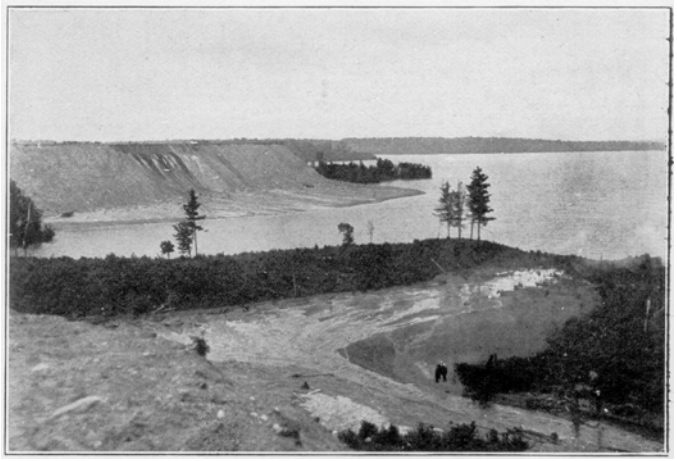

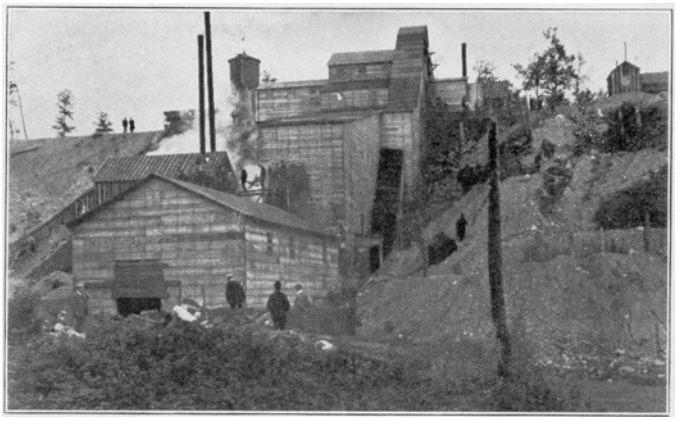

SLUSH DUMP, SHORE OF TROUT LAKE, COLERAINE.

EXPERIMENTAL WASHING PLANT AT COLERAINE.

PROCEEDINGS OF THE Lake Superior Mining Institute THIRTEENTH ANNUAL MEETING

MESABI RANGE, MINNESOTA

JUNE 24, 25, 26, 27, 1908

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(The Above Officers Constitute the Council.)

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WATSON, CHARLES H. ..... Crystal Falls, Mich.
WEBB, FRANCES J ..... Eveleth, Minn.
WEARNE, WILLIAM ..... Hibbing, Minn.

WEED, LOUIS B. ..... Sunrise, Wyoming.
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WHITBURN, HENRY ..... Virginia, Minn.
WHITE, WILLIAM ..... Aurora, Minn.
WHITEHEAD, R. G. ..... Amasa, Mich.
WHITING, S. B. ..... Swampscott, Mass.
WILKINS, WILLIAM ..... Ashland, Wis.
WILLIAMS, JAMES H. ..... Ishpeming, Mich.
WILLIAMS, THOMAS H. ..... Ely, Minn.
WILLIAMS, HERBERT H. ..... Marquette, Mich.
WILLIAMS, PERCIVAL S. ..... Montreal, Wis.
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WORDEN, JOHN ..... Crystal Falls, Mich.

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YOUNGS, FRANK W. ..... Iron River, Mich.
YOUNGS, GEORGE C. ..... Florence, Wis.
YOUNGS, G. W. ..... Iron River, Mich.
YUNGBLUTH, A. J. ..... Ishpeming, Mich.

DECEASED MEMBERS.

ARMSTRONG, J. F. ..... March 3rd, 1898

BENNETT, JAMES H. .....
BULLOCK, M. C. ..... January 12, 1899
BAWDEN, JOHN T. 1899
BROOKS, T. B. 1902

CONRO, ALBERT ..... January 10th, 1901

DANIELS, JOHN ..... September 13th, 1898
DICKENSON, W. E. ..... June 15th, 1899
DOWNING, W. H. ..... October, 1906
DUNSTON, THOMAS B. .....
DUNCAN, JOHN ..... June, 1904

GARBERSON, WILLIAM R. ..... April 29th, 1908

HOLLEY, S. H. ..... July 4th, 1899
HARPER, GEORGE VANCE ..... March, 1905
HAYDEN, GEORGE ..... July 27th, 1902
HOUGHTON, JACOB ..... December 30th, 1903
HINTON, FRANCIS 1896
HOLLAND, JAMES ..... September 3rd, 1900
HYDE, WELCOME .....

JEFFERY, WALTER M. ..... May 26th, 1906

JOCHIM, JOHN W. ..... January 17th, 1905

KRUSE, JOHN C. ..... October 28th, 1907

LUSTFIELD, A. ..... May 26th, 1904
LYON, JOHN B. ..... February 13th, 1900

MARR, GEORGE A. ..... March, 1905
MITCHELL, SAMUEL ..... May 10th, 1908
M'VICHIE, D. ..... September 14th, 1906

OLIVER, HENRY W. ..... February 8th, 1904

PEARCE, H. A. 1905
PERSONS, GEORGE R. ..... March 26th, 1908

RYAN, EDWARD 1901

SHEPHARD, AMOS ..... June 6th, 1905
STANTON, JOHN ..... February 23rd, 1906

TREVARTHEN G. C. ..... January, 1898
THOMAS, HENRY ..... December, 1905

VAN DYKE, JOHN H. 1906

WALLACE, JOHN 1898
WILLIAMS, W. H. 1897
WHITE, PETER ..... June 6th, 1908
WHITNEY, J. D. 1894

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1	Iron Mountain, Mich	March 22-23, 1893	Vol. I
2	Houghton, Mich	March 7-9, 1894	Vol. II
3	Mesabi and Vermilion Ranges	March 6-8, 1895	Vol. III
4	Ishpeming, Mich	August 18-20, 1896	Vol. IV
5	Ironwood, Mich	August 16-18, 1898	Vol. V
6	Iron Mountain, Mich	February 6-8, 1900	Vol. VI
7	Houghton, Mich	March 5-9, 1901	Vol. VII
8	Mesabi and Vermilion Ranges	August 19-21, 1902	Vol. VIII
9	Ishpeming, Mich	August 18-20, 1903	Vol. IX
10	Ironwood, Mich	August 16-18, 1904	Vol. X
11	Iron Mountain, Mich	October 17-19, 1905	Vol. XI.
12	Houghton, Mich	August 8-10, 1906	Vol. XII
13	Mesabi and Vermilion Ranges	June 24-27, 1908	Vol. XIII

Note—No meetings were held in 1897, 1899 and 1907.

RULES OF THE INSTITUTE.

I.
OBJECTS.

The objects of the Lake Superior Mining Institute are to promote the arts and sciences connected with the economical production of the useful minerals and metals in the Lake Superior region, and the welfare of those employed in these industries, by means of meetings of social intercourse, by excursions, and by the reading and discussion of practical and professional papers, and to circulate, by means of publications among its members the information thus obtained.

II.
MEMBERSHIP.

Any person interested in the objects of the Institute is eligible for membership.

Honorary members not exceeding ten in number, may be admitted to all the privileges of regular members except to vote. They must be persons eminent in mining or sciences relating thereto.

III.
ELECTION OF MEMBERS.

Each person desirous of becoming a member shall be proposed by at least three members, approved by the Council, and elected by ballot at a regular meeting (or by ballot at any time conducted through the mail, as the Council may prescribe), upon receiving three-fourths of the votes cast. Application must be acompanied by fee and dues as provided by Section V.

Each person proposed as an honorary member shall be recommended by at least ten members, approved by the Council, and elected by ballot at a regular meeting, (or by ballot at any time conducted through the mail, as the Council may prescribe), on receiving nine-tenths of the votes cast.

IV.
WITHDRAWAL FROM MEMBERSHIP.

Upon the recommendation of the Council, any member may be stricken from the list and denied the privilege of membership, by the vote of three-fourths of the members present at any regular meeting, due notice having been mailed in writing by the Secretary to him.

V.
DUES.

The membership fee shall be five dollars and the annual dues five dollars, and applications for membership must be accompanied by a remittance of ten dollars; five dollars for such membership fee and five dollars for dues for the first year. Honorary members shall not be liable to dues. Any member not in arrears may become a life member by the payment of fifty dollars at one time, and shall not be liable thereafter to annual dues. Any member in arrears may, at the discretion of the Council, be deprived of the receipt of publications or be stricken from the list of members when in arrears six months; Provided, That he may be restored to membership by the Council on the payment of all arrears, or by re-election after an interval of three years.

VI.
OFFICERS.

There shall be a President, five Vice-Presidents, five Managers, a Secretary and a Treasurer, and these Officers shall constitute the Council.

VII.
TERM OF OFFICE.

The President, Secretary and Treasurer shall be elected for one year, and the Vice-Presidents and Managers for two years, except that; at the first election two Vice-Presidents and three Managers shall be elected for only one year. No President, Vice-President, or Manager shall be eligible for immediate re-election to the same office at the expiration of the term for which be was elected. The term of office shall continue until the adjournment off the meeting at which their successors are elected.

Vacancies in the Council, whether by death, resignation, or the failure for one year to attend the Council meetings, or to perform the duties of the office, shall be filled by the appointment of the Council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; Provided, That such appointment shall not render him ineligible at the next election.

VIII.
DUTIES OF OFFICERS.

All the affairs of the Institute shall be managed by the Council except the selection of the place of holding regular meetings.

The duties of all Officers shall be such as usually pertain to their offices, or may be delegated to them by the Council.

The Council may in its discretion require bonds to be given by the Treasurer, and may allow the Secretary such compensation for his services as they deem proper.

At each annual meeting the Council shall make a report of proceedings to the Institute, together with a financial statement.

Five members of the Council shall constitute al quorum; but the Council may appoint an executive committee, business may be transacted at a regularly called meeting of the Council, at which less than a quorum is present, subject to the approval of a majority of the Council, subsequently given in writing to the Secretary and recorded by him with the minutes.

There shall be a meeting of the Council at every regular meeting of the institute and at such other times as they determine.

IX.
ELECTION OF OFFICERS.

Any live members not in arrears, may nominate and present to the Secretary over their signatures, at least thirty days before the annual meeting, the names of such candidates as they may select for offices falling under the rules. The Council, or a committee thereof duly authorized for the purpose, may also make similar nominations. The assent of the nominees shall have been secured in all cases.

No less than two weeks prior to the annual meeting, the Secretary shall mail to all members not in arrears a list of all nominations made and the number of officers to be voted for in the form of a letter ballot. Each member may vote either by striking from or adding to the names upon the list, leaving names not exceeding in number the officers to he elected, or by preparing a new list, signing the ballot with his name, and either mailing it to the Secretary, or presenting it in person at the annual meeting.

in case nominations are not made thirty days prior to the date of the annual meeting for all the offices becoming vacant under the rules, nominations for such offices may be made at the said meeting by five members, not in arrears, and an election held by a written or printed ballot.

The ballots in either case shall be received and examined by three tellers appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected. The ballot shall be destroyed, and a list of the elected officers, certified by the tellers, snail be preserved by the Secretary.

X.
MEETINGS.

The annual meeting of the Institute shall be held at such time as may be designated by the Council. The Institute may at a regular meeting select the place for holding the next regular meeting. If no place is selected by the Institute it shall be done by the Council.

Special meetings may be called whenever the Council may see fit; and the Secretary shall call a special meeting at the written request of twenty or more members. No other business shall be transacted at a special meeting than that for which it was called.

Notices of all meetings shall be mailed to all members at least thirty days in advance, with a statement of the business to be transacted, papers to be read, topics for discussion and excursions proposed.

No vote shall be taken at any meeting on any question not pertaining to the business of conducting the Institute.

Every question that shall properly come before any meeting of the Institute, shall be decided, unless otherwise provided for in these rules, by the votes of a majority of the members then present.

Any member may introduce a stranger to any regular meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

XI.
PAPERS AND PUBLICATIONS.

Any member may read a paper at any regular meeting of the Institute, provided the same shall have been submitted to and approved by the Council, or a committee duly authorized by it

for that purpose prior to such meeting. All papers .shall become the property of the Institute on their acceptance, and, with the discussion thereon, shall subsequently be published for distribution. The number, form and distribution of all publications shall he under the control of the Council.

The Institute is not, as a body, responsible for the statements of facts or opinion advanced in papers or discussions at its meetings, and it is understood, that papers and discussions should not include personalities, or matters relating to politics, or purely to trade.

XII.
AMENDMENTS.

These rules may be amended by a two-thirds vote taken by letter ballot in the same manner as is provided for the election of officers by letter ballot; Provided, That written notice of the proposed amendment shall have been given at a previous meeting.

THE THIRTEENTH ANNUAL MEETING.

The thirteenth annual meeting of the Institute was originally planned for July 24th to 27th, 1907, and all arrangements were made accordingly. A few days prior to the meetings however, the labor troubles, which then existed at certain points in the district assumed a somewhat threatening aspect, causing some of the mines to close down and it was decided to postpone the meeting and arrangements were cancelled. While the situation very soon changed and work on the docks and at the mines was again resumed. It was nevertheless still thought advisable by the committee in charge to defer the meeting until 1908. In May of this year, Mr. T. F. Cole, president of the Institute and the members In the Minnesota District, again planned for the meeting and it was decided to hold the Thirteenth Annual Meeting June 24th to 27th, 1908.

Much credit is due to the different committees for their efforts in the arrangement of the trip. The train schedule was carried out as planned without loss of time and for the greatest comfort of the party. The meeting will be long remembered and is spoken of as the best In the history of the Institute. The pleasant weather throughout the trip added greatly to the comfort and pleasure of the occasion.

The programme, prepared by Mr. D. E. Woodbrldge, and issued by the Committee on Arrangements, covering the trip to the ranges contains much valuable information about the mines, which will be of general interest to the members and the same is published herewith. Only such parts as the analysis of ore from the various Lake Superior District, which are changeable, are omitted.

Following is the list of the different committees:

Arrangement Committee.

WILLIAM J. OLCOTT, Chairman.

William C. Agnew,
Pentecost Mitchell,
C. T. Fainbairn,
Dwight E. Woodbridge.
Charles Trezona,
Joseph Sellwood,
W. W. Walker,

Transportation Committee.

W. A. McGONAGLE, Chairman.

F. E. House,
D. M. Philbin,
Thomas Owens,
J. W. Kreitter.

Entertainment Committee.

JOHN H. McLEAN, Chairman.

J. S. Lutes,
Chas. A. Duncan,
G. G. Hartley,
Wm. J. West.

ITINERARY TO THE MINNESOTA IRON RANGES, LOCAL EXCURSIONS, ETC.

The headquarters of the Institute and bureau of information will be at the Spalding Hotel. On arrival, members and their guests will please register at headquarters, receive assignments of accommodations for trip to ranges, etc. On account of both state and interstate laws regulating railroad transportation, it will ‘be necessary for all those participating in this trip to pay the regular railway fare of two cents per mile, excepting such as have, under the law, free transportation on these Minnesota roads. Eight meals will be served in dining cars en route, and for these tickets will be provided, to be bought by members and guests at about cost per meal. Such tickets should be secured prior to departure from Duluth.

Wednesday, June Twenty-fourth.

No special program has been arranged for Wednesday. For the accommodation of such members as may be in Duluth in time to take advantage of it, the privilege of the various clubs of the city has been offered. These include the Kitchi Gammi, Commercial, Northland Country, Duluth Boat and Duluth Yacht clubs. All these clubs have cafes. The golf links are at the Northland Country club, and sail boats or launches may be engaged at the Boat or Yacht club. Tickets to the various clubs may be had on application.

During Wednesday and Saturday, time not otherwise occupied may be profitably spent in an inspection of various industries in and near the city. The transformer station of the Great Northern Power Co., at 15th Avenue West, the Zenith furnace and the ore docks of the Duluth, Missabe & Northern railroad, may all be reached easily by street cars running to West Duluth. The main power station of the Great Northern Power company, at Fond du Lac, can be reached via the Northern Pacific road. In the wholesale districts, on Lake and Fifth avenues, are some of the largest wholesale hardware and other wholesaling and manufacturing houses in the world. On First street and Third Avenue West is the Wolvin building, general offices of the mining companies and railroads of the United States Steel corporation; and the Duluth Board of Trade and the new Y. M. C. A. building, the latter representing an investment of more than $225,000, are across the street. The aerial bridge, the only structure of its kind in the United States, and carrying a car on a truss elevated 140 feet, is on Lake

avenue. The boulevard drive, running behind and above the city, at an elevation of 480 feet and utilizing for its roadway the glacial beach of Lake Superior, is, with its adjacent and connecting parks, well worth a visit.

There will be an informal smoker and reception for members of the Institute, and their guests at the club house of the Northland Country club at 8 o'clock p. m. The club may be reached by Lakeside cars that pass the Spalding Hotel, going east, at 7:40, 8:00 and 8:20 p. m. Returning cars will pass the club at an hour that will be announced.

Sleeping cars for the trip to the ranges will be ready for occupancy at the Union station at 6:30 p. m. Intending passengers may find it convenient to place their baggage aboard the train early, and then go direct to the Country club for the evening.

Thursday, June Twenty-fifth.

Leave Duluth, Union Station.....1:00 a. m.
Arrive Ely .....5:30 a. m.

Visit Chandler, Pioneer, Zenith, Savoy and Sibley mines; at the Pioneer there will toe opportunity for a brief trip underground.

These mines are all operated by the Oliver Iron Mining Co., and last year produced a total of 1,582,290 tons. The underground haulage system of the Pioneer, the various steel shafts and shafthouses, and the hoisting plants here are all of more than passing interest. This "Ely trough" has produced, since 1888, 18,631,606 tons of ore.

Leave Ely .....11:00 a. m.
Arrive Soudan .....12:00 noon.

Visit Minnesota mine. This property is operated by the Oliver Iron Mining company, and was what led to the construction of the Duluth & Iron Range railway. Last year it mined a total of 102,977 tons, or 1.24 per cent, of the tonnage of that road. One of the most picturesque scenes to be found in the northwest is the view of Lake Vermilion to be had from the summit of the hill near the mine buildings.

Leave Soudan .....1:00 p. m.
Arrive Biwabik (Mesabi Range).....2:30 p. m.

Visit Biwabik mine. This property is operated by the Biwabik Mining Co., and was one of the first to ship from the Mesabi range, and was notable in the early days of the district by reason of the boldness of the plans for stripping, the rapid growth of its production and the excellent character of its ore. The yardage of overburden taken from this mine to date is about 4,500,000, and there have been mined to May, 1908, 8,212,967 tons.

Leave Biwabik .....3:00 p. m.
Arrive Eveleth .....3:45 p. m.

Visit Fayal, Adams and Spruce mines. These properties are operated by the Oliver Iron Mining Co., and last year produced as follows: Fayal, 1,878,812 tons; Adams-Spruce, 1,746,970. At these mines the various methods of mining used on the Mesabi may he seen, and from their surface 9,725,000 yards of overburden have been removed. This portion of the Mesabi was developed tfor the first shipments in 1895.

At Eveleth the trains will be transferred to the Duluth, Missabe & Northern tracks and will

Leave Eveleth .....6:30 p. m.
Arrive Virginia .....7:15 p.m.

There will be a business session of the Institute at the Roosevelt High School hall, Virginia, at 8:15 o'clock this evening.

Friday June Twenty-sixth.

A portion of the morning will be spent in visiting the Oliver Norman, Ohio, Lincoln Franklin, and other mines. The Oliver is a state lease (returning 25 cents per ton to the public schools of the state) operated by the Oliver company; the Ohio is also mined by that company; the Lincoln is operated by the Interstate Iron Co. (Jones & Laughlins Steel Co.), the Franklin group by the Republic Iron & Steel Co., the Commodore by Corrigan, McKinney & Co. The Oliver group is under extensive development and there has been removed from the properties of the group a total of 2,550,000 yards of overburden.

Leave Virginia .....10:00 a. m.
Arrive Mountain Iron.....10:45 a. m.

Visit the Mountain Iron mine. This is operated by the Oliver company and has shipped in two consecutive years a total of more than 5,000,000 tons, and in all to this date 16,992,173 tons. It was the first property to he taken by the Carnegie-Oliver coalition off some years ago, and thus, with the Oliver mine, formed the basis of the Oliver Mining Co. Stripping to the total amount of 4,825,000 yards has been taken off this ore body.

Leave Mountain Iron .....11:45 a. m.
Arrive Monroe—Tener mines .....12:45 p. m.

These mines have been opened on a very large and comprehensive scale, and are excellent examples of stripping and milling properties. A total of 3,875,000 yards of earth has been removed in the past three years.

Leave Monroe—Tener mines..... .....1:30 p. m.
Arrive Hibbing .....2:00 p. m.

The remainder of the day will be passed in visits to various mines of the district. Hibbing is almost surrounded by mines, indeed a large portion of the town lies over ore, and the Sellers is now stripping into the town from the east side. The iron bearing formation and deposit here is not far from two miles wide, and very productive, the immediate vicinity containing many hundred million tons. Notable mines here are the Burt, Sellers, Hull, Rust, Mahoning, Morris, Hartley, and others. From the Burt and Hull-Rust 8,400,000 yards of surface have been moved and they have shipped 9,405,000 tons of ore. Mahoning is stripped in such a manner that passenger trains can be taken into and through the mine itself, a somewhat unique fact. This mine is operated by the Mahoning Iron & Steel Co., and the fee is owned by the Great Northern railway, and a total of 3,500,000 yards of overburden has been removed therefrom.

There will be a business session of the Institute at the Hibbing High school at 8:15 p. m.

Saturday, June Twenty-seventh.

Leave Hibbing .....1:00 a. m.
Arrive Coleraine .....6:00 a. m.

This is the scene of the vast operations of the Oliver Iron Mining Co. in the development of sandy ores of the district that can he concentrated into merchantable ores by a washing process, and an experimental washery is in operation on the shores of Trout Lake. The stripping development here is worthy of especial note, not only for its magnitude, both in extent of area and depth of overburden to be moved, but in the labor-saving methods utilized and in the amount of earth removed month by month. Overburden so far removed amounts to 2,475,000 yards, and from the near-by Holman mine 1,600,000 yards. The town of Coleraine is owned by the company and a most successful attempt is being made to build up here a model dwelling place in which there shall be comforts and conveniences, and inducements for the best class of residents to become permanent citizens. Large sums

are being spent and able minds are directing matters towards this end.

Leave Coleraine .....12:00 noon.
Arrive Duluth .... 4:00 p.m.

MINNESOTA STEEL COMPANY.

Recently the Minnesota Steel Company has been organized to erect blast furnaces and a steel works and finishing mills at Duluth under the ownership of the United States Steel Corporation. The company has proceeded with its plans, has bought property giving it nearly three miles of deep water frontage on Duluth harbor, and containing some 1,500 acres, has made surveys, has organized a railway company to construct a belt line connecting the works with all lines of railroads running into Duluth and Superior, has bought large property holdings for railway yards and distributing docks, etc., has organized a company for constructing a bridge across the St. Louis river and secured the right to bridge the channel, and is now perfecting the plans for its equipment and surveying the route of its belt lines. Large sums have been set aside for carrying out this important project, and it is probable the works will ultimately be of great magnitude and of the utmost importance to the city and the northwest. It may be said that this is the most ambitious and well-founded plan for the manufacture of steel and its products that has ever been considered for the northwest. Initial construction will include the following: Two 500-ton blast furnaces; 7 60-ton open hearth furnacess; 160 by-product coke ovens; 1 40-inch blooming mill; 1 28 and 1 18-inch finishing mill; 1 combination finishing mill, comprising a continuous 16-inch roughing mill with 11 and 8-inch finishing mills; a pumping plant of 40,000,000 gallons capacity; a power plant of approximately 8,000 kw., and the necessary machine shops, forges, foundries, etc. with a village of about 109 dwellings, all to cost approximately $11,000,000.

