 240 feet north of the shaft. The stope on No. 2 shale is 60 feet long and 45 feet high, and the stope on No. 1 shale is 60 feet long and 60 feet high. The greater part of the broken ground was withdrawn and after several months' time the walls appear to stand up well. There is, therefore, every reason to believe that both shales may be stoped simultaneously if desired.

The main crosscut on the 4th level at the shaft was extended west of the shaft 63 feet, thus cutting across the formation a distance of 158.5 feet from the foot of No. 2 shale. A conglomerate was encountered at 105 feet to 125 feet below No. 2 shale, otherwise the crosscut was in sandstone, and no mineralization was noted.

Reviewing the results of operations to date, February 23, 1918, General Manager Theo. Dengler states as follows:

"The information obtained so far from openings made are such as will warrant the statement that only No. 2 shale can be seriously considered as a mining proposition at least during the present time, with the scarcity of labor, high wages and cost of materials prevailing; that the property must be worked on a large daily tonnage of at least 1,000 tons to afford commensurate returns. To attain this will require sinking of two shafts simultaneously, a large amount of underground opening work and the construction of a modern flotation mill, but before this work is undertaken, arrangements should be made for the construction of many houses with modern conveniences to induce an influx of steady employees and competent officials.

"There being an extreme shortage in the district of mechanics and labor of all kinds, coupled with the uncertainty of delivery of construction materials, even at the prevailing high prices, no definite estimate can be arrived at for new equipment or cost per pound running expense. Under the prevailing conditions with an average of 21.5 to 23 pounds copper per ton and a width of only 4.8 feet in the lode, I cannot advise entering into extensive constructive work of any kind or starting a new shaft. Nor does it seem proper to recommend a continuation of exploring operations as the value of the lode has been fairly determined, nor to continue sinking and drifting for future enlarged operations before a standard railroad connection has been effected."

Winona Copper Company

The stopes opened at Winona during 1917 showed about the same grade of ground; the yield of copper per ton of ore stamped was 13.33 pounds. Total production of refined copper was 1,494,472 pounds.

Concerning the operations of Winona during the year 1917, President Chas. J. Paine reports as follows:

"For about nine months of the 1917 year mining operations were carried on by your Company. Throughout that period there was a marked tendency for costs of all kinds to increase, coupled with lack of adequate labor, though for six months of that time we were able to show a small margin of profit. Beginning in July the underground openings ran into much poorer ground, the price of copper was sagging, and when the results of the month's operations were obtained it became evident that the mine would have to shut down. At that time the fixing of a price for copper by the Government was pending and it was thought best to await the announcement before giving orders to stop. Immediately upon the announcement by the National Government of a price of twenty-three and one-half cents, orders were given to shut down the mine. Your Superintendent, Mr. R. R. Seeber, recommended a continuance of operations on a somewhat smaller scale and in certain parts of the mine only. It did not seem advisable to the Board of Directors to follow his recommendation. Whereupon he made application to work the property on tribute, guaranteeing a small minimum payment per pound of copper produced and an additional payment dependent on the price at which the copper was sold exceeding a minimum figure. Your property has been operated by Mr. Seeber on this basis since October 1, 1917, and with satisfactory results to date."

Wolverine Copper Mining Company

Results of operations at the Wolverine for the year ending June 30, 1917, showed a net profit of \$1,026,404.68. Due principally to the shortage of unskilled labor, the production was not as large as that of the previous year. Receipts from sales of copper, however, exceeded those of the year 1915-1916. The total production of refined copper was 5,856,889 pounds, produced at a total cost per pound of 11.54 cents. Only \$4,740.49 was expended for construction.

Openings tributary to No. 3 shaft in general showed fair mineralization.

No. 4 shaft was sunk to 185 feet below the 41st level. On account of the flattening of the dip of the lode, the lower part of the shaft is in the foot-wall. The lode where exposed in sinking is well mineralized. Sinking, of which about 34 feet is still necessary, is in progress for the purpose of establishing the 43d level which will form the bottom of the mine. New openings made during the year showed excellent mineralization, and ground equally rich is expected on the 41st, 42d and 43d levels, each of

which may be extended to a length of 800 feet from north to south boundaries.

In addition to the regular mining, considerable work was done in cutting out the lode along the foot in old and recent stopes throughout the mine. These operations supplied 38 per cent of the total ore hoisted.

The ore mined during the year carried much more epidote than usual, and in order to prevent copper losses, it was not entirely eliminated in the milling, thus reducing the percentage of copper in the resulting concentrates sent to the smelter.

Wyandot Copper Company

Owing to the scarcity of experienced labor, high wages and excessive cost of materials and supplies, and also by reason of the fact that so many of the stockholders neglected to pay the last assessment, it was deemed inadvisable to continue the development work at this time, and accordingly all operations were suspended, and the mine has been closed until more favorable conditions shall prevail.

All work during the year ending March 31, 1918, was confined to the further development of No. 8 lode on the 10th level. Drift 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 about 250 feet. A stope was finally started 30 feet west of the winze and 200 feet in length.

A stamp-mill test was made on 654 tons from the stope, the ore being selected. The milling was done at the Winona mill under the direct supervision of James W. Shields, former superintendent of the Quincy mills. The results showed a yield of 21.6 pounds of refined copper per ton of ore stamped. The results were so surprisingly good that another shipment was made direct from the openings and unselected. The results on 667.95 tons gave a refined copper yield of 8.25 pounds. This was very encouraging, considering that no selection was made, and it indicated that with proper selection and a large tonnage the lode has commercial possibilities.

Superintendent F. L. VanOrden, concerning the future development of the property, states as follows:

"We have an encouraging condition, but as to whether a commercial vein can be developed on this lode remains yet to be proven. Long laterals should be extended both northeast and southwest of the winze with the idea of proving the lateral extent of the mineralization of this lode. It is unfortunate indeed that our property is for the most part covered with a heavy overburden, which makes it very costly to attempt to make another opening on the strike or course of the lode. In other words, the lateral extension of this vein must be proven by one of three methods: first, by lateral development by means of drifts; second, by employing a diamond drill and drilling holes at intervals along the course of the vein (this method, however, cannot prove very much as to the mineralization of the vein itself, but will give valuable information as to the continuity of the lode); thirdly, by

opening along the course of the lode by means of shafts where the overburden will permit. The last method would be very costly, as in places we know the overburden to be 100 feet deep.

"* * * * I again wish to call your attention to the unexplored area lying between Winona lode shaft and the northern boundary of our property. This area has long been unexplored, not only on our property, but from Portage Lake to Ontonagon County. I have always been a firm believer in the west third of the South Range, perhaps on account of the fact that no commercial mines have been opened in Houghton County southwest of the Champion Mine, although the east third of the Range has been very thoroughly explored. The Winona Copper Company, so far as I know, is the only company that has done any systematic drilling west of the Winona lode. As I recall, they had quite encouraging results but have never had an opportunity to follow up the several encouraging lodes disclosed as the result of their thorough drilling operations."

*For details of production, costs, dividends, assessments, assets and liabilities see statistical tables.

PART II. NON-METALLIC MINERALS

R. A. SMITH

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 1913 was only 1,138,699 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 is much improved but labor shortage will be an important factor in limiting production.

To meet the unprecedented demands, some new mines were opened and some old ones reopened. The Robert Gage No. 8, the Sun, the Superior, and the B. & K. are the most important. Two small mines have been reopened at Grand Ledge. There are large proven reserves of coal in Bay, Saginaw, Tuscola, and Genesee counties, which, if machinery and labor were available for development, would greatly relieve the present scarcity of coal in Michigan. At present, there is not sufficient labor to maintain the operating mines up to maximum capacity, much less to open and operate new mines.

