The richer parts of lodes bear no definite relation to the present surface, their origin being quite independent of this surface.

(In many cases it has been found that the richest parts of lodes are neither near the surface nor at the lowest openings yet made. In the two lodes that have been mined at greatest depth, the Calumet conglomerate and the Pewabic amygdaloid, very rich ore occurred at depths of 1,000 to 3,000 feet.)

The ore now being mined from some of the lodes at great depth is much leaner than that which was mined some years ago nearer the surface; but the change in grade with depth is quite similar to change in grade laterally and there is no good reason to believe that it is due to deposition from descending solutions rather than to solutions moving in any other direction.*

*For discussion of methods of prospecting and developing the copper deposits and mining, concentrating, smelting, and refining the ores see Mineral Resources of Michigan, 1911, Publication 8, Geological Series 6, Michigan Geological and Biological Survey.

THE COPPER INDUSTRY IN 1914.

WALTER E. HOPPER.

GENERAL REVIEW.

The year 1914 will long be remembered as a most trying one for both operators and employees. The unusual conditions of labor and market caused most serious concern, and necessitated the most careful consideration of operations by the managers.

During the first four months of the year production was low and costs were high, due to the strike conditions and to the inexperienced labor underground. During the last five months of the year production was again greatly curtailed, owing to the European war. With a few exceptions, the total costs for the year were generally lower than those of the year 1913. The production was higher than the previous year but lower than the years immediately preceding 1913. According to the U. S. Geological Survey, the production of copper in Michigan during 1914 was 158,009,748 pounds, as compared with 155,715,286 in 1913. The average price received for copper sold, however, was much lower than in previous years, and the profits were, therefore, generally reduced. Very few dividends were paid during the year.

At the beginning of the year the copper country was still in the midst of the general strike called by the Western Federation of Miners July 23, 1913. In spite of this fact, however, most of the larger producers were operating, but on a smaller scale, and with inefficient labor underground. On January 6 there were about 8,724 men employed underground, as compared with about 13,514 before the strike.

Sunday, April 12, 1914, marked the official end of the long strike, when a general vote taken throughout the district expressed the desire of the majority of the men to return to work. The conclusion of the strike was received with general rejoicing throughout the copper country. There was a rush of men to the mines seeking their old positions, forces were increased as soon as possible, and the old spirit of satisfaction and good times again prevailed among the men. It would be impossible to even estimate the cost of the strike to the men, the mining companies, the state, the county, the townships, the villages and the workmen of the country. It is safe to say, that the figure would be between five and ten million dollars.

Following the end of the strike, a spirit of confidence and optimism existed throughout the district, and all efforts were made to make the year 1914 a more successful one than 1913, when higher costs and

lower production prevailed. Production was gradually increased; many of the mines were producing normally by May and June, and a maximum production was reached in July. Several of the properties in the exploration stage resumed operations in May.

Scarcity of suitable labor was keenly felt by the mining companies during the year 1912, and it has been estimated that when the strike was called, the various mines were operating with about 1,500 men short of normal force. However, immediately following the official end of the strike, the labor situation was much improved by a continuous influx of skilled labor. The unsettled conditions and curtailment of forces in the iron mines of Michigan and Minnesota sent hundreds of excellent miners to the copper districts. The mining companies took advantage of this opportunity, with the result that in the latter part of May, the mines were employing the largest working forces in the history of the district. This large working force naturally meant a great increase in the production of the mines and a corresponding reduction of costs.

When the general strike was called in 1913, the number of men employed on surface and underground at the various mines totaled about 14,250. On July 23, 1914, one year later, the same mines had in their employ about 16,505 men, showing an increase of about 2,255. The number of men employed at smaller exploration properties and those mines not included in the above, brought the total up to about 17,205. This was the largest number of men ever employed in the copper country. Not only was the total payroll higher than at any time previously in the history of the district, but the average individual pay-check was larger than ever before. New records of production were made at several mines, and all the companies were striving to set a new record for the production of refined copper before the end of the year.

This happy state of optimism and apparent prosperity was interrupted early in August by the European war. At first it was thought by a few optimists that a great demand for American copper for war purposes would be created by a general war. It was soon realized, however, that a European war would prevent the exporting of American copper, and when they considered the fact that over 50 per cent of the American output is exported, the operators realized that the war would have a serious effect on the American copper industry.

The general curtailment of production in the western districts was followed in Michigan by the closing of the Winona mine August 6. That this action was necessitated was deeply regretted by the people of the copper country, in view of the fact that successful experiments had recently been completed with a new regrinding machine and a

leaching process was also under consideration. The Mass mine at about the same time reduced its working force. With no market for the copper produced, curtailment was an absolute necessity in the Michigan district. The following day the Hancock mine, operating on borrowed capital, suspended all operations. This property had just reached a point where it was paying expenses. The Tamarack mine suspended all work at its two operating shafts.

A number of properties in the exploration and development stage were forced to suspend operations. These forced shut-downs were most unfortunate because, in many cases, they came at a time when the properties had reached the most hopeful stage of development.

With a large amount of refined copper on hand and practically no market, the Baltic, Champion and Trimountain mines of the Copper Range Consolidated, on August 15 went on half time schedule. The mines reopened September 1, and operated day and night shifts until September 15, when they closed again until October 1. On September 1 wages were reduced from eight to ten per cent, and the salaries of all officials at the mines and eastern offices were cut 25 per cent.

Beginning September 1, all the mines, mills and smelters of the Calumet and Hecla Mining Company went on a three-quarter time schedule, and the rate of wages existing immediately prior to May 1, 1912, when an incerase of ten per cent was given the men, became effective. A reduction of 15 per cent in the pay of the officers and all those not affected by the increase of May 1, 1912, was made. A similar reduction was also made in the pay of all officers and employees of the eastern offices.

The Quincy Mining Company reduced the working force and put into effect a $12\frac{1}{2}$ per cent reduction of wages and salaries of all employees and officials of the company.

The Mohawk and the Wolverine were the only mines in the district which continued to operate full time during the latter part of the year. This was because the product of these mines is used almost entirely by domestic consumers.

In view of the unsettled conditions of the copper market in this country, and the interruption of the company's business with foreign customers, the directors of the Calumet and Hecla Mining Company decided not to declare the usual quarterly dividend September 1. The Calumet and Hecla began paying dividends in 1871, and during the long period of 43 years, only once had the company found it necessary to pass its dividend. In May, 1884, because of the low price of copper and the delays in the sale of the mine products, no dividend was paid. Since 1901 the C. & H. has paid quarterly dividends and two payments had already been made in 1914. The general feeling of the people

of the copper country was, that under the conditions of reduced wages and half time, the passing of the dividend was the only fair and proper thing to do.

With the closing of the stock exchanges in Boston and New York, the local brokerage offices in Houghton and Calumet were closed.

The first of September the American production was being curtailed about 45 per cent. Domestic buying was active and about half the normal amount of copper was being exported, in spite of the war conditions. The production of copper was about equal to the consumption. Exports to England were chiefly the filling of old contracts or shipments on consignment.

Difficulties encountered in shipping copper resulted in a decrease of exports. The interception of vessels for Italy and Scandanavia, and the seizures of copper cargoes by Great Britain the latter part of October resulted in very light shipments and a marked falling off in copper exports. The Copper Country Commercial Club sent a formal letter of protest against this action of Great Britain to Secretary Bryan at Washington. Copper producers and commercial clubs in all copper producing districts in the United States also sent similar letters of protest. The total amount of copper seized and detained by Great Britain was about 45,000,000 pounds.

The curtailment of production at the mines and the refineries, the decrease in domestic demand and the difficulty of exportation had a marked effect upon the copper market and the price of copper, which in turn, determines profit and loss in the Michigan district. The copper market opened in January at 14.55 cents. About the middle of February the price stood at 14.65 cents, the highest point of the year. The last of July the price dropped to about $12\frac{1}{2}$ cents and in August the market went to pieces. On November 1 the price was about 11.15 cents but a buying movement carried it up to about 13.2 in December. The market closed in New York at the end of the year at about 12.70 cents.

The price received by the Calumet and Hecla Mining Company varied from 12 cents to $15\frac{1}{4}$ cents. On December 31 it was about $13\frac{3}{4}$ cents.

During the last two months in the year there was an increase in the business and buying of the domestic manufacturers which resulted in an unusual and unexpected domestic demand for refined copper at the Michigan smelters. About the middle of November the largest shipment of refined copper ever made from the Michigan district was taken to Buffalo by the Mutual Transit Co.'s steamer North Star. The cargo totaled 9,000,000 pounds, and included consignments from the Calumet and Hecla dock on Torch Lake, the smelter dock at Dollar Bay and the Quincy and Copper Range docks on Portage Lake. With the close of navigation on the Great Lakes, the copper country docks were cleared of all copper on hand. The last shipments of the season were made December 1, when two large cargoes left for Buffalo. All available metal was shipped and the clean-up during November was most unusual. The vessels carried copper that was smelted even on the day of sailing.

Full wire service with Boston, New York and Chicago was resumed early in December when the Boston stock exchange reopened for business.

During the latter part of the year, the copper country was visited by several serious disasters. On December 18 one of the boilers at the No. 3 shaft of the North Kearsarge mine of the Osceola Consolidated exploded. The boiler house was almost completely wrecked, the fireman killed and the No. 3 shaft put out of commission. Several weeks previous the boiler house and compressor plant at the Superior mine were destroyed by fire.

Early Christmas morning the stamp-mill of the Isle Royale Mining Co., on Portage Lake, one mile east of Houghton, was completely destroyed by fire. The loss will exceed the insurance of $100,000 by from $30,000 to $50,000. The whole plant, with the exception of the carpenter shop, boiler house and office, was burned to the ground. Christmas day the mill was a skeleton mass of twisted pipe and machinery. As is characteristic of the Calumet and Hecla management, removal of the ruins to clear the site for the erection of the new mill was begun the following day. The advantage to the Isle Royale of being under the management of the C. & H. was clearly shown by the fact, that while the mill was completely out of commission, not an hour's time was lost at the mine. The Isle Royale ore was immediately shipped to the Centennial-Allouez mill at Point Mills.

CONSTRUCTION WORK.

Construction work during the year 1914 was restricted practically to the period from May to August. Strike conditions existed during the first few months and costs were high. The unusual conditions of the copper market, owing to the European war, made it necessary to reduce expenses as much as possible and early in August all construction was discontinued throughout the district.

Work at the White Pine was continued and $195,929.84 was expended for construction at the mine. For details of this work see report of White Pine Copper Co.

Ground was broken for the foundations of the recrushing plant at

the Tamarack mill in the summer. The foundations were completed and the steel work erected before the end of the year.

The Osceola Consolidated expended $21,109.17 for new construction at all branches. Of this amount about $6,700 was for stamp-mill reconstruction, including elevation of railroad tracks and enlargement of boiler plant. At the Osceola branch $6,765.97 was expended for the erection of a new rock-house at No. 3 shaft, the rebuilding of the boiler house and grading for railroad tracks to the rock and boiler houses. At the North Kearsarge branch $7,627.79 was expended. Of this amount $1,667.50 was for the equipment of No. 1 rock-house and collar-house. The change-house at No. 1 shaft was practically rebuilt and new equipment was installed at the pumping station at Kearsarge dam.

The Isle Royale paid out $34,858.55 in preparation for reopening No. 1 shaft, in building a boiler house at No. 5 shaft, and in installing an electrically driven plunger pump at the Huron dam pumping station.

Ahmeek expended $229,663.45 for construction, which included the installation of a low-pressure steam turbine, 46 Wilfley tables, eight Hardinge mills and foundations for two stamps at the stamp-mill.

The Calumet and Hecla continued the work in the new recrushing plant; the installation of the machinery in the large dredge was finished, and ground was broken for the large leaching plant.

The Copper Range Consolidated continued the improvements at the stamp-mills and underground, and the improvements at the Centennial-Allouez mill were practically finished.

Mohawk spent for construction $15,155.34. Several improvements were made at the stamp-mill and additional equipment installed at the shafts and rock-houses.

At the Quincy construction, equipment and betterment expense was maintained as low as possible. During the year $57,190.41 was spent for the recovery of the shafts and levels damaged by air blasts and $21,487.19 was expended in work towards preventing these damages.

MINE CASUALTIES.

The report of the Houghton county mine inspector showed a total of 29 casualties for the year ending September 30, 1914. This county includes, besides numerous properties being developed, the mines of the Calumet & Hecla, Copper Range Consolidated, Quincy, Winona, Superior, Isle Royale, Hancock, Franklin, Osceola, Kearsarge and Centennial. The largest number of casualties was four at the Baltic. The reports of the inspector since 1888 to date show that the highest percentage of accidents was in 1895, when, with 7,249 men employed,

there were 44 fatalities. During that year, however, 30 men were suffocated at the Osceola. The percentage for 1914 was 0.0022 with 12,954 men employed. The only year which shows a better percentage is 1899, when, with 13,057 men employed, 27 accidents occurred, giving a percentage of 0.0021. The report of the inspector of Keweenaw county showed four mine fatalities during the year.

SANITARY CONDITIONS.

An inspection of the sanitary conditions of the communities of the copper country by Robert Olsen and Joseph Bolton, of the U. S. Public Health Service, was completed about the first of November. Almost perfect conditions were found in the mining centers of the district, and there is no doubt that the living conditions in the Michigan copper country are far better than in the average mining district.

THE COPPER HANDBOOK.

"The Copper Handbook" will no longer be published in the Michigan copper districts. This well known publication on copper was founded in 1900 by the late Horace J. Stevens, of Houghton, and was published annually by him until his death in April, 1912. About a year later, rights of the book were sold to Walter Harvey Weed. Mr. Weed, as owner and editor, opened an office in Houghton and published the 1914 edition. It was feared at the time of the sale that Mr. Weed would not maintain an office in Houghton for any length of time. However, the news of the removal of the publication office to New York was received with much regret by the people of the copper country. Mr. Weed desired to handle all his business interests from one New York office, and the Houghton office of "The Copper Handbook" was closed about December 1.

THE DOUGLASS HOUGHTON MEMORIAL.

Upon a hill overlooking the waters of Lake Superior where they touch the shore of Keweenaw Point at Eagle River, there now stands an impressive and permanent monument to the memory of Douglass Houghton, scientist, explorer and Michigan's first State Geologist. The monument, erected through the efforts of the Keweenaw Historical Society, was dedicated October 10, 1914. It stands upon a triangular piece of land deeded to the Keweenaw Historical Society by the Cliff Mining Co. The base of the monument is composed of about 175 pieces of characteristic rocks of the copper and iron country. Upon the base rests a large mass of the Keweenawan greenstone, imbedded

in which is a tablet, made of Lake Superior copper, with a relief reproduction of the painting of Houghton by Bradish. Houghton is seen standing on a rocky shore with a geological pick in his hand and his dog Meme at his feet.

DETAILS OF OPERATIONS OF THE MINING COMPANIES IN 1914.

Ahmeek Mining Company.

Mine location: Ahmeek, Keweenaw county.
General Manager: James MacNaughton.
Superintendent: S. Russell Smith.
Controlled by the Calumet & Hecla Mining Co.

During the first few months of the year, the Ahmeek was gradually recovering from the effects of the strike. Early in August, owing to the European war, all extraordinary work was stopped and expenses were cut to the lowest possible point. For details of the general curtailment of September 1, see report of Calumet & Hecla Mining Co.

No sinking was done in any of the four shafts during the year 1914. All openings in No. 1 shaft have shown ground of average quality. To the south of the shaft there is a disturbed area due to a mohawkite seam, but President Agassiz reports that the ground opened between this and the North Kearsarge and Allouez boundaries is looking very well.

At the No. 2 shaft drift stoping was started about the middle of March. All openings show average values. President Agassiz reports that the mass copper fissure north of the shaft has been opened up for a distance of 500 feet on the 10th level, 262 feet on the 11th level, 211 feet on the 13th level, 212 feet on the 14th level and 27 feet on the 15th level, and has been reached on the 17th level, where it is as rich as at any point exposed before.

At shafts Nos. 3 and 4 construction was practically completed in May and the new equipment went into operation June 1. President Agassiz reports that all openings in both shafts show ground of average quality for this end of the mine. All operations were suspended August 6.

In shafts Nos. 2 and 3 mules are being used for tramming with very satisfactory results.

At the stamp-mill a low pressure steam turbine was put in place and completed except for electric connections. All floors and foundations for two stamps were finished; 46 Wilfley tables were installed on the main floor; eight of the 12 Hardinge conical tube mills and the anvil and stamp mortar for one of the two steam stamps were installed All outside launders, trestles, mineral tracks, etc., were completed.

All work on this addition and its equipment, however, was discontinued on August 6th.

During the year 590,694 tons of rock was hoisted and only 175 tons (0.03 per cent) was discarded in the rock-house. The company was able to pay $200,000 in dividends.

Algomah Mining Company.

Mine location: Lake Mine, Ontonagon county.
Superintendent: Thomas Bennett.

No mining was done on the property during the year 1914. A shipment of 74,560 pounds of selected ore, taken out during the sinking of the shaft, was made to the Michigan Smelter. No difficulty was found in treating it in the regular furnaces and the shipment yielded 18 per cent copper. Shaft sinking will be resumed in the spring of 1915.

Allouez Mining Company.

Mine location: Allouez, Keweenaw county.
General Manager: James MacNaughton.
Superintendent: F. W. Ridley.
Controlled by the Calumet & Hecla Mining Co.

During the first four months of the year production was low and costs were high, due to the strike conditions and to the inexperienced labor underground. Production, however, was gradually increased, reaching a maximum in July. For general curtailment of operations due to European war, see report of Calumet & Hecla Mining Co.

Openings in the upper levels of No. 1 shaft have been fully up to the average but the lower levels have developed ground somewhat leaner. Developments in No. 2 shaft have been up to average quality. Very little work was done on surface during the year.

Allouez produced during the year 6,056,548 pounds of refined copper from 354,457 tons of ore treated, an average of 17.09 pounds per ton. Assets were increased during the year by $114,530.43.

Baltic Mining Company.

Mine location: Baltic, Houghton county.
General Manager: F. W. Denton.
Superintendent: Albert Mendelsohn.
Controlled by the Copper Range Consolidated Co.

Normal conditions of operation were reached in June. Two months of full production were followed by another reduction of output caused by the European war. Beginning with August, all employees and

departments were put on half time schedule, working for half of each month and shutting down completely for the other half. During the time when the mine was not operating, necessary repair work was done in the shafts.

Improvement was found in the ground opened at the bottom of No. 3 shaft. The developments in No. 2 shaft are in good ground. Considerable stoping ground was found in explorations on the west lode at No. 5. shaft.

The use of waste stamp sand for filling stopes in the mine was begun in August, and during the year 17,670 yards was run into the stopes tributary to No. 2 shaft. This practice has been found very successful, not only in reducing the cost of filling stopes, but also in permitting more rapid and systematic work.

Baltic produced 7,001,945 pounds of refined copper at a yield of 21.59 pounds per ton stamped. The profit per pound was 2.21 cents.

Calumet & Hecla Mining Company.

Mine location: Calumet, Houghton county.
General Manager: James MacNaughton.
Superintendent: John Knox.

During the first four months of the year production was low and costs were high, due to the strike conditions and to inexperienced labor underground. Production, however, was gradually increased, reaching a maximum in July. The unusual conditions of the copper market due to the European war, and the uncertainty of being able to sell the copper produced, made it necessary for the company to curtail production and to reduce expenses as much as possible. On September 1, wages were reduced about ten per cent, or to the rates existing previous to May, 1912, salaries of all officers and employes in both the mine and eastern offices were reduced 15 per cent, and the mine operated on a three-quarters time basis.

During the year 1914 there was produced 53,691,562 pounds of copper from 2,592,462 tons of ore treated, an average of 20.70 pounds per ton. The total cost per pound was 11.35 cents and the price received for copper sold was 14.01 cents per pound.

The conglomerate lode yielded 37,996,045 pounds of copper, an average of 26.38 pounds per ton, at a total cost per pound of 10.42 cents. About 35 drills are at work removing shaft pillars and cleaning up arches and backs of old stopes. Little change has been found in the character of the openings in the Hecla and South Hecla branches.

The openings on the Osceola lode show about the same grade of ore

as in the year 1913 and the product secured from foot wall stopes was about 34 per cent of the entire tonnage.

The No. 21 shaft operating on the Kearsarge lode, was closed down July 23, 1913 and no work has been done on this lode since that date.

At the Manitou-Frontenac Branch the only work done during the year was the diamond drilling of 31 feet on hole No. 27, which completed the cross section on the northwest quarter of Section 17, T. 57 N, R. 31 W. No values were developed.

At the St. Louis branch no work of any kind was done during 1914.

At the stamp-mills 16 of the tube mills in the new No. 2 recrushing plant were started in July. All further work on the installation of the equipment was stopped August 1. An interesting comparison of the efficiency and cost of operating the new No. 2 recrushing plant with the old No. 1 plant is as follows:

	No. 1 Plant.	No. 2 Plant.	Both Plants.
Tons coarse tailings crushed	351,929	75,630	427,559
Pounds per ton in material treated	11.52	11.84	11.58
Pounds copper saved per ton	3.74	4.59	3.89
Pounds copper produced	1,316,704	347,363	1,664,067
Cost per pound, excluding smelting and selling	7.38c	5.66c	7.02c

The installation of the machinery in the large dredge was finished, the dredge was tested and the management reports that it met the guarantees and requirements fully. Plans were completed for a large leaching plant to retreat the tailings from the recrushing plants; ground was broken and contracts for the steel for building and tanks were let, but on account of the unusual copper market all work was discontinued in August.

All operations have been discontinued at the Buffalo works and the entire product of the mine is now being smelted at the Hubbell works. The new electrolytic plant is working at full capacity of about 65,000,000 pounds per year.

During the year 1914 the C. & H. paid only two dividends, amounting to $1,000,000 and received from the Ahmeek and Osceola companies in dividends $245,322. Dividends received exceeded interest paid on C. & H. notes by $78,962. The expenditures of the aid fund during the year amounted to $36,016.48.

Centennial Copper Mining Company.

Mine location: Calumet, Houghton county.
General Manager: James MacNaughton.
Superintendent: F. W. Ridley.
Controlled by the Calumet & Hecla Mining Co.

The operations for the Centennial for the year 1914 show a decrease in assets for the year of $3,213.09.

No development or stoping was done in the vicinity of No. 1 shaft. Openings to the north of No. 2 shaft showed average ground for the first nine months of the year but were lean the latter part of the year, with the exception of the 34th drift.

This decrease in copper contents and the unusual condition of the market made it impossible to operate at a profit and further reduction in costs was necessary. The first of December a system of full time work with lower wages was put in force. This plan meant larger monthly earnings to the men and a reduction of costs to the company. The Centennial suffered the same curtailment September 1 as the other C. & H. subsidiary companies. For details see report of Calumet & Hecla Mining Co.

During the year 2,287,130 pounds of refined copper was produced from 138,136 tons of ore treated, an average of 16.56 pounds per ton. The total cost per pound of refined copper was 12.56 and the price received was 12.111 cents.

Champion Copper Company.

Mine location: Painesdale, Houghton county.
General Manager: F. W. Denton.
Controlled by Copper Range Consolidated Company and St. Mary's Mineral Land Company.

During the first part of the year there was a reduction in output due to the strike. From August in the end of the year the mine produced only half time. Considerable repair work was done in the shafts during the shut-downs.

