THE CLEVELAND CLIFFS IRON COMPANY.

REPORT OF THE GEOLOGIST FOR THE YEAR ENDING DECEMBER 31, 1918.

STAFF.

The staff of the Geological department for 1918 is given in Table I below. Mr. F. R. Mitchell left the department April 5th to join the U. S. Naval Aviation Service. Mr. Leif Erickson was engaged as collector of core, etc. and began his duties April 29th. He was given a leave of absence from December 6th to the 22nd, inclusive, to act as Orderly at the Gwinn Club House during the epidemic of Spanish Influenza, following which he was himself taken ill. Mr. Peter N. Demn of the Engineering department was engaged December 6th to collect the core in Mr. Erickson's place and continued in this capacity the remainder of the year.

TABLE I.

<table>
<thead>
<tr>
<th>NAME</th>
<th>OCCUPATION</th>
<th>DURATION OF EMPLOYMENT</th>
<th>DAYS LOST</th>
<th>% OF WORKING DAYS WORKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. L. Derby, Jr.</td>
<td>Geologist in charge of department.</td>
<td>Entire year.</td>
<td>0</td>
<td>100.0</td>
</tr>
<tr>
<td>Fred Royston</td>
<td>Assistant Geologist.</td>
<td>Entire year.</td>
<td>4</td>
<td>97.1</td>
</tr>
<tr>
<td>F. R. Mitchell</td>
<td>Assistant Geologist.</td>
<td>2 months.</td>
<td>0</td>
<td>99.0</td>
</tr>
<tr>
<td>Gustaf Afuhs</td>
<td>Draftsman.</td>
<td>Entire year.</td>
<td>1/2</td>
<td>97.6</td>
</tr>
<tr>
<td>E. A. Allen</td>
<td>Collecting core, etc.; also assisting geologists.</td>
<td>Entire year.</td>
<td>0</td>
<td>96.6</td>
</tr>
<tr>
<td>Leif Erickson</td>
<td>Collecting core, etc.</td>
<td>8 months.</td>
<td>6</td>
<td>96.5</td>
</tr>
<tr>
<td>Peter N. Demn</td>
<td>Collecting core, etc.</td>
<td>1/2 month.</td>
<td>0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The year was divided into the factors shown in Table II.

TABLE II.

| Total days of eight hours worked | 276 days. |
| Sundays                          | 52 "      |
| Days resulting from 45 Saturday afternoons not worked | 22/3 " |
| Holidays                         | 14/3 "    |
| Total                            | 365 days. |

# The Geological department worked seven Saturday afternoons during the months of January and February.

GEOLOGICAL DEPARTMENT.
The following Table, No.III, shows the average number of men regularly employed on the staff of the Geological department during the past five years:

**TABLE III.**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>AVERAGE NUMBER OF MEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1914</td>
<td>5.74</td>
</tr>
<tr>
<td>1915</td>
<td>3.96</td>
</tr>
<tr>
<td>1916</td>
<td>3.17</td>
</tr>
<tr>
<td>1917</td>
<td>3.35</td>
</tr>
<tr>
<td>1918</td>
<td>4.85</td>
</tr>
</tbody>
</table>

**DIVISION OF WORK AMONG THE MEMBERS OF THE DEPARTMENT.**

H. L. Smyth. The work of the Geological department continued under the direction of Mr. H. L. Smyth as Consulting Geologist.

E. L. Derby, Jr. My time during the year has been chiefly taken up with general over sight and supervision of the work of the department. This has included, besides certain office routine work, surface drilling explorations in the Ishpeming, Negaunee, Gwinn districts and the Mesabi Range; underground drilling in the Athens, Bunker Hill, Cliffs Shaft, Fowler, Francis, Holmes, Jopling, Lake, Morris and Republic mines; surface geological surveys in the Ishpeming district; underground geological surveys in the Athens, Bunker Hill, Cliffs Shaft, Francis, Gwinn, Holmes, Jopling, Naas, Mackinaw-Gardner, Morris-Lloyd, Negaunee, Princeton, Republic and Spies mines; and in visiting and reporting on the explorations of other companies on the Michigan and Wisconsin iron ranges.

The time not taken up with these duties was chiefly spent as follows:

In January, I made a complete estimate of the ore at the Wade mine, then the Great Northern ore property, and assisted Mr. Barber in preparing a report on it.

In February, I prepared ore and stripping estimates on the several Great Northern ore, or so-called Hill properties, submitted to this Company in land offer No.1113 Mesabi Range.

In March, I made additional estimates of ore and stripping on these Hill lands to supplement and add to the ones previously made. Also, in the
absence of Mr. Stakel on his vacation, I went over the Republic mine
maps and his estimate of ore reserves with Mr. Wheelwright, Geologist
representing the Michigan State Tax Commission.

In April, I accompanied the above Mr. Wheelwright on his examina-
tion of the Spies mine workings.

In May, I prepared an estimate of ore on the York forty of the
Hill Iron Company, covered by land offer No.1104 Cuyuna Range. I made
with Mr. Jopling a joint examination and a report of the Michigan Verde
Antique Marble Company’s marble quarry, otherwise known as Carter’s
Quarry, and an examination relative to marble possibilities of the
Company’s land crossed by the Marble Company’s railway right of way.
I also made a joint examination with Messrs. Jopling and Brewer of the
surface and equipment of the Empire mine, Palmer district. Furthermore,
I examined and reported on Mr. Denny Jewell’s farm on the Escanaba river,
Northeast of Gwinn, covered by land offer No.1106 Marquette County.
Finally I assisted Mr. Jopling in reporting on various other land offers
and in preparing cost and valuation tables to be used in connection with
the so-called "fifteen year estimates" made by the superintendents of
the Company’s various properties.