*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, 1869-1917, IN SHORT TONS

Year.	Quantity, Tons.	Year.	Quantity, Tons.	Year.	Quantity, Tons.	Year.	Quantity, Tons.	Year.	Quantity, Tons.
1869.....	2,320	1871.....	32,000	1882.....	135,339	1903.....	45,979	1904.....	1,342,840
1861.....	5,000	1872.....	33,000	1883.....	71,290	1904.....	112,322	1905.....	1,479,211
1862.....	3,000	1873.....	58,000	1884.....	30,712	1905.....	112,322	1906.....	1,340,338
1863.....	8,000	1874.....	58,000	1885.....	45,178	1906.....	92,802	1907.....	2,035,858
1864.....	12,000	1875.....	62,000	1886.....	40,484	1907.....	223,592	1908.....	1,825,019
1865.....	15,000	1876.....	69,000	1887.....	71,461	1908.....	215,720	1909.....	1,731,072
1866.....	20,000	1877.....	69,137	1888.....	62,407	1909.....	185,438	1910.....	1,554,090
1867.....	25,000	1878.....	80,422	1889.....	64,577	1910.....	1,241,241	1911.....	1,104,178
1868.....	28,000	1879.....	109,833	1890.....	109,833	1911.....	964,718	1912.....	238,080
1869.....	28,150	1880.....	112,000	1891.....	77,909	1912.....	1,367,619	1913.....	1,138,699
1870.....								1914.....	1,180,360
								1915.....	1,374,805

PRODUCTION, COST OF MINING, PROFITS, AND VALUE OF COAL IN MICHIGAN, 1900-1917

Year.	*Number active mines.	Average mine output per month.	*Average daily wage.	Total tons of coal mined.	Total cost of coal mined.	Average cost per ton.	**Value of coal mined.	*Total value of coal mined.	*Average profit per ton.
1900.....	31	1,670	\$2.34	871,348	\$1,209,228	\$1.387	849,475	\$1,259,083	\$1.483
1901.....	30	1,847	2.44	1,015,990	1,442,415	1.419	1,241,241	1,733,064	1.412
1902.....	32	1,616	2.35	809,967	1,284,342	1.427	964,718	1,653,192	1.714
1903.....	34	5,014	2.41	1,001,884	2,529,027	1.579	1,367,619	2,707,527	1.959
1904.....	33	2,733	2.33	1,408,375	2,266,098	1.609	1,942,840	2,424,055	1.806
1905.....	38	2,278	2.46	1,419,907	2,244,488	1.586	1,479,211	2,313,697	1.705
1906.....	39	2,170	2.40	1,307,385	2,090,489	1.529	1,340,338	2,427,404	1.903
1907.....	39	2,907	2.34	1,011,291	2,102,437	1.625	1,032,856	3,300,825	2.798
1908.....	38	3,115	3.02	1,842,778	3,083,709	1.677	1,824,019	3,322,904	1.811
1909.....	38	2,907	2.39	1,736,578	2,903,168	1.560	1,794,090	3,199,151	1.739
1910.....	34	2,471	3.07	1,462,270	2,626,842	1.796	1,534,967	3,330,771	1.900
1911.....	32	2,339	3.39	1,389,583	2,625,244	1.887	1,476,074	2,791,461	1.901
1912.....	30	1,586	2.19	1,160,708	1,776,076	1.530	1,104,178	2,099,455	1.891
1913.....	24	1,076	2.40	1,138,163	2,250,550	1.977	1,231,796	2,455,227	1.993
1914.....	20	2,146	3.35	1,133,460	2,280,281	1.99	1,282,030	2,529,790	1.99
1915.....	20	1,842	3.43	1,060,708	1,920,360	1.77	1,156,138	2,072,797	2.05
1916.....	18	1,794	3.37	1,070,315	2,040,812	1.90	1,379,360	2,309,786	2.05
1917.....	22	1,938	3.37	1,393,180	2,149,148	1.53	1,479,211	2,646,905	2.05

*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 steam and heat.
‡Not including depreciation, interest on capital invested, etc.

PRODUCTION, COSTS, ETC., OF COAL MINED IN MICHIGAN IN 1917

No. men employed.	Average hours worked per day.	Average days worked per month.	Average daily wage.	Total paid in wages.	No. mines using power.	Kept powder used.	Picked coal mined, Tons.	Coal mined by machine, Tons.	Total cost.	Average cost per ton.
December.....	7.7	24.2	\$3.85	\$177,062.50	13	1,520	14,096	119,183	\$248,788.02	\$1.87
January.....	7.9	25.6	3.81	175,968.00	14	1,068	14,438	123,284	260,884.20	1.88
February.....	7.9	20.9	3.81	159,481.34	14	1,418	15,186	96,639	219,324.08	1.93
March.....	7.8	23.4	4.01	165,409.87	13	943	19,473	109,749	224,172.96	1.92
April.....	7.8	19.4	4.27	153,900.21	14	1,182	14,564	86,560	216,610.61	1.92
May.....	7.8	23.1	4.39	176,750.19	13	1,294	15,642	99,441	230,626.84	1.94
June.....	7.9	20.4	4.25	162,260.74	12	1,127	10,802	81,432	208,378.99	1.85
July.....	7.8	22.5	4.30	174,002.75	14	1,296	15,054	91,220	215,004.96	1.93
August.....	7.8	20.9	4.24	164,337.07	15	1,367	15,915	95,762	201,594.08	1.84
September.....	7.8	20.9	4.26	162,302.25	14	1,298	15,078	91,301	208,220.96	1.86
October.....	7.8	20.9	4.01	222,287.96	21	1,727	20,566	99,881	327,487.74	2.72
November.....	7.7	22.8	4.37	230,090.00	20	1,825	17,360	102,522	374,249.02	3.10
Aggregate.....				\$2,232,550.34		17,360	193,156	1,200,124	\$3,148,148.26	\$2.27
Average.....	1918	7.8	22.6	4.25		1,447	15,347	100,011		

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 per cent of sulphur and 47 per cent 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 per cent of sulphur and 60 per cent 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 has 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 has gradually become more or less completely cut off. Under only the most urgent conditions have ships been spared for its importation. To meet the pressing shortage the Federal Government has sought to increase domestic production through the more extensive development of operating mines, the reopening of old ones and the discovery of new deposits.

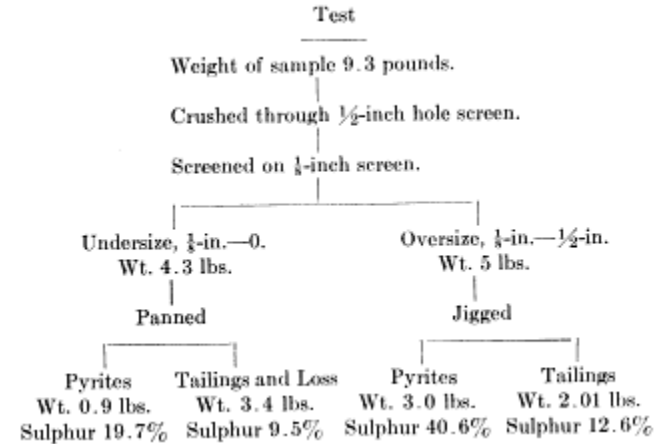
In the summer of 1918 Prof. E. A. Holbrook of the U. S. Bureau of Mines in cooperation with the State Geological Survey made an investigation of the coal brasses of Michigan coal fields. The investigation showed that pyrites occurs in sufficient abundance and in such form in some of the coals as to make 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 per cent 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 Percent.
Pure pyrite lumps. Washery of Consolidated Coal Co., 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
Shale refuse Separation not very satisfactory.	20.7

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 per cent 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 per cent of recoverable pyrite of commercial grade.

SALT

For the past eight years the production and value of salt in Michigan has showed an annual increase, increasing from 9,452,022 barrels valued at \$2,231,262 in 1910 to the maximum of 16,078,136 barrels valued at \$6,877,202 in 1917. The increase in 1917 over 1916 was 1,158,858 barrels in quantity and \$2,264,635 in value, or respectively 7.86 and 49.09 per cent. The great gain in value was due to the much higher average price which was \$0.421 per barrel as compared with \$0.309 per barrel in 1916.

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 led by a narrow margin. With the exception of 1910, Michigan has also held first rank in value since 1908.

From 1880 to 1890 Michigan produced annually from about 42 to over 49 per cent of the salt produced in the United States. Tin percentage declined from 43.69 per cent in 1890 to only 22.89 per cent in 1890. 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 producer nearly one-third of the total output and since 1880 Michigan has produced 27.3 per cent 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 per cent of the total output of the State was produced in this district.

The war has revived the industry through the great demand for bromide from abroad. Under present conditions salt is largely manufactured in Saginaw Valley as a by-product of the bromine industry. The total output of salt for 1917 in this district was only 482,450 barrels valued at \$373,812 as compared with 561,164 barrels valued at \$1,259,539 in 1916.

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. Nearly 97 per cent 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 1917 it was 10,477,922 barrels, or 65.2 per cent of the total for the State. The value was \$1,690,058 or only 24.6 per cent 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 1917 was only 2,206,171 barrels or 13.7 per cent of the State out put, yet the value was \$2,709,431 or 39.4 per cent 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 per cent 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 2,911,743 barrels of salt valued at \$2,103,901. This is equivalent to 18.2 per cent of the total quantity and 30.6 per cent of the value for the State. Most of the product is packer's salt, i. e., common fine and common coarse.