GREAT NORTHERN POWER CO.

The Great Northern Power Company is now delivering electric power from its hydro-electric station on the St. Louis river to various industries and public utilities in Duluth and Superior. The present installation consists of three 10,000 h.p. generating units operating under 375 feet of fall and furnishes power for the lighting and street railways of both cities, for pumping the Duluth water supply, for operating the unloading and conveying machinery of coal docks and grain elevators, for electrolytic processes and for driving the motors of various industries. The installation will be increased ultimately to 80,000 horse power and storage reservoirs will be constructed of sufficient capacity to make an ample water supply continuously available at all times and seasons. To insure reliability, continuity and economy of power service, the equipment and construction has been made typical of the highest state of the art.

The power market within a commercial radius of transmission includes Duluth, Superior, St. Paul, Minneapolis, and the Mesabi, Vermilion and Gogebic iron ranges. The extensive use of this power in one or more of these iron ranges is confidently expected in the near future on account of the proximity of this large water power development and the many advantages of electric power for mining work.

ZENITH FURNACE.

This is the property of the Zenith Furnace Company: it includes a stack 79’ 6”, with bosh 16’ (f and crucible 11’ 6”; has three Gordon stoves 6o’xi6 and one lamond 20x85, and has a daily capacity of 225 tons of pig iron. The slag is granulated and sluiced to fill dock space. It has a by-product coke oven plant of 50 Otto-Hoffman by-product ovens. The capacity of these is: Coal coked 350 tons daily; coke produced—250 tons daily; and the daily product includes 400 gallons tar, 10,000 pounds concentrated ammonia, 20 per cent. N. H. 3, 1,250,000 cubic feet illuminating gas of 18 candle power are produced daily. It has an auxiliary carburetted water gas plant of 2,000,000 cubic feet daily capacity, to supply gas when furnace is idle. The cities of Duluth and Superior have contracted for the daily product of oven gas, for a term of ten years. The docks of the company are fully equipped for handling and storing a large tonnage of coal. Complete dock, 1,200 feet long by 350 feet wide. A slip 150 feet wide is dredged 3,000 feet in length to a depth of 21 feet. Available dockage room on the company’s property is extension of completed dock 2,000 feet additional length and 3,000 feet by 500 feet of dock room on the other side of the present dredge slip.

THE IRON RANGES OF MINNESOTA.

There are two distinct producing iron ranges in Minnesota, the Vermilion and Mesabi. In trend they are approximately parallel (E. N. E. and W. S. W.) and about 15 miles apart. On the west both ranges disappear beneath heavy drift and on the east extend into Canada, the so-called Gunflint range near the international boundary being an eastward continuation of the Mesabi formation. This latter range is of no economic importance, however, at present. The recently discovered Cuyuna range has as yet no producing mines.

The first mention of iron bearing formation in this district is by Norwood in 1852, but it was not until 1875 that we have any record of work being done to establish the economic value of the district. In this year Prof. A. H. Chester examined the Mesabi range from Embarrass lake eastward to Birch lake. In the greater portion of the district examined by Prof. Chester the formation is highly magnetic and has never produced bodies of merchantable ore. Shortly after attention was almost wholly diverted from the Mesabi by the discovery of ore on the Vermilion range.

In the early 80's, Mr. Geo. C. Stone having succeeded in interesting Mr. Charlemange Tower in the ore deposists on the Vermilion range near Tower, docks were built at Two Harbors and the Duluth and Iron Range railroad built to Tower. The first shipment of ore was made in 1884. In 1886 the whole property, including mines, railroad, docks and land grant was sold to the Minnesota Iron Company and later, on the organization of the U. S. Steel Corporation, became a part of the holdings of that corporation. The first mine to be developed near Ely, 21 miles east of Tower, was the Chandler, which began shipping in the fall of 1887. Since then the Pioneer, Zenith, Savoy and Sibley have been opened in what is known as the Ely trough. This entire group is controlled by the United States Steel Corporation.

On the Mesabi range ore was discovered in the fall of 1890 near the present Mountain Iron mine by the Messrs. Merritt of Duluth, and in the fall of the following year on the Biwabik property by the same parties. Since these discoveries the development of this range has been phenomenal. By the end of 1893 three railways, the Duluth & Iron Range, Duluth, Mis-sabe & Northern, and Eastern Railway of Minnesota (Great Northern system) connected the mines with ore docks at Two Harbors, Duluth and Superior.

In 1907, ninety mines on the Mesabi range shipped 27,4.92,-949 tons of ore, as against 12,990,708 tons shipped from eighty-three mines on the Gogebic, Marquette and Menominee ranges.

VERMILION RANGE.

The Vermilion range extends from the vicinity of Tower to and beyond the international boundary, crossing into Canada at the eastern end of Hunter's Island. Merchantable bodies of ore have been discovered at but two localities along this extent, at Tower and at Ely, twenty-one miles east.

The iron bearing formation of this range occupies the lowest position geologically of any of the Lake Superior iron formations, being placed by Van Hise and Clements in the Archean as shown from the following succession:

Lower Huronian.	Intrusive. Granites, granite porphyries, dolerites, and lamprophyres. Knife Lake slates. Agawa formation (iron bearing). Ogishke conglomerate.
(Unconformity.)	
Archean.	Intrusive granites, granite-porphyries, and some greenstones. Soudan formation (the iron-bearing formation). (Minor unconformity). Ely greenstone, an ellipsoidally parted basic igneous and largely volcanic rock.

The ores of the Vermilion series occur in the Soudan formation (the Agawa iron bearing rocks are not of commercial importance).

At the Minnesota mine the ore is a dense hard hematite occurring in irregular connected and disconnected lense shaped bodies in the jasper, which is intricately infolded in the spheroidal greenstone or green schists, so-called on account of a characteristic spheroidal parting. The strike is about east and west and the dip approximately vertical with a westerly pitch. The underground workings at this mine are some 4,500 feet in extent east and west, and over 1,500 feet in depth. The structure here is probably the most complex in the Lake Superior iron districts. Above, the iron bearing formation, geologically, comes the basal conglomerate of the Lower Huronian carrying large boulders and masses of the iron bearing rocks.

The ores at Ely differ from the preceding, mainly in their physical structure, being much more broken and friable. The area in which they lie is a double ended trough about two miles in length east and west and some 1,500 feet in width. The general dip is nearly vertical and the pitch of the ore bodies at the west end of; the trough is to the east while the pilch of those at the east end is to the west. The iron formation here, as at the Minnesota mine, lies in a trough of the older spheroidal greenstone, but the folding is not so close. The geological succession is the same as above given. Intrusive masses and dikes of granitic porphyry and basic eruptives cut the whole series.

MESABI RANGE.

The Mesabi range extends continuously from near Grand Rapids on the Mississippi river E. N. E. for a distance of about 90 miles to near Birch lake, where it is covered by the large gabbro flow which forms the base of the Keweenawan series. The same formation (Mesabi) appears again near Gunflint lake on the international boundary and shows as far east as Thunder bay on the north shore of Lake Superior. Between Mesabi station, on the D. & I. R. Ry., and Birch lake the formation consists of alternate thin layers of chert and magnetic ore, but although considerable exploration work has been done, there is no evidence of concentration of ore in workable bodies in this area. Dr. Leith accounts for the change of ore to a magnetite by the action of the heavy flow of gabbro which is here in close proximity to the iron formation. The Gunflint beds are thin alternating layers of chert and hematite. All the workable deposits, at present known, on the Mesabi lie between Mesabi station and Grand Rapids, the greater number being in St. Louis county.

The geological succession as given by Van Hise and Leith is as follows:

Upper Huronian. (Mesabi Series.)	Virginia slate (upper slate formation). Biwabik formation (iron-bearing formation). Pokegama formation (quartzite and quartz-slate formation).
(Unconformity.)	
Lower Huronian.	Granite, intrusive in lower formations. Slate-graywacke-conglomerate formation (equivalent to the Ogishke and Knife lake formations of the Vermilion district).
(Unconformity.)	
Basement Complex of Archean.	Greenstones, including basalts, diorites, diabases, etc., hornblende-schists, and porphyritic granites and rhyolites.

The north edge of the range was easily determined as exposures of the older rocks are fairly numerous; the south edge, or more properly the north edge of the overlying black slates, was determined by drill work entirely, as there are no exposures of this slate.

The iron formation is flat-lying with a slight average dip to the south, although local high dips occur. In this respect it differs from all other districts in the Lake Superior region.

The great bulk of the iron formation is ferruginous chert more or less amphiholitic, calcareous or sideritic and gray, red, yellow, brown, or green with bands or shoots of iron ore. It is analagous to the jaspers of the other iron ranges.

A few thin beds of slate occur in the formation.

It may be said that the ore bodies in general lie with their longer axes in the direction of the trend of the formation, although they are exceedingly irregular in outline. The transition between the rich ore and the taconite (local term for the ferruginous chert of the ore formation) is usually very abrupt, and the original bedding can be plainly distinguished running through the ore. One body of ore is known to have a continuous extension of over two and a half miles and an average width of about one-half miles and to be several hundred feet thick in places. These flat-lying ore bodies vary in thickness from a few feet to over 500 feet, and a large majority occur just beneath the drift, although some have a jasper capping. The surface or overburden varies from practically nothing to some 200 feet, perhaps an average would lie between 60 and 80 feet.

The ores of the Mesabi are red, brown and yellow hematites and limonites, more or less hydrated, and are secondary replacements or enrichments of the jasper. They are supposed to be mainly derived from the silicates of iron, which are abundant in the rocks of the iron formation, and to a less degree from siderite. In physical structure they vary from a fairly compact phase to earthy or powdery phases, and are comparatively high in moisture. At the west end of the range the ores are more or less “sandy,” a condition evidently resulting from the decomposition of the cherty layers in the handed iron and chert.

In 1907 Minnesota furnished 55 per cent, of the total iron ore produced in the United States and 68½ per cent. of the Lake Superior output, the total product of the state to the end of the latter year being 177,020,984 tons.

MINING METHODS.

The mining methods employed on the Vermilion range are, at Ely, the caving system, and at Tower, longitudinal back stoping.

On the Mesabi the following methods are used: Open pit steam shovel; open pit milling; open pit milling steam shovel; slicing; square set, and slicing and caving combined.

THE CUYUNA RANGE.

The Cuyuna iron range, which lies in the vicinity of Deerwood, 80 miles west of Duluth, near the Northern Pacific railway, is the most recently discovered in Minnesota. Mr. Cuyler Adams’ attention was attracted to magnetic variations in that vicinity a number of years ago, and after detailed magnetic work, he, in 1904, started drilling near Deerwood, with the result that it was demonstrated that an iron formation exists in that vicinity. Since this time considerable drilling has been done, and shafts sunk by Pickands-Mather Company and by the Rogers-Brown Ore Company. No mines have yet been opened on this range.

The surface is rolling, dotted with glacial lakes, and the glacial drift is very heavy, in places a thickness of over 300 feet of this material occurring above the rock formation. There are few rock exposures in the immediate vicinity, practically the only indications of the iron formation being the lines of magnetic attraction mentioned above.

The diamond drilling seems to have proved that the rock succession here, from the base upward, is, 1st, either a quart-site or greenstone; 2nd, a series of iron slates containing the ore in comparatively narrow belts or lenses; 3rd, chlorite slates, and 4th, either drift of cretaceous material. This whole series is apparently cut by greenstones and granite rock.

The rocks are folded, the drilling showing that they have a practically vertical dip. There are several nearly parallel lines of magnetic attraction in this district; whether this represents the same formation brought up by repeated folding, or several different formations has not been determined, though it is probably the former.

RAILROADS.

DULUTH & IRON RANGE RAILROAD.

The Duluth & Iron Range railroad was built from Two Harbors to the Vermilion range at Tower, a distance of 67.6 miles, in 1884, and extended to Ely, 21 miles east of Tower, in 1888. It was built into Duluth in 1886, and branches were extended from its mainline to the Mesabi mines in 1892 and 1893. The original grades on this road are very steep, going north, and in the thirteen miles from Two Harbors to Highland there is a rise of 1150 feet. A new line between these points has been built with an increase of three miles in distance and with maximum grades of 1 per cent.

DULUTH, MISS ABE & NORTHERN RAILWAY.

The Duluth, Missabe & Northern railway was constructed from Stony Brook to Mountain Iron, a distance of 48.62 miles, in 1892. The Biwabik branch from Iron Junction to Biwabik, a distance of 15.54 miles, was constructed in 1892. The Superior branch from Wolf to Hibbing, a distance of 16.06 miles, was constructed in 1893. The Duluth extension from Columbia Junction to Duluth, a distance of 29.34 miles, was completed in 1893. The Alborn branch from Coleraine Junction to Coleraine, a distance of 53 miles, was constructed in 1906. The total main line mileage is 242 miles, of which 82 miles from Duluth to Hibbing is double tracked.

The maximum south bound grade against the loads is 0.3 per cent. The maximum north bound grade against the empties is 2.0 per cent., this extending only six miles from the ore docks to the south end of the yard at Proctor. The entire main line with the exception of a small part of the Biwabik branch is laid with 80 pound steel rails. The balance of the tracks arc laid with 80 pound and 60 pound steel rails.

Seven miles of the double track between the ore docks and Proctor is rock ballasted; the balance of the road is ballasted with gravel.

The shops and classification yards are at Proctor. The ore clocks, the largest in the world, are at Duluth.

GREAT NORTHERN RAILWAY LINE—Mesabi Division.

The Great Northern Railway line acquired what is now its Mesabi Division, over which line ore is transported from Mesabi range mines to docks at Allouez, Wisconsin, by purchase of the Duluth, Superior & Western railway (Duluth & Winnipeg) in 1898. At time of purchase this line extended from Duluth to Deer river, connecting with the Duluth, Mississippi River & Northern railway at Swan river, this latter road extending to the mines. In 1898 the purchase of the Duluth, Mississippi River & Northern road was effected, which gave the Great Northern a line through to Barclay Junction (now Chisholm), Minnesota. In 1900 and 1901 extension was built from Barclay Junction to Virginia, and in 1901 and 1902 line was built from Ellis (near Virginia) to a point on the old D. S. & W., known as Brookston now, then Stony Brook. In 1902 and 1903 what is now designated as the "South Range Line" was constructed from point near Hibbing (Kelly Lake) to connect with main line a few miles out of Virginia (Flanders).

There has also been built a "cut-off" known as the Kelly Lake-Fermoy line, running from point immediately south or east of Kelly Lake to west end of Fermoy, passing track on the Brookston line; length 23.4 miles; ruling grade, east bound 0.1, west bound 0.6. The actual distance from Kelly Lake to Fermoy is 24.074 miles. The object of this "cut-off" is to make a shorter haul between the mines and Allouez ore docks.

Allouez to Swan River, 87 miles; Swan River to Chisholm, 33 miles; Chisholm to Virginia, 18 miles; Ellis to Brookston, 46 miles; South Range line, 11 miles. There is a uniform grade of about .04 over entire Mesabi division.

Shops at Superior, Wisconsin. Ore docks and yards at Allouez, Wisconsin, for receiving ore lake end. Large assembling yard at Kelly Lake, for mine end.

[Data Relating to Railroads, Docks, and Shipments from Minnesota Ranges]

DATA RELATING TO LOADING AND UNLOADING IRON ORE.

AVERAGE AND TOTAL ANNUAL TONNAGE, TIME LOADING BOATS, TIME PER 1,000 TONS. D. M. & N. RY. DOCKS.

Year.	Average Tonnage.	Total Tonnage.	Time Loading Hours.	Time Loading Per 1,000 Tons Hours.
1895	1809	1,598,783	4:00	2:13
1896	2214	1,988,932	5:16	2:24
1897	3541	2,371,000	7:40	2:10
1898	3350	2,635,264	8:10	2:07
1899	3803	3,509,965	7:24	1:57
1900	3873	3,888,986	6:31	1:43
1901	4459	3,437,955	5:57	1:20
1902	4814	5,598,408	7:09	1:29
1903	5668	5,356,473	8:47	1:33
1904	5679	4,649,611	10:55	1:56
1905	6037	8,807,559	11:11	1:51
1906	6973	11,220,218	12:47	1:50
1907	7516	13,445,977	10:07	1:21

MAXIMUM DAILY SHIPMENT.

Year.	Date.	Tons.
1904	Sept. 4	62,723
1905	June 30	86,340
1906	Sept. 16	112,589
1907	July 2	126,085

In 1906, Steamship E. J. Earling loaded 9,277 tons of iron ore in 70 minutes.

RECORD OF LOADING STEAMER AUGUSTUS B. WOLVIN, AUG. 5, 1904, GREAT NORTHERN DOCKS.

Boat arrived at dock	2:45 p. m.
Started to load	4:16 p. m.
Finished loading (about 9,000 tons)	4:50 p. m.
Shifted to complete cargo	45 minutes
Loading completed (10,245 tons)	5:45 p. m.
Total time at dock	3 hours
Total time loading	1:29

This cargo unloaded at Conneaut in 4 hours and 30 minutes.

DATA RELATING TO ORE CARRYING RAILROADS OF NORTHERN MINNESOTA.

NAME OF ROAD	Weight of Rails per Yard	Weight of Freight Locomotives in working order, with Tenders in Tons	Number of Freight Locomotives	Capacity of Standard Ore Cars in Tons	Number of Ore Cars
Duluth & Iron Range Railroad	80 and 100	Twelve Wheelers 132½ Ten Wheelers 118 Consolidations 98	43 Twelve Wheelers 6 Ten Wheelers 41 Consolidations	Steel Construction 50 Wood Construction 24	Steel Construction 2545 Wood Construction 4500
Duluth, Missabe & Northern Railroad	80	19 x 26 Cyl. 61½ 22 x 28 Cyl. 82	23 19 x 26 Cyl. 51 22 x 28 Cyl.	Steel Construction 50 Wood Construction 35 and 25	Steel Construction 4455 of 50 tons Wood Construction 1685 of 35 tons. 165 of 25 tons.
Great Northern Railroad Mesabi Div.	60 75 77½ and 85	4 Consolidation 105 10 Moguls 75 30 Prairie 103 2 Mastadon 112	46	Steel Construction 50 Large Wood Construction 50 Small Wood Construction 24	Steel 3300 Large Wood 400 Small Wood 600

During the shipping season of 1907 these three roads carried to lake ports 27,492,949 tons of ore. During one month (October) the Duluth, Missabe & Northern alone carired 2,502,255 tons.

YEARLY INDIVIDUAL MAXIMUM CARGO RECORDS.

Ships Passing Out of Lake Superior.

Steamers.

YEAR	Largest Single Cargo Net Tons	Greatest Amount of Freight Carried Net Tons	Greatest Number of miles run	Greatest No. of Mile-Tons.
1900..	8,463	195,550	45,318	154,554,378
1901..	8,222	161,375	41,370	132,822,226
1902..	8,441	183,270	45,340	158,858,138
1903..	8,914	164,763	45,330	158,843,973
1904..	11,536	177,729	33,516	156,410,487
1905..	12,368	274,401	41,374	249,038,472
1906..	13,272	313,434	42,986	249,353,656
1907..	13,800	339,151	43,296	274,863,249

Sails.

1900..	8,206	149,091	30,947	124,399,966
1901..	8,288	125,301	26,424	99,429,012
1902..	8,485	250,258	32,032	119,437,488
1903..	8,671	128,201	26,569	114,536,002
1904..	8,736	117,365	24,158	106,643,498
1905..	9,184	155,772	31,481	127,243,648
1906..	8,960	141,770	31,575	126,745,992
1907..	9,408	152,144	27,039	121,205,504

Names of Vessels Making Above Maximum Records.

1900..	John W.Gates	Presque Isle	Troy	John W.Gates
1901..	W. Edenborn	Presque Isle	Buffalo	J. J. Albright
1902..	I. L. Elwood	W. Edenborn	Troy	W. Edenborn
1903..	W. Edenborn	John W.Gates	Buffalo	Bransford
1904..	A. B. Wolvin	A. B. Wolvin	Huronic	A. B. Wolvin
1905..	E. H. Gary	A. B. Wolvin	Duluth	A. B. Wolvin
1906..	J. P. Morgan	E. H. Gary	E. H. Gary	E. H. Gary
1907..	J. P. Morgan	J. P. Morgan	J. P. Morgan	A. B. Wolvin
1900..	Madeira	Madeira	Madeira	Madeira
1901..	Manila	Marsala	Sirl. L. Bell	Madeira
1902..	Jno. Smeaton	John Fritz	Alex. Holly	Marsala
1903..	Manila	A. Maitland	Barge No. 105	A. Maitland
1904..	Jno. Smeaton	A Maitland	Maida	A. Maitland
1905..	Jno. Smeaton	Manila	Marcia	Jno. Smeaton
1906..	Jno. Smeaton	A. Maitland	W.LeB.Jenny	Constitution
1907..	Jno. Smeaton	Jno. Smeaton	Jno. Smeaton	Jno. Smeaton

The maximum freight traffic through the canals for a single day was on August 26, 1907, when 487,649 tons were passed. The vessel passages on this day numbered 121, the aggregate registered tonnage being 284,385. Total traffic into and out of Lake Superior for the year was 58,217,214 tons, an increase over the year before of 7 per cent., and $58,458,345 were paid as freight charges. Of the total tonnage 68 per cent. was iron ore.

AVERAGE FREIGHT RATES ON IRON ORE PER GROSS TON FROM PORTS NAMED TO OHIO PORTS—TABLE COVERING WILD AND CONTRACT RATES FOR TWENTY YEARS PAST.

YEAR	ESCANABA		MARQUETTE		ASHLAND and other ports at the head of Lake Superior	
	Wild or Daily Rate	Contract Rate	Wild or Daily Rate	Contract Rate	Wild or Daily Rate	Contract Rate
1887	$1.50	$1.40	$1.87	$1.63	$2.23	$2.00
1888	1.05	.90	1.30	1.15	1.42	1.25
1889	1.01	1.00	1.19	1.10	1.34	1.25
1890	.89	1.10	1.07	1.25	1.17	1.35
1891	.84	.65	1.02	.90	1.11	1.00
1892	.74	1.00	.98	1.15	1.15	1.25
1893	.56	.85	.71	1.00	.77	1.00
1894	.46	.60	.60	.80	.78	.80
1895	.73	.55	92.	.75	1.13	.80
1896	.52	.70	.66	.95	.77	1.05
1897	.45	.45	.55	.65	.57	.70
1898	.51	.45	.60	.60	.62	.60
1899	.95	.50	1.08	.60	1.29½	.60
1900	.69½	1.00	.78½	1.00	.84½	1.25
1901	.64	.60	.79	.70	.89	.80
1902	.59	.60	.66	.70	.77	.75
1903	.61	.65	.72	.75	.81	.85
1904	.53½	.55	.62	.60	.70	.70
1905	.61	.60	.70	.70	.77	.75
1906	.60	.60	.70	.70	.75	.75
1907	.60	.60	.70	.70	.75	.75

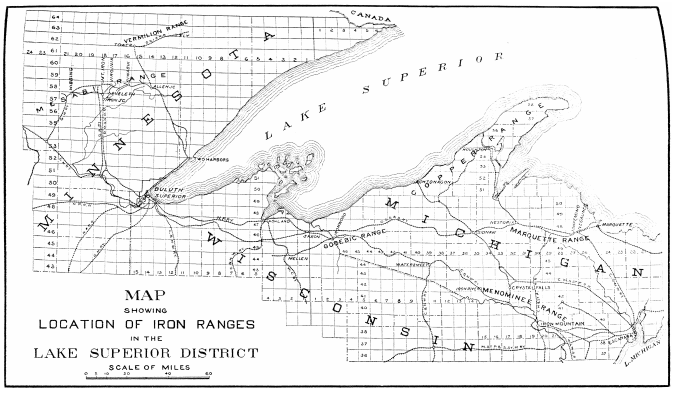
Charge to vessels in 1905 for unloading iron ore was 20 cents per ton. The wooden vessels that required trimming paid an additional charge of about 3 cents per ton for that service.

