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A report on drill steel wear at Isle Royale Mine, Houghton, Michigan

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A REPORT ON DRILL STEEL WEAR AT ISLE ROYALE MINE.

HOUGHTON, MICHIGAN.

BY

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THESIS

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TABLE OF CONTENTS.

ILLUSTRATIONS.

A Report on Drill Steel Wear at Isle Royale Mine.

Houghton, Michigan.

In 1917 the miners at the Isle Royale Copper Company's mines were constantly complaining about poor drills and an investigation was made to discover any reasons for the complaint.

The Isle Royale vein is an amygdaloidal formation with native copper as the principal mineral. Ingersoll-rand #18 Water Leyners (hammer type) were generally used at this mine (although the I.R. "Peerless" machine was being given a trial) and it was with these machines that the test was made. One-inch, hollow, hexagonal drill steel was used, being sharpened into a Carr bit (see Fig. 1). Due to the fact that in a single hole a miner may drill through minerals ranging from gypsum (in softness) to quartz (in hardness) and from calcite (in brittleness) to copper (in toughness), it was desireable as well as necessary that the drills be made to stand up under the worst conditions. Drilling through a mass of native copper is not so detrimental in itself

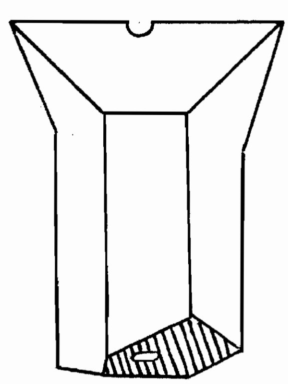
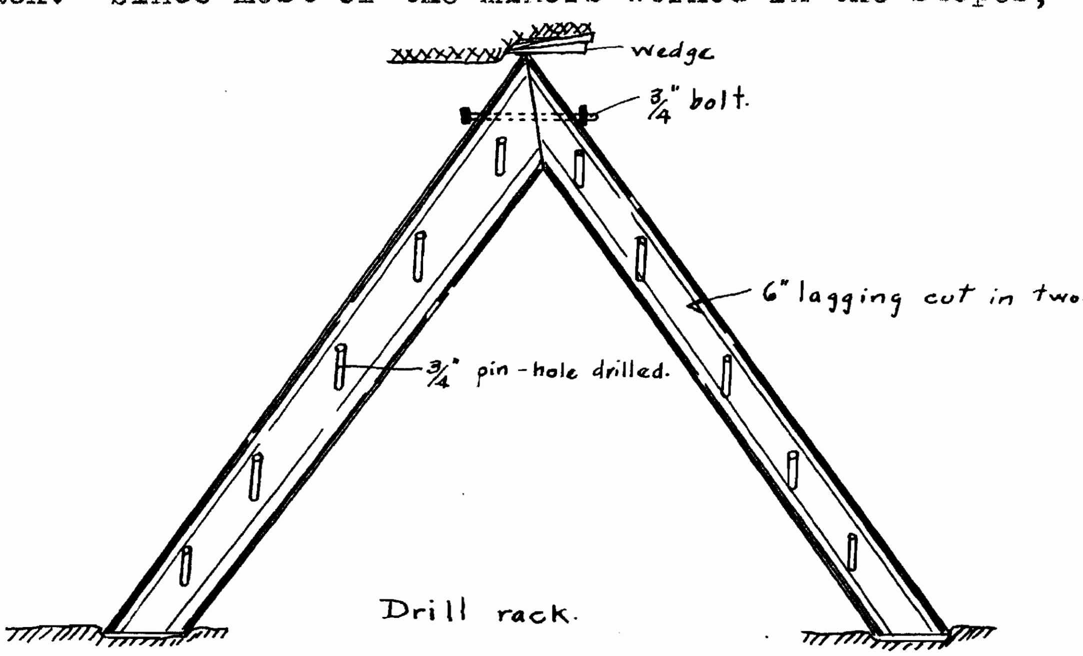


Fig. 1.

to the drill, for the copper is simply pounded out into flakes, but the danger lies in the chance of a chip off the drill itself ruining the cutting edge by being pounded to a powder. Yet, copper may ruin the drill by plugging up the water hole.

Before going into further details concerning the report, it might be well to mention something about the method of supplying the drills to the miners. The drills were sent below shortly after the day shift had ended and pitched in a heap on the respective levels. Miners coming in on the night shift would toss them into an iron tramcar and have the motor haul them to the drill rack. Since most of the miners worked in the stopes,



the greater number of complaints came from the stopers.