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

In Alpena and Presque Isle counties, the salt area although undoubtedly very large is of unknown extent.

Rock salt was struck at Onaway, Grand Lake, and Alpena in great quantities, and the greatest aggregate thickness of rock salt yet penetrated in Michigan or in Ontario, Canada, is at Onaway, Presque Isle County. A test hole drilled for oil at 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.

1,284 feet, and at Onaway, Presque Isle County, 1,630 feet.

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

PRODUCTION AND VALUE OF SALT IN MICHIGAN AND UNITED STATES, 1860-1917

Year.	U. S. Production, Quantity, bbls.	Michigan production.		Per Cent. of Total Michigan.	Rank Quantity.	Value Michigan.	Michigan.	
		State Salt Inspectors* Quantity bbls.	U. S. C. & S.† Quantity bbls.				Rank Value.	Price bbl.
1860		4,000						
1861		125,000						
1862		243,000						
1863		406,000						
1864		529,073						
1865		477,200						
1866		407,907				\$734,305		\$1.80
1867		474,721				840,255		1.77
1868		555,600				1,028,027		1.85
1869		561,288				786,835		1.58
1870		621,352				820,185		1.32
1871		728,175				1,063,135		1.46
1872		724,481				1,057,742		1.46
1873		821,346				1,127,984		1.37
1874		1,026,970				1,220,094		1.19
1875		1,081,856				1,190,042		1.10
1876		1,482,729				1,556,865		1.05
1877		1,660,097				1,411,847		0.85
1878		1,855,884				1,577,501		0.85
1879		2,058,040				2,099,200		1.02
1880	5,961,060	2,676,588	2,485,177	41.69	1	2,271,031		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	6,192,331	2,894,672	2,894,672	46.74	1	2,344,084		0.81
1884	6,514,937	3,161,806	3,161,806	48.53	1	2,392,648		0.757
1885	7,038,653	3,297,403	3,297,403	46.84	1	2,967,603		0.900
1886	7,707,081	3,667,257	3,667,257	47.58	1	2,426,980		0.661
1887	8,002,962	3,944,309	3,944,309	49.17	1	2,291,842		0.581
1888	8,055,881	3,866,228	3,866,228	47.99	1	2,261,743		0.585
1889	8,005,565	3,816,979	3,856,929	48.17	1	2,088,909		0.541
1890	8,776,991	3,838,637	3,838,632	43.72	1	2,302,579		0.600
1891	9,987,945	3,927,671	3,966,748	39.52	1	2,037,289		0.513
1892	11,098,890	3,812,504	3,829,478	32.81	1	2,046,963		0.523
1893	11,807,308	3,514,485	3,057,898	25.70	2	1,888,837		0.287
1894	12,968,417	3,138,941	3,341,425	26.53	2	1,243,619		0.375
1895	13,609,649	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	15,973,392	3,622,744	3,903,225	24.99	2	1,243,619		0.313
1898	17,612,634	4,171,916	5,263,564	29.88	2	1,628,081		0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2	2,205,924		0.369
1900	20,869,342	4,738,085	7,210,621	34.55	2	2,033,731	2	0.282
1901	20,560,061	5,580,101	7,729,641	37.58	1	2,437,677	1	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	2	1,535,823	2	0.188
1903	18,968,089	4,367,982	4,297,542	22.63	2	1,119,984	2	0.260
1904	22,030,062	5,390,812	5,425,904	24.62	2	1,579,206	2	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1	1,851,332	2	0.196
1906	28,172,380	5,644,359	9,936,892	36.31	1	2,018,700	2	0.203
1907	29,704,128	6,204,463	10,786,636	35.30	1	2,231,129	2	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	1	2,438,303	1	0.241
1909	30,107,646	6,055,061	9,966,744	33.10	1	2,732,556	1	0.274
1910	30,305,656	5,607,276	9,452,022	31.18	2	2,231,262	2	0.236
1911	31,183,968		10,320,074	33.10	2	2,633,155	1	0.255
1912	33,324,808		10,946,739	32.84	1	2,974,429	1	0.277
1913	34,393,227		11,538,800	33.52	1	3,293,032	1	0.285
1914	34,462,772		11,670,976	33.92	1	3,299,065	1	0.283
1915	38,231,496		12,588,788	32.93	1	4,304,731	1	0.342
1916	45,449,329		14,918,278	32.84	1	4,612,667	1	0.309
1917			16,078,136			6,817,202	1	0.421
Total.			252,802,014			105,692,263		

*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.

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, 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,

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY GRADES, 1906-1917

Year.	Table and dairy.		Packers.			
	Quantity.	Value.	Common fine.		Common coarse.	
			Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906	509,905	\$362,368	2,327,478	\$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	2,029,956	610,286
1909	585,370	732,007	3,530,308	1,125,005	2,103,719	647,878
1910	708,434	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	1,028,000	1,037,402	2,704,936	852,135	2,259,164	896,521
1914	1,002,344	1,025,164	2,668,989	911,010	2,380,378	870,715
1915	1,233,117	1,420,382	3,096,644	1,181,337	2,265,352	1,001,167
1916	1,305,950	1,461,085	3,109,857	1,221,901	2,133,600	1,064,709
1917	1,388,700	2,143,004	2,881,000	2,106,241	1,964,093	1,480,666

Year.	Packers.		Other, rock, etc.		Brine and other.*	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.		Barrels.		Barrels.	
1906	91,008	\$33,733			4,387,043	\$246,462
1907	119,459	48,455			4,604,552	235,729
1908	134,726	53,669			3,691,083	205,084
1909	98,367	3,985			3,648,395	185,051
1910	92,426	43,942			4,104,934	211,317
1911	105,461	45,421	576,595	\$181,865	4,387,772	219,244
1912	223,866	84,638	763,908	250,680	4,737,038	236,852
1913	50,557	25,371	727,304	244,172	4,756,779	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	506,850
1917	+	+	1,204,543	568,717	8,639,800	578,674

Year.	Total.	
	Quantity.	Value.
	Barrels.	
1906	9,936,802	\$2,018,760
1907	10,786,630	2,062,357
1908	10,194,279	2,458,203
1909	9,966,744	2,732,556
1910	9,452,022	2,231,262
1911	10,320,074	2,633,155
1912	10,946,730	2,974,429
1913	11,528,800	3,293,032
1914	11,670,976	3,299,065
1915	12,588,788	4,304,731
1916	14,918,278	4,612,667
1917	16,078,136	6,877,202

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

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES, 1917

County.	Table and dairy.		Packers.				Other, rock, etc.		Brine.	
	Tons.	Value.	Common fine.		Common coarse.		Tons.	Value.	Tons.	Value.
			Tons.	Value.	Tons.	Value.				
Bay	a	a	a	a	79,807	617,723	a	a	a	a
Benoni	a	a	a	a	a	a	a	a	a	a
Calhoun	a	a	a	a	a	a	a	a	a	a
Charlevoix	a	a	a	a	a	a	a	a	a	a
Chippewa	184,394	1,811,873	82,919	492,724	61,077	249,358	a	a	a	a
St. Clair	33,691	262,466	49,618	237,918	26,997	132,542	a	a	a	a
Wayne										
Total—Tons	194,418	\$2,143,004	403,340	\$2,106,241	274,973	\$1,480,666	109,636	\$68,717	1,209,572	\$578,674
Value	1,388,700		2,881,000		1,964,093		1,204,543		8,639,800	

PRODUCTION AND VALUE OF SALT IN MICHIGAN BY COUNTIES, 1917.—Continued.

County.	Total.		County.		Bromine.		Calcium chloride.	
	Tons.	Value.	Quantity, Percent.	Value, Percent.	Pounds.	Value.	Tons.	Value.
Bay	270,171	1,356,351	12.0	19.7	a	a	a	a
Benoni	149,969	605,835	6.7	11.7	a	a	a	a
Calhoun	35,019	315,947	2.4	4.6	a	a	a	a
Charlevoix	33,691	262,466	1.7	3.0	a	a	a	a
Chippewa	1,466,909	1,690,038	65.2	24.6				
Total—Tons	2,250,939	\$6,877,202	100.0	100.0	735,854	\$405,059	22,679	\$294,693
Value	16,078,136							

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. The War caused the price of bromine to advance to unprecedented figures, and revived the industry in the Saginaw Valley. In 1917 there were five producers.

