W. G. Mather, Esq.,

President Cleveland Cliffs Iron Co.,

Cleveland, Ohio.

My dear Sir,

The following is my report for the year 1906. This report which is to be regarded as supplementing that made by Mr. Jopling on the operations of the Engineering and Geological Departments, touches on the following topics:

I. THE HARD ORE TERRITORY.
II. THE SWANZY DISTRICT.
III. THE IRON BELT EXPLORATION.
IV. THE SUNDAY LAKE EXPLORATION.
V. THE Negaunee Situation.
VI. DISTURBANCE OF THE SURFACE PRODUCED BY UNDERGROUND CAVING.

THE HARD ORE TERRITORY.

During the past year a great deal of attention has been given to the hard ore territory of the Ishpeming basin and a number of holes have been drilled underground in the Cliffs Shaft and Neco Mines, as well as from the surface. The Lake Superior Iron Company also have drilled several vertical holes in this area, the results of which have been at our disposal. These exploratory holes as well as the underground development have served to render more definite and precise our ideas of the geological conditions in this basin, and to indicate the direction along which further exploration and opening should proceed.

(a) Geological Structure.

The result of the work of the last year as well as that of preceding years has been to confirm the broad conclusions as to the geological structure of the Cliffs Shaft and Neco Mines which were presented in my reports of 1902 and 1903. These conclusions together with the results of more recent work may be stated briefly as follows:

1. A synclinal axis runs through "B" shaft and passing south of "A" shaft continues to the east probably a little to the south of the Saw Mill Pit. From a crest a little west of "B" shaft this axis pitches on the one side towards the northwest and on the other towards the southeast, so that the hard ore formation in the
middle of the trough descends in both directions, towards the southeast as well as
towards the northwest. The deepest point along the axis in the territory east of
"A" shaft is probably in the neighborhood of the hole recently drilled near the corner
of 2nd St., and Cleveland Avenue which we commonly refer to as the Braastad Hole.
From here the hard ore formation along the axis rises again towards the east, reaching
the surface at the Saw Mill Pit. This synclinal trough, which is a broad and open
one, may be referred to as the Cliffs Shaft syncline.

2. South of this synclinal axis and parallel with it is an anticlinal
area. This is a low and warped fold, the axial line of which runs from the railway
Hard-Cre
crossing south of the office towards the northwest, passing some 600 foot south of
"B" shaft. West of "B" shaft this axis bends first towards the west, and then to-
wards the southwest and the dip of the beds on its northern side steepens. East of
"B" shaft, this anticline like the Cliffs Shaft syncline descends towards the east
probably to about the line of 2nd Street. From here eastward it ascends to the
surface.

In the More territory this anticlinal area is opened on the 3rd, 6th, and
8th levels. It is a warped sheet with small folds and faults, as a whole descend-
ing towards the northwest at gentle angles of dip. We may call this anticline
which forms the southern boundary of the Cliffs Shaft syncline, the More anticline.

3. South of the More anticline is the sharp and deep synclinal fold which
has yielded the principal part of the ore of the More Mine. It passes out of our
territory into that of the Lake Superior Iron Company at the North and South \( \frac{3}{4} \) line of
Section 10, which it crosses about 800 foot north of the centre of the section. This
fold we may call the More syncline.

4. Through the northern portion of the Cliff Shaft workings runs an East
and West fault which is probably the same as a fault having the same direction, which
may be seen at the surface at the eastern end of the Incline open-pit. The
displacement along this line is of considerable magnitude, with the downthrow on its
northern side. It is perhaps the same as the Blue fault, with which it stands in
fairly close alignment. North of it lies a depressed block of hard ore-formation
of which we possess only a comparatively narrow strip along and south of the north
line of Section 10, between the workings of "A" Shaft and the Incline Mine. This
strip has been opened on the first and second levels, but as yet is an untouched
resource on the lower levels, where, however, it requires long drifts in the foot-wall
for its development. This fault is a most important structural feature which must
be taken into account in the future extension of the Cliffs Shaft Mine towards the east.
5. The hard ore formation in Section 10, south of the Moro, terminates against greenstone the contact with which is faulted. This fault is one of great throw. Its course is easily traceable across Section 10 into Section 9 on the west, and towards the east wall into Section 11. It is possibly the same fault as that which forms the southern boundary of the basin next south of the Blue Basin in Section 8 at Negaunee.