Fire destroyed one of the old wooden change-houses located near "D" shaft. General manager Denton states that plans have been made for a new, large, modern, fireproof building which will accommodate both "D" and "E" shafts.

A special spur track and concrete loading bin were constructed at the mill to facilitate collecting and loading waste stamp sand. During the year, 84,090 cubic yards of stamp sand was run into the mine for filling stopes. Underground electric locomotives are proving profitable. Two more were added during the year and several more will be put into service in 1915.

Development was far ahead of production and openings were not pushed at the usual rate during the year. No shaft sinking was done. The number of pounds of refined copper produced was 15,807,206, and the yield of copper per ton stamped was 25.71 pounds. The total cost per pound was 9.21 cents and the profit per pound 4.17 cents.

Cliff Mining Company.

Location of property: Keweenaw county.
General Manager: James MacNaughton.
Controlled by the Calumet & Hecla Mining Co.

Balance of assets was reduced by $9,938.22 during 1914.

No work was done at the temporary shaft. Three drill holes were put down in order to complete the exploration from the Kearsarge amygdaloid to the most easterly part of the company's lands. In two holes the rock was so badly broken that definite correlation with other holes was impossible. The third hole at a depth of 638 feet reached the boundary of the property and was continued to a depth of 1,155 feet by the Tamarack Mining Co. on its property. President Agassiz reports that very little copper was disclosed by this work.

Contact Copper Company.

Location of property: Elm River, Houghton county.
Superintendent: George S. Goodale.

Owing to strike conditions in Michigan, general business conditions everywhere, and the European war, only a small amount was paid on account of the assessment of 50 cents per share called in April, 1914. Since no contract for diamond drilling could be safely made until the treasury was sufficiently supplied with funds to warrant it, no work was done on the property during the year 1914.

Superintendent G. S. Goodale states that practically all of the 2,360 acres of the property lie within the copper-bearing zone of Houghton county. He further states that "the property possesses a maximum distance along the strike of the formations of nearly 17,000 feet and a horizontal transverse distance, at right angles to the strike, of nearly 12,000 feet. The formations, so far as determined, have an average dip of about 60 degrees from the horizontal, which affords a mineral acreage of about twice the surface acreage. The property includes the horizons of practically all the mineralized formations of the district lying between the eastern sandstone and the so-called Ashbed series of Keweenaw Point."

President H. F. Fay points out to the stockholders that additional systematic drilling should be done on certain portions of the lands which have already been partially examined. Between the depths of 1,590 feet and 1,621 feet, Contact drill hole No. 5 disclosed a copper-bearing amygdaloid, lying between two conglomerates, which corresponds approximately with the indicated position of the extension of the so-called No. 8 Wyandot lode. This extension should pass through the eastern part of the Contact lands and would underlie the whole property, thus making available a maximum tonnage favorable for commercial exploitation. It is intended to determine the value of this formation by drilling one or more additional holes parallel to the No. 5 drill hole. This, however, cannot be undertaken until the stockholders have paid their assessment in sufficient amounts to warrant contracting for the work. When work was suspended for lack of funds, there remained over 3,000 feet of drilling to complete the first cross-section of the property.

President Fay states that through a timber contract the company will be relieved from paying most of its taxes in Michigan for the present. There is also a considerable stock of machinery and mining supplies in possession of the company, which can be sold whenever opportunity offers or will be available when active mining operations are undertaken.

Copper Range Consolidated Company.

Mine office: Painesdale, Houghton county.
General Manager: F. W. Denton.

Controls Copper Range Co., Baltic Mining Co., Trimountain Mining Co., and Atlantic Mining Co., and owns half of Champion Copper Co.

The production and profits for 1914 were far below the normal. The effects of the strike greatly reduced production during the first part of the year. Normal output was not reached until July. The output increased from a yearly rate of 17,086,309 pounds in January to 30,792,612 pounds in July. The European war again necessitated a reduction of production which was effected by working the first half of each month and remaining idle for the last half. The Copper Range Consolidated was one of the first companies to curtail production, the first shut-down occurring August 15th. The August output was one-half that of July and this curtailment continued for the remainder of the year.

When work was resumed September 1 wages were reduced from eight to ten per cent; the salaries of all officials at the mines and eastern offices were cut 25 per cent and all these reductions continued through the remainder of the year. By this method the output was reduced

without disturbance to the organization, and operations were carried on normally during the working periods. The cost of production, however, was greatly increased by the expense of maintenance and repair work during the idle periods. All expenditures are charged to cost of copper.

On January 1, 1915, the Copper Range Consolidated opened a sales office at 32 Broadway, N. Y., with Mr. W. Parsons Todd as manager of copper sales. Since 1906 the United Metals Selling Co., of New York, had acted as selling agent for the company. The selling commission was one per cent and the average yearly commission paid was $55,000. It was felt that the company could handle the sale of its product direct to the trade at less cost and at the same time could get n closer touch with the requirements of its customers.

The use of raises in mining has been continued and the use of stamp sand for filling in the mines has increased with profitable results. The number of electric locomotives for underground tramming was increased. President Paine states that "the physical conditions at all the mines are good and assure a successful and profitable future. Due to various improvements in underground work and in milling, it is expected that the yield of copper per ton will be materially higher in the future, and if this expectation is realized, it will result in a lower cost per pound."

Franklin Mining Company.

Mine location: Demmon, Houghton county.
Superintendent: Enoch Henderson.

The only production during the year 1914 came from the test stamping of 7,324 tons of rock taken from the new openings on the Allouez conglomerate at the 32d level. President Edwards states that the results of this test, taken in connection with the general appearance of the openings since made, warrant the belief that the lode can be mined at a profit. Regular production will probably begin about the middle of May, 1915.

A small compressor was installed in No. 1 shaft-house and other changes made to permit the economical operation of a number of drills. One drill was put into operation the latter part of January in the foot wall cross-cut on the 32d level. Other drills were added until six were in operation. The crosscut on the 32d level was advanced 927 feet easterly to the first amygdaloid under the Houghton conglomerate. Besides the Allouez conglomerate and the Houghton conglomerate, six amygdaloid beds were cut in this crosscut. Superintendent Henderson states that three of these amygdaloids were barren, two carried copper in small quantities and one showed mineral and vein

matter worthy of further development. The Calumet & Hecla conglomerate should be reached in April, 1915.

Drifting on the Allouez conglomerate at the 32d level was begun about the middle of March. A great deal of interest was shown in the openings in the Allouez conglomerate which were made for the purpose of determining the value of the lode as a whole, without selection in mining or discard from the rock broken. The drifts were cut as wide as the hanging would permit and for the first four mill-runs, all rock broken was sent to the mill. A small quantity of rock was discarded in the rock-house from the last mill-run. Superintendent Henderson reports the results of stamping as follows:

	Tons rock.	Pounds dry mineral.	Assay.	Pounds copper.	Pounds copper per ton.
April 5, 1914	906	26,220	58.35	15,300	16.89
April 25, 1914	538	14,340	55.77	7,072	13.14
May 10, 1914	1,138	22,592	54.38	12,285	10.79
June 9, 1914	2,195	48,985	46.90	22,976	10.46
August 26, 1914	2,547	63,807	55.87	35,650	14.00
	7,324	175,944	.....	93,283	12.73

Tailings averaged six pounds per ton.

Hancock Consolidated Mining Company.

Mine location: Hancock, Houghton county.
General Manager: John L. Harris.

The Hancock, operating on borrowed money, was greatly retarded in development work by the strike and the European war. During the year a total of 2,300 feet of drifting was done at six levels on veins intersected at depth in the No. 2 shaft. Stoping was done at four levels on the No. 3 lode, at three levels on the No. 4 lode, at two levels on the No. 8 lode and at two levels on the No. 9 lode.

The rock from this development work was stamped by The Lake Milling, Smelting & Refining Co., and yielded 488,678 pounds of refined copper which was sold at 13.389 cents per pound.

During the year the directors found it necessary, in order to carry on operations, to borrow $164,000 from eastern bankers.

With the exception of keeping the mine free of water, all mining operations were suspended August 8th for the balance of the year. General Manager Harris reports that the physical condition of the property is such that mining operations can be resumed at any time.

Houghton Copper Company.

Mine location: North of the Superior Mine, Houghton county.
Superintendent: R. R. Seeber.

Operations were resumed with one shift on January 13th. The sinking of the winze below the 820 foot level was continued for a depth of 102 feet. The 620 foot level was extended north 383 feet and showed an occasional bunch of good copper ground but generally was rather poor. A 70 foot crosscut was driven to the hanging. The 1,020 foot level was extended 397 feet to the south and 334 feet to the north of the winze, and superintendent Seeber reports that some very good copper ground was encountered on both sides.

A railroad spur will be run to the property in the spring which will enable a mill test to be made of the rock pile of 7,500 tons which has accumulated from the development work. All operations were discontinued on September 15th.

Indiana Mining Company.

Mine location: Indiana, Ontonagon county.
Superintendent: Thomas Bennett.

Work was resumed in May. The shaft was unwatered to the 600 foot level and all the work of the year was done on that level. The purpose of the work was to determine the extent and character of the felsite mass encountered there, with the hope that this data might lead to the definite location of the rich felsite cut by No. 2 drill hole at 1,450 feet. A total of 1,152 feet of drifting and crosscutting was done during the year.

By means of drifts, crosscuts, a raise and a winze, it was found that the felsite mass at the 600 foot level lies in the form of a wedge with its apex 30 feet northwest of the shaft and its eastern and southern boundaries still undetermined.

The thickness of the felsite was determined by two crosscuts from the drift in the western contact. The first crosscut, 40 feet south of the shaft, shows the felsite 65 feet thick; the second crosscut, 120 feet south of the shaft, shows the felsite 115 feet thick; a third crosscut, 220 feet south of the shaft, was driven east into the felsite 160 feet, and is still in felsite.

President Edwards reports that in the first and second crosscuts a wide zone of felsite was encountered heavily mineralized with carbonate of copper. Average assays of 60 feet in the second crosscut gave 13 pounds of copper to the ton, and for a width of ten feet gave 19 pounds of copper to the ton. It is the intention of the management to have a thorough geological examination made.

Work is now being confined to locating No. 2 drill hole at the 600 foot level by means of a crosscut and chamber. This hole will be surveyed to the bottom with the hope of locating positively the position of the rich felsite found by the drill at 1,450 feet.

Isle Royale Copper Company.

Mine location: Houghton, Houghton county.
General Manager, James MacNaughton.
Superintendent: James E. Richards.
Controlled by the Calumet & Hecla Mining Co.

Production was very much restricted by scarcity of labor during the first third of the year and it was not until June that production reached normal. As a Calumet & Hecla subsidiary, Isle Royale suffered the same general curtailment on September 1st as the Calumet & Hecla. For details see report of Calumet & Hecla Mining Co.

The operations for 1914 show an increase in assets of $24,374.12. From 474,349 tons of ore treated, 6,601,235 pounds of refined copper was produced, an average of 13.9 pounds per ton. The total cost per pound refined copper was 13.05 cents and the price received was 13.16 cents per pound.

In May retimbering of the old No. 1 shaft was started. The timber in this shaft was destroyed by fire on December 18, 1903 and since that time no work has been done in the vicinity. The shaft was started in the Isle Royale lode and is bottomed at 1,614 feet from surface. The greater part of the production was mined from the west lode by means of crosscuts on the 9th to the 15th levels. There is broken ore in many of the stopes and some of it can be recovered.

The management decided to reopen the No. 1 shaft and to resume sinking in order to explore and mine the West lode, especially in the Montezuma ground. In August the shaft had been retimbered to 15 feet below the 8th level when all work was discontinued owing to the European war.

Practically all of the ground opened by drifts south of the No. 2 shaft on the Isle Royale lode was of inferior quality. The water in the old Huron mine was lowered to a point below the 14th level of this shaft and the level was extended to the Huron workings.

About 50 per cent of the ground opened by drifts on the West lode to the north of No. 2 shaft was of stoping quality. The drifts on the 26th and 29th levels passed through the corner of the Montezuma property for several hundred feet and both showed average copper ground. At the Nos. 4, 5 and 6 shafts a total of 6,960 feet of drifting was done, about 70 per cent of which was in copper ground of stoping

quality. No work was done at No. 7 shaft but the management is contemplating the resumption of work at this point.

For transporting 191,597 tons of Superior ore at seven cents a ton, $13,411.79 was received. This reduced the cost of transporting Isle Royale ore over its own tracks to 3.83 cents per ton.

On the night of December 24th the stamp-mill was completely destroyed by fire. The mill and its contents were insured for $100,000, but the loss will exceed the insurance by from $30,000 to $50,000. The management hopes to have the new mill ready for operation by June 1, 1915. Until the new mill is finished, Isle Royale ore will be stamped at the Centennial-Allouez and Tamarack mills.

Keweenaw Copper Company.

Mine location: Near Phoenix, Keweenaw county.
General Manager: W. J. Uren.

This company owns nearly all of the outstanding stock of the Phoenix Consolidated Copper Company, over five-sixths of the outstanding stock of the Meadow Mining Company, and a majority of the outstanding stock of the Humboldt Copper Company. The shares in above companies were obtained by purchase or by exchange for shares of the Keweenaw Copper Co. The mineral lands of these companies are contiguous and it is essential that these lands be explored and developed by the organization to secure economical results.

Diamond drilling along the strike of the Ashbed lode was continued until May 28, 1914. President T. F. Cole reports that enough advance information to enable the management to concentrate their efforts toward the development of a mine was secured.

No work was done on the lands of the Humboldt Copper Company during 1914. For other exploratory work see reports of Phoenix Consolidated Copper Company and Meadow Mining Company.

Lake Milling, Smelting & Refining Company.

Seven of the eight boilers in the new boiler house are in commission. The wash of No. 1 head is being remodeled, and 1,000 feet of tailing-launder was completed for heads Nos. 2 and 3.

Because of the increase in production of Superior, Isle Royale, Allouez and Centennial, stamping facilities at the mill became congested in May. The remodeling of the two heads in the little Tamarack mill was completed in June and some Allouez and Centennial ore was sent to that mill. When the Isle Royale mill was destroyed late in December all the Isle Royale ore was sent to the Point mill. This necessitated another change by which the Allouez ore was handled in the

little Tamarack mill and the Centennial product by the Osceola Consolidated Mining Co. By this arrangement the Allouez and Centennial companies saved in freight rate six cents a ton.

During the year 9,685 tons were stamped for the Winona Copper Company and 4,777 tons for the Franklin Mining Co.

On September 1 the mill went on a three-quarters time schedule and a reduction in wages corresponding to that of the Calumet & Hecla mines went into effect.

La Salle Copper Company.

Mine location: South of Osceola, Houghton county.
General Manager: James MacNaughton.
Controlled by the Calumet & Hecla Mining Company.

During the year 1914 the La Salle produced 540,731 pounds of refined copper from 45,509 tons of ore treated, an average of 11.88 pounds per ton. The price received for copper sold was 12.797 cents and the balance of assets was further reduced by $48,668.30.

At No. 1 shaft some stoping was done and a larger hoist was about to be installed when the mine was closed down.

The operations at No. 2 shaft consisted of stoping on the 12th level, drifting on levels below the 12th and sinking the shaft. The management reports that the openings were generally in fair copper ground on the north side of the shaft and at the 17th, or lowest level, copper ground was beginning to show on the south side also.

The mine was closed down early in August on account of the European war. Pumping has been continued and the water has not been allowed to rise above the 13th level in either shaft. The management has planned to resume operations in the early summer of 1915.

Mass Consolidated Mining Company.

Mine location: Mass, Ontonagon county.
Superintendent: E. W. Walker.

Operations were resumed on a small scale the latter part of February. Normal operating conditions were reached in May. The low price of copper caused by the European war made it impossible for the Mass to operate successfully. Since expenses would be greater if the mine were closed than the loss when running, the management decided to continue operations, retain their organization and give work to their employees.

More development work was done during 1914 than in 1913 and an appreciable amount has been added to the ore reserves. The estimated "Butler" ore reserves December 31, 1913 were 824,196 tons; reserves

added during 1914 were 439,179 tons, making a total of 1,263,375 tons. During 1914, 151,620 tons were extracted, leaving estimated "Butler" ore reserves December 31, 1914, 1,111,755 tons.

Superintendent Walker states that so far it has been impossible to estimate the ore reserves in the Evergreen and other lodes with any degree of accuracy, but that the Evergreen has and will continue to produce a considerable tonnage of stamp rock in addition to a large part of the mass copper produced by the mine. The Evergreen, Ogima and Knowlton lodes produced in 1914, 57,734 tons of ore.

President Linnell reports that during the past few years the company has been putting excessive expenditures into development but that from now on mining will be done on a larger scale and the proportional expense of development cost will be considerably less per pound of copper produced. The president further reports that the "Butler" lode in both "B" and "C" shafts is increasing in width with depth and is showing a material increase in copper contents.

Mayflower Mining Company.

Location of property: East of Kearsarge and Wolverine mines, Houghton county.
Superintendent: George S. Goodale.

Further exploration of the property by diamond drilling was continued during the year 1914. Two diamond drills were used in holes Nos. 35 to 41 inclusive, and a total of 10,304 feet was drilled during the year. The overburden in these holes varies from 5 to 28 feet.

Holes 36 to 40 are in the northeast quarter of section 8 and were drilled to extend the investigations northward, along the strike of the formations. Holes 35, 39 and 41 are in the southwest quarter of the same section and were drilled to explore the ground to the west of the earlier drilling.

Superintendent Goodale states that holes 34 and 37, which make up a transverse vertical section across the formations, indicate a much disturbed condition of the rocks due to faulting and crushing. Holes 36, 38 and 40 show that the lower beds have undergone repeated and in some places, pronounced disturbance. Holes 35 and 39 indicate faulting of considerable magnitude, but do not show the generally unfavorable conditions found in the northern part of the property. The last hole was located farther west and should intersect the Mayflower lode much deeper than encountered elsewhere.

Meadow Mining Company.

Location of property: Adjoins Phoenix Consolidated Copper Co., Keweenaw county.

Three diamond drill holes were bored through a portion of the hanging wall and across the Ashbed lode.

President Thomas Hoatson reports that two of these holes intersected the copper-bearing part of the lode at 489 feet and 364 feet respectively from the surface. The third hole cut the same formation at 713 feet from surface and disclosed vein matter of good width with good values in both the upper and lower portions of the amygdaloidal flow.

Mohawk Mining Company.

Mine location: Mohawk, Keweenaw county.
Superintendent: Theo. Dengler.

During the year 1914 Mohawk produced 11,094,859 pounds of refined copper at a total cost per pound of 8.23 cents. A dividend of $100,000 was paid August 15th, and the strike expense for the year was $23,685.77.

Following the strike, limited operations were begun in December, 1913 but it was not until May, 1914 that normal production was started. The Mohawk continued normal production throughout the year and was one of the two producing mines in the district which did not curtail operations because of the war.

Mohawk is now operating six shafts. The mine is equipped with 90 "Ingersoll Leyner" drilling machines and also with jack hammers and stopers. It is the intention of the management to close down permanently No. 3 shaft. Blocks, pillars and foot rock of value that cannot, without much extra expense, be reached in later years from No. 2 and No. 4 shafts are being removed. Considerable mass and heavy copper were obtained during this work. Test crosscuts into the foot and hanging on the 7th level did not show any values.

There was expended for construction $15,155.34. Plans for a new rock-house at No. 5 shaft are now under way. At the stamp-mill considerable expense was incurred in keeping the intake cleared from ice and debris. In order to maintain an open channel for slimes through the stamp sand, a reinforced concrete tunnel, 314 feet long, three feet wide, and five and a half feet high inside with 330 feet of retaining walls was constructed. Four additional Wilfley concentrating tables were installed in the mill to handle slimes.

Naumkeag Copper Company.

Mine Location: Houghton, Houghton county.
Superintendent: Sidney S. Lang.

Exploration was continued by means of crosscuts and drifts and some fairly good copper was found in several of the openings.

At the beginning of the year the Dakotah Heights adit had been driven east a distance of 245 feet and had encountered a lode which contained copper, and which was presumed to be the foot wall bed of the Quincy-Pewabic series. An electrically driven compressor and an electrically operated hoist were installed at the mouth of the adit to raise the rock sufficiently high to form a dump.

Drifting was done north and south on what the management believes to be the Old Pewabic lode, and the result of this work has indicated a lode from six to eight feet wide, showing some copper throughout a length of 700 feet, the best showing being confined to the 325 feet south of the main adit.

President J. P. Channing reports that "it cannot be said that the lode developed is as yet one of commercial value, but certainly the showing is sufficiently good to warrant the continuance of development work."

New Arcadian Copper Company.

Mine location: East of Quincy mine, Houghton county.
General Manager: Robert H. Shields.

Although the operations during 1914 were greatly curtailed by the war, the development work continued to show good results.

The work during the year was confined to the development of the New Arcadian lode and consisted of sinking the shaft to the 900 foot level, crosscutting east to expose the lode on two levels, drifting on the lode at four levels and extending a crosscut east beyond the lode at the 900 foot level.

Engineer Fesing states that the showing of the lode on the 900 foot level will compare favorably with any amygdaloid in the district. A number of good looking amygdaloids were found in the east crosscut. Stoping was done on the various levels and a stock-pile of about 2,500 tons has been accumulated. Arrangements have been made with the Franklin Mining Company for a mill test of this rock and the first shipment to the Franklin mill will be made early in May, 1915.

New Baltic Copper Company.

Location of property: East of Franklin mine, Houghton county.
General Manager: Robert H. Shields.

No active mining operations was carried on during the year 1914

because of the unfavorable industrial conditions and in order to await the results of the development work on the adjoining New Arcadian property.

The very favorable results of the development work at the new Arcadian have a most important bearing on the New Baltic. All the north openings on the New Arcadian are in good copper ground and the drift on the 250 foot level is now less than 200 feet from the boundary between the two properties. Engineer Fesing states that the New Arcadian lode traverses the New Baltic property with a workable length of about 4,000 feet and that it could be worked to a depth of about 3,700 feet at its deepest portion. This would give the New Baltic approximately 170 acres on the lode and about 5,000,000 tons of recoverable rock.

The management intends to expose the New Arcadian lode from the surface at different points by means of pits and cross-trenches as soon as weather conditions will permit in 1915.

North Lake Mining Company.

Mine location: Lake Mine, Ontonagon county.
General Manager: R. M. Edwards.
Superintendent: Thomas Bennett.

Work was resumed in May and the unwatering of the shaft begun. The crosscut at the 300 foot level was continued in order to cut the extension of the lodes being developed on the South Lake property.

At 210 feet from the shaft the crosscut passed through No. 8 conglomerate, which point in the crosscut corresponds with the hanging of No. 8 conglomerate cut at a depth of 570 feet in the South Lake shaft. Since this point should be about 550 feet horizontally from the first of the South Lake lodes, the management expected to cut the first of these lodes by the crosscut at about 760 feet from the shaft. However, at 730 feet the crosscut broke through into the overburden. It then became necessary to build a concrete dam at the end of the crosscut to hold back the clay overburden and to sink an inclined winze to a greater depth, before going ahead with the crosscut. The winze was sunk 200 feet on an incline of 30 degrees and crosscutting was resumed at the 400 foot level.

In addition to the work now going on, general manager Edwards recommends that future exploration of the property should include the sinking of the shaft to at least 800 feet and the driving of a crosscut east at that depth to cut the lodes which diamond drilling has shown lie in that direction.

