F. W. Denton, General Manager.

Mine at South Range, Houghton County, Michigan.

The Baltic, one of the best mines in the district, is mining a portion of the Baltic lode. The lode and method of mining have been described above. The mine first produced copper, 25,000 pounds, in 1898, and by Dec. 31, 1910, had produced 132,646,934 pounds and paid $6,550,000 in dividends. In 1910 there was stamped 781,419 tons of ore yielding 17,549,762 pounds of copper, an average of 22.46 pounds per ton. This copper cost 8.32 cents per pound, and was sold for 12.74 cents. The production for 1911 is expected to be considerably below that of 1910. This is due largely to preparations for working the lode from the boundaries towards the shaft.

The mine being a comparatively young one, little is yet known concerning the ore at very great depth. There is, however, no good reason to fear that values will not continue down to low levels.

The mine is now being worked from four shafts. It is planned to use one of these only to the limit of its present equipment and work the lower levels from three shafts only. To do the tramming in the long levels economically electric locomotives will be used. At the mill a number of changes have been made recently. Equipment for regrinding has been added, and a tailings conveyor plant was completed this fall.

Bohemia Mining Co. 85 Devonshire Street, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. 75,000 shares issued. $8 per share paid in.

Balance in bank April 17, 1911, $124,819.88.

William A. Paine, President.

Charles A. Snow, Vice President.

Robert H. Gross, Secretary and Treasurer.

These officers and Thomas S. Dee, Stephen R. Dow, John H. Rice and Richard M. Edwards, Directors.

R. M. Edwards, Superintendent.

Mine at Lake Mine, Ontonagon County, Michigan.

This company was organized to acquire and develop 960 acres of mineral land, lying about 1½ miles northeast of the Indiana property. During 1910 several holes were drilled in search of the Indiana lode. The work did not disclose any lodes rich enough to warrant further exploration under present conditions. The directors are awaiting developments on properties north and south, and during 1911 no work was done.

Of the six holes drilled, three showed some copper. From the cores considerable information concerning the geological structure was obtained, and this will be useful when further exploration is undertaken.

No. 6 conglomerate was cut by three holes and thus traced across the property. The contract of the Eastern Sandstone was found to be at about the middle of the south side of the property, thus showing probably 600 acres to be located on the Keweenaw series. The distance from the No. 6 conglomerate to the Eastern Sandstone was found to be 3,500 feet. This includes the horizon in which occur the new lodes on the Lake, Adventure and Indiana properties. Immediately below the No. 6 conglomerate several amygdaloids were cut, and some of these showed copper, and are possibly the beds being opened on the Adventure. The remaining two-thirds of the territory between No. 6 conglomerate and the Eastern Sandstone was cut by one line of holes near the south side of the property, and the ground there found to be much broken.



Calumet and Hecla Mining Co. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each, $12 per share paid in. Total dividends paid Dec. 31, 1911, $116,550,000.

On April 29, 1911, Cash and Quick Assets were $9,159,754.12. Liabilities, $582,897.84. Notes outstanding, $8,519,000.00.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

These officers and Francis L. Higginson, Francis W. Hunnewell and James MacNaughton, Directors.

George A. Flagg, Secretary and Treasurer.

Walter C. Smith, Assistant Treasurer.

James MacNaughton, General Manager.

John Knox, Jr., General Superintendent.

The Company owns the Calumet and Hecla properties and controls the following mining companies:

Ahmeek, Allouez, Centennial, Cliff, Dana, Frontenac, Gratiot, Isle Royale, LaSalle, Laurium, Manitou, Osceola Consolidated, St. Louis, Seneca, Superior, Tamarack and White Pine.

Calumet and Hecla Mine is at Calumet, Houghton County, Michigan.

The company has mines on three lodes—The Calumet conglomerate and Osceola and Kearsarge amygdaloids. About four-fifths of the production is from the conglomerate, and the balance from the Osceola lode. The Kearsarge is at present nonproductive on this property. The three lodes are described above.

The Calumet lode is mined from nine shafts, one vertical, seven following down on the dip of the lode from surface, and one slope shaft starting below the 57th level and running parallel to the lode, but at an inclination of only 22°.

The vertical, known as the Red Jacket, is a six compartment shaft 4,900 feet deep, equipped with a Whiting hoist. The inclined shafts are either two or three compartment. In the three compartment shafts the two hoisting compartments are given different numbers. Thus there are more numbers than shafts. South Hecla Nos. 9 and 10, for instance is one three compartment shaft with two skip roads. The 7 operating shafts on the lode from north to south have respectively the following depths:—6,155 ft.; 7,995 ft.; 6,186 ft.; 7,465 ft.; 7,570 ft.; 6,102 ft. and 7,529 ft. measured down on the incline. There are three additional shafts that are being gradually closed from the bottom by the removal of shaft and arch pillars, and four other shafts that have been for some time abandoned.

The mine workings are in four branches known as the Red Jacket, Calumet, Hecla and South Hecla. The Red Jacket and Calumet shafts are permanently bottomed, and the sinking in ground commanded by these shafts is by winzes and especially by the "slope" shaft from the 57th level. At the Hecla branch two shafts, No. 6 and No. 7, and at the South Hecla one shaft, No. 9 and 10, are still being deepened. The chief new ground found on the lode in recent years is south of this latter shaft at great depth.

During 1910 from the conglomerate mine there was hoisted and stamped 1,950,040 tons of ore, which yielded 58,739,509 pounds of copper, an average of 30.12 pounds per ton. This copper was produced at a cost of 8.55 cents per pound.

The C. & H. portion of the Osceola amygdaloid lode has been opened up by six three compartment shafts, all inclined with the lode. These in order from north to south had in April, 1911, reached depths of 1,234 ft.; 2,461 ft.; 2,787 ft.; 2,554 ft. and 3,232 ft. respectively. In 1910 there were hoisted and stamped 831,194 tons of amygdaloid ore, which yielded 13,150,427 pounds of copper, an average of 15.82 pounds per ton. The cost was 10.53 cents per pound. Most of the ore came from the hanging side of the lode, but much also from the foot. Considerable new ore has been found recently in the irregular foot portion.

The total ore, conglomerate and amygdaloid, stamped in 1910 was 2,795,514 tons yielding 72,059,545 pounds copper, an average of 25.77 pounds per ton. The copper cost 8.96 cents, and was sold for 13.20 cents per pound. In the last five years there was stamped 13,185,376 tons of ore which yielded 410,614,189 pounds of copper, an average of 31.2 pounds per ton. This copper cost 8.95 cents and was sold for 15.8 cents per pound. Production for 1911 is expected to be about 75,000,000 pounds. The selling price, however, is lower. It has recently been estimated that the conglomerate will yet yield 850,000,000 pounds of copper from ore averaging 30 pounds per ton, and the amygdaloid 630,000,000 pounds from ore averaging 14 pounds per ton.

Development work on the Kearsarge lode on the C. & H. property has been done from three shafts. Two of these were sunk each to 1,350′ and then closed down. The third was sunk to greater depth, and from it exploration is still being carried on. In 1910 there was stamped 14,280 tons of ore from the Kearsarge lode, which yielded 169,609 pounds of copper.

At the C. and H. mills the most noteworthy recent change is in the regrinding department. A regrinding plant built three years ago was equipped with 48 Chili mills. In competition with these two pebble mills have been running for some time. The management now considers a conical pebble mill to be the most efficient machine for the purpose. It has greater capacity than the Chili mill and on account of grinding finer permits of greater extraction. A new regrinding plant of 3,000 tons daily capacity, and in which pebble mills will be used is now being planned. The mills are now being built in the company's shops.

During 1910 the present recrushing plant treated coarse conglomerate tailings from the Calumet mill and produced 1,951,378 pounds of copper from sands containing 12.6 pounds of copper per ton, at a cost of 5.08 cents, exclusive of smelting and marketing costs. Experiments have shown that sands now lying in Torch Lake, and containing about 16 pounds copper per ton, can be treated at a substantial profit.

An event in 1911, which had an important bearing on the future of the Calumet and Hecla and subsidiary companies, was the proposal of a plan of consolidation of the Calumet and Hecla, Ahmeek, Allouez, Centennial, Seneca, Osceola Consolidated, Tamarack, Laurium, La Salle and Superior Companies. The several properties were appraised, and to each company it was proposed to allot stock in the new Company proportional to such



valuation. March 15, 1911, was fixed as the date which the merger should take effect. The necessary majority vote was in favor of consolidation, but minority shareholders made vigorous opposition and took steps to prevent it. Suits were brought against it by G. M. Hyams as a shareholder in Osceola, by C. M. Turner and others also as shareholders in Osceola, and by F. W. Denton and W. A. Chadbourne as shareholders in Ahmeek. Hearings were had in each case and resulted in denial of application for temporary injunction by Judge Swan in the Hyams suit and by Judge Streeter in the Denton-Chadbourne suit. It was granted in Turner case by Judge Wiest, because of the excessive value of the properties which were to be capitalized at $10,000,000, the maximum allowed by Michigan law.

The Denton-Chadbourne case was later taken to the Supreme Court of Michigan, by a petition for a writ of mandamus, and a restraining order was issued pending the decision of the Court. A fourth suit was brought by J. F. Jackson, as a stockholder in Ahmeek, and a restraining order obtained, and an order to show cause why a temporary injunction should not issue was made.

At this stage the Calumet and Hecla directors decided that the plan should be abandoned. They stated that the long delay and necessary attention from company officials was likely to render the scheme fruitless.

At present W. A. Chadbourne and others are seeking to obtain from the Courts a permanent injunction, which shall forever prevent a consolidation on anything like the terms proposed.

In Dec. 1911, counsel for the various interests agreed to drop the suits.

CARP LAKE MINING CO. Ontonagon, Mich.

Explored a copper bearing sandstone bed in the Porcupine Mountain district. Long idle.

CENTENNIAL COPPER CO. 12 Ashburton place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $19.50 per share paid in. 90,000 shares issued.

Balance of liabilities Dec. 31, 1911, $54,061.19.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

These officers and H. F. Fay, G. A. Flagg, F. L. Higginson, F. W. Hunnewell and James MacNaughton, Directors.

G. A. Flagg, Secretary and Treasurer.

Geo. C. Endicott, Assistant Secretary and Assistant Treasurer.

James MacNaughton, General Manager.

Mine at Calumet, Houghton County, Michigan.

Predecessors of this company explored without any satisfactory results the northern extension of the Calumet conglomerate. The present company explored the extension of the Osceola amygdaloid, with similar unprofitable results, and in recent years has confined attention to the Kearsarge lode. The lode is developed by two shafts of which No. 1 is 3,821 ft. and No. 2 is 3,955 ft. deep. The mine has made an important contribution to the copper output, but until 1911 has done so at a loss. During 1909 and 1910 costs were considerably reduced. Development work has been advanced, so that in a period of higher prices, a larger output may be made.

In 1910 there was stamped 102,133 tons of ore, yielding 1,572,566 pounds of copper at a cost of 14.48 cents per pound. The cost was reduced in 1911 to 12.69 cents on a production of 86,543 tons of ore yielding 1,493,834 lbs. copper an average of 17.26 lbs per ton. The chief development work during the year has been in the drifts north from No. 2 shaft at the lower levels where good ore has been blocked out. It is not unreasonable to expect better ore when these workings are continued to develop ground below the rich ore found in the South Kearsarge and Wolverine Mines. It is expected that there will be a considerable increase in production in 1912.

CENTRAL MINE, at Central Mine, Keweenaw County.

Formerly property of Central Mining Company, now owned by Frontenac Mining Company. Long idle.

CHALLENGE MINE, at Painesdale, Houghton County.

Owned by St. Mary's Canal Mineral Land Co. Idle.

CHAMPION COPPER CO. 82 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of assets Dec. 31, 1911, $792,256.14.

Controlled by Copper Range Consolidated Co., and St. Mary's Mineral Land Co. Mine operated by Copper Range Consolidated Company.

Wm. A. Paine, President.

Charles J. Paine, Jr., Vice President.

Frederic Stanwood, Secretary and Treasurer.

Wm. A. Paine, Charles J. Paine, Jr., Samuel L. Smith, George P. Gardner, Nathaniel H. Stone, F. W. Denton and Richard Olney, Directors.

F. W. Denton, General Manager.

Mine at Painesdale, Houghton County, Michigan.

This company is mining from four shafts a portion of the Baltic lode. The lode is described above. The method of mining is the same as that at the Baltic mine described above. The ore produced is comparatively high grade, and the mine is one of the most profitable in the district.

The mine first produced copper, 4,165,784 pounds, for the market in 1902. At the end of 1910 there had been produced 131,111,741 pounds, valued at $19,189,440.18 and paid in dividends $5,900,000.00. During 1910 there was hoisted and stamped 722,051 tons of ore, which yielded 19,224,174 pounds of copper, an average of 26.62 pounds per ton. This was produced at a cost of 7.85 cents, and sold for 12.74 cents. During the last five years there was stamped 3,651,132 tons of ore which yielded 88,460,380 pounds of copper, averaging 24.2 pounds per ton. This copper cost 9.25 cents and was sold for about 15 cents per pound. The mine is comparatively a young one, and is expected to be a large producer for many years. For 1911 the production will probably be considerably below that for 1910, and as the copper content and the selling price are lower, the profit has been much less.

At the stamp mill delays have been caused by trouble with the water intake, and a new intake is now being constructed.



CHEROKEE COPPER CO. Houghton, Mich.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Jos. H. Hodgson, President.

Linus Stannard, 1st Vice President.

Deen L. Robinson, 2nd Vice President.

Wm. D. Calverly, Secretary and Treasurer.

These officers and J. H. Rice, B. M. Chynoweth and R. M. Edwards, Directors.

H. W. Fesing, Superintendent.

This company has been exploring, by diamond drilling, property lying between the Bohemia and King Philip properties.

CLARK MINE.

Mine at Copper Falls, Keweenaw County, owned by Dr. Leon Estivant, 47 Ave. de l'Alma, Paris, France. F. W. Nichols, Agent.

Property was explored by diamond drilling in 1910. Now idle.

CLIFF MINING CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. James MacNaughton, General Manager. Balance of assets Dec. 31, 1911, $75,756.59.

This Company, a subsidiary of the Calumet and Hecla Mining Company, owns a large acreage in Keweenaw County, including the old Cliff Mine. The Cliff Mine at one time was worked very profitably, and in 1849-1879 yielded dividends of $2,518,620. The copper was mined from fissure veins. Recently some work has been done in the horizon of the Kearsarge lode. The lode was approximately located by drilling, and an exploratory shaft started in August 1910. During 1911 a plant was installed, and the exploration continued. The shaft has been sunk to a depth of 217 ft. and at 205 ft. drifts were run north and south in the more easterly of two lodes found in the drill hole near the shaft. No copper was disclosed in either drift. A cross cut has been started from the north drift to reach the second lode. The horizontal distance between the lodes is 100 ft.

CONTACT COPPER CO. 70 State St., Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each.

Harry F. Fay, President.

C. J. Morrisey, Vice President.

These officers and John C. Watson, Stephen R. Dow and John G. Stone, Directors.

This Company was formed in 1910, and took over the Elm River Copper Company.

The company in May, 1910, began diamond drilling in Section 13, T. 52, R. 36. Holes No. 1 and No. 2 penetrated the Eastern Sandstone. Holes No. 3 and No. 4 were abandoned in overburden after driving to depths of 502 feet and 322 feet respectively. Holes No. 5, No. 6 and No. 7 gave a continuous section southeasterly across the Keweenaw series. Hole No. 5 started near the west quarter post of section 12, was started in what is supposed to be conglomerate No. 7. The drilling shows the formations to strike N. 39° E. and dip about 64° N. W. and to be markedly free from evidence of disturbance.

COPPER CROWN MINING COMPANY. 1013 Eastern Ave., St. Louis, Mo.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Jacob Maurer, President.

Dr. M. J. Hopkins, Vice President.

N. J. Cashin, Treasurer.

These officers and B. L. Brown, Geo. Bridenbach, Fred Balke and J. W. Byers, Directors.

H. B. Kirkpatrick, Secretary.

The company owns a large acreage west of Victoria, Ontonagon County. The chief property is the Norwich mine, where some copper was produced. Now idle.

COPPER RANGE CO. 82 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Wm. A. Paine, President.

Chas. A. Snow, Vice President.

Frederic Stanwood, Secretary and Treasurer.

Frederick W. Denton, General Manager.

These officers and H. T. McKeever, Directors.

Controlled by Copper Range Consolidated Company. Owns one-half the stock of the Champion Copper Company and 9,360 acres on the mineral range.

The company did considerable exploratory work in 1909 and previously on lands under option from the St. Mary's Mineral Land Company. There was drilled 7,641 feet of holes, but nothing very promising was found and the option was dropped.

COPPER RANGE CONSOLIDATED COMPANY. 82 Devonshire St., Boston.

Capital Stock $38,433,500 in 384,335 shares of $100 each.

On Dec. 31, 1910, balance of assets was $641,726.22.

William A. Paine, President.

F. W. Denton and R. T. McKeever, Vice Presidents.

Frederic Stanwood, Secretary and Treasurer.

These officers and J. Henry Brooks, Kenneth K. McLaren, Charles J. Paine, Jr., F. McM. Stanton and Samuel L. Smith, Directors.

The company owns 99,659 shares of the Baltic Mining Co., 99,659 shares of the Copper Range Co., and 99,335 shares of the Trimountain Co. Through the Copper Range it owns the Copper Range Railroad, 9,360 acres of mineral land and one-half the stock of the Champion Mining Company. The Copper Range companies own 12,000 of the 20,000 shares of the Michigan Smelting Company.

The operating companies controlled by this company together in 1910 produced 42,468,754 pounds of copper, which was sold for $5,407,628.58. The net income for the year was $1,300,857.86. Dividends paid in 1910 amounted to $1,537,340.00, making a total of $10,756,716.00 paid in 6 years.

The production for 1911 was 37,130,292 pounds copper which was sold for $4,655,127.03. The net income for the year was $804,560.93 and $1,357,104 was paid out in dividends. The directors report an unsatisfactory year but a promising future.



DAKOTA HEIGHTS CO. Hancock, Mich.

Capital Stock $25,000 in 2,500 shares of $10 each.

Henry L. Baer, President.

Thos. Coughlin, Vice President.

Chas. D. Hanchette, Secretary and Treasurer.

Henry J. Brock, Superintendent.

These officers and Geo. H. Nichols, Jas. T. Healy, Frederick W. Nichols and Frank C. Mayworm, Directors.

Owns mineral lands in West Houghton adjoining the Isle Royale property. Idle.

DANA COPPER CO. 68 Devonshire St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

C. O. Burbank, Secretary and Treasurer; and John C. Watson and Joseph H. Chandler, Directors.

Is controlled by the Calumet and Hecla Mining Company. Owns lands in Keweenaw County, adjoining Central Mine. Idle.

DELAWARE MINE.

Is part of the property of the Manitou Copper Company in Keweenaw County. Former owners worked the Allouez conglomerate lode with very unsatisfactory results. The mine has been long closed down.

ELM RIVER COPPER CO. 70 State St., Boston.

Capital Stock $1,200,000 in 100,000 shares of $12 each.

H. F. Fay, President.

C. J. Morrissey, Secretary and Treasurer.

These officers and John C. Watson, Stephen R. Dow and Chas. N. King, Directors.

Geo. L. Goodale, Superintendent.

Owns property near Twin Lakes, Houghton County, and has done on it considerable exploratory work, chiefly by shafts and cross cutting. Was taken over last year by the Contact Copper Co. and the latter company has since been doing diamond drilling on the property adjoining.

EVERGREEN BLUFF MINING CO.

Owned property which adjoins the Mass Mine, and is now part of the holdings of the Mass Consolidated Company.

FRANKLIN MINING CO. 60 Congress St., Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each. $10.20 per share paid in. 166,326 shares issued.

Balance of liabilities Dec. 31, 1910, $46,687.44.

Stephen R. Dow, President.

Albert L. Wyman, Secretary.

These officers and John C. Watson, Harry M. Howard, Henry Tolman and R. M. Edwards, Directors.

Alvin R. Bailey, Treasurer.

R. M. Edwards, Superintendent.

Enoch Henderson, Asst. Superintendent.

Mine at Demmon, Houghton County, Michigan. Property 3,276 acres.

The old Franklin mine was nearly worked out, and sold in 1908 to the Quincy Mining Company. The Franklin Company is now operating the Franklin Junior mine, on property which adjoins the Quincy on the north. The company had on Dec. 31, 1910, stamped 6,311,176 tons of ore producing 160,595,837 pounds of copper. In 1911 there was produced 820,203 pounds.

Two lodes have been worked at the Franklin Jr.,—the Allouez, or Boston and Albany conglomerate, and the Pewabic amygdaloid. The conglomerate lode was abandoned in 1909, and the amygdaloid only is now being worked. Development work during the past two years has shown the lode to be richer at the deep levels than it was nearer the surface, and it is expected that the mine will become an important producer. A large tonnage of ore has been put in sight, there being in 1910 more than five times as much ground opened as stoped. During 1911 development work was put still further ahead, and the main shaft 3,320 feet deep, has been recently equipped to handle a much larger output. The other shafts are closed down. With the new hoist and a 10 ton skip, the shaft will have a capacity of 1,200 tons per day.

During 1911 the Franklin mill was thoroughly overhauled and is expected to make a better recovery of the values.

The new equipment at mine and mill was ready about Feb. 1, 1912 and regular mining operations were then resumed. During the month the output was increased from 250 to 650 tons daily and will be further increased as fast as miners can be secured.

FRONTENAC COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

James MacNaughton, General Manager.

These officers and F. W. Hunnewell, Directors.

Controlled by Calumet and Hecla Mining Company. Owns Central Mine and adjoining lands in Keweenaw County. Idle.

GLOBE MINE.

This mine, on property adjoining the Champion, was opened by the Copper Range Company to explore the Baltic lode. The results were unsatisfactory, and the property has been idle during the past two years.

GRATIOT MINING CO. 12 Ashburton Place, Boston.

Capital Stock $300,000 in 100,000 shares of $3 each, full paid and non-assessable.

Balance of Liabilities, Dec. 31, 1910, $266,133.07.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

These officers and F. L. Higginson, F. W. Hunnewell and James MacNaughton, Directors.

Geo. A. Flagg, Secretary and Treasurer.

W. H. Draper, Asst. Treasurer.

James MacNaughton, General Manager.



The company owns a portion of the Kearsarge lode north of the Mohawk mine, and has explored it with unsatisfactory results. The ore is low grade, and the company owns but a small area on the lode. In the eight months ending December 31, 1910, there was stamped 28,522 tons of ore, yielding 265,869 pounds of copper, of 9.32 pounds per ton. Development is by two shafts, one 1,901 feet deep, and the other 1,521 feet deep. The shafts would be useful in opening Seneca ground at somewhat greater depth.

HANCOCK CONSOLIDATED MINING CO. Hancock, Mich.

Capital Stock $5,000,000 in 100,000 shares of $25 each and 100,000 shares not issued.

Balance of assets Dec. 31, 1910, $48,599.99.

John D. Cuddihy, President.

Thomas Hoatson, Vice President.

These officers and Allen F. Rees, Samuel B. Harris, John H. Hicok, James Hoatson and Frederic W. Nichols, Directors.

John H. Hicok, Secretary and Treasurer.

John L. Harris, General Manager.

Mine at Hancock, Houghton County, Michigan.

The company is sinking a vertical shaft to work the Pewabic lode at depth, and incidentally has opened up some good ground on the Hancock lodes. The property adjoins the Quincy.

The vertical, which is a 9′x30′ five compartment shaft, cut the No. 3 Hancock lode at a depth of 2,038 feet and was expected to cut the Pewabic lode at a depth of about 3,600 feet. On Nov. 29, 1911, the shaft at a depth of 3,105′ cut into a rich amygdaloid lode, known now as No. 4 lode. This has not yet been definitely identified; but as there are known to be several lodes west of the Pewabic, it is thought that this is one of these. Where cut, the lode is rich for a thickness of about eight feet, and has considerable copper further in the footwall. As this ore has been found at a vertical depth of 3,105′ it is evident that it may prove of great importance, even though it averages much lower grade than where now exposed. The shaft is close to the Quincy boundary, and the latter may also profit by the discovery. At a depth of 3,221 feet another bed showing some copper has been cut.

During 1911 the company mined enough ore on the Hancock lode to run a mill test. There was stamped 41,449 tons of ore, which yielded 754,749 pounds copper, an average of 18.21 pounds per ton. The ore was stamped at the Centennial mill, and the concentrates smelted at the Calumet and Hecla plant at Hubbell. The mill test was discontinued Nov. 1, 1911, and attention devoted to opening new ground by drifting and trial stoping. The vertical shaft is being deepened to cut the Pewabic lodes. During the last five months of 1911 the shaft was sunk and timbered for 405 ft., an average of 81 ft. per month, and on Dec. 31, 1911, was 3,197 ft. deep.

HOME COPPER MINING CO.

Owns land in Keweenaw County, adjoining the Humboldt Mine. Idle.

HOUGHTON COPPER CO. 713-199 Washington St., Boston.
Capital Stock $2,500,000 in 100,000 shares of $25 each.
Chas. J. Paine, Jr., President.
Geo. P. Gardner, Vice President.
A. E. Coe, Secretary and Treasurer.
These officers and N. H. Stone, James P. Edwards and Frederick A. Nichols, Directors.
Dr. Lucius L. Hubbard, General Manager.
The company is exploring what is supposed to be the extension of the Baltic lode north of the Superior Mine. The lode was found by diamond drilling in 1910, and a shaft has since been sunk to a depth of 623 feet. The lode and wall rocks are much fractured. The shaft is in the footwall, and cross cuts are made to the lode. One was made at 460′ and in December, 1911, a cross cut was started at the 623′ level. Both these cross cuts opened up copper bearing lodes.

HULBERT MINING CO. 199 Washington St., Boston.
Capital Stock $1,000,000 in 40,000 shares of $25 each.
Albert S. Bigelow, President.
W. A. S. Crimes, Secretary and Treasurer.
Frederick W. Nichols, Agent.
Owns a large acreage of mineral lands in Houghton and Keweenaw County. Idle.

HUMBOLDT COPPER CO. 64-50 State St., Boston.
Capital Stock $1,000,000 in 40,000 shares of $25 each.
John C. Watson, President.
John Brooks, Secretary and Treasurer.
Capt. Wesley Clark, Superintendent.
These officers and M. A. O'Neil, Directors.
Explored long ago some lands in Keweenaw County. Idle.

INDIANA MINING CO. 60 Congress St., Boston.
Capital Stock $2,500,000 in 100,000 shares of $25 each. $8 per share paid in. 80,000 shares issued.
Balance of assets Dec. 31, 1910, $76,772.55.
Stephen R. Dow, President.
Albert L. Wyman, Secretary.
Alvin R. Bailey, Treasurer.
These officers and David E. Dow, Henry Tolman and R. M. Edwards, Directors.
R. M. Edwards, Superintendent.
Mine at Indiana, Ontonagon County, Michigan. 1,200 acres.
The company explored property in 1909, 1910 and 1911 by several diamond drill holes, and is now sinking a vertical shaft to examine copper bearing ground located by these holes. Rich cores were taken from a mass of much fractured and altered felsite, and in this rock the shaft is now being sunk. It is intended to sink the shaft deep enough to allow exploratory work to be done at the several depths from which copper bearing cores were taken. As little is yet known of the nature of the deposit, the plan of exploration seems a very wise one. The stratigraphy in the neighborhood of the shaft is apparently far from uniform, and deductions from the drill cores alone are unsafe.



Further to the northwest on the same property the beds appear little disturbed and with the usual regular strike and dip. Copper has been found in some of these beds also, and an exploratory shaft was recently started to test one of them. The shaft, known as "A" shaft, is 60 feet deep.

In the drilling campaign 14 holes were put down, making a total of 20,000′. In all but two holes copper was found. It is evident that the property, concerning which previously very little was known on account of lack of outcrops, is well mineralized.

The shaft started late in 1910 went through about 110 feet of overburden, most of which is a red colored lake clay. The ledge was reached April 4, 1911. Since then sinking has been continuously in felsite. The rock is hard, and has been found unusually difficult to drill. It is traversed by very numerous joints, and when blasted breaks into small fragments. The dump looks much like a pile of crushed rock, the pieces being nearly all less than 3″ in diameter. The shaft is on Jan. 1, 1912, 533 ft. deep and being sunk at the rate of 75 ft. per month. It is intended to cut a station at the 600′ level and run cross cuts to investigate the deposits found in No. 9 drill hole which is only 60′ from the shaft.

Previous to the discovery of the Indiana lode, the felsites were always thought to be barren of copper. From the drill cores obtained it seems that there is here perhaps a workable deposit, and the result of exploration is being awaited with unusual interest.

ISLAND COPPER CO. 1400 Alworth Bldg., Duluth, Minn.
Capital Stock $1,000,000 in 40,000 shares of $25 each.
Thomas F. Cole, President.
Geo. G. Stone, Vice President.
Frederic W. Nichols, Secretary.
These officers and F. W. Heimick, Oscar J. Larson, Henry Nolte, Geo. G. Barnum, Geo. A. Tomlinson and Julius H. Barnes, Directors.
Edw. J. Maney, Treasurer.
The company owns the greater part of Isle Royale. Previous owners did a little exploratory work, but the present company has not yet done any. The island is largely composed of rocks of the Keweenaw series, and is known to contain copper bearing beds.