(b) Exploration and Development in the Hard Ore Territory.

Exploration and development in the hard-ore mines present much more difficult problems than in the soft-ore mines for the following reasons:

(1) The original deposition of the ore has in most cases no relation to the present geological structure. In this respect the hard ores differ from the soft ores which are always found in synclines or other basins.

(2) The hard ore deposits have no constant footwall and their lower limits are extremely irregular.

(3) Although the quartzite of the hanging wall, or rather the slate and conglomerate beds immediately below it, forms always an upward limit, beyond which hard ore does not extend and although conglomerate ore is almost always found at this contact, yet steel ore of high grade may occur quite far below it and to this therefore the hanging is by no means an infallible guide. A section of the iron formation from 100 feet to 200 feet thick, lying immediately below the quartzite and following all of its bends would include practically all the hard ore in the Ishpeming basin; and it is possible for ore to occur almost anywhere within this distance from the hanging.

(4) Although generally regular the hanging wall in practice has proved often difficult to follow because the bedding of the underlying jasper is usually not parallel with that of the slate and quartzite and the miner is apt to be misled by it.

(5) Finally there are many minor faults and folds, and also many altered diques the material of which is extremely difficult to distinguish from the sedimentary slates.

The fundamental principles of exploration in the hard-ore territory are to keep all exploratory drifts in close touch with the hanging; and to carry all cross-cut drill holes through either to the hanging wall slates on the one hand, or to the sideritic chert on the other and to continue them as long as they are in the hard-ore formation.

(c) Exploratory Work at the Cliffs Shaft.

"A" SHAFT. At "A" Shaft the most important development of the year was in con-
nection with the large deposit of ore in the bottom of the trough. Our drill holes have clearly proved that this continues to the 7th level undiminished in size. The same deposit has also been proved to extend above the 6th level near "A" Shaft, and it is now quite probable that it will connect to the west with the large deposit at "A" drill hole which is now being worked above the 3rd level. This will give a considerable tonnage of new ore between the 3rd and 6th levels near "A" Shaft.

On the fourth level a horizontal drill hole to the south has found ore on the southern limb of the Cliffe Shaft syncline, about 250 feet east of "A" Shaft. This together with the holes drilled in the same territory on the 1st level, indicates that the anticlinal area south of the Cliffe Shaft syncline is likely to yield a large quantity of ore. Except on its southern limb near "B" Shaft this area is as yet untouched. The faulted strip north of the Blue fault has been penetrated by a drill hole on the fourth level. It has also been opened to some extent by drift stopes and drifts on the 2nd, 3rd, and 5th levels. These explorations have found ore and make it probable that a considerable deposit will be found under this strip northeast of "A" Shaft, extending along and probably into Lake Superior Mining Company's territory, in the SE 1/4 of the SW 1/4 of Sec. 3.

"B" SHAFT. The explorations and developments of the past year have found a good deal of new ore in the territory tributary to "B" Shaft.

On the south side of the Cliffe Shaft synclinal, the drift stopes on the 3rd level have been continued in ore during the year, and are now more than 1200' southwest of the shaft. Ore belonging to the same body has been found on the fourth and fifth levels, and is being drifted for, but is not yet found on the second. This deposit promises to be a large one.