Old Colony Copper Company.

Location of property: Calumet, Houghton county.
Superintendent: George S. Goodale.

All work during the year was confined to the extension of the diamond drill investigations of the Mayflower lode. Two drills were employed continuously in eight holes and a total of 12,774 feet of drilling was done during the year ending November 19th. This is slightly greater than the total footage of the preceding year. Superintendent Goodale states that "in places a high degree of mineralization was shown, some of the rock being thoroughly impregnated with fine copper."

It was necessary to extend several holes to a much greater depth to secure information regarding fault movements. This work has been done under the direction of Consulting Engineer A. L. Dickerman, and the later drill holes are proving his theory regarding these movements.

President Fay reports that although the operations for the year have covered a much wider area, the results are considered satisfactory, both in increased footage drilled and the fact that every hole has shown persistent mineralization.

Osceola Consolidated Mining Company.

Mine locations: Osceola, Kearsarge and Tamarack, Houghton county.
General Manager: James MacNaughton.
Superintendent: Frank H. Haller.

During 1914 the balance of assets was increased by $64,136.25, and the company paid out in dividends $288,450. A total of 1,108,447 tons of ore was stamped, yielding 14,970,737 pounds of refined copper, an average of 13.5 pounds per ton.

Osceola Branch:

Mill tests of rock from No. 5 shaft made in June and July showed the rock to carry less than ten pounds to the ton and a number of the poorer stopes were abandoned. The extreme south workings of No. 6 shaft showed a gradual improvement all the year and are now in very good ore. The management decided to reopen No. 3 shaft in order to mine the large amount of foot wall rock near the shaft. A new rock-house was erected in July. Early in August all construction work was stopped and underground work at No. 5 shaft was discontinued. For general curtailment of September 1 see report of Calumet & Hecla Mining Co.

In order to prevent a loss from operations at this branch, on December 1 a system of full time with lower wages was put in force. The cost per pound, excluding mill construction, was 15.07 cents.

North Kearsarge Branch:

By the first of May production was normal, the repairing of No. 1 shaft was nearly finished and the lower workings unwatered. At this branch $7,627.79 was expended for new construction. No. 1 shaft was about ready for operation early in August when all construction work was discontinued and in October this shaft was completely shut down.

In the latter part of December the boiler house building at No. 3 shaft was wrecked and operations were stopped. No. 1 shaft was then put in shape and plans made to resume production as soon as possible. Considerable repairing was necessary so no hoisting was done in 1914. The cost per pound at the North Kearsarge branch was 11.62 cents.

South Kearsarge Branch:

Only a small amount of development work was done at this branch during 1914. Operations were restricted chiefly to straight stoping and foot wall work. President Agassiz reports that the stopes of No. 2 shaft are rather lean and that the recovery of copper per ton of ore treated from now on to the end of this branch's productive life will probably be a decreasing factor.

A total of 6,303,000 pounds of copper was produced at an average of 16.23 pounds per ton. The cost per pound was 7.92 cents.

Phoenix Consolidated Copper Company.

Mine location: Near Phoenix, Keweenaw county.
General Manager: W. J. Uren.

Exploration by diamond drilling was continued along the strike of the Ashbed lode for about 3,300 feet, approximately to the boundary line between the Phoenix and Meadow properties. Five holes, totaling 2,785 feet, were drilled through the lode and general manager Uren states that nearly all of them gave fair to good copper values in the cores. This work furnished much valuable information as to the dip of the lode at depth and the desirable location for another shaft, which President Cole reports should be started in the spring of 1915, or as soon thereafter as a mill test of rock from No. 1 shaft shall prove the rock to be commercially valuable.

The No. 1 shaft was repoened and enlarged down to the third level which was the bottom of the old workings. This work was completed during April and since that time, sinking has continued steadily, showing fair copper values. The shaft was sunk a total of 758 feet and 2,010 feet of drifting was done. The total depth of the shaft was 878 feet at the end of the year. General Manager Uren states that the drifts on the 3rd, 4th, 5th and 6th levels east and west showed fair to good copper values.

For drainage purposes the "Armstrong" fissure vein adit level was reopened from its mouth at the bed of Eagle River for a distance of 581 feet. Additional equipment was installed at the power plant at No. 1 shaft and Leyner one-man drills were put in use. A small pumping plant was completed on the bank of Eagle River and dwellings for employees and machine and carpenter shops at Phoenix were repaired.

Quincy Mining Company.

Mine location: Hancock, Houghton county.
General Manager: Charles L. Lawton.

During the year 1914 the operations of the Quincy were seriously effected by the strike, air blasts and the European war. During the first six months the company did not operate at a profit and later in the summer the European war necessitated a reduction of the working force, as well as 12½ per cent reduction of wages and salaries of all employees and officers of the company. During the last two months of the year the price of copper improved and Quincy was able to sell copper which had accumulated and resumed payment of quarterly dividends which were discontinued during the strike.

Late in March a number of heavy air blasts occurred with extensive falls of rock. It may be interesting to engineers to read of the consequences of these air blasts and the means employed to prevent them as stated by general manager Charles L. Lawton:

"On March 25th, air blasts occurred throughout the mine and continued intermittently for a week or ten days. As a consequence, various crosscuts and drifts were crushed and closed up. No. 6 shaft timbers were seriously crushed between the 51st and 58th levels, and No. 2 shaft was crushed and closed between the 40th and 50th levels.

"About 500 feet of the crushed section of No. 2 shaft had to be entirely recovered and retimbered at an expense nearly as great as that of sinking a new shaft. In the remaining portion of the damaged shaft, about half of the timbers were replaced.

"Below the 50th level, the shaft was not damaged by the air blasts, though the crosscuts at the 57th, 64th, 65th and 66th levels were entirely closed, and the levels north were badly crushed.

"It was necessary to employ a considerable force of men for several months to renew and repair a large proportion of the timbers in the crushed section of No. 6 shaft, and to strengthen it by filling the old adjacent stopes with rock, while keeping the shaft in constant operation, in reopening crosscuts and drifts that were crushed and in reopening and retimbering No. 2 shaft. Thus the cost of production was increased very much during the months following the air blasts, especially because

of the loss of three months' product from No. 2 shaft, and consequently the impossibility of operating the mine, railroad and stamp-mills as economically at about 65 per cent of capacity.

"In earlier days, when air blasts were little understood, it was the custom to stope out the lode irrespective of the shaft. If the lode was rich in copper it was stoped out close over or under the shaft; where the shaft was in the lode, the latter was stoped right up to the shaft without leaving shaft pillars. Going through the upper portions of No. 2 and No. 6 shafts, is like going down through open stopes, with practically no pillars left to protect the shafts. It was in the lower part of these sections that the caving and crushing took place, with such serious results.

"For several years there has been a rigid adherence to the policy of leaving increasingly larger shaft pillars as the shafts are sunk, in order to sustain the litho-static pressure about the shafts. The air blasts have never caused any damage to these sections of the shafts. At the present bottom of the mine, these pillars are being left two hunderd feet each side of the shaft.

"Air blasts have continued with more or less frequency since July, though they have not damaged or retarded the work to any great extent. There were but three fatal accidents during the year, involving less than one-fourth of one per cent of the working force.

"In order to meet the air blasts and prevent as far as possible the damages caused by them, as fast as the mining in each stope is finished, the bottom of the stope along the back of the level is filled with poor rock, constituting what is termed 'rib work.' Experience has taught that these rock packs are the most effective means yet employed to lessen the damage caused by air blasts.

"After a careful investigation and study of the effects of the series of air blasts that occurred in 1906, rib work was employed for the first time throughout what were then the lower workings of the mine to combat the damages caused by these disturbances. For a number of years, these rock packs proved effective, until the series of 1909. Again careful investigation and study readily showed that the rib work was along proper lines, but had not been carried far enough. Therefore, the packs were made deeper in the stopes—that is, doubled in size. For a still longer period of time these rock packs proved sufficient, until March 25th, 1914, when another series of air blasts occurred. For the third time it has been shown that the rock packs proved to be the best means of limiting such damage.

"In order, however, that the highest effectiveness possible may be secured within the limits of profitable mining at the greater depths, this rib work should be still further strengthened. It is estimated

that the voids in the rock give it a shrinkage of about 20 per cent at the present depth of the mine. In order to lessen this shrinkage and strengthen the rib work, the question of filling the voids in the rock with bank sand, stamp sand, or crushed rock, is receiving serious consideration, inasmuch as provisions must be made for better and stronger supports to the back of each level, as fast as stoping is finished. This must be done so as to avoid extended crushing, and thus guard the safety of the employees, minimize the losses and expenses caused by air blasts, and make permanent the mine's future operations with depth."

Throughout the year, the eight-hour work day has been in force in the mine and stamp-mills. This has necessitated the adjustment of the entire operations of the mine, in order to maintain the same output in the shorter number of hours. The mine was fully equipped with the light weight one-man hammer drilling machines in April. General Manager Lawton states that the upper levels of the mine contain many thousands of tons of lower grade ore in narrow lodes, which can be profitably mined with the lighter drilling machines. Development work was continued underground and all shafts were sinking throughout the year. An interesting fact is that the bottom drifts and stopes are showing an increase in copper contents. No. 9 shaft was not operated during the year for the sake of economy.

The new daily card system of time keeping has been improved, now includes the stamp-mills and is proving very satisfactory. At the beginning of each shaft the miners are provided with individual pocket carbide-retainers for mine lighting. These cans hold just enough carbide for a shift's work and waste is thus prevented. Small pocket lubricating oil cans have been provided for miners or machine runners and hold just enough oil for a shift's work of the drilling machine. Regular classes in First Aid Instruction have been held by the medical staff throughout the year and each successful graduate is given a certificate. As a result of this work a large decrease in the compound fracture accidents and in the percentage of infection in all accident cases have been very marked. A rigid physical examination by the medical staff is required of all applicants for positions with the company.

At the smelter the costs were high in the first six months of the year but by strict economy, improvement, and reduction of wages, about the same costs as in the previous year were maintained. The eight-hour work day went into effect at the smelter July 1st.

Smith Explorations.

As a result of the favorable development work at the White Pine, further explorations to the west on the Nonesuch formation were started about November 1st. The exploratory work was done in Section 7, T. 50 N., R. 43 W. and Section 12, T. 50 N., R. 44 W., about eight miles west of the White Pine.

Mr. Fred Close is in charge of the exploration work and Mr. A. E. Seaman is acting as consulting geologist. Mr. Close states that at the end of Janurary, 1915, some test-pitting has been done, a shaft had been sunk 70 feet, a crosscut made into the formation for 40 feet and 15 feet of drifting done.

The results obtained were very favorable and extensive diamond drilling will be done in the spring of 1915.

South Lake Mining Company.

Mine location: Greenland Junction, Ontonagon county.
General Manager: R. M. Edwards.
Superintendent: Thomas Bennett.

Work was resumed in April and total openings of 1,952 feet were made during the year. The shaft was unwatered and sunk from 537 feet to 626 feet. At the 600 foot level a crosscut was driven 19 feet northwest and 1,379 feet southeast, at an average rate of better than 200 feet per month for the entire distance. This crosscut was made to explore that portion of the property in which four distinct copper bearing horizons, dipping to the south, were found by diamond drilling several years ago. The dip at the shaft is northerly and at 900 feet from the shaft the dip was found to be distinctly southerly. At the end of the year two of the copper bearing horizons dipping south had been cut in the crosscut; these have been called No. 4 south and No. 3 south. The section through shaft and crosscuts suggests the possibility that No. 4 south may be the same as No. 3 north, and No. 3 south the same as No. 1 north, as they lie approximately the same distance above No. 8 conglomerate. The 600 foot level crosscut will be extended and drifting will be pushed on the different lodes.

On the 300 foot level the crosscut was extended to the No. 1 lode and the No. 3 lode and both were opened east and west by drifts. General Manager Edwards states that all the lodes mentioned carry copper, No. 4 south where cut by crosscut and No. 3 north as far as opened, being particularly good looking.

A considerable stockpile has accumulated from the drifting on Nos. 1 and 3 north and arrangements for stamping will probably be made in the near future.

St. Mary's Mineral Land Company.

Agent: F. W. Nichols, Houghton.

No sales of mineral land were made during the year. The real property of the company at the close of the year consisted of 93,032.69 acres, besides the mineral rights to 14,112.96 additional acres.

During the year the company paid in assessments to the Winona Copper Company $56,778, to the Mayflower Mining Company $25,000 and to the Old Colony Copper Company $80.

The St. Mary's company owns shares of stock in the following companies: Champion Copper Co., Hancock Consolidated Mining Co., La Salle Copper Co., Pacific Copper Co., Copper Range Consolidated Co., Winona Copper Co., Old Colony Copper Co., Mayflower Mining Co., Ojibway Mining Co., North Lake Mining Co., Franklin Mining Co., Houghton Copper Co., Naumkeag Copper Co. and the Douglas Copper Co.

Superior Copper Company.

Mine location: South of Isle Royale, Houghton county.
General Manager: James MacNaughton.
Superintendent: Ocha Potter.
Controlled by the Calumet & Hecla Mining Company.

The Superior increased its balance of assets in 1914 by $23,175.75. A total of 3,217,635 pounds of refined copper was produced at 16.79 pounds per ton. The total cost per pound was 12.43 cents.

At the No. 1 shaft the 18th and 19th levels south on the West lode continued in fairly good copper-bearing ground. On the 18th level at 1,400 feet south of the shaft about 120 feet of stoping ground was opened. The 19th level north developed nothing of value. On the Superior lode at No. 1 shaft no new copper-bearing ground was opened. At No. 2 shaft both the West lode and the Superior lode were barren at the points opened.

As a Calumet & Hecla subsidiary, the Superior suffered the general curtailment of September 1st. For details see report of Calumet & Hecla Mining Co.

Tamarack Mining Company.

Mine location: Calumet, Houghton county.
General Manager: James MacNaughton.
Superintendent: John T. Been.
Controlled by the Calumet & Hecla Mining Co.

The operations of the Tamarack for the year 1914 resulted in a decrease in assets of $174,944.97. A total of 1,074,808 pounds of re-

fined copper was produced at a total cost per pound of 29.08 cents. The copper was sold at 12.80 cents per pound.

No mining was done at No. 2 shaft during the year. In June all tram cars, engines, pumps, drills and haulage ropes were removed from the workings. No. 3 shaft was retimbered where it passes through the crushed ground. Early in the spring the drifts and stopes were repaired and hoisting began May 18th. At No. 5 shaft hoisting began May 11th. Being a high cost mine, the Tamarack early in August was closed down.

In March diamond drilling was started to continue the cross-section carried by the Cliff Mining Co. to the boundary of the Tamarack lands. Five holes were drilled and President Agassiz reports that in all of the holes a very little copper was found scattered throughout the formation, but not sufficient to warrant further exploration. All drilling was discontinued early in August.

The Tamarack was one of the few companies to continue construction work during the last quarter of the year. During the summer ground was broken for the foundations of the recrushing plant. The foundations were completed and all the steel work erected before the end of the year. When completed the plant will contain 32 Hardinge conical mills and 92 Wilfley tables.

This new mill is being built for the purpose of treating the old stamp sand in Torch Lake. Until the dredge is ready for operation part of the recrushing mill equipment will be installed to treat the tailings from the conglomerate mine. The cost of the recrushing plant will be provided by the $230,000 the company will receive for the sale of its mill to the Lake Milling, Smelting & Refining Co.

Trimountain Mining Company.

Mine location: Trimountain, Houghton county.
General Manager: F. W. Denton.
Superintendent: Richard Bowden.
Controlled by the Copper Range Consolidated Co.

During the year 1914 Trimountain produced 227,251 tons of ore which yielded 5,048,306 pounds of refined copper, giving 18.21 pounds per ton. The total cost per pound was 12.21 cents and the price received per pound was 13.38 cents.

Operations were effected by the strike during the first third of the year and from August the mine was worked during the first half of each month only. Extraordinary expenditures amounted to $12,674.93, covering completion of regrinding equipment and renewals at stamp-mill.

General manager Denton reports as follows: "Openings made during year showed average values. The property is in excellent condition and improved results are assured under favorable conditions."

Victoria Copper Mining Company.

Mine location: Victoria, Ontonagon county.
Superintendent: George Hooper.

In 1914 Victoria produced 1,486,242 pounds of refined copper, an increase of 57,549 pounds over the production of any previous year. However, the low price received for copper during the last half of the year, owing to the unsettled business conditions and the European war, resulted in a loss from mining operations of $30,388.

Considerable development work was done and very good results obtained. A small diamond drill has been used in the mine to locate the lode when lost and to prove its width and value. A large amount of poor rock was sorted out and stored underground, especially in the lower levels. No operations were carried on at No. 6 shaft during the year.

Superintendent Hooper states that the copper from the lower levels is coarser and the stopes opened have given good results. He further states that the results obtained from the lower levels and the excellent ground shown in the shaft between the 25th and 26th levels certainly warrant the further opening of all lower levels in the mine.

The power plant was short of water during the latter part of the year and its deficiency of power made it necessary to reduce operations to one shift, thus curtailing production and adding to costs.

Extensive general repairs have been made at the stamp-mill. A compressed air locomotive for underground haulage was purchased during the year but is not yet in use. Considerable repairing was done to dwellings.

On February 1 all men employed in the mine and stamp-mill and hoisting engineers were put on an eight-hour shift and all other surface men on a nine-hour shift. This change raised the cost of production somewhat. On September 1 a general reduction in wages of 15 per cent was made.

With higher prices and ordinary condition of water supply, the Victoria should operate at a fair profit.

White Pine Copper Company.

Mine location: Porcupine Mountain District, Ontonagon county.
General Manager: James MacNaughton.
Superintendent: Thomas H. Wilcox.
Controlled by the Calumet & Hecla Mining Company.

Development work was carried on without interruption throughout the year. President Agassiz reports that the openings on the first level west of the No. 2 shaft have been rather poor. The 2nd level east of No. 4 shaft is badly faulted but shows good values when in the lode. The 2nd and 3rd levels west of No. 3 shaft are in fair ground and between shafts Nos. 3 and 4 are very good. The drifts on the 4th level east of Nos. 3 and 4 shafts are good as far as opened. A total of 8,000 tons of ore was hoisted, increasing the stockpile to about 28,000 tons.

Considerable construction work was done at the shafts and stamp-mill during the year. Permanent hoists are being installed at shafts Nos. 3 and 4. A boiler house to furnish power for both hoists has been built and the boilers are being put in. No. 3 permanent shaft-house is built and foundations for No. 4 are in place. The trestle connecting the two shafts with the crushing plant is being erected.

At the stamp-mill the coarse crushing plant, conveyor, mill, boiler and power house are closed in and installation of machinery is underway. The management plans to have the mill in operation May 1, 1915.

The operations for the year 1914 show an excess of expenses over receipts of $128,479.42 and the balance of liabilities was increased to $134,559.74.

Winona Copper Company.

Mine location: Winona, Houghton county.
Superintendent: R. R. Seeber.

During the first few months of the year conditions at the Winona were gradually approaching normal and by July the company had reached the maximum output in its history.

A great deal of attention was being paid to the regrinding department and President Paine reports that this department in the mill was aiding materially in the saving of the finely disseminated copper in the ore and the cost of producing copper was slowly working down month by month when the European war broke out. For detailed results of the Hardinge mill regrinding department for the year see statistical tables.

As a result of the war operations were suspended on August 6th.

In October a tributary arrangement was made with mining captain Broan and about 40 former employees and on October 15th production was resumed by the leasers from certain stopes on the 3rd, 4th and 5th levels of No. 3 shaft. The results of this arrangement proved very satisfactory to the miners and to the company. A total of 9,685 tons of ore was stamped at the Centennial-Allouez mill up to the end of the year.

The only construction work done during the year was in connection with the experimental work on the Shields Classifier and the Lovett Grinding Machine.

Wolverine Copper Mining Company.

Mine location: Kearsarge, Houghton county.
Superintendent: Theo. Dengler.

The mine was closed on July 23, 1913 by the strike and no work was done until November 12, 1913, when, with a force of 20 men, underground operations were resumed. Shipments of ore increased slowly and normal production was reached in April, 1914. The normal production was maintained throughout the year and the Wolverine was one of the very few mines which did not suffer by the general curtailment caused by the European war. A total of 3,435,459 pounds of refined copper was produced during the year ending July 1, 1914, at an average of 18.86 pounds per ton stamped.

Blocks of ground left in the older workings with copper contents below the average of new openings are being stoped and the ore selected on various levels tributary to shafts Nos. 3 and 4. A total of 6,020 tons, or 3.2 per cent, of waste rock was hoisted during the year. This reduction in waste is due in part to careful selection underground and also to the fact that little sinking and no crosscutting was done during the year. Little regular drifting and stoping was undertaken for several months after hoisting began and about 60 per cent of the rock hoisted was obtained in cleaning up and blasting out the lode along the foot in old stopes. "Jack hammer" machines are used in cutting out the lode along the foot and the mine has been equipped throughout with inproved drilling machines. At the mill a six foot Hardinge mill has replaced the Chilean mill.

Wyandot Copper Company.

Mine location: Winona, Houghton county.
Superintendent: Frank L. Van Orden.

The Wyandot carried on actual mining work for only five months

during the year 1914. Owing to the general business depression resulting from the war, all mining operations and development work were suspended September 1st.

During the year the winze was sunk from the 815 foot level to the 915 foot level and drifting was begun at the latter depth, about July 1. Superintendent Van Orden states that "in sinking the winze from the 815 to the 915 foot level, well mineralized vein matter was encountered 30 feet above the 915 foot level which continued, and still shows, in the sump in the bottom of the winze." He further states as follows:

"The southwest drift was driven 65 feet in splendid vein matter, the first 25 feet of which carried excellent copper values while the remainder of the distance driven, 40 feet, while showing a decrease in values, showed fair values until the time work was suspended.

"The northeast drift was driven 63 feet and showed intermittent values. The breasts of both drifts showed values at the time work was suspended."

In order to furnish the married men employment during the fall and winter months, about 350,000 feet of mixed timber was logged and sold.

President Ashley Watson reports the following:

"The Wyandot lode, which we are now developing, and which averages 28 feet in width, lies in the Baltic lode horizon, some 2,300 feet east of the Winona lode, and there is little doubt that the latter lode (Winona) is the Isle Royale lode, as No. 8 conglomerate underlies both, and can be traced from Portage Lake to and beyond the Lake mine. Other beds of conglomerate occur in such manner as to make it difficult to correlate them. However, we do know from the general location of the Wyandot lode, that we are working in the horizon where we might expect to develop the Baltic lode, and some of the local mining men do not hesitate to say that the Wyandot lode is the Baltic lode."

The prospects of developing a commercial lode appear very promising at the present time.

STATISTICAL TABLES.

COPPER AND IRON ORE.

PRODUCTION OF MICHIGAN COPPER MINES.

(In pounds refined copper.)

Compiled by R. E. Hore from mining company reports, Mineral Industry, U. S. Geological Survey Report, Reports of Commissioners of Mineral Statistics of Michigan and Horace Stevens Copper Hand Book.