ISLE ROYALE COPPER CO. 12 Ashburton Place, Boston.
Capital Stock $3,750,000 in 150,000 shares of $25 each.
Balance liabilities Dec. 31, 1911, $137,976.75.
Rodolphe L. Agassiz, President.
Quincy A. Shaw, Vice President.
Geo. A. Flagg, Secretary and Treasurer.
These officers and Francis L. Higginson and Charles N. King, Directors.
Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.
James MacNaughton, General Manager.
Mine at Houghton, Houghton County, Michigan.
The company is working the Isle Royale and Grand Portage lodes south

of Portage Lake. The ore mined is comparatively low grade, and until recently much of the work has been done at a loss to the owners. A better showing has been made during the past two years. In 1910 there was produced 7,567,399 pounds of copper at a small profit. This copper was obtained from 520,860 tons of ore—an average of 14.5 pounds per ton. The copper cost 11.84 cents and most of it was sold for 12.68 cents per pound. During the last five years there was stamped 1,508,740 tons of ore, yielding 21,902,821 pounds of copper, an average of 14.6 pounds per ton. This copper cost 17.8 cents per pound and was sold for 14.2 cents. In 1911 production was 457,440 tons of ore which yielded 7,490,120 pounds copper, an average of 16.4 pounds per ton. This copper cost 10.85 cents per pound. The average price received for sales made during 1911 was 12.38 cents. There was received for silver in 1911 the sum of $20,336.55.

During 1911 extensive exploration work has been carried on at four shafts, No. 2, No. 4, No. 5 and No. 6 which have now reached depths of 3,162; 1,517.5; 1,006; and 1,234.5 ft respectively. The results are very satisfactory and the southern part of the lode, which has not yet been developed to any great depth, has been found rather above the average. The seventh level has been extended south to 1,932 ft. and has opened up good ground. In spite of the low price of copper and a slight decrease in output, the mine showed in 1911 a profit of $136,708.10. With better prices for the metal and a larger production, it is not unreasonable to suppose that the mine will soon become a very important profit maker. It has been found advisable to sort the ore carefully and the discard in 1911 amounted to 19.0% of the rock broken.

During the past few years the Isle Royale Company has done some exploratory work in the horizon of the Baltic lode. The ground has been found much broken up, and the results so far obtained are not very satisfactory. Some cross cutting and drifting was done during 1911 but no copper was found and the work at this point, "A" shaft, was discontinued in September. Further exploration at "A" shaft will depend upon results obtained by the Houghton Copper Co.

It is expected that the production of Isle Royale will be very considerably increased in the near future. At present the mill is being worked at its full capacity and increase in mine output will necessitate increase in milling facilities. The directors have recommended the purchase for the sum of $140,000 of a stock interest in the Lake Milling, Smelting and Refining Company, which will assure the use of two heads.

KEARSARGE MINE.

Is one of the producing mines owned by the Osceola Consolidated Company.

KEWEENAW ASSOCIATION. 33-87 Milk St., Boston, Mass.

F. M. Davis, Chairman.

Dudley S. Dean, Secretary and Treasurer.

John M. Longyear, General Agent.

Owns a large acreage of timber land and some mineral land on the range.



KEWEENAW COPPER COMPANY. Hancock, Mich.

Capital Stock $2,800,000. $14 per share paid in.

Thomas F. Cole, President.

Spencer R. Hill, Vice President.

Thomas Hoatson, 2nd Vice President and mining director.

C. A. Wright, Secretary and Treasurer.

These officers and James Hoatson, Directors.

The company owns a large acreage of mineral and timber lands in Keweenaw County. Some exploratory work has been carried on in the past few years chiefly by diamond drilling, and an exploratory shaft at Mandan. Copper was found in cores taken from the Kearsarge amygdaloid, and a shaft was sunk to a depth of 1,355′ to explore the lode. Comparatively little was found, and the work was recently discontinued.

KING PHILIP COPPER CO. 705 Sears Bldg., Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Charles J. Paine, Jr., President.

Geo. P. Gardner, Vice President.

These officers and Nathaniel Thayer, Charles J. Paine, Walter Hunnewell, Nathaniel H. Stone and Rufus R. Goodell, Directors.

Edward B. O'Conner, Secretary and Treasurer.

The company owns 960 acres in Houghton County, adjoining the Winona Mine, and works the same lode—the Winona amygdaloid. Recently the company has been merged with the Winona, and some reduction of operating costs should result. The two companies have recently erected a 2 stamp mill at the mine, and one head was put in operation in March, 1911.

The company has developed the Winona lode by two shafts, and put in sight a considerable tonnage of ore.

LAKE COPPER CO.

Capital Stock $2,500,000 in 100,000 shares of $25 each, all issued. $3 per share paid in. Balance of assets April 30, 1911, $357,988.79.

William A. Paine, President.

John H. Rice, Vice President.

Robert H. Gross, Secretary and Treasurer.

These officers and Galen L. Stone, William F. Fitzgerald, Robert T. McKeever and Reginald C. Pryor, Directors.

Charles K. Hitchcock, Jr., Mine Manager.

Mine at Lake Mine, Ontonagon County, Michigan. Property 1,150 acres.

This company is opening up a wide lode in the lower part of the copper bearing series. The lode has been described above. Development has until recently been entirely from one shaft. Drifts have been run at eight levels, and a raise put through for a new shaft on the lode. In May, 1911, the lode had been opened up for a length of 2,100 feet, and a depth of nearly 1,300 feet on the dip. Since that date the new shaft has been sunk to the ninth level, and drifts on several levels have been steadily extended. The old shaft is bottomed at a depth of 1,130′. The new shaft is 1,366′ and being deepened.

Under former management there was hoisted and stamped at the Franklin mill, 14,485 tons of ore, which yielded 318,050 pounds of copper, an

average of 21.957 pounds per ton. During 1910 there was a change in management, and no ore has been stamped since. All efforts have been concentrated on development work, and the ore produced from these openings is piled at the surface.

In 1910 a new compressor plant was installed, and during 1911 a new hoist and rockhouse of large capacity have been erected. The development work is now well ahead, and with the new and well equipped shaft in operation, the mine can begin production very soon. Further extensive development work will probably be done however before mining on a large scale is begun. There are 8 levels developed and some dry walls similar to those at the Baltic Mine have been built preparatory to stoping.

Development has shown the lode to vary in strike from due north at the No. 1 shaft to due west at the end of the northern drifts. The structure is not yet well understood. The opening thus far made suggest that it may be a syncline pitching to the southwest.

LAKE MILLING SMELTING AND REFINING CO.
12 Ashburton Place, Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

This company controlled by Allouez and Centennial Mining Companies, owns the stamp mills at Point Mills, Portage Lake, and stamps the product of the Allouez and Centennial Mines. It is proposed to increase the capitalization to 250,000 shares and purchase the Tamarack two-stamp mill and 30% of the stock of the Mutual Light and Power Co. The Tamarack mill will then be enlarged and remodelled and used for stamping ore from Allouez and Centennial Mines, while the plant at Point Mills will be used for ore from Superior, Isle Royale and Hancock Mines.

LAKE SHORE MINING CO.
990 West Kensington Road, Los Angeles, California.

Capital Stock $500,000 in 20,000 shares of $25 each. Owns idle lands in Porcupine Mountain district, Ontonagon County.

LAKE SUPERIOR COPPER CO. Rockland, Mich.

Capital Stock $500,000 in 20,000 shares of $25 each. Owns idle property in Ontonagon County.

LAKE SUPERIOR SMELTING CO. 12 Ashburton Place, Boston.

Capital Stock $1,200,000 in 48,000 shares of $25 each.

Is controlled by Tamarack, Osceola and Isle Royale mining companies, and smelts ores from the mines owned by these companies, and from some other mines.

LA SALLE COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $10,000,000 in 400,000 shares of $25 each.

Quincy A. Shaw, President.

R. L. Agassiz, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

James MacNaughton, General Manager.



These officers and F. L. Higginson, F. W. Hunnewell and C. C. Douglas, Directors.

W. C. Smith, Asst. Treasurer.

Controlled by Calumet and Hecla Mining Company.

This company has been exploring the Kearsarge lode, south of Osceola, Houghton County. The ore found so far is low grade, and the lode is in places very thin. During the last eight months of 1910 the company stamped 35,520 tons of ore, which yielded 472,100 pounds refined copper, an average of 13.29 pounds per ton. The 1911 output was much less than that of 1910. During 1911 exploration has been carried on from two shafts, and a large tonnage of ore developed; but it is too low grade to be produced profitably with the present equipment and prevailing low price of copper. Recently all work has been discontinued. It is proposed to do some exploring east of the Kearsarge lode.

The output for 1911 was 18,970 tons of ore yielding 280,598 pounds copper, an average of 14.77 pounds per ton. The development work was chiefly drifting at No. 1 shaft and drifting and sinking at No. 2 shaft. The No. 1 shaft is now 2,146 feet, No. 2 is 1,770 feet, No. 5 is 1,450 feet, and No. 6 is 882 feet deep.

LAURIUM MINING CO. 12 Ashburton Place, Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

Geo. A. Flagg, Secretary and Treasurer.

James MacNaughton, General Manager.

These officers and Francis L. Higginson, Directors.

Geo. C. Endicott, Asst. Secretary and Treasurer.

This company, controlled by the Calumet and Hecla Mining Company, is exploring the Kearsarge lode at Laurium, Houghton County. The work being done is at one shaft 1,500 feet deep. Drifts have been run north and south at several levels, and some fair copper ground developed. The ore is too low in grade to be mined profitably at present.

MANITOU MINING CO. 12 Ashburton Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

James MacNaughton, General Manager.

These officers and Francis W. Hunnewell and Francis L. Higginson, Directors.

Geo. A. Flagg, Secretary and Treasurer.

Controlled by Calumet and Hecla Mining Co.

The Company owns a large acreage in Keweenaw County, including the old Delaware Mine. The Delaware worked extensively, but very unprofitable, a deposit in the Allouez conglomerate. The property has been for some time idle.

MASS CONSOLIDATED MINING CO. 79 Milk St., Boston, Mass.

Capital Stock $2,500,000. Capital paid in $2,300,000. Balance of assets Dec. 31, 1910, $130,069.73.

John W. Linnell, Jr., President.
Theo. O. Nicholson, Vice President.
Wilfred A. Bancroft, Secretary and Treasurer.
These officers and Wm. F. Fitzgerald, James B. Hill, D. A. Carrick and Fred J. Schultheis, Directors.
Elton W. Walker, Superintendent.
Mine at Mass, Ontonagon County, Michigan.

The company has for several years mined the Evergreen series of lodes in Ontonagon County. The operations, have, until recently, not resulted satisfactorily; but it appears now that the mine may yet prove a profitable one. A new system of mining and sorting the ore has proven more economical. More extensive development work has been carried on, and a large tonnage of ore put in sight. The company in 1911 purchased the Evergreen Bluff Mining Company's property adjoining the Mass Mine, and larger scale operations will now be possible.

In 1910 there was stamped 90,747 tons of ore, which yielded 1,321,885 pounds copper, an average of 14.59 pounds per ton. The average yield for 1911 has been higher than that of 1910, and it is expected that the average for the ore blocked out will be over 17 pounds per ton. During 1911 attention has been devoted to development work rather than to mining, and it has been found that the Butler lode carries ore more uniformly than was expected. The lode is on the whole not very high grade; but stretches of good ground have been blocked out, and will probably be mined at a profit.

At present one shaft, "C," is being equipped to handle a greater tonnage. Foundations for a new rockhouse have been laid, and a hoist of large capacity is to be installed. By the time the hoist is ready, there should be a large tonnage of ore developed, and the present output can be doubled. From the same shaft the Evergreen lode on property recently acquired can also be worked. At present the mine is producing about 300 tons per day and is expected to be producing 700 tons by July 1.

It has been found possible to sort the ore economically underground. One man sorts all the rock broken by one drill crew. As the ore runs down the stope, he sorts out trap and barren pieces of lode rock, and diverts them from the ore chute. Use is being made of the waste rock. The lode dips at an angle of about 45° and is about 9 feet thick. The levels are therefore protected by building one rock wall vertically from foot to hanging. Openings are left at intervals in the wall to draw off ore.

The mine had three shafts, known as A, B and C, in operation early in 1911; but the A shaft has been dismantled and its territory will be worked from B shaft. B shaft which is bottomed at the 18th level is in the Evergreen lode. It was until recently idle, and during 1911 much of the work here has been necessarily devoted to repairing the shaft itself, and unwatering the workings. Extensive development has been done, however, 2,503 ft. of drifting on the Butler and Evergreen lodes. C shaft which is 1,275 ft. deep is in the Butler lode, and it is on this lode that most of the development work has been done during 1911. There are, however, cross cuts to the other lodes at both B and C shafts, and from each of these it will be possible to work the Butler, Evergreen, Ogima and Knowlton amygdaloids. A small amount of work was done on the Knowlton lode in 1911 with fair results.



During 1911 the mine produced 73,475 tons of ore which yielded 1,326,898 pounds copper, an average of 17.58 pounds per ton.

MAYFLOWER MINING CO. 70 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.
Harry F. Fay, President.
C. J. Morrissey, Secretary and Treasurer.
These officers and John C. Watson, Stephen R. Dow, Manning Emery and John G. Stone, Directors.
Geo. S. Goodale, Superintendent.

The company holds property east of the Kearsarge and Wolverine mines in Houghton County. It has done considerable exploratory work east of the Kearsarge lodes, partly by shafts; but chiefly by diamond drilling. A campaign begun in August 1909 located the Eastern sandstone contact, at a point 330 feet south and 210 feet east of the S. E. corner of Section 8-56-32.

The work has been confined to the investigation of a zone 4,700 feet in horizontal width lying immediately west of this contact.

Recent drilling has disclosed a promising copper bearing bed at No. 16 hole at a depth between 1,328′ and 1,443′. According to Mr. Goodale's description the core from 1,328 feet to 1,349 feet and from 1,366 feet to 1,379 feet and from 1,386 feet to 1,405 feet shows a nearly continuous mineralization, with heavy small and fine copper.

No. 16 is a vertical hole located near the south quarter post of section 8, T. 56, R. 32. It is about 90 feet from the north boundary of Old Colony.

A vertical hole, No. 17, has since been sunk 200 ft. north of No. 16. As the beds dip to the west the new hole cut the lode at less depth. For 72 ft., from a depth of 1,016 to 1,088 ft. the drill was in a copper bearing bed. The sludge from this bed was kept in 15 parts according to depth, each part representing the fines made in 3 to 7 ft. of drilling. The assays given out show that the sludge averaged 26.25 lbs. copper per ton. Sludge from depth of 1,033 to 1,043 ft. averaged about 70 lbs. per ton. Copper was also found in many places from 1,094 to 1,159 ft. Another hole No. 18 has been started 250 ft. north of No. 16.

It appears that the Mayflower has an important ore body. The cores obtained indicate that the lode is thick and of good grade. It is reasonable to expect that development will show the deposit to be of sufficient size to be profitably worked.

MEADOW MINING CO. 50 State St., Boston.

Geo. Napier Towle, President.
John Brooks, Secretary and Treasurer.
Capt. Wesley Clark, Agent.

Owns lands in Keweenaw County adjoining the Phoenix Mine. Some mining was done on the Ashbed lode on the property years ago; but it has now long been idle.

MEDORA MINE.

At Mandan, Keweenaw County, is owned by the Keweenaw Copper Company. Idle.

MICHIGAN COPPER MINING CO. 15 William St., New York.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of liabilities, Dec. 31, 1910, $67,932.92.

Joseph E. Gay, President.

J. Wheeler Hardley, Secretary.

J. R. Stanton, Treasurer.

These officers and Geo. T. Roessler and Alfred M. Low, Directors.

Samuel Brady, Superintendent.

Mine at Rockland, Ontonagon County, Michigan.

On this property an unusually large number of deposits—amygdaloids and veins—have been worked. On Dec. 31, 1910, the mine had produced 16,670,438 pounds of copper valued at $2,515,934.19. One vein, the Minesota, was an important producer and returned profits in the early days. Most of the other lodes, while yielding considerable copper, have been worked at a loss and the mine was recently closed down. It is, however, being worked on tribute by 24 miners.

In 1909 there was stamped 148,172 tons of ore, which with 485,846 pounds of mass, yielded 1,979,305 pounds of copper. In 1908 there was stamped 190,331 tons of ore, which with 1,226,845 pounds of mass, yielded 3,000,206 pounds of copper. The percentage of mass was much higher than at other mines.

In 1910 attention was confined to exploratory work. Three holes were put down through the Ogima and Evergreen lodes, and copper found in encouraging quantities. Underground work was discontinued in January, 1911. Diamond drill work was continued until March 1st, and then all operations ceased.

During the year a number of miners have been "tributing" on what is known as the "Branch Vein," and it is expected that both men and company will make some profit from this work. The estimated output for 1911 is 327,773 pounds. While the company has done considerable exploratory work, it has still a large acreage that is untested.

MICHIGAN SMELTING CO. 82 Devonshire St., Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Wm. A. Paine, President.

John R. Stanton, Vice President.

Frederic Stanwood, Secretary and Treasurer.

Frederick I. Cairns, Superintendent.

These officers and Chas. A. Snow, Directors.

John Mugford, Assistant Superintendent.

The Company is controlled by the Copper Range and Mohawk-Wolverine Mining Companies, and smelts all the ore produced by them. The smelter is located west of Houghton on Portage Lake, and is the largest and most recently constructed one in the district.

MOHAWK MINING CO. 15 William St., New York.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets Dec. 31, 1910, $496,374.78.

Joseph E. Gay, President.



J. R. Stanton, Treasurer.

J. W. Hardley, Secretary.

These officers and Wm. A. Paine and Fred Smith, Directors.

Fred Smith, Agent.

Mine at Mohawk, Keweenaw County, Mich.

The company is mining a portion of the Kearsarge lode adjoining the Ahmeek property. The mine is one of the regular producers, and has returned large profits to the owners. The lode has been described above. The method of mining is very similar to that at the Wolverine, described above. The lode is opened up by six shafts. The chief production was for some time from the northern shafts; but the recent opening up of the southern part of the property has shown a large body of good ore there.

During the past five years there was stamped a total of 3,566,699 tons of ore yielding 52,415,939 pounds of copper, an average of 14.7 pounds per ton. In 1910 there was stamped 802,537 tons of ore, which yielded 11,412,066 pounds of copper, an average of 14.22 pounds per ton. The 1910 copper was produced at a cost of 11.44 cents and sold for 13.09 cents per pound. The ground opened in 1910 at the No. 4 and No. 5 shafts is reported to be higher grade than the average for the rest of the mine. The production in 1911 was 802,548 tons ore from which was recovered 12,091,056 pounds copper, an average of 15.07 pounds per ton. The recovery made was 76.71% of the copper content. The copper cost 10.399 cents and was sold for 12.63 cents per pound.

The Mohawk is one of the few Michigan mines that has mined copper arsenided from fissure veins in commercial quantities. Since the company has been conducting operations, it has sold mohawkite valued at $116,407.79. Little is now being produced however.

MULOCH MINE.

Is an idle property northwest of the Norwich mine, Ontonagon County.

NATICK COPPER CO. Houghton, Mich.

F. W. Nichols, Agent.

Owns idle lands adjoining property of the Frontenac Copper Co. in Keweenaw County.

NATIONAL MINING CO. 6 Beacon St., Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

B. T. Morrison, President.

Harry Highley, Secretary and Treasurer.

These officers and Chas. M. Baker, Harry M. Howard and W. S. Warn, Directors.

Owns the National Mine west of the Michigan at Rockland, Ontonagon County. Has long been idle, and no work whatever was done during the past year.

NATIVE COPPER CO. 68 Devonshire Place, Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

M. Augustus O'Neil, President.

John C. Watson, Secretary and Treasurer.

These officers and Ashley Watson, Arthur C. Paine, and Frank L. Van Orden, Directors.

Owns idle property in Keweenaw County.

NEW ARCADIAN COPPER CO. Houghton, Mich.

Capital Stock $3,750,000 in 150,000 shares of $25 each.

Robert H. Shields, President and General Manager.

Col. Sylvester T. Everett, Vice President.

This Company succeeded, in 1909, the Arcadian Copper Company. It owns a large acreage east of the Quincy Mine in Houghton County. The old company opened up the northern extension of the Isle Royale by several shafts; but failed to get any satisfactory results. The new company has during 1910 and 1911 been doing considerable exploratory work, chiefly by diamond drilling but also by trenching and exploratory shafts. There are at present two drills at work, one in section 21 and one in section 31.

NEW BALTIC COPPER CO. 87 Milk St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Simon J. Beahan, President.

James P. Edwards, Vice President.

Robert H. Shields, General Manager.

F. H. Baird, Secretary and Treasurer.

These officers and J. B. Hardon, Directors.

The company owns Section 16, T. 55, R. 33, east of the Franklin Mine in Houghton County. Exploratory work was begun in 1909, and diamond drilling disclosed copper bearing beds in the lower part of the Keweenaw series. In 1910 an exploratory shaft was started to investigate the lodes located by the drills. At a depth of 360 feet cross cuts were run, and the lodes investigated. Recently the lodes have been opened up by a cross cut from the shaft at a depth of 500 feet.

NEW YORK CONSOLIDATED MINING CO. Houghton, Mich.

Frederic W. Nichols, Agent.

Owns idle property adjoining the Ojibway, Keweenaw County.

NONESUCH MINE. 78 Prospect Ave., Milwaukee, Wis.

Idle property in Porcupine Mt. district, Ontonagon County. The owners tested some time ago by diamond drilling and exploratory shafts, some cupriferous sandstone beds in the Nonesuch formation.

NORTH KEARSARGE MINE.

Is one of the chief producing mines of the Osceola Consolidated Mining Co. It is on the Kearsarge lode, north of the Wolverine and south of the Ahmeek.

NORTH LAKE MINING CO. 60 Congress St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $8.00 per share paid in. Balance of assets Dec. 31, 1910, $65,217.45.

Stephen R. Dow, President.

Albert L. Wyman, Secretary.



These officers and John C. Watson, Henry Tolman and R. M. Edwards, Directors.

Alvin R. Bailey, Treasurer.

R. M. Edwards, Superintendent.

Property at Lake Mine, Ontonagon Co., Mich. 1,120 acres.

The company has during the past three years been exploring its property by diamond drilling. Copper has been found in several of the fourteen holes, and it is expected that an exploratory shaft will soon be started to investigate some of the amygdaloid lodes located by the drills. In Dec., 1911 the 14th and last drill hole is being sunk, and is now down 450′. The total exploratory work in 1911 was 3,211′.

Drilling showed much of the ground to be underlain by the regularly bedded northwesterly dipping formation; but some of the holes near the eastern part of the property revealed the presence of a mass of felsite similar to that on the Indiana property adjoining. Considerable chrysocolla and native copper was found in the felsite, but additional holes did not show any regularity in the shape of the rock mass, and further work on this deposit will not likely be done until the deposit in felsite on the Indiana property has been opened up and its nature better known.

To explore the several amygdaloid beds a vertical shaft is to be sunk and all the beds showing copper will be tested by drifts and cross cuts at a depth of about 1,000 ft. The shaft will be started close to No. 3 drill hole where there is very little overburden.

OJIBWAY MINING CO. 1400 Alworth Bldg., Duluth, Minn.

Capital Stock $2,500,000 in 100,000 shares of $25 each. 84,000 shares issued. $12 per share paid in.

Balance of assets Dec. 31, 1910, $34,391.48.

Lucius L. Hubbard, President.

Charles A. Duncan, Vice President and Treasurer.

Oscar J. Larson, General Solicitor.

These officers and Thomas F. Cole, Chester A Congdon, Charles D'Autremont, Jr., James Hoatson, Thomas Hoatson and John D. Ryan, Directors.

William G. Hegardt, Assistant Treasurer.

Frederic R. Kennedy, Secretary.

Daniel R. Smith, Asst. Secretary.

Henry B. Paull, Auditor.

Andre Formis, Superintendent.

Mine at Ojibway, Keweenaw County, Mich.

The Ojibway has opened up the Kearsarge group of amygdaloid beds, and during the last two months of 1911 produced 5,203 tons of ore. The lode being mined is developed by two shafts, which had on Dec. 13, 1911, reached depths of 1,954 and 1,617 feet. The work done so far has shown good copper ground in several openings, and a zone of barren or faulted ground, 250 feet in width, that runs diagonally from south to north across No. 1 shaft. From the bottom of No. 2 shaft some exploratory work has been done by diamond drilling.

It was stated by the president of the company during the year, that not enough ground has yet been opened up to permit of production on a profitable scale; but with an adequate tonnage of equal value with that now available, there is no doubt that ore can be produced at a profit.

To determine definitely the average values in the ore, preparations were made for a mill run to extend over several months, and on Nov. 1, 1911, shipments to the Tamarack mill were begun.

All the ore is being hoisted from No. 1 shaft, and No. 2 shaft is at present closed down.

OLD COLONY COPPER CO. 70 State St., Boston, Mass.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Harry F. Fay, President.

C. J. Morrissey, Secretary and Treasurer.

These officers and John C. Watson, Stephen R. Dow, F. L. MacQuire and John G. Stone, Directors.

Geo. C. Goodale, Superintendent.

Property at Calumet, Houghton County.

The company has done considerable exploratory work on its lands by shafts, a long cross cut and diamond drill holes. The property lies east of the Calumet mine, and is underlain by the lower portion of the Keweenaw series. In July, 1911, the company began the exploration by diamond drill of a zone, approximately 2,100 feet in width, which at the southern boundary of the property lies next to the Eastern sandstone. The contact between the latter and the trap series was found at a point 440 feet west and 70 feet north of the south quarter post of Section 17, T. 56, R. 32. The dip of the contact to a point 800 feet from surface (inclined measurement) is to the west at an angle of 24 degrees, and three holes in nearly one vertical plane show the line of dip to be practically straight for a distance of at least 500 feet. The dip of the formation 300 feet above the contact is 43 degrees. The Mayflower, drilling, where it was possible to arrive at a definite conclusion, showed the dip of the formation to be 50 degrees.

Some copper bearing beds were located by the holes, and the company hopes to find a continuation of the ore body found by diamond drilling on the St. Louis property to the south.

One complete section across the zone being investigated, was made by holes No. 7, 8, 9, 10 and 11. These holes have a total length of 3,042 feet. A second section is now being made, and the first hole, No. 12, has been started at a point about 500 feet north of No. 11.

The recently located copper-bearing bed on the Mayflower property was found by drill holes put down vertically about 90 feet north of the Old Colony boundary. It is therefore likely to be found on the latter property also.

ONECO COPPER CO. 64-50 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets March 1, 1912, $11,699.

John D. Cuddihy, President.

John Brooks, Secretary and Treasurer.

John L. Harris, General Manager.

These officers and Wm. F. Fitzgerald, Geo. Napier Towle and John C. Watson, Directors.

The company owns 800 acres southeast of the La Salle, Houghton County.



During the past few years several holes have been drilled and copper bearing veins been obtained from two amygdaloid beds. In 1910 an old shaft was reopened, and during 1911 this has been deepened. Cross cuts have been run at intervals to intersect the lode. The shaft is on March 1, 1912, 1,110 feet deep.

OSCEOLA CONSOLIDATED MINING CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of assets Dec. 31, 1911, $1,832,183.52.

Rodolphe L. Agassiz, President.

Quincy A. Shaw, Vice President.

George A. Flagg, Secretary and Treasurer.

These officers and Francis W. Hunnewell, Francis L. Higginson, T. Nelson Perkins and James MacNaughton, Directors.

Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mines at Osceola, Kearsarge and Tamarack, Houghton County, Mich.

The company owns four mines—Osceola, Kearsarge, North Kearsarge and Tamarack Junior. The Osceola mine is on the Osceola lode, south of the Calumet and Hecla mine. The Kearsarge and North Kearsarge are on either side of the Wolverine mine on the Kearsarge lode. The Tamarack Junior mine is on the Calumet conglomerate, north of the Red Jacket shaft of the Calumet and Hecla.

The Tamarack Junior was unprofitable, and was closed down in 1903.

The Osceola mine was for some time an important producer and profit maker. The north end of the property yielded ore of good grade; but as work advanced southward from the early openings, poorer ore was encountered, and as operation was then at a loss, the mine was on March 1, 1910, temporarily closed down. The No. 5 shaft is 4,623 ft. and No. 6 is 4,592 ft. deep. Alterations and repairs have been made, and it is expected that more economical operation will be possible when the mine is again opened up. The southernmost shafts have been overhauled, and the rockhouses improved. The reopening of the mine will depend partially on the market conditions, as it is not thought advisable to resume operations while the price of copper is low, and partially on the progress made in remodelling the stamp mill, as two heads are at present out of commission.

The falling off in production consequent on the closing down of the Osceola branch, has been partially offset by increased output from the two mines on the Kearsarge lode. At the South Kearsarge No. 1 shaft is bottomed at 2,805 ft. and No. 2 shaft at 1,992.5 ft. At the North Kearsarge No. 1 shaft is down 3,873.5 ft.; No. 3 shaft 3,192 ft.; and No. 4 shaft 1,449 ft. The only sinking done during 1911 was 306 ft. at No. 4 North Kearsarge. Sinking at No. 3 has been started.

In the period of five years 1906-1910 the Osceola Consolidated stamped 5,781,808 tons of ore, yielding 98,617,221 pounds of copper, an average of 17.2 pounds per ton. This cost 10.53 cents, and was sold for 15.2 cents per pound.