In July, in company with Mr. Frank Trebilcock, I examined several
gold-quartz veins which he had discovered in the Kitchi schists North of
Ishpeming in the SW\(^4\) of Section 33, 48-27. They proved of no commercial
importance.

In September, I joined with Mr. Jopling in conducting Messrs. Chinn
and Rose, of Pickands, Mather & Company, on a tour of inspection and
examination of the Athens, Imperial, Portland and Webster mines.

In October, I made an estimate of the stripping necessary to mine
by open pit or milling the ore on the Longyear No.2 property of the Hill
lands on the Mesabi Range. This has since been leased by the Company
and is known as the Bourne mine.

In December, I prepared an estimate of the ore remaining in the
Isabella mine on the Cascade Range at Palmer, Michigan.
Mr. Fred Royce. Mr. Royce has spent most of his time making underground surveys and posting the maps and cross-sections of the Company's operating mines in the Ishpeming, Negauwee, North Lake and Gwinn districts, with the exception of the Angeline, Lake and Salisbury mines at Ishpeming. Since Mr. Mitchell left, the first part of March, Mr. Royce has been the only assistant in the department available for this class of work so that it has been impossible to keep the geological surveys up to date at all of these properties. He has also assisted me in practically all of the ore estimates which I made during the year and has prepared maps and cross-sections of them. He spent the rest of his time in the office routine work.

F. R. Mitchell. Mr. Mitchell spent the first two months of the year in making underground geological surveys at the Maas and Negauwee mines and posted the geological maps and cross-sections. He also assisted in the general routine work of the department. He left the Company's employ on March 5th to join the Aviation Branch of the U. S. Navy, in which he was later commissioned an ensign and placed in the Observation Balloon Section.

Gustaf Afuhs. Mr. Afuhs continued as draftsman throughout the year. His work has been chiefly that of preparing cross-sections of drilling, monthly drill reports, geological maps and cross-sections but he has also assisted in making several ore estimates, etc.

E. A. Allen. Mr. Allen spent the first five months of the year collecting and labeling core and sludge from all the various current explorations, filing samples of these in the core room and surveying of the holes where necessary. During May, the fifth month, he trained Mr. Leif Erickson to do this work and for the remainder of the year acted as regular geologist's assistant, both in making the underground geological surveys and laying out new tracings to be used as geological maps and cross-sections, etc. He continued making all the rock slides or thin sections required; also the regular monthly carbon statement. He visited all the outside explorations being conducted on the Michigan and Wisconsin iron ranges. He also made a compass survey of all the GEOLOGICAL DEPARTMENT.
serpentine marble outcrops on the Company’s lands North of Ishpeming in the vicinity of Mr. Carter’s Michigan Verde Antique Marble Quarry.

Leif Erickson. Mr. Erickson was engaged by this department on April 29th to take the place of Mr. Allen in the core room and in collecting core from the drills, surveying the drill holes, etc. This he has very ably accomplished after a month’s training under Mr. Allen’s guidance. On December 6th he was called to Gwinn during the Influenza epidemic there and because of his previous experience in hospital work was made an orderly. He returned to the department December 23rd but was himself taken ill and unable to resume work during the rest of the year.

Peter N. Denn. Mr. Denn’s services were loaned to the Geological department by the Engineering department from December 6th to the end of the year. He collected the core from the diamond drills in Mr. Erickson’s absence and assisted Mr. Allen in the core room, the latter having temporarily assumed a portion of Mr. Erickson’s work during his absence.

SURFACE GEOLOGICAL SURVEYS.

Very little surface geological work was done the past year. It was as follows:

ISHPEMING DISTRICT.

In September, Mr. Allen made a compass survey of all the serpentine marble outcrops on the Company’s lands and along the new C. & N. W. Railway Company’s spur into the Michigan Verde Antique Marble Company’s quarry, North of Ishpeming, and in the vicinity of the old Hope’s gold mine. This survey was run from transit lines previously established by Mr. Charles Cummings of Marquette for the Engineering department and is preliminary to a more careful study, including the determination of its commercial value, of the marble on the Company’s land in this vicinity.

MARQUETTE RANGE GENERAL.

During the year Mr. Afuha prepared two large surface tracings on a scale of 600’ to the inch. One of these covers the North part of the Marquette Range from the East end of the Negaunee basin to a point half
way between Ishpeming and North Lake and the other from the latter point to the West side of the old Chase mine. In addition to general surface information, these maps show all drill holes, test pits, open pits, caves, rock outcrops, etc, and are designed to serve as base maps for a set of detailed surface geological maps of the productive part of the Marquette Range.

**UNDERGROUND GEOLOGICAL SURVEYS.**

There has been a decided improvement during the last year in the condition of underground geological surveys but it was not possible to bring them all up to date. It is probable this might have been done if a competent assistant geologist could have been employed to take the place of Mr. Mitchell at the time he left the early part of March. An effort will be made the coming year to supply this deficiency and should be entirely possible now that so many desirable men are being released from government service.

**ANGELINA MINE.**

The Happy Hollow or Side Hill deposit and the East End pit were worked steadily during the summer; also continued throughout the fall and winter. Practically all ore removed from the former was taken from underground by milling. During the shipping season the ore at the East End pit was won by steam shovel but after the season closed scrumming of ore in the banks to the pit was resorted to and placed in stockpile. Mr. Jansen, engineer, posted the geology of both pits.