	Previous to 1855.	1855.	1856.	1857.	1858.
Adventure	68,000	62,034	143,336	233,941	115,678
Aztec	38,000	3,467	51,139	29,361	6,251
Caledonia	.....	54,000	5,500	.....	.....
Central	.....	83,836	64,903	53,875	.....
Cliff	6,980,000	1,874,197	2,220,934	2,360,850	2,260,433
Copper Falls	316,000	200,000	208,010	307,305	303,852
Delaware	.....	.....	.....	.....	.....
Evergreen Bluff	2,599	14,100	25,110	46,942	6,665
Eagle River	.....	1,500	2,600	2,000	6,637
Franklin	.....	.....	.....	6,699	113,104
Flint Steel River	8,651	4,000	.....	.....	2,106
Hilton	4,000	.....	705	.....	.....
Huron	.....	6,000	24,000	70,000	48,000
Isle Royale	116,000	186,000	.....	465,124	356,810
Mass	.....	.....	.....	16,228	12,000
Madison	.....	.....	4,000	.....	16,000
Minesota	3,020,000	2,080,000	3,490,714	3,952,000	3,802,914
National	157,477	48,302	176,483	316,158	264,804
North American	900,000	307,822	408,252	375,958	38,919
Northwestern	144,000	154,900	80,830	5,913	.....
Norwich	334,000	216,000	220,000	116,000	39,000
Ohio Trap Rock	2,500	.....	.....	.....	38,685
Pennsylvania (Northwest)	1,110,000	198,080	3,348	58,543	166,100
Pewabic	.....	4,301	107,667	236,254	416,603
Phoenix	38,000	6,000	16,000	34,000	.....
Quincy	.....	.....	13,462	122,762	306,772
Ridge	60,000	70,631	73,874	58,790	78,690
Rockland	20,000	116,000	293,000	756,396	623,140
Star	.....	1,000	.....	.....	.....
Toltec	100,000	60,000	118,401	83,036	.....
Windsor	.....	68,000	.....	.....	.....
Total pounds copper	13,419,227	5,820,170	7,752,268	9,708,135	9,023,163
Total value	$3,146,400	$1,586,160	$2,218,320	$2,382,500	$2,129,235

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1859.	1860.	1861.	1862.	1863.
Adventure	198,431	42,749	4,676	22,089	.....
Albany & Boston (Peninsula)	.....	.....	.....	7,982	.....
Ash Bed	.....	.....	.....	31,822	133,183
Amygdaloid	.....	.....	.....	97,591	138,124
Aztec	18,493	6,203	.....	.....	.....
Caledonia	15,000	40,400	.....	.....	7,730
Carp Lake	.....	6,428	.....	.....	976
Central	241,622	114,197	248,741	484,764	619,268
Cliff	1,415,007	1,343,393	1,928,011	2,004,960	2,100,354
Copper Falls	346,174	510,818	560,011	458,299	319,348
Douglass	.....	27,220	.....	.....	.....
Evergreen Bluff	38,811	63,817	99,187	119,257	141,446
Franklin	233,211	484,196	1,402,078	1,466,645	1,278,684
Grand Portage	.....	100,000	.....	.....	355,793
Eagle River	12,000	9,651	.....	5,652	.....
Garden City	4,000	.....	14,000	.....	36,000
Huron	45,387	9,000	98,000	139,305	138,206
International	3,903	.....	.....	.....	32,563
Isle Royale	416,056	338,198	917,274	896,139	721,841
Knowlton	.....	.....	.....	22,439	85,451
Mass	52,682	.....	.....	.....	.....
Minesota	3,344,587	2,680,500	3,016,824	2,520,000	1,677,500
National	488,176	1,078,609	1,383,760	865,752	561,179
Ogima	.....	.....	.....	.....	53,530
North American	22,852	.....	.....	.....	.....
Northwestern	.....	.....	.....	.....	5,920
Pennsylvania (North west)	148,144	242,097	109,920	.....	.....
Pewabic	1,029,949	1,917,426	1,849,992	1,571,281	1,691,562
Phoenix	56,590	40,062	68,790	63,590	144,118
Quincy	357,114	1,940,414	2,364,852	2,306,218	2,225,407
Rockland	479,190	689,000	776,358	564,000	344,000
Shelden & Columbia	.....	100,000	.....	.....	.....
Toltec	32,186	7,140	.....	.....	.....
Total pounds copper	8,999,565	11,791,518	14,842,474	13,647,785	12,812,183
Total value	$1,950,355	$2,654,960	$3,487,995	$3,634,255	$4,415,600

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1864.	1865.	1866.	1867.	1868.
Adventure	1,755	7,491	4,439	.....	.....
Albany & Boston (Peninsula)	7,000	318,160	163,906	62,493	234,536
Aetna	6,857	4,131	58,996	62,855	2,389
Ash Bed	51,228	9,369	128,090	326,660	.....
Amygdaloid	135,795	418,964	340,668	161,375	122,694
Atlantic	.....	.....	13,475	1,760	1,528,258
Aztec	.....	8,700	32,000	80,000	72,000
Bay State	.....	75,000	210,000	114,115	.....
Caledonia	31,977	.....	.....	.....	26,243
Calumet & Hecla	.....	.....	.....	1,351,173	5,098,375
Carp Lake	10,546	13,185	.....	.....	.....
Central	901,292	1,099,242	1,333,036	1,244,441	1,800,943
Cliff	1,351,334	1,498,626	1,642,928	1,121,725	1,227,746
Concord	.....	.....	9,980	52,020	171,185
Conglomerate	58,700	102,492	.....	.....	.....
Copper Falls	358,808	470,000	1,137,169	2,257,485	479,384
Douglass	.....	6,809	16,209	65,877	50,109
Eagle River	.....	.....	738	8,389	.....
Evergreen Bluff	.....	375,213	.....	.....	.....
Franklin	1,211,335	1,559,481	1,638,994	1,402,455	1,467,476
Grand Portage	489,104	483,592	.....	.....	159,282
Hilton	11,179	6,411	5,767	.....	.....
Huron	101,745	468,011	.....	1,367,169	1,480,080
International	22,069	63,502	69,823	.....	.....
Isle Royale	582,386	689,836	617,336	762,852	295,033
Knowlton	.....	196,724	.....	.....	.....
Lake	.....	.....	.....	.....	.....
Madison	.....	14,881	34,000	.....	.....
Mass	9,452	12,937	10,112	10,040	18,939
Mesnard	4,000	15,600	.....	.....	5,510
Minesota	1,446,000	403,000	391,500	376,500	230,900
Mohawk	.....	.....	.....	.....	.....
National	628,516	696,168	647,371	660,922	619,820
Ogima	50,000	140,990	277,310	168,480	199,360
Northwestern	6,650	.....	.....	.....	.....
Norwich	9,730	53,330	.....	.....	.....
Pennsylvania (North-west)	163,960	379,369	128,090	336,660	.....
Pewabic	1,429,857	1,731,394	1,346,140	1,646,458	1,043,523
Phoenix	284,187	405,000	410,000	310,115	260,000
Quincy	2,498,574	1,847,500	2,114,220	1,831,448	1,461,000
Ridge	16,917	170,433	142,411	189,537	172,000
Rockland	521,624	217,500	120,000	70,400	98,500
St. Clair	.....	8,815	62,200	87,720	136,665
Shelden & Columbia	.....	72,912	133,497	618,946	333,118
Star	.....	1,760	.....	.....	.....
Sundry companies	.....	.....	.....	.....	1,000,000
Total pounds copper	12,402,577	14,046,528	13,240,405	16,750,070	19,795,068
Total value	$5,870,300	$5,635,515	$4,629,375	$4,442,841	$4,940,404

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1869.	1870.	1871.	1872.	1873.
Adventure	1,154	2,931	6,391	17,055	7,345
Albany & Boston (Peninsula)					66,200
Aetna					4,650
Allouez	3,775				a21,163
Amygdaloid	33,010	47,610			28,250
Ash Bed					
Atlantic	1,646,857	372,617		10,570	13,348
Aztec	175,267	25,288			863,366
Caledonia	103,853	87,508	13,153	11,550	
Calumet & Hecla	12,315,771	14,061,584	3,377		
			16,222,590	16,163,836	18,848,265
Centennial	a8,290	a426,366	a743,288	a384,242	a309,785
Central	1,807,801	1,327,156	1,432,662	1,244,349	1,503,117
Clark				17,749	
Cliff	725,247	444,381	142,238	118,386	751,203
Conglomerate				163,161	280,743
Copper Falls	691,400	772,990	478,883	520,861	1,086,640
Concord		9,815	123,628	143,792	122,168
Evergreen Bluff	147,662	111,420	45,048		
Flint Steel River		30,889	92,500	45,879	76,698
Franklin	1,559,940	1,178,000	700,000	372,000	366,000
Grand Portage	72,314				
Hilton		3,345			
Huron	1,682,863	a84,183	a265,453	a553,689	a547,883
International		8,630	19,482	65,100	100,845
Isle Royale	a150,672		a181,217	a250,164	a240,100
Knowlton	106,977			17,559	70,442
Lake					
La Salle					
Mass	3,213	3,408	18,692	1,903	8,265
Mesnard					9,269
Minesota	227,500	401,500	368,000	552,000	148,171
Norwich	5,300				
National	256,947	260,660	411,086	336,770	167,870
Ogima	18,045		9,839		
Pewabic	960,409	546,000	444,600	467,000	572,400
Phoenix	796,630	999,000	1,219,862	728,470	521,080
Quincy	2,460,635	2,572,980	2,338,882	2,296,308	2,800,005
Ridge	253,840	245,400	350,150	257,920	231,140
Rockland	119,000	95,000	60,000	51,000	23,400
St. Clair	46,197			18,072	81,867
Shelden & Columbia	186,368				
Star					
Tamarack				535	
Tamarack Junior					
Trimountain					
Victoria					
Winona					
Wolverine					
Sundry companies	17,022	168,000	16,000	11,220	4,800
Total pounds copper	26,583,959	24,286,661	25,707,021	24,821,140	29,876,478
Total value	$6,230,016	$5,096,752	$5,728,485	$7,979,400	$8,726,100

a Since this table includes mines reporting their output both for the calendar and for the fiscal years, and since some of the companies report the refined copper equivalent of mineral produced and others report refined copper, the amounts do not necessarily agree with the total of either mine or smelter output.

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1874.	1875.	1876.	1877.	1878.
Adventure	4,165	30,470	40,784	64,609	54,115
Albany & Boston (Peninsula)			6,015	11,998	1,746
Allouez	a1,008,134	a1,385,574	a1,561,875	a1,300,279	1,131,146
Amygdaloid	14,840				1,259
Ash Bed	172,291	152,946	85,224	14,633	
Atlantic	1,372,406	1,531,531	1,835,041	2,054,304	2,043,863
Aztec	13,412	16,252	27,378	29,934	23,392
Calumet & Hecla	20,125,225	21,473,954	21,690,737	22,568,468	25,251,128
Centennial	a10,618				
Central	1,740,603	1,466,952	2,161,400	1,995,609	1,891,053
Clark	7,244	67,475	38,774	34,813	21,520
Cliff	1,054,901	1,162,873	900,146	161,319	414,415
Concord	22,518	440			
Conglomerate	81,271	25,220	177,701	33,417	280,345
Copper Falls	1,070,359	407,587	17,488	11,950	11,790
Douglass				3,258	
Evergreen Bluff					71,873
Flint Steel River	48,772	33,054	30,115	26,067	38,356
Franklin	567,790	1,166,800	1,926,641	2,339,817	2,599,528
Grand Portage					34,124
Gratiot				3,555	6,807
Hilton					
Huron	a251,005	a63,289	a63,857	a82,161	65,100
International	7,535	8,762	10,653	17,703	1,488
Isle Royale	180,876	a96,682	28,199	31,985	31,933
Island			48,340	88,867	
Knowlton	6,215	6,562		5,975	8,629
Lake Superior	5,228			2,106	
Madison					1,676
Mass	11,925	3,014	81,952	100,238	412,339
Mesnard				6,589	
Minong		48,344	114,537	104,892	90,596
Minesota	186,338	133,419	88,954	113,148	175,027
National	142,052	98,878	166,647	68,737	22,736
Ogima					2,800
Nonesuch	27,450	49,667			
Osceola	936,000	1,330,303	1,693,737	2,774,777	2,705,998
Pewabic	294,607	625,271	568,995	693,777	522,826
Phoenix	1,398,400	1,404,276	1,396,530	1,022,493	301,172
Quincy	3,046,698	2,892,617	2,949,863	2,720,558	2,991,950
Ridge	374,113	328,447	290,018	296,815	251,837
Rockland	45,260	11,440	57,600	38,700	17,877
St. Clair	5,400				
Saginaw				1,800	
Shelden & Columbia					1,622
Sundry companies	33,120	48,000	83,800	55,000	4,186
Total pounds copper	34,266,771	36,070,099	38,143,001	38,880,351	41,486,252
Total value	$8,009,356	$8,180,625	$7,998,430	$7,327,880	$6,920,540

a Since this table includes mines reporting their output both for the calendar and for the fiscal years, and since some of the companies report the refined copper equivalent of mineral produced and others report refined copper, the amounts do not necessarily agree with the total of either mine or smelter output.

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1879.	1880.	1881.	1882.	1883.
Adventure	21,785	2,951	7,500	429	
Albany & Boston (Peninsula)					
Allouez	1,431,452	1,318,471	1,204,209	1,683,557	849,400
Ash Bed			24,804	73,636	1,751,377
Atlantic	2,339,073	2,341,145	2,528,009	2,634,675	2,682,197
Aztec	16,737	5,757		1,329	
Calumet & Hecla	26,270,943	31,675,239	31,360,781	32,053,528	33,125,045
Central	1,799,493	2,026,078	1,418,465	1,353,597	1,268,556
Clark	340				
Cliff	134,336	78,962	79,392	66,053	10,374
Concord					
Conglomerate	140,012	233,814	10,464	28,849	
Copper Falls		6,615	386,091	734,249	222,117
Evergreen Bluff	30,405	10,651	669,121	587,500	804,000
Flint Steel River	43,192	28,080	968		
Franklin	2,829,703	2,236,466	4,140		
Grand Portage	35,423	77,860	2,667,952	3,264,120	3,489,308
Hilton	2,050		26,264	757,080	735,598
Huron	29,760	70,285	254,515	364,579	720,213
International	417			5,625	16,462
Isle Royale	26,880	77,469	47,308	35,447	16,874
Lake Superior	1,806				
Madison			1,534		
Mass	456,294	517,159	467,684	737,440	659,474
Minesota	92,762	32,033	24,227	10,672	6,226
Minong	72,515	27,407	15,397	21,380	
National	17,506			17,060	26,006
Ogima	17,937	5,885	16,776	4,207	3,000
Nonesuch	31,973	55,584	119,061	46,450	
Osceola	3,197,387	3,381,061	4,176,976	4,179,782	4,256,409
Pewabic	332,519	970,509	1,876,244	1,482,666	1,171,847
Phoenix	543,426	436,010	409,357	537,177	512,291
Quincy	2,639,958	3,696,263	5,702,706	5,682,663	5,549,087
Ridge	215,469	223,353	235,606	102,936	60,155
Rockland	1,924				
St. Clair		13,195	125,493	87,126	125,225
Saginaw	49,464				
Shelden & Columbia		46,931	10,031	3,299	
Tamarack					
Tamarack Junior					7,435
Wolverine					
Sundry companies	15,527	6,166	884	25,623	1,188,110
Total pounds copper	42,838,468	49,601,399	53,871,959	56,582,734	59,256,786
Total value	$7,327,350	$9,947,673	$9,971,702	$10,522,416	$9,457,853

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1884	1885.	1886.	1887	1888.
Adventure	4,333	8,436	985		
Albany & Boston (Peninsula)	1,225,981		131,556		
Alimeek					
Allouez	1,932,174	2,170,476	1,725,463	885,010	314,198
Arcadian					
Arnold					
Atlantic	3,163,585	3,582,256	3,503,670	3,641,865	3,974,972
Aztec					
Baltic					
Belt					
Calumet & Hecla	40,474,585	47,247,990	50,518,220	46,016,123	50,295,721
Centennial					
Central	1,446,747	2,157,408	2,512,886	1,923,279	1,817,023
Champion					
Cliff	28,255	8,332	22,342	145	
Conglomerate	1,198,691	41,155	44,505	8,913	
Copper Falls	891,168	1,150,538	1,396,679	736,477	1,160,000
Delaware					
Evergreen					
Bluff	955	6,736	1,006	1,077	26,888
Franklin	3,748,652	3,999,172	4,264,297	3,915,838	3,655,751
Grand Portage					
Gratiot					
Hancock					
Hilton		10,342	19,135	17,155	14,961
Huron	1,927,660	2,671,163	1,996,695	1,484,103	2,375,147
International	178,351	27,433	7,488		
Isle Royale	30,164				
Kearsarge					829,185
Keweenaw					
Knowlton	21,368	21,976	38,806	38,870	
Lake					
La Salle					
Mass	562,718	363,500	247,179	16,000	70,944
Michigan					
Minesota	1,144	12,608			
Mohawk					
National	87,368	162,252	184,706	25,187	
Ogima	1,106	12,291		952	
Ojibway					
Osceola	4,247,630	1,939,169	3,560,786	3,583,723	4,134,320
Pennsylvania (North west)					
Pewabic	231,543				
Phoenix	621,004	361,108	101,804	13,497	
Quincy	5,680,087	5,848,530	5,923,519	5,924,519	6,367,809
Ridge	74,030	73,390	158,272	84,902	50,890
St. Clair	139,407	79,686			
Seneca					
Shelden & Columbia	9,828				
Superior					
Tamarack		181,669	3,646,517	7,405,606	11,409,217
Tamarack Junior					
Trimountain					
Victoria					
Winona					
Wolverine					
Sundry companies	1,399,262	621,466	253,316	70,122	5,860
Total pounds copper	69,327,796	72,759,082	80,259,832	75,793,363	86,502,886
Total value	$9,494,306	$7,942,597	$8,788,476	$8,530,342	$14,510,001

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1889.	1890	1891.	1892.	1893.
Adventure		15,485	56,008		
Albany & Boston (Peninsula)	736,507	1,108,660	1,599,670	973,217	
Ahmeek					
Allouez	1,762,816	1,409,828	1,241,423	546,530	
Arcadian					
Arnold					
Atlantic	3,698,837	3,619,972	3,653,671	3,703,875	4,221,933
Aztec					
Baltic					
Belt					
Calumet & Hecla	48,668,296	59,868,706	63,586,620	57,925,000	62,825,674
Centennial			435,784		
Central	1,270,592	1,413,397	1,321,417	1,562,867	1,177,500
Champion					
Cliff					
Conglomerate					
Copper Falls	720,000	660,000	1,440,000	1,400,000	1,000,000
Delaware					
Evergreen					
Bluff					
Franklin	4,346,062	5,638,112	4,319,840	3,767,000	3,504,244
Grand Portage					
Gratiot					
Hancock					
Hilton			6,400		
Huron	2,219,473	1,736,777	1,215,734	460,000	562,776
International					
Isle Royale					
Kearsarge	1,918,849	1,598,525	1,727,390	1,580,192	1,546,318
Keweenaw					
Knowlton			7,120		
Lake					
La Salle					
Mass			30,114	17,450	22,737
Michigan					
Minesota					
Mohawk					
National	470,301	123,897	103,888	36,385	63,433
Ogima					
Ojibway					
Osceola	4,534,127	5,294,792	6,543,358	6,894,256	6,216,975
Pennsylvania (Northwest)					
Pewabic					
Phoenix					
Quincy	6,405,686	8,064,253	43,049	11,103,926	14,39. 477
Ridge	31,969	17,645	10,542,519	41,462	
St. Clair					
Seneca					
Shelden & Columbia					
Superior					
Tamarack	10,605,451	10,106,741	16,161,312	16,426,683	15,085,113
Tamarack Junior				796,769	1,610,259
Trimountain					
Victoria					
Winona					
Wolverine			312,112	187,962	1,025,062
Sundry companies	25,000	18,569	61,197	116,780	251,304
Total pounds copper	87,413,996	100,695,359	114,408,626	107,540,354	113,511,805
Total value	$11,894,942	$15,819,960	$14,574,727	$12,431,624	$12,105,145

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1894.	1895.	1896.	1897.	1898.
Adventure					
Albany & Boston (Peninsula)					
Ahmeek					
Allouez					
Arcadian					
Arnold					
Atlantic					152,320
Aztec	4,437,609	4,832,497	4,832,497	5,109,663	4,397,339
Baltic					42,766
Belt					
Calumet & Hecla	61,842,722	77,439,907	89,280,621	83,248,054	86,426,320
Centennial					672,000
Central	584,950	370,381	469,243	614,891	291,339
Champion					
Cliff					
Conglomerate					
Copper Falls					
Delaware					
Evergreen					
Bluff					
Franklin	3,602,608	3,086,933	2,746,076	2,908,384	2,623,702
Grand Portage					
Gratiot					
Hancock					
Hilton					
Huron					
International					
Isle Royale					
Kearsarge	1,998,710	1,946,163	1,337,226	(Consolidat	ed Osceola)
Keweenaw					
Knowlton					
Lake					
La Salle					
Mass	41,805	18,372	53,507	65,250	
Michigan					
Minesota					
Mohawk					
National	36,390	50,128			
Ogima					
Ojibway					
Osceola	6,879,000	6,270,373	9,526,415	11,201,103	12,682,297
Pennsylvania (North west)					
Pewabic					
Phoenix					
Quincy	15,484,014	16,304,721	16,863,477	16,924,618	16,354,061
Ridge					
St. Clair					
Seneca					
Shelden & Columbia					
Superior					
Tamarack	15,375,000	14,840,000	16,044,860	20,222,529	19,660,480
Tamarack Junior	2,350,000	2,605,000	2,330,000	(Consolidat	ed Osceola)
Trimountain					
Victoria					
Winona					
Wolverine	1,665,255	1,817,806	2,196,791	2,316,296	4,588,114
Sundry companies	176,011	94,121	64,013	91,798	75,000
Total pounds copper	114,474,074	129,676,402	145,744,726	142,702,586	147,965,738
Total value	$10,852,122	$13,877,109	$15,758,935	$16,530,843	$17,829,871

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1899.	1900.	1901.	1902.
Adventure		23,572	29,361	606,211
Albany & Boston (Peninsula)				
Ahmeek				
Allouez				
Arcadian	500,000	1,350,000	500,000	600,000
Arnold	763,911			
Atlantic	4,675,882	4,930,149	4,666,880	4,949,366
Aztec				
Baltic	621,336	1,735,060	2,641,432	6,285,819
Belt				
Calumet & Hecla	89,610,963	77,761,382	82,519,676	81,248,739
Centennial	730,240			
Central				
Champion				4,165,784
Cliff				
Conglomerate				
Copper Falls				
Delaware				
Evergreen				
Bluff				
Franklin	1,230,000	3,663,710	3,757,419	5,237,460
Grand Portage				
Gratiot				
Hancock				
Hilton				
Huron				
International				
Isle Royale			2,171,955	3,569,748
Kearsarge				
Keweenaw				
Knowlton				
Lake				
La Salle				
Mass	42,800	122,239	950,000	2,345,805
Michigan	730,240	892,500	806,400	166,898
Minesota				
Mohawk			160,897	226,824
National				
Ogima				
Ojibway				
Osceola	11,358,049	12,566,471	13,723,487	13,416,396
Pennsylvania (Northwest)				
Pewabic				
Phoenix		88,206	93,643	100,000
Quincy	14,301,182	14,116,551	20,540,720	18,988,491
Ridge				
St. Clair				
Seneca				
Shelden & Columbia				
Superior				
Tamarack	18,565,602	19,182,502	18,000,852	15,961,528
Tamarack Junior				
Trimountain				5,732,160
Victoria				
Winona	763,911	856,000	108,000	101,188
Wolverine	4,500,373	4,789,829	4,946,126	6,473,181
Sundry companies	50,000			
Total pounds copper.	148,444,489	142,078,171	155,616,848	170,175,598
Total value	$26,098,382	$23,691,928	$26,038,857	$20,711,592