Average ore rates for the entire period of twenty years: Escanaba, wild 76 cents, contract 76 cents; Marquette, contract 91 cents, wild 91 cents; Ashland and other ports at the head of Lake Superior, contract 98 cents, wild $1.03.

Average for past ten years: Escanaba, contract 60 cents, wild 62 cents; Marquette, contract 71 cents, wild 72 cents; Ashland and other ports at the head of Lake Superior, contract 76 cents, wild 78 cents.

RAILWAY	LOCATION	Dock No.	Number of Pockets	Storage Capacity	Height, Water to Center of Hinge Plate	Height, Water to Deck of Dock	Width of Dock Outside to Outside of Partition Posts	Length of Spouts	Length of Dock	Angle of Pockets
				Tons	ft. in.	ft. in.	ft. in.	ft. in.	ft.	DEG. MIN.
C. & N. W. Ry	Escanaba, Mich.	1	184	21243	38-10	48- 8	37- 0	21- 0	1104	38-30
" "	"	3	226	28792	31- 2	52- 8	37- 0	27- 0	1256	45- 0
" "	"	4	250	34925	33-6	59- 2	37- 0	30- 0	1500	45- 0
" "	"	5	232	33663	28- 6	58- 3	37- 0	21- 8	1392	40- 0
" "	"	6	320	69760	40- 0	70- 0	50- 2	30- 0	1920	45- 6
" "	Ashland, Wis.	1	234	42120	40- 0	70- 0	50- 2	30- 0	1404	45- 0
" "	"	2	234	42120	40- 0	70- 0	50- 2	30- 0	1404	45- 0
			1680	TOTAL 272523						
D. & I. R. R. R.	Two Harbors, Minn.	1	202	40400	35- 5	59- 6	49- 0	27- 0	1388	38-42
" "	" "	2	208	41600	33- 5	57- 6	49- 0	27- 0	1280	38-42
" "	" "	3	170	34000	40- 0	66- 0	49- 0	27- 0	1054	43-32
" "	" "	4	168	36960	37- 0	62- 0	49- 0	29- 0	1042	38-42
" "	" "	5	168	35450	39- 0	66- 9	49- 0	30- 0	1050	43-32
" "	" "	6	148	45880	40- 0	73- 0	53- 0	32- 4	1462	45- 0
			1064	TOTAL 234290						
D. M. & N. Ry	Duluth, Minn.	2	384	69120	32- 0	57- 6	49- 0	27- 9	2336	45- 0
" "	"	3	384	80640	40- 7	67-½	59- 0	27- 9	2304	45- 0
" "	"	4	384	119274	41- 9½	72- 6	57- 0	30- 1½	2304	45- 0
			1152	TOTAL 269034						
G. N. Ry	Superior, Wis.	1	374	100980	40- 0	73- 0	62- 8	32- 4	2244	45- 0
"	"	2	350	94500	40- 0	73- 0	62 8	32- 4	2100	45- 0
"	"	3	326	88020	40- 0	73- 0	62- 8	32- 4	1956	45- 0
			1050	TOTAL 283500						
D., S. S. & A. Ry.	Marquette, Mich.	4	200	28000	27- 9	47- 3	36- 8	21- 1	1200	39-45
" "	"	5	200	50000	40- 0	70-10	51- 0	32- 4	1236	45- 0
			400	TOTAL 78000						
L. S. & I. Ry.	Marquette, Mich.	1	200	36000	30- 9	54- 0	50- 0	27- 7	1232	38-40
W. C. Ry	Ashland, Wis.	1	314	48356	40- 0	66- 2	36- 0	27- 0	1908	50-45
C. M. & St. P. Ry.	Escanaba, Mich.	1	240	50400	40- 2⅝	66- 6	52- 0	[illegible]	1500	45- 0
" "	"	2	240	63500	40-11½	69- 2	54- 0	30- 4½	1500	45- 0
			480	TOTAL 113900						
Algoma Cen. & H. B. Ry.	Michipicoten, Ont.	1	12		34- 0	43- 4	25- 0	22- 6	311-9	44- 0
Total Storage Capacity				1333603						

This table is compiled annually by the cheif engineer of the Duluth & Iron Range Railway, and includes the steel dock No. 6 of that road, not quite completed June 23rd, 1908.



[Map Showing Location of Iron Ranges in the Lake Superior District]

MINUTES OF MEETING.

WEDNESDAY, JUNE 24TH, 1908.

Headquarters for the Institute were established at the Spalding Hotel, Duluth, where members and guests were provided with programs, badges and assigned accommodations for the trip to the ranges. There were about two hundred in the party. The afternoon was spent in a visit to the plant of the Great Northern Power Co., at Thompson and other points of interest in the city. The Duluth clubs and the Northland Country club entertained the members during the afternoon and evening until the departure of the trains at one o'clock Thursday morning. There were two special trains, one made up of C. M. & St. P. sleepers and diners and one of private cars. Some of the points of interest visited in Duluth are described in the program furnished for the occasion and printed in this volume. The brief stay in Duluth was much enjoyed by the members.

THURSDAY, JUNE 25TH, 1908.

At 5 130 a. m. the party arrived at Ely on the Vermilion range where the Chandler, Pioneer, Zenith, Savoy and Sibley mines were visited; leaving there at 11:00 a. m. and stopping for a brief visit at the Minnesota mine at Soujdan near Tower. At this property work was first started as early as 1875, but no ore was shipped until 1884. This mine has to its credit a total shipment to the close of 1907 of 8,153,820 tons. During 1907 the shipments amounting to only 102,977 tons.

Leaving Soudan, the Biwabik, Fayal, Adams and Spruce mines on the Mesabi range were next visited, the train leaving Eveleth at 6:30 p. m. for Virginia. The members found many improvements in the plants at the different mines since the last visit of the Institute, due mostly to the plan to standardize the buildings and equipment.

Upon arrival at Virginia at 7:15 p. m. the party was met by a committee of citizens who escorted them to the high school where the first business session was held. This is a beautiful three-story building of which the people of Virginia are justly proud, it indicates the thrift and enterprise of its citizens in thus providing for the education and welfare of its children.

EVENING SESSION.

The meeting was called to order by Mr. T. F. Cole, President. The attendance numbered two hundred and twenty-five members and guests. Mr. Cole introduced Mr. Louis M. Osborn, who had been delegated by the citizens of Virginia, to welcome the members. He spoke, as follows:

Mr. President and Members of the Lake Superior Mining Institute, our guests and fellow citizens: On behalf of our little city of 8,000 or 10,000 persons, we welcome you here this evening. We feel highly complimented that this most notable gathering of practical and scientific mining men should have chosen Virginia for one of its most important meetings. You are all busy men with limited time for this trip. We are glad you will be with us until ten o'clock tomorrow, and trust that you as a body, and also as individuals, will soon spend more time among us.

For those of you who have not been here before, it might not be amiss to say that you are now in the Roosevelt High school, almost directly in the center of the city. Four blocks to the north is the north limit, and the south boundary of the settled portion is seven blocks distant. Your trains are just four blocks to the east, with many active mines just beyond. From any portion of the city, this building will act as a guide post. Being the geographical center of St. Louis county and of the iron ranges, our four railroads make us the railroad center as well, and give us direct communication with Canada, and all points east, west and south. Our sister cities depend almost entirely upon their minerals. We have, in addition to many mines, three saw mills, the largest one having been built last summer at a cost of about a quarter of a million dollars. The oldest built, as you may have noticed, is now being remodeled for the purpose of cutting some 30,000,000 feet of timber for the Oliver Iron Mining Company. In spite of hard times, we are still growing. A new addition, platted about a year ago, has been entirely sold and half of the lots have already been built on. Uncle Sam has also been good to us. A few days ago free mail delivery was established here and congress has recently appropriated $60,000.00 for a federal building—the first city on these ranges to be so favored. We are now vigorously discussing where it should be built. We hope soon to have a city park—the first one in these mining towns—-and pleasure boats on our two lakes, and when you next visit us, which we trust will be soon, you may hardly recognize Virginia.

Gentlemen, to Virginia now, and at all times, you are welcome, doubly welcome.

Mr. W. J. Olcott, of Duluth, Vice-President of the Oliver Iron Mining Co., responded to the address of welcome, as follows:

Mr. President, Mr. Osborn, Members of the Lake Superior Mining Institute and friends all: This world is one continual surprise; when I came here today I had no idea that I should be called from such a number more able to respond. Mining men, from the nature of their business, are operators. Many have been connected with large corporations, called closed corporations, told to say little or nothing and that the lawyer should do the talking; it is embarrassing, therefore, to be called upon with such short notice. We, however, feel such regard for the President of the Institute and our Company that when he asks us to do a thing we do it cheerfully and to the best of our ability.

We appreciate, as members of the Institute, the cordial web come given by the people of Virginia. We appreciate also and congratulate you on the fact, that you have such a beautiful building to offer us in which to hold our meeting. I remember my first visit to Virginia in

1892, when there was only one small log building here and that was on the hill near the Missabe Mountain mine. Some people reported, before I made the trip, that the ore on the Missabe range was no good and would never be merchantable. However, I went on horseback from Mesaba station on the Duluth & Iron Range through to Hibbing, took my own samples from test-pits and found high-grade ore. Since then the territory around Virginia has been quite thoroughly explored and has developed deposits of ore that will last for many years. Unfortunately it is high in phosphorus, but it is a question of only a few years when the furnace people will have sufficient open-hearth plants to successfully handle this character of ore. When that time arrives Virginia will double in size and this building will be supplanted with other buildings to accommodate the children, which, I presume, you will have to fill them.

I just returned from a visit across the water and am glad to be able to say that during my twenty-five years in the mining business I have known and become associated with many classes of men and I think the Cornish people deserve the greatest credit for the progress made in mining in the Lake Superior region. They came from a country of sturdy manhood to our hard northern climate, encountered the dangers of pioneer mining and we owe more to them than any other race. I have heard these men tell Cornish tales, both amusing and interesting; heard them tell of the towns from which they came, their people and their friends, and no one can imagine the pleasure it gave me to go to the Levant mine, the big mine under the sea; to visit Penzance, Truro, Camborne and other towns. Camborne is the place from which many of our greatest mining men have come. I had the pleasure of going to the home where the Trezona brothers were brought up and it is a great credit to this country that these men have been so successful. It was a pleasure to go there and meet their family and receive such a cordial reception. I also had the pleasure of going to Liskeard, where Captain Goldsworthy was brought up, and going to the mine where he worked. These are only two of many examples that could be cited. There was no part of the trip through Italy, France, Switzerland, Germany and England that I appreciated more than traveling through the mining district of Cornwall. To be sure, I did not see many points to be gathered in the way of improvement in mining methods or equipment. Most of these mines are worked out or abandoned; those now working are operated under the most unfavorable conditions. They are hoisting at the Dolcoath mine from a depth of 3,000 feet, with one-ton skip. To dump these it is necessary to unlatch the door in the bottom and then latch it again by hand before lowering. It takes ten minutes to make a hoist and it takes two and a half to three hours to get the men out of the mine; they say four men get in the cage going down and six crowd in coming up. However, these are the mines where the start was made in mining, and the men who came over here, although they brought their homely ideas and primitive methods, have been the ones to take the lead and follow up improvements. Today we hoist in one shaft, in a month, as much as they hoist in a year. After traveling through the different countries and seeing the conditions under which the laboring classes work and live, the meager pay which they receive, the small opportunities for them to rise above their station, I come back to America loving my country better than ever before, appreciating the opportunities it affords a man, providing he has ability, courage and energy to get to the front, and I hope that each and every one of you will, whenever the opportunity presents, avail yourself of such a trip and, seeing conditions under which your fellow men work, I am sure you will come back feeling better satisfied with your own country, with a greater love for its institutions and laws and most important of all, you will look at conditions as they arise, from a much wider point of view.

Following the response of Mr. Olcott, President Cole addressed the members as follows:

PRESIDENT'S ADDRESS.

Members of the Lake Superior Mining Institute. I am sure that all the people, living on the iron ranges of Minnesota, join with me in extending to you a hearty welcome to this, the Thirteenth Annual Meeting of the Institute and it gives me much pleasure to greet you tonight. I assure you that your return will be looked forward to by the people of these ranges with a great deal of gratification.

I would like to call attention to a few facts regarding the work of the past two years in the Lake Superior mining districts. I will not attempt to go into details for papers on some of the subjects have either been prepared or will be written and presented at some future meeting.

Steel Construction—

The use of steel for mine buildings and head frames for shafts is increasing, in addition a considerable quantity of this metal is now used for frames to support the walls of shafts. Whenever it is possible to locate shafts in stable rocks affording a permanent and fairly secure outlet steel or concrete lining should be used. Danger from fire is lessened and the cubic feet of rock to be broken and hoisted is reduced by using steel frames instead of timber.

The Oliver Iron Mining Company is now planning to use steel frames to support the walls of the main openings such as drifts and crosscuts on each level instead of using large timber for such support. We expect to save money in protecting our drifts and crosscuts with this material for the large timber we will secure from our lands will then be cut into merchantable lumber, and good value can be secured for this product. The people of the country will be benefited for high grade lumber from that part of the tree free from knots and other defects is each year becoming more difficult to secure in requisite quantities. The first ore dock to be constructed of steel and concrete is now being erected at Two Harbors in this state.

Water Power Development—

Notable installation of structures, buildings and equipment to utilise the energy of water powers in the Lake Superior region have been made during the past two years; one at the Sturgeon Falls near Vulcan, Michigan, by the Penn Iron Mining Company,* the other at the falls on the St. Louis river near the City of Duluth. Conservation of natural resources should mean the development and utilization of energy that all our water powers will produce. The saving to the people of this nation is well illustrated by the fact that with ordinary waste in numerous steam power plants necessary to serve the growing industries located near the head of the lakes, the full utilization of this one water power near Duluth will equal the energy that can be secured from the output of a mine producing 1,300,000 tons of good steam coal per annum.

State governments should construct reservoirs of ample capacity to store flood watery and ensure an average flow of water in its rivers each day of the year, making a reasonable charge to individuals or power companies who may be benefited thereby.

*This plant is fully described in the paper by Messrs. Orbison and Armstrong, entitled "The Hydro-Electric Plant of Penn Iron Mining Co." and published in this volume.—Secretary.

Conservation of Forest Products—

United effort should be made by all members of this Institute to secure careful consideration by state officials and members of state legislatures of the important subject of conservation of our forests, and advocate the enactment of laws that will be just and equitable to all individuals or corporations who may desire to foster the growth of young thrifty timber and reforest areas of land that is not valuable for agricultural purposes, the soil of which is suitable for reforestation. Much land of this character is now comparatively valueless and taxes are not being paid thereon.

Steel Manufacturing In the Northwest—

The decision of the United States Steel Corporation to erect blast furnaces and steel works to manufacture steel in Duluth is of tremendous importance to the people living in Minnesota, as well as in the entire Northwest. The raw materials to make iron can be assembled in Duluth at reasonable cost, and the volume of finished steel that should be distributed from Duluth is already a very important tonnage and is increasing in quantity very rapidly each year. From that city steel can be distributed to points comprising two-thirds of the area of the Dominion of Canada. The states comprising the Northwest are tributary to the head of the lakes and the mileage from Duluth to Omaha, Denver, Salt Lake City and San Francisco is the same as from Chicago. This means steel can be made in Minnesota and distributed in the middle Rocky Mountain states and the entire Pacific coast.

Western Missabe—

During 1906 and 1907 extensive development of the sandy ore deposits located in the Western Missabe district has been made. Openings in the ore disclosed the character of material to be concentrated. It was found the ore and sand would have to be subjected to a very effective abrading treatment before the mineral could be successfully concentrated. A committee was selected to visit the iron ore concentrating plants in the South, and Mr. John U. Sebenius of our engineering department with General Superintendent John C. Greenway, Mr. J. W. Leech, and Superintendent Dudley composed this committee. It was found the log washers used for concentrating the brown ores in Alabama would give the abrading effect required. It was decided to erect a temporary concentrating plant and install a log washer with other equipment, such as revolving screens and picking belt. The log washer not only is effective in giving the necessary treatment but it is a good concentrator and the improved type of log washer or Turbo invented by Mr. Greenway may be selected for the final treatment of material delivered by the log washer or caught from the overflow in settling tanks instead of revolving screens.

Valuable assistance was rendered by Doctor L. D. Ricketts of Cananea, Mexico, and William Nicholls, now in charge of the concentrating plants of the Nevada Consolidated Copper Company and Cumberland-Ely Copper Company operating in Nevada. Much credit is due the persons mentioned and their assistants for the successful outcome of the experimental work, and a concentrating mill with large capacity will be erected near Coleraine in the near future.

Mr. Cole then introduced Prof. N. H. Winchell, of Minneapolis, Minn. Mr. Winchell has long been identified with mining operations in the state and was among the first to report on the geology of the Vermilion and Mesabi ranges. His paper on the "Structures of Mesabi Ores," is published in this volume.

Mr. Spencer S. Rumsey, of the mechanical engineering department of the Oliver Iron Mining Co., Duluth, read a paper entitled, "Automatic Throttle Closing Device for Hoisting .Machinery." This paper with complete drawings appears in this number.

Prof. L. S. Austin, of the Michigan College of Mines, Houghton, Mich., read a paper on "Sampling of Iron Ores," which was received with much interest. It is the object of the Institute to gather as much information as possible on this import ant subject and members are invited to prepare papers for the next annual meeting. Also to further discuss previous papers presented on this topic.

This concluded the reading of papers for the evening and the president on motion appointed the following committees to report at the session on Friday evening:

AUDITING COMMITTEE—John M. Bush, Ironwood, Mich.; Charles T. Kruse, Ishpeming, Mich.; Charles Grabowsky, Ely, Minn.

COMMITTEE ON NOMINATIONS—Frank E. Keese, Ishpeming, Mich.; Norman W. Haire, Houghton, Mich.; Charles H. Munger, Duluth, Minn.; Wm. J. Richards, Crystal Falls, Mich.; D. E. Sutherland, Ironwood, Mich.

On motion by Prof. F. W. McNair, of the Michigan College of Mines, a vote of thanks was extended by the Institute to the people of Virginia and the Commercial Club, for their kind reception and to Professor Bliss for the use of the school building for its meeting.

There being no further business the meeting adjourned to Friday evening, at Hibbing.

FRIDAY, JUNE 26TH.

The early morning was spent in visiting the mines at Virginia and at ten o'clock the party left to continue the trip over the range. The first stop was made at the Mountain Iron mine. This mine has the distinction of being the first discovered on the Mesabi range and was also the first in making shipments, and stands today at the head of the list in total tonnage. The guide prepared by Horace V. Winchell for the first meeting of the Institute, in March, 1895,* gives the date of the discovery of merchantable ore on the Mesabi range, as 1891 and 1892. It was in the latter year that the Mountain Iron mine made its first shipment of 4.245 tons, and for which year it was the only shipper from this range. The total tonnage up to end of 1907, is 16,992,173, which is the largest for any one mine in the entire Mesabi district.

At the Monroe-Tener mines the party was met by a reception committee from Hibbing. A train of seven flat cars equipped with comfortable seats had been prepared by the committee to take the visitors through the open pits where the regular coaches could not be handled. The party was conveyed by this observation train to Hibbing where the Morris, Hull-Rust and Mahoning mines were inspected. The train was taken to the bottom of the pits, affording a splendid opportunity to see the workings. This feature added greatly to the interest of the trip.

The Institute was accorded a splendid reception by the citizens of Hibbing, a circular and map of the district had been prepared and was distributed to the visitors. A ball game between the Hibbing and Virginia teams being among the features of entertainment furnished. Following is copy of circular:

To the Members of the Lake Superior Mining Institute:

The citizens in general and the resident mining men in particular welcome you to the Hibbing district. Herewith will be handed you a map of the Hibbing district showing location of mines, roads, etc., also the shipments for 1907. Upon your arrival at the Monroe-Tener mine, a committee of one hundred of the representative citizens of Hibbing and vicinity, each bearing a badge with the inscription: ''Reception, Ask Me" will meet and circulate among you; you will find them all good fellows and willing and anxious to do your bidding. After inspecting the mines in the east end of the district including the Hartley, Myers, Shenango, Monroe-Tener, Chisholm, Pearce, Clark, Leonard, Glen and Pillsbury, you will arrive at Hibbing between two and three o'clock p. m.; and you will be given an opportunity of looking over the Morris, Albany, Buffalo, Burt, Sellers, Hull-Rust and Mahoning mines, among which you will see the largest exposed ore body in the world.

Not alone content with having the largest mines in the world, we believe we have the best base ball club in Northern Minnesota, and to those who enjoy this kind of amusement we will give an opportunity of witnessing a first-class article of ball between the home team and a team from Virginia. A separate section of the grand stand will he set aside for the .members of the Institute and their friends; refreshments will be served and you are at liberty to root for the visiting team.

The parlors of the Algonquin Club will be open afternoon and evening to members, of the Institute and also to any member of the local reception committee.

We will be glad to show you through our school buildings, our Carnegie library and would also be glad to show you our fair grounds.

In the evening at 8 p. m. you are earnestly requested to attend the business session of the Institute at the High school, and finally the mayor has kindly instructed the police force to see that you leave town on schedule time.

F. L. COVENTRY,
Chairman Reception Committee.

*Published in Vol. Ill, 1895, pages 11 to 32.

EVENING SESSION.

At 8:30 p. m. the members and guests together with many of the citizens of Hibbing, met at the auditorium of the High school where the business session was held. The program opened with several selections by the High School orchestra which were very well rendered. The meeting was called to order by President T. F. Cole who introduced the Rev. Frank Durant, delegated by the people of Hibbing to extend their welcome to the members. Mr. Durant spoke as follows:

Mr. President, members of the Lake Superior Mining Institute and friends: It is with great pleasure that we welcome you to our city. When the reception committees' badge was pinned upon my coat and the all-embracing words "Ask me" demanded some knowledge of your great industry I protested that iron mines and mining were a sealed mystery to me. I was then asked what I knew about copper, to which I could but reply, "I have some to sell"; the answer came, "There are more like you." We do welcome you most heartily to our city; we have endeavored to express that welcome since we met you this noon and it will be simply impossible for you, sleeping or waking, to get away from our care and oversight until you take your final departure from our midst. Indeed, we wish that your stay could be prolonged, that you might see something of the hospitality of our homes, the sweetness and beauty of our young womanhood, the graciousness of our wives and mothers; we have these in great abundance and

gladly would we share them with you gentlemen of the Mining Institute.