The work of exploring ore pillars remaining in the Middle Deposit of the old Lake Angemine mine was commenced the middle of the year and progressed steadily. This work has not gone far enough, however, to demand the attention of this department.

**ATHENS MINE.**

Opening up main level drifts on the 4th, 8th, 9th and 10th levels at this mine progressed steadily during the year. During the last few months several sub-levels have been started above the 8th level in an attempt to define the hanging jasper and commence actual mining opera-

GEOLOGICAL DEPARTMENT.
tions. Detailed geological surveys have been made and posted regularly by Mr. Royce and myself and assisted by Mr. Allen.

**BARNES-BECKER MINE.**

The Barnes-Becker shaft, which was started in October 1917 but temporarily discontinued early in January of the present year to erect the head frame, was resumed in April and continued throughout the rest of the year. It is located approximately 1700' West and a little North of the center of the ore body. The geology is being posted by Mr. Trosvig, engineer.

**BUNKER HILL MINE.**

The first opening on this property was occasioned by the extension of the 10th level Athens mine approximately 70' over the line. A crosscut North about 160' long and another South about 140' long were driven from this drift. From these two crosscuts drilling explorations were conducted to determine the depth of ore below the level at the boundary between the two properties. This work was geologized in connection with the surveys of the Athens mine.

**CLIFFS SHAFT MINE.**

The Cliffs Shaft mine worked continuously during the year. The only geological surveys made were of new development work in the West end of the "B" shaft workings on the 10th to 14th levels inclusive. This was done by Mr. Royce and myself. Much of the geological work in the other mines has been done at the expense of the Cliffs Shaft realizing that the latter workings remain open practically indefinitely and that the work here can be caught up as opportunity permits. The Cliffs Shaft work is highly essential, however, and an attempt will be made to match it up as soon as additional assistance is acquired.

**FRANCIS MINE.**

This mine worked continuously throughout the year. The ore horizon is considerably folded and mixed with lean areas so that a periodic geological survey is imperative. Both Mr. Royce and myself have kept this work up to date.

**GEOLOGICAL DEPARTMENT.**
GWINN MINE.

This mine also produced continuously throughout the year. Mr. Royce has kept the geological surveys of all main level developments and the principal sub-levels posted. I also assisted in some of this work and Mr. Sterling, engineer at the property, has supplied us with the necessary geological data of the remaining workings.

HOLMES MINE.

The Holmes mine operated regularly during the past year and Mr. Royce kept the geological surveys fairly well posted. Mr. Allen assisted in this work.

JOPLING MINE.

The work at this property for the year consisted in raising the shaft several hundred feet and driving two sub-levels to explore the iron formation. These sub-levels are, 260 and 540 respectively. The results on the former were very discouraging and the work on the latter is progressing at present in the direction of the ore found a short distance above this level in surface hole No.37. Mr. Royce geologized the sub-levels and Mr. Sterling, engineer, mapped the geology of the shaft raise.

LAKE MINE.

This mine operated continuously throughout the year but no geological surveys were made other than a few details collected by Mr. Jansen, engineer at the property. The mine is of course very nearly worked out.

MAAS MINE.

Mr. Mitchell, until he left, kept the Maas mine geology fairly well posted and from the middle of the year on Mr. Royce kept this work up to date on the main levels and principal development sub-levels. Mr. Moulton, engineer at the property, assisted in all this work and did what he could in the time permitted to keep the most important sections of the mine posted during the interval between Mr. Mitchell's departure and Mr. Royce's initial survey.

GEOLOGICAL DEPARTMENT.
MACKINAW-GARDNER MINES.

The work at these properties during the year consisted in raising the Gardner shaft from the 4th level drift connecting with the Mackinaw shaft and developing the ore on this level. A start was also made on the 3rd level drift. Thus far the ore has been disappointingly narrow and, more unfortunate still, has been found to be quite generally high in sulphur. The sulphur is chiefly in the form of gypsum or calcium sulphate and so thoroughly penetrates the ore mass in thin films and plates that removal by direct solution seems economically impossible.

Mr. Royce and myself have kept the geology posted up to date. Mr. Allen has assisted Mr. Royce in this work.

MORRIS-LLOYD MINES.

These mines have worked continuously throughout the year and Mr. Royce has kept the geology fairly well posted. Both Messrs. Allen and Tresvig, the latter engineer at these properties, have assisted Mr. Royce underground.

MEGAUMER MINE.

Mr. Mitchell posted the geology at this property once before leaving the Company. Mr. Cheneour, engineer, after this collected all the data he could in the limited time he had. This was mapped by the Geological department. During the latter part of the year, however, both Mr. Royce and I geologized the current developments on the main levels. Mr. Allen at times also assisted in this work.

REPUBLIC MINE.

Except for a small amount of work that I was able to do while examining some of the new developments on the bottom levels of this mine, no geological surveys were made during the year. Fortunately, like the Cliffs Shaft mine, the workings remain accessible for a long time and with an increased force we can bring this work up to date.

SALISBURY MINE.

No geological surveys were made at this property during the year, although the mine worked continuously. This can only be explained by lack of help as there are several portions of the mine which should be geologized.

GEOLOGICAL DEPARTMENT.
SPIRES MINE.

It was possible to make but one geological survey at this mine during the year, this early in November, but both Mr. Royce and I made quite a thorough observation at that time and have the geology reasonably well up to date.

STEPHENVSON MINE.

No geological work was done in this mine during the year as it remained flooded with water. Slow progress has been made, however, in attempting to unwater it and should be accomplished within another year.

EXPLORATIONS.