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1903.	1904.	1905.	1906.
Adventure	2,182,608	1,380,480	1,606,208	1,552,628
Ahmeek		350,000	1,552,957	3,077,507
Allouez				4,486,900
Atlantic	5,505,598	5,321,859	4,049,731	1,439,082
Aztec				
Baltic	10,580,997	12,177,729	14,384,684	14,397,557
Calumet & Hecla	76,490,869	80,341,019	95,100,160	100,023,420
Centennial		641,294	1,446,584	2,253,015
Champion	10,564,147	12,212,954	15,707,426	16,954,986
Franklin	5,309,030	4,771,050	4,206,085	4,571,570
Isle Royale	3,134,601	2,442,905	2,973,761	2,937,098
Mass	2,576,447	2,182,931	2,007,950	2,106,739
Michigan	275,708	2,746,127	2,891,796	2,875,341
Mohawk	6,284,327	8,149,515	9,387,614	9,352,252
Osceola	16,059,636	20,472,429	18,938,965	18,588,451
Phoenix	202,823	1,162,201	273,219	
Quincy	18,498,288	18,343,160	18,827,557	16,194,838
Tamarack	15,286,093	14,961,885	15,824,068	9,832,644
Trimountain	9,237,051	10,211,230	10,476,462	9,507,933
Victoria				546,334
Winona	1,036,944	646,025		278,182
Wolverine	9,024,034	9,764,455	9,464,418	9,548,123
Total pounds copper.	192,249,201	208,279,248	229,119,645	230,524,600
Total value	$26,383,449	$27,107,107	$36,616,586	$43,940,489

PRODUCTION OF MICHIGAN COPPER MINES.—*Continued.*

	1907.	1908.	1909.	1910.
Adventure	1,244,874	90,870	.....	.....
Ahmeek	5,510,985	6,280,241	9,198,110	11,844,954
Allouez	2,934,116	3,047,051	4,031,532	4,655,702
Baltic	16,704,868	17,724,854	17,817,836	17,549,762
Calumet & Hecla	83,863,116	82,549,979	80,096,995	72,059,545
Centennial	2,373,572	2,196,377	2,583,793	1,572,566
Champion	16,489,436	17,786,763	18,005,071	19,224,174
Franklin	4,401,248	3,707,518	1,615,556	966,353
Isle Royale	2,667,608	3,011,664	5,719,056	7,567,339
Keweenaw	.....	122,474	57,091	36,682
Lake	.....	.....	.....	318,050
La Salle	.....	.....	.....	.....
Mass	2,078,677	1,766,930	1,723,436	1,321,885
Michigan	2,665,404	3,000,206	1,979,305	.....
Mohawk	10,107,266	10,295,881	11,248,474	11,412,066
Osceola	14,134,753	21,250,794	25,296,657	19,346,566
Quincy	19,796,058	20,600,361	22,511,984	22,517,014
Superior	.....	21,244	1,781,315	3,181,041
Tamarack	11,078,604	12,806,127	13,533,207	11,063,606
Trimountain	8,190,711	6,034,908	5,282,404	5,694,868
Victoria	1,207,237	1,290,040	1,062,218	1,164,564
Winona	1,285,863	.....	.....	.....
Wolverine	9,272,351	9,955,233	9,971,482	9,666,534
Total pounds copper.	216,006,747	223,539,515	233,515,522	221,163,271
Total value	$43,751,290	$29,601,603	$30,586,693	$28,459,270

PRODUCTION OF MICHIGAN COPPER MINES.—*Concluded.*

	1911.	1912.	1913.	1914.
Ahmeek	15,196,127	16,455,769	9,220,874	13,634,605
Allouez	4,780,494	5,525,455	4,091,129	6,056,548
Baltic	15,370,449	13,373,961	7,736,126	7,001,945
Calumet & Hecla	74,130,977	67,856,429	45,016,890	53,691,562
Centennial	1,493,834	2,567,385	1,612,262	2,287,130
Champion	15,639,426	17,225,508	12,080,594	15,807 206
Franklin	820,203	1,710,651	1,021,440	93,283
Gratiot	14,275	.....	.....	.....
Hancock	754,729	.....	.....	488,678
Isle Royale	7,490,120	8,186,957	4,158,548	6,601,235
Keweenaw	633,778	.....	.....	.....
Lake	.....	.....	287,200	.....
La Salle	.....	.....	43,906	540,731
Mass	1,326,998	2,045,006	1,713,545	2,944,952
Michigan	327,773	162,950	.....	.....
Mohawk	12,091,056	11,995,598	5,778,235	11,094,859
Osceola	18,388,193	18,413,387	11,325,010	14,970,737
Quincy	22,252,943	20,634,800	12,184,128	15,356,380
Superior	3,236,233	3,921,974	2,992,765	3,217,635
Tamarack	7,494,077	7,908,174	4,168,743	1,074,808
Trimountain	6,120,147	6,980,713	4,990,938	5,048,306
Victoria	1,303,331	1,224,911	1,428,693	1,486,242
Winona	1,275,675	2,307,337	1,448,737	1,352,085
Wolverine	9,630,639	9,120,485	8,350,312 (1912–1913)	3,435,459 (1913–1914)
Total pounds copper.	219,771,477	217,617,450	139,650,075	166,184,386
Total value	$27,743,572	$38,001,784	$24,042,440	$21,426,122

PRODUCTION OF COPPER IN THE UNITED STATES IN 1913 AND 1914.[1]

(Smelter output, in pounds fine.)

	1913.	1914.
Alaska	23,423,070	24,985,847
Arizona	404,278,809	382,449,922
California	32,492,265	29,784,173
Colorado	9,052,104	7,316,066
Idaho	8,711,490	5,875,205
Maryland	.....	12,248
Michigan	155,715,286	158,009,748
Missouri	576,204	53,519
Montana	285,719,918	236,805,845
Nevada	85,209,536	60,122,904
New Mexico	50,196,881	64,204,703
North Carolina	180	19,712
Oklahoma	11	.....
Oregon	77,812	5,599
Pennsylvania	245,337	422,741
Philippine Islands	22	.....
South Dakota	4,549	.....
Tennessee	19,489,654	18,661,112
Texas	39,008	34,272
Utah	148,057,450	160,589,660
Vermont	5,771	.....
Virginia	46,961	17,753
Washington	732,742	683,602
Wisconsin	.....	10,098
Wyoming	362,235	17,082
Undistributed	46,803	55,381
Totals	1,224,484,098	1,150,137,192
Total value	$189,795,035	$152,968,246

[1]Figures from U. S. G. S. report by B. S. Butler.

SUMMARY OF RESULTS OBTAINED BY MICHIGAN COPPER MINING COMPANIES IN 1914.

	Tons of ore treated.	Cost of mining, transportation, and stamping per ton.	Pounds of concentrate obtained.	Pounds of refined copper produced.	Per cent of refined copper in concentrate.	Pounds of refined copper per ton of ore treated.	Cost per pound at mine excluding construction.	Cost per pound, construction.	Cost per pound smelting, freight, commission and eastern office.	Other costs per pound.	Cost per pound interest paid.	Total cost per pound.	Price received for copper sold.
Ahmeek	590,519	1.55	20,333,000	13,634,605	67.06	23.1	6.73	1.68	1.30	.....	.....	9.71	13.08
Allouez	354,457	1.583	9,408,470	6,056,548	64.37	17.09	9.26	.....	1.83	.....	0.09	11.18	12.853
Baltic	324,433	2.17	.....	7,001,945	.....	21.58	9.90	.....	1.11	0.16	.....	11.17	13.38
C. & H. (all ore)	2,592,462	1.85	.....	53,691,562	.....	20.70	.....	1.00	.....	.....	.....	11.35	14.01
C. & H. (Conglomerate)	1,439,986	2.37	.....	37,996,045	.....	26.38	.....	.....	.....	.....	.....	10.42	14.01
C. & H. (Osceola lode)	1,152,476	1.19	.....	15,695,517	.....	13.62	.....	.....	.....	.....	.....	10.20	14.01
Centennial	138,136	1.838	3,311,780	2,287,130	.....	16.56	11.10	.....	1.11	0.31	0.35	12.56	12.111
Champion	614,854	2.11	.....	15,807,206	69.06	25.71	7.92	.....	0.98	.....	.....	9.21	13.38
Franklin	7,324	.....	175,944	93,283	.....	12.73	.....	.....	.....	.....	.....	.....	13.99
Hancock	.....	.....	.....	488,678	.....	.....	.....	.....	.....	.....	.....	.....	13.389
Isle Royale	474,349	1.49	9,451,115	6,601,235	69.85	13.9	10.67	0.53	1.46	0.48	0.21	13.05	13.16
La Salle	45,509	.....	.....	540,731	.....	11.88	.....	.....	.....	.....	.....	.....	12.707
Mass	209,354	.....	4,487,425	2,944,952	65.62	14.07	.....	.....	1.394	0.526	.....	13.526	12.751
Mohawk	649,649	1.24	14,591,000	11,094,859	76.04	17.08	7.27	.....	.96	0.35	.....	8.23	12.47
Osceola	1,108,447	1.29	20,997,900	14,970,737	71.296	13.5	9.52	0.14	1.12	.....	0.01	10.79	13.14
Quincy	1,016,660	.....	22,612,460	15,356,380	.....	.....	.....	.....	.....	.....	.....	.....	13.3
Superior	191,628	1.75	.....	3,217,635	.....	16.79	10.41	3.28	2.01	.....	0.01	12.43	12.645
Tamarack	57,410	4.49	1,743,145	1,074,808	61.66	18.7	24.00	.....	1.80	.....	.....	29.08	12.80
Trimountain	227,251	2.01	.....	5,048,306	.....	18.21	10.78	.....	1.18	0.25	.....	12.21	13.38
Victoria	124,842	.....	2,272,430	1,486,242	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winona	123,339	.....	2,239,170	1,352,085	.....	10.96	.....	.....	.....	.....	.....	.....	14.2
Wolverine (1913-14)	182,127	1.92	4,606,015	3,435,459	74.59	18.86	9.85	.....	1.45	.....	.....	11.30	14.09

SUMMARY OF FINANCIAL STATEMENTS OF MICHIGAN COPPER MINING COMPANIES FOR 1914.

	Balance of Assets (+), Liabilities (−). December 31, 1913.	Receipts.		Assessments.	Dividends.	Balance of Assets (+), Liabilities (−). December 31, 1914.
		Sale of Copper.	Sale of Silver.			
Ahmeek	+$706,128 53	$1,783,411 07	$4,025 54		$200,000 00	+$968,774 98
Algomah	+27,707 39	1,695 51				+14,597 64
Allouez	+249,292 42	778,418 38	13,402 65			+363,822 85
Atlantic	+220,657 06					+231,330 39
Baltic	+336,317 72	936,627 19				+490,550 85
Calumet & Hecla	+2,419,964 05				1,000,000 00	[1]+3,118,204 33
Centennial	+27,847 78	279,001 69				+24,634 69
Champion	+548,643 45	2,114,468 18				+1,206,819 44
Cliff	+46,317 52					+36,379 30
Contact						+4,703 36
Copper Range Consolidated						+1,105,226 21
Franklin	−100,264 87	7,617 97		$334,564 00		+117,165 81
Gratiot	−379,852 73					−400,833 59
Hancock		65,427 05		200 00		[2]+14,923 53
Houghton	+15,265 23			5,424 00		−7,650 05
Indiana	+6,730 05					−29,532 51
Isle Royale	+175,441 57	868,410 10	17,477 98			+199,815 69
La Salle	+158,827 04	69,199 90	3,583 25			+110,158 74
Laurium	−8,020 94					−14,657 14
Mass	−18,658 94	375,530 16		100,000 00		+45,887 12
Mayflower	+14,684 88			75,064 00		+55,115 64
Mohawk	+521,155 92	1,383,330 34			100,000 00	+852,208 98
New Arcadian	+24,558 22			11,623 75		+10,431 95
New Baltic	+3,908 27					+869 80
North Lake	+49,408 33					+18,946 84
Old Colony	+25,151 15			79,153 00		+56,971 80
Osceola	+1,549,300 06	1,967,725 27			288,450 00	+1,613,436 31
Quincy	+746,938 34	2,041,992 31	12,630 00		55,000 00	+897,531 77
Seneca	−154,454 75					−166,939 51
South Lake	+46,606 36					−3,790 64

[1]Surplus of cash and quick assets Dec. 31, 1914, $6,902,866.46: notes outstanding dated Feb. 18, 1909, $4,134,000. On Dec. 31, 1914, $450,000 of these notes had been purchased.
[2]During the year Hancock borrowed $164,000 from eastern bankers.

SUMMARY OF FINANCIAL STATEMENTS OF MICHIGAN COPPER MINING COMPANIES FOR 1914.—*Concluded.*

	Balance of Assets (+), Liabilities (−). December 31, 1913.	Receipts.		Assessments.	Dividends.	Balance of Assets (+), Liabilities (−). December 31, 1914.
		Sale of Copper.	Sale of Silver.			
St. Mary's	+224,903 23					+115,929 69
Superior	+193,697 01	406,871 78	16,247 05			+216,872 76
Tamarack	+1,070,938 19	137,600 45				+895,993 22
Trimountain	+444,757 68	675,293 75				+503,397 61
Victoria	+10,685 51	133,867 15		74,234 00		+40,624 36
White Pine	−6,080 32					[3]−134,559 74
Winona	+74,508 16	109,797 25		172,829 00		+92,648 62
Wolverine	+748,034 20	484,061 05				[4]+829,109 29
Wyandot	+26,887 68			1,010 00		[5]+12,205 94

[3]Received from sale of 7,275 shares of preferred stock at par ($25) per share, $181,875.00.
[4]For year ending June 30, 1914.
[5]For year ending March 31, 1915.

DETAILED RESULTS OF THE HARDINGE MILL REGRINDING DEPARTMENT AT THE WINONA MINE.

	Total.	Cents per ton reground.	Per cent.	Units per ton reground.
Power at 1.054 cents per K. W. Hr...	$8,116 05	13.64	79.22	12.94 K. W. Hr.
Labor	384 70	.65	3.75	.....
Supplies.				
Pebbles at .8 cents per pound	1,237 12	2.08	12.07	2.60 lbs.
Silex Lining at 1.436 cents per pound..	57 48	.09	.56	.07 lbs.
Steel lining at 5.242 cents per pound..	197 40	.33	1.93	.063 lbs.
Incidentals	252 91	.43	2.47	.....
	$10,245 66	17.22	100.00	.....

Tons stamped	123,339.45
Copper by assay from Hardinge mill mineral	265,518.00 lbs.
Copper from Hardinge mill mineral per ton stamped	2.1527
Tons reground	59,500
Copper per ton reground	4.462
Regrinding cost per pound copper obtained	.03859
Regrinding cost per ton stamped	.083069

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.

Name of Mine.	1905 and prior years.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	Total.
American (Sterling)	112,930	419	13,764	23,222	90,001	163,290	195,197	122,211	162,253	84,845	68,132
Ames	6,298										6,298
Barnum (Cliff Shaft)[1]	801,851										801,851
Bay State	16,637										16,637
Bessemer (See Lillie)											
Bessie	57,451	1,646									59,097
Beaufort (Ohio)	354,654		78,029	61,035	72,987	23,427	2,683				592,85
Blue (See Queen Group)											
Boston (with American)	62,542										62,542
Braastad { Mitchell	136,636										136,636
Braastad { Winthrop	831,445										831,445
Breitung No. 1							63,497	57,085	30,994	49,590	201,166
Breitung Hematite No. 2	17,723	83,671	59,667	55,849	129,673	114,202	72,688	63,995	83,280	27,705	708,453
Buffalo[2]	217,730										217,730
Cambria	1,639,152	40,628	135,145	85,977	136,815	150,422	85,954	69,904	169,153	132,834	2,645,984
Champion	4,160,289	115,007	107,577	313	11,199	18,746					4,413,131
Chase									52,930	19,708	72,638
Chester (See Rolling Mill)											
Chicago	9,012										9,012
Cleveland[3]	2,806,298										2,806,298
Cleveland Hematite (Included under Cleveland)											
Cleveland Cliffs Group[4]	11,562,222	1,330,944	1,030,928	438,379	877,433	955,374	514,305	1,032,836	922,005	672,428	19,336,854
Columbia (Kloman)	94,813										94,813
Curry	16,671										16,671
Dalliba (Phoenix)	59,114										59,114
Detroit	140,841										140,841
Dexter	118,512										118,512
Dey	2,709										2,709
East Champion	76,002										76,002
East New York	327,604										327,604
Edison	893										893
Edwards (See Sampson)											
Empire			40,565	53,537	108,993	53,687	16,954	33,124	38,348		345,208
Erie	8,136										8,136
Etna	1,091										1,091
Fitch	31,817										31,817
Foster[5]	171,893										171,893
Foxdale	31,447										31,447
Gibson	16,357										16,357
Goodrich	49,754										49,754
Grand Rapids (Davis)	110,736										110,736
Green Bay (See Bay State)											
Hartford	544,943	364,801	328,161	278,366	250,680	183,471					1,950,422
Himrod										14,466	14,466
Hortense (North Champion)	30,574										30,574
Home (P. and L. S.) (Now Volunteer)	26,022										26,022
Humboldt (Washington)	713,961										713,961
Imperial	152,150	5,076	55,756	48,231	115,478	83,404	86,959	53,943	37,543		638,540
Indiana (See Bay State)											
Iron Cliffs[6]	1,700,537										1,700,537
Iron Mountain	393										393
Jackson	3,802,042	5,066	61,345		11,060	40,320	22,303	53,559	1,519	20,241	4,017,455
Keystone (See East Champion)											
Lake[10]											
Lake Angeline	7,232,262	269,116	283,373	220,410	280,298	244,923	167,258	151,910	102,762	128,073	9,080,385
Lake Superior	13,010,436	635,671	674,066	261,955	349,435	271,445	167,352	169,326	164,834	133,519	15,838,039
Lillie	1,564,824	32,781	80,545	8,632	61,708	10,121	25,597	26,119			1,810,327
Loyd							28,003	44,224	135,746	123,211	331,184
Lucy (McComber)	516,159	85		1,115	1,672	11,257	16,676	72,724			619,688
Maas			32,378	29,036	159,197	208,103	24,926	46,664	171,475	55,903	727,682
Magnetic (Stock Pile)		292									292
Manganese (Negaunee)	6,359										6,359
Marquette[7]	152,847										152,847
Mary Charlotte	304,926	257,088	155,633	99,104	240,433	197,522	340,335	250,700	262,431	57,138	2,165,310
Mesabi's Friend	16,043										16,043
Michigamme[6]	880,362										880,362

See foot notes 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 on pages 224 and 225

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.—*Continued.*

Name of Mine.	1905 and prior years.	1906.	1907.	1908.
Miller	4,756			
Milwaukee-Davis	375,451			
Mitchell	17,780			11,539
Moore	68,131			
Morris				
National	150,216			
Negaunee	2,568,073	253,448	196,170	232,219
Negaunee Construction Works	12,708			
New York (York)	1,123,071			
New York Hematite	37,587			
North Champion (See Hortense)				
North Republic	289			
Nonpareil (St. Lawrence)	23,395			
Northwest	1,687			
Norwood	5,753			
Ogden	986			
Pascoe	59,806			
Pendill	45,993			
Palmer	1,041	13,131		
Palmer (Cascade) (See Volunteer)				
Pioneer	15,409			
Pittsburg & Lake Angeline (See Lake Angeline)				
Platt	73,844			
Portland				
Primrose	6,040			
Prince of Wales[2]	32,415			
Quartz	491			
Queen[2]	180,866			
Queen Group[3]	4,443,378	221,096	309,917	104,098
Republic	5,601,121	177,220	170,554	67,999
Republic Reduction Co	47,174			
Richards	8,261			
Richmond	400,176	89,563	35,156	60,994
Riverside	16,160			
Rolling Mill	344,426		49,204	52,147
Saginaw	451,424			
Salisbury[5]	686,411			
Sam Mitchell (See Mitchell)				
Sampson (Argyle)	267,805			
Shadt	1,261			
Section 12	21,887			
South Buffalo[2]	245,412			
Spurr	165,244			
Star West (Wheat)	204,649			
St. Lawrence (See Nonpareil)				
Sterling (See American)				
Taylor	32,970			
Teal Lake (See Cambria)				
Titan	90,371			
Volunteer (See also Home)	1,344,609	38,544	10,022	
Washington				20,625
Webster	34,905			
West Republic	133,077			
Wetmore	50,870			
Wheeling	433,771			
Winthrop[9]	1,335,839			
Wheat (See Star West)				
Totals	75,873,089	3,935,293	3,907,955	2,214,782

[1]Under Iron Cliffs 1890-1895; under Cleveland-Cliffs group after 1895.
[2]Under Queen group after 1890.
[3]Under Cleveland-Cliffs group after 1883.
[4]Includes Cleveland after 1883; includes Barnum, Foster, Iron Cliffs, Michigamme and Salisbury after 1895.
[5]Under Iron Cliffs 1891-1895; under Cleveland-Cliffs group after 1895.

IRON ORE SHIPMENTS FROM THE MARQUETTE RANGE.—*Concluded.*

1909.	1910.	1911.	1912.	1913.	1914.	Total.
						4,756
		7,781	11,536	10,310		405,078
	23,428	21,387	21,141	15,970		111,245
						68,131
			1,529	18,394	29,063	48,986
						150,216
312,217	348,818	140,040	442,190	327,447	247,484	5,068,106
						12,708
						1,123,071
						37,587
						289
						23,395
						1,687
						5,753
						986
						59,806
						45,993
						14,172
						15,409
						73,844
79,652	49,584				45,324	174,560
						6,040
						32,415
						491
						180,866
237,509	230,119	295,962	224,862	235,648	178,574	6,481,163
176,575	150,732	113,137	156,867	135,879	52,562	6,802,646
						47,174
						8,261
102,566	95,772	47,293	117,873	138,394	129,551	1,217,338
						16,160
133,139	115,193	96,584	115,784	163,287	98,010	1,167,774
						451,424
						686,411
						267,805
						1,261
						21,887
						245,412
						165,244
						204,649
						32,970
						90,371
		51,240	9,008	47,220	38,438	1,539,081
44,716	96,769	62,010	66,540	60,171	1,659	352,490
						34,905
						133,077
						50,870
						433,771
						1,335,839
3,983,436	3,840,129	2,666,121	3,415,654	3,487,993	2,340,326	105,664,778

[6]Under Cleveland-Cliffs group after 1895.
[7]Under Winthrop after 1892.
[8]Includes Buffalo, Prince of Wales, Queen and South Buffalo after 1890.
[9]Prior to 1890. see Braastad; includes Marquette after 1892.
[10]Included in Cleveland Cliffs Group.