In welcoming you I will not point with pride to our beautiful school buildings, symbolizing our interest in education. These things are our first thought and are characteristic of American interest everywhere; enough that Hibbing has them, that there are no better or finer anywhere and that this youngest and biggest and busiest range town—for it is that—has education as her first and chief concern. Neither will I point to you our Carnegie library—something to be had for the asking—but I do call attention to the splendid zeal that has mothered the enterprise and the greater zeal that will make our library one of the best institutions in our city.

Those of you who were here a few years ago cannot but see a vast improvement today, in the appearance of our store buildings, our substantial business blocks, and above all, the large and ever-increasing number of men and women pioneers of brain and brawn who are making for civilization in our northern country.

These iron ranges demand men and women of the highest type. There is no room for the mollycoddle. As a mother looks forward to the birth of her first born, longing for and awaiting the advent of a strong, manly character, so our range country longs and yearns and welcomes strong manhood and womanhood. There is no place for the weakling in her posts of position; the morally weak will be lost in the saloon and the low resort; the morally weak will find his place on the outskirts; the careless and indifferent will help fill the rank of the unemployed and dissatisfied. It is the strong and brave and true that are wanted and our town boasts of her fair share. As in the mines around here there is ore of many shades and grades, low and high, grading into finest bessemer, and the one strong quality in all is the iron, so with our men and women—many grades of workmen, many positions of trust and responsibility to fill, captains of industry, hardy workmen in the commercial and mining industries, and the one chief uniting characteristic of all is the iron in the blood.

To the town made by such men and women we bid you welcome—to Hibbing, the largest, busiest and biggest. We hope your visit here will be profitable and your hearts happy.

Responding to Rev. Durant, Mr. Cole spoke; as follows:

On behalf of the members of the Institute I thank you for the hearty and cordial good will extended to us; the words you have spoken tonight were hearty. The greeting we received when we arrived at the Monroe-Tener mine was hearty; they had big and strong men there. It was good to our members to see the evidences of welcome on every hand.

All along, as we visited various mines on the Eastern Mis-sabe, we saw lines of splendid locomotives and steam shovels awaiting the time when we could put them to work; they were prepared as for winter, being well greased and oiled to withstand any encroachment of the elements. I think last year there were none of these machines idle. There has come a financial depression. Many locomotives and steam shovels are idle because we cannot sell the ore. Copper suffered first. In the metal family it is looked upon as somewhat of a luxury, but it is a good metal; it is enduring and will withstand the ravages of the elements for all time; it is a beautiful metal and is today used for finishings of the high priced furniture that enters our homes; it enables mankind to take advantage of falling waters, but naturally it is a metal that is the first to suffer a decline when adverse conditions in the commercial world befall us. I want to say to you that we cannot sell iron ore freely this year and this is not an opportune time to sell copper at remunerative figures, but the day is coming when the metal will again be in demand and certificates will sell in the market at a figure that will more nearly evidence the real value of the mines on which they were issued. Say this to your good friends and the people of Hibbing. It may not be long before we will have to start the idle steam shovels and locomotives and it is not going to be long before the engineer will be ready with plans to utilize water powers and we shall again have prosperity in this land of ours. They cannot keep industry back for any long period.

The members of the Institute have evidenced their delight in Hibbing and its people and selected it as a place to hold a business meeting. The people of Hibbing not only extended us a hearty welcome today, but they even provided athletic exhibitions for us; I never saw a better ball game in my life than that played on the Hibbing field this afternoon, and with reference to the good wives, the mothers, the daughters; we know that they were pleased to have us with them; this was evidenced by their goodness in serving refreshments to the mining men. The residents of the city clearly evidenced their appreciation, of our coming.

I believe it was six years ago since we met here and the development of the iron ore business in this district has been marvelous since that time. We hope by the time of our next meeting here your esteemed people will have enjoyed and be enjoying greater prosperity and the development has reached a point very much larger than it has today.

Mr. J. H. Hearding, of Eveleth, Minn., addressed the meeting on the subject of “Biographies of the Early Settlers of the Lake Superior District.” This work was first suggested by Mr. Hearding at the Houghton meeting in August, 1906, since then he has devoted considerable time to the subject.

BIOGRAPHICAL ADDRESS BY J. H. HEARDING.

The Lake Superior region of the United States comprises the Upper Peninsula of Michigan, Iron, Ashland, Bayfield and Douglass counties of Wisconsin, and St. Louis, Lake and Cook counties of Minnesota, all of which territory lies adjacent to the lake and also practically includes Florence county, Wis., and adjacent territory on the

Menominee iron range. The term itself, though not at all indicative, has grown to mean the mineral bearing districts and the mining regions which practically surround the lake itself, and the towns and cities that have grown up in consequence of the mining operations.

When the southern part of Michigan and Wisconsin were comparatively well settled regions, the Lake Superior country was practically a wilderness, populated by savages and game. Many rumors existed of untold mineral wealth, and in the latter part of the eighteenth century and the early part of the nineteenth century, one or two sporadic attempts were made to exploit this region by French and English explorers and capitalists, but these attempts proved fruitless, and the region again relapsed into its original quiet and obscurity.

It was not until 1840 or a little after that the inhabitants of southern Michigan began to look towards the northern peninsula with any degree of interest, for it was at that time that Dr. Douglass Houghton was appointed State Mineralogist and commenced to investigate the possibilities of both peninsulas in the way of mineral wealth. His efforts were successful in many ways, but owing to his untimely end on the shores of the lake at Eagle river, at what was practically the beginning of his career, he accomplished much less than he would have, had he been spared. His investigations, however, attracted to the upper peninsula many men of many types who were associated intimately on account of their environment and unity of purpose, and these men eventually developed into what might be called a distinct type through the power of association.

That they impressed their personal character on their descendants and successors and that their characters were good and true, is attested by a statement made to me in 1904 by a Chicago machinery manufacturer, when he stated that he frequently would take a contract from a Lake Superior man and commence the manufacture of the material before a paper was signed, something which he never would do in other localities, a statement that certainly attributes a high standard of honesty and integrity to the men of this region. It is with the lives of these men that this paper has to deal, and any interest that it may excite is merely reflected from the memory of those that have gone before.

At the last meeting of the Institute at Houghton, I suggested to the meeting the preparation of biographical data relating to the lives of the prominent men in years past in the Lake Superior region. It was made as a suggestion, knowing that, if it were acted upon as a motion, the burden of the work would fall upon some one's shoulders, and I felt that, at that late hour, it could not be done without doing some injustice to the secretary of the Institute or some other person equally busy. Subsequently, Mr. Yungbluth asked me to prepare a paper bringing into it some of the biographies of the older men in the Lake Superior region; and for the last fifteen to eighteen months I have been trying to collect such biographies as I thought would be interesting. Before reading them I would like to present to the meeting a few ideas on the subject and would invite discussion of the same.

Biography as you all know is practically history, written in the form of the history of an individual and, therefore, should be as accurately stated as is possible, as in a few years it may become a matter of reference, and, if inaccurate, will cause a great deal of misstatement and confusion. The history of a given time is written in the lives of the men that lived at that time and were prominent in the affairs of the period. These affairs may not be of national importance, but they are of great local interest and very often are extremely valuable. The sources from which history is drawn are tradition, writings and personal memoranda of individuals, and public documents of record.

Tradition of necessity, must to some extent be inaccurate, as it depends largely on the memory of the person relating it and is therefore very likely to be colored to suit his ideas or prejudices, and should require corroborative evidence before being taken as a fact. An event related by one to another may seem entirely different to the person listening from what it actually is, and, if repeated by him, may give a very wrong impression of the original narrative. Personal memorandum has always the error of statement to contend with and the differences arising from the individual point of view. Public documents and records are the most accurate source of information, but even they at times are erroneous.

For these reasons I have felt that we should, in gathering this biographical data, have it presented to the meetings of the Institute, and as we still have in our midst many who were actually connected with the early days of the Lake Superior region, we can then have any errors in statement corrected as they are made in reading the biographies, and the records altered to agree with the facts. I find from my experience of the last few months in gathering the few biographies to follow, that in many instances letters will be written to people who are not conversant with the history of the individual desired, that some of the persons written to are absent from the address to which the letter is sent and that in some instances the letters are not answered on account of apparent indifference or neglect. Of course one cannot blame a correspondent who often is too busy to answer or who cannot find the data desired, for it certainly necessitates a good deal of investigation.

In regard to the data to be used; that which especially applies to the history and development of the Lake Superior region should be of primary importance; other side lights in the history of the individual are interesting and instructive but what would seem to me to be the essential part would be the individual's connection with the work in the Lake Superior region. Of course outside influences that lead up to the persons coming to the Lake Superior region are also important. Another way of furthering the work would be to have the members of the Institute send in names of those whom they know of but whose histories they do not know, and these can be

referred to others who are familiar with or have access to the facts and the results can be obtained in that way. An effort was made in this direction by the secretary in a circular letter, sent to members in April, 1907, but was productive of but one biography, hence I am making a personal appeal to you all to send them in.

We also have as members of the Institute most all of the newspaper men in the mining region and, if they would send in any obituary notices that they may print, they would confer a great favor on the person preparing the data and greatly facilitate the work. Another point is that it would seem most fitting that the biographies of all of our deceased members of the Institute should be published in our records. At present we have 35 names in our list and I think they should all appear, with biogaphical notices in the proceedings.

There is, of course, a great temptation to ask some of the older members to write the story of their lives and work, but it involves a great deal of work on their part and without wishing to appear flippant would be a good deal like asking a man to write his own obituary notice. If, however, they could be persuaded to present papers dealing with their connection with the Lake Superior region, they certainly would confer a great favor on the members and add greatly to the pleasure of all of us. I think though that such requests should come from the President of the Institute rather than from a private individual believing it to be much more courteous and effective, and I think that an evening with the pioneers would be as enjoyably a feature for all as could be introduced.

From my short experience I feel that whoever takes up the work in the future should have provided for him, a suitable letter head by the Institute. If it devolves on the Secretary, of course, the official letter head of the Institute will be all that is necessary, but to have a private individual write to you for personal and intimate data regarding the life of one who was near and dear to you is even a little worse than to be questioned by a total stranger as to the size of your pocketbook. For that reason I have introduced myself very frequently to strangers, to whom I have written by using my official letter head, hoping thereby to add at least the respectability of the company to my request. Then in conclusion comes the question, who is to do the work, if it is to be done, and further, if the Institute wishes to extend it from this insignificant beginning, and assume the extra expense of printing its proceedings.

It would appear that a committee of interested and patriotic members would be the easiest and most efficient way to carry on the work, but that point is certainly up to the meeting. Personally I believe the work should go on and should be made a feature of our transactions. We all are more or less interested, and we all may well be for the Northern Peninsula from 1843 to 1870 was by no means an Elysian field. The climate during the summer was certainly delightful, excepting such things as sandflies, mosquitoes, gnats and the like, but as late as ‘69 there was no connection by rail with the Copper Country and when winter came with unusual force as it most always did, the hardy band of pioneers located at the different settlements were absolutely cut off from civilization, excepting for a monthly mail by dog sledge delivered by one of our own sturdy members, the Hon. Peter White. Since this article was written he has passed beyond to be numbered with the illustrious dead of this Institute. I had hoped that he might be present to correct and amplify the data submitted.

I have a keen recollection of many of the incidents told me by my mother of the early sixties in Houghton and they can be duplicated from all of the old settlements such as Ontonagon, Hancock, Marquette, L’Anse and others. Cut off from all intercourse with civilization, the inhabitants of the U. P. had to live by themselves and for each other, and such a condition must produce either very bad or very good results. The character of the men and women who went to the Upper Peninsula at that time was such that they developed within this environment, as broad a charity, as high principles of honor and integrity and as wide and hearty a hospitality as has ever been known in the history of our country.

Mr. Yungbluth: I think that the manner in which Mr. Hearding has started this feature of the work in connection with the Lake Superior Mining Institute, and the progress he has made the first year of the effort, suggests the advisability of continuing the research for information along the lines mentioned in his paper. In securing the biographies of the pioneers of the mining regions of the Lake Superior district, we will also secure more or less data which is of great importance, historically, and I would like to see this made a permanent feature. Instead of throwing the whole burden of the work upon Mr. Hearding it might relieve him somewhat if a committee would be appointed to assist him, of such men as have some personal knowledge and information in regard to the early days, and selected possibly with a view to covering the different ranges. The copper country would perhaps offer the earliest information and much has already been gathered up by Mr. Hearding with a view of accomplishing something in this direction. I would suggest further consideration and discussion as to future work relative to biographical and historical research for the benefit of the Institute and for the informs ton of people who read the proceedings. I might state that the proceedings are now placed in many of the libraries of the United States; also in Canada, England, Australia, Germany and South Africa. Our work seems to be appreciated; only recently we received request for a complete set of volumes for the Calumet & Hecla library and you will find extracts quoted in various books in connection with work along mining and metallurgical lines.

The first paper for the! evening was read by Mr. William Kelly, of Vulcan, Mich., on “The Hydro-Electric Plant of Penn Iron Mining Co., at Vulcan, Mich.,” which was prepared by Mr. Thomas W. Orbison, of Appleton, Wis., and Mr. Frank H. Armstrong, of Vulcan, Mich. The paper

was illustrated by stereopticon views, showing many very interesting pictures during construction as well as after completion of the plant. The work on this plant was begun in the fall of 1905 and completed in the spring of 1907.

Mr. Alexander M. Gow, of the mechanical department of the Oliver Iron Mining Co., presented a paper entitled, "The Standard Boiler House of the Oliver Iron Mining Co." At some of the mines visited during the trip the members had the opportunity to carefully inspect the type of building described in this paper.

Dr. Alfred C. Lane, State Geologist of Michigan, prepared an exhaustive paper on the subject of mine waters and presented a brief abstract of the same. The paper is published in full in this volume.

Mr. W. F. Slaughter, of Republic, Mich., read a paper entitled, "Acetylene Gas As An Underground Light." The writer gives the results of some tests made as to the efficiency and economy of this method of lighting.

Following the reading and discussion of papers, the Secretary presented the report of the Council since the last meeting.

REPORT OF THE COUNCIL.

The Secretary's report of Receipts and Disbursements from August 8th, 1906, to June 16th, 1908, is as follows:

RECEIPTS.

Cash balance on hand August 8th, 1906		$4,396.12
Dues for 1906	$1,895.00	
Entrance fees, 1906	285.00	
Back dues	250.00	
Advance dues, 1908	100.00	
Sales of proceedings	71.65	
Sale of Institute pins	248.00	
Total	$2,849.65	
Interest on deposits	254.78	
Total receipts		3,104.43
Grand total		$7,500.55

DISBURSEMENTS.

Stationery and printing	$ 69.85		
Postage	151.20		
Freight and express	23.89		
Telephone and telegrams	14.61		
Secretary's salary	750.00		
Clerical and stenographic work	62.50		
Total		$1,072.05	
Publishing proceedings, Vol. XII—			
Printing and binding	$576.50		
Advance papers, 1906, 1908	153.25		
Photographs, maps and cuts	317.99		
Total		$1,047.74	
Institute pins		379.00	
Badges for 1907, meeting postponed		135.00	
For badges and expenses, meeting 1906		196.12	
Total disbursements			$2,829.91
Cash on hand June 16th, 1908			4,670.64
Grand total			$7,500.55

Membership—	1908.	1906.
Members in good standing	444	410
Honorary members	4	4
Life members	1	1
Members in arrears	26	50
Total	475	465
New members admitted	60	64
Members not qualified	3	7
New members added	57	57

TREASURER'S REPORT.

The Treasurer's report from August 8th, 1906, to June 16th, 1908, is as follows:

Cash on hand August 8th, 1906	$4,396.12	
Received from Secretary	2,849.65	
Interest on deposits	254.78	
Paid drafts issued by the Secretary		$2,829.91
Cash on hand June 16th, 1908		4,670.64
	$7,500.55	$7,500.55

The undersigned committee appointed to audit the books of the Secretary and Treasurer, beg leave to report that they have carefully examined the same and find them to be in accordance with the above statements.

We have also examined the bank statements and find that the deposits agree with the cash statement.

CHAS. T. KRUSE,
JOHN M. BUSH,
Committee.

[Candidates Approved for Membership]

The following applications for membership have been received since the last annual meeting and are approved by the Council:

Adgate, F. W., Civil Engineer, Kansas City, Mo.

Amberg, William A., President Loretto Iron Co., 438 Fulton St., Chicago, Ills.

Angst, Robert A., Mine Superintendent, Hibbing, Minn.

Benson, A. F., Chief Engineer Republic Iron & Steel Co., Virginia, Minn.

Biscombe, Joseph R., Mining Captain, Kearsarge, Mich.

Binney, Joseph, Mining Captain, McKinley, Minn.

Bowen, Reuben, General Sales Manager, Fred M. Prescott Steam Pump Co., Milwaukee, Wis.

Brewer, L. C, Superintendent Newport Mine, Ironwood Mich.

Brown, John Jacob, Mechanical Engineer, 1539 First National Bank Bldg., Chicago, Ills.

Chamberlain, Paul F., Assistant Superintendent, Soudan Minn.

Chambers, H. P., M. D., Florence, Wis.

Cheyney, H. C, Assistant General Freight Agent, C. & N. W. Ry. Co., 215 Jackson Blvd., Chicago, Ills.

Connors, Thomas, Timber Contractor, Negaunee, Mich.

Cotter, W. H., Carbon Salesman, 108 Fulton St., New York City.

Coyne, William, Traffic Manager, E. I. DuPont de Nemours Powder Co., Wilmington, Del.

Croxton, David T., Iron Manufacturer, Cleveland, Ohio.

Damkroger, H. C, Mining Engineer Oliver Iron Mining Co., Coleraine, Minn.

Dawe, Peter, Mine Inspector, Houghton Co., Calumet, Mich.

Donovan, Percy W., Superintendent of Explorations E. J. Longyear, Hibbing, Minn.

Dormer, George H., Superintendent Fayal Mine, Eveleth, Minn.

Drake, Rollin E., Secretary Vermillion Pine & Iron Land Co., Ishpeming, Mich.

Duff, Harry E., Mining Captain, Riverton Mine, Iron River, Mich.

Edwards, J. P., Mining Captain, Mansfield, Mich.

Fairchild, David L., Diamond Drill Contractor, 616 Lonsdale Bldg., Duluth, Minn.

Ferguson, J. A., Northern Sales Agent, Pittsburg Coal Co., Duluth, Minn.

Glass, Frank A., Mining Engineer, Randall, Minn.

Harden, James H., Broderick & Bascum Rope Co., Stratford Hotel, Chicago, Ills.

Hart, William C, Mining Engineer, Hibbing, Minn.

Henderson. Enoch, Manager Copper Crown Mining Co., Matchwood, Mich.

Hine, S. K., iron Manufacturer, Girard, Ohio.

Hodgson, J. A., Broker, Houghton, Mich.

Hunner, Earl E., Civil and Mining Engineer, Hibbing, Minn.

Kerr, George H., Manager Sales Records E. I. DuPont de Nemours Powder Co., Wilmington, Del.

Koch, Arthur A., Instructor of Analytical Chemistry, Michigan College of Mines, Houghton, Mich.

Kruse, Charles T., Assistant Superintendent Pittsburgh & Lake. Angeline Iron Co., Ishpeming, Mich.

Lamont, John D., Mining Engineer, Virginia, Minn.

LaRue, William G., Mining, 208 Exchange Bldg., Duluth, Minn.

Latham, Arthur;. M., Chief Clerk Meriden Iron Co., Hibbing, Minn.

Lewis, Charles H., Manager of Mines, Hibbing, Minn.

Lindberg, John F., Superintendent Diamond Drills, Hibbing, Minn.

Linn, A. E., Mining Engineer, Norway, Mich.

Martin, Alfred, Superintendent of Mines, Virginia, Minn.

Matthews, William C, Assistant Director of Sales, E. I. DuPont de Nemours Powder Co., Wilmington, Del.

Meyers, William R., Mining Engineer, Princeton, Mich.

Moore, Clarence E., Mining Superintendent, Virginia, Minn.

Morris, Charles S., Mining Engineer, 2232 E. First St., Duluth, Minn.

Murray, Robert, Superintendent, Hibbing, Minn.

McCammon, George H., General Sales Agent Beall Bros., 753 Railway Exchange Bldg., Chicago, Ills.

Orton, Hugh J., Mining Engineer, Hibbing, Minn.

Pentecost, John, Mining Captain, Calumet, Mich.

Quinn, Clement K., Mining Engineer, Virginia, Minn.

Richards, Morris E., Mining Engineer and Mining Superintendent, Buhl, Minn.

Roskilly, Joseph, Superintendent of Mines, Virginia, Minn.

Russell, C W., Assistant Manager, Russell Wheel & Foundry Co., Detroit, Mich.

Savage, J. A., Mine Superintendent, Hibbing, Minn.

Schulze, W. J., Mining Engineer, Virginia, Minn.

Simmons, Charles, Machinist Foreman, Champion Mine, Beacon, Mich.

Smith, Willard J., Mining Superintendent, Mohawk, Mich.

Skinner, Mortimer B., Vice President and Secretary, James McCrea & Co., 63-65 W. Washington St., Chicago, Ills.

Smith, George M., General Agent, C. & N. W. Ry. Co., Duluth, Minn.

Tappan, William U., Mine Superintendent, Hibbing, Minn.

Thieman, Edward, Cashier, Florence, Wis.

Thompson, Greer H., Contractor, Hibbing, Minn.

Thompson, Henry S., Assistant Superintendent Oliver Iron Mining Co., Beacon, Mich.

Tillinghast, Edmund S., Mining Engineer, Lutonia Mine, Hibbing, Minn.

Tobin, James, Retired Mining Captain, Florence, Wis.

Van Evera, Wilbur, Mining Engineer, McKinley, Minn.

Webb, Francis J., Mining Inspector, St. Louis County, Eveleth, Minn.

Wearne, William, Superintendent, Laura Mine, Hibbing, Minn.

Welker, W. R, Assistant Superintendent, C. & N. W. Ry. Co., Ashland, Wis.

Wessinger, Henry J., Chief Engineer, Oliver Iron Mining Co., 610 Wolvin Bldg., Duluth, Minn.

Williams, Percival S., Assistant Superintendent., Montreal Mine, Montreal, Wis.

The Council recommends that the Secretary be paid the salary of seven hundred and fifty dollars for the past year.

On motion the report of the Council was adopted and the Secretary instructed to cast the vote of the Institute for the Section of the applicants presented.

The report of the Auditing Committee was read and adopted.

Mr. Walter Fitch, of Calumet, Mich., presented the following resolution which was on motion adopted:

Resolved, That Messrs. J. H. Hearding, W. J. Olcott, Geo. A. Newett and J. B. Cooper be requested to act as a committee to consider the character and scope of the records, to be prepared for publication in the Proceedings, covering the Lake Superior mining industry and a biography of the individuals concerned in its early history and submit to the Council such plan, and the Council be authorized to pass and approve such plans as it may see fit, and authorize the committee's expenditures.

On motion by Mr. Dwight E. Woodbridge, of Duluth, a vote of thanks was tendered to the committee and the citizens of Hibbing for the splendid reception given to the members and the entertainment provided during their stay. Also to the authorities for the use of the school building and the members of the High school orchestra for the music furnished.