Drilling explorations were carried on during the past year in the following districts and mines:

FROM SURFACE.

<table>
<thead>
<tr>
<th>DISTRICT</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ishpeming,</td>
<td>Marquette.</td>
</tr>
<tr>
<td>Negaunee,</td>
<td>&quot;</td>
</tr>
<tr>
<td>North Lake,</td>
<td>&quot;</td>
</tr>
<tr>
<td>Gwinn,</td>
<td>&quot;</td>
</tr>
<tr>
<td>Aurora,</td>
<td>Mesabi.</td>
</tr>
<tr>
<td>Kinney,</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

FROM UNDERGROUND.

<table>
<thead>
<tr>
<th>MINES</th>
<th>DISTRICT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens,</td>
<td>Negaunee</td>
</tr>
<tr>
<td>Bunker Hill</td>
<td>&quot;</td>
</tr>
<tr>
<td>Cliff's Shaft,</td>
<td>Ishpeming</td>
</tr>
<tr>
<td>Fowler,</td>
<td>Aurora.</td>
</tr>
<tr>
<td>Francis,</td>
<td>Gwinn.</td>
</tr>
<tr>
<td>Holmes,</td>
<td>Ishpeming</td>
</tr>
<tr>
<td>Jopling,</td>
<td>Gwinn.</td>
</tr>
<tr>
<td>Lake,</td>
<td>Ishpeming</td>
</tr>
<tr>
<td>Morris,</td>
<td>North Lake</td>
</tr>
<tr>
<td>Republic,</td>
<td>Republic</td>
</tr>
</tbody>
</table>

No options for explorations were executed or relinquished in 1918. The only option in force is from the Spies Mineral Land Company. It is No. 98 and comprises the E 1/2, the NW 1/4 of the NW 1/4, the NE 1/4 of the SW 1/4 and the SW 1/4, all in Section 24, 43-35.

Mining leases were acquired on the Wade and Helmer mines in the Kinney district of the Mesabi Range and explorations from surface by drilling were conducted at both the properties.

GEOLOGICAL DEPARTMENT.
Table IV gives the footage drilled, the ore encountered and the
cost per foot of drilling for both the surface and underground explora-
tions. It will be noted that the average cost of surface drilling was
$3.56 per foot, excluding certain items from the drilling done by the
Company in order to compare these results with the contract drilling
costs. By including these items, the average cost was $3.72 per foot.
The average cost of underground drilling in the same way was $3.50 per
foot and $3.45 per foot respectively. The average cost of all the drill-
ing was $3.49 per foot and $3.65 per foot respectively. The increase of
these costs over those of last year is no greater than the proportionate
higher wages and increased cost of supplies makes it in spite of the
noticeable decrease in efficiency of some of the classes of labor involved.
## TABLE IV.

### SUMMARY OF DRILLING FOR 1918.

<table>
<thead>
<tr>
<th>Exploration, Description</th>
<th>Stand Piping</th>
<th>Stand Drilling</th>
<th>Diamond Piping</th>
<th>Diamond Drilling</th>
<th>Total</th>
<th>First Class</th>
<th>Second Class</th>
<th>Lean Ore</th>
<th>Total Cost</th>
<th>Cost Per Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angelina</td>
<td>15, 47-27</td>
<td>44</td>
<td>10</td>
<td>108</td>
<td>162</td>
<td>1</td>
<td>260</td>
<td>698</td>
<td>$1,163.40</td>
<td>$7.18</td>
</tr>
<tr>
<td>Barnes-Becker</td>
<td>15, 47-27</td>
<td>207</td>
<td>21</td>
<td>2646</td>
<td>2994</td>
<td>26</td>
<td>100</td>
<td>9,670.55</td>
<td>3.25</td>
<td>9,175.18</td>
</tr>
<tr>
<td>Golf Club</td>
<td>15, 47-27</td>
<td>327</td>
<td>21</td>
<td>2646</td>
<td>2994</td>
<td>26</td>
<td>96</td>
<td>6,604.87</td>
<td>3.81</td>
<td>9,175.18</td>
</tr>
<tr>
<td>Palmer</td>
<td>15, 47-27</td>
<td>280.5</td>
<td>311.5</td>
<td>592</td>
<td>223</td>
<td>26</td>
<td>100</td>
<td>9,670.55</td>
<td>3.25</td>
<td>9,175.18</td>
</tr>
<tr>
<td>Ishpeming Sec. 3</td>
<td>15, 47-27</td>
<td>547</td>
<td>357</td>
<td>463</td>
<td>101</td>
<td>45</td>
<td>45</td>
<td>18,642.45</td>
<td>4.25</td>
<td>18,642.45</td>
</tr>
<tr>
<td>Mike</td>
<td>15, 47-27</td>
<td>343</td>
<td>1238</td>
<td>1437</td>
<td>45</td>
<td>116</td>
<td>116</td>
<td>21,379.74</td>
<td>4.01</td>
<td>21,379.74</td>
</tr>
<tr>
<td>Jackson</td>
<td>15, 47-27</td>
<td>103</td>
<td>103</td>
<td>133</td>
<td>47</td>
<td>4</td>
<td>4</td>
<td>7,710.45</td>
<td>2.29</td>
<td>7,710.45</td>
</tr>
<tr>
<td>South Jackson Pit</td>
<td>15, 47-27</td>
<td>2306</td>
<td>333</td>
<td>263</td>
<td>263</td>
<td>6</td>
<td>6</td>
<td>10,920.45</td>
<td>4.15</td>
<td>10,920.45</td>
</tr>
<tr>
<td>Stephenson Sec. 29</td>
<td>15, 47-27</td>
<td>2329</td>
<td>4</td>
<td>2329</td>
<td>2329</td>
<td>6</td>
<td>6</td>
<td>10,920.45</td>
<td>4.15</td>
<td>10,920.45</td>
</tr>
<tr>
<td>Union Park</td>
<td>15, 47-27</td>
<td>4</td>
<td>2673</td>
<td>2673</td>
<td>2673</td>
<td>6</td>
<td>6</td>
<td>10,920.45</td>
<td>4.15</td>
<td>10,920.45</td>
</tr>
<tr>
<td>Wade</td>
<td>15, 47-27</td>
<td>2617</td>
<td>811</td>
<td>1741</td>
<td>555</td>
<td>23</td>
<td>23</td>
<td>15,749.02</td>
<td>3.72</td>
<td>15,749.02</td>
</tr>
<tr>
<td><strong>Total Surface Drilling</strong></td>
<td><strong>6653</strong></td>
<td><strong>3647.5</strong></td>
<td><strong>22970.0</strong></td>
<td><strong>33270.5</strong></td>
<td><strong>813</strong></td>
<td><strong>587.5</strong></td>
<td><strong>1556</strong></td>
<td><strong>$123,655.66</strong></td>
<td><strong>$3.72</strong></td>
<td><strong>$118,299.40</strong></td>
</tr>
</tbody>
</table>