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

	1905 and prior years.	1906.	1907.	1908.
(Austin)			195,950	111,229
Gwinn				
(Princeton) (Swanzy or Chesire)	847,447	166,894	177,863	36,033
Stegmiller				
(Stephenson)			6,305	52,588
Total	847,447	166,894	380,118	199,850

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

	1905 and prior years.	1906.	1907.	1908.
Ada (included in Ironton)				
Anvil and North Anvil	543,420	79,493	39,495	35,937
Ashland	4,228,036	341,841	298,056	259,611
Asteroid				
Aurora (Norrie-Aurora Group after 1904)	3,961,684			
Bessemer	20,889			
Blue Jacket	1,799			
Brotherton	1,301,127	147,281	104,224	96,776
Castile		2,108	6,157	
Chicago	68,727			
Colby	2,014,467	113,001	94,480	58,305
Davis (Wisconsin)	103,961			
Eureka	128,719	37,525	57,904	122,324
Federal	36,443			
First National	1,997			
Geneva	7,108			
Imperial (See Federal)				
Iron Chief	12,199			
Iron Chief No. 2	551			
Iron King (See Newport)				
Ironton	182,233	106,158	190,968	92,932
Jack Pot	99,090			
Meteor (Comet)	216,367			
Mikado	493,339	154,043	163,891	86,617
New Davis (See Davis)				
Newport and Bonnie	3,156,054	549,745	551,496	579,390
Norrie-Aurora Group (after 1904)	13,639,279	1,245,997	1,109,085	773,243
Pabst (Norrie-Aurora Group)	2,366,583			
Palms	1,278,867	5,622		
Pike	27,399	17,934	24,922	6,303
Puritan (Ruby)	109,572			
Royal				
Section 13				
Sparta	4,862			
Sunday Lake	913,355	86,879	101,899	111,130
Tilden	4,340,752	169,697	312,496	111,184
Vaughn (See Aurora) (Norrie-Aurora Group after 1904)				
Wakefield				
Wisconsin (See Davis)				
Yale (West Colby)	192,174	56,657	38,010	14,874
Total	39,451,053	3,113,981	3,093,083	2,348,626

IRON ORE SHIPMENTS FROM THE GWINN DISTRICT. (GROSS TONS)

1909.	1910.	1911.	1912.	1913.	1914.	Total.
125,858	188,588	110,839	102,530	107,365	30,493	972,852
		230			20,159	20,389
42,934	89,441	54,442	143,519	53,479	13,607	1,625,659
39,869	48,842	45,122	50,963	45,431	40,972	271,199
64,075	225,726	135,474	214,386	96,298	93,796	888,648
272,736	552,597	346,107	511,398	302,573	199,027	3,778,747

IRON ORE SHIPMENTS FROM THE GOGEBIC RANGE, MICHIGAN.

1909.	1910.	1911.	1912.	1913.	1914.	Total.
22,927	7,235	310	55,610	238	5,771	790,436
259,612	231,506	151,478	211,927	2,635	123,702	6,108,404
		20,569	70,239	42,419	135,120	268,347
						3,961,684
						20,889
						1,799
103,090	102,626	65,015	148,930	70,138	47,662	2,186,869
26,982	20,197	23,597	136,703	57,595	36,569	309,908
						68,727
170,095	194,754	41,673	245,195	305,744	291,947	3,529,661
						103,961
115,662	41,611	98,609	65,723	14,562	23,430	706,069
						36,443
						1,997
				31,303		38,411
						12,199
						551
277,594	109,025	63,359	173,135	166,123	51,138	1,412,665
						99,090
						216,367
99,195	52,715			33,111	2,094	1,085,005
1,008,354	1,182,324	555,853	966,435	1,139,666	702,861	10,392,178
977,054	1,333,006	883,910	1,500,758	1,503,451	985,199	23,950,982
						2,366,583
			39,152	88,644	173,792	1,586,077
22,174	3,324					102,056
	50,019		90,683	64,463	58,410	373,147
				10,659	11,686	22,345
				3,844		3,844
						4,862
93,712	115,486	56,096	155,485	110,374	54,327	1,798,743
154,506	99,937	138,387	158,191	97,686	114,777	5,697,613
				15,261	313,050	328,311
71,458	108,253	154,944	76,772	89,482	19,074	821,698
3,402,415	3,652,918	2,253,800	4,094,938	3,847,398	3,150,609	68,407,921

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

	1905 and prior years.	1906.	1907.	1908.
Antoine	1,056,941	195,855	100,996	.....
Aragon	4,490,305	431,000	441,636	226,354
Breen	34,055	21,004	20,366	.....
Briar Hill	14,981	.....	.....	.....
Chapin	13,404,416	943,425	855,308	391,620
Clifford & Traders	.....	.....	.....	.....
Cornell	49,302	.....	.....	.....
Cuff	58,419	.....	.....	.....
Cundy	807,967	.....	.....	1,410
Curry	416,928	.....	.....	.....
Cyclops	286,093	.....	.....	.....
Eleanor (Appleton)	13,921	3,121	1,677	.....
Emmett	66,655	.....	.....	.....
Forest	11,988	.....	.....	.....
Half and Half	7,524	.....	.....	.....
Hamilton	96,072	.....	.....	.....
Hersel	955	.....	.....	.....
Indiana	17,871	.....	.....	.....
Keel Ridge	93,101	.....	.....	.....
Loretto	844,884	140,390	99,779	13,354
Ludington	1,001,518	.....	.....	.....
Millie (Hewitt)	298,550	36,815	18,691	3,322
Munro	133,254	47,454	46,834	27,773
Norway	1,291,352	.....	.....	.....
Penn Iron Mining Co	3,355,423	496,582	381,128	176,211
Perry	3,138	.....	.....	.....
Pewabic	5,135,259	493,891	457,796	365,341
Quinnesec	499,756	.....	.....	.....
Saginaw (Perkins)	396,225	21,017	26,080	38,669
Stephenson	39,350	.....	.....	.....
Sturgeon River	19,404	.....	.....	.....
Verona	130,975	.....	.....	.....
Vivian	224,286	122,577	48,493	10,056
Vulcan (with Penn Mines)	1,668,654	.....	.....	.....
Walpole	19,089	.....	.....	.....
Total	36,018,571	2,953,131	2,498,784	1,254,110
METROPOLITAN TROUGH.				
Groveland	26,123	.....	13,913	9,123
Metropolitan	107,027	.....	.....	.....
Northwestern	35,810	.....	.....	.....
Total	168,960	.....	13,913	9,123
CALUMET TROUGH.				
Calumet	38,713	15,773	51,646	15,222

IRON ORE SHIPMENTS FROM THE MENOMINEE DISTRICT, MICHIGAN.

1909.	1910.	1911.	1912.	1913.	1914.	Total.
.....	.....	.....	.....	.....	.....	1,353,792
246,984	241,046	201,269	244,812	230,958	188,765	6,943,129
.....	.....	.....	.....	.....	.....	75,425
.....	.....	.....	.....	.....	.....	14,981
587,647	465,543	357,598	327,999	369,822	341,493	18,044,871
103,626	91,081	90,940	74,144	95,311	66,329	521,431
.....	.....	.....	.....	.....	.....	49,302
.....	.....	.....	.....	.....	.....	58,419
5,512	.....	.....	.....	.....	.....	844,889
.....	.....	.....	.....	.....	.....	416,928
.....	.....	.....	.....	.....	.....	286,093
.....	.....	.....	.....	.....	.....	18,719
.....	.....	.....	.....	.....	.....	66,655
.....	.....	.....	.....	.....	.....	11,988
.....	.....	.....	.....	.....	.....	7,524
.....	.....	.....	.....	.....	.....	96,072
.....	.....	.....	.....	.....	.....	955
.....	.....	.....	.....	.....	.....	17,871
.....	.....	.....	.....	.....	.....	93,101
96,613	116,048	18,579	135,177	158,257	45,449	1,668,530
.....	.....	.....	.....	.....	.....	1,001,518
10,887	.....	18,556	.....	.....	361	387,182
23,241	20,022	9,303	20,100	18,509	.....	346,490
.....	.....	.....	.....	.....	.....	1,291,352
428,004	344,760	377,026	426,743	416,410	214,827	6,617,114
.....	.....	.....	.....	.....	.....	3,138
465,453	380,376	352,598	279,771	364,176	299,228	8,593,849
3,147	744	.....	.....	.....	.....	503,647
19,994	.....	.....	.....	.....	.....	501,985
.....	.....	.....	.....	.....	.....	39,350
.....	.....	.....	.....	.....	.....	19,404
.....	.....	.....	.....	.....	.....	130,975
.....	14,827	5,971	28,800	27,177	.....	482,187
.....	.....	.....	.....	.....	.....	1,668,654
.....	.....	.....	.....	.....	.....	19,089
1,991,108	1,674,447	1,431,840	1,537,546	1,680,620	1,156,452	52,196,609
24,933	26,462	33,758	12,468	9,251	.....	156,031
.....	.....	.....	.....	.....	.....	107,027
.....	.....	.....	.....	.....	.....	35,810
24,933	26,462	33,758	12,468	9,251	.....	298,868
.....	.....	.....	35,587	18,976	.....	175,917

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

	1905 and prior years.	1906.	1907.	1908.
Alpha	1,370			
Armenia	247,061	27,882	36,665	
Bristol (Claire)	954,535	298,031	345,676	190,300
Carpenter				
Columbia	942,703			
Crystal Falls	1,507,940	111,871	114,158	296
Delphic	33,770			
Dunn	1,086,178	91,476	141,992	8,829
Fairbanks	8,500			
Genesee (Ethel)	285,899	80,971	38,984	
Gibson	16,357			4,548
Great Western	1,089,526	311,218	234,492	124,246
Hemlock	1,169,885	106,437	117,181	83,834
Hilltop	12,409	7,820		
Hollister	4,098		6,371	10,671
Hope	28,530			
Judson				
Kimball			16,224	
Lamont (Monitor)	423,271	89,980	42,090	
Lee Peck	2,844			
Lincoln	233,366	5,890	714	
Magnate	6,844			
Mansfield	756,120		183,532	44,633
Mastodon	425,708			
McDonald				
Michigan	113,219	146	39,819	603
Monongahela	9,310			
Paint River (Fairbanks)	267,163	28,321	75,805	
Ravenna				
Richards				
Sheldon & Shafer (Union) (See Columbia)				
South Mastodon	8,203			
Tobin	399,779	235,867	237,781	161,642
Youngstown	151,425			
Total	10,186,013	1,395,910	1,631,484	629,602

IRON ORE SHIPMENTS FROM THE CRYSTAL FALLS DISTRICT, MICHIGAN.

1909.	1910.	1911.	1912.	1913.	1914.	Total.
						1,370
396,825	65,473 270,742	51,862 322,729	150,808 438,900	83,202 379,169	50,501 172,006	713,454 3,768,913
					51,147	51,147
						942,703
986						1,735,251
						33,770
193,396	136,144	232,092	242,304	61,080	52,883	2,246,374
						8,500
65,585	66,185	25,342	4,248			567,214
36,246	45,202	56,528				158,881
112,747	80,709	84,338	3,342	50,464		2,091,081
112,481	115,407	107,753	126,132	113,201	46,449	2,098,760
					8,223	28,452
25,842	49,434	5,022		25,251	16,430	143,119
						28,530
					6,619	6,619
						16,224
	3,183					558,524
						2,844
1,657						241,627
						6,844
118,713	114,357	54,646		190,503		1,462,504
						425,708
1,114	6,022	5,240	1,384	16,499		30,259
	17,922			27,917	9,471	209,107
						9,310
						371,289
		127	18,303	70,766	49,308	138,504
					7,069	7,069
						8,203
359,668	235,812	308,456	319,318	154,896	65,351	2,478,570
						151,425
1,425,261	1,206,592	1,254,135	1,304,739	1,172,948	535,457	20,742,149

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

	1905 and prior years.	1906.	1907.	1908.
Baker				
Baltic	489,586	186,495	189,119	129,037
Bengal				
Berkshire				3,440
Beta	4,211			
Caspian	16,578	80,875	138,867	102,628
Cortland				
Chatham-Riverton			14,883	45,826
Davidson No. 1				
Davidson No. 2				
Chicagon				
Fogarty			7,949	32,560
Forbes				
Hiawatha	210,663	20		138,190
Iron River	904,587			
James (Osana)			2,360	59,760
*Dober-Isabella	65,192			
Nanaimo	227,890	91,792	53,778	305
Riverton (Dober and Isabella)	670,763	161,704	90,358	47,073
Rogers				
Selden	2,092			
Sheridan	116,299			
Tully				
Virgil				
Wauseca				
Wickwire				
Youngs	10,926	47,583	92,632	70,094
Zimmerman				1,832
Total	2,718,787	568,469	589,946	630,745

*Riverton.

IRON ORE SHIPMENTS FROM THE IRON RIVER DISTRICT, MICHIGAN.

1909.	1910.	1911.	1912.	1913.	1914.	Total.
45,003	39,417	3,290		24,286	113,733	225,729
174,426	171,930	66,502	100,736	130,631	29,206	1,667,668
				23,259	5,539	28,798
34,295	97,999	22,272	33,422		23,826	215,254
						4,211
189,023	171,334	165,660	306,914	295,841	279,379	1,747,099
			17,499	26,823	15,316	59,638
68,730	51,988	58,054	135,298	107,604	19,455	501,838
		215	27,614	115,499	70,881	214,209
		45,219	98,760	79,948	51,686	275,613
		108,947	149,619	137,002	114,849	510,417
77,356	51,071	67,616	84,074	124,568	15,329	460,523
				69,435	77,960	147,395
136,739	128,884	116,633	220,106	160,511	91,370	1,203,116
						904,587
90,851	78,388	50,439	75,702	176,634	73,832	607,966
						65,192
						373,765
171,200	84,269	200,142	171,493	160,818	176,274	1,934,094
					27,081	27,081
						2,092
						116,299
	2,726	8,323		16,650	63,411	91,110
			3,750	48,395	5,972	58,117
		749		12,377		13,126
		1,919	40,417	40,322	25,584	108,242
154,150	98,399	89,450	83,528	43,649		690,411
10,303	25,555	110,084	187,584	149,309	172,720	657,387
1,152,076	1,001,960	1,115,514	1,736,516	1,943,560	1,453,403	12,910,976

SUMMARY OF IRON ORE SHIPMENTS FROM MICHIGAN RANGES. (GROSS TONS.)

	1901 and prior years.	1902.	1903.	1904.	1905
Marquette	62,368,847	3,749,977	2,956,022	2,767,242	4,086,943
Gwinn	440,636	118,048	84,223	76,461	129,079
Menominee	26,033,394	3,001,189	2,528,819	1,712,800	2,741,169
Crystal Falls	6,265,440	1,003,785	824,461	917,969	1,174,366
Iron River	1,464,196	355,110	276,785	284,273	337,973
Gogebic	29,072,290	3,018,255	2,465,263	2,042,398	3,215,352
Metropolitan	136,826	8,923	18,574	4,737	.....
Calumet	38,913	.....	.....	.....	.....
Total	125,820,442	11,255,287	9,154,147	7,805,880	11,684,432

	1906.	1907.	1908.	1909.	1910.
Marquette	3,935,293	3,907,955	2,214,782	3,983,436	3,840,129
Gwinn	166,894	380,118	199,850	272,736	552,597
Menominee	2,953,131	2,498,784	1,254,110	1,991,108	1,674,447
Crystal Falls	1,395,910	1,631,484	629,602	1,425,261	1,206,592
Iron River	568,469	589,946	630,745	1,152,076	1,001,960
Gogebic	3,113,981	3,093,083	2,348,626	3,402,415	3,652,918
Metropolitan	.....	13,913	9,123	24,933	26,462
Calumet	15,773	51,646	15,222	.....	.....
Total	12,149,451	12,166,929	7,302,060	12,251,965	11,955,105

	1911.	1912.	1913.	1914.	Total.
Marquette	2,614,881	3,406,646	3,487,993	2,340,326	105,660,022
Gwinn	346,104	510,398	302,573	199,027	3,778,747
Menominee	1,431,840	1,538,746	1,680,620	1,156,452	52,196,609
Crystal Falls	1,254,135	1,304,739	1,172,948	535,457	20,742,149
Iron River	1,115,514	1,736,966	1,943,560	1,453,403	12,910,976
Gogebic	2,102,322	3,883,011	3,847,398	3,150,609	68,407,921
Metropolitan	33,758	12,468	9,251	.....	298,868
Calumet	.....	35,387	18,976	.....	175,917
Totals	8,898,554	12,428,361	12,463,319	8,835,274	264,171,209

SHIPMENTS OF IRON ORE FROM MICHIGAN RANGES BY COUNTIES. (GROSS TONS.)

County.	1901 and prior years.	1902.	1903.	1904.	1905.
Gogebic	29,072,290	3,018,255	2,465,263	2,042,398	3,215,352
Iron	7,729,636	1,358,895	1,101,246	1,202,242	1,512,339
Dickinson	26,209,033	3,010,112	2,547,393	1,717,537	2,741,169
Marquette	62,258,919	3,808,244	2,905,597	2,817,195	4,175,605
Baraga	550,564	59,781	134,648	26,508	39,967
Total	125,820,442	11,255,287	9,154,147	7,805,880	11,684,432

County.	1906.	1907.	1908.	1909.	1910.
Gogebic	3,113,981	3,093,083	2,348,626	3,402,415	3,652,918
Iron	1,964,379	2,221,430	1,260,347	2,577,337	2,208,552
Dickinson	2,968,904	2,564,343	1,278,455	2,016,041	1,700,909
Marquette	4,097,111	4,154,288	2,305,366	3,888,055	4,236,311
Baraga	5,076	133,785	109,266	368,117	156,415
Total	12,149,451	12,166,929	7,302,060	12,251,965	11,955,105

County.	1911.	1912.	1913.	1914.	Total.
Gogebic	2,102,322	3,883,011	3,836,739	3,150,609	68,407,921
Iron	2,369,649	3,041,705	3,116,508	1,988,860	33,653,125
Dickinson	1,465,598	1,585,601	1,708,847	1,156,452	52,671,394
Marquette	2,871,116	3,864,101	3,753,023	2,494,029	107,590,647
Baraga	89,642	53,943	37,543	45,324	1,848,122
Totals	8,898,327	12,428,361	12,452,660	8,835,274	264,171,209

LIST OF THE ACTIVE IRON MINES OF MICHIGAN,

Name of mine.	Location.				First shipment.	No. of men employed.	Depth, 1914.
	County.	Section.	Twp.	Rge.			
CRYSTAL FALLS DISTRICT:							
Bristol	Iron	19	43	32	1892	135	1,060
Carpenter	Iron	31	43	32	1914	187	.....
Dunn-Richards	Iron	1	42	33	1887	76	1,623
Genesee (with Tobin)	Iron	29;30,31	43	32	1902	.....	.....
Great Western	Iron	21	43	32	1882	48	1,257
Hemlock	Iron	4	44	33	1891	105	1,015
Judson	Iron	13	42	33	1914	95	300
Michigan (with Hemlock)	Iron	9	44	33	1893	.....	1,015
Ravenna	Iron	19	43	32	1911	135	350
Tobin	Iron	30	43	32	1901	8	1,235
IRON RIVER DISTRICT:							
Baker-Tully	Iron	31	43	34	1909	214	548
Baltic	Iron	7	42	34	1901	73	553
Bengal	Iron	36	43	35	1913	19	281
Berkshire	Iron	6	42	34	1908	14	365
Caspian	Iron	1	42	35	1903	303	292
Chatham-Riverton	Iron	35	43	35	1907	26	700
Chicagon	Iron	26	43	34	1911	111	712
Cortland	Iron	34	43	35	1912	8	405
Davidson No. 1	Iron	23	43	35	1912	101	450
Davidson No. 2	Iron	14	43	35	1912	78	240
Fogarty (see Baltic)	Iron	1	42	35	1907	.....	365
Forbes	Iron	14	43	35	1913	122	275
Hiawatha	Iron	35	43	35	1893	96	895
Osana (James)	Iron	23	43	35	1907	92	428
Dober Isabella (Riverton)	Iron	1,35,36	42,43	35	1898	195	900
Rogers	Iron	29	43	34	1914	96	330
Tully (see Baker)	Iron	36	43	35	1910	.....	548
Virgil	Iron	24	43	35	1912	.....	273
Wauseca	Iron	23	43	35	1910	8	398
Wickwire	Iron	35	43	35	1911	42	313
Youngs	Iron	12	42	35	1905	2	515
Zimmerman	Iron	7	42	34	1908	140	350
GOGEBIC RANGE:							
Anvil and Keweenaw	Gogebic	14	47	46	1887	40	1,663
Asteroid	Gogebic	13	47	46	1906	157	1,135
Ashland	Gogebic	22	47	47	1885	188	1,900
Brotherton	Gogebic	9	47	45	1886	133	1,157
Castile	Gogebic	10	47	45	1906	157	1,470
Colby	Gogebic	16	47	46	1884	277	1,289
Davis, Geneva, Royal, Puritan	Gogebic	17, 18 19, 20	46	47	1886	187	1,754
Eureka	Gogebic	13	47	46	1890	140	1,500
Ironton (see Colby)	Gogebic	17	47	46	1886	.....	1,350
Keweenaw (see Anvil)	Gogebic	11	47	46	1914	.....	1,663
Mikado	Gogebic	18	47	45	1895	29	1,131
Newport and Bonnie	Gogebic	24	47	47	1886	899	2,154
Norrie-Aurora Group	Gogebic	22, 23	47	47	1884	1,323	[1]1,676
Palms (see Anvil)	Gogebic	14	47	46	1912	310	1,663
Puritan (see Davis)	Gogebic	17	47	46	1886	.....	.....
Sunday Lake	Gogebic	10	47	45	1885	216	1,291
Tilden	Gogebic	15	47	46	1891	276	1,326
Wakefield	Gogebic	16,17	47	45	1913	283	256
Yale	Gogebic	16	47	46	1901	93	861

[1]Depth of North Norrie.

1914, WITH LOCATION, OWNERSHIP, ETC.