In the bottom of the basin west of "B" Shaft, the ground is very much disturbed and it is extremely difficult on account of the numerous faults, most of them of small throw, to work out the geological structure with sufficient accuracy to be helpful in drifting. The ore occurs in irregular bodies of moderate size. The levels are so close together that the developments on one are generally reliable guide for that below, and it is probable that no ore of importance has remained undiscovered in this territory. On the north side of the Cliffe Shaft syncline the hanging wall is less disturbed than on the south side, and the dip also is more gentle. Three vertical holes from the surface were completed in this territory during 1906 and a fourth was started which was finished in February of this year. Of these holes Nos. 3 and 4 found ore in advance of the underground development. Holes 1 and 5 both entered sheared diorite at the hard ore horizon, and were therefore blank.
It seems to me probable that this diorite is dike rock in both cases, and that iron ore may exist in the neighborhood of both holes.

(d). Future Explorations.

The various ore bodies east of "A" Shaft may be expected to continue eastward with the usual interruptions and lean spots. The two important general questions in connection with their development are: (1) the depth of the basin in this direction; and (2) how much of the territory may profitably be developed from the Noro or from some other shaft. It is indispensable to know the depth of the basin because this will fix the ultimate depth of "A" Shaft, and that of the lowest level to be opened from it. The Braastad hole shows ore to the 10th level, and it will probably be necessary to drill other holes in order to discover whether there is yet ore below this.

Beyond the bottom of the basin towards the east the ore-bearing territory lies very far from "A" Shaft and to get into it from that side would require a long extension of the upper levels through barren rocks. We hope that it may be possible to open at least part of this ground from the Noro side, with less rock drifting, or as regards part of it perhaps even to find a connection in ore most of the way. An important part of our exploratory work in the immediate future will be directed to the extension of these questions.

In Section 5 we have a corner in the NW 1/4 of the SE 1/4 which should contain the western prolongation of the hard ore formation of the New York Mine. A hole will be drilled south of the old High School Building in the Excelsior second addition to test this ground.

Although the hard-ore territory lying east of "A" Shaft and tributary to it is quite large, its limits are fixed on all sides by the workings of other mines or by our land boundaries. The great possibilities of the future are west of "B" Shaft. While the two holes, which are farthest west, failed to find ore: this fact should not discourage us from continuing our drilling in this direction. On the contrary I confidently anticipate favorable results and the discovery of large amounts of ore in this area. The drifts on the south side of the trough should be pushed ahead, and drilling should be started in the NW 1/4 of the NE 1/4 of Section 9. The hard ore formation should also be explored northwest of holes three and four.

(e). Exploratory work at the Noro Mine.

The new ore found during 1906 at the Noro lies in the anticlinal area.
already described, within this thin on the 3rd and 8th levels a considerable tonnage has been developed and mined.

The exploration of this portion of the mine by the drill is peculiarly difficult not only because the ore is thin and interrupted, but also because the formation is, on the whole, so flat that it is impossible to get stations underground from which it may be crosscut except at very acute angles. Hence the drill may pass close above or below ore without disclosing it.

The mining problem in this territory is equally difficult for the same reason, namely, the general flatness combined with minor irregularity of the dip. On this account it is extremely difficult to follow the ore with drift stopes as well as to mine the flore between levels without drifting in rock. Our explorations indicate that but little of the anticlinal area is likely to be productive below the 8th level, that is to say, the ore formation appears to cross our boundary into the Lake Superior ground for the most part at or above this elevation. It is hoped, however, that with some rock drifting to the north we may be able to get our ore connection on the 8th level through to the eastern end of the Cliffs Shaft basin. The exploration of the anticlinal area, therefore, is the most important work before us at the Noro.

(f) Underground Development.

An important matter, which was taken up with Mr. Graff during the summer, and frequently discussed, was the question of the possible modification of the present method of mining in the two hard ore mines, and especially in the Cliffs Shaft.

Our present system is to develop ore discovered by the diamond drill by carrying wide and high breast stopes through it. This system is very satisfactory from the mining standpoint, because it yields a product at a low cost per ton. From the point of development, however, it has three great defects, namely; (1) the openings are extended very slowly; (2) too large a proportion (about 60%) of the product is taken on the advance, and too small a proportion left behind as reserve; and (3) when a stope runs into rock it is necessarily discontinued and further development along that line usually ceases.