The committee on nominations presented the following report:

Your committee on nominations beg leave to submit the following names as officers of the Institute for the term specified:

For President: (one year)
M. M. Duncan, Ishpeming, Mich.

For Vice-President: (two years)
1, W. J. Richards, Crystal Falls, Mich.
2, Charles Trezona, Ely, Minn.

For Managers: (two years)
1, F. E. Keese, Ishpeming, Mich.
2. W. J. Uren, Calumet, Mich.
3, L. M. Hardenburgh, Hurley, Wis.

For Treasurer: (one year)
1, E. W. Hopkins, Commonwealth, Wis.

For Secretary: (one year)
1, A. J. Yungbluth, Ishpeming, Mich.

F. E. KEESE,
C. H. MUNGER,
W. J. RICHARDS,
D. E. SUTHERLAND,
NORMAN W. HAIRE.

The report of the committee was on motion adopted and the Secretary instructed to cast the vote of the meeting for the election of the officers as presented by the committee.

Mr. Walter Fitch presented the following resolution which' was on motion unanimously adopted:

Resolved, That the thanks of this Institute be tendered to the Mining Companies of Minnesota and their officials and to the Clubs and Citizens of Duluth for the very handsome entertainment extended to the Institute and its members on the occasion of their visit to the cities and iron ranges of the state.

After announcement being made of the program for Saturday, the meeting was on motion adjourned.

SATURDAY, JUNE 27TH, 1908.

At seven o'clock Saturday morning, the members arrived at Coleraine and were met by the band and members of the Commercial club. The local members took the party in charge and after boarding the observation train a trip was made through the Canisteo and Walker pits. The concentrating mill was next visited, and considerable time was spent here. This mill was erected to carry on experimental work before construction on the large plant was begun. The committee conducted the party through the new town to the John C. Greenway High school. As we are promised a paper on Coleraine for this issue no extended mention is here necessary. The trains left for Duluth at 12 o'clock noon, arriving there at four where the party disbanded.

The thirteenth meeting will be long remembered by those present. The arrangements were admirably carried out which made it possible to cover so large an area in so short a time. Mr. Cole and his associates are to be complimented on the great success of the meeting.

The following is a partial list of members and guests in attendance at the meeting:

[Members and Guests in Attendance]

ABEEL, GEORGE H. ..... Hurley, Wis.
ABELL, S. J. ..... Chicago, Ills.
AMBERG, J. WARD ..... Chicago, Ills.
AMBERG, W. A. ..... Chicago, Ills.
ANGST, R. A. ..... Hibbing, Minn.
ARMSTRONG, F. H. ..... Vulcan, Mich.
AUSTIN, L. S. ..... Houghton, Mich.

BACON, L. H. ..... Ishpeming, Mich.
BARTLETT, E. P. ..... Chicago, Ills.
BAXTER, CHARLES H. ..... Loretto, Mich.
BEYENKA, THOMAS ..... Houghton, Mich.
BIRCKHEAD, LENNOX ..... South Milwaukee, Wis.
BLACKWELL, FRANK ..... Ironwood, Mich.
BLACKWELL, FRANCIS ..... Ironwood, Mich.
BOWDEN, F. J. ..... Houghton, Mich.
BOWEN, REUBEN ..... Milwaukee, Wis.
BREMER, D. F. ..... Chicago, Ills.
BREWER, K. W. ..... Chicago, Ills.
BREWER, LUTHER C. ..... Ironwood, Mich.
BRIGHAM, E. D. ..... 215 Jackson Blvd., Chicago, Ill.
BROUGHTON, H. P. ..... Duluth, Minn.
BURR, FLOYD L. ..... Vulcan, Mich.
BUSH, JOHN M. ..... Ironwood, Mich.

CAMPBELL, S. G. ..... Bessemer, Mich.
CARMICHAEL, WILLIAM ..... Biwabik, Minn.
CARPENTER, C. S. ..... Duluth, Minn.
CARSON, JOHN A. ..... Appleton, Wis.
CARTER, R. B. ..... Chicago, Ills.
CASTLE, WILLIAM B. ..... Marquette, Mich.
CHAMPION, CHARLES ..... Champion, Mich.
CHEYNEY, H. C. ..... Chicago, Ills.
CHINN, W. P. ..... Hibbing, Minn.
CLARK, KIMBELL ..... Ironwood, Mich.
CLIFFORD, J. M. ..... Escanaba, Mich.
COAD, RICHARD ..... Ely, Minn.
COLE. CHAS. D. ..... Ishpeming, Mich.
COLE, T. F. ..... Duluth, Minn.
COLE, WM. H. ..... Duluth, Minn.

COLE, WM. T. ..... Ishpeming, Mich.
COOPER, JAMES B. ..... Hubbell, Mich.
COTTER, W. H. ..... New York City, N. Y.
COVENTRY, F. L. ..... Hibbing, Minn.
CRANE, E. E. ..... Duluth, Minn.

DAVIDSON, O. C. ..... Iron Mountain, Mich.
DICKENSON, E. S. ..... Iron Mountain, Mich.
DORMER, GEORE H. ..... Eveleth, Minn.
DUDLEY, HARRY C. ..... Coleraine, Minn.
DUFF, HARRY E. ..... Iron River, Minn.

EATON, LUCIEN ..... Iron Belt, Wis.
EISELE, GEORGE J. ..... Iron Mountain, Mich.
ELLARD, H. F. ..... Silver City, N. M.
ELLIOTT, MARK ..... Virginia, Minn.
FAIRBAIRN, C. T. ..... Duluth, Minn.
FAIRCHILD, D. L. ..... Duluth, Minn.
FAVOR, GEO. W. ..... Chicago, Ills.
FAY, JOSEPH ..... Marquette, Mich.
FISHER, JAMES, JR. ..... Houghton, Mich.
FITCH, WALTER ..... Calumet, Mich.
FLODIN, NELS P. ..... Marquette, Mich.
FOLEY, DAVID F. ..... Duluth, Minn.
FRASER, WILLIAM H. ..... Crystal Falls, Mich.

GRABOWSKY, CHARLES ..... Ely, Minn.
GILBERT, C. B. ..... Duluth, Minn.
GLASS, FRANK A. ..... Deerwood, Minn.
GODFREY, M. H. ..... Hibbing Minn.
GOLDSWORTHY, JOSEPH ..... Iron Mountain, Mich.
GORDON, ALEXANDER T. ..... Mountain Iron, Minn.
GOW, A. M. ..... Duluth, Minn.
GREENE, W. E. ..... Cleveland, Ohio.
GREENWAY, JOHN C. ..... Coleraine, Minn.
GRIERSON, EDWARD S. ..... Calumet, Mich.
GUNSOLUS, F. H. ..... Wilmington, Del.

HAIRE, NORMAN W. ..... Houghton, Mich.
HULL, E. M. ..... Chicago, Ills.
HAMMOND, T. A. ..... Duluth, Minn.
HARRIS, S. T. ..... Houghton, Mich.
HARRISON, G. E. ..... Hibbing, Minn.
HARTLEY, G. G. ..... Duluth, Minn.
HART, WILLIAM C. ..... Hibbing, Minn.
HAWKINS, M. S. ..... Mountain Iron, Minn.
HEARDING, JOHN H. ..... Eveleth, Minn.
HEARLEY, MICHAEL T. ..... Cleveland, Ohio.
HELPS, S. E. ..... Eveleth, Minn.

HEYN, HOWARD J. ..... Ishpeming, Mich.
HOLLY, V. C. ..... Marquette, Mich.
HOLMAN, J. W. ..... Chicago, Ills.

JACKSON, H. L. ..... Princeton, Mich.
JONES, JOHN T. ..... Eveleth, Minn.
JOHNSTONE, O. W. ..... Abbotsford, Wis.
JONES, CHARLES C. ..... Ramsey, Mich.

KARKEET, J. H. ..... Iron Mountain, Mich.
KEESE, FRANK E. ..... Ishpeming, Mich.
KELLY, WILLIAM ..... Vulcan, Mich.
KIESWETTER, CHARLES W. ..... Duluth, Minn.
KING, C. B. ..... Ishpeming, Mich.
KIRKPATRICK, J. CLARK ..... Escanaba, Mich.
KNIGHT, R. C. ..... Eveleth, Minn.
KOEPEL, ED. ..... Beacon Hill, Mich.
KOCH, ARTHUR A. ..... Houghton, Mich.
KRIEGER, A. H. ..... Duluth, Minn.
KRUSE, CHARLES T. ..... Ishpeming, Mich.

LAMBRIX, GEORGE ..... Hurley, Wis.
LAMBRIX, MICHAEL ..... Hurley, Wis.
LANE, ALFRED C. ..... Lansing, Mich.
LANG, T. H. ..... Duluth, Minn.
LARSON, EDWARD ..... Florence, Wis.
LA RUE, W. G. ..... Duluth, Minn.
LAWTON, CHARLES L. ..... Hancock, Mich.
LEONARD, C. M. ..... Princeton, Mich.
LESLIE, S. I. ..... New York City, N. Y.
LETZ, JOHN F. ..... Milwaukee, Wis.
LEWIS, CHARLES H. ..... Hibbing, Minn.
LEIN, NELS. ..... Eveleth, Minn.
LINDBERG, F. C. ..... Hibbing, Minn.

MACKIE, E. M. ..... Chicago, Ills.
MANEY, E. J. ..... Duluth, Minn.
MARS, WILLIAM P. ..... Duluth, Minn.
MATTHEWS, WM. C. ..... Wilmington, Del.
MYERS, W. R. ..... Ishpeming, Mich.
MINER, ANSON B. ..... Ishpeming, Mich.
MITCHELL, WM. A. ..... Chicago, Ills.
MONROE, W. G. ..... Iron Mountain, Mich.
MOORE, CLARENCE ..... Virginia, Minn.
MORGAN, DAVID T. ..... Ishpeming, Mich.
MOWATT, NEVILLE P. ..... Houghton, Mich.
MUNGER, CHARLES H. ..... Duluth, Minn.
McCORKINDALE, W. J. ..... Ishpeming, Mich.
McDONALD D. B. ..... Virginia, Minn.

McDOWELL, JOHN ..... Hibbing, Minn.
M'GEE, M. B. ..... Crystal Falls, Mich.
M'GREGOR, SILAS J. ..... Iron Mountain, Mich.
McLAUGHLIN, H. ..... Iron Mountain, Mich.
McLEAN, JOHN H. ..... Duluth, Minn.
McNAIR, F. W. ..... Houghton, Mich.

NEWETT, GEORGE A. ..... Ishpeming, Mich.
NINNESS, EDMUND ..... Ironwood, Mich.
NORMAN, J. L. ..... Duluth, Minn.

OLCOTT, WILLIAM J. ..... Duluth, Minn.
ORR, FRANK D. ..... Duluth, Minn.

PASCOE, PETER W. ..... Republic, Mich.
PASCOE, WILLIAM ..... Republic, Mich.
PENTECOST, JOHN ..... Calumet, Mich.
PHILLIPS, W. G. ..... Calumet, Mich.
PRESCOTT, FRED M. ..... Milwaukee, Wis.
PRESHO, E. W. ..... Hughton, Mich.
POWELL, D. W. ..... Marquette, Mich.

QUINE, JOHN T. ..... Ishpeming, Mich.
QUINLAN, J. H. ..... Houghton, Mich.
QUINN, JOHN H. ..... Ishpeming, Mich.

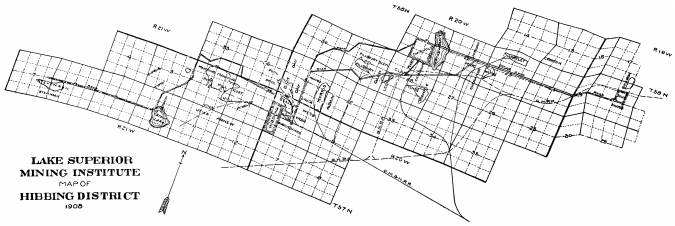
RAISHLEIGH, WM. ..... Aurora, Minn.
RAISKY, F. H. ..... Ishpeming, Mich.
READY, CHAS. W. ..... Chicago, Ills.
RICHARDS, WILLIAM J. ..... Crystal Falls, Mich.
ROBERTS, HARRY ..... Duluth, Minn.
ROBERTS, RICHARD ..... Negaunee, Mich.
ROBINSON, JAMES A. ..... Hibbing, Minn.
ROSS, D. E. ..... Eveleth, Minn.
ROUGH, JAMES H. ..... Negaunee, Mich.
RUMSEY, SPENCER S. ..... Duluth, Minn.
RUNDLE, A. J. ..... Iron Mountain, Mich.
RUSSELL, C. W. ..... Detroit, Mich.

SAMPSON J. D. ..... Ashland, Wis.
SAVAGE, J. A. ..... Hibbing, Minn.
SCHULZE, W. J. ..... Virginia, Minn.
SHEA, JOHN ..... Negaunee, Mich.
SHERRERD, JOHN M. ..... High Bridge, N. J.
SHIELDS, IRVIN J. ..... Duluth, Minn.
SHIPMAN, CHARLES G. ..... Ely, Minn.
SHUBERT, GEO. P. ..... Houghton, Mich.
SIEBENTHAL, W. A. ..... Republic, Mich.
SILLIMAN, A. P. ..... Hibbing, Minn.
SISLEY, GEO. E. ..... Chicago, Ills.

SKINNER, M. B. ..... Chicago, Ills.
SLAUGHTER, W. F. ..... Republic, Mich.
SMITH, W. J. ..... Mohawk, Minn.
SMITH, GEORGE M. ..... Duluth, Minn.
SOADY, HARRY ..... Iron Mountain, Mich.
SPITZER, J. D. ..... Ishpeming, Mich.
SPORLEY, CHARLES L. ..... Negaunee, Mich.
STEPHENS, JAMES ..... Ishpeming, Mich.
STOEK, H. H. ..... Scranton, Pa.
SULLIVAN, F. J. ..... Ironwood, Mich.
SUTHERLAND, D. E. ..... Ironwood, Mich.
SUTHERLAND, W. G. ..... Eveleth, Minn.
SWAIN, R. A. ..... Duluth, Minn.
SWIFT, GEORGE D. ..... Duluth, Minn.

TARR, S. W. ..... Duluth, Minn.
TAPPAN, WILLIAM M. ..... Hibbing, Minn.
THOMPSON, G. H. ..... Hibbing, Minn.
THOMPSON, HENRY S. ..... Beacon, Mich.
TILLSON, F. P. ..... Ishpeming, Mich.
TREBILCOCK, JOHN ..... Ishpeming, Mich
TREZONA, CHARLES ..... Ely, Minn.
TRIPP, CHARLES D. ..... Chicago, Ills.
TRUETTNER, IRVING W. ..... Bessemer, Mich.
UREN, WILLIAM J. ..... Calumet, Mich.

VANDEVENTER, JOSEPH ..... Ishpeming, Mich.
VAN HAGEN, G. E. ..... Chicago, Ills.
VAN VALKENBURG, ALLEN J. ..... Chicago, Ills.
VOGEL, FELIX A. ..... New York City, N. Y.
WARE, J. F. ..... Dayton, Ohio.
WARREN, O. B. ..... Hibbing, Minn.
WEBB, CHARLES E. ..... Houghton, Mich.
WELKER, W. F. ..... Ashland, Wis.
WENSHEIMER, E. C. ..... Ishpeming, Mich.
WESSINGER, H. J. ..... Duluth, Minn.
WEST, WM. J. ..... Hibbing, Minn.
WHITEHEAD, L. G. ..... Duluth, Minn.
WILLIAMS, J. P. ..... Schullsburg, Wis.
WINCHELL, N. H. ..... Minneapolis, Minn.
WIVELL, WILLIAM ..... Nashwauk, Minn.
WOLVIN, A. B. ..... Duluth, Minn.
WOODBRIDGE, D. E. ..... Duluth, Minn.
YUNGBLUTH, A. J. ..... Ishpeming, Mich.



PRODUCTION FROM MINES IN THE HIBBING DISTRICT FOR 1907.

Name of Mine.	Tons-1907.						
Agnew	149,084	Glen	205,426	Mahoning	1,564,332	Sellers	155,060
Albany	437,521	Hartley	334,646	Monroe	156,809	Shenango	387,093
Burt	1,501,272	Hull	157,366	Morris	2,076,288	Stevenson	1,142,977
Chisholm	258,793	Hull-Rust	2,900,493	Myers	153,770	Susquehanna	137,397
Clark	319,983	Jordan	61,996	Nassau	19,172	Tener	190,903
Croxton	349,853	Laura	149,410	Pearce	68,886	Utica	304,864
Cyprus	209,948	Leetonta	301,368	Pillsbury	489,718	Webb	113,334
		Leonard	137,316	Rust	213,555	Winifred	94,867

[Map of the Hibbing (Minn.) District]

MINE WATERS.

BY ALFRED C. LANE.

(With Chemical Assistance Especially of Dr. G. Fernekes.)

INTRODUCTION.

Some two years ago* I brought the question of the chemical character of the deeper mine waters to the attention of the members of the Lake Superior Mining Institute. As a result quite a body of facts was with their help obtained which lead to some conclusions which are practical and "important if true". I will summarize some of these beginning with those which are most firmly established.

"Volume XII, L. S. M. I. pp. 154-163.

GENERAL INFERENCES.

1. *Both in the iron country and in the copper country* the surface waters are soft as compared with those of the Mississiippi valley.

2. *Both in the iron country and copper country*, with increasing depth the amount of chlorine increases, and in time becomes more than enough to combine with the sodium. The calcium (lime) rises, too, so that we may say that calcium chloride is present. Such waters are extremely corrosive on boilers and pumps, and of course hard.

3. In this presence of calcium chloride they resemble waters which are found in the older rocks all over the Mississippi valley, in fact more or less all over the world. They seem to have been in part at least buried with the strata. Such waters laid down with the strata when they were laid down may be called connate waters, for short.

4. Flows of the deeper or connate water decrease and generally soon drain off.

5. The strength of these connate waters varies greatly, but below 1500 feet it is not uncommon to find them stronger than sea water.

6. Both iron and copper deposits are found in chutes of waters working downward.

7. In both cases there is a tendency to accumulate iron oxide in place of sodium silicate which goes into solution, the silica being later precipitated and the sodium remaining as sodium chloride in solution taking the place of calcium chloride.

8. In both cases, but more especially in the copper country the downward wandering of the surface water may be *not wholly a mere up and down circulation, but an absorption of water by the strata, like a sponge*. To such an extent as this is true the formation of ore chutes is not limited by any chance for circulating waters to escape, but may extend to an indefinite depth, after passing a zone of greatest richness.

9. In both cases the downward course of the water and the formation above is likely to be more active where the surface topography favors it, under high ground for instance. But such a feature is by no means the only or most important factor. A porous or fractured condition of the beds aiding circulation, and impervious dikes of clay seams to concentrate and guide the flow are also important, and there is no reason why ore chutes may not occur under low ground.

Of course in details of reaction, deposition, and structure the copper and iron countries differ very widely, and I do not know anything about the mine waters of Minnesota, which may introduce entirely new factors. It seems therefore better at present to separate our handling and treat the waters of the iron country and the copper country separately.

Before final publication some tests of mine waters have been added.

To properly treat and present various tests and analyses variously incomplete, by various men and at various times is not very easy. It has seemed on the whole best to give all the references that I know to Lake Superior mine waters in a nearly historical order, with the original figures, conditions of sampling and occurrence, authorities, etc., distinguishing as carefully as possible the results of computations, and then to follow this with a discussion of what seem to me the significant facts.

It will be noticed that most, if not all, the organic matter and ammonia will be eliminated from the total solids heated to incipient fusion, and that any remainder might be more than balanced by loss of chlorine and CO_2. Thus extremely small differences between total solids and the sum of the constituents determined do not *of necessity* imply that such constituents were not present.

Since in .these studies we have to guard against being misled by the effects of human contaminations, nitroglycerine fumes and urine, it may be well to include an analysis of a urine* made by Parkes as follows:

Water	1500 grains contains
total solids	72 made up as follows:
Hydrocarbons.	
Urea $CO(NH_2)_2$	33.18
Uric acid $C_5H_4N_4O_3$	.555
Hippuric acid $C_9H_9NO_3$	.400
Kreatinin $C_4H_7N_3O$	.910
Pigment	10.
Sulphuric acid	2.012
Phosphoric acid	3.164
Chlorine	7.000
Ammonia	.770
Potassium	2.500
Sodium	11.090
Calcium	.260
Magnesium	.207
SiO_2, Fe	trace
Nitrates, sugar, gases, etc	small

Normal urine varies in concentration from Sp. Gr. 1.015 to 1.025. It is quite clear that no serious adulteration with urine or nitroglycerine could be introduced without introducing quantities of nitrogen in some shape—it might be oxidized to nitrates that should be recognizable. It is also clear that the tendency of such adulteration will be to increase the relative proportions of sodium.

No such adulteration can change our general results.

*From the New International Cyclopedia.

I. IRON COUNTRY MINE WATERS.

The first definite indication of calcium chloride waters in the iron mines came to my attention in testing to see whence a flood of waters in the lower levels of the Vulcan mine might have come. From the analysis of this water, page 155 of the annual report for 1903, taken in connection with the surface water analyses (p. 156) I inferred an admixture of a small quantity of calcium chloride water, and that there was no *direct* connection with the surface, or the alkalis would be higher. I suspected this flood to be connected with caverns in the Randville dolomite, and it is said (priv. com. W. Kelly) to come from the talcose underlying schists.

The temperature of the water at the 12th level, 1,000 feet from the surface, was: at the shaft, 57.°2 F.; at the first winze, about 100 feet west of the shaft, 60.°6; and the west end, almost 300 feet west of the shafts, 58.20. (See annual for 1901, p. 246). According to the observations there, the mine water at 1,210 feet was 56°, and at 270 feet, 45.°8. This water is then, abnormally warm—either from working up (?) or the heat from casing, friction and decayed timber.

The question arose whether it had any immediate surface source, and accordingly, analyses were made of the surface waters, which will be found in the Annual for 1903, p. 156. In them the chlorine is from 3.8 per million down, the alkalis high.

In this flood water* the output increased from 600 gallons per minute to 2,000, the increase being from a flow of water in the pump station on the 15th level. About Dec. 10, a sample was taken and analyzed, column (1). On March 19, 1904, it reached a maximum of 2,807 gallons and has since fallen off fairly steadily, being not much affected by the seasons. By March 26, 1907, the flow had fallen to about 1,000 gallons per minute when it was analyzed again by Dr. G. Fernekes with the results given in column 2. The decrease was principally in the flow in the 15th level pump station which "comes from the talcose slates underlying the north ore formation".[1] In the mean time at the west end of the 15th level a flow was struck "coming from the slates overlying the north ore formation", 1,300 feet west, about Sept. 1, 1906, amounting to about 250 gallons a minute, and this was tested, analysis 3.[2] Comparing these Vulcan analyses 1, 2 and 3, it is clear that the hardness remains fairly constant, and there is always practically all the bicarbonate it can hold if there is no excess of CO_2,[3] but with time and the addition of the new sources at the west end the chloride is dropped, the alkalies rose and approached the amount in the surface waters. Judging from the analyses of the talcose schists given by Bayley (loc. cit.) the alkalies are

not leached from them or the Randville dolomite, and the first water struck which had no alkali *seemed* to come from that direction. The abundance of potassium relative to sodium column 2, may be connected with the fact (loc. cit. p. 379-389) that potash was found in 11 of 15 samples of ore analyzed, soda in but five and generally seems less abundant in the ore. The later analyses and the exhaustion of the flood which has come to pass show quite clearly that no mistake was made in inferring from the analysis that it was not directly from the surface and would run down.