### UNDERGROUND DRILLING.

<table>
<thead>
<tr>
<th>Exploration</th>
<th>Stand Piping</th>
<th>Stand Drilling</th>
<th>Diamond Piping</th>
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<th>Total</th>
<th>First Class</th>
<th>Second Class</th>
<th>Lean Ore</th>
<th>Total Cost</th>
<th>Cost Per Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athens</td>
<td>5, 6, 47-27</td>
<td>819</td>
<td>819</td>
<td>5</td>
<td>32</td>
<td>55</td>
<td>101</td>
<td>4,740.39</td>
<td>4.74</td>
<td>4,740.39</td>
</tr>
<tr>
<td>Bunker Hill</td>
<td>5, 6, 47-27</td>
<td>354</td>
<td>354</td>
<td>66</td>
<td>110</td>
<td>110</td>
<td>101</td>
<td>4,740.39</td>
<td>4.74</td>
<td>4,740.39</td>
</tr>
<tr>
<td>Cliffs Shaft</td>
<td>9, 10, 47-27</td>
<td>1670</td>
<td>1670</td>
<td>247</td>
<td>110</td>
<td>110</td>
<td>101</td>
<td>4,740.39</td>
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**Note:** Cost "A" includes taxes, office expense, engineering, analysis, legal, and personal injury.
Cost "B" excludes "A" (to compare with contract price).
Cost "C" also excludes cost of cutting the drill station for the Lake mine drilling, $50.50.

The contract drilling for the year comprised the surface drilling at the Belmer and Wade explorations, done by the Duluth Diamond Drilling Company, and at the Meadow done by the Cole & McDonald Exploration Company; also the underground drilling in the Fowler mine done by the Cole & McDonald Exploration Company.
SURFACE EXPLORATIONS.
MARQUETTE RANGE.
GREENING DISTRICT.

GOLF CLUB, NE, SECTION 2, 47-27.

The Golf Club exploration was commenced in August 1917 and completed the last of July 1918.

The object here was to explore the iron formation above the lower or footwall greenstone sheet and particularly immediately North of the East-West fault zone separating this area from the so-called East New York area to the South.

The basin was cross-sectioned by a series of eight holes on the 12000 West Meridian and was also drilled in four other places. It was found to be disappointingly flat and shallow and contained no commercial ore; also very little evidence of enrichment.

UNION PARK, SE, SECTION 2, 47-27.

Drilling on this description continued until the middle of July without encountering a merchantable body of ore. The 30' of ore found in hole No. 23 in December 1917 is apparently a local concentration of no great extent on a small dike within the main East-West fault zone.

SECTION 3, 47-27.

This exploration was continued throughout the year. The drill which formerly employed on Section 4, was moved over the line on this section the very last of 1917, was used to sink three holes, Nos. 10, 13 and 15, along the strike. These were all located in the NW 1/4 of the NW 1/4 of the section and approximately 400' apart to explore for possible ore on the slate footwall. Nothing was found, however, and the drill returned to Section 4 the latter part of May.

Five additional holes were drilled by the other outfit in the basin to the South, Northeast of Lake Bancroft and lying on the greenstone. This is a Westerly continuation of the formation explored in the Golf Club basin. The results here in Section 3 were likewise very disappointing as no merchantable ore was found.

GEOLOGICAL DEPARTMENT.
Hole No. 18, which was drilling at the end of the year, is located in the SE\textsuperscript{1} of the NW\textsuperscript{2}, about 500' North of No. 7 and approximately 430' South and 200' East of the old Union hole. The drilling at hole No. 23 Section 4 and vicinity demonstrated a fault which is apparently striking Southeasterly. This discovery, together with the enriched character of the bottom of the old Union hole, which had a few feet of first class ore, warranted a deeper hole at about No. 18 location. The latter was drilling in soft ore jasper at 792' on the last of the year.

\textbf{SECTION 4, 47-27.}

Exploring on this section was suspended until the end of May while the drill was being used on Section 3, as explained above. For most of the time after that, however, two drills were used on this section.

Standing to locate the slate-jasper contact was completed late in 1917 so that the work this year has been mainly to explore the iron formation down to the slate at regular intervals along its strike. A small amount of lean and second class material was encountered but no merchantable ore and nothing sufficiently encouraging to follow up on the strike with deeper holes. Drilling at regular intervals along the strike, however, will be continued across the entire section and hole No. 28, located on the North-South center line, was just starting at the end of the year.