It was felt that on the lower levels, which on account of the distance of the ore from the shafts, take so long to develop, it would be desirable to cut down the size of the breast stopes and therefore advance them more rapidly, and leave behind a larger reserve. In association with Mr. Graff a plan embodying this principle was outlined which it is hoped will soon add largely to the developed ore in the mine, without ultimately increasing the cost per ton.
THE SWANZY DISTRICT.

During the past year our explorations in the Swanzy district have been vigorously prosecuted and have been directed to the following principal objects: (1) The determination of the value of the D.M. and N. lands which involved the exploration of the western and southern boundaries of the Swanzy basin; and (2) the determination of the extension and limits of the ore-bodies already discovered.

The details of the location of the holes and their results are familiar to you from the reports of this department and of Mr. Jackson. In the following statement I shall confine myself to a more general consideration of the objects aimed at, and the extent to which they have been attained, together with the bearing which the results have on our future work in this district.


The D.M. & N. Company own a large acreage of swamp lands in T 44 N R, 24 and 25 W in the direct prolongation of the Swanzy basin, as its boundaries were known a year ago. Since our hold on these lands was slender and without definite term, it seemed imperative in view of their possibilities, to discover as soon as possible the continuation and boundaries of the basin towards the southeast. With these requirements in view, it was felt to be expedient to push on to points as near the large blocks of D.M. and N. lands as possible. Accordingly, in the autumn of 1905, drilling was started on the north and south sides of the trough at points over a mile in advance of its boundaries as previously located. These boundaries are indicated in red on the accompanying map.

(a). Work on the Continuation of the Northern Side of the Basin.

The first holes drilled on the continuation of the northern boundary of the basin were in Section 38, 45-28; they were followed by others farther south in Sections 1 and 12, 44-28, so placed as to spread a net across the path of the basin of a mesh too fine to permit it to pass through unobserved. But all encountered granite or other Archaean rocks under the sand or sandstone.

Work in this territory has been very slow and expensive, partly on account of its remoteness from our base at Princeton, but mainly on account of its swampy character, which made it almost impassable during the summer season to move the drills to the critical points of the area. Also since the first holes encountered granite we had to move back to the Swanzy series with short and necessarily uncertain steps in order to avoid getting too far and thereby incurring the expense of drilling deep holes in the slate. The original plan made in the autumn of 1905 was to
push the work vigorously after the swamps had frozen, but unfortunately the winter proved to be unusually mild, and the swamps remained impassable throughout the season.

In the summer we decided to construct corduroy roads across the swamps in order to reach certain indispensable points in Sections 2 and 3. The series of holes planned in these sections is not yet completed, but enough has been done to make it fairly certain that the Swanzy basin comes to an end by the convergence of its northeastern and southwestern sides somewhere near the northwestern corner of Section 1, 44-25.

We do not yet possess sufficient data for drawing the boundaries accurately: it seems fairly certain, however, that he N.M. & M. lands within the basin, and which therefore possess chances of iron ore will be five fortiess in the southern half of Section 35, 45-25, one forty in Section 3, 44-25, two fortiess in Section 4, 44-25, one forty in Section 32, 44-25, and eleven fortiess in Section 33, 44-25, or in all twenty fortiess.


**SECTION 35.** The only holes on D.M. & M lands on which ore has as yet been found are holes 4 and 12, Section 35. Hole 4 is in the south line of the section in the SW ¼ of the SE ¼; it encountered 18 feet of ore 1800 feet below the surface, being the deepest hole in the Swanzy district. The ore is of good quality, running 58 per cent, metallic iron. This hole is equally significant for the adjoining land in Sec 2, 44-25 which belongs to the Northwestern Company.