Analysis (1) has the characteristic of the early connate waters, chlorine high relative to sodium,

Analyses in parts per million. Analyst, for i and 2, G. Fernekes. Location given above.

*Priv. Com. Agent W, Kelly, Mar 10, 1907, and earlier.

[1] U. S. G. S. Mono. 46 by Bayley, p. 221-2, p, 452.

[2] Analysed by G. Fernekes, May 10, 1907.

[3] Volume VIII, Part 3, saturation is 95 parts per million Ca, 105 fixed, 210 total CO2.

VULCAN MINE WATERS

	1	2	3
Insoluble matter, clay & SiO_2	4.4		
Solid solubles	340.00	344.00	303.63
Organic matter	52.3		
Carbon dioxide	37.3	163.00	171.00
Non volatile solids	250.4		
In solution.			
SiO_2	5.8	9.8	11.2
Al_2O_3	4.4	18.2	1.7
Fe_2O_3	trace		
Ca	60.3	62.29	62.3
Mg.	37.7	28.20	30.5
SO_4	43.0	13.14	11.2
Cl	61.	18.68	
K	trace?	13.	3.7
Na K	p. n. d tr.	6.	11.03
Sr. Li.	0		
Total by addition	209.2	332.31	
Diff., organic, and undetermined Li, Ba, Cr, etc		11.96	

Analyses in parts per million. Analyst, for 1 and 2, G. Fernekes. Location given above.

In the same way the Ishpeming mine water (loc. cit. p. 157), given below, shows a greater amount of chlorides than is at all normal to the superficial waters of the Upper Peninsula, though not so much that it might not be attributed to organic contamination, which however, the geological conditions render unlikely.

An Ishpeming mine water, collected by A. Formis, coming out of a diamond drill hole at a depth of 825 feet, gave the following results:

	1	2
Lime as carbonate		15.8
Oxide determined		31.3
Magnesium as carbonate		17.0
Oxide determined		8.1
Oxide determined		.7
Iron and alumina carbonate		.5
Oxide determined		34.3
Requiring CO_2	33.2	
Total encrusting solids		73.3
Chlorides as sodium chloride		56.2
Chlorine determined		34
Sulphates as sodium sulphate		67.0
SO_3 determined		33.4
Total corrosive solids		123.2
Silica		10.5
Water of crystallization[1]		3.2
Excess of CO_2		1.1
Combined CO_2		33.2
Sodium chloride		56.2
Organic matter by difference from ignition loss		19.9
19.9. Ignition loss		113.6
Total by computation		229.1
Total by evaporation at 105° C.		232.2
Difference (minor errors, extra weight of potash over soda and undetermined)		3.1

Analysis by Kirschbraum, computation by A. C. L.

[1] The sulphates are probably in large part calcium sulphate, etc., and the soda correspondingly carbonate, reducing the amount of crystallization water.

I took, myself, with Mr. E. A. Separk, the chemist, a sample of water from the Aurora mine, Gogebic range, 200 feet west from A shaft about 900 feet down, on the fifth level at a point which had been opened five months. The temperature of the water as taken was 67° F.; of the drift at a dryer place 570 F. The water was coming down on top of the 60-foot kaolinized dike which crosses the formation there.

The analysis is as follows:

December 8, 1904.

Sample marked—Oliver Mining Co., Aurora mine water, Ironwood, Michigan.

	Grams per Ton.
Total solids	1420
Loss on ignition	544
Silica	122
Iron and aluminum oxides	012
Lime	354
Magnesia	150
Sulphuric anhydride	044
Chlorine	160
Sodium oxide	037
Carbon dioxide	510
Organic matter	034

F. K. Ovitz, Analyst.

Upon evaporating fifty cc. of the water to which a few drops of hydrochloric acid had been added to three or four cc. the spectroscope showed no test for potassium. No phosphorous was found. The organic matter is taken as difference between loss on ignition and carbon dioxide.

We may suppose this combined as:

$CaSO_4$	.8	grams per ton
NaCl	7.0	
$CaCl_2$	18.3	
$CaCO_3$	46.6	
$MgCO_3$	48.3	
$FeCO_3$	1.7	
SiO_2	12.2	
Organic	3.4	
CO_2	4.7	
	143.0	

Here again while the total solids are not greater than might be found in any surface water, and the chlorine not greater than might have been artifically introduced, the amount of chlorine is more than twice what can be combined with the alkalies (Na : Cl :: 23 ; 35.5 :: .0037 : .0057) and the presence of calcium chloride and the admixture of a small quantity of water containing this in solution must be inferred. The bulk of the water is percolating downward no doubt.

Sometimes the amount of residual chlorine is so great as to affect the use of the mine waters in boilers. This instigated the following tests of the Hurley (Superior and Ottawa) mine waters given me by Mr. Geo. H. Abeel.

The chlorine is sometimes said to be "free" but I think this really means in the boiler. Of course a weak solution of calcium or magnesium chloride may also be considered as a solution of calcium or magnesium hydrate and H Cl.

These tests were made for the Wickes Brothers, boiler manufacturers. No. 1 is of a sample taken from boiler at the end of the usual running period; No. 2 from the heater during operation; No. 3 of the raw (mine) water delivered to heater. It may be added that the water from the fifth level shows no free acid, and only .34 grains of chlorine per U. S. gallon. The chloride is said to have become noticeable at 400 feet depth. The boiler water has also no free acid according to another report but 15.04 grains per U. S. gallon or 258 per million of chlorine.

	1	2	3
Mineral matter	43.79*	18.88*	14.79*
Organic matter	17.98	4.35	3.19
Mg	.78	.58	.49
Iron and alumina	.116	.058	.174
(A trace of iron)			
Ca	11.09	2.59	2.31
SO_3	6.04	1.87	2.4
Cl	13.92	3.94	3.48
Oil	present	present	present
Reaction	acid	acid	
Solids suspended			5.5

Iron in combination with oxygen or sulphur.

Additional tests at the Yale mine obtained through Mr. Abeel give the following results:

New or West Colby at 9th level	40 parts per million chlorine
Yale down to 15th level	225 parts per million
Yale down to 20th level	709
Yale 10th down to 20th level	1070 parts per million Cl ;Ca 429

The upper two tests by E. B. Smith, the lower two by Koch.

*The figures are in grains per U. S. gallon.

I have been on the watch for something stronger. This I was enabled to obtain through the kindness of Peter W. Pascoe of the Republic mine, who reported such a water at a vertical depth of 1153 feet from the surface in the 16th level 600 feet northwest of the No. 9 shaft. With Messrs. Siebenthal, Slaughter and Pascoe I visited several places in the deeper part of the mine where saline waters came in, testing with total reflectometer and urinometer, and taking a sample of the strongest.

At 1153 feet down, 600 feet northwest of the No. 9 shaft a drip from a drill hole and fissure which has a temperature of 55° F. precipitated iron freely on the floor of the drift, seemed fresh and showed an index of refraction, near that of fresh water corresponding to a Sp. Gr. of 1.009 or so. On the 1435-foot level, say 100 feet from No. 9 shaft, was another flow, temperature 590 and there was a still more appreciable amount of salt. On the 1710 level near the Pascoe or south end of the mine the strongest water was almost drained off* from a fissure making an angle of 32° with the drift, dipping 24° or so north of west. The temperature was 57° to 57½°, the Sp. Gr. by urinometer 1.025 to 1.027. The analysis by Dr. G. Fernekes is as follows:

	Parts per million grams per ton.
Ca	7,902
Na	7,290
Mg	566
Cl	25,360
SO_4	1,045
CO_2	not determined
Al_2O_3	700
Mn	tr
Fe	tr
Sum	42,863
Total solids	45,590

We may for comparison suppose this combined as:

Na Cl	18,510
Ca Cl_2	21,800
$CaSO_4$	822
$MgSO_4$	381
$MgCO_3$	1,560
Al_2O_3	700
Fe, Mn, SiO_2, etc	1,617
	45,590

*It is characteristic of the strong calcium chloride waters that they appear in limited quantity. More than once I have been told of one by a mining captain, and upon going to the place not found enough to test. Somewhere lower we might find it.

From the Champion Iron mine a sample was sent in by the agent, W. H. Johnston, which came from the 28th level, 800 feet east of No. 5 shaft. It gave the following results:

Sp. Gr. 1.0037. This would correspond to about .5% $CaCl_2$ and .51 NaCl.

	Per Grams per Ton
Total solids by evaporation, including combined and crystal water	7,100
Chlorine Cl	3,050
Calcium Ca	810
Sulphate iron SO_4	370
Alumina Al O_3	present
Carbonates CO_2	very low
Iron	0

M. A. Cobb, Analyst.

This may be assumed to be:

Sodium and magnesium chloride	3,120
Calcium chloride	1,780
Calcium sulphate	520
Calcium carbonates	00
Balance of solids on evaporation mainly crystal water united with calcium sulphates and chloride	1,680
	7,100

The ratio of Ca ; Cl = .27 is not very far from that of the Republic sample just cited (.313).

Salt water is also said to have come out of a drill hole south from the 17th level No. 4 shaft and no doubt traces of calcium chloride water could have been found higher up if tested for. It must not be forgotten that we get news of it only when it gets so strong as to appreciably affect boiler waters.

II. COPPER COUNTRY WATERS.

1. The first published analysis of Lake Superior mine waters of which I know is that of Silver Islet, within sight of Isle Royale but on the Canadian side of the boundary.[1]

2. I am told*, however, that notably salt water was about the same time struck in the Cliff mine at about sea level and that Mr. L. G. Emerson, one of the more prominent of the early engineers who assisted R. Pumpelly in the preparation of Volume I of these reports, took samples of the same and made some tests, but I have found no printed reference to the same. It was probably struck therefore about 1879.

The water in the Silver Islet mine** was noted also for the presence of combustible gas, which came in vugs penetrated by drills with salt water below 500 feet. Two gallons gave a pint of acid and deliquescent calcium chloride.

The salt water I am informed by W. M. Courtis, who was employed as chemist there, came in a bore hole on the north side of the shaft at the 9th level (560 feet from the surface) in 1878. At the request of Dr. Selwyn a sample was collected by Mr. Tretheway and analyzed by G. C. Hoffman in 1882.

The results were as follows:

1. Total dissolved solids by drying at 180°C. 39.9566 per thousand.

Potassium chloride	.4582
Sodium chloride	16.8098
Calcium chloride	17.0867
Magnesium chloride	1.2937
Calcium sulphate	.0672
Calcium carbonate	.2936
Silica	.0540
Sum	36.0632

1 This should perhaps be geologically included with the iron country waters as it occurs in Huronian rocks, but it is very strong and may be associated with a Keweenawan intrusive.

*W. W. Stockley says at about sea level. Johnson Vivian, says 1800 feet down. The plan of the mine in the Min. Stat, report for 1880 shows the bottom of the mine at the 2200 bottom level, 1680 below the top of the greenstone, and it was soon after abandoned, the vein being a "cold green quartzite", the rocks much slicken sided and muddy.

**See Canada Geological Reports H. 1887, p. 28, 58.
W. McDermott, Eng. & M. J., Feb. 3, '77, p. 53.
T. Macfarlane, Trans. A. I. M. E., VIII, 1880, p. 226; XVII, p. 296, and earlier volumes, i. e., IV, V, IX, XV, p. 671.

Comment and Calculated Figures.

The difference between the solids and the sum is quite probably in large part crystal water.

We calculate.

Cl	22.53
Na	6.45
Ca	6.23
SO_4	.047
CO_3	.177
Na : Cl	.287

Combustible gas is often found in old mine workings and some of the best informed men, who have had painful experience with it do not think it comes from decaying mine timber and the like.

Dr. R. T. Chamberlin has found gases absorbed in the rock of fresh drill cores, taken far from the present surface.

3 and 4. Franklin mine. The next analysis published and the first I personally heard of was the one made by Prof. R. L. Packard, of water reported by an error as from the *Huron* mine, in Wadsworth's annual report for 1892, p. 174.

The full figures, both of the analysis of the mine water and of the boiler water are given below.

Attention was first called to it and the analysis made because of the trouble it made in the boilers. This was when the mine was down to the 25th or 26th level (1610' on the lode) about 1300' below the surface. I am assured* by Capt. Vivian that the sample was really from the Franklin.

* Houghton, Dec. 12, 1905.

The water from the Franklin mine that was analyzed by Prof. Packard was taken, I think, from) a depth of about 2,800 feet on the line of the lode which dips 54 degrees. It was about the average of the mine from a depth of about 2,500 feet to where it was taken. From the surface to a depth of 1,500 or 1,600 feet the water was as it seems good enough to drink. I remember hearing Mr. L. G. Emerson say that the first water of the kind that we had in the Franklin was found in the Cliff mine at a depth of 1,800 feet perpendicular.

Yours respectfully,

(Signed) J. VIVIAN.

The water from the boiler contained a large quantity of salts in solution besides a large sediment.

"Its specific gravity was 1.04951, and on evaporation it left a residue, deposited from solution, of 69.09 grammes per 1,000 grammes of water, or 4027 grains per gallon. Disregarding the sediment, the residue left insoluble on evaporating to dryness and the organic matter the water contained in 1,000 parts.

Chlorine	39.171
Lime	14.727
Magnesia	.144
Sulphuric acid (SO_3)	.417
Carbonic acid (combined)	.110
Potassa	.850
Soda	17.651
These figures may be combined as follows:	
Sodium chloride (common salt)	33.265
Calcium chloride	30.467
Potassium chloride	1.345
Calcium sulphate	.622
Magnesium suphate	.078
Magnesium carbonate	.248

"The mine water had a specific gravity of 1.00647 and contained 8.515 grammes of soluble salts in 1,000 grammes of water, or 496 grains to the gallon. Neglecting the organic matter and insoluble residue the water contained in 1.000 parts.

Chlorine	4.739	Sodium chloride	4.021
Lime	1.9293	Calcium chloride	3.553
Magnesia	.0493	Potassium chloride	.163
Sulphuric acid	.145	or Calcium carbonate	.056
Combined carbonic acid	.079	Calcium sulphate	.247
Soda	2.132	Magnesium carbonate	.104
Potassa	.103		

Very truly yours,
(Signed) R. L. PACKARD."

COMMENTS AND COMPUTATIONS.

The ratio of K : Na : Cl in the boiler water and mine water is practically the same. Some sulphate and carbonate of lime and magnesia have been deposited as scale from the boiler water, but on the whole they check each other up very well, and we have:

4.	Cl	4.739 per thousand
	Na	1.583
	Ca	1.378
	K	.086
	Mg	.030
	Fe, Al, Si p.n.d. compare following analysis.	
	Organic	
	CO_3	.088
	SO_4	.174
		8.078
	Undetermined	0.437
	Total solids	8.515
	Na:Cl	.33
	Ca:Cl	.29

5. Franklin mine. Some time in the 80's another analysis was made of the Franklin mine[1] water, as follows:

Franklin Copper Mine Company—

	U. S. Gallon, grains.
Silica	7.813
Iron sesquioxide	1.022
Alumina	.932
Lime	63.911
Magnesia	5.463
Potassa	5.433
Soda	59.952
Carbonic acid	1.945
Sulphuric acid (SO_3)	10.596
Chlorine	156.828
Organic matter	1.566
Total	315.461

1 Messrs. Clow & Son got tills made in Chicago but never gave the name of the man that made it.—J. Vivian.

COMMENT AND COMPUTATION.

This is very much like 4, contains a little less sodium in proportion, but otherwise, and even in minor ingredients pot. ash, magnesia, carbonate and sulphate checks with No. 4 quite well. This, like 3 and 4, is in analysis of the mine water as pumped and contains the deeper water considerably diluted and no doubt was essentially a boiler water analysis.

5. We compute:

Cl	2.694 per thousand
Na	.763
Ca	.784
Mg	.056
K	.077
Fe	.012
Al	.016
Si	.134
CO_3	.046
SO_4	.213
Organic	.027
Sum	4.827
Na : Cl	.283

It comes from the same general lode and horizon as the Quincy mine waters analyzed by Koenig, Fernekes and Steiger below, and the water from seams in the Franklin Junior crosscut (analyses 86-88) is also from geologically a similar horizon and depth. The relatively greater amount of sodium as compared with them is marked.

G. A. KOENIG, ANALYST.

6. Tamarack Pond. The next analyses made may have been some by G. L. Heath, of the Calumet & Hecla mine water, but I will first give tests by Dr. G. A. Koenig of the water of the Tamarack mine, as it contaminated the pond from which the boiler water was taken. There is an error in copying the figures below, probably in the calcium carbonate, and the original figures cannot be found. The water was white, opalescent, neutral, boiling gives a white precipitate and the reaction be comes alkaline.

Total		.79544 per thousand
(CO_2 as)	$CaCO_3$	.254
	$CaCl_2$	.19564
	$MgCl_2$	.0608
	SiO_2	.0215
	NaCl	.2603
	Na_2SO_4	.0242
	Sum	.81644
Organic matter		p. n. d.
Bromine		p. n. d.

This may be computed as:

Cl	.33990		
Na	.08904		
Ca	.17073	?	Probably .15073
Mg	.02408		
SiO_2	.02150		
CO_3	.15384	?	
SO_4	.01635		
Sum	.81544		
	.79544		
Na : Cl	.264		

In this pond water the deep mine water is diluted with surface water rich in lime carbonate but not in sodium silicate as is the case in analyses 4 and 5, where it is diluted with the upper level mine waters. The kind of water which is thus diluted as is shown by Wilson's analysis 22.

7. Quincy Mine. Dr. Koenig made some tests on a deep water from the 47th level of the Quincy running into a sump on the 50th level, given in our annual report for 1903, p. 243, as follows:

Sp. Gr.	1.1898
$CaCl_2$	179.1 per thousand
NaCl	29.6*
$MgCl_2$	0
SO_3	0
CO_2	0
Fe	.004
Cu	.009

The Sp. Gr. would indicate 216.27 grains per kilo of $CaCL_2$. We may compute this as:

Cl	132.5
Na	11.7
Ca	64.5
	208.7

Na : Cl .0885.

This is essentially the same as the water obtained by G. Fernekes from the pump at the 62nd level, and as tested by Geo. E. Steiger, U. S. G. S. Bull. 330, p. 144, and the discrepancies are clue to the difficulty of determining small quantities of other things beside such large quantities of calcium chloride. After running along the level the copper dropped to 7 grams per ton.

*Misprinted 2.96 in the 1903 annual report, p. 243.

8. Freda. Dr. Koenig also made some tests of the water of a deep well put down at Freda by the Copper Range Co., which, with the record of the well, are given in the 1903 annual report. It is worth remembering that this is by the side of Lake Superior, five or six miles from the traps of the main copper range in the formation which I have concluded to call the Freda sandstone, the western sandstones of some writers, the Upper Keweenawan of Irving. The well all the way down was in red sandstones, red clays, and fine grained conglomerates, with a good proportion not only of felsites but of grains of more basic rocks. Computing the figures in ions we have:

Cl	40.42
Na	7.60
Ca	16.04
Mn	.57
Mg	.03
K	.30
Br	.21 to .35*
	65.17

Na : Cl .173.

*Midland Chemical Co.

It is worth noting that the much deeper wells at Lake Linden in the eastern sandstone are not reported to have struck any salt water and the analyses (1903 report, pp. 163-164), show only a few, 52.69 parts per million of salt (sodium chloride). It is said, however, that the 1200' well at Grand Marais struck salt water. A well at Pickford put down in 1907, which reaches down into the Potsdam sandstone and has a heavy flow of water below 1,000 feet, probably at about 1,400 feet, has only .307 of Cl with .9649 mineral constituents.

Other tests of shallow mine waters mixed with surface waters, etc., by Dr. G. A. Koenig are also given in the report for 1903:

9. Winona mine, (annual for 1903, p. 146).

10. Clark mine (annual for 1903, p. 143).

11. Portage Lake water (annual for 1903, p. 144).

This lake receives the drainage of the Quincy and other mines. Compare 31 and 32.

Other well water tests by him, and surface waters are given there.

12. Arcadian shaft (annual report for 1903, p. 243), analyzed Aug. 23, 1898. The shaft was probably not over 250' deep.

ANALYSES BY G. L. HEATH.

Through the courtesy of the Calumet & Hecla officers I can cite various analyses by the chemist, most of them already published in previous reports.

13. In the annual report for 1903, pp. 143, 163, 164 are a number of analyses of waters from the sandstone around Lake Linden, the strongest of them only .1842 grams per liter. The deepest well was 1,500 feet. Mr. G. L. Heath writes that "no salt water was ever found in it, the well is now filled up several hundred feet so that they are pumping from the upper 500 feet".

"I think that the 1,500-foot well never did furnish much of the supply from the bottom".

14. In the report for 1903 (p. 166) is also an analysis of the water from the vertical, the Red Jacket (or "Whiting") shaft of the Calumet & Hecla Mining Co. A partial section of this shaft from the company officials is given in Volume V of our reports, which shows its general relation to the Calumet & Hecla conglomerate. It has been continued, and passes through the same at 3,287 feet, down to 4,960 feet. The upper water is so far as possible cased out although there is more or less dripping, and the remaining water is so little that it needs no pump, but can be handled by a tank car, which automatically dumps the water at the top of the shaft. These salt waters are also hard on pumps so that the use of bailers has more than one advantage.

No doubt a good part of the water comes through the lining of the shaft, for as Heath remarks* "the water pumped from the Hecla end of the mine at much less depth is even more saline—from above the 24th level it is bad.

Capt. J. Pollard has shown me cubes of salt from the 9th level, several mm. in diameter, probably due to the slow oozing out and evaporation of the salt water.

The Tamarack No. 3 shaft, Volume V, Part 1, shows "salt water at 1,267 feet" so that the water from the Whiting and similar vertical shafts must not be ascribed to any one horizon.

Mine water, C. & H. vertical shaft. Details of probable composition:

	Grains per U. S. gallon.
Insoluble silica— in sediment	1.29
Insoluble oxide of iron—in sediment	.74
Dissolved silica (SiO_2)	.19
Dissolved chloride of iron	.26
Zinc chloride (with trace nickel)	1.69
Copper chloride ($CuCl_2$)	.26
Magnesium chloride	5.10
Sodium chloride (salt)	109.37
Potassium chloride	4.31
Calcium chloride	182.87
Calcium sulphate	3.23
Calcium carbonate (dissolved by free carbonic acid)	14.46
Loss on ignition (actual determination)	63.0
No lithium. Undetermined balance, traces carbon, etc.	
Sum of all constituents	386.77
"Total solids" on evaporation as weighed. (383+) (354+)	368.5+

G. L. HEATH.

*Letter, Feb. 22, 1904.

The water was slightly alkaline, and owing to difficulty in weighing a hygroscopic brine residue like this Mr. Heath thinks the sum of constituents as reliable as total solids, since it is impossible to drive off the water without volatilizing other things.

Comment and computations.

The amount of calcium carbonate is nearly that of saturation with the bicarbonate. Bromine and fluorine were not determined

14. We compute:

Cl	3.2632
Na	1.740
Ca	1.2496
Mg	.0216
K	.0388
Fe	.0026
Cu	.0029
Zn	.0134
CO_3	.149+
SO_4	.0392

Na : Cl .543.

The amount of sodium is relatively very high.

15. A stronger but yet mixed water derived by tapping the water that had accumulated in the Tamarack Junior mine is given by Mr. G. L. Heath, July 27, 1905.