They really had another alibi for complaining, viz., they had to pack the drills up the stope, over broken rock etc., by themselves, and every drill that proved unfit for duty, meant another trip down the stope for one or two to replace it. Sometimes near the end of the shift, rather than go down for one drill to finish a hole, the hole would be shot short and this practise was entirely objectionable for it left the stope faces very uneven, which meant a smaller amount of drilling and rock (ore) obtained per shift.

The test covered a period of 16 shifts (each eight hours) and was conducted in the same stope in order to approximate a uniform hardness of rock as nearly as possible. The test was made in the following manner: With the aid of a stop-watch, the writer kept the machine record for each shift. Start was made with a sharp set of drills; the set comprising one each of the following:

Starter	approx.	3 feet long	gauge	1 5/8 inch
4 foot	"	4 1/2 feet long	"	1 9/16 "
6 "	"	6 1/2 " "	"	1 1/2 "
8 "	"	8 2/3 " "	"	1 7/16 "
10 "	"	10 2/3 " "	"	1 3/8 "
12 "	"	12 2/3 " "	"	1 5/16 "

After the machine was rigged up and was ready for drilling, the time was caught by the stop-watch from the time the air throttle was opened until it was closed. This was done for each drill. Should the throttle be closed for some reason, other than changing the drill, the watch was stopped until the air was again turned on. In this manner, the total number of minutes of reciprocation of the drill was obtained. Before the drill was removed from the hole, a mark was made thereon at the collar of the hole and upon removal of the drill, the depth of hole drilled by that particular drill was measured. Should the collar of the hole have chipped off after the hole was drilled, the depth of hole drilled before breaking was measured and recorded. After using each drill, it was examined and the condition of the cutting edge recorded. If the cutting edge was found to be good, the drill was laid aside and used for the next hole. Should the drill be found unfit for further service, it was discarded, the proper notation made after its record, and a sharp drill of the same length substituted for it in the test. A drill was considered dull when its cutting edge was 1/8 inch wide or more.

At the end of each shift, the drills of the set which were found fit for further service were tied in a bundle and left at the bottom of the stope. The following shift was started with the left-over set and filled in with new drills as necessary to make a complete set. The number of holes drilled per shift was recorded and from it, the "life" of the drill in shifts was calculated. For instance: suppose six holes were drilled during the shift, but in two of them, it was not necessary to use the starter. If only one starter was used during the shift, (it being new at the beginning and dull at the end of the shift), its life in shifts would be two-thirds. If two starters were used (both being new at the beginning and dull at the end of the shift), then the life of each would be one-third, providing each was used in the same number of holes. Or

$$X = \frac{a}{b} \quad \text{when}$$

a equals No. of holes in which drill was used

b " " " " drilled per shift

X " life of the drill in shifts.

If drill was used more than one shift and was still sharp, then X equals $\frac{a}{b}$ plus $\frac{a'}{b'}$ etc.

Since there was little interference from mass copper, another value was considered in making comparisons of the results of the test. This value is the product of the total time of reciprocation by the total depth, in feet, drilled by the drill and is noted as "foot-minutes". This value balances the uneven hardness of the ground. For example:- a bit used for five minutes in soft ground has less chance for wear than the same bit used for fifteen minutes in hard ground (both drilling the same depth hole). Also a drill drilling a hole two feet deep in hard rock and requiring five minutes to do so, should be given a higher rating than one which drills one-tenth of a foot (in copper) and reciprocating the same length of time. However, if mass copper had been encountered in appreciable quantity, the foot-minute value would not have had a correct meaning, for in drilling native copper, a drill may reciprocate for hours and not drill more than an inch.

The following remarks apply to the causes for discarding drills used in this work and correspond to the letters in the last column of the classified data, which follow:

A:- Drill dull by wearing, due to pounding.

B:- Part of used set taken, so made start with new set, even though this drill was not dull.

C:- Dull and broken on cutting edge.

D:- Gauge too small.

E:- Plugged with copper.

F:- Broke about six inches from bit.

G:- Cutting edge chipped off, steel too brittle.

H:- Drill stuck in chuck.

I:- Gauge too large.

J:- Steel flattened, bit too soft.

K:- Wore round like ball (smooth)-too soft.

L:- Drill stuck in hole.

M:- Still sharp at end of experiments.

N:- Broke about three feet from bit.

O:- Steel chipped round like ball (rough)-brittle

P:- Broke shank.