Two holes were also drilled in the vicinity of the old Isaac's pit in the SW\textsuperscript{1} of the NE\textsuperscript{2} and one of them, No. 27, at an incline which carried it below the pit bottom. It is reported that several hundred tons of good ore were removed from this pit many years ago but no ore was found in the present drilling.

The off set in the slate-jasper contact that was discovered by stand-piping in 1917 and spoken of in my last year's report was explored by two holes, Nos. 23 and 26. No merchantable ore was found but, as mentioned above, No. 23 demonstrated a Southeasterly striking fault that may prove of importance in locating an ore body in the vicinity of No. 18 Section 3.

\textbf{SECTION 5, 47-27.}

The work of exploring on this section was started the last of July with one drill. The program here is similar to the one followed along

GEOLITICAL DEPARTMENT.
the strike of the iron formation in Section 4 with holes at regular intervals, about 400' apart in this case, to encounter the slate at from 600' to 800' in depth. Hole No.1 was completed and No.2 drilled to a depth of 563' and still in soft ore jasper on the last of the year. Fourteen feet of 50% material and 40' of 52% material; also some lean ore, were encountered in No.1 but no merchantable ore has thus far been found in either hole. The general appearance and character of the iron formation in this section, however, is much more promising than the ground so far explored in Section 4.

ANGELINE SURFACE, SECTION 16, 47-27.

During the course of removing ore from the East Side of the Angeline East End pit the past summer, Captain Rough was rather inclined to think that the ore extended considerably farther East than the limits established by recent drilling. Accordingly, in order to assist him in his plan of operation, one additional hole was drilled somewhat Northeast of a line connecting holes Nos.14 and 61 and between them. Nothing but greenstone was encountered, which confirmed our original ore limits.

One more hole was drilled in this basin of iron formation to complete the systematic search for another pocket of ore. It was located near the Southeast corner of the area and just North of the Lake Angeline fault. Iron formation was found and it extended to a depth of 48' but was not enriched.

NEGAUNEE DISTRICT.

JACKSON EXPLORATION, SECTION 1, 47-27.

Drilling has been continuous throughout the year at this property and since the first of August two drills have been employed. Hole No.102, which was drilling on the first of the year, was completed, as were also two other holes, Nos.107 and 109. No.119 was cementing a vug at 1245' and the machine employed at No.108 was moving to a new location about 450' North of No.107 at the end of the year. All holes except No.108 are located North of the County Road and East of the Cornishtown location, the latter just South of the County Road and in the same vicinity.
Hole No. 107 encountered 40' of good ore in two runs, one of 25' and one of 15' divided by 15' of soft ore jasper and 5' of 51½% material. This zone is at a depth of from 1645' to 1705' and virtually rests on a greenstone sheet or dike. It was hoped to catch this ore at a higher elevation in hole No. 119, which is located about 380' to the Southwest. Considerable trouble was experienced cementing two vugs encountered in the latter hole and the delays entailed prevented the drill from reaching the ore zone by the end of the year. This ore will be followed up during the coming year by holes to the North and East of No. 107.

SOUTH JACKSON PIT, SECTION 1, 47-27.

Drilling in connection with the South Jackson pit was continued until the latter part of November. The holes were all West of the actual pit area but in ground more or less tributary to it. Drilling was done with the Keystone churn drill outfit. The holes were comparatively shallow and spaced regularly in checker-board fashion where possible, the object being to explore for ore of the South Jackson manganiferous grade that could be readily stripped and mined either in an open pit or by a milling system. One hole, No. 106, however, was deepened with a diamond drill to 1210' to test this formation at depth but no high grade ore was found.

Twenty three of these churn drill holes were drilled and added approximately 125,000 tons of 33.6% combined iron and manganese material to the South Jackson reserves.

ATHENS MINE SURFACE, SECTION 6, 47-26.

Holes Nos. 1, 2, 4, 5, 7, 8, 10, 11, 12, D, E, F, I, K, and L were during the summer plugged with cement to cut off the surface water from the underground workings.

MAAS MINE SURFACE, SECTION 6, 47-26.

Hole No. 9 was also plugged with cement during the summer.

MAGNERS MINE SURFACE, SECTION 6, 47-26.

Hole No. 10 was likewise plugged with cement.
NORTH LAKE DISTRICT.

BARNES-BACKER MINE SURFACE, SECTION 2, 47-28.

Holes Nos. 51, 67, 68, 85, 86, 87, 88 and 89 were plugged with cement during the summer and the standpipes were found pulled. There was no standpipe in No. 82 but an attempt was made to sink another and recover the old hole to plug it with cement. Ledge was reached practically at the collar of the old hole but a piece of old standpipe was found broken off in it which made it impossible to get into it.

GWINN DISTRICT.

STEPHENSON MINE SURFACE, SECTION 20, 45-28.

Twelve standpipes, Nos. 54 to 65 inclusive, were sunk on the N2E of this description between the last of January and the middle of May. Enough drilling was done at each location to determine the depth of surface and character of ledge. The object of this work was to contour the ledge basin which held the water that flooded the Stephenson mine.

MESABI RANGE.

AURORA DISTRICT.

MEADOW MINE SURFACE, SECTION 3, 58-15, MINNESOTA.

The work of systematically exploring the NSE of the NW1/4 of Section 3, West of the Meadow mine workings, which was commenced late in November, 1917, was completed the last of March. This work was done under contract by the Cole & McDonald Exploration Company. No merchantable ore was encountered.