Prior to the War the bromine of Michigan was marketed largely as bromides, but the increased demand has caused the marketing of a large amount in the crude state. Bromine is used in many chemical reactions, in the manufacture of disinfectants, in photography, and in drugs, and recently it has been used on a large scale in the manufacture of asphyxiating gases employed in the War.

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.

In 1917, the quantity of bromine marketed in Michigan amounted to 735,654 pounds or 82.2 per cent of the total for the United States. The Government ordered additional wells drilled in Michigan in 1918 and the State's output for this year doubtless will be much greater. The value of bromine marketed in 1917 was \$405,059 or \$.55 per pound. The average price was less than half that of the average for the country in 1916 which was \$1.34 per pound.

The output of calcium chloride in Michigan in 1917 was 22,679 tons valued at \$294,693 or \$12.99 per ton. For a number of years there were less than three producers but in 1917 there were four.

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 and wood ashes. In 1917 the production of potash reckoned as K_2O , amounted to 381 tons valued at \$275,215, of which 68 tons were from industrial wastes and 313 tons from wood ashes.

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. 1, p. 48, Clays and Shales of Michigan, Geol. Surv.

PRODUCTION OF CLAY IN MICHIGAN, 1910-1917.								
Year.	Slip clay.		Brick clay.		Miscellaneous clay.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1910.....	1,363	\$3,889	60	\$105	1	\$400	1,424	\$4,394
1911.....	1,744	5,090	18	32	150		1,912	5,272
1912.....	2,034	6,164			9		2,043	6,173
1913.....	1,710	6,504					1,710	6,504
1914.....	1,463	4,572					1,463	4,572
1915.....	1,198	3,805					1,198	3,805
1916.....		10,509						10,509
1917.....	2,153	8,824					2,153	8,824
Total.....								\$37,340

*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 per cent or more of lime. They also contain sand, pebbles, and boulders, hence the name boulder clay. Due to their sandy or calcareous nature, most of the clays are adapted for making only common brick and tile or low grade pottery. The high lime content causes most of the clays to burn white or cream colored. In some places, leaching has removed the lime to the depth of a few feet and clay from this surface portion burns red. Recent investigations indicate that the occurrence of low lime surface clays is more common than formerly supposed.

Exposures of clay or shale beds suitable for the manufacture of fire, vitrified, and front brick, vitrified tile, fire-proofing, 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 1917 the value of brick and tile products was \$2,846,264 exclusive of pottery, or \$141,210 more than in 1916. This was an increase of 5.2 per cent as compared with 20.3 per cent in 1916. The quantity of common brick, however, was only 236,612,000 or 42,563,000 brick less than 1916. This represents a decrease of 15.2 per cent in quantity. The average price of common brick in 1917 was \$7.95 per thousand as compared with \$6.65 per thousand in 1916. This was an advance in price of nearly 20 per cent. The value of drain tile increased from \$548,795 in 1916 to \$734,042, a gain of about 33.7 per cent. The gain was chiefly through the increase in price rather than in quantity. Lack of coal curtailed the output which was much less than the demand.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1917												
Year	Common brick.		Average price per M.	Front brick.		Average price per M.	Vitrified brick.		Average price per M.	Fire brick.		Average price per M.
	Quantity.	Value.		Quantity.	Value.		Quantity.	Value.		Quantity.	Value.	
1899	200,144,000	\$33,170	\$4.66	4,299,000	\$58,920	\$13.72	*	*	*	*	*	*
1900	190,882,000	965,200	4.77	8,421,000	48,411	5.75	*	*	*	112.42		
1901	215,836,000	1,093,294	5.07	9,476,000	44,031	4.76	*	*	*	12.90		
1902	227,254,000	1,331,732	5.81	5,884,000	42,792	7.34	*	*	*	17.29		
1903	215,791,000	1,251,573	5.80	2,225,000	19,000	8.54	*	*	*	13.27		\$13.00
1904	205,190,000	1,110,714	5.43	1,980,000	17,902	9.00	6,112,000	81,700	13.37	19.37		
1905	211,556,000	1,152,505	5.45	2,359,000	22,116	9.42	6,229,000	81,814	13.13	19.05		
1906	206,263,000	1,175,202	5.70	1,474,000	14,102	9.61	7,011,000	94,601	13.06	12.96		
1907	200,811,000	1,115,207	5.55	1,896,000	19,496	10.28	6,165,000	76,639	12.43	12.82		\$12.00
1908	191,089,000	994,525	49.9	2,379,000	18,654	7.84	10,473,000	129,283	12.34			
1909	211,836,000	1,253,771	5.92	2,379,000	18,654	7.84	9,080,000	116,446	12.82			
1910	232,551,000	1,363,316	5.87	2,408,000	31,372	12.46	6,597,000	78,339	12.54	*	*	18.08
1911	271,189,000	1,592,283	5.87	3,034,000	41,476	10.19	6,600,000	92,000	13.94	*	*	17.41
1912	271,189,000	1,592,283	5.87	3,034,000	41,476	10.19	6,600,000	92,000	13.94	*	*	17.41
1913	277,809,000	1,626,287	5.94	3,063,000	39,641	11.76	8,571,000	126,002	14.63	*	*	19.01
1914	277,809,000	1,626,287	5.94	1,488,000	21,121	14.15	*	*	*	*	*	19.78
1915	277,809,000	1,626,287	5.94	*	*	11.28	5,539,000	80,917	14.50	*	*	19.78
1916	279,175,000	1,806,487	6.47	*	*	18.02	*	*	*	*	*	19.78
1917	236,612,000	1,862,042	7.86	*	*		*	*	*	*	*	
Totals	4,367,056,000	\$25,065,069										

*Consolidated; less than three producers.

ANNUAL PRODUCTION OF BRICK AND TILE PRODUCTS IN MICHIGAN, 1899-1917.—Continued											
Year.	Stove linings.	Drain tile.	Sewer pipe.	Fire-proofing.	Tile (not drain).	Miscellaneous.	Hollow building tile or blocks.	Per cent of total products in U. S.	Rank of state.	No. of firms operating.	Total Value.
	Value.	Value.	Value.	Value.	Value.	Value.	Value.				
1899.....		\$140,171	\$50,300	\$5,000		\$22,700		1.08	13	196	\$1,244,256
1900.....		114,747	57,916	2,350		409		1.00	17	199	1,147,378
1901.....		95,072	*	1,880		778		0.76	18	200	1,075,969
1902.....		129,628	*	3,290				1.69	13	182	1,000,542
1903.....		205,445	*	*			\$19,138	1.58	14	174	1,002,214
1904.....		244,018	*	*			8,080	1.58	14	168	1,029,592
1905.....		283,808	*	*			2,585	1.41	16	154	1,219,146
1906.....		283,808	*	*			4,290	1.38	16	142	1,798,267
1907.....		277,630	*	*		1,500	6,866	1.39	17	130	1,796,190
1908.....		364,000	*	4,100		60,128	1,444	1.44	16	132	1,699,281
1909.....		327,030	*	*				1.44	16	122	1,917,059
1910.....	\$5,971	313,072	*	*		228,630	*	1.53	15	118	2,083,225
1911.....		387,043	*	1,461		292,459	*	1.53	15	111	2,053,412
1912.....		415,644	*	*		309,000	*	1.73	13	101	2,350,690
1913.....		421,941	*	3,752		334,299	*	1.73	13	95	2,431,132
1914.....		505,156	*	10,830		49,755	*	1.79	11	90	2,434,572
1915.....		549,795	*	2,492		70,996	*	1.71	13	82	2,248,068
1916.....		734,042	*	*			4,621	1.71	13	73	2,105,054
1917.....											2,846,264
Totals.....		\$3,763,387									\$36,878,867

*Included under miscellaneous; less than three producers.

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. Another was projected at Williamston, Ingham County, but this probably will not be built until after the close of the War. Most of the front brick used in Michigan are imported from Ohio and bordering States.

POTTERY

The pottery industry in Michigan has made almost uninterrupted growth since 1899 and since 1908 the growth has been rapid, particularly in the last three years. In 1899, the total value of the4 pottery output was \$29,741; in 1908, \$62,409; in 1910, \$112,697; in 1916, \$792,716, and in 1917, \$1,187,981. The value in 1916 increased \$270,727, or 51.8 per cent, and in 1917, \$395,265 or 50 per cent. The increases were largely due to the greatly increased output of porcelain and decorated ware and porcelain sanitary and electrical supplies.