During 1910 there was stamped 1,217,720 tons of ore, yielding 19,346,566 pounds of copper, an average of 15.9 pounds per ton. This copper cost 9.37 cents per pound. The lower content per ton for the year's output is re-

ported to be due to the workings during this period in the North Kearsarge mine being below average grade. In 1910 South Kearsarge ore averaged 18 pounds and North Kearsarge 14.7 pounds copper per ton. It has been found advisable to modify the washing apparatus at the stamp mill.

Woodbury-Benedict jigs and Wilfley tables have been installed in place of other jigs, and Hardinge conical pebble mills are now used to regrind the sands. Two sections have been recently completed and two others are in process of construction. It is stated that the remodeled milling system extracts 79% of the copper compared with 73% under the old system. About $70,000 was spent in changing the two sections and it is estimated that the cost to complete the remodeling will be $175,000. The capacity of the new head is the same. The cost for treatment is increased about one cent per ton of ore. The production for 1911 was 1,246,596 tons ore yielding 18,388,193 pounds copper at a cost of 9.28 cents per pound. The average yield was 14.8 pounds per ton. South Kearsarge ore averaged 18.2 pounds per ton. The development work at South Kearsarge is practically completed and mining costs will be low. At North Kearsarge the ore opened up is below average grade.

PACIFIC COPPER CO. 705-199 Washington St., Boston.

Capital Stock $1,250,000 in 50,000 shares of $25 each. 40,000 shares issued. $2 paid in.

Nathaniel Thayer, President.

Chas. J. Paine, Jr., Secretary and Treasurer.

These officers and Samuel N. Brown, N. H. Stone, J. Henry Brooks, Geo. P. Gardner, Walter Hunnewell and R. R. Goodell, Directors.

Fredric W. Nichols, Agent.

Controlled by St. Mary's Canal Mineral Land Co. Owns idle property northwest of Atlantic, Houghton County.

PHOENIX CONSOLIDATED COPPER CO. Hancock, Mich.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Thomas F. Cole, President.

Spencer R. Hill, Vice President.

Chas. A. Wright, Jr., Secretary and Treasurer.

These officers and Capt. Thos. Hoatson, Directors.

Controlled by Keweenaw Copper Co.

Owns a large acreage in Keweenaw County, including the old Phoenix mine. The Phoenix worked several fissure veins in the early days, but has long been idle. Later work was done on the Ashbed lode without satisfactory results. Some diamond drilling was done in 1910; but the property is now idle.

QUINCY MINING CO. 32 Broadway, New York.

Capital Stock $3,750,000 in 150,000 shares of $25 each, of which 110,000 shares have been issued.

Balance of assets Dec. 31, 1911, $972,499.31.

William R. Todd, President.

Walter P. Bliss, Vice President.

These officers and Cleveland H. Dodge, James L. Bishop, Charles J. Devereaux, Isaac H. Meserve, William M. Belcher, John M. Longyear and Otto Kirchner, Directors.



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

Charles L. Lawton, General Manager.

Mine at Hancock, Houghton County, Mich.

The Quincy is one of the leading copper mines. Up to Dec. 31, 1910, it had produced 457,903,404 pounds of copper, which with some silver, was sold for $68,168,774.83. In the last five years there was produced 101,620,255 pounds of copper from ore yielding about 16 pounds per ton. This cost 11.30 cents per pound, and was sold for 15.45 cents. In 1910 there was produced 22,517,014 pounds of copper at a profit over all expenses of $642,693.03. The cost in 1910 was 10.48 cents per pound, and the selling price 13.20 cents. In 1911 there was produced 22,252,943 pounds copper at a cost of 10.62 cents per pound. This was sold at an average price of 12.725 cents. During 1911 there was stamped 1,382,254 tons of ore. New openings during the year were at No. 7 shaft ¾ mile; at No. 2 shaft 1½ miles; at No. 6 shaft 1¾ miles and at No. 8 shaft 1½ miles. All the shafts have been deepened and the new openings show ore of good grade. Some very good ore has been developed north of No. 8 shaft in a part of the lode which was comparatively poor near the surface.

The company began paying dividends in 1862, and at the end of 1911 has paid to shareholders a total of $19,880,000.00.

The Quincy is mining the Pewabic lodes from four shafts. The southern part of the property has been extensively worked but there still remains a large amount of ore to be taken out.

The central part of the property can be worked to great depth, and this will be the source of a large quantity of ore for many years. The north end of the property is not yet developed at all, and there is, therefore, a large area of the lode yet unexplored.

Three of the four productive shafts, No. 2, No. 7 and No. 6, have reached depths, measured on the incline, of a little over one mile. The fourth, No. 8, is nearly one mile deep. A fifth shaft, No. 9, is being sunk to connect at a depth of about 2,600 ft. with a drift north on the 20th level from No. 8 shaft. No work other than sinking is now being done at No. 9. It has reached a depth of 1,800 ft. and it is expected to connect during 1912.

While in recent years the mining has been carried on at great depths, improved facilities for mining, hoisting and crushing, have made it possible to produce the ore at a lower cost than prevailed when the workings were shallow. If the copper contents continue to be as good as at the present bottom of the mine, the lode will doubtless be worked profitably to very much greater depths. Excluding the virgin territory north of No. 8 shaft the bottom of the mine has reached an average depth on the dip of the lode of about 5,200 feet.

No. 8 shaft is being electrified for power tramming. The other deep shafts are already thus equipped.

At the stampmill much attention has been given to experiments on classifiers and it has been demonstrated that a higher percentage of the copper can be saved by more careful hydraulic classification. A new classifier is now being built.

RHODE ISLAND COPPER CO.

Formerly owned part of what is now property of the Franklin Mining Co., Houghton County.

RIDGE COPPER CO.

Formerly owned part of what is now property of the Mass Consolidated Mining Co.

ST. LOUIS COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each. Controlled by the Calumet and Hecla Mining Company.

James MacNaughton, General Manager.

Property southeast of Calumet, Houghton County.

The lands were explored by diamond drilling in 1910 and 1911. At a point 7,100 feet east of the outcrop of the Kearsarge lode, several drill holes cut an amygdaloid lode from which cores showing a good mineralization of copper were taken. From the results of the drilling it was thought that a shaft should be sunk to make more extensive explorations on this lode, which has been called the "St. Louis amygdaloid." During 1911 a three compartment inclined shaft was started. The shaft is in rock from the surface, and has reached a depth of about 200 feet. Some drifting on the lode has been done; but comparatively little is yet known of the value of the deposit.

Neither the shaft nor the drifts on the first level have opened up deposits of commercial value, but the south drift showed some fair ore.

Of the several drill holes cutting the lode five showed copper and four showed none. The No. 7 hole cut 29 ft. of lode of which 5 ft. showed copper. The No. 8 hole showed fine copper in a width of 10 ft. The No. 10 and No. 12 holes showed the lode 8 ft. wide with no copper. The No. 13 hole showed a width of 39 ft. with a good showing of copper. The No. 15 showed a width of 14 ft. with no values. The No. 16 and No. 17 holes showed a width of about 30 ft. with good values and No. 18 showed the lode 25 ft. wide with no values.

SAINT MARY'S CANAL MINERAL LAND CO. 705-199 Washington St., Boston.

Capital Stock $5,000,000 in 200,000 shares of $25 each, of which 160,000 shares have been issued.

On Dec. 31, 1910, Notes Receivable, $456,400.00; Cash on deposit, $368,576.31; Liabilities, none.

Nathaniel Thayer, President.

Charles J. Paine and J. Henry Brooks, Vice Presidents.

Charles J. Paine, Jr., Secretary and Treasurer.

These officers and Samuel N. Brown, Albert S. Bigelow, George P. Gardner, Walter Hunnewell, Charles N. King, Nathaniel H. Stone and Thomas N. Perkins, Directors.

Arthur E. Coe, Asst. Treasurer.

Frederic W. Nichols, Resident Agent in Michigan.

Dr. Lucius L. Hubbard, Consulting Geologist.

The company owns mineral rights to 14,039 acres, and owns shares of stock in the following mining companies:



50,000 Champion; 83,905 King Philip; 20,000 Hancock Consolidated; 20,165 La Salle; 20,000 Pacific; 208 Copper Range Consolidated; 842 Winona; 80 Old Colony; 25,000 Mayflower; 2,000 Ojibway; 9,000 North Lake; 1,571 Franklin and 37,222 Houghton.

SECTION TWELVE EXPLORATION CO. Hancock, Mich.

Is a private syndicate owning lands adjoining Superior and Isle Royale. Has done some exploratory work, but did none in 1911.

SENECA MINING CO. 12 Ashburton Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each. Balance of liabilities Dec. 31, 1910, $112,952.91.

R. L. Agassiz, President.

G. A. Flagg, Secretary and Treasurer.

These officers and F. W. Hunnewell, F. L. Higginson and James MacNaughton, Directors.

A. Garceau, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mine at Ahmeek, Keweenaw County, Mich.

The company owns a large acreage on the Kearsarge lode. Development work has been done from one shaft, which on Dec. 31, 1910, was 957 feet deep. Drifting has shown some good copper ground in places, but the greater part developed is low grade.

SENTER-DUPEE DEVELOPMENT CO. Calumet, Mich.

Is a private syndicate owning lands in Keweenaw County. Has done some diamond drilling during 1911.

SHELDEN AND COLUMBIAN MINE.

Is idle property north of the Isle Royale, Houghton County.

SOUTH KEARSARGE MINE.

Is one of the producing mines on the Kearsarge lode, owned by the Osceola Consolidated Mining Co.

SOUTH LAKE MINING CO. 68 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $4.60 paid in. 60,000 shares issued.

On Dec. 31, 1910, cash on hand, $7,444.82.

John C. Watson, President.

Arthur C. Paine, Secretary and Treasurer.

These officers and Charles E. Adams, Ashley Watson and P. W. Scott, Directors.

Dr. L. L. Hubbard, consulting geologist.

Property at Greenland Junction, Ontonagon County, Michigan. 334.19 acres.

During 1909 and 1910 this company drilled several holes on the property west of the Lake Mine. The drill located four copper bearing beds, two above and two below a thick bed of ophite. The cores showed much copper, and the company has during the past year, been making preparations for

shaft sinking, to develop the deposits. Where the copper was found the overburden is thick, being 272 feet in each of five holes. During the past summer, therefore, the overburden was tested at various other points to find a suitable place for a shaft. The shaft was started at a point where sand piping showed the overburden to be thin, but the shaft, tapping the supply of a nearby spring, made an extraordinary amount of water, and was abandoned. A new site has since been selected, but shaft sinking is temporarily postponed, pending the financing of the company and the selection of a permanent superintendent and engineer for the development of the property.

The exploratory work at the South Lake property has shown the Keweenaw series to be there dipping towards the south instead of to the northwest as is usually the case. It is thought that the copper bearing bed overlying the ophite is the Lake lode, and that the strata must curve from nearly north at the Lake shaft to west at the South Lake boundary. Recent developments at the Lake Mine make this appear very probable.

SOUTH RANGE MINING CO. 199 Washington St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

John W. Belches, President.

Irving J. Sturgis, Vice President.

Arthur E. Coe, Secretary and Treasurer.

These officers and John C. Watson, Henry H. Stevens and Rufus R. Goodell, Directors.

Fredric W. Nichols, Resident Agent.

Owns a large acreage of undeveloped property in Houghton and Ontonagon Counties.

SOUTH SIDE MINING CO. 14-68 Devonshire St., Boston.

Capital Stock $1,000,000 in 40,000 shares of $25 each.

John C. Watson, President.

Arthur C. Paine, Secretary and Treasurer.

These officers and Harry F. Fay, Ashley Watson and D. C. Forbes, Directors.

Fredric W. Nichols, Agent.

Owns idle property west of Houghton.

SUPERIOR COPPER CO. 12 Ashburton Place, Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Balance of liabilities Dec. 31, 1911, $73,089.06.

Quincy A. Shaw, President.

Rodolphe L. Agassiz, Vice President.

These officers and Francis W. Hunnewell, Francis L. Higginson and James MacNaughton, Directors.

George A. Flagg, Secretary and Treasurer.

A. J. Garceau, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

The Superior has opened up what is supposed to be the northerly extension of the Baltic lode. There are two shafts in operation. At No. 1 a large body of good ore has been partially developed, and is being mined.



The No. 2 shaft is in comparatively poor ground further southwest. The two are being connected by a drift at the 12th level. The No. 1 shaft is on Dec. 31, 1911, 1,763 ft. and No. 2 is 1,210 ft. deep.

In 1910 there was stamped 140,514 tons of ore, which yielded 3,181,041 pounds of copper, an average of 22.64 pounds per ton. The recovery was not as good as usual, as the system of milling was not specially designed for the type of ore being mined here. The production in 1911 was 162,599 tons ore yielding 3,236,233 pounds copper, an average of 19.9 pounds per ton. The copper cost 15.31 cents and the price received averaged 12.652 cents.

During 1911 attention has been directed to improving the method of mining. The hanging wall has proven very difficult to support and changes have been made so that the danger from rock falls is lessened. The lode is being developed extensively by running drifts through to the north boundary. The stoping will then be begun at the boundary and carried back towards the shaft. It is proposed to use a method in which ore instead of waste rock will be used for filling. Sorting is not successful, as the ore is not readily distinguished from waste. At the Superior, Mr. Ocha Potter has demonstrated very decidedly the advantages of a one-man piston drill, and the mine is now fully equipped with the light machines.

The company reports that on the north side of the No. 1 shaft down to the 9th level no copper has been developed north of the first fault. From the 9th to the 14th level some good ground has been found north of this fault; but none has yet been found beyond a second fault, which is about 500 ft. north of the first one. Explorations at the 12, 13 and 14th levels have resulted in the discovery of a good lode west of the lode being worked and separated from it by 45 ft. of trap. The West lode, as it is called, has proven up very encouragingly.

TAMARACK MINING CO. 12 Ashburton Place, Boston.

Capital Stock $1,500,000 in 60,000 shares of $25 each.

Balance of assets Dec. 31, 1910, $1,052,422.46.

Rodolphe L. Agassiz, President.

Quincy A. Shaw, Vice President.

George A. Flagg, Secretary and Treasurer.

These officers and Francis W. Hunnewell, Francis L. Higginson, Thomas N. Perkins and James MacNaughton, Directors.

Clarence H. Bissell, Asst. Secretary and Asst. Treasurer.

James MacNaughton, General Manager.

Mine at Calumet, Houghton County, Mich.

The Tamarack is one of the best known deep mines of the world, and was until recently a very profitable one. In the period from 1888 to 1907, the company paid $9,420,000 in dividends. The past few years have resulted in a loss to the company, owing to low copper content of the ore now being mined, and the increased cost of mining at very great depth and without good ventilation.

The mine works the underlay of the Calumet and Hecla. The chief production is from the Calumet conglomerate. The Osceola amygdaloid was worked in places, but is not now being mined.

To develop the conglomerate on Tamarack property, five vertical shafts

were sunk. These have depths of 3,409 feet, 4,355 feet, 5,253 feet, 4,450 feet and 5,308.5 feet respectively. From No. 3 shaft workings, an inclined shaft started at a vertical depth of 5,223.5 feet has a further depth of 335 feet on the dip. The bottom of the No. 3 incline is therefore 5,430 ft. vertically from surface.

In 1910 there was stamped 525,554 tons of ore, which yielded 11,063,606 pounds of copper, an average of 21.1 pounds per ton. This was produced at a cost of 14.7 cents, and most of it was sold at 12.97 cents.

Owing to the unprofitable nature of operations at low copper prices, the working force has been cut down, and much of the development work suspended.

The 1911 production was 392,338 tons ore yielding 7,494,077 pounds copper at a cost of 15.56 cents. The selling price during 1911 averaged 12.71 cents. The average yield was 19.1 pounds per ton.

In November, 1911, further development work was discontinued and the amount of ore stoped was somewhat increased. The results for November and December show a cost of about 12 cents per lb. Whether or not the margin of profit will warrant further development work, must be determined by future conditions.

TAMARACK JUNIOR MINE.

Is an abandoned mine on the Calumet conglomerate, owned by the Osceola Consolidated Mining Company.

TOLTEC MINE.

An idle property at Greenland, Ontonagon County.

TORCH LAKE MINING CO. 5-19 Exchange Place, Boston.

Capital Stock $500,000 in 20,000 shares of $25 each.

Thacher Loring, President.

Chilton Cabot, Secretary.

Frederic W. Nichols, Agent.

Owns idle property east of the La Salle, Houghton County.

TREMONT AND DEVON MINING CO. Hancock, Mich.

Capital Stock $250,000 in 10,000 shares of $25 each.

Hon. Chas. Smith, President.

Fred H. Begole, Vice President.

Chas. D. Hanchette, Secretary.

These officers and Jos. Bosch, James B. Cooper, Henry L. Baer and Robt. P. Dunstan, Directors.

Owns idle lands west of Victoria, Ontonagon County.

TRIMOUNTAIN MINING CO. 82 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each $20.00 paid in. Balance of assets Dec. 31, 1911, $522,921.79.

William A. Paine, President.

Frederic Stanwood, Secretary and Treasurer.

These officers and J. R. Stanton, J. Henry Brooks, Charles A. Snow, R. T. McKeever and F. W. Denton, Directors.



F. W. Denton, General Manager.

Controlled by Copper Range Consolidated Co.

Mine at Trimountain, Houghton County, Mich.

The Trimountain is mining the Baltic lode between the Baltic and Champion mines. While it has proven a success, it has not yet made a record anything like that of its richer neighbors.

In the last five years there was hoisted and stamped 1,926,936 tons of ore, yielding 34,710,824 pounds of copper, an average of 18 pounds per ton. The copper cost 12.8 cents and was sold for 15.6 cents. In 1910 there was stamped 317,299 tons of ore, which yielded 5,694,868 pounds of copper, an average of 17.95 pounds per ton. This copper cost 12.17 cents and was sold for 12.74 cents per pound.

During 1911 very marked improvement has been found in the lower levels, and the future of the mine is very promising.

The production in 1911 was 347,885 tons yielding 6,120,417 pounds copper an average of 17.59 pounds per ton. The cost was 11.55 cents and the selling price 12.54 cents per pound.

UNION COPPER LAND AND MINING CO. 70 State St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each.

Harry F. Fay, President.

Harold H. Anthony, Ezra H. Baker, Samuel Carr, Albert B. Merrill and John G. Stone, Directors.

E. J. Morrissey, Secretary and Treasurer.

J. Abner Sherman, Land Agent.

Geo. S. Goodale, Superintendent.

Owns a large acreage of mineral and timber lands. During the period between August, 1910 and September 1911 the company made a diamond drill cross section of its property included in the N. E. ¼ of Section 1, T. 56, R. 33, and the S. E. ¼ of Section 36, T. 57, R. 33. The formations included in this work have a total thickness of approximately 3,270 feet, 180 feet of which lies below, and the balance above, the Allouez conglomerate.

VICTORIA COPPER MINING CO. 60 Congress St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of assets Dec. 31, 1911, $64,044.26.

Fred H. Williams, President.

Charles D. Hanchette, Vice President.

James P. Graves, Treasurer.

These officers and Willard S. Martin and David A. Barker, Directors.

Sydney S. Millet, Secretary.

George Hooper, Superintendent.

Mine at Victoria, Ontonagon County, Mich.

The company is mining the Forrest amygdaloid lode. The ore is low grade. Operations have not yet proven profitable. The costs are, however, remarkably low and if fairly good ore is encountered good profits are to be expected. From the beginning of operations up to Dec. 31, 1910, there had been stamped 445,152 tons of ore yielding 5,353,835 pounds copper valued at $797,762.94.

In 1910 there was stamped 122,497 tons of ore, which yielded 1,164,564 pounds of copper. This cost $155,999.67 and was sold for $144,103.33. The cost per ton of ore mined is the lowest in the district. Cheap power is available at Glenn Falls on the Ontonagon river, near which the mine is located. The waterfall is used to compress air by the Taylor system, and sufficient power is obtained for all mine and mill purposes.

During part of 1910 the company was forced to curtail production on account of a scarcity of water, and would otherwise have made an even more remarkable record for low costs.

Developments during 1910 were regarded as more encouraging than they have been for some time. Considerable work has been done during 1911 at the new No. 6 shaft with fair results.

In recent work some unusually good ore has been encountered in drifting between the old and new shafts. The new shaft is 827.5 ft. deep on Dec. 31. The old shaft is bottomed at 2,089′. It is intended to connect the two shafts at the 12th level.

The production for 1911 was 1,303,331 pounds, recovered from 126,894 tons ore. The cost of mining, smelting, freight, marketing and office expense was $170,808.46, leaving a mining profit of $2,200.32. There was a further expense of $39,850.75 for interest, construction, development of water power, legal expense and cost of sinking shaft No. 6.

WHITE PINE COPPER CO. 12 Ashburton Place, Boston.
Capital Stock $5,000,000 in 200,000 shares of $25 each.
Controlled by Calumet and Hecla Mining Co.
Quincy A. Shaw, President.
Geo. A. Flagg, Secretary.
James MacNaughton, General Manager.
Thos. H. Wilcox, Superintendent.
Mine in Porcupine Mt. district, Ontonagon County.

The company is exploring the Nonesuch lode. The ore is native copper with some chalcocite in a grey sandstone. During the past few years the Calumet & Hecla Company has done 31,206 feet of diamond drilling on the property, and is now exploring the lode by a shaft. The results of exploration so far is considered satisfactory, good copper values being shown. The structure of the formation has been found not very regular, and the lode is not easily followed.

WILMOT MINING CO.
Capital Stock $500,000 in 20,000 shares of $25 each.
W. H. Garlick, President.
W. B. Gonchie, Secretary.
Owns idle property in Ontonagon County.

WASHINGTON COPPER MINING CO. Hancock, Mich.
Capital Stock $2,500,000 in 100,000 shares of $25 each.
Controlled by Keweenaw Copper Company.
Owns idle property at Delaware, Keweenaw County.



WEST MINNESOTA MINING CO. 14-68 Devonshire St., Boston.
Capital Stock $500,000 in 20,000 shares of $25 each.
Francis H. Whitman, President.
Arthur C. Paine, Secretary.
Owns idle property in Ontonagon County.

WHEALKATE MINING CO. Houghton, Mich.
Capital Stock $50,000 in 20,000 shares of $25 each.
Nathan F. Leopold, President.
R. R. Goodell, Vice President.
Reginald C. Pryor, Secretary.
Albert F. Leopold, Treasurer.
Owns idle property in Houghton County.

WINONA COPPER CO.
Capital Stock $2,500,000 in 100,000 shares of $25 each. Balance of assets Dec. 31, 1911, $146,814.01.
Charles J. Paine, President.
Nathaniel H. Stone, Vice President.
These officers and George P. Gardner, Walter Hunnewell, Charles J. Paine, Jr., William A. Paine and James H. Seager, Directors.
Edward B. O'Connor, Treasurer and Secretary.
Dr. Lucius L. Hubbard, General Manager.
Mine at Winona, Houghton County, Mich. 2,320 acres.
Combined with King Philip Copper Co., in May, 1911.

The company is mining the Winona lode, which on the Winona and King Philip properties has been opened up by 6 shafts.

The Winona produced copper in the period 1902-1907, was not producing in 1908-1910, and resumed production in 1911. From the beginning of operations up to Dec. 31, 1910, there was stamped 210,716 tons of ore, which yielded 3,348,201 pounds copper. The production for 1911 was 97,445 tons ore yielding 1,275,675 lbs. copper, an average of 13.09 pounds per ton.

During the past two years a mill has been erected at the mine, and one head was started in March, 1911. The water supply is from the Sleeping River, and settling tanks have been put in, so that the water can be reused if necessary. A considerable saving in transportation of ore to the mill, will make the cost lower than in former periods of production, and the special designing of concentrating apparatus for the treatment of Winona ore only, should make a further saving. The output is from two shafts, No. 4 Winona and No. 1 King Philip. These are now (Dec. 1911) 1,460 ft. and 1,324 feet deep respectively. The remaining shafts are closed down. Production is being gradually increased and is now about 600 tons per day.

WOLVERINE COPPER MINING CO. 15 William St., New York.

Capital Stock $1,500,000 in 60,000 shares of $25 each.

Balance of assets June 30, 1911, was $673,339.62.

Jos. E. Gay, President.

J. R. Stanton, Treasurer.

J. Wheeler Hardley, Secretary.

These officers and E. B. Hinsdale and Samuel L. Smith, Directors.

Fred Smith, Agent.

Mine at Kearsarge, Houghton County, Mich.

The Wolverine is mining one of the richest parts of the Kearsarge lode, and is one of the most profitable mines in the district. In the last five years there was stamped 1,779,273 tons of ore, which yielded 48,163,660 pounds of copper, an average of 26.7 pounds per ton. This copper cost 7.65 cents and was sold for 15.6 cents per pound. In the year 1910-1911, there was stamped 388,476 tons of ore, which yielded 9,617,168 pounds of copper, an average of 24.75 pounds per ton. This copper cost 7.542 cents and was sold for 12.58 cents per pound.

The Wolverine ore body is unusually uniform in grade, and very little of the lode is left unbroken. Of the rock hoisted in the last year only 2.95% was discarded as poor. The new ground opened is of the usual grade. Mr. J. R. Finlay, for the State Tax Commission, in 1911 estimated a future output for Wolverine of 3,600,000 tons of ore, containing 80,000,000 pounds of copper. The directors consider this estimate too low, and Mr. Stanton has been reported as stating that the present output can be maintained for 15 years instead of only 10 years. Development work is well ahead of stoping, and the whole ore body will in a few years be completely developed.

The ore on the Kearsarge lode being now pretty well blocked out, more attention is being given to exploration for other lodes. Diamond drilling has been done, and a shaft sunk on the Osceola lode. At a depth of 186 feet in the No. 5 shaft, drifts were extended north and south on the hanging wall. The Osceola lode was found to be well defined and of good width, but the values were low. Drifting was then discontinued, and the shaft sunk to greater depth, and the lode tested at a second level.

Exploration has also been carried on by a cross cut driven east from the Kearsarge lode between No. 3 and No. 4 shafts at the 28th level. In July, 1911, this cross cut had been driven 1,000 feet, and it is expected that it will soon cut a series of amygdaloid beds, which were discovered by diamond drilling on the Old Colony property.

WYANDOT COPPER CO. 68 Devonshire St., Boston.

Capital Stock $2,500,000 in 100,000 shares of $25 each. $10 per share paid in. Balance of assets March 31, 1911, $34,091.95.

John C. Watson, President.

Charles E. Adams, Secretary and Treasurer.



These officers and Joseph Dorr, M. A. O'Neil and Frank L. Van Orden, Directors.

Frank L. Van Orden, Agent.

Mine at Winona, Houghton County, Mich.

The company has explored part of its property by shafts, cross cuts and diamond drill holes. Diamond drilling and trenching during 1910 showed a copper bearing bed which was considered promising, and a shaft was sunk to explore it further. During 1911 exploration has been carried on by driving a cross cut east from the bottom of a 700 foot shaft. The cross cut has opened up several beds, which it is proposed to test by drifting. An assessment of $1 per share has recently been called to provide funds to continue the work.