KINEY DISTRICT.

HELMER PIT, SECTION 14, 58-19, MINNESOTA.

When the Company assumed control of this mine it was known from the old drilling that some ore remained below the present bottom in the NE1/4 of the pit. To more accurately determine the amount and its depth, since the old holes were a considerable distance apart, 17 holes were drilled and were all bottomed in tacomite. An average of 15' of ore was found over the area, although in places it was from 25' to 35' thick.

GEOLOGICAL DEPARTMENT.
WADE MINE SURFACE, SECTION 13, 58-19, MINNESOTA.

The Wade mine was leased from the Great Northern interests early in the year. From the last of March until the early part of November two drills, under contract from the Duluth Diamond Drilling Company, were employed on the NE_4 of the NW_4 of Section 13, checking the old drilling done by the Oliver Company and outlining the West ore body more completely. Fourteen holes were drilled. The results were more or less conformable to the old drilling but the developed tonnage was considerably increased by the outside holes.

Two holes were drilled outside of two of the previous outside holes on the East deposit, which also slightly increased its tonnage.

Seven holes were also drilled near the Southeast corner of the NE_4 of the NW_4 of Section 13 to follow up the ore extending on to the property from the Beacon mine ore body. A small tonnage increase was also recorded here.

UNDERGROUND EXPLORATIONS.

ATHENS MINE.

The first drilling in this mine was done during 1918, the work commencing in July. Two horizontal radiating holes were drilled from the first Northwest crosscut on the 8th level through the main East-West dike to test the iron formation on the North side. Hole No.1 was stopped after drilling 12' of soft ore jasper on the North side of this dike due to its encountering an excessive flow of water too great to be handled by the mine pumping equipment in use at that time. The hole was immediately plugged. A water pressure of 625 pounds per square inch was registered at this point. Hole No.2 had drilled 82' of iron formation on the North side of the dike when the ground caved so badly that a connection was probably made with the water course penetrated by the first hole so that the second hole had to be temporarily abandoned. It encountered enriched ground, however, on the North side of the dike, 5' of which was good ore averaging 57.40% iron and .101% phosphorus. It was bottomed in 56% material.

GEOLOGICAL DEPARTMENT.
Hole No. 3, the last hole drilled in this mine during the year, was located at the South end of the 4th level. It was drilled horizontally and practically due South to test for the true slate footwall. It encountered no additional merchantable ore.

**Bunker Hill Mines.**

The first drilling in this mine was started early in November and continued for the rest of the year. The first hole was drilled horizontally and practically due South from the South end of the 10th level to test the slate footwall as far as the South boundary of the property and also to expose any possible fold that might contain ore.

Following hole No. 1, a series of holes was planned from the North crosscut, which runs parallel to the North-South boundary between the Athens and Bunker Hill properties, to determine the limits of ore in depth along this line. The first of these holes, No. 2, was drilling in dike at 161' at the end of the year. It was drilling vertically from a point about 40' South of the main East-West dike and had encountered 65' of good ore starting at the level.

**Cliffs Shaft Mine.**

Drilling in this mine was resumed the middle of January but was discontinued late in March in order to drill a few holes in the Holmes mine. Drilling was again resumed the last of August, however, and continued the rest of the year.

Ten holes were completed and the eleventh, No. 293, drilled to a depth of 125' during this time. The first three holes were drilled to explore the slate hanging contact on the 1204' and 1220' sub-levels above the 1st level "B" shaft. The others were located, five on the 4th level, two on the 5th level and one on the 6th level, all in "A" shaft. A total of 247' of first class ore, 110' of second class ore and 101' of lean ore were encountered, which is a little less proportionally to the total drilling, than encountered in 1917.

**Powder Mine.**

Two shallow vertical drill holes were sunk in this mine on contract by the Cole & McDonald Exploration Company, but both of them caved badly and the results are consequently of little value.

**Geological Department.**
FRANCIS MINE.

Three holes, all horizontal, were drilled in this mine during the year. The first was drilled Southwest across the formation from the 4th level shaft plat but was in hanging wall material all the way. The other two were drilled on the 5th level to aid in the development of both the North and South limbs of ore. The South limb so far has proved much leaner than the North on any given elevation, very little of it being merchantable.

HOLLES MINE.

Six holes were drilled in this mine from the last of March to the middle of November.

One hole was drilled horizontally and Southwest from the West end of the second level to explore the iron formation to the hanging wall. Only 5' of good ore was encountered. Two inclined holes were also drilled from the second level, one at -30° and the other at -60°, both on a Northeast course, crosscutting the formation and exploring principally for a downward continuation of the soft ore on the level. The upper hole found very little commercial ore and it was of a mixed character but the 60° hole encountered 104' of good ore averaging 62.97% iron and 0.05% phosphorus, a most encouraging development.

The other three holes were drilled horizontally and practically due North, two on the 570' and one on the 660' sub-level, to explore the iron formation back to the greenstone footwall. One hole on the 570' sub-level, No.9, found a little hard ore but none of the holes encountered merchantable soft ore.

JOPLING MINE.

The first drilling in this mine was done during 1918. It consisted of four horizontal holes which were drilled between the last of March and the last of May.

Three of these holes were drilled from the 260' sub-level to explore the iron formation but found no enrichment. The fourth hole was drilled Southwest from the 7th level shaft plat across the entire jasper formation from foot to hanging walls. Mixed lean and second class ore was encountered.
encountered but none of a merchantable grade.

LAKE MINE.