The original figures are:

Sediment (over ½ iron oxide).. .03630 grams per kilo

In clear water:

Silica	.0062
Copper chloride	.0022
Ferrous chloride	.0094
Zinc chloride	.0016
Magnesium chloride	.0346
Calcium sulphate	.0011
Calcium carbonate	.1409
Calcium chloride	8.0912
Strontium chloride	.03152
Lithium chloride	.0038
Potassium chloride	.01174
Potassium bromide	.04736
Sodium chloride	1.9687
Sum	10.38662
Organic matter by diff.	1.3643
Total solids	11.7509
Direct approximate test: organic matter by loss on ignition of solids at redness	1.328

Comment and Computation.

The very small amount of sulphate is noteworthy, and the presence of strontium may be connected with it, for strontium sulphate is but very slightly soluble in salt solutions.

Very rarely barite (and celestite?) are found in the Calumet mine.

15. We may compute:

Cl	6.421
Na	0.776
Ca	2.875
Mg	.009
K	.019
Fe	.006
Cu	.00144
Zn	.00076
Sr	.01742
Li	.00063
CO_4	.084
SO_4	.001

Na : Cl .121.
Ca : Cl .448

The sodium is lower. The Tamarack Junior was not rich.

16. Calumet and Hecla 3,000 feet.

None of the above analyses represent the lower mine water of the Calumet & Hecla. They merely represent the upper mine waters more or less contaminated with

the lower. The following test is entirely different being of a sample taken for Prof. H. L. Smyth of Harvard, at 3,000 feet depth, vertical probably. Analysis made by Robert Forsyth. The figures are:

66.94 grams per liter solids of which—

Ca	24.77
Mg	0.06
Na	12.14
Cl	61.97
SO_4	0.22
$Si\ O_2$	0.09
Br	.15
Al	.17
	99.57

16. Assuming a Sp. Gr. of 1.05 we should find:

Total solids	63.80
Cl	39.6
Na	7.8
Ca	15.9
Mg	.04
SO_4	.14
$Si\ O_2$	.06
Br	.10
Al	.11
Sum	63.75

Na : Cl .199.
Ca : Cl .403.

ANALYSES BY F. B. WILSON.

When I came to prepare for my 1903 report my paper on the deposition of copper the distribution and chemical character of these mine waters assumed an importance for me that it had not heretofore and I made up my mind to make some personal tests arid obtain samples.

The first mine visited was the Wolverine. This is on the Kearsarge lode, an amygdaloid which dips 40°-41°, but there have been a number of exploratory crosscuts. The Sp. Gr. of the water (at 48° F.) in the

17. 8th level crosscut was 1,000 by urinometer.

18. 13th level crosscut was 1,000 by urinometer.

19. 17th level crosscut was 1,017 by urinometer.

19. The sample from the 17th level was tested by F. B. Wilson with the following results:

Sp. Gr.	1.022	
Cl	15.2287	grams per liter
Na	2.731	
Ca	6.300	
Mg	.013	
SO_4	.0724	
Sum	24.3451	

We may compute this

Na : Cl	.181
NaCl	6.920
$CaCl_2$	17.280
$MgCl_2$	.049
$Ca\ SO_4$	.149
Total	24.398

This total agrees with the Sp. Gr. which I found. This agrees pretty closely with Fernekes' tests at the 20th level south, Wolverine No. 3.

20. 24th level in lode (possibly some water working down through the slopes) 1.012 by urinometer.

21. 29th level crosscut was 1.033.

A some months later test (it may have evaporated) 1.041.

Drops of water from the 17th and 29th levels (19) left to dry seemed to show the water of the 17th level to have rhombs of carbonate ($CaCO_3$) and cubes of salt more conspicuous and abundant. The 17th level water seemed (21) to show gypsum crystals, the 29th crystals with parallel extinction that might be anhydrite.

The residue from drop of water from the 29th level was notably more hygroscopic and deliquescent.

The behavior agrees with what was found by Fernekes, comparing the 20th and 26th levels.

22. Tamarack mine, Osceola lode.

Later that year in collecting the samples from the 30th level crosscut of Tamarack in connection with President McNair's gravity work, I had a good chance to get a sample from that depth. The results are as follows:

22. Water from Tamarack mine, 4,300 feet down at 1,794-1,800 feet from shaft No. 2. Taken by A. C. Lane, Sept. 14, 1905. Analyzed by F. B. Wilson—letters of Oct. 8, 9, 28 and Nov. 22.

Wilson's determinations.

Sp. Gr.	1.135	
Total solids at their melting point	157,411.5	per million grams per ton parts
Cl	97,963	
Ca	47,166	
Mg	tr	
CO_3	0	
Ba & Sr by flame test on precipitate	0	
Na	8,278	
K	837	
SO_4	226	
NH_4 Cl by distillation	2,456.7	
Whence we may compute (A. C. L.)—Na : Cl =.085.		
NH_4	829.8	
Total determined solids	155,299.8	
Undetermined (organic matter crystal water traces of Fe, Mg, etc).	2,111.7	
Which may be combined as		
Ca Cl_2	130,508	requiring 83,436 Cl_2
Ca SO_4	320	
Na Cl	21,009	requiring 12,731 Cl
K Cl	1,595	758
NH_4 Cl	2,457	1,627
	156,478	98,552
Excess of salts, shortage of Cl, perhaps replaced by organic acids	1.169	.589

Organic matter leaves a small residue of carbon in the total solids.

The Sp. Gr. agrees quite well with the total solids. The ratios are:

Na : Cl	.0846
Ca : Cl	.482

A ratio of Na : Cl like this (compare Wolverine No. 3 shaft at the 30th level S.) seems to be that normal to the deep waters.

This analysis has been cited by me in discussing the chemical evolution of the ocean.*

23. I also made urinometer tests of the waters at other points in the 29th and 30th level crosscuts but in every case noted they were stronger than 1.060 the limit of the urinometer scale. In particular is this true of water dripping from a winze up to the 29th level, about 400 feet from No. 2 shaft, which seemed to be between 1.08 and 1.16.

24. As reported in Volume V in the Tamarack No. 3 shaft salt water was struck at 1,267 feet depth, about the horizon of the Quincy lode,[1] in an amygdaloid horizon much above the C. & H.

25. One of the specimens, too, from Tamarack shaft No. 4 from an ophite close above the Calumet & Hecla conglomerate—No. 16,472,]4b72, though kept in our collection from 1894 to 1906 was still damp and bitter with calcium chloride. In fact I believe that President McNair has found this feature a serious difficulty in obtaining specific gravities very accurately.

*Jour. Geol. XIV (1906) p. 221, Bull. G. S. A. XVII (1906).

1 Annual report for 1903, p. 258.

26. Osceola mine. As No. 22 comes between the Osceola amygdaloid and Calumet & Hecla conglomerate, we may here note that Prof. James Fisher of the M. C. M., reports salty water that was popularly supposed to be depositing copper at the 26th level of the Osceola, following down the foot.

30. Challenge mine. The Challenge mine at the 3rd level at about. 700 feet from the surface is distinctly saline. Mr. P. B. Wilson found Ca .232 per thousand which is more than in the ordinary hard water, while the field assay outfit gave me Cl 3.480 about.

Later tests show even stronger waters in a crosscut at this level.

The index of refraction is also distinctly greater than that of pure water, and corresponds to a specific gravity somewhere about 1.015. The sample was not, however, so taken as to be free from possibility of urine contamination.

BOILER WATERS.

Before passing to the chief suite of analyses, that of Dr. G. Fernekes, it will be well to introduce for comparison a group of boiler water analyses from W. A. Converse, of the Dearborn Drug & Chemical Works.

31. Is of Portage Lake at the Isle Royale mill, contaminated both with mine water and sewage. Compare II.

32. At the Franklin mill, of the same body of water. They are both in a wider part of the lake and a little more dilute than the samples tested by Koenig.*

33. Mass creek and mine. Taken while the mine water was yet fresh. Compare Frapwell's analyses (46, 50 53, 55), from the Mass mine.

34. Michigan Copper Mining Co., Rockland Spring is a typical water of the drift or upper levels. One would expect, however, with so much sodium carbonate more silica.

*Annual for 1903, p. 144.

35. Osceola; stamp mill creek, contaminated but probably not with mine water as the lime does not go up.

36. Creek at Painesdale (near Champion mine). Has the normal amount of chlorides; no mine contamination.

37. Creek at Tri-mountain, very much like 36, typical surface waters.

38 and 39. Atlantic mine boiler water, a very similar surface water. The higher amount of chlorides is probably due to organic pollution.

40. The Salmon Trout river at Baltic mill is another surface water just like 36 and 37.

41. Spring near Quincy mill; is very low in hardness; reminds one of the sandstone waters, and is over the eastern sandstone; a rain water; the contamination is probably surface.

42. Pond at Allouez mine; very soft; surface contamination.

43. Creek at Mohawk mine.

44. Tobacco river, March 27, 1903.

45. Tobacco river, April 6, 1904.

Compare 44 and 45 with Koenig's analyses of Tobacco river annual for 1903, p. 145.

These are not mine waters and are only introduced here to show what the mine waters would be if they were mainly made up of these surface waters and to show practically what may be expected by using surface waters instead. The normal analysis of a surface water is obviously:

Ca	19	
Mg	4	
Cl	3.5+	if contaminated.
Na	2.3+	if contaminated.
SiO_2	10.	
CO_3	40 +	
SO_4	6 +	
$(FeAl)_2 O_3$	1.5	
Sum	86.3	per million.

BOILER WATER ANALYSES, DEARBORN DRUG & CHEMICAL CO.,, CHICAGO, ILL.

ALL ARE IN GRAINS PER GALLON.

	31.	32.	33.	34.	35.	36.	37.
SiO_2	.537	.408	.846	.204	.607	.846	.782
$(FeAl)_2O_3$	.152	.151	.233	.321	.023	.152	.035
$CaCO_3$	2.192	2.709	1.880	2.803	4.147	2.920	2.826
$CaSO_4$	.664	trace	trace	trace	.166	trace	trace
$MgCO_3$	.756	.725	.398	.442	1.592	.973	.924
$(NaK)_2SO_4$	trace	trace	1.628	....	....	trace	trace
$(NaK)_2CO_3$	....	....	....	7.255	....	....	....
(NaK) Cl	1.014	1.352	.338	1.005	8.160	.338	.338
Loss, etc	.174	.145	.167	....	.138	.027	.235
Min. Sol.	5.489	5.490	5.490	12.030	14.833	5.256	5.140
Org. matter	trace	trace	trace	.818	.701	....	.584

31. Specimen of water, marked "Portage Lake," received from Isle Royale Stamp Mill, Houghton, Michigan. Feb. 7, '03.

32. Specimen of water, marked "Portage Lake," received from Franklin Mining Co.'s Mills, Pointe Mills, Michigan. Feb. 13, '03.

33. Specimen of water, marked "Creek & Mine," received from Mass Cons. Mining Co., Mass City, Michigan. May 23, '03.

34. Specimen of water, marked "Spring," received from Michigan Copper Mining Co., Rockland, Michigan. April, 1899.

35. Specimen of water, marked "Creek," received from Osceola Stamp Mills, South Lake Linden, Michigan. July 17, '02.

36. Specimen of water, marked "Creek," received from Copper Range Mining Co., Champion mine, Painesdale, Michigan. Feb. 25, '03.

37. Specimen of water, marked "Creek," received from Tri-Mountain Mining Co., Tri-Mountain, Houghton Co., Michigan. Jan. 23, '03.

ALL IN GRAINS PER GALLON.

	38.	39.	40.	41.	42.	43.	44.	45
SiO_2	.630	.584	.642	.642	.233	.478	.508	.513
$(FeAl)_2O_3$	.093	.081	.088	.082	.075	.327	.087	.648
$CaCO_3$	2.239	1.925	2.576	.882	1.068	2.253	1.798	....
$CaSO_4$	.664	.996	.332	.498	trace	.796	trace	....
$MgCO_3$	.898	.949	.721	.570	.455	.681	.628	....
$(NaK)_2SO_4$	trace	trace	trace	trace	trace	trace	trace	....
(NaK) Cl	.676	.338	.338	.676	.676	1.352	.660	.338
CaO								.520
MgO								.157
SO_3								.113
Loss, etc	.056	.032	.091	.037	.062	.186	.056	.047
Min. solids	5.256	4.906	4.788	3.387	2.569	6.073	3.737	2.336
Oil & Organic matter	trace	trace	trace	.467	.467	10.512	trace	2.803
Suspended						1.752		1.168

38. Specimen of water, marked "Creek or Dam," received from Atlantic Min. Co., Atlantic Mine, Houghton Co., Michigan, Feb. 27-03. Contains a little less than 5½ grains of mineral matter and a trace of organic matter, per U. S. gallon.

39. Specimen of of water, marked "From creek after passing through heater," received from Atlantic Min. Co., Atlantic Mine, Mich., Feb. 27-03. Contains nearly 5 grains of mineral matter and a trace of oil and organic matter, per U. S. gallon.

40. Specimen of water, marked "Salmon Trout River" (after passing heater.) received from Baltic Stamp Mill, Redridge, Mich., March 18-03. Contains a little less than 5 grains of mineral matter and trace of oil and organic matter, per U. S. gallon.

41. Specimen of water, marked "Spring after passing through heater," received from Quincy Stamp Mills, Mason, Houghton Co., Mich., Jan. 26-03. Contains a little less than 3½ grains of mineral matter and a small amount of oil and organic matter, per U. S. gallon.

42. Specimen of water, marked "Pumped from mine into pond," received from Allouez Min. Co., Calumet, Mich., April 27-03. Contains a trifle over 2½ grains of mineral matter and a small amount of organic matter, per U. S. gallon.

43. Specimen of water, marked "Mixture of creek and mine" (taken from heater.) received from Mohawk Min. Co., Mohawk, Mich., April 16-03. Contains a trifle over 6 grains of organic matter in solution and a little less than two grains of solid matter in suspension, per U. S. gallon.

44. Specimen of water, marked "Tobacco River," received from Wolverine and Mohawk Stamp Mills, Houghton, Mich., April 6-04. Contains a little over 3½ grains of mineral matter and a trace of organic matter, per U. S. gallon.

45. Specimen of water, marked "Tobacco River" received from Wolverine Copper Min. Co. Mills, Gay Sta., Mohawk, Mich., March 27-03. Contains a little over 2 grains of mineral matter, a little less than 3 grains of organic matter in solution, and a trifle over 1 grain of solid matter (principally organic) in suspension, per U. S. gallon.

SURFACE WATERS OF KEWEENAW RANGE.*

	31. Isle Royale Portage Lake.	32. Franklin Mills.	33. Mass Creek and Mine.	34. Michigan C. M. Rockland Springs.	35. Osceola Stamp Mill Creek.	36. Painesdale Creek.	37. Tri-mountain.	38. Atlantic.	39. After Heating.
Ca	18.3	18.6	12.9	19.2	29.2	20.0	19.4	18.7	18.2
Mg	3.8	3.6	2.0	2.2	8.	4.8	4.6	4.5	4.7
Na	6.8	9.1	11.3	60.9	55.	2.2	2.3	4.5	2.3
K									
Fe Al O_3	2.6	2.6	4.0	5.5	.4	2.6	.6	1.6	1.4
SiO_2	9.2	7.0	14.5	3.5	10.4	14.5	13.4	10.8	10.
Organic		tr.	tr.	(14)b	(12)b		(10)b	tr.	tr.
SO_4	8.0	tr.	18.8	tr.	62.	42.	40.4	4.	31.4
CO_3	31.8	36.7	24.2	104.8	2.	tr.		8.0	12.
Cl	10.5	(a)14.	(a) 3.5		84.5	3.5	3.5	7.	3.5
Loss		2.4	2.8		2.4	.4	4.	.9	.5
Sum	94	94	94	206.5	255.9	90	88.2	90	

(a) Contaminated by Quincy mine water and sewage of Houghton, Hancock and Dollar Bay.
(b) Not included in summation.
(c) 130 parts per million suspended.
(d) 20 parts per million suspended. Oxygen with Mg and Ca 3.6, organic acids combined with bases instead of CO_2 and the sample is acid.

* Boiler water analyses by Dearborn Chemical Works, Chicago. Compare with 11 and 12, Annual for 1903, p. 144; 24 and 25, 145; compare with 22, analyses of Boston pond at the Franklin Junior; analyses p. 146; compare with 14, Annual for 1903, p. 163; compare with the upper mine waters, Annual for 1903, pp. 135-157.

SURFACE WATERS OF THE KEWEENAW RANGE.*

	40. Baltic Salmon Trout River.	41. Quincy Mill Spring.	42. Allouez Mine Pond.	43. Creek and Mine Mohawk.	44. Tobacco River March 27, 1903.	45. Tobacco River April 6, 1904.
Ca	19.3	8.6	6.9	19.4	6.4	12.3
Mg	3.6	2.8	2.3	3.4	1.6	3.1
Na	2.3	4.5	4.6	9.1	2.3	4.4
K						
Fe Al O_3	1.5	1.4	1.3	5.6	11.1	1.5
SiO_2	11.	11.	4.	8.2	8.8	8.7
Organic	tr.	(8)b		(180)b	(48)b	
CO_3	35.2	16.1	16.6	31.4	?	261
SO_4	4.0	6.0	tr.	tr.	2.3	tr.
Cl	3.5	7.0	7.0	14.0	3.5	6.9
Loss	1.6	.6	1.1	3.2	.8	1.0
Sum	82	58	43.8	103.8(c)	(40)d	64

(a) Contaminated by Quincy mine water and sewage of Houghton, Hancock and Dollar Bay.
(b) Not included in summation.
(c) 130 parts per million suspended.
(d) 20 parts per million suspended. Oxygen with Mg and Ca 3.6, organic acids combined with bases instead of CO_2 and the sample is acid.

*Boiler water analyses by Dearborn Chemical Works, Chicago.

Compare with 11 and 12, Annual for 1903, p. 144.

24 and 25, 145.

Compare with 22, Analyses of Boston pond at the Franklin Junior.

Analyses of Boston pond at the Franklin Junior, p. 146.

Compare with 14, Annual for 1903, p. 163.

Compare with upper mine waters, Annual for 1903, pp. 135-157.

TESTS BY A. P. FRAPWELL.

Mr. A. P. Frapwell, assistant in chemistry at Ann Arbor, 1906-7, was with its in the summer, and I had him make the tests of the following table with the field assay outfit. They are arranged in the table according to decreasing amount of chloride. The Ca runs from 19 to 60, though the results are not very reliable. The same comment applies to SO_4 determinations, as the electric cells were old. Still that would tend to give SO_4 too high, and we may be sure that SO_4 is at least as low as the low figures shown. Of these waters Nos. 52, 53, 57, 58, 59, 60, 61, 63, and 64 are surface waters and it will be noticed that while 52 to 53 are probably contaminated and have 19 and 12 parts per million chlorine the rest have from 3 to 6 parts of Cl. The tests were made in August.

46. Mass mine. Water from seam on 17th level is a typical lower water. This is the only one that showed an increase in Sp. Gr. which according to Frapwell was (? on 18th level) 1.041 by urinometer, or about 5% solids. Compare with No. 50 and note that down to the 10th level it is fresh.

47. This was a sample sent in by Mr. Dennis from the Rhode Island mine on the Allouez conglomerate, at the 1,000' level. This was also tested by Fernekes just as he was leaving and pronounced fresh. This is the same lode as the Franklin Junior is working and is about the same strength as that at the 7th level according to Fernekes.

48. This water flows from diamond drill hole No. 5 of the Belt mine. It is 3,680 feet S. and 1,960 feet E. of the N. quarter post of Sec. 31, T. 51, R. 37, in a swamp 408' above Lake Superior. It was put down at an angle of 62° 26' and it was 127' to bed rock, i. e. 112 feet vertical. The presence of sodium carbonate and its softness are noticeable. It flows nearly one cubic foot per minute at a temperature of 45 ° F. A similar water comes from a Calumet and Hecla drill hole. The conditions are favorable for a flow (see cross section Fig. 1), as the clip is to the north and there is a hill to the south. Taking the temperature and all considerations together, it is probable that the water comes in not below 5,207 feet of drill hole or 180 feet vertically, and it is interesting as showing how close to the surface the saline, water comes where the hydrostatic pressure is upward, even though shielded by drift from active circulation and with no great depth of circulation.

49. The water of the Michigan mine, B shaft, down to the 10th level inclusive, as pumped to surface. One is tempted to believe that there was also some turbidity here as well as in No. 51 counted in the sulphates.

50. The water of Mass mine, C shaft, for the first thou sand feet, down to and including the 8th level.

51. Adventure Mining Co., No. 4 shaft, water as pumped down to the 8th level inclusive. This shows a little greater strength than No. 54.

52. Rockland town pump, depth 25 feet. The chlorine here is possibly due to sewage contamination.

53. Mass mine hospital well. The chlorine here is also possibly sewage contamination, though very likely not recent.

54. Adventure mine No. 1 shaft, water down to and including the 6th level.

55. Mass mine, A shaft, water from seam in 10th level.

56. Adventure mine, No. 3 shaft, water as pumped down to and including 12th level.

Taking such analyses as 54, 55, and 56, it is obvious that they are as good boiler water practically as the surface waters and that 53 may have contained a good deal of mine water. Analyses 49, 50 and 51 begin to show contamination with chlorine, but on the whole the water is very fresh. Comparing them with drill hole water No. 48 we see the difference produced by the topography, for the latter is in a valley in the rock surface, while the Mass, Michigan and Adventure mines are beneath high ground, on the sides of hills that rise a couple of hundred feet above the general level and 500 or 600 feet at least above the valleys of the rock surface.

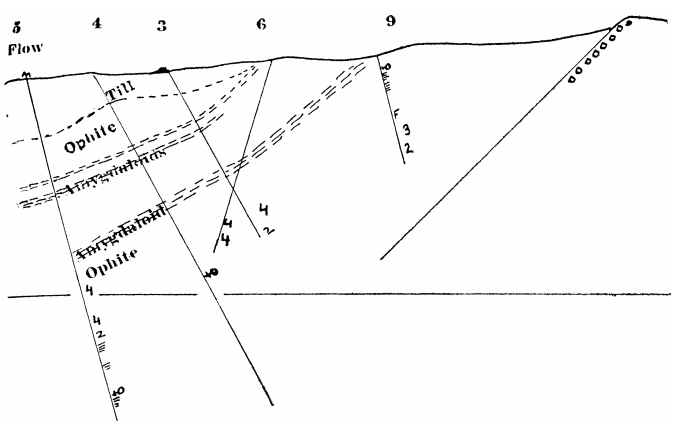


FIGURE I. Cross section at Lake Copper Company, illustrating the flow at drill hole 5.

57. Greenland town pump, depth 25 feet, in the center of the town surrounded by houses.

58. Well at carriage barn, Michigan mine.

59. Boarding house well at Adventure.

60. Surface spring top of Knowlton Hill.

61. C. R. R. tank, near Belt station, surface springs on south front of Aztec hill, Sec. 31, T. 51 N., R. 37 E.

62. This was sent in by Mr. Dennis from the Rhode Island mine from a diamond drill hole into the hanging of the Pewabic lode, and should be compared with tests at the Quincy and Franklin Junior mines.