The products are chiefly porcelain electrical supplies, decorated and white ware, and flower pots. Of eight firms, three, the Detroit Flower Pot Company, and Anton Hupprich, of Detroit, and the Ionia Pottery Company manufacture flower pots exclusively. The Jeffery-DeWitt Co. of Detroit, manufacture a variety of porcelain products,—sanitary ware, insulators, spark plugs, tumbling jars, crucibles, etc. The Mt. Clemens Pottery Company, Macomb County, manufactures decorated ware and the Pontiac Clay Pipe Novelty Co., Oakland County, clay pipes and novelty ware.

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

VALUE OF POTTERY PRODUCTS IN MICHIGAN, 1899-1917.										
Year.	Rank of state.	No. firms.	Red earthen-ware value.	Porcelain electrical supplies value.	C. C. ware value.	Miscellaneous value.	Total value.	Gain per cent.	Per cent. of total product in U. S.	
1899	18	4	\$29,741		\$100		\$30,741			
1900	17	4	34,217				34,217			
1901	16	3	42,465				42,465	15.4		
1902	14	4	44,098				44,098	30.2		
1903	19	4	42,507				42,507	87.4		
1904	17	4	46,000				46,000	42.87		
1905	17	5	40,821				40,821	-9.1		
1906	17	6	43,510				43,510	4.5		
1907	16	6	54,474				54,474	11.2		
1908	16	6	54,409				54,409	13.2		
1909	13	6	60,436				60,436	1.5		
1910	13	6	84,450				84,450	42.9		
1911	12	6	80,580				80,580	18.1		
1912	12	6	99,545				99,545	23.8		
1913	10	5	65,000				65,000	49.8		
1914	10	5	100,432				100,432	20.8		
1915	8	5	112,863				112,863	33.0		
1916	8	7	103,714				103,714	31.7		
1917	7	8						49.9		
Totals							\$3,021,234			

*Included in the total. Included under miscellaneous.

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

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

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

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

"PRODUCTION AND VALUE OF SANDSTONE IN MICHIGAN, 1899-1917.

Year.	Rough building Value.	Dressed building Value.	Curbing Value.	Flagging Value.	Rubble Value.	Ritersp. Value.	Crushed stone.		Other Value.	Total Value.
							Road making Value.	Concrete Value.		
1899...	\$102,447	\$51,082	\$109	a					\$29,800	\$178,038
1900...	73,809	39,809			\$26,519	b			19,000	152,030
1901...	126,069				27,108					174,428
1902...	130,299	23,600			15,854	\$900				169,753
1903...	80,931	19,363			10,827		\$2,050	\$4,450		121,560
1904...	47,093	14,819			10,332		1,400	400	12,740	76,383
1905...	64,056	36,035			9,403	270				101,764
1906...	35,272	18,018			5,100	96				53,485
1907...	33,561	19,018		\$528	5,100					58,103
1908...	15,100	18,415			6,394					39,909
1909...	12,085	16,405			2,565				285	31,243
1910...	13,312	15,445			8,006	1,140				37,903
1911...	5,082	2,809				c				10,438
1912...						3,127				19,224
1913...	d	d			d					d
1914...	d	d			d					d
1915...	d	d			d					d
1916...	d	d			d					d
1917...	d	d			d					d

a Included under curbing.
b Included under rubble.
c Included in total.
d Figures not given—less than three operators.
*Exclusive of sandstone made into grindstones and scythestones.

GRINDSTONES AND SCYTHESTONES

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

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 ones a foot in diameter to those seven feet in diameter having a 14-inch face. 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.

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 1917, the reported production of sand and gravel in Michigan was 3,814,445 tons or 593,030 tons less than in 1916. The value of the product however was \$1,841,748 or \$546,031 more than in 1916. Most of the loss in tonnage was due to the great decrease in building sand produced which was only 782,305 tons in 1917 as against 1,234,280 tons in 1916. The amount of gravel produced for road making was 2,292,374 tons in 1917 or only 65,496 tons more than in the previous year.

Most of the producers report that lack of cars and labor was the chief cause of the decrease in production, though the curtailing of building operations through war conditions was an important factor.

PRODUCTION AND VALUE OF SAND AND GRAVEL IN MICHIGAN, 1904-1917

Year.	Glass sand.		Molding sand.		Building sand.		Fire sand.		Engine sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.		Tons.	
1904			167,147	\$76,299	69,454	\$30,856				
1905			19,342	15,247	263,113	148,965	5,000	\$2,500		
1906	990	\$5,000	61,287	20,108	403,199	127,937			4,000	\$400
1907	4,390	8,000	54,172	24,190	451,646	157,150	4,000	3,000	1,534	153
1908	17,090	34,000	4,584	2,892	474,218	228,398			1,691	319
1909	65,000	79,000	33,224	20,756	1,090,419	327,247	4,900	2,900	12,415	1,493
1910	16,212	25,675	63,812	24,094	1,151,588	334,316	5,000	3,000	12,270	2,172
1911	*	*	68,878	17,901	885,729	247,907	*	*	18,302	4,447
1912	*	*	152,433	40,143	902,551	294,115			18,575	4,774
1913	*	*	50,763	17,493	1,339,016	415,737	4,545	4,545	4,447	647
1914	26,025	32,500	53,409	16,583	1,088,659	360,152			4,357	1,099
1915	*	*	82,666	28,908	845,897	236,384	4,601	5,751	70,057	2,794
1916	*	*	112,200	31,978	1,234,280	350,138	*	*	4,606	1,103
1917	*	*	147,255	52,680	782,305	433,546				
Totals			1,128,307	410,281	10,915,484	3,702,469			171,154	19,398

Year.	Furnace sand.		Paving sand.		Other sand.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.	
1904					50,187	\$14,478
1905					51,098	12,149
1906	5,600	\$2,500			173,724	12,187
1907	3,836	3,131			29,187	6,850
1908	3,329	3,828			256,412	56,053
1909	3,183	3,699			372,886	37,285
1910	3,185	4,924			114,901	52,035
1911			152,144	\$29,650	130,624	54,748
1912			68,453	16,596	113,318	30,242
1913	†	†	533,261	108,328	115,291	107,292
1914	†	†	320,422	74,806	111,106	12,248
1915	*	*	131,496	14,021	228,000	103,722
1916	*	*	154,413	38,668	94,227	41,207
1917			130,214	49,649		
Totals			1,466,273	337,500		

Year.	Railroad ballast.		Gravel.		Total.		Rank.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.		Tons.		Tons.		Tons.	
1904					234,863	\$107,197		
1905			74,625	\$32,321	414,506	210,609	10	11
1906			72,596	35,614	597,788	197,699	12	13
1907			229,407	81,182	1,024,641	299,595	19	11
1908			312,262	94,081	942,591	379,365	8	9
1909			695,962	100,523	2,219,757	685,622	8	8
1910			1,197,791	364,841	2,892,738	816,337	7	8
1911			935,672	265,218	2,185,245	568,969	9	10
1912			1,402,140	407,925	2,681,821	818,003	9	8
1913			2,629,874	915,205	6,422,818	1,328,892	4	5
1914	7,565	\$781	2,140,359	530,838	3,757,979	1,143,771	8	7
1915			2,457,094	671,970	3,776,728	1,036,729		
1916			2,226,878	728,053	4,407,475	1,293,717		
1917	267,837	21,829	2,592,374	1,011,182	3,814,485	1,641,748		
Totals			18,074,416	\$5,369,433	35,345,257	\$10,798,873		

*Included under other sand.

†Included under fire sand.

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

Glass sand pits known as "Toll Pits" were opened many years ago near Steiner, Monroe County. These properties later were taken over by the National Silica Co. which operated them up to 1916 when its plant was burned down. The property was then sold to the Ford Plate Glass Co. of Toledo, Ohio. 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 waters. However, most of the sandstone is very free from iron and the washed product from some horizons contains only about .001 of one per cent of iron. In the quarry of the Rockwood Silica Company near Rockwood, there are numerous masses of celestite, or strontium sulphate, and native sulphur, produced by the reduction of the celestite. The masses of celestite are most numerous near the horizon of the dolomitic sandstone. Washing removes practically all of the small amount of dolomitic cement in the incoherent sandstone and also removes most of the cement from the dolomitic portions. The

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

sand as marketed is stated to contain over 99 per cent of silica.