# CHAPTER XII—Statistical Tables.

## DIVIDENDS PAID BY MICHIGAN COPPER COMPANIES.

| | Capital stock. | 1907. | 1908. | 1909. | 1910. | 1911. | All years. |
|---|---|---|---|---|---|---|---|
| Ahmeek | $1,250,000 | | | | | | |
| Atlantic | 2,500,000 | | | | | $100,000 | $100,000 |
| Baltic | 2,500,000 | $1,000,000 | $900,000 | $1,000,000 | $1,000,000 | 500,000 | 990,000 |
| Calumet & Hecla | 2,500,000 | 6,500,000 | 2,000,000 | 2,700,000 | 2,900,000 | 2,400,000 | 7,050,000 |
| Central | | | | | | | 114,900,000 |
| Champion | 2,500,000 | 1,000,000 | 500,000 | 500,000 | 900,000 | 500,000 | 2,130,000 |
| Cliff | | | | | | | 6,400,000 |
| Copper Falls | | | | | | | 2,518,620 |
| Franklin | 5,000,000 | | | | | | 100,000 |
| Kearsarge | | | | | | | 1,240,000 |
| Minnesota | | | | | | | |
| Mohawk | | | | | | | 160,000 |
| Osceola | 2,500,000 | 900,000 | 250,000 | 300,000 | 200,000 | 150,000 | 1,820,000 |
| Quincy | 2,500,000 | 1,249,950 | 192,300 | 769,200 | 961,500 | 721,125 | 2,300,000 |
| Tamarack | 3,750,000 | 1,350,000 | 495,000 | 440,000 | 412,500 | 440,000 | 10,064,375 |
| Trimountain | 1,500,000 | 420,000 | | | | | 19,742,500 |
| Wolverine | 2,500,000 | | | | | | 9,420,000 |
| | 1,500,000 | 1,050,000 | 600,000 | 600,000 | 600,000 | 540,000 | 800,000 |
| | | | | | | | 6,840,000 |



## ASSESSMENTS CALLED DURING 1911.

| | Per share. | Amount. |
|---|---|---|
| Adventure | $1 00 | $100,000 |
| Franklin | 2 00 | 332,652 |
| Hancock | 4 00 | 400,000 |
| Indiana | 1 50 | 120,000 |
| King Philip | 1 00 | 100,000 |
| Mass | 2 00 | 200,000 |
| Mayflower | 1 00 | 100,000 |
| Quincy | 2 00 | 168,000 |
| Old Colony | 1 00 | 100,000 |
| St. Louis | 2 50 | 100,000 |
| Victoria | 1 00 | 100,000 |
| Winona | 1 00 | 165,647 |
| Wyandot | 1 00 | 100,000 |
| Total | | $2,086,299 |

PRODUCTION OF COPPER IN THE UNITED STATES.
(Smelter output in pounds.)

| | 1907. | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|---|
| Alaska | 7,034,763 | 4,438,863 | 4,057,142 | 4,311,026 | 22,314,889 |
| Arizona | 256,778,437 | 289,523,267 | 291,110,298 | 297,250,538 | 303,202,532 |
| California | 33,696,602 | 39,643,833 | 53,568,708 | 45,760,200 | 35,835,651 |
| Colorado | 13,998,496 | 13,943,878 | 11,485,631 | 9,307,497 | 9,791,861 |
| Georgia (a) Maryland and Alabama | (a)90,655 | ..... | ..... | 724 | (a)23,555 |
| Idaho | 9,707,299 | 7,256,086 | 7,096,132 | 6,877,515 | 4,514,116 |
| Michigan | 219,131,503 | 222,289,584 | 227,005,923 | 221,462,984 | 218,185,236 |
| Montana | 224,263,789 | 252,503,651 | 314,858,291 | 283,078,423 | 271,814,491 |
| Nevada | 1,998,164 | 12,241,372 | 53,849,281 | 64,494,640 | 65,561,015 |
| New Hampshire | ..... | 135,139 | 88,944 | 12,409 | ..... |
| New Mexico | 10,140,140 | 4,991,351 | 5,031,136 | 3,784,609 | 2,860,400 |
| North Carolina | 544,040 | 29,391 | 120,451 | 181,263 | 13,699 |
| Oregon | 518,694 | 271,191 | 245,403 | 22,022 | 125,943 |
| Pennsylvania | ..... | ..... | 994,089 | 740,626 | 661,621 |
| Philippine Islands | ..... | ..... | ..... | 1,781 | 9,612 |
| South Dakota (b) includes Maryland, Alabama, South Carolina and Texas | ..... | (b)30,488 | 41,988 | 43 | 1,607 |
| Tennessee | 19,745,119 | 19,710,103 | 19,207,747 | 16,691,777 | 18,965,143 |
| Texas | ..... | ..... | 3,456 | 2,961 | 105 |
| Utah | 66,418,370 | 71,370,370 | 101,241,114 | 125,185,455 | 142,340,215 |
| Vermont | ..... | ..... | ..... | ..... | ..... |
| Virginia | 696,102 | ..... | ..... | 1,935 | ..... |
| Washington | 57,008 | 25,087 | 231,971 | 105,313 | ..... |
| Wyoming | 122,263 | 162,201 | 120,611 | 65,021 | 195,503 |
| Missouri and unapportioned (c) and other states | 3,026,004 | 2,416,197 | 433,672 | 217,127 | 130,499 |
| | 1,299,043 | 1,580,831 | 2,159,636 | 603,570 | 685,056 |
| | 868,996,491 | 942,570,721 | 1,092,951,624 | 1,080,159,509 | 1,097,232,749 |

These figures for 1907-1911 are from U. S. G. S. reports.



PRODUCTION OF MICHIGAN COPPER MINES IN RECENT YEARS.
(Pounds Avoirdupois.)

| | 1906. | 1907. | 1908. | 1909. | 1910. | 1911. |
|---|---|---|---|---|---|---|
| Adventure | 1,552,628 | 1,244,874 | 90,870 | ..... | ..... | ..... |
| Ahmeek | 3,077,507 | 5,510,985 | 6,280,241 | 9,198,110 | 11,844,954 | 15,196,127 |
| Allouez | 3,486,900 | 2,934,116 | 3,047,051 | 4,031,532 | 4,655,702 | 4,780,494 |
| Atlantic | 1,439,082 | ..... | ..... | ..... | ..... | ..... |
| Baltic | 14,397,557 | 16,704,868 | 17,724,854 | 17,817,836 | 17,549,762 | 15,370,449 |
| Calumet and Hecla | 100,023,420 | 83,863,116 | 82,549,979 | 80,096,995 | 72,059,545 | 74,130,977 |
| Centennial | 2,253,015 | 2,373,572 | 2,196,377 | 2,583,793 | 1,572,566 | 1,493,834 |
| Champion | 16,954,986 | 16,489,436 | 17,786,763 | 18,005,071 | 19,224,174 | 15,639,426 |
| Franklin | 4,571,570 | 4,401,248 | 3,707,518 | 1,615,556 | 966,353 | 820,203 |
| 7—Hancock | ..... | ..... | ..... | ..... | ..... | 754,729 |
| Isle Royale | 2,937,098 | 2,667,608 | 3,011,664 | 5,719,056 | 7,567,339 | 7,490,120 |
| Keweenaw | ..... | ..... | 122,474 | 57,091 | 36,682 | ..... |
| 7—LaSalle | ..... | ..... | ..... | ..... | 633,778 | 280,598 |
| Lake | ..... | ..... | ..... | ..... | 318,050 | ..... |
| Mass | 2,106,739 | 2,078,677 | 1,766,930 | 1,723,436 | 1,321,885 | 1,326,898 |
| Michigan | 2,875,341 | 2,665,404 | 3,000,206 | 1,979,305 | ..... | 327,773 |
| Mohawk | 9,352,252 | 10,107,266 | 10,295,881 | 11,248,474 | 11,412,066 | 12,091,056 |
| Osceola | 18,588,451 | 14,134,753 | 21,250,794 | 25,296,657 | 19,346,566 | 18,388,193 |
| Quincy | 16,194,838 | 19,796,058 | 20,600,361 | 22,511,984 | 22,517,014 | 22,252,943 |
| Superior | ..... | ..... | 21,244 | 1,781,315 | 3,181,041 | 3,236,233 |
| Tamarack | 9,832,644 | 11,078,604 | 12,806,127 | 13,533,207 | 11,063,606 | 7,494,077 |
| Trimountain | 9,507,933 | 8,190,711 | 6,034,908 | 5,282,404 | 5,694,868 | 6,120,417 |
| Victoria | 546,334 | 1,207,237 | 1,290,040 | 1,062,218 | 1,164,564 | 1,303,331 |
| Winona | 278,182 | 1,285,863 | ..... | ..... | ..... | 1,275,675 |
| Wolverine | 9,548,123 | 9,272,351 | 9,955,233 | 9,971,482 | 9,666,534 | ..... |
| Gratiot | ..... | ..... | ..... | ..... | 265,869 | 14,275 |
| Ojibway | ..... | ..... | ..... | ..... | ..... | ..... |
| Totals (U. S. G. S. figures, including products of some other mines). (Smelter returns) | 229,695,730 | 219,131,503 | 222,289,584 | 227,005,923 | 221,462,984 | 219,840,201 |
| Value copper | $43,791,600 | $43,553,446 | $29,473,844 | $30,437,749 | $28,280,800 | ..... |
| Value silver | 148,889 | 197,844 | 127,759 | 148,944 | 178,470 | ..... |
| Total | $43,940,489 | $43,751,290 | $29,601,603 | $30,586,693 | $28,459,270 | ..... |

Most of these figures are from reports of the Mining companies. The remainder are the best obtainable from other sources.

SUMMARY OF RESULTS OBTAINED IN 1908, 1909, 1910 AND 1911 BY THE OUTPUT OF

| | | Tons of ore stamped. | Per ton of ore. Cost of mining, transportation, stamping and taxes. | Pounds of mineral obtained. | Pounds of refined copper produced. |
|---|---|---|---|---|---|
| 1. C. & H. All ore | 1911 | 2,909,972 | 1.84 | ..... | 74,130,977 |
| | 1910 | 2,795,514 | 1.92 | ..... | 72,059,545 |
| | 1909 | 2,842,880 | 1.93 | ..... | 80,095,995 |
| | 1908 | 2,643,938 | 2.15 | ..... | 82,549,979 |
| 2. C. & H. Conglomerate | 1911 | 1,924,480 | 2.07 | ..... | 58,469,399 |
| | 1910 | 1,950,040 | 2.11 | ..... | 58,739,509 |
| | 1909 | 1,999,880 | 2.11 | ..... | 66,285,684 |
| | 1908 | 1,958,200 | 2.25 | ..... | 70,427,877 |
| 3. Tamarack | 1911 | 392,338 | 2.69 | 12,793,430 | 7,494,077 |
| | 1910 | 525,554 | 2.67 | 22,053,480 | 11,063,606 |
| | 1909 | 689,099 | 2.44 | 20,286,174 | 13,533,207 |
| | 1908 | 654,894 | 2.57 | 19,134,429 | 12,806,127 |
| 4. C. & H. Amygdaloid | 1911 | 985,492 | 1.34 | ..... | 15,661,578 |
| | 1910 | 831,194 | 1.41 | ..... | 13,150,427 |
| | 1909 | 838,200 | 1.42 | ..... | 13,752,276 |
| | 1908 | 685,738 | 1.75 | ..... | 12,122,102 |
| 5. Osceola | 1911 | 1,246,596 | 1.14 | 24,452,912 | 18,388,193 |
| | 1910 | 1,217,720 | 1.28 | 25,669,913 | 19,346,566 |
| | 1909 | 1,494,845 | 1.36 | 33,107,579 | 25,296,657 |
| | 1908 | 1,241,400 | 1.45 | 26,912,944 | 21,250,794 |
| 6. Ahmeek | 1911 | 598,549 | 1.42 | 21,917,925 | 15,196,127 |
| | 1910 | 530,365 | 1.42 | 16,758,521 | 11,844,954 |
| | 1909 | 406,045 | 1.72 | 12,409,042 | 9,198,110 |
| | 1908 | 298,178 | 1.78 | 8,029,960 | 6,280,241 |
| 7. Allouez | 1911 | 288,610 | 1.668 | 7,532,490 | 4,780,494 |
| | 1910 | 247,119 | 1.769 | 7,406,970 | 4,655,702 |
| | 1909 | 253,049 | 1.806 | 6,384,450 | 4,031,532 |
| | 1908 | 220,905 | 2.051 | 4,716,105 | 3,047,051 |
| 8. Wolverine | 1911–1912 | ..... | ..... | ..... | ..... |
| | 1910–1911 | 388,476 | 1.64 | 12,227,500 | 9,617,168 |
| | 1909–1910 | 390,837 | 1.61 | 12,359,000 | 9,757,101 |
| | 1908–1909 | 394,433 | 1.60 | 12,692,610 | 9,995,748 |
| 9. Mohawk | 1911 | 802,548 | 1.406 | 15,760,700 | 12,091,056 |
| | 1910 | 902,537 | 1.43 | 15,013,500 | 11,412,066 |
| | 1909 | 819,019 | 1.40 | 14,690,200 | 11,248,474 |
| | 1908 | 685,823 | 1.44 | 13,310,820 | 10,295,881 |
| 10. Centennial | 1911 | 86,543 | 1.869 | 2,321,200 | 1,493,834 |
| | 1910 | 101,133 | 1.9477 | 2,380,566 | 1,572,566 |
| | 1909 | 196,525 | 1.818 | 3,941,820 | 2,583,193 |
| | 1908 | 169,693 | 2.086 | 3,352,790 | 2,196,377 |
| 11. Baltic | 1911 | 696,795 | 1.714 | 25,254,160 | 15,370,449 |
| | 1910 | 781,419 | 1.67 | 28,067,300 | 17,549,762 |
| | 1909 | 814,260 | 1.55 | 27,421,000 | 17,817,836 |
| | 1908 | 764,117 | 1.56 | 25,282,145 | 17,724,854 |
| 12. Champion | 1911 | 734,392 | 1.743 | 26,137,007 | 15,639,426 |
| | 1910 | 722,051 | 1.86 | 30,508,690 | 19,224,174 |
| | 1909 | 753,908 | 1.80 | 27,851,720 | 18,005,071 |
| | 1908 | 794,703 | 1.62 | 26,579,795 | 17,786,763 |
| 13. Trimountain | 1911 | 347,885 | 1.819 | 10,705,685 | 6,120,417 |
| | 1910 | 317,299 | 2.00 | 9,598,900 | 5,694,868 |
| | 1909 | 323,408 | 2.09 | 9,118,095 | 5,282,404 |
| | 1908 | 334,929 | 2.05 | 9,634,979 | 6,034,908 |



18 COPPER MINES WHICH PRODUCED OVER 99 PER CENT OF THE TOTAL MICHIGAN.

| Per cent refined copper in mineral. | Pounds of refined copper per ton of ore stamped. | Cost per pound at mine excluding construction. | Cost per pound construction. | Other costs per pound. | Cost per pound smelting, freight commission eastern office. | Cost per pound interest paid. | Total cost per pound, copper. | Price received for copper sold |
|---|---|---|---|---|---|---|---|---|
| ..... | 25.47 | ..... | ..... | ..... | ..... | ..... | 8.52 | 12.82 |
| ..... | 25.77 | ..... | ..... | ..... | ..... | ..... | 8.96 | 13.20 |
| ..... | 28.18 | ..... | ..... | ..... | ..... | ..... | 8.28 | 13.61 |
| ..... | 31.22 | ..... | ..... | ..... | ..... | ..... | 9.00 | 13.62 |
| ..... | 30.38 | ..... | ..... | ..... | ..... | ..... | 8.25 | 12.82 |
| ..... | 30.12 | ..... | ..... | ..... | ..... | ..... | 8.55 | 13.20 |
| ..... | 33.14 | ..... | ..... | ..... | ..... | ..... | 7.77 | 13.61 |
| ..... | 35.96 | ..... | ..... | ..... | ..... | ..... | 8.38 | 13.62 |
| 58.58 | 19.1 | 14.07 | 0.06 | ..... | 1.23 | 0.20 | 15.56 | 12.71 |
| 50.17 | 21.1 | 12.66 | 0.57 | ..... | 1.30 | 0.17 | 14.70 | 12.97 |
| 66.71 | 19.6 | 12.41 | 0.33 | ..... | 1.18 | 0.38 | 14.30 | 13.32 |
| 66.93 | 19.6 | 13.14 | 0.64 | ..... | 1.36 | 0.10 | 15.24 | 13.39 |
| ..... | 15.89 | ..... | ..... | ..... | ..... | ..... | 9.95 | 12.82 |
| ..... | 15.82 | ..... | ..... | ..... | ..... | ..... | 10.53 | 13.20 |
| ..... | 16.40 | ..... | ..... | ..... | ..... | ..... | 10.41 | 13.61 |
| ..... | 17.67 | ..... | ..... | ..... | ..... | ..... | 12.25 | 13.62 |
| 75.198 | 14.8 | 7.73 | 0.49 | ..... | 1.06 | ..... | 9.28 | 12.72 |
| 75.367 | 15.9 | 8.04 | 0.35 | ..... | 0.98 | ..... | 9.37 | 13.04 |
| 76.407 | 16.9 | 8.04 | 0.44 | ..... | 0.99 | ..... | 9.47 | 13.30 |
| 78.961 | 17.1 | 8.25 | 0.69 | ..... | 1.10 | ..... | 10.25 | 13.39 |
| 69.33 | 25.4 | 5.61 | 0.32 | ..... | 1.19 | 0.05 | 7.17 | 12.78 |
| 70.68 | 22.3 | 6.37 | 1.85 | 1.56 | 1.16 | 0.11 | 11.05 | 12.99 |
| 74.12 | 22.7 | 7.61 | 5.27 | 1.47 | 1.10 | 0.03 | 15.48 | 13.37 |
| 78.21 | 21.1 | 8.64 | 2.40 | 0.51 | 1.11 | 0.00 | 12.66 | 13.46 |
| 63.47 | 16.56 | 10.07 | 0.90 | ..... | 1.95 | 0.38 | 13.30 | 12.822 |
| 62.86 | 18.84 | 9.39 | 0.00 | ..... | 1.81 | 0.37 | 11.57 | 12.68 |
| 63.14 | 15.93 | 11.34 | 0.21 | ..... | 1.51 | 0.33 | 13.39 | 13.26 |
| 64.61 | 13.80 | 14.86 | 0.22 | ..... | 1.40 | 0.33 | 16.81 | 13.35 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 78.65 | 24.75 | 6.628 | 0.023 | ..... | 0.891 | ..... | 7.542 | 12.58 |
| 78.947 | 24.96 | 6.453 | 0.03 | ..... | 0.93 | ..... | 7.413 | 13.24 |
| ..... | 26.75 | 6.002 | 0.45 | ..... | 0.923 | ..... | 7.375 | 13.35 |
| 76.71 | 15.07 | 9.33 | 0.259 | ..... | 0.81 | ..... | 10.399 | 12.63 |
| 76.01 | 14.22 | 10.076 | 0.48 | ..... | .889 | ..... | 11.44 | 13.09 |
| 76.57 | 13.73 | 10.22 | 0.01 | ..... | .875 | ..... | 11.21 | 13.20 |
| 77.35 | 15.01 | 9.60 | 0.21 | ..... | .938 | ..... | 10.75 | 13.43 |
| 64.36 | 17.26 | 10.83 | 0.00 | ..... | 1.43 | 0.43 | 12.69 | 12.842 |
| 66.05 | 15.40 | 12.65 | 0.00 | ..... | 1.49 | 0.34 | 14.48 | 13.12 |
| 65.55 | 13.15 | 13.82 | 0.08 | ..... | 1.56 | 0.15 | 15.61 | 13.28 |
| 65.51 | 12.94 | 16.12 | 0.74 | ..... | 1.63 | ..... | 18.49 | 13.39 |
| ..... | 22.06 | ..... | ..... | ..... | ..... | ..... | 9.09 | 12.54 |
| ..... | 22.46 | ..... | ..... | ..... | ..... | ..... | 8.32 | 12.74 |
| ..... | 21.88 | ..... | ..... | ..... | ..... | ..... | 7.98 | 13.00 |
| ..... | 23.20 | ..... | ..... | ..... | ..... | ..... | 7.72 | 13.39 |
| ..... | 21.296 | ..... | ..... | ..... | ..... | ..... | 9.63 | 12.54 |
| ..... | 26.62 | ..... | ..... | ..... | ..... | ..... | 7.85 | 12.74 |
| ..... | 23.88 | ..... | ..... | ..... | ..... | ..... | 8.45 | 13.00 |
| ..... | 22.38 | ..... | ..... | ..... | ..... | ..... | 8.34 | 13.39 |
| ..... | 17.59 | ..... | ..... | ..... | ..... | ..... | 11.55 | 12.54 |
| ..... | 17.95 | ..... | ..... | ..... | ..... | ..... | 12.17 | 12.74 |
| ..... | 16.33 | ..... | ..... | ..... | ..... | ..... | 13.89 | 13.00 |
| ..... | 18.02 | ..... | ..... | ..... | ..... | ..... | 12.5 | 13.39 |

SUMMARY OF RESULTS OBTAINED IN 1908, 1909 AND 1910.—CONCLUDED.

| | | Tons of ore stamped. | Per ton of ore. Cost of mining, transportation, stamping and taxes. | Pounds of mineral obtained. | Pounds of refined copper produced. | Per cent refined copper in mineral. | Pounds of refined copper per ton of ore stamped. | Cost per pound at mine excluding construction. | Cost per pound construction. | Other costs per pound. | Cost per pound smelting, freight commission eastern office. | Cost per pound interest paid. | Total cost per pound, copper. | Price received for copper sold. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14. Superior | 1911 | 162,599 | 2.39 | ... | 3,236,233 | ... | 19.90 | 12.01 | 0.89 | ... | 2.02 | 0.39 | 15.31 | 12.652 |
| | 1910 | 140,514 | 2.69 | ... | 3,181,041 | ... | 22.64 | ... | ... | ... | ... | ... | 14.29 | 12.63 |
| | 1909 | 81,641 | ... | ... | 1,781,315 | ... | 21.82 | ... | ... | ... | ... | ... | ... | 13.56 |
| | 1908 | 962 | ... | ... | 21,244 | ... | 22.08 | ... | ... | ... | ... | ... | ... | ... |
| 15. Quincy | 1911 | 1,382,254 | ... | 32,550,440 | 22,252,943 | 68.4 | 16.1 | 9.25 | 0.48 | ... | 0.89 | ... | 10.62 | 12.725 |
| | 1910 | ... | ... | 34,177,380 | 22,517,014 | 65.88 | ... | 8.80 | 0.50 | 0.25 | 0.93 | ... | 10.48 | 13.20 |
| | 1909 | ... | ... | 35,025,225 | 22,511,984 | 64.27 | ... | 8.85 | 0.50 | 0.26 | 0.91 | ... | 10.52 | 13.40 |
| | 1908 | ... | ... | 32,754,745 | 20,600,361 | 60.28 | ... | 9.615 | 0.58 | 0.23 | 0.85 | ... | 11.27 | 13.57 |
| 16. Franklin | 1911 | ... | ... | ... | 820,203 | ... | ... | ... | ... | ... | ... | ... | ... | 12.516 |
| | 1910 | 113,859 | ... | ... | 966,353 | ... | ... | ... | ... | ... | ... | ... | ... | 13.33 |
| | 1909 | 170,456 | 1.94 | 3,306,820 | 1,615,556 | ... | 9.47 | ... | ... | ... | ... | ... | ... | ... |
| | 1908 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 17. Isle Royale | 1911 | 457,440 | 1.42 | 10,339,171 | 7,490,120 | 72.44 | 16.4 | 8.97 | 0.25 | 0.13 | 1.21 | 0.29 | 10.85 | 12.38 |
| | 1910 | 520,860 | 1.42 | 10,433,060 | 7,567,399 | 72.53 | 14.5 | 9.75 | 0.16 | 0.33 | 1.26 | 0.34 | 11.84 | 12.68 |
| | 1909 | 401,280 | 1.87 | 7,926,015 | 5,719,056 | 72.16 | 14.3 | 13.12 | 1.28 | 0.55 | 1.44 | 0.25 | 16.64 | 13.00 |
| | 1908 | 218,940 | 2.33 | 4,013,590 | 3,011,664 | 75.04 | 13.8 | 16.91 | 9.65 | 0.44 | 1.99 | 0.00 | 28.99 | 13.29 |
| 18. Victoria | 1911 | 126,894 | ... | 2,128,245 | 1,303,331 | ... | 10.3 | ... | ... | ... | ... | ... | ... | ... |
| | 1910 | 122,497 | ... | 1,923,599 | 1,164,564 | ... | ... | ... | ... | ... | ... | ... | 13.4 | 12.3 |
| | 1909 | 118,605 | ... | 1,843,152 | 1,062,218 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | 1908 | 109,015 | 1.51 | 2,259,928 | 1,290,040 | ... | 11.18 | 12.366 | ... | ... | 1.97 | ... | 14.335 | 13.10 |
| 19. Mass | 1911 | 73,475 | ... | 1,949,720 | 1,326,898 | 68.055 | 17.58 | ... | ... | ... | ... | ... | ... | 12.50 |
| | 1910 | 90,747 | ... | 1,790,795 | 1,321,885 | 73.837 | 14.59 | ... | ... | ... | ... | ... | ... | ... |
| | 1909 | 139,404 | ... | ... | ... | ... | 12.36 | ... | ... | ... | ... | ... | ... | ... |
| | 1908 | 171,268 | ... | ... | ... | ... | 10.31 | ... | ... | ... | ... | ... | ... | ... |
| 20. Michigan Mine | 1911 | ... | ... | ... | 327,773 | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | 1910 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | 1909 | 148,172 | ... | 2,457,346 | 1,979,305 | ... | ... | ... | ... | ... | ... | ... | ... | 13.16 |
| | 1908 | 190,331 | ... | Mass. 485,846<br>3,270,250<br>Mass. 1,226,845 | 3,000,206 | ... | ... | ... | ... | ... | ... | ... | ... | 13.305 |
| Total production (from U. S. G. S. Reports). | 1911 | 10,978,827 | ... | ... | 219,840,201 | ... | 20.0 | ... | ... | ... | ... | ... | ... | ... |
| | 1910 | 10,869,561 | ... | 360,840,547 | 222,683,461 | 61.71 | 20.5 | ... | ... | ... | ... | ... | ... | 13.00 |
| | 1909 | 11,429,394 | ... | 358,862,935 | 234,136,529 | 65.24 | 20.5 | ... | ... | ... | ... | ... | ... | 12.7 |
| | 1908 | 10,531,271 | ... | 339,233,252 | 223,286,700 | 65.82 | 21.2 | ... | ... | ... | ... | ... | ... | 13.2 |

SUMMARY OF RESULTS OBTAINED IN 1911.

| | Tons of ore stamped. | Cost of mining, transportation and stamping, per ton, ore | Pounds of concentrate obtained. | Pounds of refined copper produced. | Per cent of refined copper in concentrate. | Pounds refined copper per ton of ore stamped. | Cost per pound at mine excluding construction. | Cost construction. | Cost per pound smelting, freight, commission eastern office. | Other costs. | Cost per pound interest paid. | Total cost per pound, copper produced. | Price received for copper sold. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ahmeek | 598,549 | $1.42 | 21,917,925 | 15,196,127 | 69.33 | 25.4 | 5.61 | 0.32 | 1.19 | ... | 0.05 | 7.17 | 12.78 |
| Allouez | 288,610 | 1.668 | 7,532,490 | 4,780,494 | 63.47 | 16.56 | 10.07 | 0.90 | 1.95 | ... | 0.38 | 13.30 | 12.822 |
| Baltic | 696,795 | 1.714 | ... | 15,370,449 | ... | 22.06 | ... | ... | ... | ... | ... | 9.09 | 12.54 |
| C. & H. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| C. & H. Conglomerate | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| C. & H. Amygdaloid | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Centennial | 86,543 | 1.869 | 2,321,200 | 1,493,834 | 64.36 | 17.26 | 10.83 | 0.00 | 1.43 | ... | 0.43 | 12.69 | 12.842 |
| Champion | 734,392 | 1.743 | ... | 15,639,426 | ... | 21.296 | ... | ... | ... | ... | ... | 9.63 | 12.54 |
| Franklin | ... | ... | ... | 820,203 | ... | ... | ... | ... | ... | ... | ... | ... | 12.516 |
| Hancock | 41,449 | ... | ... | 754,749 | ... | 18.21 | ... | ... | ... | ... | ... | ... | ... |
| Isle Royale | 457,440 | 1.42 | 10,339,171 | 7,490,120 | 72.44 | 16.4 | 8.97 | 0.25 | 1.21 | 0.13 | 0.29 | 10.85 | 12.38 |
| Mass | 73,475 | ... | 1,949,720 | 1,326,898 | 68.055 | 17.58 | ... | ... | ... | ... | ... | ... | ... |
| Michigan | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Mohawk | 802,548 | 1.406 | 15,760,700 | 12,091,056 | 76.71 | 15.07 | 9.33 | 0.259 | 0.81 | ... | ... | 10.399 | 12.63 |
| Osceola | 1,246,596 | 1.14 | 24,452,912 | 18,388,193 | 75.198 | 14.8 | 7.73 | 0.49 | 1.06 | ... | ... | 9.28 | 12.72 |
| Quincy | 1,382,254 | ... | 32,550,440 | 22,252,943 | 68.4 | 16.1 | 9.25 | 0.48 | 0.89 | ... | ... | 10.62 | 12.725 |
| Superior | 162,599 | 2.39 | ... | 3,236,233 | ... | 19.90 | 12.01 | 0.89 | 2.02 | ... | 0.39 | 15.31 | 12.652 |
| Tamarack | 392,338 | 2.69 | 12,793,430 | 7,494,077 | 58.58 | 19.1 | 14.07 | 0.06 | 1.23 | ... | 0.20 | 15.56 | 12.71 |
| Trimountain | 347,885 | 1.819 | ... | 6,120,417 | ... | 17.59 | ... | ... | ... | ... | ... | 11.55 | 12.54 |
| Victoria | 126,894 | ... | 2,128,245 | 1,303,331 | ... | 10.3 | ... | ... | ... | ... | ... | ... | ... |
| Winona | 97,445 | ... | 2,533,870 | 1,275,675 | ... | 13.09 | ... | ... | ... | ... | ... | ... | ... |
| Wolverine | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |

# THE IRON MINING INDUSTRY OF MICHIGAN.

BY R. C. ALLEN.

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# CHAPTER I.

## IMPORTANCE OF THE INDUSTRY.

For nearly a half century prior to 1901 Michigan held first place in production of iron ore. In this year and annually to the present time the production from the great Mesabi range of Minnesota has over-shadowed the production of all other iron ranges and this range is now sending out more than two-thirds of the tonnage annually mined in the entire Lake Superior region and one-half of the total production of the United States. Notwithstanding the overwhelming magnitude of the Mesabi range production in recent years Michigan at the close of 1910 had shipped nearly half (221,122,495 tons) of the total tonnage mined in the Lake Superior region and about one-fourth of the entire tonnage mined in the United States in all preceding time. If these comparisons were expressed in weight of metallic iron Michigan's proportion of the total would be still greater.

## PERMANENCY OF THE IRON MINING INDUSTRY.

The backward view is eminently satisfactory but what of the future? A recent estimate (1911) by J. R. Finlay for the Michigan State Tax Commission, places the Michigan iron ore reserves in sight at 196,354,883 tons, an amount which is almost equal to the total shipments to 1911. This estimate does not include low grade material which will be salable at some future time, but iron ore of salable grade under 1911 conditions. This estimate supports the contention that shipments are on the average annually exceeded by developed new tonnage to the end that reserves increase more rapidly then shipments. There is no good reason to believe that reverse conditions will begin to operate in Michigan in the immediate future. Michigan's supply of iron ore is of course exhaustible, but relatively the supply is a permanent one. No one, no matter what completeness of information he may have at his command, would care to set the date when iron mining on a large

scale in Michigan will cease. There is more high grade ore in sight today than ever before, almost as much as has been extracted in some sixty-five years of continuous mining. The low grade ores have not been touched. Of these the supply is enormous. In our present state of knowledge it is quite useless to speculate on the grand total of available iron ore. All that can be said is that the end of iron mining in Michigan is so far removed that speculations regarding the date of its appearance have no present value or interest.