Hole 12 is in the N ¼ of the SE ¼ of Section 35 on the line between the two fortiess, both of which belong to the D.M. & M. Co. The ore in this hole is mixed and of low grade. It is promising mainly because it may indicate the proximity of richer ore. Three other holes drilled in these 40's, namely, 7, 8, and 9 have, however, failed to find ore.

The ore found in Hole 4 belongs to a body, which will undoubtedly mount high towards the surface, but as yet we do not know in what direction. It seems most probable that its continuation will be towards holes 11, 13, 14, 16, and 18 on the adjoining forty on the east, which belongs to the Northwestern Company. If so, the SW ¼ of the SE ¼ may contain a deposit of large size. But until we have drilled additional holes no estimate of the amount of ore can be made.

**SECTION 35. SE ¼ NE ¼.** No holes have been drilled on these lands as yet.

The iron formation under them may lie too deep for oxidation and concentration.

**SECTION 3. NE ¼ NE ¼.** This forty has not been drilled but we have located
a hole at the north \( \frac{1}{3} \) post of the section to which a drill will soon be moved. This will be a union hole as regards the adjacent forties, which belong to the I. Stephenson Co., and to the Northwestern Company respectively.

**SECTION 4.** N \( \frac{1}{3} \) NW\( \frac{1}{2} \). Our drill holes have shown that these forties carry the iron formation only in a narrow fringe and to a shallow depth. Its character and thickness as shown in these holes were not encouraging.

**SECTION 33.** The eleven forties which the D.N. & H. Co., own in this section are all underlain by the iron formation, for the most part at considerable depth. One hole in the SW \( \frac{1}{2} \) of the NE \( \frac{1}{4} \) on D.N. & H. lands, which was drilled several years ago, found the iron formation thin and unoxidized at a depth of feet. Although the territory is practically virgin, it should be said that holes on Northwestern lands in the SW \( \frac{1}{2} \) of the SW \( \frac{1}{2} \) and on the nearest portions of Section 27 have found the formation of generally unpromising character. The best chances would seem to lie in the two western and in the three southern forties, and these will be explored as soon as possible.

**SECTION 32.** Lots 4 and 5. These lots probably contain the iron formation. The holes drilled on the SW \( \frac{1}{2} \) of the SW \( \frac{1}{2} \) of Section 33 do not indicate that it has much promise.

Altogether our explorations indicate that we are likely to have at least one deposit of workable size and quality on the D.N. & H. lands in Section 35.

(c) **Work for the future on the D.N. & H. lands.**

As just indicated the work for the future may be summed up as follows:

1. The further exploration of the ore shown by holes 4 and 12, Section 35.
2. The exploration of the lands in the north half of Section 3, 44-25.
3. The exploration of the lands in Sections 32 and 33, 44-25. The drill now at work in Section 29 is approaching this territory, and, as soon as it is free, will be located on lot 4, Section 33, east of the river. If the formation here proves favorable, the adjacent portions of Section 33 may be investigated by a second drill as soon as one is free.
B. Other Work in the Swansea District.

(a). Extensions of deposits already known.

During the year drilling has been in progress on Sections 19, 27, 28, and 29, in order to follow and define more closely the limits of ore previously known to exist. The results of this work are as follows.

SECTION 19. On Section 19 on the northwest quarter near the old Princeton Mine, several holes have been drilled from the surface proving the existence of about 125,000 tons of ore of merchantable grade. This ore is a part of the old Princeton deposit.

SECTION 27. In the SE 1/4 SE 1/4 several holes have been drilled in the endeavor to trace the continuation of the ore found in hole 10, but without success. A large area in this forty is underlain by ore, but it is thin and the deposit is of doubtful value.

West of Johnson Lake several standpipes have been sunk and shallow holes drilled about the northern border of the ore body. Some of these have found ore.

SECTION 28. On Section 28 standpipeing, in order to find a practiceable site for a shaft, has been going on at the Smith and exploration for ore at the Kidder. At the latter we have found a body of ore of workable size and quality. Exploration has not yet been completed, but by the end of the year, we had proved the existence of 400,000 to 500,000 tons.