63. Well at dwelling house on a farm at Riddle Junction. This is in the drift in lake clays, and N. B. not marine clays.

64. Spring near top of Flint Steel hill near road. This is practically a surface water having no great depth.

	Cl.	SO_4	Total Hardness		Alkalinity			Alkalinity			Total CO_3
				as Ca	$CaCO_3$	Ca	det CO_3	Na_2CO_3	Na_2	det CO_3	
46	22476	135	109	44	15	6	9	21	9	12	21
47	760	Not determined									
48	264	82	61	24	25	10	15	32	14	18	33
49	58	120	123	49	340	136	204	0			204
50	30	110	82	33	263	105	158	0			158
51	20	foot note *	113	45	187	75	112	0			112
52	19	less than 20	133	53	165	66	99	0			99
53	12	" "	205	82	341	136	205	0			205
54	7	" "	48	19	195	78	117	0			117
55	6	38	41	16	225	100	125	0			125
56	6	less than 20	123	43	175	70	105	0			105
57	6	" "	96	38	146	58	88	0			88
58	5	" "	82	33	75	30	45	0			45
59	5	" "	92	37	120	48	72	0			72
60	4	" "	48	19	59	24	35	0			35
61	4	" "	116	46	147	60	87	0			87
62 x	3	Not determined									
63	3	" "	150	60	213	85	128	0			128
64	3	" "	48	19	48	19	29	0			29

*The SO_4 determination wais not accepted, as the water was very heavily charged with suspended matter.

In the case of the 1st and 3rd determinations, if $CaCl_2$ were present, the dissociation theory might account for the abnormal results obtained in the tests for carbonates.

The springs at top of Knowlton and Flint Steel Hills are on the road from Greenland to Rockland. When the water, is said to come from more than one level, the tests were made on the water after it was pumped to surface.

xDrill hole, northwest into hanging.

The amounts are in milligrams per liter.

The methods are those of U. S. water supply paper, No. 151, Field Assay of Water.

DR. G. FERNEKES' ANALYSES.

In talking over the matter with Dr. G. Fernekes, of the chemical department of the College of Mines, he expressed a very keen interest and willingness to take the matter up more systematically. His experiments in reproducing copper were his own free contribution to the advancement of science, and he also made a series of tests of mine waters, which went far beyond what he was paid for.

In all cases chlorine, calcium and total solids were determined. In many cases computing sodium enough to satisfy the acid, made solids enough by summation very nearly to agree with those obtained by "heating to incipient fusion", which latter is the way the total solids were determined for the lower stronger waters. This gave results a "little too low" as "some of the calcium chloride was broken up". This method was not employed for the upper waters that might contain large proportions of carbonates. In a number of cases other substances were determined, the bromine most commonly. In a few cases exhaustive tests were made, and tests for copper and nickel more widely. Iron and alumina were measurable in the Quincy waters.

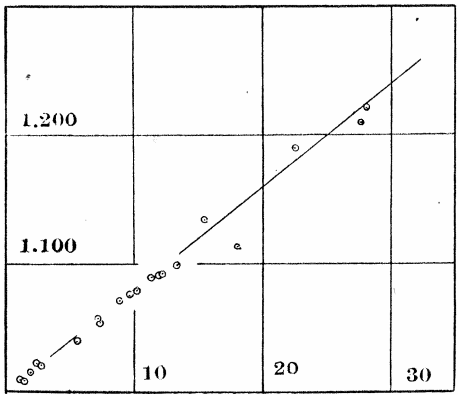


FIGURE II.

The results are in grams per liter, oz. per cubic foot. Sp. Gr. was determined for about a dozen of the waters. As is shown by figure it pretty closely follows the rule that ten eighths of the excess of Sp. Gr. is the proportion of total solids. The NH_3 was not titrated but distilled. Distillation tests failed to detect ammonia generally.

Connecting the Sp. Gr. and the total solids the percentage are represented by abscissas from left to right, the specific gravity by ordinates. The total solids as here given therefore will not include organic matter or ammonia, or a very small amount of the chlorine perhaps, but the moment we try to include them in the total solids we find ourselves also including more or less crystal water.

TESTS OF THE BALTIC LODE.

This is the lowest of the lodes. It lies between a conglomerate (the Baltic conglomerate) as it is generally called (No. 3) and a heavy ophite, known as the Mabb ophite, whose mottles are up to 7 mm. across. The distance above the conglomerate varies, but is about (150) feet more or less, and it is 170 to 200 feet below the ophite. It is no one well defined amygdaloid top to a flow but rather an impregnated shear zone or stock werk, copper being found over a belt more than 40 feet wide.

Besides Fernekes' tests see other tests and reports from the Baltic, Trimountain, Champion and Challenge shafts. (130-133).

65. Trimountain. On a visit to the Trimountain mine of the Copper Range Company, Sept. 4, 1906, I took a sample of salt water from 200 feet N. of shaft No. 3 S. 9th level in a lean streak of rock that comes under a cross seam which dips about 450 to the south.

The Sp. Gr. as estimated in the mine was 1.078 at the mine temperature, probably about 51° F.

Dr. Fernekes found, Sept. 8, 1906.

Sp. Gr.	1.053	(= 65.8 $CaCl_2$)
Total solids	74.44	parts per thousand
Cl	46.02	
Na	3.36	
Ca	24.58	
SO_3	.484	
Fe, Mg, CO_2	tr.	
Sum	74.444	

We may compute:

NaCl	8.54
$CaCl_2$	63.90
$CaSO_4$	.823
Excess of Ca combined with CO_2 in part	1.28
	74.543

Na : Cl .076
Ca : Cl .535

A larger sample taken for and tested by Dr. Fernekes was less strong (perhaps this latter was of the water of the drift as a whole) as follows:

66. Trimountain 9th level.

Cl	19.874	per thousand
Ca	9.000	
(to satisfy acids) Na	2.653	
Br	.243	
	31.770	
Diff.	.230	
Total	32.000	

Na : Cl .133
Ca : Cl .453

Both in concentration and proportion of sodium this No 66 is of a distinctly higher type than No. 65, but as it was taken later, the water may have run down from a higher level. I have elsewhere noted that salt water was reported from tins mine at the 6th level.

The Baltic water appears to be fresher than the Trimountain. The drift covering was much thinner, the bed rock surface higher and the lode on the whole richer.

67. Baltic mine. 15th level. Dr. Fernekes reports:

Cl	27.264	
Ca	13.682	
Na	1.929	
Br	0.3112	
Sum	43.187	
Difference	.813	(CO_3 or SO_4)
Total solids	44.000	

Na : Cl .073

We may compute:

$CaCl_2$ 38,	Cl =	24.3
$NaCl_2$ 3.79,	Cl =	2.946
NaBr .402,	Br =	.312
Na_2CO_3 2.3		
44.492		

—Where the carbonate and sulphate really combine more with the lime.

Franklin Junior. This is the same property formerly known as the Peninsula and earlier yet as the Albany & Boston. It has worked upon two horizons, the one the

Pewabic lode, at the same horizon as the Old Franklin and Quincy mines, the other a conglomerate, Marvine's No. 15, which has been called the Albany & Boston, and may be safely identified with the Allouez. Most of the observations refer to the conglomerate but those in the crosscuts, 87 and 88 especially, do not, and should be compared with those of the Pewabic lode. See also Packard's tests on the Franklin water (3, 4 and 5).

68. On a visit May 24th, 1906, I found in the 14th level crosscut 270 feet above the Allouez conglomerate a drip with Sp. Gr. 1.000.

69 and 70. On the 15th and 16th levels I did not find enough water to test. There was more in the north end of the 15th level and the south end was very dry.

71. On the 17th level the water on the floor seemed to have Sp. Gr. 1.000.

72. 400 feet north of shaft it was dripping freely and seemed to have increased in gravity (1.002?).

73. On the 18th level S. a dripping tested had Sp. Gr. 1.000.

74. At the reservoir for drill water near shaft it was 1.003.

75. On the 19th level I could only find a drop to taste—quite salt.

76. The 20th level was dry.

77. The 21st level water of drift has Sp. Gr. 1.003.

78. The change from fresh to salt was according to Capt. J. Donev between 14th and 17th levels and his observation was later fully confirmed by Fernekes' tests. The rock also seems to get richer in the lower part of No. 2 shaft, toward the south end of the mine.

The Allouez conglomerate has a straighter "hanging" top than "foot" bottom, and where it is thin it is generally barren. There is good copper bearing conglomerate in the 22nd level.

The dip flattens from 48½° down to 46¾° at the bottom of the mine.

Mr. Rickard in his book on the copper mines of Lake Superior has some notes on the distribution of copper in this lode.

On Oct. 13, 1906, I again visited the Franklin Junior mine and incidentally made observations as follows:

79. At the fourth level crosscut which runs from the Allouez conglomerate to below the Kearsarge amygdaloid, the water was in no case noted other than apparently fresh. Sp. Gr. 1.000. Temp. 45° to 46° F. We failed to get any at crevices on the 17th and 19th level where Capt. Doney had noticed it. But Fernekes found it later, and I introduce his tests on the conglomerate before those he made from the samples I took on the crosscut at the 21st level.

All the samples below are from the No. 1 shaft, on the Allouez conglomerate, and taken by Fernekes in 1906.

80. Is from a drip in the 15th level.

Cl	.416
Ca	.134
Na	.115
Sum	.665
Difference	85
Total solids determined	.750

We may compute:

Na : Cl	.277		
Ca : Cl	.322		
NaCl	.292	Cl	.177
$CaCl_2$	.375	Cl	.239
	.667		

The high ratio of sodium to chlorine and of difference not chlorides show the mixture of upper water quite plainly. This is just on the line.

81. Franklin Junior is from a dripping 1,000 feet S. of No. 1 shaft on the Allouez conglomerate, 17th level.

Cl	.858
Ca	.211
Na	.313
Sum	1.382
Difference	.313
Total solids	1.695
Na : Cl	.1382

This seems to be fresher than No. 74 011 the same level north. It is said that No. 2 shaft 1200' S. of No. 1 is better than No. 1 and better than at 1200' or so than higher up. At the Rhode Island mine which is further north and not so rich Mr. Frapwell found No. 47 about as strong at 1,000 feet.

82. Franklin Junior reservoir 100' north of No. 1 shaft, 17th level on Allouez.

Cl	1.066
Ca	.249
Na	.404
Sum	1.719
Difference	.281
Total solids	2.000
Na : Cl	.39

83. Franklin Junior water dripping 1200 feet S. of No. 1 shaft on 18th level.

Cl	3.621
Ca	1.516
Na	.609
SO_4	.040
Sum	5.756
Difference	.274
Total solids determined	6.030

This is a *good deal fresher* than the next analysis, the 19th level north.

Na : Cl .167

84. Franklin Junior from a dripping on the 19th level 200 feet north.

Cl	8.320
Ca	3.166
Na	1.750
Sum	13.236
Difference	.224
Total solids determined	13.560

Na : Cl .21

We compute:

$CaCl_2$	8.79
Na Cl	4.45
	13.24

This is essentially the same water as No. 70 of which apparently No. 85 is another test.

85. From pump on 23rd level near bottom of mine.

Cl	7.540
Ca	2.493
Na	2.032
Sum	12.055
Difference	.295
Total solids determined	12.350

This is practically the same as 81 and 82, slightly diluted. The ratio of sodium is similar.

Na : Cl .269

The line between fresh and salt is perhaps higher at the north and leaner end of the mine corresponding to the rise of ground. The depth is something like 1300 feet below the surface or about 200' below sea level.

86. Franklin Junior. Dripping from crosscut on 21st level S.

Cl	8.580
Ca	3.289
Na	2.349
Sum	14.216
Difference	.044
Total solids determined	14.260

Na : Cl .272

87. Sample No. I, 2100' down on the dip, 1600' deep. The sample is in a crosscut over from the Allouez conglomerate 460' toward the Pewabic lode on which the Quincy mine is working. It is from a seam dipping 500 to S.E., i. e., about at right angles to dip of bed. It is slowly dripping. The distance from the Allouez conglomerate No. 15 is 192'4 (about 100' above the Mesnard epidote).

87. Sp. Gr. by urinoineter in mine 1.045. Temperature 61° F.

Dr. Fernekes determined (on about 30 cc).

Cl	7.912
Ca	2.926

Whence we may compute:

Na to satisfy Cl	1.764
Sum	12.602
Difference SO_4, Mg. etc	.298
Total solids at 160°C	12.900
$CaCl_2$	8.116
(To satisfy Cl) Na Cl	4.486
	12.602

Na : Cl .223
Ca : Cl .368

This agrees quite fairly with the larger sample 86 taken later by Dr. Fernekes himself. I cannot very well account for the high Sp. Gr. Of this and 88, unless we assume that the water gave off little bubbles of gas not observed in the dim light of the mine, or that evaporation tends to very rapidly concentrate the water in the puddles on the floor where the urinometer was floated. The sample was caught in a small vial from the roof.

88. Another sample II was flowing much more freely down the side of the level from a similar seam 386 feet above the Allouez conglomerate and dipping 400 into the foot from the hanging. It must pretty nearly represent the Pewabic lode.

Sp. Gr. 1.055.

Dr. Fernekes determined:

Total solids at 160° C	46.100
Cl	28.680
Ca	12.290

Whence we compute:

(To satisfy chlorine Na)	4.45
	45.42
$CaCl_2$	34.09
Na Cl	11.33
	45.42

QUINCY MINE.

The Quincy mine was of especial interest as offering the deepest mining on the amygdaloid, and as being the one in which copper in the mine water first attracted attention. It was not easy to obtain satisfactory samples in the upper old workings. The tests of the Franklin mine which is on the same lode may be taken in connection (analyses 4 and 5).

I am informed by Prof. J. Fisher that in the Quincy mine flows good to drink were found.

89. On the 13th level.

90. And on the 26th level.

91. But that on the other hand a drill hole in the hanging between shaft 1 and 2 just N. E. of the old man engine shaft on the 26th level was too salt to drink. This is about 2,000 feet deep on this lode, which at a dip of 53° is 1600 feet vertically. This would bring the salt water in at about the same depth as in the Franklin—a little

deeper possibly. It should be remembered that the Pewabic lode worked by the Quincy Mining Co. is in the "ashbed" group, a series of extra feldspathic traps containing unusually much sodium.

Certain of the Quincy samples were tested for CO_2 by distillation, and also for ammonia. A very small amount of the latter was found on which no stress can be laid as it might come from organic contamination or dynamite fuses.

92. Dr. Fernekes' first test is from drippings in the 49th level north of No. 6 shaft, as follows:

Cl	142.173 grams per liter
Ca	70.072
Na	12.064
Br	1.891
Cu	tr.*
Sum	226.206
Difference	.320
Total solids determined	226.52

Sp. Gr. 1.19.

Whence we compute:

Na : Cl .083

*Analyses 89 to 97 all contain a trace of copper estimated as most probably 8 to 16 mg. per liter.

93. From the 53rd level north of No. 6 shaft running from walls.

Cl	174.287 grams per liter
Ca	86.500
Na	14.068
Br	2.180
Cu	tr.*
Sum	277.035
Difference	.465
Total solids Determined	277.500**

Sp. Gr. 1.2 1

We compute:

Na : Cl .081

94. Quincy mine. 53rd level N., stream near No. 6 shaft.

Cl	177.380 grams per liter
Ca	87.478
Na	14.920
Cu	trace*
Br	2.240
SO_3	.123
Sum	282.141
Difference	.359
	282.500

We compute:

Na : Cl .0843

This analysis was published by Dr. Fernekes in Economic Geology II, p. 584, with a slight error.

95. Quincy mine. In stope 10 feet below 53rd level N, of No. 6 shaft—a running stream.

Cl	173.735 grams per liter
Ca	87.380
Na	13.470
Br	2.272
Cu	tr.*
Sum	276.857
Difference	.243
Total solids determined	277.100

We compute:

Na : Cl .078

This sodium ratio is abnormally low—an error in analysis is possible but not probable.

**Solids when not heated quite so not 281.900.

96. Quincy mine. Dripping on 55th level N. of No. 6 shaft.

Cl	176.027 grams per liter
Br	2.200
Ca	86.478*
Na	15.188
K	411
SO_4	110
$Si\ O_2$	20
Fe_2O_3 and Al_2O_3	10
Mn	4
Cu	16
Ni	6
Sr	trace
Ba	none
Li	none
Mg	20
B	trace
CO_2	none
Sum	280.489
Difference	.011
Total solids determined	280.500

This is the most complete analysis made of the deep water and may be taken as the standard. Nos. 93, 94 and 97 are all very similar. It is worth noting that calcium and sodium chlorides form 99% of the total salts, and sodium bromide three-fourths the remainder.

Na : Cl .0865
Ca : Cl .49

*Compare test of Dow Chemical Co., .17 per cent or 2.13 grams per liter.

97. Quincy mine. N. of No. 6 shaft, running 10 feet below 55th level.

Cl	176.400
Ca	85.200
Na	17.580
Br	2.460
Cu	tr.*
K	.450
Sum	282.090
Difference	.310
Total solids	282.4

Sp. Gr. 1.22
Boiling point 104°.5 C.

We compute:

Na : Cl. .099

This higher ratio of sodium might be due to urine, etc. A sample at about this level gave the Dow Chemical Co., .17% with a Sp. Gr. of 1.293 or 2.190 grams per liter. The same sample gave Fernekes 2.390, which is a pretty close check as bromine analyses go.

98. Quincy mine. Pool with good drainage on 57th level N. of No. 6 shaft.

Cl	113.7	grams per liter
Ca	57.33	
Na	7.70	
Br	1.2	
Sum	179.93	
Difference	.270	
Total solids determined	180.2	
Sp. Gr.	1.13	
Na : Cl	.068	

*Trace in all Quincy waters, estimated at 8 to 16 mg. per liter. Compare test (7) of Dr. G. A., Koenig of 7 mg. per liter as running along the drift.

99. Quincy mine. 59th level, said to be a fine slow drip.

Cl	166.56
Ca	82.486
Na	13.129
Br	1.92
Sum	264.035
Difference	1.165
	265.2

We compute:

Na : Cl .0785

100. Quincy mine. 62nd level, N. from pump.

Cl	131.46	grams per liter
Ca	65.35	
Na	10.56	
Br	2.004	
Sum	209.374	
Difference	.426	
Total solids determined	209.8	

We compute:

Na : Cl .08

101. In Bulletin 330 of the U. S. Geological Survey p. 144, is an analysis of the water from the "lower level of the Quincy mine, Hancock, Michigan", by Geo. E. Steiger for C. K. Leith as follows:

	E.	
Cl	635.5	135.
SO_4	.1	.2
CO_3	.1	.2
PO_4	.0	.0
Na	56.3	12.0
Ca	307.8	65.3
Mg	.1	.2
Al, Fe, Mn, Co	.0	
SiO_2	.1	.2
	1000.00	sum 213.1
Salinity	212.3	212.3
Na : Cl	.0885	
Ca : Cl_2	.485	

The column to the right is computed. The analysis is like that of Fernekes (96) from the Quincy from the pump at the 62nd level, but not as complete. The most noteworthy discrepancy is in the CO_2. These Quincy analyses are all of the lower water and show what variation we may be prepared to expect.

The Calumet Conglomerate. See also the analyses by Heath and Smyth. (14-16)

102. Tamarack shaft No. 5. This sample was taken from an inclined winze on the conglomerate lode:

Cl	57.550	grams per liter
Ca	25.429	
Na	8.032	
Br	1.070	
Sum	92.081	
Difference	.419	
Total solids determined	92.500	

We compute:

Na : Cl .14

When we compare this with No. 22 we see that it is less strong and the ratio of Na : Cl is higher. This agrees with the miner's impression reported by Mr. J. C. Reeder and others that amygdaloid water is stronger than that of the conglomerate, which is confirmed by other tests for chlorine only.

It is somewhat stronger than Smyth's water at 3,000 feet (16). The ratio of sodium has dropped a little. The ratio of Na : Br is about the same.

The Kearsarge Lode. This lode is now opened up for several, miles, and Dr. Fernekes could get salt tests for over three miles. His results are arranged from south to north.

103. Centennial mine. At the 11th level "no salt" was reported; that is not enough to make the customary analysis on a small sample. Fernekes estimates that a gallon would have been needed.

104. At the 13th level we have:

Cl	1.711
Ca	.626
Na	.389
Sum	2.726
Difference	232
Total solids determined	2.958

We compute:

Na : Cl .228

105. 15th level.

Cl	3.549
Ca	.880
Na	1.287
Sum	5.716
Difference	.264
Total solids determined	6.000

We compute:

Na : Cl .357

This is a typical top salt water, and was published as such in Economic Geology II, p. 584, but assigned to the 11th level.

106. Centennial 20th level.

Cl	5.780
Ca	1.880
Na	1.584
Sum	9.244
Difference	.216
Total solids	9.460

We compute:

Na : Cl .275

The ratio of sodium begins to drop. This analysis was published in part in Economic Geology II, p. 584.

107. Centennial 25th level.

Cl	27.114
Ca	11.6
Na	4.22
Cu	p.n.d.*
Sum	42.934
Difference	.266
Total solids determined	43.200

We compute:

Na : Cl .156

108. Centennial 30th level

Cl	34.263
Ca	15.700
Na	4.140
Cu	p.n.d.*
Sum	54.103
Difference	.377
Total solids determined	54.480

Na : Cl .121

Note that the most rapid rise in saltness comes between the 20th and 25th levels.

109. South Kearsarge No. 2 shaft, 9th level, drippings collected by F. W. McNair and C. D. Hohl.

Cl	.842
Ca	.111
Na	.418
Sum	1.371
Difference	.61
Total solids determined	1.432

This is essentially a duplicate of No. 110. Compare the 10th and 11th levels Mohawk.

Na : Cl .495
Ca : Cl .132

110. South Kearsarge No. 1 shaft, 9th level, dripping collected by F. W. McNair and C. D. Hohl.

Cl	.702
Ca	.0912
Na	.414
SO_4	.075
SiO_2	.035
Fe_2O_3)	.030
Al_2O_3)	
Sum	1.3472
Difference	.0028
Total solids determined	1.350

*Estimated as 2 to 8 mg. per liter.

This is a complete analysis intended to show the character of the water in the upper levels, before the calcium chloride becomes conspicuous, though even here there is chlorine, which may be considered combined with calcium. There is even here little or no CO_2 and the Ca is not abnormal for any water.

Probably the iron and alumina may exist as chloride.

(Fe_2O_3 = .030) = (Fe = .021)

We have:

Na : Cl .58
Ca : Cl .13

We may combine this as

Water glass Na_2O 4 SiO_2	= .0097+.0034+.035	=	0.048 6
Salt Na Cl	= .4043+.624 Cl	=	1.028 3
Fe Cl_3	= .021 +.039	=	.060
	.663		
Ca Cl_2	= .022 +.039	=	.061
Ca SO_4	= .0312+.075 SO_4	=	.1062
	.0532		
CaO	= .038 +.015 O	=	.053
			1.3571

Note the tendency to alkalinity, both in the water glass and the excess of lime, and the sodium more than could be obtained by dilution of a deeper water with a surface water.

Wolverine Mine. Shaft No. 3. All the samples below were taken about 300 feet S. of the shaft, and were all drippings. To get the complete suite include also tests 17 to 21. See also my tests in crosscuts, etc.

111. Wolverine No. 3, 300 feet S. of 20th level.

Cl	17.395
Ca	7.321
Na	2.852
Sum	27.568
Difference (Mg, SO_4, etc)	.252
Total solids determined	27.82

Sp. Gr. 1.021
Na : Cl .165

This is slightly stronger and with slightly less sodium in proportion than No. 19.