### THE MICHIGAN IRON FORMATIONS.

The names of the copper bearing and iron bearing formations and their age relationships are given below.

- Algonkian
  - Keweenawan. Copper on Kewenaw Point and in Ontonagon Co. Series.
  - Huronian Series
    - Upper—Iron in Ironwood formation of the Gogebic range.
      Iron in Vulcan formation of Iron River.
      Crystal Falls, and Menominee districts, and Bi iki iron bearing member of Marquette and Gwinn districts.
    - Middle—Iron in Negaunee formation of Marquette and Gwinn districts.
    - Lower—
- Archean
  - Keewatin Series. Iron bearing formations reported near Marenisco.
  - Laurentian Series.

The entire iron ore production of Michigan has come from the Upper and Middle Huronian series. The Middle Huronian is not known in the Lake Superior region outside of Michigan and is productive only in the Negaunee formation of the Marquette district. It has produced over forty per cent of the total output of the state.

*Character of the Iron Formations:* The iron formations, in which the iron ore bodies are found are sedimentary rocks composed, in an altered condition, chiefly of silica in the form of chert and quartz, and the iron bearing minerals, ferrous carbonate (siderite), ferrous silicate (greenalite) and iron oxide (mainly hematite). Oxidation has transformed most of the ferrous iron contents to iron oxide in the exposed parts of the formations producing *ferruginous cherts* ("soft ore jasper") *ferrouginous slates* and by further metamorphism (anamorphism) *jaspilites* ("hard ore jasper"). If oxidation is complete and the silica content sufficiently reduced by leaching, ore bodies result.



*Relations to Other Formations:* The iron formations are interbedded with other sedimentary rocks such as slate, quartzite and dolomite and in some places with igneous rocks of volcanic origin. In some areas they are cut by dikes and irregular masses of younger intrusive igneous rocks, notably in the Gogebic and Marquette districts.

*Thickness of the Iron Formations:* The iron bearing beds vary greatly in thickness in the different iron ranges. In the Gogebic district the maximum thickness is 800 to 1,000 feet, in the Marquette district from 1,000 to possibly 1,500 feet in the Iron River and Crystal Falls districts not more than 350 feet to 400 feet, and in the Menominee district the combined thickness of the two productive beds varies on the average between 300 feet and 400 feet.

*Deformation and Alteration of the Iron Formation:* These rocks were deposited in about flat lying or horizontal position and were subsequently folded by compressive earth movements into synclines (troughs) and anticlines (arches). During deformation the iron formations were not only folded but fractured, and along many of these fractures faults or displacements occurred. Deformation was mainly accomplished while the iron bearing beds were buried beneath overlying formations but erosion has since removed the overlying rocks in those areas where the iron formations are now exposed at the surface.

*Formation of the ore bodies:* The ore bodies are concentrations of iron oxide in exposed parts of the richer layers of the iron formation. They are further very largely limited in occurrence to places where structural conditions combine with other factors to render the agents of alteration exceptionally effective. The main agent of alteration is oxygenated and carbonated meteoric water. The waters descend from the surface oxidizing the ferrous carbonate and silicate to ferric oxide and leaching out the silica. Those parts of the iron formation most happily situated to receive a vigorous circulation of oxidized and carbonated waters are more apt to carry ore bodies than parts not so situated. Concentration of downward moving meteoric waters is favorably influenced by certain structural conditions such as (1) the occurrence of impervious foot walls of slate or other rocks, (2) pitching troughs with impervious basements, (3) an inclined position of the iron formation, (4) a brecciated or porous condition of the iron formation, (5) a large area of the iron formation exposed at the surface.

Ferruginous chert and ferruginous slate are iron formation rocks which represent a part way stage between the unaltered phase and iron ore. In them the original ferrous carbonate and ferrous silicate minerals are partly or wholly oxidized to ferric oxide but the silica has not been removed. Rocks thus altered make up the great bulk of the iron formation.

*Depth to which Iron Ore Occurs:* Nearly all of the ore bodies are exposed at the rock surface. Those deposits which are not exposed at the rock surface are connected with this surface by ferruginous chert or slate, that is to say, by rocks which have been altered by processes which if completed would result in ore concentration. Ore deposits may be expected to occur to depths to which an active circulation of oxidizing waters has penetrated. Obviously such depths will depend on factors of uncertain character which vary widely in different localities. For these reasons speculation as to the maximum depth at which ore will ultimately be found is hazardous to say the least. The Newport mine at Ironwood has developed a large body of high grade ore under 2,000 feet in depth. A greater depth (2,200 feet) is attained by the ores of the Champion mine in the Marquette district. Other mines are approaching this depth. Deep drilling is meeting with encouraging results in many explorations. The ultimate maximum depth at which iron ores may be found and from which they may be profitably mined has not been attained.

### THE CHARACTER OF MICHIGAN IRON ORES.

The great bulk of Michigan iron ore is hematite with some limonite and a small amount of magnetite. In statistical tables nearly all Michigan ores are graded as hematite. The textures vary from soft, granular, and powdery to hard, specular, and schistose. The lowest grade of ore shipped from Michigan mines has averaged about 40% metallic iron. The annual shipments from Michigan mines vary mainly between 50% and 60% metallic iron. For the chemical composition of Michigan ores for 1910 see statistical tables.



# CHAPTER II.

## IMPORTANT FEATURES OF THE IRON MINING INDUSTRY.

The Geological Survey is often asked for information relative to particular features of the iron mining industry. Naturally, these inquiries come not so frequently from those connected with the industry as from other sources, including land owners, legislators, publishers, etc., both in and out of the state. In the following pages is discussed in an elementary way some of the more important factors in the business of mining and marketing iron ore, including (1) exploration, (2) royalties, values and ownerships, (3) prices and price determinations, (4) sampling and analyses, and (5) transportation.

### EXPLORATION FOR IRON ORE.

In the early days on the Michigan ranges prospecting was confined to a search for exposures of iron ore. It was not long in the early history of each range before the more promising exposures of ores were located and thereafter further discoveries resulted only from underground exploration, either projected from the workings of the mines or conducted in new ground by test pitting and drilling. In order to eliminate barren ground it was found advantageous to indicate on maps or plats the known occurrences of iron formation, thus initiating the construction of geological maps. The early prospectors were beset with the difficulties inherent in a wooded country with few or no roads. Furthermore they had to deal with complex geological structures of the rocks, and did not have the aid furnished to the modern explorer through the publication of geologic maps and volumes of literature, the product of many years of experience and study by miners, geologists and engineers. In fact the oft repeated sayings of the Cornish miner "*where* it is *there* it is," and "where there is *some* there is *more*," well illustrate the status of knowledge of the early explorers for iron ore.

Through study and experience the geologic structure of the rocks and the conditions of ore occurrences became increasingly better understood and has had its effect in better and more intelligently

directed exploration. With the discovery of each successive new range there has, however, always been a tendency for the explorer to assume that geologic conditions on the new range were analagous to those on the older range with which he was more particularly familiar. These assumptions, when strongly held, have proven more of a handicap than a help for the different ranges are unlike in succession and structure of the rocks and the most successful methods of exploration take this fact into account. The inability to quickly apprehend new or modified conditions and to meet them with a corresponding change in procedure in exploration, i. e., and inelasticity of thought and method, is less common among explorers now than it was a few years ago.

The methods of modern exploration for iron ore may best be illustrated by an outline of procedure in a suppositious case. Suppose a mining company feels the need of increasing its ore reserves by exploration in new territory. This is the condition generally obtaining in Michigan for the strength of a mining company and its continued existence depend on the opening of new reserves to take place of those which become exhausted. Those companies which are both miners and steel and iron makers find it expedient not only to maintain a large reserve of minable ore but reserves of different grades of ore for use in properly mixing furnace charges.

It may be taken for granted that the company is able to use discriminating judgment in selection of lands to explore. The larger companies maintain a force of engineers and geologists whose business it is to keep well abreast of the developments in geology and mining throughout the ranges in which the company operates.

If the lands which it is desired to explore are not owned by the company they may be obtained (1) by purchase or (2) by lease. Transfers to title of minerals in iron bearing lands on developed Michigan ranges are not common, the owners preferring to retain title as a source of income under lease. An option to explore with privilege of lease at or before the expiration of the option is practically always preliminary to a lease on undeveloped lands. The terms of the option vary, but usually contain the following major stipulations: (1) The mining company is given a certain stated length of time to explore. The owner may demand and in some cases receive a cash bonus for the option, the amount of which is conditioned on the strength of the probability of ore occurrence, etc., and may, under certain conditions, agree to an extension of the option period on request of the company. The option commonly obligates the company to make a stated minimum expenditure for



exploration, to do a certain number of feet of drilling or to work continuously during the life of the option. (2) The terms of lease which may be exercised or rejected by the company are stated in the option. They include (a) stipulation of the *royalty*. The fee owner usually receives a *minimum royalty* which is a lump sum to be paid annually for the privilege of holding the lease and a per ton royalty on shipments from the property. The amount of the latter varies in different districts and localities and for different grades of ore. It may be a flat or a graded rate per ton, a certain percentage of the sale price, or under certain conditions a minimum flat or graded rate plus a premium based on the sale price. The per ton royalties are usually credited against the minimum royalties and if the former totals less than the minimum, the difference is paid. (b) The company exercising lease is usually obligated to pay taxes. (c) In lieu of a low minimum royalty there is sometimes a provision for continuous operation of the property. Under a low minimum royalty a company may find it expedient not to operate but to hold the ore in reserve. Many other items which are not here considered are included in the average lease.

Having settled the terms of the option and lease the company is ready to begin exploration. The property is surveyed, sometimes both topographically and geologically, and the engineers correlate all available geologic data having a bearing on the method to be followed. The first holes are "spotted" and the drilling begins.

The business of *mining* and *exploration* have in recent years become differentiated. With the increasing use of the drill companies have been formed who conduct purely a drilling business. There are something like 400 drills in more or less continuous operation in the Lake Superior country giving employment to about 1,400 to 1,500 men. Some of these companies are large operators and employ well trained engineers and geologists to conduct the exploratory operations. These companies are equipped to handle not only the mechanical but the scientific work of exploration charging only the "going" rates for drilling but using their superior organizations as a main factor in competition for business. In most cases the mining companies desire to handle the scientific end of the exploratory work but there are increasing instances of the assumption under contract by the drilling company of the full responsibility of conducting thorough and adequate exploration as great importance attaches to the results of

drilling operations, the business demands in its employ men of the highest integrity.

We may suppose that the company in this case contracts with a drilling concern for a certain minimum number of feet of drilling. For vertical holes the churn drill may be used but in any case it will be less satisfactory than the diamond drill. The latter preserves a core of rock which is useful to the engineer or geologist in charge for determining structure and succession of the strata which has a most important bearing on the location of ore bodies. Great care is used to obtain and preserve the drill cores. During the progress of drilling the samples are carefully examined and identified. Each hole is platted, often in such a way that it may be considered with others in three dimensions. Geologic sections are drawn from the acquired data and used to determine position and angle of successive holes. If ore is encountered both core and sludge are sampled for determination of iron and phosphorous content.

After the ore has been found drilling continues until something is known regarding the size, shape and quality of the deposit. The subsequent initial expenditure for mine equipment is determined most largely by the character of this information.

In general the deposits in Michigan ranges are of a shape and structure so complex that the drilling must be supplemented by underground work. Relatively little drilling is done on the Gogebic range where the portion of the iron formation at the surface is accurately known. On the other hand in drift covered areas of complex structure like the Iron River district, the iron formation must first be located by the drill preliminary to its exploration for ore deposits. Where exploration by drilling is attempted on land under option the results are usually sufficient to determine the advisability of exercising or abandoning the lease. However, there are many producing mines on lands that have been repeatedly explored and abandoned by different concerns, which serves to illustrate the fact that conditions are often such as to baffle the skill of the best equipped explorers. The element of luck still plays an important role in exploratory operations. There are comparatively few iron ore deposits in Michigan whose character and size were fully predetermined by drilling. On the Mesabi range of Minnesota the reverse is probably true.

In the case under consideration we may suppose that the results of the drilling are sufficiently encouraging to justify the exercise of the lease. The next step is the sinking of a shaft and the cutting



of underground openings, involving installation of pumping and hoisting machinery. At every step the structure of the iron formation and ore body is studied and platted until the probable size and character of the deposit is disclosed. When this information is completed or well advanced the plan of the mine is laid out and the mining methods best adapted to the conditions is determined by competent engineers. The mine is now rapidly brought to the producing stage. In most cases it is necessary to continue exploration throughout the life of the mine for in perhaps the majority of Michigan iron mines the conditions found on opening one level do not necessarily imply that the same or similar conditions will be found on other levels. The cost of exploration forms a continuous, though fluctuating charge against the cost of the ore.

### ROYALTIES.

The term *royalty* refers to payment by mining companies for the ore in properties which they operate but in which they own a part or none of the mineral values. The royalty is paid per ton of ore shipped and may be a flat or a graded rate or a combination of the two. The sum paid for the privilege of holding the lease is called the *minimum royalty*. The per ton royalty is commonly charged against the minimum.

It may occasion surprise to many to learn that more than three quarters of the Michigan iron mines are not owned by the operating companies. For the producing mines in the period 1906-1910 inclusive the figure is 78+%. If the Marquette range is excluded the percentage is 95 which about represents the present status of this factor in the iron mining business. The fees in most of the non royalty paying mines on the Marquette range were acquired long ago. There are few recent transfers of title to mineral fees in undeveloped iron range lands mainly because of the uncertainty of values. Both owners and miners prefer to deal with these lands under the leasing system.

Royalties which were actually paid by Michigan mines in 1905-1910 range from 82 cents to 5 cents per ton. The highest average per ton royalties are paid on the Gogebic range, then follows in decreasing order the Marquette, Gwinn, Crystal Falls, Menominee, and Iron River districts.

ROYALTIES PAID BY MICHIGAN IRON MINES, 1906-1910, INCLUSIVE.[1]

| Range. | No. of mines producing in 1906-1911. | No. of shipping mines paying royalties. | Average royalties 1906-1911. | | | |
|---|---|---|---|---|---|---|
| | | | High. | Low. | Average per mine. | Average per ton. |
| Gogebic | 14 | 12 | $0.82 | $0.226 | $0.405 | $0.388 |
| Iron River | 11 | 11 | .62 | .11 | .2107 | .209 |
| Crystal Falls | 14 | 13 | .50 | .13 | .268 | .262 |
| Menominee, including Metropolitan and Calumet | 12 | 12 | .38 | .05 | .211 | .242 |
| Marquette | 27 | 12 | .57 | .10 | .2864 | .331 |
| Gwinn | 4 | 4 | .57 | .20 | .307 | .323 |
| | 82 | 64 | | | | |

[1]Compiled from "Appraisal of the Mining Properties of Michigan" by J. R. Finlay. Report of the Board of State Tax Commissioners, 1911.

VALUES.

The royalty is the *sale price* of a ton of ore in the ground and is therefore in a sense the value of the unmined ore. Royalties are usually stipulated in options to explore with privilege of lease in undeveloped land in advance of the actual exploration. The results of the exploration determines whether the ore was sold by the owner at a high or low price. J. R. Finlay determined the average value of developed but unmined Michigan ore at 61 cents per ton in 1911. This is about double the average royalty for the whole state.

There is given below a summary statement of the ore reserves, total value, and equalized assessed value, for the state for 1911 compared with Minnesota for 1910. The approximate value per ton of Michigan iron ore in stock by years at the mines is given in a later table.

| | Total reserves (gross tons). | Assessed equalized value. | Total value. | Total value per ton. | Assessed value per ton. |
|---|---|---|---|---|---|
| Minnesota[2], 1910 | 1,347,596,291 | $220,423,038 | ..... | ..... | $0.163 |
| Michigan[3], 1911 | 196,354,883 | 93,933,629 | $119,485,000 | $0.61 | 0.473 |

[2]By Minnesota State Tax Commission.
[3]By Michigan State Tax Commission.

OWNERSHIPS.

It has been stated above that the *titles* to ore reserves are for the most part not vested in the operating companies. The mining business including *control* of ore reserves is, however, in the hands



of the operating companies. In the period 1906-1911, 82 mines controlled by 34 operating companies including subsidiaries made shipments. The Oliver Iron Mining Co. of the U. S. Steel Corporation is the largest shipper but does not hold the position of preponderance in Michigan as in the Lake Superior region in general, as shown in the table below.

PERCENTAGE OF TOTAL IRON ORE SHIPMENTS BY UNITED STATES STEEL CORPORATION FROM MICHIGAN AND THE LAKE SUPERIOR REGION.[4]

| | Total. | U. S. Steel Corporation. | Independent companies. | Percentage U. S. Steel Corporation. |
|---|---|---|---|---|
| 1909. | | | | |
| Lake Superior Region | 42,586,869 | 21,876,246 | 20,710,623 | 51.4 |
| Michigan | 11,979,229 | 2,894,516 | 9,084,713 | 24.08 |
| 1910. | | | | |
| Lake Superior Region | 43,442,397 | 22,185,972 | 21,256,425 | 51.00 |
| Michigan | 11,402,508 | 2,975,251 | 9,427,257 | 25.07 |

[4]Figures for Lake Superior Region taken from report of American Iron and Steel Association for 1910.

Of the total ore reserves as estimated by Finlay the independent companies control 142,047,548 tons or 72.3%, the U. S. Steel Corporation 54,307,335 tons or 27.7%.

MICHIGAN IRON ORE RESERVES BY RANGES, 1911.[5]

| | Total reserves 1911. | Controlled by U. S. Steel Corporation. | Per cent. | Controlled by independent companies. | Per cent. |
|---|---|---|---|---|---|
| Gogebic | 43,000,000 | 19,600,000 | 45.5 | 23,400,000 | 54.5 |
| Iron River | 42,122,000 | 1,400,000 | 3.3 | 40,722,000 | 96.7 |
| Crystal Falls | 8,054,000 | 625,000 | 7.7 | 7,429,000 | 92.3 |
| Menominee, Metropolitan, Calumet | 19,306,074 | 10,800,000 | 56 | 8,506,074 | 44.0 |
| Marquette | 77,126,651 | 21,616,335 | 28 | 55,510,316 | 72 |
| Gwinn | 6,746,158 | 266,000 | 3.9 | 6,480,158 | 96.1 |
| | 196,354,883 | 54,307,335 | 27.7 | 142,047,548 | 72.3 |

[5]Compiled from Appraisal of Michigan Mines, 1911, by J. R. Finlay.

Shipments by the Corporation and the Independent Companies seem to be about in proportion to reserves controlled.

PRICES OF MICHIGAN NATURAL IRON ORES AT LAKE ERIE PORTS FOR 1911 AND METHODS OF PRICE DETERMINATIONS.

In a subsequent table there is given the annual prices of Michigan iron ores at Lake Erie ports from 1855 to 1911. It must not be understood that the prices there given were actually paid per

ton of ore handled. The desirability of an ore of a given class for furnace use varies with the iron, phosphorous, and moisture percentages, and for different physical characteristics, such as porosity, density, lumpiness, etc.

The figures given in the table are called *base prices*. The *base price* serves as a point of departure for determining the actual value of an ore, and is paid only for ores which exactly fill certain arbitrarily fixed percentages of iron, phosphorous, and moisture. The ores as mined and sold vary in both directions from these arbitrarily fixed standards.

Iron ores are sold by the gross or long ton of 2,240 pounds. The amount of metallic iron in a long ton of ore is the primary or chief (though not the only) measure of its value. The *unit of value* should therefore be based on a *unit* of metallic iron. The *iron unit* has, therefore, been established as 1% of a long ton. The number of *iron units* in a ton of *natural iron ore*, i. e., which has its natural percentage of moisture, is determined by subtracting from 100% the percentage of moisture in the natural iron ore and multiplying the remainder by the percentage of iron in the ore dried at 212° F.

The base value of a *unit* of *iron* in the standard grades is obtained by dividing the *Valley price* (which is the Lake Erie price, plus 60 cents) by the stipulated percentage of natural iron.

BASE PERCENTAGES, PRICES, AND IRON UNIT VALUES FOR LAKE SUPERIOR ORES, 1911.

| Standard grade. | Natural iron per cent. | Phos. per cent. | Moist. per cent. | Iron dried per cent. | Lake Erie. | Valley. | Base unit value. |
|---|---|---|---|---|---|---|---|
| Old Range-Vermillion Bessemer | 55.00 | .045 | 10 | 61.12 | $4.50 | $5.10 | $0.0927273 |
| Mesabi Bessemer | 55.00 | .045 | 10 | 61.12 | 4.25 | 4.85 | 0.0881818 |
| Old Range-Vermillion Non-Bessemer | 51.50 | ..... | 12 | 58.52 | 3.70 | 4.30 | 0.0834951 |
| Mesabi Non-Bessemer | 51.50 | ..... | 12 | 58.52 | 3.50 | 4.10 | 0.0796116 |

The above table forms the basis for determining the prices of super standard and sub standard grades. The *iron unit value* in each grade fluctuates upward for each additional percent of natural iron and for Bessemer ores each decrease of .001% of phosphorous and downward for each decrease of 1% of natural iron and for Bessemer ores each increase of .001% of phosphorous.

The method for figuring premiums and penalties on Michigan ores, as illustrated in the Iron Trade Review[6] is as follows:

[6]Volume XLVIII, pp. 495-498. March 9, 1911.



BESSEMER ORES.

"To arrive at the value in figuring old range Bessemer ores varying from the base of 55 per cent iron natural to 50 per cent iron natural, there should be allowed from the base price for each unit under 55 per cent iron natural down to 50 per cent iron natural, the value of the base unit.

Mesabi Bessemer ores are figured in exactly the same way as old range Bessemer ores. In the case of both Mesabi and the old range Bessemeres, to better compensate the furnace-men on ores when running under 50 per cent iron natural, in addition to the value that would be arrived at on an ore running 50 per cent iron natural, there should be allowed for the unit of iron from 49 per cent to 50 per cent iron natural, the base unit value plus 50 per cent, and for the unit 48 per cent to 49 per cent, the allowance should be the base unit value of the ore plus 100 per cent.

The phosphorous adjustment should be made as per accompanying table. On Bessemer old range ores running above 55 per cent iron natural and up to 60 per cent iron natural, the value is arrived at as follows:

METHOD OF FIGURING PENALTIES AND PREMIUMS ON OLD RANGE BESSEMER ORES. VALUE OF UNIT OF IRON. (INCREASE OR DECREASE) BETWEEN POINTS SHOWN ONLY. BASE UNIT, $0.10182.

| For penalty. | Value. |
|---|---|
| Per cent natural iron: | |
| 48 to 49 | $0.20364 |
| 49 to 50 | 0.15273 |
| 50 to 51 | 0.10182 |
| 51 to 52 | 0.10182 |
| 52 to 53 | 0.10182 |
| 53 to 54 | 0.10182 |
| 54 to 55 | 0.10182 |
| For premium. | |
| 55 to 56 | 0.11182 |
| 56 to 57 | 0.12182 |
| 57 to 58 | 0.13182 |
| 58 to 59 | 0.14182 |
| 59 to 60 | 0.15182 |
| 60 to 61 | 0.10182 |
| For each succeeding unit beyond 60 per cent | 0.10182 |

For the value of the unit:

| Per cent. | Cents. |
|---|---|
| 55 to 56—Add base unit value plus | 1 |
| 56 to 57—Add base unit value plus | 2. |
| 57 to 58—Add base unit value plus | 3. |
| 58 to 59—Add base unit value plus | 4. |
| 59 to 60—Add base unit value plus | 5. |

Thus adding a premium of 15 cents per ton on ore running as high as 60 per cent and above in the iron natural condition. For each unit above 60 per cent iron natural, add simply the value of the base unit.

The method of figuring penalties and premiums may be illustrated in the following example on old range Bessemer ores running over and under the base ore of 55 per cent iron natural:

| | |
|---|---|
| Value of base ore 55 per cent iron natural and 0.045 per cent phosphorous at 212 degrees Fahr. | $5.00 |
| Descending scale—Ore guaranteed 48 per cent iron natural figured as follows: | |
| Per cent. | Cents. |
| 55 to 50 equals five units at $0.10182 | $0.5091 |
| 50 to 49 equals one unit at $0.10182 plus 50 per cent | 0.15273 |
| 49 to 48 equals one unit at $0.10182 plus 100 per cent | 0.20364 |
| Deduct penalty | 0.86547 |
| Value of 48 per cent iron natural | $4.13 |
| Value of base ore 55 per cent iron natural and 0.045 per cent phosphorous at 212 degrees Fahr. | $5.00 |
| Ascending scale—Ore guaranteed at 61 per cent iron natural, figured as follows: | |
| Per cent. Cents. | |
| 55 to 56 equals one unit at $0.10182 plus 1 | $0.11182 |
| 56 to 57 equals one unit at 0.10182 plus 2 | 0.12182 |
| 57 to 58 equals one unit at 0.10182 plus 3 | 0.13182 |
| 58 to 59 equals one unit at 0.10182 plus 4 | 0.14182 |
| 59 to 60 equals one unit at 0.10182 plus 5 | 0.15182 |
| 60 to 61 equals one unit at 0.10182 | 0.10182 |
| Add premium | 0.76092 |
| Value of 61 per cent iron natural | $5.76 |

Any variation in phosphorous from the base of 0.045 per cent, to increase or decrease the value of ores, is figured by the table of phosphorous values.

### NON-BESSEMER ORES.

In figuring the value of non-Bessemer ores, both old range and Mesabi, running from 50 per cent iron natural to 53 per cent iron natural, adjustments are made by addition and subtraction from the base ore at the rate of the base unit for each unit.

METHOD OF FIGURING PENALTIES AND PREMIUMS ON OLD RANGE NON-BESSEMER ORES. VALUE OF UNIT OF IRON. (INCREASE OR DECREASE) BETWEEN POINTS SHOWN ONLY.
Base Unit, $0.0932.

| For penalty. | Value. |
|---|---|
| Per cent natural iron: | |
| 48.00 to 49.00 | $0.1864 |
| 49.00 to 50.00 | 0.1398 |
| 50.00 to 51.00 | 0.0932 |
| 51.00 to 51.50 | 0.0466 |
| For premium. | |
| 51.50 to 52.00 | 0.0466 |
| 52.00 to 53.00 | 0.0932 |
| 53.00 to 54.00 | 0.1032 |
| 54.00 to 55.00 | 0.1132 |
| 55.00 to 56.00 | 0.1232 |
| 56.00 to 57.00 | 0.1332 |
| 57.00 to 58.00 | 0.1432 |
| 58.00 to 59.00 | 0.0932 |
| For each succeeding unit beyond 58.00 per cent | 0.0932 |



In figuring the value of an iron ore running below 50 per cent iron natural, the allowance for the unit between 50 and 49 per cent, should be the base unit plus 50 per cent, and for the unit between 49 and 48 per cent the allowance should be the base unit value of the ore plus 100 per cent.

On ores running over 53 per cent iron natural, there should be added to the base unit:

| Iron ore, per cent. | Cents. |
|---|---|
| 53 to 54—Base unit value plus 1. | |
| 54 to 55—Base unit value plus 2. | |
| 55 to 56—Base unit value plus 3. | |
| 56 to 57—Base unit value plus 4. | |
| 57 to 58—Base unit value plus 5. | |

In this way, adding a premium of 15 cents per ton to all ores running 58 per cent iron natural, or above, and for each unit above 58 per cent iron natural, add the value of the base unit. This method should be used on all ores in adjusting values and penalties down to 48 per cent iron natural condition.

The method of figuring penalties and premiums may be illustrated in the following example on old range non-Bessemer running over and under the base ore of 51.50 per cent iron natural:

| | |
|---|---|
| Value of base ore 51.50 per cent iron natural | $4.20 |
| Descending scale—Ore guaranteed 48 per cent iron natural. | |
| 51.50 to 50.00 equals 1.50 units at $0.0932 plus 50 per cent | $0.1398 |
| 51.50 to 49.00 equals one unit at $0.0932 plus 50 per cent | 0.1398 |
| 49.00 to 48.00 equals one unit at $0.0932 plus 100 per cent | 0.1864 |
| Penalty to deduct from base price | 0.4660 |
| | 0.47 |
| Value of old range Non-Bessemer ore at 48 per cent iron natural | $3.73 |
| Value of base ore, 51.50 per cent iron natural | 4.00 |
| Ascending scale—Ore guaranteed 59 per cent iron natural: | |
| 51.50 to 53.00 equals 1.50 units at $0.0932 | $0.1398 |
| 53.00 to 54.00 equals one unit at $0.0932 plus 1 cent | 0.1032 |
| 54.00 to 55.00 equals one unit at $0.0932 plus 2 cents | 0.1132 |
| 55.00 to 56.00 equals one unit at $0.0932 plus 3 cents | 0.1232 |
| 56.00 to 57.00 equals one unit at $0.0932 plus 4 cents | 0.1332 |
| 57.00 to 58.00 equals one unit at $0.0932 plus 5 cents | 0.1432 |
| 58.00 to 59.00 equals one unit at $0.0932 | 0.0932 |
| Premium to add to base price | 0.8490 |
| | 0.85 |
| Value of old range Non-Bessemer ore at 59 per cent iron natural | $4.85 |

In using the accompanying phosphorous table in figuring Bessemer ores the per cent of phosphorous above or below 0.045, determines the value to be added to or subtracted from the value as determined from the iron content. If, for example, the ore has a phosphorous content of 0.046, 0.0080 is deducted from the value of the base unit. If the ore analyzes 0.044 per cent phosphorous, there must be added 0.0080, and so on, according to phosphorous content, the ore being more valuable for use in the Bessemer process as the phosphorous content decreases."