SECTION 29. A number of holes were drilled on this section south of the Stephenson to follow up that deposit. As a result we have demonstrated the existence of about 250,000 tons of ore in a long and narrow deposit. This portion of Section 29 is covered with a very deep mantle of sand, making the exploitation of this ore from a separate shaft a slow and very costly operation. The ore ought to be mined from the Stephenson side.

The Work at Helena.

In addition to the exploratory work on Section 1 and 12, a drill was employed during part of the summer on D.H. & H. lands along the Northwestern Railway. Three holes were located across the prolongation of the line of the Swansea basin, in order to see whether the basin continued to the southeast, but all encountered granite.
under the Cambrian sandstone. The line of the railway was chosen for this section because, as already explained, it was the only line of transportation available across this Swampy area.

III. THE IRON BELT EXPLORATIONS.

In August 1906, I recommended that the Iron Belt property should be taken under option and in September of the same year, a plan for beginning explorations at this locality was outlined by Mr. Jopling and myself, and soon after put into effect. The geological conditions at the Iron Belt, and the complete scheme of exploration of which the plan just mentioned formed a part are set forth below.

The Iron Belt property includes eight sections in Section 11 T 46 N R 1 E Wisc; namely, the NE ¼, the SE ¼ NW ¼, the NE ¼ SW ¼, and the W½ SW ¼. The range crosses the section diagonally from southwest to northeast, so that the Iron Belt possesses approximately 6000 feet in length of the outcrop of the iron formation. This length is divided into two nearly equal portions by a cross fault west of No. 7 shaft. The length of the eastern block from the fault to the Atlantic line is about 2800 feet; while the length of the western block from the fault to the Shores line is about 3200 feet. These two blocks, the eastern and the western, have to be treated as entirely separate problems from the point of exploration, for the reason that along the fault, which divides them, the horizontal displacement appears to be 120 feet, corresponding to a vertical displacement many times as great, and involving a complete break in conditions.

Moreover, each of these blocks is itself divided into two separate fields for exploration by a longitudinal band of black slates, which run through the property parallel with the footwall quartzite and some 150 to 200 feet above it. These slates lie in the great longitudinal fault of the Cogebic range. They form the hanging wall of the lower ore zone of which the quartzite constitutes the foot. They also form the footwall of the upper ore zone. The two blocks, each of which has two ore zones, rendered quite independent of one another by the longitudinal fault, therefore afford in all four individual fields in which ore may occur and in which its occurrence is to be investigated.
The large deposit already found at the Iron Belt, from which its product has mainly come, occurs in the upper zone of the east block on a dike pitching east about 150° into the Atlantic territory. The only other ore found occurred in a very irregular deposit along the cross fault already mentioned. The lower zone in the western block had been somewhat explored by No. 6 shaft near the Shores line. Besides these openings, a good many shallow diamond drill holes had been drilled both underground and from surface. In carefully taking into account this previous work it seemed that the upper ore horizon in the east block, (which had already yielded a large amount of ore), could not be drilled to advantage, and might be regarded for the present as sufficiently explored. Also as regards the lower horizon in the east block, it seemed better to wait until the mine was pumped out before attempting exploration in depth. This left the western block on which to begin operations.

The plan adopted contained, as its essential features, the following:

1. The holes were to be located near the respective footwalls and were to be drilled parallel with the dip of the formation.

2. The holes were to be placed in each zone in such positions that (having in mind the prevalent pitch of the dikes towards the east at an angle of 150°) when completed the property would be completely explored down to depths ranging from 1600 feet near the Shores line to about 2400 feet at the cross fault.