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

ANALYSIS OF GLASS SAND

	Crude Per Cent	*Mashed Per Cent
Silica	96.50	99.70
Calcium carbonate	1.50	0.08
Magnesium carbonate	1.04	0.22
Iron oxide	0.00	--
Surphuric 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. The washed sludge containing the fine grit is used for the ignition surfaces on match boxes.

There is but one producer of glass sand, hence figures of 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. This plant probably will be producing toward the close of 1918.

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

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. In 1916 twelve plants produced 72,004,000 brick of all grades, valued at \$499,711. This is the maximum in the history of the industry. In 1917, owing to general war time conditions as well as to the scarcity of coal, the production of sand-lime brick decreased to 47,998,000 brick of all classes valued at \$370,723. The average price of brick in 1917 was \$7.72 per thousand as compared with \$6.94 per thousand in 1916.

The improved trade conditions of 1916 did not continue during all of 1917. This was due in part to war-caused inactivity in the building trades but principally to the freight car shortage during the latter half of the year. During the early half of the year a few of the eleven producers reported business as normal or, in one instance, booming, but when in August of 1917 the car shortage became acute, business fell off rapidly and at least two plants were closed. Thus the production for 1917 was but 466,000 more than that for 1915, and but 66f per cent of that of 1916.

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.

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 1917 eleven plants were in operation in Michigan. Two plants are located in Detroit, and one each in Flint, Grand Rapids, Kalamazoo, Ripley (Houghton County), Rives Junction (Jackson County), Rochester, Saginaw, Sebawaing (Huron County), and Sibley (Wayne County). The plant at Menominee has been dismantled.

ANNUAL PRODUCTION AND VALUE OF SAND-LIME BRICK IN MICHIGAN AND UNITED STATES, 1904-1917.

Year.	No. of plants in operation.	No. of kilns in operation.	Michigan production.										Total value Michigan.	Change per cent Michigan.	Total value United States.	Per cent of total production U. S.	Pro- duction.	Value.
			Common brick.		Front brick.		Average price per thousand.		Fancy brick.		Total value Michigan.							
			Quantity (thous- ands).	Value.	Quantity (thous- ands).	Value.	Quantity (thous- ands).	Value.	Quantity (thous- ands).	Value.	Quantity (thous- ands).	Value.						
1904	10	57	9,886	\$61,034	\$6.64	580	\$5.234	\$9.02	19	\$197	\$69,765	142.7	\$403,128	15.6	1	1	1	
1905	12	84	24,841	155,883	6.28	1,577	12,800	9.70	24	526	169,302	14.3	1,179,065	15.4	1	1	1	
1906	11	87	27,281	162,879	5.97	1,786	12,027	6.90	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1907	13	94	25,488	158,606	6.22	2,000	12,800	6.40	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1908	10	87	21,917	131,827	6.00	1,900	11,284	5.90	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1909	11	74	34,237	207,082	6.05	1,600	11,244	6.97	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1910	10	76	37,648	218,627	5.81	3,256	12,027	6.71	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1911	10	66	32,880	192,234	5.84	2,726	17,777	6.52	12	11	210,001	-12.7	808,825	23.4	1	1	1	
1912	11	71	48,129	307,106	6.38	1,464	9,626	8.27	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1913	12	86	40,453	251,809	6.24	3,726	17,777	4.70	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1914	12	86	40,453	251,809	6.24	3,726	17,777	4.70	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1915	11	56	46,413	281,009	6.04	888	7,845	8.83	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1916	12	53	71,116	491,866	6.92	888	7,845	8.83	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
1917	11	46	66,979	362,246	7.71	1,019	8,477	8.31	10	7	174,521	3.3	1,179,065	15.4	1	1	1	
Total	.....	.....	517,813	297,384	\$6.30	.....	.....	.....	.....	.....	\$3,445,656	.....	.....	.....	.....	.....	.....	

*—Estimated. —Included in total.

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 per cent.

The great increases in the annual value of the output for the past three years are due not only to greater production but also to constantly increasing prices for the various products. The chief increases in 1917 were in stone for blast furnace flux, for the manufacture of soda ash and allied products, and for concrete. The output of flux stone in 1917 was 3,757,178 tons valued at \$1,633,965 as compared with 3,033,155 tons valued at \$1,207,326 in 1916. This was a gain of 542,023 tons and \$426,639, or 17.88 per cent in quantity and 35.34 per cent in value. The value of stone sold to alkali plants increased from \$438,783 in 1916 to \$787,760 in 1917, a gain of 79.5 per cent. Crushed stone for concrete increased in 1916 from 323,479 tons valued at \$155,084 to 418,403 tons in 1917, valued at \$244,648. This was a gain of 29.3 per cent in quantity and 57.8 per cent in value. Railroad ballast however decreased from 186,949 tons to 182,375 tons in 1917 and road making stone from 834,937 tons to 726,937 tons. The value of ballast stone increased from \$57,950 to \$90,560 in 1917 but the value of road making stone decreased from \$420,467 to \$344,970 in the same period.

The great increases in the output and value of flux and chemical limestone are due to the enormous demands of

the War upon the iron and steel and chemical industries, which consume large quantities of limestone.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1917

Year.	Rough building Value.	Dressed building Value.	Paving Value.	Curbing Value.	Flagging Value.	Rubble Value.	Riprap Value.	Crushed stone.	
								Road making.	
								Tons.	Value.

1899	\$30,399	*	\$62,815	.....	.....	.....	.....	\$1,111	709
1900	32,362	*	105,266	.....	\$380	\$5,098	.....	.....	.....
1901	47,743	*	.....	.....	.....	.....	.....	.....	.....
1902	58,707	*	.....	.....	\$490	49,430	.....	.....	.....
1903	36,519	*	49,000	.....	500	5,150	.....	.....	.....
1904	12,021	\$605	37,955	.....	.....	.....	.....	.....	.....
1905	12,021	.....	.....	160	.....	.....	.....	.....	.....
1906	15,100	.....	.....	.....	75	.....	.....	.....	.....
1907	15,100	100	56,500	.....	.....	.....	.....	.....	.....
1908	1,274	.....	10,825	.....	.....	.....	.....	.....	.....
1909	4,450	7,445	.....	.....	.....	.....	.....	.....	.....
1910	1,274	.....	35,500	.....	.....	.....	.....	.....	.....
1911	7,526	.....	.....	.....	.....	.....	.....	.....	.....
1912	6,597	.....	.....	.....	.....	.....	.....	.....	.....
1913	8,274	.....	.....	.....	.....	.....	.....	.....	.....
1914	3,587	.....	.....	.....	.....	.....	.....	.....	.....
1915	4,203	.....	.....	.....	.....	.....	.....	.....	.....
1916	5,688	.....	.....	.....	.....	.....	.....	.....	.....
1917	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	\$2,843,302

*Included in total for year.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1917.—Continued

Year.	Crushed stone.				For blast furnace flux.		To sugar factories.		To alkali works.	
	Railroad ballast.		Concrete.		Tons.	Value.	Value.	Value.	Value.	Value.
	Tons.	Value.	Tons.	Value.						

1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1904	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1905	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1906	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1907	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1908	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1909	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1910	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1911	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1912	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1913	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1914	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1915	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1916	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1917	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

*Included in total.

PRODUCTION AND VALUE OF LIMESTONE IN MICHIGAN, BY USES, 1899-1917.—Continued.

Year.	To carbonic acid plants.	To paper mills.	Fertilizer.		Other purposes.	To lime burners.	Rank of state.	Total.
	Value.	Value.	Tons.	Value.				
1899.				\$2,375.	\$337,657.			\$281,799.
1900.				124,230.	66,000.			520,547.
1901.				107,300.	250,173.	12.		1,279,172.
1902.				68,164.	98,600.	13.		413,148.
1903.				4,747.	132,600.	18.		609,478.
1904.				123,223.	180,883.	10.		201,708.
1905.				142,790.	9,580.	12.		214,774.
1906.					278,297.	10.		636,200.
1907.					269,865.	11.		740,333.
1908.				\$27,171.	11.			669,017.
1909.				31,000.	449,837.	12.		1,259,229.
1910.				3,447.	25,000.	11.		730,500.
1911.				10,000.	25,000.	8.		1,000,000.
1912.				78,425.	300,874.	8.		1,408,763.
1913.	\$58,138.	10,007.		11,104.	13,000.	10.		1,517,600.
1914.				9,740.	31,229.	7.		1,828,760.
1915.				11,088.	38,866.	7.		2,080,719.
1916.				24,097.	68,148.	9.		3,203,885.
Total.		\$84,282.		\$100,504.	\$2,666,585.			\$19,122,004.
*Included in total.								