PHOSPHOROUS TABLE.

| Percentage phosphorous. | Rate of progression. | Phosphorous values. | Percentage phosphorous. | Rate of progression. | Phosphorous values. |
|---|---|---|---|---|---|
| 0.070 | 0.0200 | 0.3500 | 0.037 | 0.0115 | 0.0780 |
| 0.069 | 0.0195 | 0.3300 | 0.036 | 0.0120 | 0.0900 |
| 0.068 | 0.0190 | 0.3105 | 0.035 | 0.0125 | 0.1025 |
| 0.067 | 0.0185 | 0.2915 | 0.034 | 0.0130 | 0.1155 |
| 0.066 | 0.0180 | 0.2730 | 0.033 | 0.0135 | 0.1290 |
| 0.065 | 0.0175 | 0.2550 | 0.032 | 0.0140 | 0.1430 |
| 0.064 | 0.0170 | 0.2375 | 0.031 | 0.0145 | 0.1575 |
| 0.063 | 0.0165 | 0.2205 | 0.030 | 0.0150 | 0.1725 |
| 0.062 | 0.0160 | 0.2040 | 0.029 | 0.0155 | 0.1880 |
| 0.061 | 0.0155 | 0.1880 | 0.028 | 0.0160 | 0.2040 |
| 0.060 | 0.0150 | 0.1725 | 0.027 | 0.0165 | 0.2205 |
| 0.059 | 0.0145 | 0.1575 | 0.026 | 0.0170 | 0.2375 |
| 0.058 | 0.0140 | 0.1430 | 0.025 | 0.0175 | 0.2550 |
| 0.057 | 0.0135 | 0.1290 | 0.024 | 0.0180 | 0.2730 |
| 0.056 | 0.0130 | 0.1155 | 0.023 | 0.1085 | 0.2915 |
| 0.055 | 0.0125 | 0.1025 | 0.022 | 0.0190 | 0.3105 |
| 0.054 | 0.0120 | 0.0900 | 0.021 | 0.0195 | 0.3300 |
| 0.053 | 0.0115 | 0.0780 | 0.020 | 0.0200 | 0.3500 |
| 0.052 | 0.0110 | 0.0665 | 0.019 | 0.0205 | 0.3705 |
| 0.051 | 0.0105 | 0.0555 | 0.018 | 0.0210 | 0.3915 |
| 0.050 | 0.0100 | 0.0450 | 0.017 | 0.0215 | 0.4130 |
| 0.049 | 0.0095 | 0.0350 | 0.016 | 0.0220 | 0.4350 |
| 0.048 | 0.0090 | 0.0255 | 0.015 | 0.0225 | 0.4575 |
| 0.047 | 0.0085 | 0.0165 | 0.014 | 0.0230 | 0.4805 |
| 0.046 | 0.0080 | 0.0080 | 0.013 | 0.0235 | 0.5040 |
| **0.045** | **0.0000** | **0.0000** | 0.012 | 0.0240 | 0.5280 |
| 0.044 | 0.0080 | 0.0080 | 0.011 | 0.0245 | 0.5525 |
| 0.043 | 0.0085 | 0.0165 | 0.010 | 0.0250 | 0.5775 |
| 0.042 | 0.0090 | 0.0255 | 0.009 | 0.0255 | 0.6030 |
| 0.041 | 0.0095 | 0.0350 | 0.008 | 0.0260 | 0.6290 |
| 0.040 | 0.0100 | 0.0450 | 0.007 | 0.0265 | 0.6555 |
| 0.039 | 0.0105 | 0.0555 | 0.006 | 0.0270 | 0.6825 |
| 0.038 | 0.0110 | 0.0665 | 0.005 | 0.0275 | 0.7100 |

## TRANSPORTATION.

Compared with other producing districts Michigan ore lies far from the main centers of smelting, manufacture and distribution. This disadvantage is more than offset by the richness of the ores. In the Lake Superior region Michigan enjoys over Minnesota the advantage of shorter rail and boat hauls and consequent lower freight rates.

The movement of ore to furnace is accomplished in three stages (1) mine to dock (2) lake haul (3) dock to furnace.

*Mine to dock:* At the mines the ore is loaded during the lake shipping season in part from pocket by gravity directly into hopper bottom or saddle back cars of 25 to 50 tons capacity and in part by steam shovel from stock pile. During the winter season the ore is stock-piled. The loading charge is borne by the mining companies. The ore carrying railroads, of the Lake Superior Region with, distances, rates, etc., appear in the following table.[7] The Michigan tonnage is carried by independent roads, with the exception of the Lake Superior and Ishpeming Railway which is controlled by the Cleveland Cliffs and Jones-Laughlin interests.

[7]Mon. 52, U. S. Geological Survey, p. 495.



ORE-CARRYING RAILROADS OF THE LAKE SUPERIOR REGION.

| Railroads. | Ranges supplying traffic. | Principal range shipping points. | Lake termini at which ore docks are located. | Average haul, miles. | Approximate average cost per ton from mine to dock. |
|---|---|---|---|---|---|
| Duluth and Iron Range | Vermilion | Tower, Ely | Two Harbors, Minn | 70–90 | $0.90–$1.00 |
| | Mesabi | Eveleth, Sparta, Biwabik | | 65 | 80 |
| Duluth, Mesabi and Northern | Mesabi | Virginia, Hibbing, Coleraine | Duluth, Minn | 80 | 60 |
| | Mesabi | Virginia, Hibbing, Nashwauk | Superior, Wis | 120 | 80 |
| Great Northern | Gogebic | Hurley, Ironwood, Bessemer, Wakefield | Ashland, Wis | 40 | |
| Chicago and Northwestern | Marquette | Michigamme, Negaunee | Escanaba, Mich | 70 | |
| | Swanzy | Princeton | | 45 | |
| | Menominee | Iron Mountain, Norway | | 45 | 40 |
| | Crystal Falls | Crystal Falls, Amasa | | 80 | |
| | Iron River | Iron River | | 83 | |
| | Florence | Florence | | 63 | |
| Duluth, Shore Shore and Atlantic | Marquette | Ishpeming, Negaunee, Michigamme | Marquette, Mich | 12–15 | .25 |
| | | | | 35 | |
| Lake Superior and Ishpeming | Marquette | Negaunee, Ishpeming | Marquette, Mich | 12–15 | .25 |
| | Swanzy | Gwinn | | 36 | |
| Wisconsin Central | Gogebic | Bessemer, Hurley, Ironwood | Ashland, Wis | 50 | .40 |
| Chicago, Milwaukee and St. Paul | Menominee | Crystal Falls, Iron Mountain | Escanaba, Mich | 40–60 | .40 |

*Ore Loading Docks:* The loaded ore trains move out upon the ore docks where the ore is dropped directly into the dock pockets by opening the car bottoms. "There are many important considerations involved in the construction of the dock. The foundation is frequently 40 feet below water level and consists of a series of piling that cannot have much cross-bracing until the surface of the water is approximately reached. Above the water there is a height of from 60 to 70 feet and on top of this is the enormous moving loads of trains and locomotives, for an average of which 4,000,000 pounds is a low estimate. Air brakes on the trains stop them within a yard or two and consequently there is a pressure of about 2,500,000 foot-pounds to be taken up every time a train stops by the longitudinal bracing of the pier. Added to this is the fact that the center of permanent load may be 93 feet above foundation. The earlier docks were constructed of timber exclusively, but concrete and steel enter largely into the construction of the modern types. As the ships have grown larger and larger the docks have grown higher and higher in order to give the necessary slope to the chutes. Formerly the base of the pockets was only about 20 feet above water. In the more modern docks the hinge hold,

MICHIGAN

| Railroad. | Location. | Dock No. | No. of pockets. | Storage capacity. |
|---|---|---|---|---|
| | | | | Tons. |
| Chicago and Northwestern | Escanaba, Mich | 1 | 184 | 21,143 |
| Chicago and Northwestern | Escanaba, Mich | 3 | 226 | 28,792 |
| Chicago and Northwestern | Escanaba, Mich | 4 | 250 | 34,925 |
| Chicago and Northwestern | Escanaba, Mich | 5 | 202 | 29,310 |
| Chicago and Northwestern | Escanaba, Mich | 6 | 320 | 69,760 |
| Chicago and Northwestern | Ashland, Wisconsin | 1 | 234 | 42,120 |
| Chicago and Northwestern | Ashland, Wisconsin | 2 | 234 | 42,120 |
| | | | 1,650 | 268,170 |
| Duluth, South Shore and Atlantic | Marquette, Mich | 4 | 200 | 28,000 |
| Duluth, South Shore and Atlantic | Marquette, Mich | 5 | 200 | 50,000 |
| | | | 400 | 78,000 |
| Lake Superior and Ishpeming | Marquette, Mich | 4 | 200 | 36,000 |
| Chicago, Milwaukee and St. Paul | Escanaba, Mich | 2[2] | 200 | 50,000 |
| Chicago, Milwaukee and St. Paul | Escanaba, Mich | 1 | 240 | 50,400 |
| | | 2 | 240 | 63,500 |
| | | | 480 | 113,900 |

[1]From outside to outside of semicircular bay.
[2]New dock will be in commission in 1912.



however, is 40 feet or more, above the water level."[8] The ore pockets of the loading docks are spaced 12 feet centers. This corresponds to the spacing of the hatches on some modern boats enabling a cargo to be taken by them without a shifting of position. Previous to 1902 the type ore freighter had hatches spaced at 24 feet centers.

The problem of unloading involves rapid manipulation of trains and shunting of cars to maintain definite fixed composition of the ore in individual pockets. The ore runs from the pockets of the dock directly into the hatches of the freighters. The cost of handling the ore from train to boat aggregates four cents per ton.[9] The boats are loaded with surprising rapidity. On Oct. 10th, 1909 at Two Harbors, Minnesota, the steamer William E. Corey loaded 10,111 gross tons of ore in 39 minutes.[10] The storage capacity of the docks is small compared to the tonnage which annually passes through them.

The location and capacities of the loading docks handling Michigan ore is given in table below.

[8]Ralph D. Williams in Iron Trade Review. April 27, 1911.
[9]Monograph 52 U. S. Geological Survey, p. 496.
[10]R. D. Williams in Iron Trade Review, April 27, 1911.

ORE DOCKS.[3]

| Height from water to center hinge hole. | | Height from water to deck of dock. | | Width of dock from outside to outside of partition. posts. | | Length of spouts. | | Length of dock. | Angle of pockets. | | Capacity per pocket to bottom of stringers. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ft. | In. | Ft. | In. | Ft. | In. | Ft. | In. | Feet. | Deg. | Min. | Cubic Ft. |
| 28 | 10 | 48 | 6 | 37 | | 21 | | 1,104 | 39 | 30 | 1,918 |
| 31 | 2 | 52 | 8 | 37 | | 27 | | 1,356 | 45 | | 1,969 |
| 36 | 6 | 59 | 2 | 37 | | 30 | | 1,500 | 45 | | 2,191 |
| 28 | 6 | 53 | 3 | 37 | | 21 | 8 | 1,212 | 40 | | 2,832 |
| 40 | | 70 | | 50 | 2 | 30 | | 1,920 | 45 | | 4,114 |
| 40 | | 70 | | 50 | 2 | 30 | | 1,404 | 45 | | 3,915 |
| 40 | | 70 | | 50 | 2 | 30 | | 1,404 | 45 | | 3,915 |
| 27 | 9 | 47 | 3 | 36 | 8 | 21 | 1 | 1,200 | 39 | 45 | 1,839 |
| 40 | | 70 | 10 | 51 | | 32 | 4 | 1,236 | 45 | | 3,848 |
| 30 | 9 | 54 | | 50 | | 27 | 7 | 1,232 | 38 | 40 | 2,713 |
| 43 | | 75 | | 54[1] | | 35 | | 1,200 | 45 | | 4,546 |
| 40 | 2¾ | 66 | 6 | 52 | | 120 | 27 | 1,500 | 45 | | 2,900 |
| 40 | 11½ | 69 | 2 | 54 | | 30 | 4½ | 1,500 | 45 | | 3,150 |

[3]From Mon. 52, U. S. Geological Survey except data on Lake Superior and Ishpeming Ry., new dock No. 2 which was submitted by the owners.

*The Lake Haul:* From the loading docks the ore is carried in bulk freighters to lower lake ports. The first shipment was billed by the Hon. Peter White of Marquette in 1852 and comprised five barrels of ore. Since that time the size of cargo has increased by leaps and bounds with the deepening and widening of the Soo locks and growth of capacity of lake freighters. The largest cargo in 1856 was 400 tons; in 1866, 697 tons; in 1876, 1,360 tons, in 1886, 2,450 tons; in 1895, 3,843 tons, in 1900, 7,450 tons and in 1910, 13,410 tons.[11]

*Unloading Docks:* The cost of unloading at the lower lake ports is borne by the vessels out of freight earnings. The unloading charge in 1910, was 15 cents per ton. Williams states that the actual cost with clam shell buckets is less than 5 cents per ton.[12]

*Dock to Furnace:* From the unloading docks the ore is distributed by rail haul to the furnaces. The freight rates to principal smelting centers as compiled by the Pittsburgh Chamber of Commerce are given below.[13]

| | Average distance. | Average rate per gross ton. | Average rate per ton per mile in mills. |
|---|---|---|---|
| Pittsburgh district | 160 | 0.96 | 6.0 |
| M. & S. valleys | 81 | 0.56 | 7.1 |
| Ashland, Ky | 256 | 0.90 | 3.5 |
| Bellaire, O | 167 | 0.60 | 3.6 |
| Columbus, O | 124 | 0.50 | 4.0 |
| Jackson, O | 219 | 0.62½ | 2.9 |
| Josephine, Pa | 228 | 0.85 | 3.7 |
| Max Meadow, Va | 537 | 1.55 | 2.9 |
| Midland, Pa | 115 | 0.78 | 6.8 |
| Punxsutawney, Pa | 181 | 0.60 | 3.3 |
| Roanoke, Va | 550 | 1.55 | 2.8 |
| So. Bethlehem, Pa | 353 | 1.45 | 4.1 |
| Wellston, O | 208 | 0.62½ | 3.0 |
| Wheeling, W. Va | 164 | 0.60 | 3.7 |
| Johnstown, Pa | 224 | 1.16 | 5.2 |
| Ironton, O | 251 | 0.90 | 3.6 |
| Zanesville, O | 146 | 0.55 | 3.8 |
| Philadelphia, Pa | 422 | 1.45 | 3.4 |
| Sparrows Point, Md | 470 | 1.50 | 3.2 |
| Wilmington, Del | 471 | 1.45 | 3.1 |

TOTAL COST OF TRANSPORTATION.

The average rate per ton mile of moving iron ore on the Great Lakes is stated by Williams to have been .7 mill in 1909. For the same year the corresponding figure for freight transportation on

[11]Crowell & Murray. The Iron Ores of Lake Superior, 1910, p. 23.
[12]Ralph D. Williams in Iron Trade Review, April 27, 1911.
[13]Iron Trade Review, January 18, 1912.



the Lake Shore Ry. is 5.16 mills. In 1907 the average cost per ton of transporting Lake Superior ore to the furnaces was $2.14.[14] Annual Lake Erie prices and rail and boat freight rates from Michigan ranges from 1855 to 1911 are given in a subsequent table.

IRON ORE ANALYSES.

Iron ore is bought and sold mainly on the basis of chemical composition. Each cargo is sampled and analyzed at the mine and the mine analyses are checked by the furnacemen or buyers. In order to insure uniformity of results standard methods of sampling and analyses have been developed.

The ore is first dried at 100° C. (212° F.) to expel the uncombined moisture. This insures uniformity of physical and chemical composition at both ends of the haul. When the ore is charged into the furnace, however, it contains more or less uncombined moisture making necessary the calculation from the "dry" analysis the "natural" analysis for the use of the furnacemen. All ore analyses are carefully recorded and average cargo analyses by mines are annually published by the Lake Superior Iron Ore Association.

The accuracy of the sampling and analyses is illustrated by check figures on mine and furnace analyses on 21,030,909 tons of ore by the Oliver Mining Company in 1909.[15] The figures are given below.

| | Iron. | Phos. | Silica. | Moisture. |
|---|---|---|---|---|
| Ave. Mine Analyses..... | 59.19 | .068 | 6.38 | 12.22 |
| Ave. Furnace Analyses... | 59.04 | .068 | 6.66 | 12.33 |

STANDARD CARGO SAMPLING METHOD.

The following is a description of the Sampling Method employed by the Independent Chemists of Cleveland.[16]

A continuous sample shall be taken from all cargoes, the weight of the sample varying with the size of the cargo.

This sample shall be taken with a galvanized iron scoop 3½" wide, 2¼" long and 1¼" deep, the handle 8" long; and with a hammer 12" long (the scoop holds approximately ½ pound).

It shall be the aim to take an equal bulk of ore from every point selected. When a lump is encountered a portion shall be broken off equal in bulk to a scoopful of soft ore. In sampling cargoes no sample shall be taken from the original outside surfaces on account of the presence of foreign matter and an undue proportion of fines.

[14]Mon. 52, U. S. Geological Survey, p. 497.
[15]Mon. 52 U. S. Geological Survey, p. 498.
[16]Quoted from Crowell & Murray, The Iron Ores of the Lake Superior Region, 1910, p. 29-32.

SAMPLING OF SOFT ORE.

The sampler shall enter any hatch and begin sampling when the unloading machines have exposed five or six feet of the face.

In order to keep the size of samples within reasonable bounds and to gauge this size to the size of the boat, the sampler shall on cargoes up to 3,500 tons, begin sampling at a convenient point at the bottom of the face of the ore, and shall take one standard scoopful every two scoop lengths up the face of the ore to the top, and then shall move four scoop lengths to one side of the starting point before again sampling vertically. He shall continue in this manner keeping the above distances around the face of the ore to the place of beginning.

On cargoes from 3,500 to 6,000 tons, he shall use the two scoop lengths for vertical distances up the face of the ore, but move six scoop lengths horizontally.

On cargoes over 6,000 tons, he shall use the two scoop lengths for vertical distances up the face of the ore, but move eight scoop lengths horizontally.

The sampler shall then enter the next hatch working, and proceed to sample in the very same way, and so continue in every hatch.

The sampler shall then begin over again in the hatch in which he first started and continue the sampling in all the hatches provided there has been sufficient ore removed in the hatches since the faces were sampled to expose fresh ore.

The sampler shall continue this method of sampling in each hatch worked, until there is less than one-tenth of the ore left.

In sampling horizontal surfaces, as in boats where scrapers are used, the sampler shall sample every two scoop lengths lengthwise of the boat, the spaces between the lines of sampling to be 4-6-8 scoop lengths, according to the tonnage as described before.

SAMPLING OF HARD ORE.

In sampling hard lump ore the sampler shall begin sampling, and use the same spacing as defined for soft ore, using hammer lengths instead of scoop lengths. At each point sampled he shall take lump or fine ore equal to one cubic inch. In taking this cubic inch, the sampler shall take an average from the lump from which the cubic inch is broken.

MOISTURE SAMPLE.

The moisture sample shall be taken from the standard sample in the following manner:

When as many cans of ore have been filled as the stage of unloading will permit, the lump ore shall be broken up and the entire amount of ore so far taken shall be mixed and quartered twice, and from the last quarters to be rejected one scoopful for each can in the original sample shall be put into the moisture can, provided the total number of scoopfuls taken will produce a moisture sample weighing about 20 lbs. In case a moisture sample of such weight is not produced, the sampler shall take two or more scoopfuls per can from the rejected quarters, enough to produce about 20 lbs.



The moisture sample shall at once be placed in a standard moisture can with tightly fitted cover. This shall be accurately weighed, dried at 100° C. until the weight is constant. The loss in weight will represent the moisture in the cargo.

At certain unloading points, it is desired of the consignee of the ore, that the entire sample shall be dried and crushed before any quartering is done. At such unloading points the moisture sample shall be taken as follows:

The sample shall take one round from each hatch when it is one-half unloaded, three scoop lengths vertically and twelve scoop lengths horizontally, taking only ore from fresh surfaces which have not been exposed to sun or rain. It must be thoroughly mixed at once without breaking down, and 20 lbs. placed in a standard moisture can.

Whenever it is not practical to hold the entire sample until the close of the sampling, before mixing and quartering, it may be quartered at convenient stages of the sampling. This must be done each time exactly alike, by breaking down to one-half inch, mixing and quartering twice, thus preserving the proper proportion of the whole sample.

If in the final quartering the last two quarters exceed a can full, the ore shall be quartered again and one quarter rejected.

The sample may be quartered on the vessel, or may be taken to some other place suitable for that purpose. Samples must be shipped to the crushing plant in standard cans.

CAR SAMPLING.

Not less than ten equal sized samples are taken from each car. When cars are loaded with fine ore with piles in opposite ends, at least five samples are taken from each pile; the first one at the apex of the pile, and the other four at points symmetrically arranged around the sides of the pile, two-thirds of the distance from the apex to the base of the pile or sides of the car. With cars loaded in the center, the system is the same, except that the center of the side of the pile lengthwise of the car, is the first point and the other four being symmetrically arranged around this point.

When the ten points are located in a car, each of them is supposed to represent a definite area, equal to one-tenth of the ore surface of the car. If the car contains all fine ore, then ten equal sized samples are taken, one from each of the points. If the car contains a mixture of fine and lump ore, with varying amounts of each in the areas included in the different divisions, then each area is judged separately and stamped accordingly. The fine and lump ore are taken each in its proper proportions, the former with the scoop, the latter being chipped, or selected small pieces being taken, each about the size of the first joint of the thumb. The combined sample of fine, shipped and selected pieces from each area, equals the amount taken were it all fine ore. If the contents of the car were all lump ore, the proper sized pieces were chipped from four or five of the lumps in each of the ten areas, making forty or fifty pieces from each car, the total amount of the chipped pieces from each of the areas equalling the amount that would be taken were it all fine ore. All samples of fine ore are taken from well underneath the surface to obtain the ore in its natural state.

This method is based primarily on the assumption that a small representative portion of the ore taken from a large number of places in different parts of the cargo, will necessarily show the average composition of the cargo. Each year the Lake Superior ores are being more and more mixed, to establish certain grades. This mixture starts in the pockets of the loading docks, is continued as the various pockets are loaded in the boat, and further mixed as the ore is unloaded from the boat into cars or in stock pile, and again mixed as the ore is unloaded at its destination. It is in the case of the more or less mixed ores that the present standard method is particularly applicable. The Independent Chemists fully realize the importance of the sampling, and are ever ready to consider suggestions, whereby the present method may be improved.



# CHAPTER III.

## RECENT DEVELOPMENTS ON THE IRON RANGES.

With the exception of the Menominee, Calumet and Felch Mountain districts where exploration has been less active, recent development work on the Michigan iron ranges has in recent years added enormously to the available reserve iron ore tonnage. Some of the older mines have been rejuvenated by discovery of ore bodies at great depth and many new mines have been opened. Deep exploration, particularly in the Gogebic and Marquette districts has shown the existence of valuable large ore bodies and has removed the apprehension prevalent among many a few years ago regarding a possible general failure of the iron ore bodies to extend below moderate depths.

The Crystal Falls and Iron River districts, producers of non-Bessemer ore[1], have enjoyed several successive years of active exploration. The recent activity in these districts is due to the relative increase in consumption of non-Bessemer ore, to competition for reserves mainly among the independent producers of ore and iron products and to the existence in these districts of relatively large areas of unexplored ore-bearing formations under lands owned by a large number of small holders. The depression in the iron industry in 1911 had little effect on exploration in these districts.

In the following paragraphs there is briefly outlined recent progress in exploration and development on the different ranges.

### MENOMINEE RANGE.

In common reference the Menominee Range includes the Menominee, Crystal Falls, Iron River, Calumet and Felch Mountain (Metropolitan) districts in Michigan and the Florence district of Wisconsin. The location of these districts and their relations are shown in Fig. 5.

### MENOMINEE DISTRICT.

*Opening of the District:* "The opening of the Menominee range may be stated as being in 1870, when the first logs were cut, and

[1]The Mansfield Mine produces Bessemer ore.

floated down the Menominee river in 1871. Also in 1871, John L. Buel in company with John Armstrong made the first reported discovery of iron ore, and in 1872 the first exploring party entered this region under the guidance of Dr. N. P. Hulst, representing the Milwaukee Iron Co. In 1873 the discovery made by Buell and Armstrong was explored and developed. In 1874 fifty-five tons of this ore was hauled to Menominee and smelted, the results being most satisfactory and gratifying. The first mining of iron ore and its smelting was followed by numerous explorations and the rapid development of mines."[2] Shipments began in 1877 from the Breen and Vulcan mines over the Menominee River Railroad (Chicago and Northwestern Ry.) which reached the village of Quinnesec in this year and was extended to Iron Mountain in 1880. The district is served by the Chicago and Northwestern, the Chicago, Milwaukee and St. Paul and the Wisconsin and Michigan Railroads.

RECENT DEVELOPMENTS. WATER POWER, ETC.

*The relation between the Hanbury slate and Quinnesec Schist:* The true relations between the Quinnesec schist (effusive schistose greenstone) which occurs along the Menominee river and the Hanbury slates immediately adjacent to them on the north has long been a matter of doubt among geologists. W. S. Bayley concluded[3] that the Quinnesec schist is of Archean age and hence older and below the Hanbury slate. The contact between the two formations is not exposed in the Menominee district. If the Quinnesec schist is Archean, the occurrence of the Huronian formations along its northern edge is just short of a geological necessity, since under this view it is a legitimate inference that the schists are brought up on an anticlinal fold from the crest of which the Huronian series, which are developed in great thickness two to three miles north, have been eroded but should appear, in consequence of the structure, on the northern limb of the fold. The economic application of this theory consists in the possibility of the reappearance of the Vulcan iron-bearing member between the southern limits of the Hanbury slate and the Quinnesec schists.

Recent work, mainly by W. O. Hotchkiss,[4] in the Florence district of Wisconsin, has shown that the Quinnesec schists of that district, which are really continuous with the same formation of the southern part of the Menominee district, *overlie* the youngest

[2]Thomas Conlin and P. O'Brien. Lake Sup. Min. Inst. Vol. 16, p. 7, 1911. See also Proceedings of the Lake Sup. Inst. Min. Eng. for 1905.
[3]Monograph 46 U. S. Geological Survey.
[4]State Geologist of Wisconsin.



Huronian rocks, and are probably of late Upper Huronian age. The acceptance of this view clears up the question entirely and relieves us of the awkward necessity of explaining under the former theory why the Vulcan formation does not reappear, somewhere between the Hanbury slate and the Quinnesec schists. Exploration has not yet proved or disproved the absence of the Vulcan formation here, the reluctance of mining interests to undertake such exploration reflecting a disbelief in the probability of its occurrence. In the light of present information such disbelief is well founded.

*Exploration in the Hanbury Slate.* Some exploration has been done in the Hanbury slate none of which, however, has given encouragement for further work. Most of the formation is drift covered but enough is known to establish the fact that within it are beds of slaty siliceous iron carbonate and some ferruginous chert. The occurrence of ore bodies in the Hanbury formation is therefore a possibility, although not at present in the least degree an alluring one.

*Water Power:* The Menominee district possess an asset in the water powers of the Menominee river which bids fair to be in the future vigorously utilized. For many years a great compressor plant has been in operation at the Upper Quinnesec falls from which compressed air is conducted to the Chapin mine at Iron Mountain. The Sturgeon Falls is utilized by the Penn Iron Mining Co. in generating electric power which has displaced steam almost entirely for mine power.

The latest power project is that of the Peninsula Power Co., begun in 1911 at Twin Falls in Sec. 12, T. 40 N., R. 31 W. The dam is located at the lower fall and will develop a head of 42 feet, raising the water to a depth of 12½ feet over the rock sill of the upper fall. The plant is designed to generate 5,000 electrical H. P. which will be distributed over transmission lines to all of the mining districts in the Menominee ranges. The plant will be operated on the customs plan and the power sold to mines tributary to the various transmission lines.

### ORE RESERVES.

The ore reserves of the Menominee district reported by Mr. J. R. Finlay to the Michigan State Tax Commission are given below.

ORE RESERVES. MENOMINEE DISTRICT. 1911.

| Mine. | Reported in sight above bottom level. | Total tonnage expected by J. R. Finlay. |
|---|---|---|
| Cyclops, Norway, E. & W. Vulcan, Curry, Brier Hill | 1,537,245 | 3,800,000 |
| Pewabic | 1,233,000 | 1,233,000 |
| Loretto | 1,107,424 | 2,000,000 |
| Chapin | 4,194,679 | 9,000,000 |
| Aragon | 1,085,000 | 1,800,000 |
| Millie | 20,000 | 400,000 |
| Breen | ..... | ..... |
| Vivian | ..... | ..... |
| Quinnesec | ..... | ..... |
| Munro[5] | 423,074 | ..... |
| | 9,600,422 | 18,233,000 |

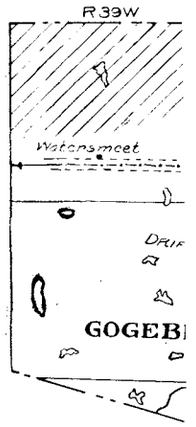
[5]Ores are low grade. Not included in reserve tonnage estimate.