In order to attain this result the full number of holes planned and their depths are as follows:

<table>
<thead>
<tr>
<th>Western Block</th>
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</thead>
<tbody>
<tr>
<td>(1) Footwall Zone.</td>
</tr>
<tr>
<td>Hole</td>
</tr>
<tr>
<td>No. 101</td>
</tr>
<tr>
<td>No. 102</td>
</tr>
<tr>
<td>No. 103</td>
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<tr>
<td>No. 103</td>
</tr>
</tbody>
</table>

(2) Hanging-wall zone.

| Hole | Location | Dip | Depth |
| No. 201 | 250 feet north No. 6 shaft | 70° | 1500' |
No. 202  200 feet north No. 103  700'  900'

Diamond Drill hole

Total  5600'

EASTERN BLOCK.

Footwall zone.

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE No. 1 shaft 40' from foot</td>
<td>1600'</td>
</tr>
</tbody>
</table>

In addition it was planned (1) to test-pit along the footwall near the cross fault, and, when the mine should be pumped out, (2) to crosscut on the fourth level, at No. 1 shaft, south to the quartzite, and (3) to sink No. 1 shaft deeper.

Of the general plan of exploration sketched above the following portions have been or are being carried out.

(1). Hole 201 was drilled to a depth of 1073 feet. For practically the whole distance it was in well oxidized and promising iron formation, but no rich ore was found. No important dike was encountered.

(2). Hole 101 was not started in the proper direction and consequently entered the footwall at a depth of 550 feet. It was continued to 948 feet in the hope that its dip might flatten sufficiently to carry it again into the iron formation. No important dike was encountered in this hole.

(3). Hole 103 has been started and is now going down.

(4). The surface test-pitting in the eastern block near the cross-fault failed to find ore.

While our work has so far not found ore, I think our chances are still sufficiently good to justify its continuation along the lines indicated.
IV. THE SUNDAY LAKE EXPLORATIONS.

In the autumn of 1906, we took options in the vicinity of Sunday Lake on two blocks of land, one comprising the western six forties of the north half Section 8, T 47 N R 46 W, and the other the whole of Section 17. Both these areas were explored during the winter of 1906-07, and the following spring.

SECTION 8 T 47 N R 46 W. Our exploration on Section 8 were continued to nearly the first of June, 1906, and were without result. They showed that a cross fault follows close to the west line of Section 8; and that the quartzite, which forms the Mikado footwall, has been heaved towards the north on the eastern side of this fault, almost to the east and west quarter line of the section. Only a narrow fringe of the iron formation therefore is included within the property which we were exploring. If any ore should occur on this land it would pass at a moderate depth to the property of the Steel Corporation on the north. Our explorations were therefore discontinued.

SECTION 17 T 47 N R 45 W. In the northern portion of Section 17 the iron formation extends probably entirely across the section from east to west. To the east at the Fenton exploration the material in the dump is of promising character. The same is true of the Pilgrim exploration in Section 18 to the west. These facts attracted us to this field.

Our drilling showed that on Section 17 the iron formation was shallow, thin, and generally unpromising. The exploration therefore was discontinued.

V. THE Negaunee Situation.

During the year a great deal of attention has been given to the drilling at the Negaunee Mine, and on the Harvey lots; and to the general problems of development and mining at Negaunee. These subjects have been treated fully in a special report made to Mr. Duncan on Oct. 30, 1906, and no further reference need be made to them here.
VI. DISTURBANCE OF THE SURFACE PRODUCED BY MINING. ON THE CAVING SYSTEM.

In planning new development work, and locating shafts, buildings, stock-piles, and tracks, we are constantly meeting the problem of the limits of the disturbance likely to be produced at the surface by mining ore on the caving system. This question is one that cannot be settled by deductions from general principles. It is one, however, with which this Company has had a large amount of experience at its Lake and Salisbury Mines. During the past summer a good deal of time was spent in getting together the facts at these mines, and putting them in a form in which they will be useful. This work may profitably be extended in the future to all the mines of soft ore in which we have an interest. When this is done we shall be able to deal with similar problems with confidence firmly based on experience.

Yours truly,

[Signature]

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