*Included in total.

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 on the limestone resources of Michigan see Pub. 21, Geol. Ser. 17, Min. Res. of Mich. for 1915, pp. 103-312.

LIME

From 1904 to 1914, the lime industry made little or no growth, the production in these years being respectively 66,601 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 per cent greater than in 1914. The value increased from \$385,341 in 1916 to \$892,682 in 1917, an increase of \$507,341 or about 1.32 per cent. The great increase in value was due not only to increased production but also to the large advance in the average price which in 1917 was \$6.72 per barrel as compared with only \$4.45 in 1916.

PRODUCTION AND VALUE OF LIME IN MICHIGAN, 1904-1917

Year.	Total lime burned.		Average price per ton.	No. of plants operating.	Rank of state production.
	Quantity. Tons.	Value.			
1904.....	63,601	\$256,955	\$4 04	.....	.....
1905.....	48,089	192,844	4 01	.....	.....
1906.....	68,133	281,445	4 13	13	.....
1907.....	65,822	276,534	4 20	12	16
1908.....	68,050	282,023	4 14	10	15
1909.....	83,108	354,135	4 26	12	13
1910.....	72,345	303,377	4 19	10	14
1911.....	80,709	352,608	4 37	14	14
1912.....	74,720	311,448	4 17	11	16
1913.....	77,088	331,852	4 05	10	14
1914.....	66,507	287,648	4 33	10	14
1915.....	81,359	340,979	4 20	10	15
1916.....	86,447	385,341	4 45	7	13
1917.....	135,920	892,682	6 72	7	.....

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.

CEMENT*

Growth of Industry

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 present production in Michigan.

Prior to 1895, the kilns were of the vertical type but in that year rotary kilns, using powdered coal as a fuel, were successfully introduced. These inaugurated 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.

History

A vertical kiln plant was erected near Kalamazoo as early as 1878 for manufacturing cement from marl and clay. 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 Portland 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 are now in operation.

A new company, the Petoskey Portland Cement Co., has been organized at Petoskey but the plant probably will not be built before 1919.

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 new company, the Petoskey Portland Cement Co., intend 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.

The following table shows that Michigan produced 4,688,899 barrels of cement in 1917 as compared with 4,919,023 barrels in 1916. This was a decrease of 220,124 barrels. Shipments decreased from 5,151,818 barrels in 1916 to 4,313,771 barrels in 1917, a loss of 838,047 barrels. The decreases are due chiefly to war conditions, which resulted in a general curtailing of building operations. The value of the cement shipped, however, shows an increase, the total value in 1917 being \$6,122,887, or an increase of \$104,976. The average price in 1916 was \$1.103 per barrel, and in 1917 the average price was \$1.419, an increase of \$.251 per barrel.

*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, 1896-1917.															
Year	No. of plants in operation	Michigan Rank	No. of U. S. Plants	Daily capacity, Bbls.	Michigan, cc. Min. made	U. S. Cement made, Bbls.	Michigan per cent of U. S.	Michigan cement shipped, Bbls.	Michigan cement value	U. S. Cement value	Michigan per cent of U. S.	Michigan stock on hand Dec. 31	Michigan average price per barrel	U. S. average price per barrel	
1896	1	1	1	1	4,000	1,543,023	0.25	275,000	87,000	82,424,011	0.29	81,715	81.27	1.61	
1897	1	1	1	1	4,000	2,077,775	0.50	275,000	29,250	4,315,891	0.6	75	1.61	1.61	
1898	1	1	1	1	4,000	3,052,261	1.1	443,353	134,740	5,959,773	2.3	1747	1.62	1.62	
1899	1	1	1	1	4,000	3,652,266	1.6	346,500	313,849	8,074,373	6.36	492	1.43	1.43	
1900	1	1	1	1	4,000	664,730	0.8	65,000	830,090	2,290,125	8.6	25	1.09	1.09	
1901	10	10	10	10	1,025,718	12,711,225	8.0	54,100	1,128,290	12,532,360	9.0	10	0.99	0.99	
1902	10	10	10	10	1,577,000	17,230,448	9.1	55,200	2,134,290	20,864,478	10.2	2	358	1.21	1.21
1903	13	13	13	13	1,955,183	22,242,970	8.7	25,900	2,713,310	9,100,000	10.1	307	1.24	1.24	
1904	16	16	16	16	2,547,100	28,593,841	8.5	11,900	3,365,656	25,555,119	10.1	1	0.86	0.86	
1905	16	16	16	16	3,573,283	35,246,812	9.0	25,400	4,921,307	35,345,867	8.7	1	0.94	0.94	
1906	14	4	14	4	3,747,525	46,463,424	8.06	35.5	4,814,965	52,466,186	9.2	1	284	1.13	1.13
1907	14	4	14	4	3,572,668	49,785,060	7.3	-4.6	4,284,781	53,092,531	8.1	1	227	1.11	1.11
1908	15	2	15	2	3,892,276	51,072,812	5.6	-10.0	2,556,215	48,547,679	5.8	0	883	0.85	0.85
1909	12	8	12	8	3,132,731	64,991,431	4.9	11.6	2,019,550	52,836,164	4.9	0	815	0.813	0.813
1910	13	1	13	1	3,687,719	70,549,951	4.8	11.7	3,378,940	68,200,800	4.9	0	916	0.891	0.891
1911	11	8	11	8	3,686,716	78,528,607	4.69	-0.01	3,054,676	66,248,817	4.56	506	738	0.82	0.843
1912	11	8	11	8	3,494,521	82,439,090	4.28	-5.21	3,145,091	69,109,806	4.05	379	550	0.819	0.819
1913	11	7	11	7	3,494,521	82,439,090	4.28	-5.21	3,145,091	69,109,806	4.05	379	550	0.819	0.819
1914	11	7	11	7	3,494,521	82,439,090	4.28	-5.21	3,145,091	69,109,806	4.05	379	550	0.819	0.819
1915	11	6	11	6	4,019,023	91,521,108	5.37	-4.2	4,434,608	80,891,681	5.11	569	919	0.942	0.86
1916	11	6	11	6	4,688,899	92,844,202	5.03	-4.47	4,313,771	94,552,090	6.36	386	1168	1.103	1.354

*Minus sign indicates decrease.

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 three 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 after the War.

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.

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.

In 1916 the production increased 67,384 tons or about 17 per cent over that of 1915. This was due to the general activity and prosperity in industrial lines, particularly in the building trades. After the entry of the United States into 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 the year, the production falling from 457,375 tons to 375,803 tons, a loss of 81,572 or 17.8 per cent.

PRODUCTION OF GYPSUM IN MICHIGAN, 1868-1917.

Year.	Ground into land plaster. Tons.	Calcined into plaster. Tons.	Sold crude. Tons.	Total mined. Tons.	Gypsum and gypsum products. Total value.	Rank.	
						Quantity.	Value.
Before 1868	132,043	14,285		146,328	\$671,022		
1868	28,837	6,244		35,081	163,298		
1869	29,096	7,355		37,351	178,824		
1870	31,437	8,246		39,683	191,718		
1871	41,126	8,694		49,820	284,054		
1872	43,536	10,673		54,209	259,524		
1873	44,972	14,724		59,696	297,678		
1874	39,126	14,723		53,849	274,284		
1875	27,019	10,914		37,933	195,486		
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	288,872		
1882	37,821	24,136		61,957	344,374		
1883	40,082	28,410		68,492	377,567		
1884	27,898	27,950		55,847	333,382		
1885	28,184	25,281		53,465	286,802		
1886	20,373	27,370		47,743	208,014		
1887	28,794	30,376		59,170	321,392		
1888	22,177	35,125		57,302	347,531		
1889	19,823	36,800		56,623	353,809		
1890	12,714	47,163	15,000	74,877	192,049		
1891	15,100	53,600	11,000	97,700	223,725		
1892	14,458	77,599	47,500	139,557	306,527		
1893	16,263	77,327	31,000	124,590	303,921		
1894	11,982	47,976	20,000	79,958	189,620		
1895	9,003	51,028	6,488	66,519	174,067		
1896	6,582	60,352	700	67,634	146,424		
1897	7,193	71,680	16,001	94,874	193,576		
1898	13,345	77,852	1,984	93,181	204,310		
1899	17,196	88,315	39,206	144,716	283,537		
1900	10,304	86,972	33,328	129,654	285,119		
1901	9,808	120,256	46,086	185,150	267,243	2	2
1902	13,022	158,320	68,885	240,227	459,621	1	1
1903	18,409	198,110	52,565	269,084	709,912	1	1
1904	18,294	185,422	34,669	238,385	541,197	1	1
1905	20,285	203,313	24,281	247,882	634,434	1	2
1906	30,220	208,715	27,517	341,716	753,878	1	2
1907	15,500	197,666	30,543	317,261	681,351	3	3
1908	11,414	192,403	40,324	327,810	401,928	1	3
1909	11,800	344,171	45,781	394,907	1,213,347	2	1
1910	7,097	240,905	44,566	352,174	667,199	2	2
1911	15,548	206,299	79,050	347,296	523,926	3	3
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	9,739	245,484	69,572	389,791	686,369	3	4
1916	9,072	292,109	80,298	457,375	1,066,588	3	4
1917	7,090	257,688	68,155	375,803	1,568,655	3	3
Totals...	1,258,438	4,980,816	1,140,314	8,117,545	\$21,566,874		

On the other hand, due largely 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 per cent.