In contrast to the conditions in the Crystal Falls district and particularly the Iron River district the reserve tonnage is all in mines which have been producers for many years. The possibilities for opening new mines in the Menominee district are not, however, by any means exhausted.

### CALUMET TROUGH.

*Location and Extent:* The Calumet trough is a synclinorium of Huronian sediments lying north of the Menominee district and trending in a general E-W direction through T. 41 N., Rs. 27, 28, 29 and 30 W. On the east the trough is lost beneath a covering of Paleozoic rocks and on the west it merges with the Menominee and Florence districts. (Fig. 5.)

*The Iron (Vulcan) Formation. Distribution and Occurrences:* The iron formation of the Calumet trough has been traced mainly by magnetic methods. (Fig. 6.) Natural exposures are rare. The formation has been opened at the old Hancock exploration in Sec. 30, T. 41 N., R. 27 W., at the Calumet Mine and vicinity in sections 8 and 9 and in pits and drill holes on Sections 16, 17 and 18, T. 41 N., R. 28 W. and farther east in an old shaft on the N. E. ¼ of the N. W. ¼ of Sec. 15, T. 41 N., R. 29 W. On the east end of the trough in township 40 and 41 N., Rs. 25, 26, and 27 W. are several small magnetic fields (Fig. 7) which indicates the presence of iron formation beneath the horizontal beds of sandstone and limestone which are here of considerable thickness. In the




CALIFORNIA
STATE MINING BUREAU
FERRY BLDG.
SAN FRANCISCO, CALIF.

SKE

DISTRIB

The ore
Finlay to

Cyclops, Nor
Pewabic....
Loretto ....
Chapin.....
Aragon.....

Millie.....
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N. W. part of Section 3, T. 41 N., R. 37 W., a drill hole, put down several years ago, passed through 68 feet of limestone into steeply inclined gray quartzites and hard ferruginous slates, containing many streaks and then layers of red and gray hematite and magnetite. There is little in this hole to indicate that the formation would repay development.

Outside the Calumet mine, explorations in the Calumet trough have developed no iron formation of promising character.

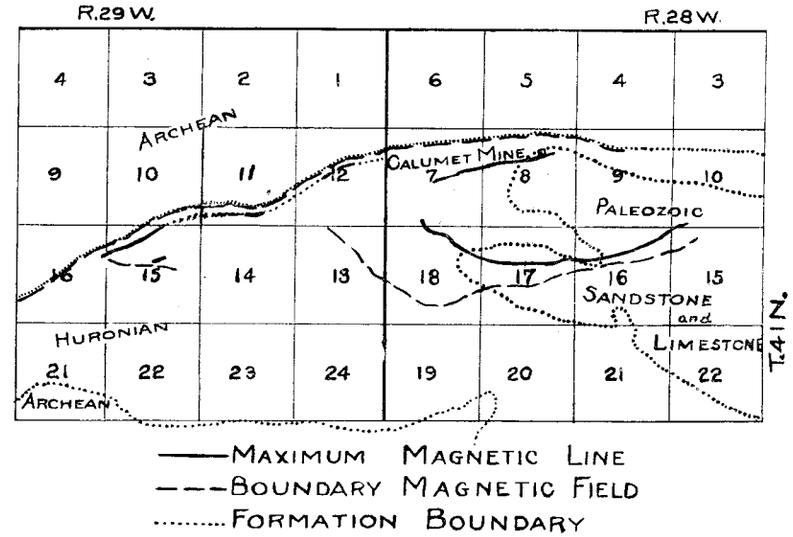


Fig. 6.—Magnetic lines indicating distribution of iron formation. From private surveys by R. C. Allen. Edw. Steidtman and others.

*Calumet Mine:* The strike of the iron formation at the Calumet mine is about N. 80° E, the dip varies from vertical to 80° south. There are three distinct iron bearing beds. The lens farthest north is about 60 feet thick, is overlain to the south by 35 feet of soft iron stained altered slate, 15 feet of iron formation, 15 feet of altered slate, 60 feet of iron formation. The upper iron bearing bed has a hanging wall of black slate. Beneath the iron bearing series lie in order the quartz schist, quartzite (combined thickness 250 feet) and dolomite of the Lower Huronian.

The iron formation consists of banded ferruginous chert and lean iron ore running between 40% and 50% iron. All of the ore in sight is low grade although some small high grade pockets have been mined. The Calumet mine has never been worked actively except at intermittent short periods. It was closed in May, 1910 and has on stock pile about 75,000 tons of 42% ore.

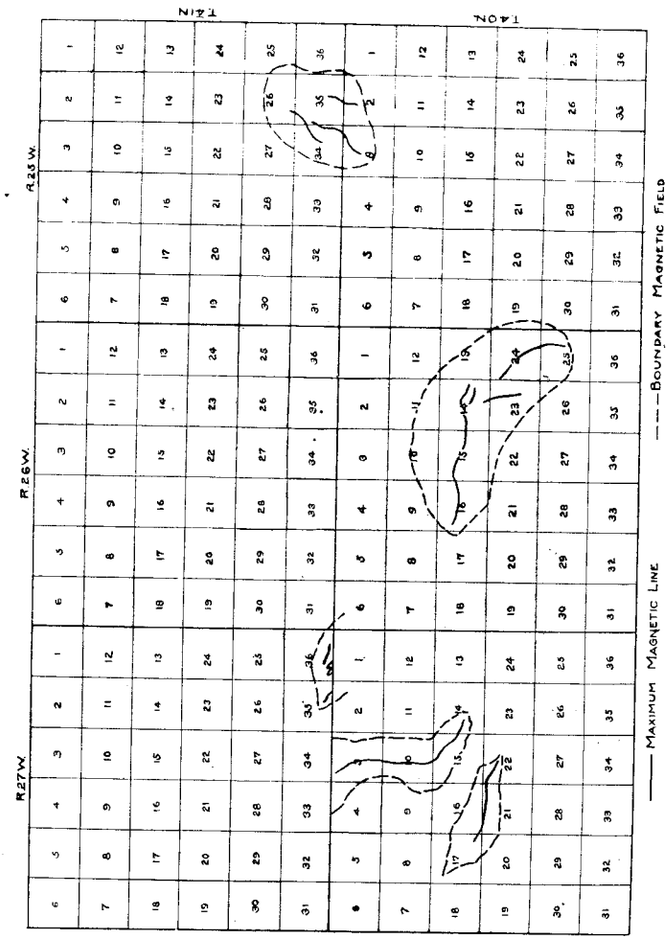


Fig. 7—Magnetic fields in southwest extension of Calumet trough. Compiled from private surveys.

THE METROPOLITAN TROUGH. (FELCH MOUNTAIN DISTRICT.)

The Metropolitan trough is a narrow complex synclinorium of Huronian rocks trending E.-W. through the southern portions of T. 42 N., Rs. 28, 29 and 30 west, thence across the northwest corner of T. 41 N., R. 30 W. into section 12, T. 41 N., R. 31 W. beyond which the structure is lost underneath glacial drift. The synclinorium is some eighteen miles long and varies from a half up to nearly two miles in width.

*Distribution of the Iron (Vulcan) Formation.* "In the Felch Mountain district the Vulcan formation is magnetic and has been



traced by means of compass and dip needle. Excellent natural as well as numerous artificial exposures render the data concerning the distribution of the formation very satisfactory.

On the west the iron-bearing formation is exposed in ledges and test pits in sec. 5, T. 41 N., R. 30 W., from which a line of attraction extends southwestward through sec. 6 into sec. 12, T. 41 N., R. 31 W., where it is lost. The presence of the Vulcan formation through secs. 34, 35, and 36, T. 42 N., R. 30 W., is shown by one principal and other minor lines of attraction, as well as by test pits and outcrops. The principal line of attraction begins in sec. 34, near the southwest corner, and runs to the northeast, in conformity with the strike of the northern belt of dolomite, finally ending in the northeastern portion of sec. 36. This line of attraction is very vigorous and strongly marked. Two other lines, parallel with the principal line but more feeble and much shorter, cross the boundary between secs. 35 and 36. Another line, marking the west end of the Groveland syncline, begins near the center of sec. 36 and continues for 1½ miles eastward to the eastern portion of sec. 31, T. 42 N., R. 29 W. Along the western portion of this line are many test pits and in sec. 31 occur the fine exposures of the Groveland hill.

Another line of attraction begins 400 paces north of the center of sec. 32, T. 42 N., R. 29 W. which may be followed eastward without interruption nearly to the east line of sec. 33 of the same township. Along this line, which is comparatively feeble and crosses wet ground, there are but few test pits. In the eastern part of sec. 33, beyond the point at which the attraction ceases, many pits have been sunk to and into the Felch schist, which is there somewhat ferruginous. From this point eastward for 4 miles the Vulcan formation has not been recognized.

In the northern part of secs. 32 and 33, T. 42 N., R. 28 W., the ferruginous rocks are well exposed on Felch Mountain for nearly a mile along the strike, and may be identified for half a mile farther by the vigorous disturbances produced in the magnetic needles. In the S. E. ¼ sec. 33 the Vulcan formation is again encountered in a small and much disturbed area, in faulted contact with the Archean."[6]

*Groveland Mine:* The only active mine on the Metropolitan range is the Groveland in sec. 31, T. 42, R. 39, operated by the Groveland Mining Co. The mine is developed on three levels to a depth of 275 feet. The ore is hard blue hematite and specular

[6]Monograph 52, U. S. Geological Survey.

hematite of low grade. A forty acre tract adjacent to the Groveland on the east was recently drilled by the Breitung interests. The formation here is of the character shown in the Groveland workings.

### CRYSTAL FALLS DISTRICT.

The opening of the Crystal Falls district dates from the spring of 1882 when shipments began over the Chicago and Northwestern Ry., which was completed from Stager in April of that year. In 1888 a branch was built to Amasa thus affording an outlet for the ore of that vicinity. The Chicago, Milwaukee and St. Paul Ry. was built from Channing to Amasa in 1893, the vicinity of Crystal Falls being served by a spur from Kelso.

As in the Iron River district, ore had been discovered and considerable development work accomplished before the building of the railroad, which came after the prospectors had demonstrated the ore bearing possibilities of the district. The earliest of these prospectors was Mr. "Jack" Armstrong who is credited with the first discovery of ore, the sight being on Lot 3, sec. 20, 43-32.

The production of the district rose steadily to 1892 when 603,048 tons were shipped. This figure was not reattained until 1898 due to slump following the panic of 1893. Since 1898 the production has fluctuated between 1,631,484 tons in 1907 and 629,602 tons the following year.

### THE IRON FORMATION AND ITS OCCURRENCES. RECENT DEVELOPMENTS.

The distribution of the iron (Vulcan) formation is indicated in Fig. 5. The thickness of the formation is not above 300 to 400 feet. As in the Iron River district the iron formation occurs in lenses in the Michigamme slate and at different horizons in the slate and presents therefore precisely similar (but not so great) difficulties to successful structural interpretation. At Amasa and in the vicinity of Crystal Falls, the iron formation is separated from the Hemlock greenstone by small but variable thicknesses of slate and is therefore near the base of the Upper Huronian series.

In the northeastern part of the district a great oval area of Archean and Lower Huronian rocks is almost surrounded by a belt of iron formation. That on the east side of the oval is believed to be of Negaunee age but that on the west is Upper Huronian. Little is known of the character of the Negaunee formation over the greater part of the belt on the west. It was mapped mainly on the basis of a magnetic line but is partially opened in the Sholdice



exploration in the S. E. ¼ of the N. E. ¼ of Section 21, T. 45 N., R. 31 W. On the Sholdice exploration the formation is fine grained, dense banded, hematite and reddish quartz or chert. The hematite bands vary from less than an inch to a few feet in width. The ore thus far shown is too lean for present use.

On the west side of this oval, going southward, the first important exploration is the Red Rock (Channing) on the N. E. ¼ of the S. E. ¼ of Sec. 20, T. 45 N., R. 33 W. The exploration was temporarily abandoned in 1911 by the Verona Mining Co. A shaft, located 180′ east and 125′ north of the center of the S. E. ¼ of the section was sunk 327′. Considerable lean ore was encountered on the first level and on the second level west of the shaft at 228′ from the surface ore was found which, however, did not extend downward to the third level. The strike of the formation is N. E.-S. W.

From the Red Rock the iron formation probably extends at least as far north as the middle of section 16, T. 45, R. 33, from which point south through the Red Rock property and thence into the iron formation at Amasa is a practically continuous magnetic belt.

At Amasa are the Hemlock and Michigan mines. The Hemlock is developed to the fourteenth level at a vertical depth of 1,020 feet. The shaft is in greenstone and is inclined at about 60°. The ore is separated from the greenstone by a slight thickness of slate but at least in one place the iron formation lies directly on the greenstone. The ore in this mine from the 12th level to the surface averaged 15′ to 20′ thick and formed a tabular body striking N. W.-S. E. and dipping S. W. at about 70° with a minor fold on the 6th level throwing the ore about 20′ further west on lower levels. At the 12th level the dip flattened out, the ore maintaining a thickness of about 20′ and pitching at an angle of about 20° northwest through the 13th level down to about the 14th level where it apparently disappears. On the failure or success of efforts to locate a possible extension of the ore body depends the life of the Hemlock mine. The outlook is not at present very encouraging.

The Hemlock ore body has on most levels extended southeast into the Michigan mine of the Oliver Mining Co. The Michigan has been closed for much of the time in recent years and is not being actively worked. About two miles southeast of the Michigan mine is the Gibson Exploration where work has been under way for a number of years by the Rogers-Brown Ore Co. The Gibson is presumably on the same iron bearing horizon as the Hemlock and

Michigan mines but has not developed any considerable tonnage of marketable ore. The pumps were pulled and the mine closed in July, 1911. A considerable tonnage which had accumulated in stock pile was shipped.

Between the Michigan and the Gibson, the iron formation is being explored by the Pickands-Mather interests on Sec. 9, T. 44 N., R. 33 W. The exploration is known as the Warner-Corry. The results of the work here thus far show a formation of promising character.

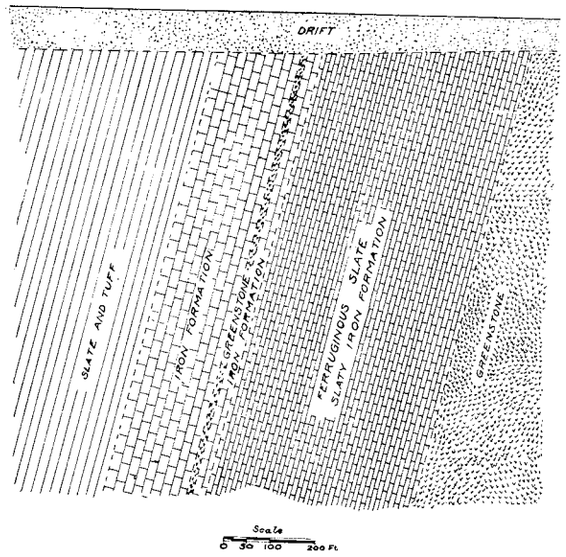


Fig. 8.—Generalized section showing thickness and relations of the iron formation on the Porter-Amasa property. Compiled from plats furnished by the E. J. Longyear Co.

Southeast of the Gibson on the N. E. ¼ of Section 22, T. 44 N., R. 33 W. is the Porter-Amasa exploration owned by the Nevada Land Co. Drilling by the Shenango Furnace Co. demonstrated the presence of iron formation here some years ago. Recent exploration by the E. J. Longyear Co. has revealed an ore body of considerable dimensions, part of it of Bessemer grade. The ore body so far as known from drill records is of tabular shape and steeply inclined to the southwest similar to other deposits on this belt. Steps have not yet been taken to open a mine but it is probable that an ore body of this desirable quality will not long remain unopened.

Southeast of the Porter-Amasa exploration work, has been in



progress by the Rogers-Brown Ore Co. and the St. Clair interests on Sec. 23 and by the Florence Iron Co. on Sec. 36, T. 44 N., R. 33 W. These properties are said to be crossed by a magnetic line and it is thought that the iron bearing horizon of the Hemlock, Michigan, Gibson and Porter properties passes through the section. (Fig. 5) Ore is reported to have been cut on Sec. 26 to the N. W. and also on Sec. 6, T. 43, R. 32, adjacent on the S. E.

Still farther southeast in the northern part of Sec. 14, T. 43 N. R. 32 W. the iron bearing horizon was penetrated in drill holes several years ago. The records of some of these holes are of encouraging character and unite to further exploration.

From Section 14, the iron bearing horizon turns south and passes through the Hollister, McDonald and Armenia mines. The Hollister mine has been developed on mine levels to a depth of 750 feet. The strike of the formations here is 10° E. of south. The workings are all west of the shaft in a steeply westward dipping series of slate and iron formation. East of the shaft about 1,500′ are greenstone outcrops. The Hollister ore runs so high in moisture that experiments have been conducted on drying before shipment. A plant was installed by G. C. Olmstead in the summer of 1911 with capacity of 300 tons per 24 hours. Ore is taken from the skips and, broken through a grizzly, from which it is caught on a Robbins belt conveyor and carried into a hopper feed discharging into an inclined revolving drum heated by stokers. Hot gases are carried through the drum over the ore and out the stack. The ore is received at the low end of the revolving drum by a bucket elevator and delivered to tram cars operated on trestle above stock pile. The Hollister experiments if thoroughly carried out will determine the commercial feasibility of ore drying at the mine. If the saving on freight and ultimately fuel in smelting is greater than the cost of drying the process will be profitable.

South of the Hollister about ¾ mile on the S. E. ¼ of the N. E. ¼ of T. 43 N., R. 32 W. is the McDonald, a new property which has been in course of development by the McDonald Mining Co. for the past four years. The shaft is now 300′ deep and the property is partly developed on three levels. The iron formation is said by Capt. A. E. Drake in charge to measure about 500′ wide, is highly folded and brecciated and lies on a slate foot wall dipping steeply east. The workings lie west of the shaft which is in slate. Some ore is showing on three levels. The bodies thus far opened are irregular small concentrations but the property is only partially explored and its possibilities are not yet tested.

East of the Hollister and McDonald mines, the slate-iron formation series is caught in a deep southward projecting embayment in the Hemlock greenstone. In this embayment is the site of the old Bird exploration. The shaft, 80′ to 100′ deep, is on the S. E. ¼ of the S. E. ¼ of Sec. 13, T. 43 N., R. 32 W. The Bird section is interesting in that it displays on exposure and in an E.-W. trench a short distance north of the shaft the relations between the greenstone and the slate-iron formation series. Beginning on the top of the greenstone belt west of the shaft and proceeding eastward there is exposed in a steeply eastward dipping series:

| | | |
|---|---|---|
| 0-15 | paces. | Six flows of green stone, the top and bottom of each flow showing well develowed amygdaloidal textures. |
| 20-26 | " | Greenstone flow. |
| 26-29 | " | Greenstone flow. |
| 29-34 | " | Greenstone flow. |
| 34-48 | " | Covered. |
| 45-53 | " | Greenstone flow. |
| 53-91 | " | Greenstone flow. |
| 91-106 | " | Lean ferruginous slate. |
| 106-118 | " | Greenstone-jasper conglomerate. |
| 118-135 | " | Iron formation. |
| 135-158 | " | Ferruginous slate. |
| 158- | | Beyond 158 paces a trench continues into a swamp but no rock is showing in the bottom. Across the swamp to the east are greenstone outcrops. |

This succession indicates the conformable relations and interbedding of the greenstone flows and iron formation slate rocks. In some flows there are banded siliceous jaspery stringers following around between the ellipsoids, simulating flow structure. In one instance a stringer of this material is 8 inches wide and 8 feet long passing off the outcrop beneath the drift covering. Some of the jasper bands plainly follow flow lines in the greenstone and are plainly contemporaneous and genetically related in origin to the greenstone. (Compare Porter-Amasa Section, Fig. 8.)

East of the Bird location in the N. W. ¼ of Section 20, T. 43 N., R. 31 W. is the Mansfield mine which has the distinction of being the only producer of Bessemer ore in the Crystal Falls district. The mine is located in a narrow tongue of slate, averaging about a quarter of a mile wide, extending northward 3 miles into the greenstone from sections 31 and 32 into the south edge of sections 7 and 8. The Mansfield ore bearing horizon is from 8 to 15 feet



thick dipping steeply westward between slate walls. The mine is developed to a depth of 1,390 feet.

About ¼ mile south of the McDonald is the Armenia mine on the N. E. ¼ of the S. E. ¼ of Section 23, T. 42 N., R. 32 W., operated by Corrigan-McKinney Co. The mine is developed to the seventh level at a depth of 690 feet. From the Armenia it is about ¾ mile slightly east of south to the old Lee Peck exploration. From the vicinity of the Lee Peck the iron bearing horizon probably extends a little south of east through the old Hope exploration, which is in promising looking iron formation, and thence on about the same course through the old May exploration in the S. E. ¼ of the S. E. ¼ of Section 28, and thence east through the Kimball mine on the S. E. ¼ of the S. E. ¼ of Sec. 29, a low grade property controlled by Corrigan, McKinney Co. which has been idle for a number of years.

From the Kimball it is about 2 miles slightly south of east through the old Shaefer mine to the Tobin mine and the iron formation, from all available structural data, if continuous, should cross the intervening area. The Tobin is developed to the eleventh level at 1,100 feet depth. Development is in progress on the twelfth level 125 feet lower.

One of the most important explorations of the year 1911 is that in progress by the M. A. Hanna Co. just south of the Tobin on Sec. 31, T. 43 N., R. 32 W., lying between the Tobin mine on the north and the Dunn on the south. The property is known as the Monongahela-Carpenter. The results of over a year's drilling has shown up a considerable tonnage of ore of good grade and the Monongahela-Carpenter bids fair to become one of the large mines of the district.

South of the Monongahela in the N. E. ¼ of Sec. 1, T. 42 N., R. 33 W., is the Dunn mine the deepest and one of the oldest mines in the district. It is opened to the 11th level at a depth of 1,420 feet. The reserves in the mine are approaching exhaustion and its continued operation will depend on opening new tonnage which is considered by the management not likely to occur.

From the Dunn the trend of the iron formation continues southward through the South Dunn exploration on the N. E. ¼ of the S. E. ¼ of Section 1, T. 42 N., R. 33 W. Exploration was conducted here in 1908 by the Munroe Iron Mining Co. A shaft was sunk and considerable underground work was done which on the whole seemed not to yield satisfactory results and the exploration was abandoned. The best ore was encountered south of the shaft

in a drift from the 175 foot level which passed through forty feet averaging about 60% in iron, non-Bessemer. Although the formation is twisted and contorted, the general strike is probably about south. In this general direction a local magnetic field occurs on the N.-S. quarter line of the section about ¾ mile from the south Dunn shaft.

Still farther south in sections 12, 13 and 14 is the Alpha-Mastodon-Delphic area. This area which has not produced for many years has been rejuvenated by recent exploratory work of the Nevada Land Co. Drilling was conducted for over two years on the old Alpha location (S. W. ¼ of S. W. ¼ of Sec. 12, T. 42 N., R. 33 W.) and the vicinity of the workings thoroughly explored without encouraging result. Proceeding southeastward on the strike of the iron formation with closely spaced drill holes ore was finally located near the south line of the section in a swamp along Mastodon Creek. The ore lies on a gray slate foot wall dipping about 35° S. E., is of high grade non-Bessemer quality and the deposit has already assumed very considerable dimensions. Drilling is still in progress.

Considerable drilling has also been done by the Nevada Land Co. on the old Delphic location (N. W. ¼ of S. E. ¼ of Sec. 24, T. 42 N., R. 33 W.) and is still in progress. The iron formation strikes northeast from the old Delphic pit and has been followed by drilling into the swamp in the northern part of the section. From the Delphic location the general trend of the slate iron formation series continues apparently slightly south of east into Wisconsin.

We have now traced for upwards of 30 miles a practically continuous iron bearing horizon. Along this belt there doubtless remains to be discovered many ore deposits in addition to these now known. Considering the amount of explorable ground on this belt with the character and number of deposits already known it is probably true that its reserves are hardly more than beginning to be known.

North of Crystal Falls is a second productive belt trending from the Ravenna exploration in Sec. 19, T. 43 N., R. 32 W., east through the Bristol and Great Western mines and thence apparently northeast through the Crystal Falls and Hill Top properties into the Victoria exploration in the N. W. ¼ of the N. W. ¼ of Sec. 22. The active mines on this belt are the Bristol and Great Western but the Great Western was practically idle during 1911. This belt is paralled on the north by greenstone to which it bears about the same stratigraphic relation that is exhibited by the Amasa belt discussed above. It is, however, apparently considerably higher up in the slate series.



The Ravenna is a recent exploration of M. A. Hanna & Co. It adjoins the Bristol on the west. Considerable drilling has been done and a shaft put down from which drifting is being done on the first level proving the continuation of the iron formation from the Bristol property. Some ore has been encountered but as yet not in any considerable quantity.

The Bristol Mine (N. E. ¼ of S. E. ¼ of Sec. 19, T. 43 N., R. 32 W.) is developed to a depth of 960 feet. The iron formation strikes E.-W., dips vertical or steeply southward and is about 350′ thick enclosed in black slate walls. In the west end of the mine a black slate wedge appears in the middle of the formation. It is 50′ thick at the hoisting shaft and widens westward. Its thickness is included in that of the iron formation. The ore is now being drawn from a low grade body running 49 to 55% iron and 3% manganese. It lies just south of the open pit and extends downward to the 8th level and below dipping south at a high angle and pitching slightly west. The workings extend to the east line of the property but in this vicinity the ore runs only about 45% iron. The ore in the Bristol mine is apparently not related to slate walls or slate troughs but is simply enriched layers in the iron formation which may occur anywhere in the mine. The phosphorous content of the ore has been about the same throughout the mine but the sulphur content according to Capt. Bjork rises with depth. A new shaft is being sunk in black slate about 360′ N. W. of the hoisting shaft now in use.

Geological conditions very similar to those of the Bristol mine are met with in other properties on this belt including the Great Western.

An important recent development on this belt is that made by Mr. B. F. Neely east of the Great Western mine on the N. E. ¼ of the S. E. ¼ of Section 21, 43 N., 32 W. A large tonnage of ore has been located by drilling on this description but as yet no steps have been taken to mine it. This deposit is considered practically an extension of the Great Western ore body.

From the above location the iron formation extends northward through the Crystal Falls and Hilltop mines which have long been idle into the Victoria exploration (N. W. ¼ of N. W. ¼ of Sec. 22) where it is reported that development work will be resumed in the near future.

ORE RESERVES.

The following is the estimated ore reserves of the district reported by J. R. Finlay to the Michigan State Tax Commission in 1911.

ORE RESERVES, CRYSTAL FALLS DISTRICT, 1911.

| Mine. | Reported in sight above bottom level. | Total tonnage expected by J. R. Finlay. |
|---|---|---|
| Hollister | ..... | ..... |
| Crystal Falls | 42,000 | 500,000 |
| McDonald | 10,000 | ..... |
| Mansfield | 32,000 | 525,000 |
| Fairbanks | ..... | ..... |
| Bristol | 522,000 | 1,500,000 |
| Armenia | 50,300 | 550,000 |
| Great Western | 97,300 | 800,000 |
| Tobin | 135,300 | 1,800,000 |
| Kimball | ..... | ..... |
| Dunn | 67,000 | 117,000 |
| Michigan | 78,000 | 100,000 |
| Hemlock | 125,000 | 180,000 |
| Channing | 75,000 | 75,000 |
| Youngstown | ..... | 40,000 |
| Amasa-Porter | ..... | 330,000 |
| Alpha | ..... | 60,000 |
| Neely | ..... | 587,000 |
| Hill Top | ..... | 10,000 |
| Monongahela-Carpenter | ..... | 320,000 |
| Extension Great Western | ..... | 200,000 |
| | 1,233,900 | 8,054,000 |

From the above estimates it appears that the reserves are equal to about half of the total shipments and that 21 per cent of the reserves are in properties which have not reached the producing stage.

IRON RIVER DISTRICT.

The Iron River district lies north, east, south and west of Iron River the center of industry. The district has no natural well defined geological boundaries, except on the south. The area of mining operations is being constantly extended.

Ore was discovered by Mr. Harvey Mellen, a United States land surveyor on Aug. 8th, 1851, on the west face of Stambaugh hill in Sec. 36, T. 43 N., R. 35 W. The opening of the district dates from the fall of 1882 when the Chicago and Northwestern Ry. reached the district with a spur from Iron River Junction, now Stager. In 1887 this line was completed to Ironwood.

From 1882 to 1893 the only important shippers were the Iron River and Beta mines, the former being on the site of Mr. Mellen's



discovery of 1851. The shipments to 1893 totaled 1,130,444 tons. From 1893 to 1899 practically no mining was done but since the latter date development has gone steadily and in recent years rapidly forward.

Regarding the distribution of the iron formation much is yet to be known because of the general absence of exposures and the necessity of reliance on information furnished by underground exploration. Rapid as has been the exploration of this district in recent years the results are still far from adequate for purposes of general mapping. The areas of known iron formation were mapped by the Michigan Geological Survey in 1909.[7] These areas have been considerably extended by recent work.

DISTRIBUTION OF THE IRON FORMATION.