Number or name of level.	Operators.	Address of Home Office.
11th	Bristol Mining Co	Wade Building, Cleveland, Ohio.
1st	Hollister Mining Co	1300 Leader-News Bldg., Cleveland, Ohio.
13th	Corrigan, McKinney Co	Wickliffe, Ohio.
.....	Corrigan, McKinney Co	Wickliffe, Ohio.
16th	Corrigan, McKinney Co	Wickliffe, Ohio.
14th	Hemlock River Mining Co	Cleveland, Ohio, Western Reserve Bldg.
1st	Judson Mining Co	First National Bank Bldg., Chicago, Illinois.
14th	Hemlock River Mining Co	Cleveland Ohio, Western Reserve Bldg.
2d	Hollister Mining Co	1300 Leader News Bldg, Cleveland, Ohio.
12th	Corrigan, McKinney Co	Wickliffe, Ohio.
4th	Corrigan, McKinney Co	Wickliffe, Ohio.
7th	Verona Mining Co	Cleveland, Ohio, Western Reserve Bldg.
2d	Verona Mining Co	Cleveland, Ohio, Western Reserve Bldg.
4th	Brule Mining Co	76 Wade Building, Cleveland, Ohio.
3d	Verona Mining Co	Cleveland, Ohio, Western Reserve Bldg.
7th	Brule Mining Co	76 Wade Bldg., Cleveland, Ohio.
6th	Munro Mining Co	55 Erie Co. Bank Bldg., Buffalo, N. Y.
4th	Wickwire Mining Co	Buffalo, N. Y.
1st	Davidson Ore Mining Co	403 White Bldg., Buffalo, N. Y.
2d	Davidson Ore Mining Co	403 White Bldg., Buffalo, N. Y.
4th	Verona Mining Co	Western Reserve Bldg., Cleveland, Ohio.
2d	Jones & Laughlin Ore Co	3d Ave. & Try St., Pittsburg, Pa.
9th	Munro Mining Co	55 Erie Co. Bank Bldg., Buffalo, N. Y.
4th	Mineral Mining Co	910 Wells Bldg., Milwaukee, Wis.
9th	Oliver Iron Mining Co	Wolvin Bldg., Duluth, Minn.
1st	Munro Iron Mining Co	55 Erie Co. Bank Bldg., Buffalo, N. Y.
.....	Corrigan, McKinney Co	Wickliffe, Ohio.
2d	Wickwire Mining Co	Buffalo, N. Y.
4th	Mineral Mining Co	910 Wells Bldg., Milwaukee, Wis.
4th	Huron Iron Co	Iron River, Mich.
5th	Wickwire Mining Co	Buffalo, N. Y.
4th	Spring Valley Iron Co	Wellston, Ohio, Jackson Co.
11th	Newport Mining Co	First National Bank Bldg., Milwaukee, Wis.
12th	Castile Mining Co	76 Wade Bldg., Cleveland, Ohio.
25th	Hayes Mining Co	808 1st National Bank Bldg., San Jose, Cal.
21st	Brotherton Iron Mining Co	Western Reserve Bldg., Cleveland, Ohio.
14th	Castile Mining Co	76 Wade Bldg., Cleveland, Ohio.
14th	Corrigan, McKinney Co	Wickliffe, Ohio.
18th	Oliver Iron Mining Co	Wolvin, Bldg., Duluth, Minn.
15th	Castile Mining Co	76 Wade Bldg., Cleveland, Ohio.
.....	Corrigan, McKinney Co	Wickliffe, Ohio.
11th	Newport Mining Co	First National Bank Bldg., Milwaukee, Wis.
16th	Verona Mining Co	Western Reserve Bldg., Cleveland, Ohio.
19th	Newport Mining Co	First National Bank Bldg., Milwaukee, Wis.
23d	Oliver Iron Mining Co	Wolvin Bldg., Duluth, Minn.
11th	Dunn Iron Mining Co	First National Bank Bldg., Milwaukee, Wis.
.....	Oliver Iron Mining Co	Wolvin Bldg., Duluth, Minn.
22d	Sunday Lake Iron Co	Western Reserve Bldg., Cleveland, Ohio.
21st	Oliver Iron Mining Co	Wolvin Bldg., Duluth, Minn.
1st	Wakefield Iron Co	1300 Leader-News Bldg., Cleveland, Ohio.
10th	Lake Superior Iron & Chemical Co.	Penobscot Bldg., Detroit, Mich., F. W. Blair, Receiver.

LIST OF THE ACTIVE IRON MINES OF MICHIGAN,

Name of mine.	Location.				First shipment.	No. of men employed.	Depth, 1914. Feet.
	County.	Section.	Twp.	Rge.			
MARQUETTE RANGE:							
American and Boston	Marquette	32	48	28	1880	277	1,460
Breitung Hematite No. 1	Marquette	8	47	26	1903	172	585
Breitung Hematite No. 2	Marquette	8	47	26	.....	51	435
Cambria	Marquette	35	48	27	1875	125	1,300
Champion	Marquette	31,32	48	29	1867	.....	1,984
Chase	Marquette	3	47	28	1913	79	351
Cliff Shaft	Marquette	9,10	47	27	1887	285	987
Empire	Marquette	19	47	26	1907	2	200
Gwinn	Marquette	28	45	25	1914	133	1,009
Hartford (Cambria No. 2)	Marquette	36	48	27	1889	.....	1,300
Himrod	Marquette	7	47	26	1914	45	.....
Imperial	Baraga	25	48	31	1890	1	185
Jackson	Marquette	1	47	27	1846	29	208
Lake and Moro	Marquette	10	47	27	1892	246	591
Lake Superior (Hard Ore)	Marquette	9,10	47	27	1858	211	1,080
Lake Superior (Soft Ore)	Marquette	10	47	27	1858	81	820
Lake Angeline	Marquette	15	47	27	1864	194	615
Lloyd (see Morris)	Marquette	6	47	27	1911	.....	808
Lucy (with Jackson)	Marquette	6,7	47	26	1878	.....	281
Maas	Marquette	31	48	26	1907	212	1,100
Maitland (Volunteer)	Marquette	30	47	26	.....	.....	.....
Mary Charlotte	Marquette	8	47	26	1903	129	435
Morris and Lloyd	Marquette	1	47	28	1912	243	798
Moro (with Lake)	Marquette	10	47	27	1881	.....	812
Negaunee	Marquette	5, 6	47	26	1887	302	986
Ohio	Baraga	22	48	31	1882	1	250
Portland	Baraga	26	48	31	1896	55	50
Queen Group	Marquette	5	47	26	1888	252	1,010
Republic	Marquette	7	46	29	1872	264	2,050
Richmond	Marquette	28	47	26	1896	43	.....
Rolling Mill	Marquette	7	47	26	1872	215	786
Salisbury	Marquette	15	47	27	1872	117	709
Volunteer	Marquette	30	47	26	1871	25	505
Washington (Barron)	Marquette	11	47	29	1865	45	875
SWANZY DISTRICT:							
Austin	Marquette	20	45	25	1907	1	364
Princeton	Marquette	18,20	45	25	1872	10	782
Stegmiller	Marquette	17	45	25	1909	63	300
Stephenson	Marquette	20	45	25	1907	246	562
MENOMINEE RANGE:							
Aragon	Dickinson	8,9	39	29	1889	279	1,155
Chapin	Dickinson	25,30	40	31,30	1880	553	1,501
Cyclops & Norway (Penn Gr'p)	Dickinson	5	39	29	1878	.....	355
East Vulcan (Penn Group)	Dickinson	10,11	39	29	1877	.....	1,400
Loretto	Dickinson	7	39	28	1893	168	800
Millie (Hewitt)	Dickinson	31	40	34	1881	10	600
Munro	Dickinson	6	39	29	1903	1	170
Pewabic	Dickinson	32	40	30	1890	326	941
West Vulcan, Curry & Brier Hill	Dickinson	9,10	39	29	1879	[1]632	1,770
Clifford and Traders	Dickinson	20	40	30	.....	61	143

[1]Total for Penn Group.

1914, WITH LOCATION, OWNERSHIP, ETC.—*Concluded.*

Number or name of level.	Operators.	Address of Home Office.
18th	American Boston Mining Co	1300 Leader-News Building, Cleveland, Ohio.
9th	Breitung Hematite Mng. Co	Marquette, Mich.
4th	Breitung Hematite Mng. Co	Marquette, Mich.
.....	Republic Iron & Steel Co	Youngstown, Ohio.
33d	Champion Iron Co	Wolvin Building, Duluth, Minnesota.
3d	Cleveland Cliffs Iron Co	Ishpeming, Mich.
10th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
2d	Empire Iron Co	Rector Building, Chicago, Illinois.
.....	Cleveland Cliffs Iron Co	Ishpeming, Mich.
.....	Republic Iron & Steel Co	Youngstown, Ohio.
.....	Mary Charlotte Mng. Co	Marquette, Mich.
4th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
.....	Cleveland Cliffs Iron Co	Ishpeming, Mich.
5th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
.....	Oliver Iron Mining Co	Wolvin Building, Duluth, Minn.
.....	Oliver Iron Mining Co	Wolvin Building, Duluth, Minn.
9th	Pittsburg & Lake Angeline Iron Co	Cleveland, Ohio.
2d	Cleveland Cliffs Iron Co	Ishpeming, Mich.
.....	Cleveland Cliffs Iron Co	Ishpeming, Mich.
3d	Cleveland Cliffs Iron Co	Ishpeming, Mich.
.....	Volunteer Ore Co	1400 Alworth Bld., Duluth, Minn.
4th	Mary Charlotte Mining Co	Marquette, Mich.
2d	Cleveland Cliffs Iron Co	Ishpeming, Mich.
.....	Cleveland Cliffs Iron Co	Ishpeming, Mich.
9th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
6th	Niagara Iron Mining Co	North Tonawanda, N. Y.
Open pit	Niagara Iron Mining Co	North Tonawanda, N. Y.
.....	Oliver Iron Mining Co	Wolvin Bldg., Duluth, Minn.
"Pasco"	Cleveland Cliffs Iron Co	Ishpeming, Mich.
Open pit	Richmond Iron Co	1300 Leader-News Bldg., Cleveland, Ohio.
8th	Jones & Laughlin Ore Co	3d Ave. & Try St., Pittsburg, Pa.
16th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
5th	Volunteer Ore Co	1400 Alworth Bldg., Duluth, Minn.
10th	Washington Iron Co	Marquette, Mich.
6th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
6th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
2d	American Mining Co	Western Reserve Building, Cleveland, Ohio.
6th	Cleveland Cliffs Iron Co	Ishpeming, Mich.
12th	National Tube Works Co	Frick Bldg., Pittsburg, Pa.
17th	Chapin Mining Co	Wolvin Bldg., Duluth, Minn.
.....	Penn Iron Mining Co	1703 Morris Bldg., Philadelphia, Pa.
.....	Penn Iron Mining Co	1703 Morris Bldg., Philadelphia, Pa.
8th	Loretto Iron Co	1400 Fulton St., Chicago, Ill.
.....	Dessau Mining Co	Care B. J. Clergue, Montreal, Que.
2d	Munro Iron Mining Co	55 Erie Co. Bank Bldg., Buffalo, N. Y.
8th	Pewabic Co	910 Wells Bldg., Milwaukee, Wisconsin.
18th	Penn Iron Mining Co	1703 Morris Bldg., Philadelphia, Pa.
1st	Antoine Ore Company	Republic Building, Youngstown, Ohio.

IRON ORE RESERVES OF MICHIGAN.

Range.	1911.[1]		1913.[2]		1914.[3]		1915.[3]	
	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.	Developed. Tons.	Prospective. Tons.
Gogebic county	18,296,721	13,308,279	23,813,191	7,754,388	23,765,158	21,113,192	33,764,457	12,838,990
Iron county: (Iron River District) (Crystal Falls District)	7,934,687	25,689,155	13,249,683	47,536,233	13,337,913	45,045,227	19,258,369	42,961,778
Menominee: (Dickinson county)	9,082,750	2,567,700	9,682,994	3,100,458	11,062,700	2,129,950	10,134,241	1,701,540
Marquette: (Baraga county) (Marquette county)	36,228,742	56,473,068	34,692,034	51,529,275	33,095,467	47,919,718	28,629,708	50,235,260
State	71,542,900	98,038,202	81,437,902	109,920,354	81,261,238	116,208,087	91,786,775	107,737,568
Total	169,581,102		191,358,256†		197,469,325*		199,524,343‡	

*Of date Jan. 1, 1914 in addition to which there was in stock 4,954,830 tons of ore, making a grand total of ..... 202,424,155 tons
†Of date Jan. 1, 1913 in addition to which there was in stock 4,366,349 tons of ore, making a grand total of ..... 195,724,605 tons
‡Of date Jan. 1, 1915 in addition to which there was in stock 6,596,195 tons of ore, making a grand total of ..... 206,120,538 tons
[1]Estimated by C. K. Leith for Board of State Tax Commissioners.
[2]Estimate by C. K. Leith and R. C. Allen for Board of State Tax Commissioners.
[3]Estimate by R. C. Allen and O. R. Hamilton for Board of State Tax Commissioners.

VALUE OF MICHIGAN IRON ORE SHIPMENTS 1914.[1]

Range.	Gross receipts.	*"Beyond the Mine" charges.	Net receipts (f. o. b. at mine).	Shipment. Tons. 1914.	Value per ton 1914.	Value per ton 1913.
Gogebic county	$10,488,388 25	$2,725,549 42	$7,762,838 83	3,150,609	$2 46	$3 08
Iron River, Crystal Falls } Iron county	5,081,766 92	1,506,001 84	3,575,765 08	1,988,860	1 80	2 08
Dickinson county	2,899,452 73	712,239 20	2,187,213 53	1,156,452	1 89	2 38
Marquette { Marquette county / Baraga county }	6,935,991 76	1,496,751 01	5,439,240 75	2,539,353	2 14	2 38
State of Michigan	$25,405,599 66	$6,440,541 47	$18,965,058 19	8,835,274	$2 14	$2 52

*Includes: 1. Rail freight.
2. Boat freight.
3. Cargo insurance.
4. Lower lake analyses.
5. Selling commissions.

1914 U. S. Production = 39,714,280 long tons.
Valued at $71,905,079 or average price
of $1.81 per ton.

[1]From report of Appraiser of Mines to Board of State Tax Commissioners 1915.

TABLE SHOWING AVERAGE COST OF DELIVERY OF IRON ORE TO SALE POINTS FOR THE FIVE YEAR PERIODS, 1909-1913 AND 1910-1914.[1]

Range.	Number of mines.		Total tonnage.		Total cost.		Average cost per ton mined.	
	1909-1913.	1910-1914.	1909-1913. Mined.	1910-1914. Mined.	1909-1913.	1910-1914.	1909-1913.	1910-1914.
1 Marquette	39	40	19,299,746	18,624,664	$51,428,569 14	$45,426,953 75	$2.58401	$2.48757
2 Gogebic	29	31	16,480,159	17,371,091	47,037,450 88	48,353,983 95	2.86218	2.78358
3 Menominee	17	17	8,433,188	7,792,930	20,752,050 74	19,276,469 02	2.47865	2.47358
4 Iron River and Crystal Falls	33	37	13,751,488	12,260,693	31,919,664 20	30,840,372 40	2.35158	2.51038
State	118	125	57,964,581	56,049,378	$151,137,734 96	$143,897,779 12	$2.63194	$2.58294

[1]From report of Appraiser of Mines to Board of State Tax Commissioners, 1915.

APPRAISED VALUE OF MICHIGAN IRON MINES.[1]

Range.	Total acreage appraised 1915.	Previous appraisals.			1915 appraisal.		Combined value of mine and ore in stock.	Total tonnage in mine and in stock Jan. 1, 1915.	Assessed value per ton.
		1912.	1913.	1914.	Mine.	Ore in stock.			
Gogebic	5,987.00	$27,226,300	$25,849,873	$34,667,028	$29,563,056	$4,814,736	$34,377,792	48,242,119	$0.71260
Iron county:									
(Iron River District)									
(Crystal Falls District)	8,087.00	15,359,664	20,978,709	21,275,945	18,178,474	2,678,445	20,856,919	63,342,684	.32927
Menominee:									
Dickinson county	3,877.60	7,240,625	6,641,925	6,413,003	4,074,448	1,831,995	5,906,443	12,571,939	.46981
Marquette:									
Baraga county	580.00	*							
Marquette county	7,611.22	31,270,500	29,063,714	29,216,139	23,012,166	5,604,287	28,616,453	81,963,796	.34913
State	26,142.82	$81,097,089	$82,534,221	$91,572,115	$74,828,144	$14,929,463	$89,757,607	206,120,538	$0.43546

*Ten per cent cut from 1911 assessment (approximate figure).
[1]By Board of State Tax Commissioners.

PART II. NON-METALLIC MINERALS.

R. A. SMITH.

COAL IN MICHIGAN.

MICHIGAN COAL BASIN.

Location and Extent.

The Michigan Coal Basin* is the only coal field in the St. Lawrence drainage basin. It covers an area of about 11,000 square miles almost in the geographic center of the Southern Peninsula, extending from the central part of Tuscola county on the east to the western part of Newaygo county on the west and from the south central part of Roscommon and Ogemaw counties on the north to the central portion of Jackson county on the south.

The limits of the Coal Basin on the south and east have been approximately determined, but the margin is more or less irregular. On the north and northwest the boundary is more uncertain owing to the thick screen of surface deposits.

Surface Features.

The greater part of the Coal Basin lies in a low flat to gently undulating region bordered by a rim of higher and more broken land, broken on the northeast by Saginaw Bay and on the west by the valley of the Grand. The low flat portion of the interior basin, largely included in Saginaw Valley, has an elevation ranging from about 580 feet above sea level to 800 feet, and the higher undulating portions from 800 to 1,000 feet above sea level. The marginal higher broken tracts on the south and east rise from a height of about 1,000 feet to over 1,200 feet and those on the north and northwest from 1,000 to 1,600 feet, or respectively 400 to 600 feet and 400 to 1,000 feet above Lakes Huron and Michigan.

To a large extent the rim of high land is due primarily to an underlying rim of hard limestone (Bayport) and heavy sandstone (Marshall) of the Upper Mississippian. On the northeast this rock rim is breached by Saginaw Bay and on the northwest by an old pre-glacial valley which runs southwest from the head of the bay through northern Gratiot county and, veering to the west and then northwest through

*See 22nd Ann. Rept. U. S. G. S., The Northern Interior Coal Field by A. C. Lane; also Vol. VIII, Pt. II Mich. Geol. Survey, Coal in Michigan by A. C. Lane.

Montcalm and Newaygo counties, enters the basin of Lake Michigan in western Mason and Manistee counties. The height of the rim was further accentuated in the Pleistocene period by a greater piling up of glacial debris along the rim than in the interior of the basin.

Though the rock surface is very uneven the mantle of drift is so thick that nearly everywhere it completely buries and conceals the coal measures. Southwest of a line from the mouth of Saginaw River to Grand Rapids the drift over the Coal Basin is generally 50 to 150 feet thick and only in a few places is it more than 200 feet. Northwest of this line, excepting in Arenac county, the drift is generally much thicker. Particularly is this true along the northern and northwestern margin and over the old pre-glacial valley previously noted where the glacial deposits are usually from 300 to 600 feet or more in thickness. This excessive thickness of drift has been an effective barrier to exploration and development.

The areas in the Coal Basin in which the drift is thin or absent are few and small. Most of the exposures of the Coal Measures are generally along stream courses, as along the Rifle River in Arenac county; the Cass and some of its tributaries near Tuscola, Tuscola county; the Flint near Flushing, Genesee county; the Shiawassee from Corunna, Shiawassee county, north to the Saginaw county line; the Cedar and the Grand from Williamston, Ingham county, to six miles below Grand Ledge, Eaton county; and the Grand and its tributaries around Dimondale and Eaton Rapids, Eaton county, Ionia, Ionia county and Jackson, Jackson county.

Accessibility.

The Coal Basin, especially the more developed southeastern half, lies in a thickly populated and rapidly growing industrial section of the state. Saginaw Bay breaks through the rim on the northeast and, with its estuary, Saginaw River, penetrates to the heart of the chief coal districts. Numerous manufacturing cities within or just outside the Basin, a natural water route to the Great Lakes, and a web of railroads radiating in every direction from Saginaw and Bay City, the chief coal centers, afford exceptional means for transportation and marketing.

Geology.

Structure.—In structure the coal field is that of a very flat synclinorium with its longer axis extending north and south. The strata in general do not conform to the basin-like structure of the pre-coal measure formations but are nearly flat except for minor undulations and folds. Locally the strata are faulted but most of the observed

faults are small, having a throw or displacement of only a few inches or feet. Recently several faults of considerable size have been found and one in Bay County has a displacement of over 50 feet. Further observations may show that faults are much more prevalent in the coal series than formerly supposed.

Character of the coal beds.—The Coal Measures belong to the Upper Carboniferous or Pennsylvanian and consist of an upper productive portion called the Saginaw formation, and a lower barren one, the Parma sandstone.

The Saginaw formation is essentially a series of relatively thin beds of white shale or so-called fire clays, blue or gray and black shales, sandstones, and coal seams. Limestone is uncommon but locally thin seams of black band ore (siderite) and nodules of the same with zinc blend and iron pyrites occur in the coal or the associated shales.

In general the beds vary markedly in thickness and character within relatively short distances. Many of the beds are merely local lenses and few are continuous over any considerable area. Rapid variation is also characteristic of the coal seams. They generally undulate sharply and the rise and fall may be more than 20 feet in a few hundred feet. Locally the coal thins, pinches out, or grades into black shale, or is cut out entirely by sandstone. In some localities, however, the strata are predominately sandstone, in others, shale. The manner of the occurrence of coal is similar; in some areas there are several beds and in others none.

There is a more or less orderly sequence of the different strata. Generally white shale, the "fire" or "underclay" of miners, underlies the coal seams. The coal beds usually grade upward into so-called "cannel" or "bone" coal, or into black shale which in turn is followed by blue shale. Sandstone may succeed the shale or it may cut out the shale entirely and rest directly on the coal. The "fire" clays are locally very sandy or may be replaced by sandstone. These clays are not true fireclays since they do not possess particularly high refractory properties. The blue shales above the coal locally contain thin bands and nodules of siderite or iron carbonate. Some of the nodules contain sulphides of iron and zinc, and also kaolin. In some places, carbonaceous limestone replaces the blue shale. Sandstones, some of which are very massive, occur at any horizon but the repetition of the sequence upward—white shale or "fire clay", coal, "cannel" or "bone" coal, black shale, blue shale or limestone and in many places, sandstone, for each of the coal beds is characteristic.

The Parma is a white sandstone locally conglomeratic. The pebbles, generally of very white quartz are small and scattering. The Parma is to be considered as the basemental and shoreward facies of the

overlying Saginaw formation, hence is not referable to a definite age. It is very persistent, being continuous over most of the Coal Basin and varies in thickness from about 170 feet to a feather edge. Locally, however, it is either absent or not present as a sandstone. Generally it yields an abundance of water, fresh near the margin and saline in the central part of the Basin. Its waters and brines contain a relatively high content of sulphates in comparison with the waters and brines of the Marshall sandstone below.

The Coal Measures were deposited upon the much eroded surface of the Grand Rapids group of the upper Mississippian, hence, in Michigan, there is a great unconformity separating the Mississippian and the Pennsylvanian. The erosion which followed the continental uplift in North America at the close of the Mississippian was so severe that deep valleys were carved in the land surface and in places these cut completely through the Bayport limestone and into or even through the Michigan Series below. The topography was much rougher than that of the present land surface. Along much of the southeastern side of the Coal Basin both the Bayport limestone and the Michigan Series appear to be absent, probably having been removed by erosion, or perhaps never deposited. As a consequence, the Parma sandstone locally rests directly but unconformably on the Marshall sandstone and, since the two are lithologically similar, they cannot be readily distinguished in well records. In northern Jackson and northeastern Calhoun counties and perhaps along the southeastern margin of the Coal Basin, coal measures were deposited in the bottom of valleys between ridges and hills capped with Bayport limestone and rocks belonging to the Michigan series.

Thickness of the Coal Measures.—The Coal Measures in some parts of the Coal Basin vary greatly in thickness within very short distances. This is due to two causes; first they were deposited upon a very uneven basement, the eroded surface of the Grand Rapids group, as noted above and, second, their upper surface has been heavily eroded. The Appalachian Revolution, the general upheaval at the end of the Pennsylvanian permanently converted the Michigan sea and its bordering swamps into a land surface probably a thousand feet higher at least than the present. During the ensuing long period of erosion, extending to the Pleistocene, the surface of Michigan was greatly dissected. A large drainage system trending to the west was developed in the central portion of the Southern Peninsula. The trunk stream, represented by the old pre-glacial channel previously noted, headed in Saginaw Bay, ran southwest into the center of the Coal Basin, and then, veering northwest through Manistee county, entered the valley or basin now occupied by Lake Michigan. The bottom of this channel at the head

of Saginaw Bay is nearly 200 feet below the surface of Lake Huron, over 325 feet in Gratiot county, and more than 700 feet below Lake Michigan in Manistee county, or over 100 feet below sea level. Numerous tributary streams dissected other parts of the Coal Basin producing a topography much rougher than that of the present land surface. The relief of the former surface was later more or less modified by the ice invasions of the Pleistocene which, in general, smoothed and rounded off the sharper topographic features.