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 1917 was

only 7,090 tons as compared with the maximum of 44,972 tons in 1873.

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 1917, the value of land plaster was only \$22,903 as compared with \$1,452,002 for calcined products.

The most important of these products is mixed wall plaster; stucco is next in order of importance. In 1917 wall plaster was valued at \$949,511, or 60.5 per cent of the total value of raw and calcined products for the State. Stucco was valued at \$384,661 or 24.5 per cent of the total value. The value of these two products was 84.4 per cent of the total value for the State.

In 1917, 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 Ft. 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, 1911-1917										
Year.	Crude gypsum mined.		Gypsum sold crude.							
	To Portland cement mills.			As land plaster.		For other purposes.		Total sold crude.		
	Quantity.	Value.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	
1911.....	347,296	63,489	\$69,497	15,548	\$15,706	13	\$52	79,050	\$85,255	
1912.....	384,297	53,711	52,420	10,103	9,375	5	20	62,819	61,845	
1913.....	423,596	*	*	6,604	10,222	10,320	9,011	69,749	60,706	
1914.....	403,090	*	*	9,322	10,761	*	*	61,227	51,242	
1915.....	369,791	*	*	5,706	5,864	*	*	69,572	63,236	
1916.....	375,968	60,846	92,874	9,072	16,408	*	*	80,268	90,973	
1917.....				7,000	25,903	*	*	68,155	116,653	
*Included in total.										
PRODUCTION OF GYPSUM IN MICHIGAN, 1911-1917.—Continued										
Year.	As mixed wall plaster.		As plaster of Paris, etc.		As stucco.		As dental plaster.		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	\$381,262	47,989	\$88,168	82,010	\$168,734	20	\$110	11,370	\$19,031
1912.....	146,099	368,576	937	3,229	95,402	202,675	*	12	8,214	8,076
1913.....	166,711	437,720	*	*	85,780	175,172	*	*	*	*
1914.....	163,072	475,830	*	*	80,172	177,317	*	*	*	*
1915.....	155,961	436,832	*	*	87,465	279,597	*	*	*	*
1916.....	193,810	608,785	224	1,325	85,426	384,661	*	*	*	*
1917.....	147,371	649,511	*	*	*	*	*	*	*	*

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 1,069,164 gallons valued at \$105,641 in 1917. In 1916 the gain in production was .091 per cent in quantity but 50 per cent in value, the gain being due to the greater average price per gallon

which was 10.9 cents in 1916 as compared to 8 cents in 1915. The value for 1917 decreased to 9.8 cents per gallon.

PRODUCTION AND VALUE OF MINERAL WATERS IN MICHIGAN, 1900-1917								
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	1,195,014			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	2,684,809	277,188	\$38,900	\$238,288	0.100
1906.....	13	23	19	902,528	74,357			0.081
1907.....	8	15	19	1,472,679	127,133	35,691	92,442	0.086
1908.....	8	16	24	2,004,433	88,910	5,995	82,915	0.044
1909.....	5	16	19	2,760,604	194,454	6,099	98,355	0.035
1910.....	9	17	17	1,464,020	69,538	190	69,438	0.048
1911.....	11	24	23	1,713,401	72,253	12,156	60,097	0.042
1912.....	12	19	17	1,429,465	75,611	777	74,834	0.053
1913.....	17	24	20	884,893	52,642	3,605	49,037	0.059
1914.....	16	20	22	931,343	70,310	12,252	58,058	0.075
1915.....	16	18	19	913,765	72,111	5,165	67,546	0.080
1916.....	17	13	18	996,875	108,867			0.109
1917.....			11	1,069,164	105,641	500	105,141	0.098
Total.....				48,585,606	\$3,503,017	\$114,640	\$995,751	\$0.09

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 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 Onkama. 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 2,442,000 cubic feet in 1914, dwindling to 1,184,000 cubic feet in 1917, 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, 1911-1917.

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	900	\$450	800	\$400	1,730	\$1,330
1912	17	1,020	1,020	900	\$450	800	\$400	1,900	\$1,470
1913	17	1,020	1,020	900	\$450	800	\$400	1,805	\$1,405
1914	17	2,442	2,442	900	\$450	800	\$400	2,442	\$1,442
1915	16	960	960	900	\$450	1,100	\$550	2,060	\$1,510
1916	12	598	598	900	\$450	700	\$350	1,298	\$948
1917	10	613	613	900	\$450	571	\$285	1,184	\$593

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. A 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 1917, hence figures of production and value are omitted.

*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.

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 three years ago but lack of transportation facilities, labor shortage, etc., has hindered operations. A considerable amount of stone has been quarried and stocked pending the completion of a railroad spur to the quarry. This was expected to be finished about August 1, 1918.

Other projects have been started in the past three years to develop other deposits of marble in this region but nothing came of them.

In this locality, apparently, there are several undeveloped deposits of verde antique marble which are under favorable quarrying conditions, but war conditions doubtless will prevent their immediate development. After the War it is possible that 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 per cent of graphite is ground and used for paint. The production is intermittent, the quarries being operated only as the crude supply becomes depleted, enough being quarried in a year to supply the needs of the companies for several years.

There was but one operator in 1917.

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 was the only producer of mineral paints in 1917.

CELESTITE

Celestite or strontium sulphate (SiSO₄) occurs at several horizons in the Monroe formation in southeastern Michigan. Near Maybee, Monroe County, it occurs in the Lower Monroe in scattered crystals and masses associated with native sulphur and occurs similarly in the Sylvania sandstone at Rockwood, Wayne County. Near Gibraltar, Wayne County, it occurs in disseminated crystals in Upper Monroe dolomites. In the glass sand pit of the Rockwood Silica Co., the masses are numerous in places and some of them are large. The commercial recovery of the celestite has been but partially investigated. The masses are imbedded in a friable to incoherent sandstone and can be readily separated from it.

FELDSPAR

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

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

Silica (SiO ₂)	65.25	Magnesia (MgO)	0.23
Alumina (Al ₂ O ₃)	18.60	Sodium oxide (Na ₂ O)	1.99
Iron Oxide (Fe ₂ O ₃)	0.40	Potassium oxide (K ₂ O)	13.40
Lime (CaCO ₃)	0.38		

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 rock knob 20 to 25 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 1917.

TRAP ROCK

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

Most of the quarry product and considerable amounts of field-stone or "hardheads" are crushed for road material and concrete. In some years, a small amount has been sold for rip-rap. 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 1917.

PRODUCTION AND VALUE OF TRAP ROCK IN MICHIGAN, 1911-1917.								
Year.	No. of producers.	Crushed stone.				Riprap. Rubble Value.	Total Value.	Rank Value.
		Road making.		Concrete.				
		Quantity.	Value.	Quantity.	Value.			
		Tons.		Tons.				
1911.....	3			45,250	\$38,429		\$51,000	8
1912.....	5	21,805	\$18,366	11,355	9,340	\$8,500	36,206	8
1913.....	5	24,920	23,369		*		92,201	10
1914.....	5	25,690	24,863	4,448	4,771		34,406	12
1915.....	6	28,262	29,764	18,775	22,047	*	105,855	12
1916.....	8	38,193	37,475	9,601	9,715	*	83,072	
1917.....	4	50,420	64,098		*	*	70,197	
Total.....							\$472,637	

SLATE*

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

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

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



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