The known main occurrences of the Vulcan formation may be referred to three different areas, viz., (1) the Jumbo belt just south of Brule river in Florence county, Wisconsin, about 1½ mile east of Saunders; (2) the central producing area of unestablished boundaries; (3) the Morrison Creek belt in Sec. 24, T. 44 N., R. 35 W. and (4) the Atkinson belt, southwest of Atkinson. Exploration has not demonstrated that the Jumbo, Morrison Creek, and Atkinson belts carry important ore bodies. Such exploration as they have received has not been encouraging.

The Vulcan formation of the producing area has a thickness at maximum of 300 to 400 feet. It is nearly everywhere steeply inclined and in consequence its exposures are generally narrow and not greatly in excess of its thickness. From the studies which have been made in this district, I am convinced that the Vulcan formation occurs here in more or less discontinuous lenses in the Michigamme slate. A given horizon which carries in one place slate may in another not far distant carry iron formation and vice versa. This concept has a direct bearing on exploration. In one sense it simplifies the structural problems, which will in time be solved as new data is obtained, and in another sense it complicates the problems. If true, it limits the value of the iron formation as a horizon marker over any but local areas but on the other hand obviates the necessity of introducing great faulting and improbable structures to account for the facts of distribution. These considerations do not, however, complicate the problem of the general structure of the district of which much is known.

[7]Publication 3. Geological Series 2, Mich. Geol. Sur. 1910. Monograph 52, U. S. Geological Survey, 1911.

WESTWARD EXTENSION OF THE IRON RIVER IRON-BEARING SERIES.

In 1910 I called attention[6] to features of general structure which seemed to indicate a westward extension of the iron bearing series of the Iron River district. Mining men have had in mind for some years a possible connection between the Gogebic and Iron River districts. On early general geological maps the supposed Archean boundary to the south of the Menominee ranges was brought in from Wisconsin in the vicinity of Lac Vieux Desert and extended thence, in general, northwesterly to connect with the north boundary of the Archean mass which lies immediately south of the Gogebic district.

The work of 1909 in the Iron River district encouraged us to push on westward in quest mainly of information bearing on the problem of a possible westward extension of the iron-bearing series of the Iron River district. The results thus far have not been altogether discouraging and I shall outline below the aspects of the problem as they appear.

Referring now to Fig. 5, it will be seen that the producing area of the Iron River district is cut off on the south by the Lower Huronian series striking west into the south part of T. 42 N., R. 36 W. On the north it is limited by a great series of presumably but not certainly younger metamorphosed graywackes, slates and volcanic greenstones trending on the average a little south of west. Between the Lower Huronian on the south, and its projected westward extension, and the graywacke-slate-greenstone mass on the north lie the drift covered townships 42 N., Rs. 36, 37 and 38 W., west of Iron River. Here, if anywhere, lies the westward extension of the Iron River series. In this area there are no exposures. Dip needle readings taken on N.-S. lines run at ¼ and ½ mile intervals show no appreciable variations up to the middle of T. 43 N., R. 37 W. Beginning in Section 16 of this township a magnetic belt extends through sections 17 and 18 into Section 13, T. 43 N., R. 38 W. where it dies out reappearing, however, in section 15 extending thence westerly across the state boundary into Wisconsin. (Fig. 9.)

This magnetic belt is probably caused by an iron formation. It indicates the strike or trend of the formations in this area which is in line with the supposed strike determined as above by study of the structure of the rocks lying north and south of the Iron River iron bearing series and their westward extension. Presumably,

[6]Publication 3, Michigan Geological Survey.



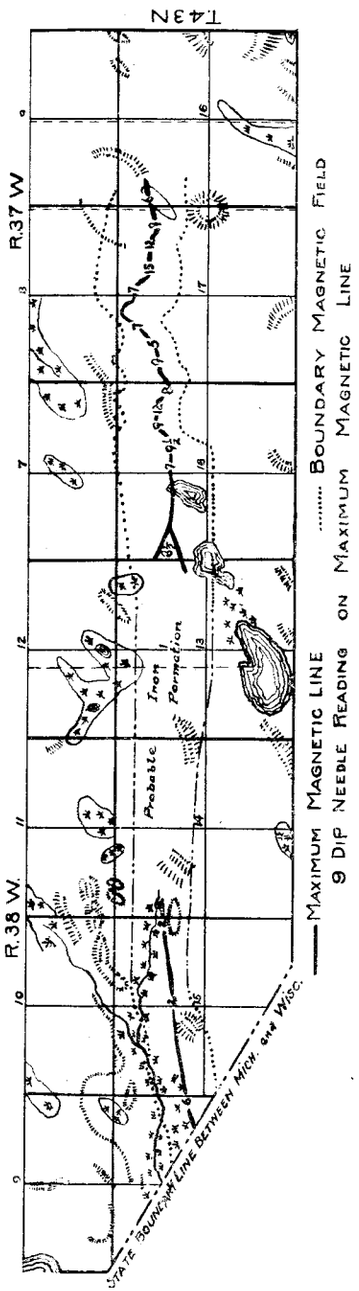


Fig. 9.—Magnetic belt in T. 43 N., R. 37 W., and T. 43 N., R. 38 W.

the probable iron formation underlying this magnetic belt, and probably extending eastward where no magnetic variations occur, is of Upper Huronian age and is decidedly worth exploring.

In township 45 N., R. 39 W., extending in an E.-W. direction just south of Watersmeet is another magnetic belt. In the north part of this township are outcrops of acid gneisses which are probably Archean. It is not known how far south in this township these rocks extend owing to lack of exposures but the south edge is undoubtedly north of the Watersmeet magnetic belt. This belt is in all probability underlain by iron formation, whether of Archean or later age is not known. It extends westward beyond the point shown on the plat where it was dropped at the close of the 1911 field season.

Further work planned for the season of 1912 will throw more light on the structural conditions here discussed but enough is already known to demonstrate that there is no direct connection between the Gogebic and the Iron River districts. The iron bearing series of the latter if continuous westward, which is a probability, passes south of the Archean mass which limits the Gogebic district on the south. Further work west of Watersmeet and southward to the state line is expected to reveal magnetic lines indicating the probable presence of iron formation and a continuance of the westward trend of the structures discussed above.

### ORE RESERVES.

The development work of the last few years has shown two important and striking facts bearing on the future of this district, viz., (1) the ore bearing formation is exceedingly rich, i. e., the ratio of the volume of known ore to known iron formation is relatively high and (2) ore reserves have already mounted to a high figure. The Iron River district has one of the great ore reserves of the state if not actually the largest. The following table is taken from the report of J. R. Finlay to the State Tax Commission, 1911.



ORE RESERVES, IRON RIVER DISTRICT, 1911.

| | Reported in sight above bottom level. | Total tonnage expected by J. R. Finlay. |
|---|---|---|
| Osana (James) | 520,000 | 2,000,000 |
| Chatham | 43,000 | 100,000 |
| Hiawatha | 254,993 | 1,000,000 |
| Baker & Tully | 3,500,000 | 3,500,000 |
| Dober (Riverton) | 713,000 | 1,700,000 |
| Baltic, Fogarty | 460,000 | 3,000,000 |
| Caspian | 3,505,500 | 10,000,000 |
| Youngs | 250,000 | 1,000,000 |
| Zimmerman | 1,000,000 | 1,000,000 |
| Berkshire | 563,000 | 1,000,000 |
| Davidson | 2,000,000 | 2,000,000 |
| Wauseca | 40,000 | 1,000,000 |
| Chicagon | 390,305 | 600,000 |
| Michael Expl | 1,000,000 | 1,000,000 |
| Blair Expl | 372,259 | 1,400,000 |
| Houlihan | 578,000 | 5,000,000 |
| Rogers | 349,306 | 2,500,000 |
| Donahue | 371,437 | 800,000 |
| McGovern | 258,413 | 350,000 |
| Bates | ..... | 400,000 |
| Wickwire | ..... | 40,000 |
| Erickson | ..... | 732,000 |
| N. Y. State Steel | ..... | 2,000,000 |
| | 10,169,213 | 42,122,000 |

The above estimates bring out the striking fact that this district has an expected tonnage in mines and explorations of 7 times the total shipments and furthermore that 15,822,000 tons or over 37% of the reserves is in properties which have not reached the producing stage.[9]

### RECENT DEVELOPMENTS.

In 1910 attention was called to a possible southwestward extension of the iron formation through sections 15, 16 and 17, T. 42 N., R. 34 W. Since that date exploration has not been active on this indicated extension.

Proceeding northwestward important developments have been made at the Zimmerman Mine. The management here who formerly were dependent for the small output of the mine on small irregular ore bodies has succeeded in locating on the 4th level what bids fair to be a body of considerable proportions. The ore lies in a syncline of the drag fold type pitching northeast and slightly overturned toward the southwest. The ore extends upward from the 4th level to the surface. Its downward extension has not been

[9]The Chicagon shipped in 1911.

determined, but ore is known at 600 feet in depth. In its present state of development this body is estimated to contain not less than 1,000,000 tons.

At the Baltic, Youngs and the Fogarty properties, we have to record no important recent development. The Baltic is developed to the seventh level 553′ below collar of No. 2 shaft. The reserves above this level are still nearly half the total shipments from the mine with promise of substantial tonnage below this level. The Fogarty is developed to the third level at a depth of 260′. The mine was closed for over a year prior to May 15, 1911. The mine can produce steadily a moderate tonnage, which is also true of the Youngs mine adjacent to it on the south.

The Berkshire Mine has developed levels at 165, 265 and 365 feet. The strike of the ore body is eastward with the iron formation. The pitch is apparently also eastward, particularly in the west end of the mine where the ore is thrown eastward 160 feet in a vertical distance of 100 feet. The ore lies on a black slate wall dipping south at a high angle to the second level and thence downward vertical. The formation in the east end of the mine is swinging northward. The mine is young and the reserves already known are hardly more than opened up.

Adjacent to the Berkshire on the east is the Corry exploration which was drilled with encouraging results by the Verona Mining Co. It has been taken over by the Michigan Mining Co.,[10] who are conducting development work through a vertical shaft near the east central side of the property.

At the Caspian Mine, developments have not proceeded beyond the 3rd level 292 feet below surface. The area of developed ore on this level is 377,000 sq. feet. The ore body is by far the largest in the district and bids fair to development into one of the great deposits of the Lake Superior region.

North of the Caspian is the Tully property, which has now reached a producing stage. Drilling on the Tully has shown a large tonnage of ore. The ore from the Baker, adjacent to the Tully on the east, will be hoisted through the Tully shaft. The Baker was closed in June of 1911, owing to a refusal of the fee owners to allow operators to hoist Tully ore through the Baker shaft.

The Verona Mining Co. after several years of exploration has developed a very promising ore body on the Barrass-Houlihan property. The ore body lies in the middle east side of the N. W. ¼ of the S. E. ¼ of Sec. 36, 43 N., 35 W. It is partially developed on

[10]The Michigan Mining Co. was recently merged with the Iron County Steel Co.



the first level only where it has dimensions of at least 450 by 200 feet, second only to the Caspian in area of developed ore. This property looks like the beginning of a very large mine.

The Brule Mining Company has added a considerable tonnage to the reserves of the Chatham Mine by taking over an option on the S. E. ¼ of the N. E. ¼ of Sec. 35, T. 43 N., R. 35 W. The ore body was located at depth in the south part of this description by the Cleveland Cliffs Iron Co. in 1909. This ore will be mined through the Chatham shaft.

Explorations conducted by W. H. Selden in the summer of 1911 in the N. E. ¼ of the S. E. ¼ of Sec. 34, T. 34 N., R. 35 W. known as the Manhattan, resulted in the discovery of an ore body, the dimensions of which are not yet known. The property has been leased by the Wickwire Mining Co. and a small shipment of ore was made in the fall of 1911. Exploration and development work is going rapidly forward. The ore body is on a belt of iron formation which strikes north of west into the middle of section 34, and in the opposite direction swings apparently southeast and then northeast into the North Hiawatha property where exploratory work was conducted by Mr. Selden in 1911.

North of Iron River very important developments have been made in what is known as the James belt. On the Osana (James) property an ore body of very considerable dimensions has been opened on the 4th level near the west end of the mine. The workings extend to within 200 feet of the east line of the adjacent Davidson No. 1 mine, formerly known as the Gleason. On the latter property the New York State Steel Co. is developing an ore body of considerable dimensions and north of it on the southern part of the S. E. ¼ of the S. W. ¼ of Sec. 14, the Jones-Laughlin interests have developed a large tonnage by drilling. The ore here seems to extend eastward into Davidson No. 2 and westward across the S. E. corner of S. W. ¼ of the S. W. ¼ of the section where a small tonnage of ore has been shown by exploration conducted by the Wickwire Mining Co. The ore formation continues apparently southwestward and westward across the Donahue and McGovern leases of the Munroe Mining Co., into the middle of the W. ¼ of the N. E. ¼ of Section 22 where the Iron River Ore Co. is reported to have encountered ore in drilling in the fall of 1911. This latter reported discovery I have, however, not verified. The results of exploration on the James belt during the past two years indicates that it contains a large tonnage of marketable ore. Developments are being rapidly pushed on the Davidson No. 1 and Davidson No.

2 and the Jones-Laughlin property, but steps have not yet been taken to open the deposits known to exist westward on this belt.

From the Osana (James) mine the belt extends east into the Spies exploration.

South of the James belt and striking about parallel to it through the middle of section 23 is an ore bearing formation on which the Mineral Mining Company has opened a very promising exploration known as the Wauseca, formerly the Konwinski. A considerable tonnage of ore has already been opened and the prospects are so favorable as to lead Mr. J. R. Finlay to place the expected tonnage at one million. The iron formation apparently dips steeply to the south between slate walls. Drilling east and south of the Wauseca location by the Republic Iron and Steel Co. is reported to have shown promising results and the property has been leased for mining.

From the Osana (James) Mine the ore-bearing belt extends east into the Spies exploration in the N. W. ¼ of the N. W. ¼ of Sec. 24, and possibly eastward across the north part of this section to the Hall exploration of the Bates Mining Co. in the N. ½ of the N. W. ¼ of Sec. 19, 43 N., 34 W. The latter property has been explored by drilling and shaft sinking is now in progress.

The ore-bearing belt extending diagonally northeastward through the center of Sec. 29 and into the S. W. ¼ of Sec. 21, T. 43 N., R. 34 W. will be first opened on the Rogers location (N. E. ¼ of Sec. 29) by the Munro Mining Co. The sinking of the Rogers concrete drop shaft during the summer of 1911 was a notable piece of construction work, the first of its kind to be undertaken in this district. Following the successful experience of the Cleveland Cliffs Iron Company in dropping concrete shafts through deep, wet overburden in the Gwinn district, the Munro Mining Co. in 1911 introduced the first concrete drop shaft in the Iron River district. The shaft was started in February and completed in July, the work being done under contract by the Foundation Company of New York. The shaft was dropped through 140 feet of glacial drift. It is circular, 29 feet in diameter with rectangular compartment 16½ ft. by 11 ft., divided into pipe and ladder way, cage road, and a double skip road. The main advantages of the concrete shaft are its dryness, stability, and permanency. It is expected that similar conditions on other undeveloped properties will increase the number of concrete shafts in the Iron River district.

The Chicago Mine in the N. W. ¼ of the N. E. ¼ of Sec. 26, 43-34 which was the scene of one of the earliest explorations in the



Iron River district, after a long period of persistent exploration by the Munro Mining Company, has been brought to a producing stage. The first shipments from this mine were sent out in the summer of 1911 over the recently completed spur of the Chicago and Northwestern Railroad from the main line about two miles east of Saunders. The strike of the ore formation in the Chicagon mine is about N. E. and S. W. The formation lies on a black slate wall, dipping S. W. at an angle of about 70 degrees. Black slate also occurs on the hanging walls. As measured on a cross section at a depth of 480 feet the iron formation is between 400 and 500 feet thick, making no allowance for folding. The ore body, from which shipments are being made, has been opened up on the 5th or 500 foot level. In the development of the body thus far, reserves totaling in the neighborhood of 400,000 tons are known to exist above this level.

It is thought probable that the ore bearing formation of the Chicagon Mine is at the same horizon as that of the Rogers Mine and may possibly be connected directly with the latter through the S. ½ of Secs. 21, 22 and 23. Some drilling is being done along this hypothetical line by the Cleveland Cliffs Iron Co., but results are not yet available for publication.

In the above paragraphs there has been outlined the more important developments which have been made in the last couple of years. Stagnation in the iron market during 1911 had no appreciable effect on exploratory activity in the Iron River district and from all indications the work of exploration will go steadily forward for some time to come. A large number of strong competing interests have secured a foothold in the district. Notwithstanding, the difficulties inherent in prospecting a drift covered field, the Iron River district offers in the proved richness of the ore bearing formation and the successful outcome of many recent operations, one of the most attractive areas for exploration in the Lake Superior region.

### GOGEBIC DISTRICT.

The Gogebic iron district extends from Lake Gogebic westward to the Montreal River and is prolonged southwestward in Wisconsin to near Lake Numakagon under the name of Penokee range. Its total length is about eighty miles. In earlier years the name Agogebic was applied to the Michigan portion. In contrast to the history of other iron ranges the Gogebic was known and geologically mapped prior to the opening of ore deposits. The simplicity of

rock structure and succession of strata combined with the topographic prominence of the range and the magnetism of the iron formation made possible early accurate geologic mapping. No ore discoveries have been made outside the limits of the iron formation thus early determined.

The earlier explorations were made on the western (Wisconsin) end of the range on the more highly magnetic and better exposed parts of the iron formation. The years immediately following the opening of the range in 1884 were marked by a frenzy of speculation. The companies formed in 1886 alone had a total capitalization of above $1,000,000,000.00.[11] In the crash that followed in 1887 the small investor was squeezed out, but some of the stronger companies survived and formed a neucleus which kept the work of exploration and development moving while business conditions were being readjusted. Despite the collapse of the speculative craze the production rose steadily from 1884, reaching a mark in 1892 that was not reattained until a decade later, 1902. The production curve is plotted in Fig. 11.

The district is served by the Duluth, South Shore and Atlantic Ry., the Wisconsin Central which crossed the range at Penokee Gap in 1873, extending a branch to the center of the district in 1887, and the Chicago and Northwestern Ry. which reached Ironwood from the Menominee Range in 1882 and made connections with Ashland in 1885.

*The Ore Deposits:* The ore deposits are confined to the central part of the range extending from near Iron Belt in Wisconsin to Sunday Lake in Michigan, though ore is known on Secs. 15 and 21, T. 47 N., R. 43 W. west of Gogebic Lake. Up to 1910 Michigan had produced about 84% of the total output.

The important factors affecting the formation of the ore deposits are (1) the steeply inclined position of the iron formation, which limits the exposed part to a belt not greatly in excess of its thickness and favors great vertical component for the ore bodies compared to horizontal section. The ore deposits occupy only about 1 per cent of the area of the exposed iron formation.[12] (2) The underlying impervious quartzite dipping northward forms the footwall of the majority of the ore bodies and in many cases forms with (3) impervious basic dikes, which cut the bedding of the Huronian series at an average 90° angle, natural troughs, pitching usually gently eastward but in some cases westward, carrying the great

[11]Mon. 52, U. S. Geological Survey.
[12]Mon. 52, U. S. Geological Survey, p. 235.



ore deposits of the district. The ore deposits are generally best developed in the troughs thus formed extending upward along either or both limbs of the trough and following it downward along the pitch. The number of such pitching troughs on a given cross section is limited only by the number of intersecting dikes, and sections through many properties exhibit several ore bodies lying one above another each bottomed in a trough formed by the intersection of a dike with the footwall quartzite. The dikes vary up to about a hundred feet in thickness. (4) Interbedded slate or quartzite may function as a footwall carrying ore bodies in horizons which are far above the underlying Palms quartzite. (5) Minor structures such as bedding, brecciation and faulting serve as guides to downward moving water, and are thus favorable to secondary concentration. Some or all of these factors are operative in every instance in localizing ore bodies and in some cases are apparently alone adequate to induce alteration to ore. (6) Certain horizons in particular places were originally above average richness requiring less concentration to form ore bodies. This factor is believed to have been important in those places where ore bodies exist in the absence of structural conditions particularly inducive to secondary concentration, as at the Mikado, Brotherton and Sunday Lake mines.[13]

### DEVELOPMENT.

As stated above no ore has been found outside the limits of the Ironwood formation as mapped prior to 1884. Exploratory work on the Gogebic Range is therefore not of necessity first directed toward locating the iron bearing rocks as in some other districts particularly the Iron River, Crystal Falls, and Gwinn areas but proceeds more directly to the opening of promising parts of the ore bearing formation. The methods employed elsewhere are used on the Gogebic but diamond drilling is carried on to less extent. In the working properties much attention has been directed to exploration at greater depths following the lead of Mr. J. R. Thompson whose persistent efforts revealed at the Newport, a large body of high grade ore at a depth of 2,000 feet and over. The proved occurrence of ore at great depth will prolong indefinitely the life of many properties on the Gogebic range. Whereas only a few years ago there was considerable apprehension among geologists and engineers regarding the existence of rich iron ores at any-

[13]Mon. 52, United States Geological Survey.

thing over moderate depths, there is now a strong presumption that ores will be found at depths greater than that of the Newport deposit, possibly to the lower limits of profitable mining.

### ORE RESERVES.

The tonnage of ore reserves reported to the Michigan State Tax Commission in 1911 is given below:

ORE RESERVES, GOGEBIC RANGE, 1911.

| | Reported in sight by company. | Total tonnage expected. Estimates by J. R Finlay. |
|---|---|---|
| Ashland | 197,000 | 200,000 |
| Norrie-Aurora | 9,361,500 | 18,000,000 |
| Newport | 5,475,000 | 16,000,000 |
| Puritan | 50,000 | 100,000 |
| Ironton | 130,000 | 500,000 |
| Yale | ..... | 1,000,000 |
| Colby | 815,800 | 1,500,000 |
| Tilden | 404,500 | 1,000,000 |
| Anvil and Palms | 379,000 | 1,000,000 |
| Eureka | 65,000 | 200,000 |
| Asteroid | 10,000 | ..... |
| Mikado | 20,000 | 500,000 |
| Chicago | 184,000 | 500,000 |
| Brotherton | 995,000 | 1,000,000 |
| Sunday Lake | 150,000 | 1,500,000 |
| Castile | 1,000 | ..... |
| Total | 17,338,800 | 43,000,000 |

### MARQUETTE RANGE.

The Marquette district is the oldest of the iron districts of the Lake Superior region. It had been producing ore for 24 years prior to the opening of the Menominee district in 1872. The first discovery of iron ore in the Marquette district and the Lake Superior Region was made in 1844 at the site of the old Jackson mine at Negaunee by a U. S. land surveying party under charge of W. A. Burt who was working under Dr. Douglass Houghton, the first state geologist of Michigan. Lack of space forbids a sketching of the long and interesting history of the Marquette district. It is interesting to note that a large number of the important mines now worked in the Marquette district were opened prior to 1872, although very important discoveries have been made since that time, particularly in recent years.



### RECENT DEVELOPMENTS.

The Marquette district, which has produced iron ore since 1848 or for 63 years, and in this time has sent to market 93,749,928 tons (to 1911) has an available estimated reserve of 75,977,006 tons (1911) of marketable ore or 80% of total shipments. There is more ore in sight today than ever before, a fact which illustrates in striking manner the relative permanency of the iron mining industry. Recent deep drilling in bottom horizons of the Negaunee formation "suggests that the beds of this horizon at great depths may ultimately be found to carry a larger tonnage of ore than those of any of the other horizons,"[14] a matter of transcendant importance to the future of the district. On the Marquette as well as in the Gogebic district development at great depth has changed what was formerly a hope into a practical certainty, viz., that deeply buried portions of the iron formation are ore-bearing and are likely to be fully as productive as the shallower parts.

The area underlain by the iron-bearing formations has long been known and appears on accurate maps of the U. S. Geological Survey. Explorers may therefore proceed to the opening of promising parts of the iron formation without necessity of first locating the formation itself as is necessary in the drift covered and less accurately mapped areas. In recent years there have been relatively fewer new explorations on the Marquette range than in the Crystal Falls and Iron River districts. This is not surprising in an area where the data of many years has thrown more light on the ore bearing possibilities of different localities. In other words, exploration on the Marquette range does not now of necessity proceed in many cases blindly but on the contrary with considerable assurance regarding the geological conditions expected to prevail. The stronger companies which operate in the district are well fortified with reserve tonnage and land holdings and in contrast with the conditions in the Crystal Falls and Iron River districts, in the main producing localities have neither the same necessity nor the opportunity to compete for new acquisitions. The field is an old one and partition of interests was practically established long ago.

Important construction work has been under way by the Cleveland Cliffs Iron Co. A new concrete shaft was sealed to ledge at the Maas mine in September, 1911. The concrete work is circular, 200 feet deep with rectangular open-

[14] Mon. 52, U. S. Geological Survey.

ing 11 ft. 2 in. by 15 ft. 2 in. inside including a pipe and ladder way, one cage and two skip roads. A similar shaft was constructed at the Negaunee mine. The most important recent work undertaken by this company, however, is the installation of an hydro-electric power system, the largest project of its kind ever undertaken in the Michigan mining regions.

The Carp river is to be harnessed through a plant of two 4,000 H. P. units equipped for 60,000 volts, located just opposite the state prison near Marquette, driven by a fall of 600 feet on a 25% grade from a stand pipe one-half mile distant on the top of Mt. Mesnard. The dam is four miles up stream from the power house. It is 50′ wide at the base and 120′ in length. From the dam the water will be conveyed through a 22,000′ line of pipe 66″ in diameter, 12,000 feet of steel and 10,000′ of Washington fir staves. The power will be conveyed from the generating station over a double circuit transmission line some 36 miles long to the company's mines at North Lake, Ishpeming, Negaunee and the Gwinn district. The cost of the installation is estimated at about $1,000,000.00.

Four new mines should be added to the producing list in 1912, viz., the Maitland, Morris (North Lake No. 1), Lloyd (North Lake No. 2) and the Chase (Barnes). During 1910 and 1911 work has gone steadily forward at the three latter properties. Steel headframes have been erected and the ore deposits partially opened up. The Maitland is a new property of the Volunteer Ore Co. located at the east end of Palmer Lake. The shaft is down about 300 feet and a soft ore body of high grade partially developed.

Another event of importance is the installation of the Ardis furnace at the old Kloman mine for the treatment of low grade ores by the Jones Step Process. The problem of the utilization of low grade ores is an important one and we have, therefore, chosen to give separate and detailed treatment of the Jones Step Process in a separate chapter.

### ORE RESERVES.

The tonnage of ore reserves on the Marquette range as reported by J. R. Finlay to the Michigan State Tax Commission is given below.



ORE RESERVES, MARQUETTE DISTRICT, 1911.

| Mine. | Reported in sight above bottom level. | Total tonnage expected by J. R. Finlay. |
|---|---|---|
| Lillie | 72,651 | 72,651 |
| Cambria (Old Hartford) | 825,000 | 825,000 |
| Mary Charlotte No. 1 and No. 2 | 1,500,000 | 2,775,000 |
| Breitung Hematite No. 1 and No. 2 | 250,000 | 2,000,000 |
| Lake Angeline-Mitchell | 430,000 | 475,000 |
| Rolling Mill | 1,152,177 | 1,500,000 |
| Lake | 3,707,110 | 3,707,000 |
| Negaunee | 13,635,200 | 13,635,000 |
| Salisbury | 584,000 | 584,000 |
| Mass | 9,662,400 | 9,662,000 |
| Lake Superior Soft Ore | 2,250,000 | 4,000,000 |
| Queen | 1,893,000 | 1,900,000 |
| Race Course | ..... | 1,500,000 |
| Lucky Star | ..... | 4,000,000 |
| Harvey Lots | ..... | 4,000,000 |
| North Range | ..... | 1,510,000 |
| Republic | 1,358,000 | 2,000,000 |
| Washington | ..... | ..... |
| Barron | 310,000 | 432,000 |
| Franklin | ..... | ..... |
| American Boston (not reported) | ..... | 500,000 |
| Volunteer | 30,000 | 150,000 |
| Lake Superior Hard Ore | 1,470,000 | 2,270,000 |
| Section 16 | 5,311,355 | 9,446,355 |
| Champion | 1,625,000 | 2,825,000 |
| Cliff Shaft | 2,167,000 | 2,500,000 |
| Moro | 50,000 | 50,000 |
| North Lake 6-47-27 | ..... | 594,000 |
| Imperial | 1,500,000 | 1,500,000 |
| Ohio | 117,100 | 317,000 |
| Portland | 247,085 | 247,000 |
| Total | 50,147,078 | 75,977,006 |

### GWINN (SWANZY) DISTRICT.

The Gwinn district lies south of the Marquette range in T. 45 N., R. 25 W. It is served by the Chicago and Northwestern Ry. and the Munising Ry. The district has produced more or less steadily from the old Swanzy (Princeton) Mine since 1872. Development work of the last decade has brought the district rapidly into prominence. The Stephenson and Austin made first shipments in 1907, the Stegmiller in 1909. The Smith began hoisting in September, 1911, and concrete shafts are sealed to ledge on the Kidder and Northwestern. The district is controlled with the exception of the Stegmiller mine which is operated by the Oliver Iron Mining Co., by the Cleveland Cliffs Iron Co., by whom active exploration has been conducted since 1902. Electric power will be supplied by the Cleveland Cliffs Iron Co. transmission line from their plant on Carp River near Marquette.