The following tables are the tabulated results of the investigation:

Data for drill steel 2 feet long (single-bit starters):

No. of Holes	No. of Shifts	Minutes of Reciprocation.	Feet Drilled	Ft.→min.	Reason for Discard (See Remarks).
2	.4	12.0	3.6	43.2	A
12	3.4	57.0	19.0	1,083.0	B
3	1.2	15.0	5.2	78.0	F
1	.2	6.0	2.2	13.2	G
1	.2	8.0	1.8	14.4	A
3	.6	18.0	5.3	95.4	F
7	1.5	28.5	12.0	332.0	F
2	.4	12.0	3.0	36.0	A
2	.4	6.0	2.6	16.9	A
3	.6	11.0	4.7	51.7	A
2	.4	9.5	3.8	36.1	G
4	.8	20.00	7.0	140.0	A
3	.6	13.5	4.6	62.1	E
5	1.0	21.5	8.0	204.0	A
6	1.0	25.5	10.8	232.2	M
56		263.5	93.6	2,438.2	

Data for drill steel 4 feet long.

No. of Holes	No. of Shifts	Minutes of Reciprocation.	Feet Drilled	Ft.-min.	Reason for Discard (See Remarks).
1.0	.2	3.0	1.8	5.4	A
1.0	.2	6.0	2.0	12.0	D
3.0	.6	17.5	5.5	93.5	A
5.0	1.0	32.0	9.0	288.0	A
8.0	1.8	44.0	15.0	660.0	B
1.0	.2	2.2	2.0	4.4	A
4.0	1.0	33.0	9.0	297.0	A
1.0	.2	10.0	2.0	20.0	A
3.0	.6	13.0	3.5	45.5	H
2.0	.5	12.0	4.0	48.0	A
7.0	1.4	41.0	10.8	442.8	A
8.0	1.5	53.5	15.3	818.5	A
3.9	1.0	16.0	5.0	80.0	J
1.0	.2	4.0	2.1	8.4	N
3.0	.5	19.5	5.5	107.3	A
2.0	.3	7.5	4.0	30.0	O
7.0	1.4	41.5	12.8	531.2	A
1.0	.2	6.0	1.8	10.8	A
4.0	.9	23.0	8.3	190.9	A
8.0	1.5	37.0	15.5	573.5	A
3.0	.8	15.0	5.5	82.5	P
76.0		436.7	140.4	4,349.7	

Data for drill steel 6 feet long.

No. of Holes	No. of Shifts	Minutes of Reciprocation.	Feet Drilled	Ft.-Min.	Reason for Discard (See Remarks(.
1	.2	11.0	1.8	19.8	A
3	.6	13.0	5.8	75.4	A
2	.4	17.0	4.3	73.1	A
8	2.0	38.0	15.0	570.0	A
3	.6	19.0	5.3	100.7	A
1	.2	4.0	.5	4.0	A
6	.4	7.0	3.3	22.1	B
6	1.4	68.0	11.3	768.4	A
10	2.4	60.0	17.5	1,050.0	A
1	.2	4.0	1.5	6.0	G
2	.4	16.0	3.7	59.6	A
1	.2	6.0	1.8	10.8	A
1	.2	8.0	2.0	16.0	A
1	.2	7.0	1.8	16.2	A
5	1.0	30.0	8.5	255.0	A
1	.2	11.5	1.9	21.8	A
2	.4	12.0	3.9	46.8	A
3	.5	17.5	5.5	97.5	A
3	.5	33.0	6.3	207.9	A
7	1.0	19.0	12.2	231.8	A
3	.5	35.0	5.5	192.5	A
4	.5	19.0	8.0	162.0	A
3	.5	17.0	5.5	93.5	A
1	.1	6.5	1.8	11.5	C
8	1.5	40.0	15.2	608.0	M
86		518/5	149.9	4,720.4	

Data for drill steel 8 feet long:

No. of Holes	No. of Shifts	Minutes of Reciprocation.	Feet Drilled	Ft.-Min.	Reason for Discard (See Remarks).
4	.8	29.0	8.0	232.0	A
1	.2	6.0	2.0	12.0	A
2	.4	16.0	3.6	57.6	F
6	1.2	40.0	12.0	480.0	A
1	.2	2.0	.2	.4	F
1	.2	13.0	1.9	24.7	A
1	.2	6.0	1.5	9.0	D
4	1.0	20.0	5.0	100.0	B
1	.2	12.0	1.8	19.2	A
5	1.0	34.0	9.0	306.0	A
5	1.0	30.0	9.0	270.0	A
1	.2	6.0	2.0	12.0	A
4	.8	31.0	8.3	257.3	A
4	.8	19.0	7.3	138.7	A
1	.2	15.0	.9	13.5	E
1	.2	11.5	1.8	20.7	A
3	.5	11.5	6.5	74.8	A
5	.8	38.0	9.5	361.0	A
1	.2	2.0	.8	1.6	F
2	.4	9.0	3.0	27.0	A
11	2.8	57.5	20.2	1,161.5	A
1	.2	2.0	.5	1.0	E
7	1.0	29.5	10.7	315.6	A
2	.4	11.5	3.7	42.5	G
1	.2	6.0	1.8	10.8	A
5	1.0	23.5	8.0	188.0	A
4	1.0	23.5	8.0	188.0	A
84		504.5	147.0	4,324.1	

Data for drill steel 10 feet long.