The pre-glacial channels or "washouts," as they are termed by the miners, are now filled with drift, in places heavily water bearing. They cut out the coal beds and make mining uncertain and hazardous, particularly in the upper veins. In numerous instances, miners in driving entries have encountered these drift filled channels, sometimes with serious consequences from floods of water and quicksand. The amount of coal lost through pre-glacial erosion is very considerable but the data necessary for its calculation is insufficient. Few of the present rivers have cut through the thick mantle of drift, hence little coal has been lost through post-glacial erosion.

The troughlike deposits of the productive Coal Measures along the southern margin are very thin, being generally less than 100 feet in thickness. In the vicinity of Saginaw, the thickness is from 260 to about 325 feet, near Bay City, about 350 feet, and nearer the center of the Coal Basin at Mt. Pleasant and Midland, 410 and 525 feet respectively. Around the northern and northwestern border no drillings of reliable record penetrate completely through the productive Measures, hence little definite information is known of their average thickness in that part of the basin. In the central part of the Coal Basin, however, the thickness averages from 300 to 400 feet and probably nowhere is it much more than 500 feet.

Occurrence of the coal.—Coal does not occur in all parts of the Coal Basin. In several borings near the center of the Basin which penetrate completely through the coal bearing series neither coal nor black shale were found, the Saginaw formation being a series of sandstones and gray shales. Coal beds are apparently thicker and more numerous toward the margin of the Basin and tend to thin and disappear toward the center.

Thousands of test drillings have shown the presence of more than a dozen coal seams, most of which are too thin for mining under present conditions. Lane* recognized seven distinct beds and made the following provisional series: Lower Coal, Lower Rider, Saginaw Coal, Middle Rider, Lower Verne, Upper Verne, and Upper Rider. Cooper†

*Mich. Geol. Surv., Vol. VIII, Pt. II, p. 46.
†Mich. Geol. Surv., Ann. Rept. 1905, Bay County Report, p. 174.

added seven more, making fourteen in all, the complete series from bottom upwards being: Bangor Coal, Bangor Rider, Lower Coal, Lower Rider, Saginaw Coal, Middle Rider, Lower Verne, and Lower Verne Rider, Upper Verne and Upper Verne Rider, Salzburg Coal, and Salzburg Rider.

When it is considered that the whole coal series is characterized by extreme variation, that the fourteen or more coal seams occur in a section of barely 400 feet, that a given coal bed may rise or fall from 30 to 50 feet or more in a quarter of a mile, thicken, thin, or pinch out entirely in a few hundred feet, or split into two or more distinct seams, that many of the seams are merely local lenses or "pockets," that faults occur locally and that all of the above phenomena may be observed in a single mine, little weight should be attached so such an elaborate system of correlations. None of the coal beds extend continuously over the whole basin and few are continuous over any considerable part of it, and most of the areas in which the coal is of minable thickness are very small indeed. A rider of coal may or may not occur over each prominent coal seam but some beds have two or three lenses or so-called riders over them in the deeper troughs or valleys. The prominent coal seam of one locality may be unimportant in another and the main coal of the latter may correspond to a rider in the former. This reflects the transfer of favorable coal forming conditions from one part of the basin to another.

In the field of Wolverine Mine No. 3, Bay county, no less than ten seams of coal, not including the parts of split seams, occur in a section barely 175 feet in thickness, the seams averaging but little more than 15 feet apart. Deeper drilling in adjacent territory shows that there are at least three or four coal beds lower down. Of the upper ten veins only the so-called Verne, a split seam, is of minable thickness over any considerable area while some of the beds appear to be only thin lenses or "pockets" of coal of very limited extent. The "Verne Split" is continuous over a relatively large area, but it is variable in thickness, quality of the coal and number and distance apart of its members. Generally it is composed of two parts, the "Upper" and the "Lower Verne" seams, separated by a parting of "bone" coal or black shale. The bed in the field of Wolverine Mine No. 3 has a combined thickness of four to seven feet exclusive of the parting of shale. In turn either or both of the parts of the Verne may divide into a number of seams too thin for mining. Other coal beds exhibit this tendency to divide and it is certain that the "Verne" seams of one locality are not always related to the "Verne" of other localities.

It is generally impossible to satisfactorily correlate the thin lenses or "pockets" of coal encountered in different parts of the same field and

it is very difficult to trace accurately the thicker and more continuous beds even with closely spaced drillings on account of the great variation in thickness, character and elevation. In test hole No. 965, in the field of Wolverine Mine No. 3, the split seam between 180 and 183 feet occurs at the depth at which the "Verne" split might be expected and it was not definitely known that the group of splits between 191 and 196 feet was the "Verne" until a tunnel entry was driven through the coal at this point. It is possible that the upper split represents the "Upper Verne" and the lower the "Lower Verne." In one part of the Bliss mine at Swan Creek, Saginaw county, test holes showed a thin coal seam at the depth at which the main bed should occur and this part of the field was marked on the mine maps as unminable. Mining operations later showed that the main seam at this point was depressed into a trough and occurred at some distance below the thin seam in greater thickness than the average for the field.

In the field of Wolverine Mine No. 2 several faults have been dicovered and one has been encountered in the mine workings for more than a quarter of a mile along the southern limit of the coal area, where the coal bed on the south of the fault line has been upthrown approximately 55 feet.

Since it is so difficult to make satisfactory correlations between coal seams in different parts of the same field, correlations between different fields and over long distances, where test holes are far apart, must be very uncertain and any elaborate system of coal seams based on such data can have very little value.

Of the fourteen or more distinct coal beds but four or five are known to contain areas of minable coal of any considerable size. The minable deposits are in the form of conclave lenses, though generally very irregular in outline and thickness. Most of the proven areas of minable coal contain less than 150 acres, only a few, more than 250 acres, and but two or three, more than 1,000 acres, and none exceed 2,000 acres.

Few of the deposits average more than three feet in thickness and some of them average only about 30 inches, which in Michigan appears to be the lower limit of average thickness at which coal can be profitably mined, unless other conditions are exceptionally favorable. Even in these thicker areas, the coal in places is inferior in quality, too thin for profitable mining, or is cut out entirely. The undulating floor of the coal basins results in a series of "rolls" or hills and valleys, which make haulage of coal and drainage of water to the central shaft difficult. The irregular form of the coal basins and the rapid variation in thickness and quality of the coal necessitate close and careful drilling in proving up a coal field. Some fields not sufficiently tested by drilling have

proved to be so "pockety" or variable in the quality of the coal that mining operations were unprofitable.

Quality of the coal.—All of the coals of Michigan are bituminous, but are of the domestic variety, non-coking for the greater part. In general the coals are of a lower grade than those of Ohio, Pennsylvania, and West Virginia, but the quality varies greatly not only in the different seams but also in the same seam within very short distances. The shallow and marginal beds are characteristically high in ash and sulphur and low in fixed carbon. Most of the coal formerly mined near Jackson, Jackson county; at Owosso and Corunna, Shiawassee county; and at Grand Ledge, Eaton county, contains from 2% to 14% of ash, 3% to 7% of sulphur, and only 40% to 45% of fixed carbon. Much of the coal mined in Bay county, is similar in that it is high in ash and low in fixed carbon. The sulphur, however, is low in some beds and very high in others, the range being from 1.5% to 6% and over. Some of the Bay county coals resemble lignite in their weak physical character, low specific gravity, and high content of volatile matter.

The coals mined in the vicinity of Saginaw and St. Charles, Saginaw county, are of better grade, the ash varying from 1% to 7%, the sulphur from 0.5% to 2%, and the fixed carbon from about 50% to 58%.

Many of the Michigan coals are characterized by a high content of moisture, the extreme range being from 2% to about 13%. The Bay county coals contain on the average from 3% to 8% and those from Saginaw county from 6% to over 12%. While most of the coals are high in volatile matter and many of them are coking coals, they are not used for gas and coke making. The coke is usually inferior, being light and friable; the sulphur injures the quality of both the coke and gas, and the moisture gives more or less trouble in the ordinary types of gas producers. The Saginaw and St. Charles coals, though low in sulphur, are largely non-coking and high in moisture.

Most of the coals are good to excellent domestic coals and fair to good steam coals. Unfortunately they are weak and friable and do not stand long shipment well or permit of stocking. On exposure to the action of the air, sun, and rain many of the coals are rapidly reduced to slack. Owing to these qualities there is also a relatively large amount of slack produced in mining, especially in thin veins when shot "off the solid."

The ash content in most seams varies greatly from place to place. In portions of some fields, the coal is so high in ash (see analyses) that it is not marketable. Such coal is popularly called "cannel" coal, but it is not true cannel as it burns with much smoke. At the bottom or top of coal beds there is locally an inch to a foot or more of shaly and, in places, pyritous coal termed by the miners "Black Jack" or "dirty" coal. The early drillers failed to recognize this impure coal, and some of the areas of supposedly good coal have been found later to contain much "cannel" or "Black Jack" coal. This is the case in certain parts of the St. Charles coal field in Saginaw county.

The following analyses may be taken as fairly representative of the general character of Michigan coals. It is to be noted that the Bay county coals are in general lower in fixed carbon and higher in sulphur than those of Saginaw county.

*ANALYSES OF MICHIGAN COAL.

	Locality.	Mine.	Bed.	Sample.
	Arenac county.			
1	Rifle river, Sec. 3, T. 19, N. R. 4 E.	.....	Rifle river "cannel."	Air dried sample.....
2	Rifle river, Sec. 3, T. 19, N., R. 4 E.	.....	Rifle river, lower seam.	Air dried.....
	Bay county.			
3	Secs. 21 and 22, T. 14 N., R. 4 E.	Monitor.....	.....	Run of mine sample...
4	Secs. 16 and 17, T. 14 N. R. 4 E.	Wolverine No. 2.....	.....	Sample from car lots; commercial.....
5	Secs. 16 and 17, T. 14 N., R. 4 E.	Wolverine No. 2.....	.....	Lump coal; dried.....
6	Secs. 16 and 17, T. 14 N., R. 4. E.	Wolverine No. 2.....	.....	Lump coal; commercial.
7	Sec. 7, T. 14 N., R. 3 E. and Sec. 12, T. 14 N., R. 4. E.	Wolverine No. 3.....	"Verne".....	Lump coal; air dried...
8	Sec. 30, T. 13 N., R. 6 E.	What Cheer.....	.....	Run of mine; commercial.
	Calhoun county.			
9	Sec. 13, T. 2 S., R. 4 W.	Albion.....	.....	Composite sample from sections from different Places. Includes slaty coal at top of seam. Dried.
	Eaton county.			
10	Grand Ledge	Jenkins "drift".....	.....	Lump sample; dried.
11	Grand Ledge	Jenkins "drift".....	.....	Selected lump sample; air dried.
	Huron county.			
12	Sebewaing.....	Standard.....	"Verne".....	Sample from stockpile; air dried.
	Jackson county.			
13	Jackson, Sec. 21, T. 1 N., R. 2 W.	New Hope.....	.....	Selected lump.....
	Saginaw county.			
14	Saginaw.....	Pere Marquette No. 1	.....	Section (92 inches) of main coal; natural. Same bed as Caledonia No. 3.
15	St. Charles.....	Robt. Gage No. 1...	"Saginaw".....	Same field as Robt. Gage Mine No. 2. (New) 25 lb. sample; natural.
16	St. Charles.....	Robt. Gage No. 1...	"Saginaw".....	Average of 13 analyses; air dried.
17	St. Charles.....	Robt. Gage No. 1...	"Saginaw".....	Bone or cannel coal from top of seam, 8 inches; natural.
18	Saginaw.....	Saginaw and St. Charles mines.	"Saginaw".....	Coal as marketed from Saginaw and St. Charles mines by the Consolidated Coal Co.
	Shiawassee county.			
18	Owosso.....	Owosso.....	.....	Section (33 inches) from main coal, natural.
19	Corunna.....	Corunna.....	.....	Average analysis of coal shipped.

*A. C. Lane, 22nd Ann. Rept. U. S. G. S., p. 322; also Vol. VIII, Pt. II, Mich. Geol. Surv.' pp. 110-119.

*ANALYSES OF MICHIGAN COAL.

Sp. Grav.	Moisture.	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.	Heating power in B. T. U. (British Thermal units.)	Authority.
.....	11.35	35.80	41.10	11.87	5.84	.....	Sample through S. G. Higgins. Dickman and Mackenzie, analysts.
.....	3.60	40.00	55.40	1.00	.....	.....	
.....	4.60	38.70	48.40	8.30	1.20	12,732	Handy Bros. Mining Co.
.....	6.72	42.67	42.01	8.65	3.50	12,842	Analysts, Dickman and Mackenzie.
.....	.....	42.36	51.01	6.63	3.39	13,712	Wolverine Coal Co.
.....	7.72	39.08	47.09	6.11	3.11	12,653	Wolverine Coal Co.
.....	4.14	45.70	42.14	8.02	3.53	12,520	Wolverine Coal Co.
1.26	6.96	37.08	52.90	3.56	1.01	13,694	What Cheer Coal Co.
.....	.....	44.31	43.14	12.55	7.64	13,410	Analyst F. S. Kedzie. Sample contained 11.43 per cent of moisture, as received.
.....	.....	38.48	.....	10.14	4.61	.....	
.....	7.00	39.10	46.40	7.50	3.42	.....	Analyst, A. N. Clark.
1.34	6.09	39.54	46.06	8.26	5.72	12,767	Analyst, H. J. Williams.
1.24	5.93	46.59	44.64	2.84	3.07	13,580	Analyst, H. J. Williams.
1.269	10.15	33.14	53.95	2.76	1.10	12,726	Analyst, H. J. Williams.
1.285	7.79	34.74	52.58	4.89	1.01	12,836	Analyst, H. J. Williams.
.....	2.37	35.67	58.47	2.46	1.03	.....	Analyst, F. S. Kedzie.
.....	8.08	30.74	49.29	11.89	0.88	.....	Analyst, F. S. Kedzie.
.....	7.60	37.90	50.73	3.77	0.99	12,521	Analyst. Solvay Process Co., Syracuse, N. Y.
1.27	7.58	35.70	52.96	3.76	1.50	13,016	Analyst, H. J. Williams.
.....	6.33	35.46	45.45	12.04	.....	.....	

Development.

History of Coal Mining.—Coal mining apparently began at Jackson, Jackson county, as early as 1835, and certainly at Grand Ledge, Eaton county, in 1839. Until 1910 small mines were operated in Jackson county in the small shallow trough-like deposits of coal which were generally not more than 200 or 300 yards wide and a few hundred in length. At the present time a similar deposit is being worked near Spring Arbor, Jackson county, and a larger deposit is being developed just across the county line in Calhoun county four miles north of Albion. At Grand Ledge two coal beds 18 to 26 inches in thickness formerly outcropped in places in the bed of Grand River and along the banks for more than a mile. Most of the easily accessible coal has been mined out, but at present small quantities are obtained from clay pits of tile companies, utilizing the so-called fire clays which are locally associated with the coal beds. Coal was mined near Corunna and Owosso, Shiawassee county, prior to 1860. The coal deposits thus far discovered in the vicinity of these places have been small and pockety and of poor quality, hence mining operations have been intermittent and largely unprofitable.

In 1858-9 an unsuccessful attempt was made to mine coal near Millets, Eaton county, and a successful one at Williamston, Ingham county in the early 60's. A small mine is still in operation at the latter place. About 1875 several small pockets of coal were discovered along Rifle River, Arenac county, and some cannel coal was mined. The deposits were near the margin of the Coal Measures and were without proper roof, which together with much water and lack of transportation facilities discouraged further exploration and development.

In 1861 coal was discovered at Bay City by William Walker in drilling a salt well. The discovery created considerable interest at the time, but since there was an abundance of cheap wood fuel from the lumber industry nothing came of the discovery. In the early 90's coal was discovered in Saginaw and Bay counties, but it was not until 1897 that the real growth of the coal industry began. Numerous mines were opened up, chiefly in the vicinity of St. Charles, Saginaw, and Bay City. A few years later coal mining began in Huron, Tuscola, and Genesee counties, and in 1913 in Calhoun county. The production grew from about 90,000 tons in 1896 to more than 2,000,000 tons in 1907, the maximum amount in the history of the industry.

Mining conditions.—The irregular form of the minable coal areas and the variable thickness and quality of the coal makes systematic plans of mining difficult or impracticable to carry out. Some of the coal basins are very irregular in form, being made up of several subordinate basins. For ease in handling the coal and water the shaft should

be sunk in the lowest part of the basin but the uneven bottom makes the location of this uncertain without thorough drilling. Even when located at the most advantageous point the numerous hills and valleys are so pronounced that it is difficult to drain the water to the central shaft. In some mines auxiliary pumps are installed at various points to pump the water over the "rises" or to the surface through drill holes. To take advantage of gravity in hauling the coal to the shaft the entries follow the troughs in the coal bed as far as possible but heavy grades cannot always be avoided and auxiliary power must be provided at these points. The areas of "cannel," "Black Jack," or thin coal are very irregular in extent and mining plans must be constantly changed to meet the varying conditions. As a consequence maps of the workings of some mines resemble gigantic spiders.

Faults have been observed in a number of mines but most of faults are very small, the vertical displacement being measured in inches or two or three feet at most. In the Wolverine Mine No. 2 a large fault has been discovered in the workings for more than a quarter of a mile along the south side of the field. The coal bed on the south side of the fault has been upthrown a vertical distance of 55 feet along a fault plane having a hade of about 35° to the south. Such faults are apparently very rare in the Coal Measures of Michigan and most of the faults are so small that they interfere but little with mining operations.

Practically all of the coal seams except at Grand Ledge and Williamston are below the water table and largely in artesian territory, hence the most of the mines are very wet. The water comes in through the roof, the foot wall or both, or from the coal seam itself. Water has caused the abandonment of several mines and it is a serious menace to the successful operation of some of the present mines. The drift generally contains thick beds of quicksand and gravel, heavily water bearing. This makes shaft sinking very costly and uncertain. Several shafts have been lost owing to the quicksands and floods of water encountered. The erosion channels or "washouts" which are numerous in Bay county, are very wet and are a source of great danger. Several mines have been flooded, some permanently and such channels were encountered in mining. In general, water is very troublesome and its control and removal forms an important item in mining costs, especially in summer when the mines are practically idle.

Most of the proven areas of minable coal in Michigan have an average thickness of only about three feet, therefore the maximum yield of coal per acre which can be expected is relatively small. It follows that a larger acreage is required for a tonnage sufficiently great to warrant mining operations. The rapid variation in the thickness of the coal beds gives rise to local areas of thin coal, perhaps too thin for profitable

mining. The coal in such areas is not only lost but much expense is entailed by the extra dead work of driving entries through or around these areas. Areas of "bone," "cannel," or "black jack" coal further reduce the total expected tonnage. In general the greater acreage, the irregular form of the coal bodies, their variable thickness and the uneven bottom, necessitate longer and more numerous entries, greater trackage, and more dead work to win a given amount of coal than in Ohio, West Virginia, or Pennsylvania. The roof is generally weak and treacherous requiring heavy and costly timbering to support it. In places the shale roof slacks upon exposure to the air and breaks into innumerable fragments. The cost of sustaining such a roof is usually prohibitive. The "fire" or "underclays" beneath the coal likewise slack upon exposure to air and water and become soft and plastic. The pressure from the overlying strata forces them up into the workings, causing constant trouble and expense through heaving the tracks and choking the entries.

Mining Costs.—The thick surface materials, usually heavy water bearing, makes shaft sinking in Michigan very expensive. In Ohio a shaft may be sunk and a small plant built and equipped for $15,000 to $20,000 but in Michigan a shaft, mine-plant and equipment of similar capacity would generally cost from $40,000 to $50,000 or even more. The amount of dead work—entry driving, timbering, track laying, cutting through bars and areas of unminable coal, etc. is greater than in competitive fields. The expense of pumping and keeping the mines in running order during the idle season is excessive. The wage scale is higher and is interpreted more liberally for dead work than elsewhere. In addition the mines work but six eight hour shifts per week and are practically idle during part of the summer. All this tends to make mining costs very high, or two or three times as high as in Ohio and West Virginia. To make matters worse the relatively inferior quality and weak nature of Michigan coals demand that they shall sell at lower average prices than the firmer higher grade coals from bordering states.

The future of coal mining in Michigan depends largely upon the ability of the operators to reduce the present excessive mining costs and to increase the average sale price by improving the average quality of the coal through better methods of mining. The following table shows that the average daily wage increased from $2.34 in 1900 to $3.49 in 1913, and that the average cost of mining a ton of coal correspondingly has increased during the same period from $1.387 to $1.977. (See table of production and mining costs.)

Methods of mining.—The room and pillar double entry system of mining is the principal one used in Michigan. Attempts have been made to use the long wall system but it was found impracticable on

account of the weak and treacherous roofs in most of the mines, and the difficulty of adapting the long wall mining scale of other states to the scale conditions in Michigan.

Until 1898 all of the coal was mined by hand or "shot off the solid." The latter method is very wasteful particularly in Michigan where the seams are thin and the coal weak. The inordinately heavy charges of powder required in "shooting off the solid" shatters the coal producing much fine coal or slack and rendering the lump coal so friable that it disintegrates badly in handling and transportation. In addition the heavy charges shatter the weak roofs, which become a source of trouble and great danger.

In 1898 seven coal cutting machines were introduced into Michigan and they were so successful that eighteen more were brought in the following year. At first considerable difficulty was experienced, however, in adapting the machines, particularly the chain breast types to thin seams and to the weak roofs which require the timbering to be kept up close to the face. As a result there were only 46 machines in use in 1903, five years after their introduction. In the next five years, however, the number of machines increased to 120, but with the decline in coal production, which began in 1908 and has continued to the present, the number of machines also decreased. In 1912 and 1913, however, with the introduction of the short wall type of machine the number increased to 126 and 130 respectively.

In 1903, 13.2 per cent of the total production of coal was mined by machines and in 1908 the percentage increased to 29.2 per cent, in 1910 to 45.5 per cent, in 1912, to 52.7 per cent and in 1913, to 70 per cent. While nearly 30 per cent of the coal is still shot off the solid, the wonderful increase in the percentage of machine mined coal during the last three years is indicative of the recognition on the part of the operators of the importance of using efficient methods of mining. If the present rate of increase in machine mined coal is maintained, coal mining in Michigan will soon be conducted as efficiently as in West Virginia, Pennsylvania, and Ohio, where the per cent of coal shot from the solid in 1913 ranged from less than one per cent in the first state to 3.7 per cent in Ohio.

Up to 1904, the machines were chiefly of the pick or puncher type but after this the chain breast machine came into prominence. They never became so widely used as the puncher type since they are not well adapted to thin coal seams and to the close timbering required by the weak and treacherous roofs. A few long wall machines were experimentally used in a number of mines but they were impracticable as their use requires more room at the face than the chain breast type. In 1910 the short wall machine was introduced with such success that it threatens to displace all other types