Drilling from the 6th or bottom level of this mine was begun the last of November. The object of this drilling is to test the iron formation just North of the Lake mine fault and below the main greenstone or diorite sheet which is the footwall of the Lake ore body. From the information we have it appears probable that this horizon of iron formation rests in turn on a lower greenstone sheet and is also dammed up on the South side of the Lake fault by greenstone, thus forming a second or lower crotch much the same as that containing the Lake ore body. The first hole No.502, was still in the upper greenstone sheet at a depth of 520' on the last of the year.

MORRIS MINE.

Drilling was carried on continuously in this mine except for the period between the middle of March and the middle of July.

The deep hanging wall hole, No.61, which was being drilled vertically from the 6th level at the beginning of the year, was deepened in interrupted stages so that it was 1513' deep at the end of the year. It was still in soft ore jasper. No attempt was made to drill in it continuously when the machine was needed in other parts of the mine and no ore has been encountered in it.

A series of six holes was laid out at the West end of the 6th level to test the fault crotch in which good ore was found below the 6th level by surface hole No.4. Two holes were drilled to the North to the slate footwall, one horizontally and the other on a dip of -61 1/2°. The former encountered no merchantable ore but the latter, or inclined hole, encountered 30' averaging 59.90% iron and .157% phosphorus.

Two holes were then drilled to the South, one horizontally and the other dipping -61 1/2°, principally to locate and determine the attitude of the fault dike forming the supposed crotch. No ore was expected or found in the first hole but the inclined hole encountered 20' averaging 60.26% iron and .256% phosphorus; also considerable second class ore.
One hole was then drilled westerly dipping into the crotch at -50°. It encountered 40' of good ore averaging 61.60% iron and .085% phosphorus, but quite high up in the crotch, another second hole is being drilled northwesterly and a little flatter, -42.8°, to try and catch the ore deeper and farther to the West. It struck good ore at 275' and was still in it at 330' on the last of the year. This ore averaged 61.11% iron and .24% phosphorus.

REPUBLIC MINE.

Drilling was carried on in this mine until the middle of May when it was discontinued for the rest of the year. Ten new holes were completed and one old one deepened during this period. One hole, No.404, was drilled vertically from the 2080' level No.9 shaft expressly to determine the dip of the quartzite hanging wall contact about 150' below the 2080' level in order to plan the position of a vertical winze from this level. The rest of the holes, all horizontal, were drilled for general exploratory purposes and in connection with the development work along the ore lenses.

Seven holes were drilled from 1335' level to the West of the Pascoe shaft, but the first, No.406, was the only one to find a commercial quantity of merchantable ore. It encountered 23' averaging 67.00% iron and .070% phosphorus. Since then the ore has been practically stope out above the level. Additional drilling will be done from this level to more thoroughly explore the West Republic basin after a drift has been driven well out into the hanging wall.

The results from drilling in the Republic mine will never be spectacular with regard to the discovery of ore except perhaps in special cases where exploratory drifts are first driven well out into the hanging from which radiating holes may be drilled back to the quartzite-jasper or hanging wall contact. By this I do not insinuate that drilling is not necessary, - it is by all means in locating the smaller lenses back towards the footwall.

GEOLOGICAL DEPARTMENT.
It is a clearly demonstrated fact that most, yes practically all, of the large ore lenses in this mine are found to be very close to the hanging or jasper-quartzite contact. This region on a new elevation or level cannot be advantageously reached by drilling from levels above so drifts must be driven along it. It is therefore by this slow and expensive means and not by drilling that the larger ore bodies will be discovered. Smaller ore lenses are found farther back in the footwall which jasper and they are the ones we depend on drilling for discovery and development. The hanging contact drifts also serve as good locations from which the footwall formation can be advantageously explored by drilling.

EXPLORATIONS BY OTHER COMPANIES.

Mr. Ernest Allen continued to visit the explorations of other companies on the Michigan and Wisconsin iron ranges. He has prepared maps of these explorations and also written special reports covering each visit, giving detailed information thus acquired.

This entire work, as given in the accompanying table, No.V, cost $254.22, of which $147.79 was Mr. Allen's salary while engaged in it and the balance, $106.43, his travelling expenses.

Mr. Afuhs has copied for our files all outside exploration results of any importance which have come to this office in the form of land offers, etc. The proportional time required was so small that no separate cost of this work was kept.
### TABLE V.

**DETAIL STATEMENT OF CHARGES TO GEOLOGICAL EXPENSE FOR YEAR 1916.**

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### TABLE VI.

**COMPARATIVE STATEMENT OF CHARGES TO THE GEOLOGICAL DEPARTMENT FOR THE LAST THREE YEARS.**

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<td><strong>Miscellaneous</strong></td>
<td>$4.89</td>
<td>$12.23</td>
<td>$125.36</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$19,489.47</td>
<td>$14,799.76</td>
<td>$14,509.57</td>
</tr>
<tr>
<td><strong>Expenses of Mr. H. L. Smyth, i.e. travel, supplies and miscellaneous</strong></td>
<td>$763.86</td>
<td>$569.05</td>
<td>764.30</td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td>$20,253.33</td>
<td>$15,368.81</td>
<td>$15,274.37</td>
</tr>
</tbody>
</table>

The increase in the item of salaries is of course due to two reasons:

1. The larger force employed as seen from Table III.
2. The war time increases in individual salaries.

**GEOLOGICAL DEPARTMENT.**

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The remaining items also show increases over the previous years from perfectly obvious causes, namely, excessive war time expenses of travelling, costs of supplies, etc; also the much greater volume of work handled by this department in 1918.