No. of Holes	No. of Shifts	Minutes of Reciproca-tion.	Feet Drilled	Ft.-Min.	Reasons for Discard (See Remarks).
3	.6	23.0	5.5	126.5	A
13	3.0	80.0	22.0	1,760.0	C
11	.4	11.0	3.7	40.7	B
6	1.4	60.0	10.8	648.0	A
2	.4	8.0	3.7	29.6	A
1	.2	10.0	1.0	10.0	G
3	.6	17.0	5.2	88.4	A
3	.6	17.0	5.8	88.6	A
1	.2	6.0	1.9	11.4	I
1	.2	9.0	2.0	18.0	J
3	.6	7.0	5.3	37.1	A
6	1.0	39.5	11.5	454.3	A
1	.2	2.5	1.2	3.0	A
2	.4	9.5	3.5	33.3	A
2	.4	9.0	3.5	31.5	A
1	.2	5.5	2.0	11.0	A
1	.2	7.0	2.0	14.0	C
1	.2	5.0	1.5	7.5	A
3	.6	14.0	5.3	74.3	A
4	.6	16.0	7.5	120.0	A
7	1.0	30.0	12.5	375.0	A
3	.5	13.0	5.3	68.9	A
3	.5	15.0	5.8	87.0	A
2	.4	9.5	5.3	50.4	A
4	1.0	28.0	7.9	221.2	A
87		451.5	141.7	4,409.7	

Data for drill steel 12 feet long:

No. of Holes	No. of Shifts	Minutes of Reciprocation.	Feet Drilled	Ft-Min.	Reasons for Discard (See Remarks).
9	2.0	52.0	15.5	806.0	A
8	2.0	45.0	14.5	652.5	B
4	.8	44.0	8.0	352.0	F
3	.6	20.0	5.3	106.0	G
4	.8	27.0	8.0	189.0	K
1	.2	4.0	2.0	8.0	F
1	.2	10.0	1.7	17.0	A
2	.4	13.0	4.0	52.0	A
6	1.0	37.5	9.7	363.8	A
8	2.0	28.0	14.3	400.4	A
7	1.0	24.5	12.4	306.2	A
7	1.0	44.5	15.3	680.9	A
3	.6	53.0	5.3	280.9	J
3	.5	14.0	4.2	58.8	A
6	1.4	28.5	11.0	313.5	A
72		445.0	131.2	4587.0	

Table 7.

Reason for Discard	2 ft. Drill		4 foot Drill		6 ft. Drill		8 ft. Drill		10 ft. Drill		12 ft. Drill	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	7	46.6	14	66.68	21	84.0	19	70.4	19	76.0	9	59.9
B	1	6.7	1	4.76	1	4.0	1	3.7	1	4.0	1	6.7
C	-	----	--	-----	1	4.0	--	----	2	8.0	-	----
D	-	----	1	4.76	--	----	1	3.7	--	----	-	----
E	1	6.7	--	-----	--	----	2	7.4	--	----	-	----
F	3	20.0	--	-----	--	----	3	11.1	--	----	2	13.3
G	2	13.3	--	-----	1	4.0	1	3.7	1	4.0	1	6.7
H	-	----	1	4.76	--	----	-	-------	--	----	-	----
I	-	----	--	-----	--	----	-	----	1	4.0	-	----
J	-	----	1	4.76	--	----	-	----	1	4.0	1	6.7
K	-	----	--	-----	--	----	-	----	--	----	1	6.7
M	1	6.7	--	-----	1	4.0	-	----	--	----	-	----
N	-	----	1	4.76	--	----	-	----	--	----	-	----
O	-	----	1	4.76	--	----	-	----	--	----	-	-----
P	-	----	1	4.76	--	----	-	----	--	----	-	-----
Totals	15	100%	21	100%	25	100%	27	100%	25	100%	15	100%

Continued Page 15.

Table 7 Concluded.

Reason for Discard.	Total Number.	Total Percent.
A	89	69.41
B	6	4.70
C	3	2.34
D	2	1.56
E	3	2.34
F	8	6.25
G	6	4.70
H	1	.80
I	1	.80
J	3	2.34
K	1	.80
L	-	----
M	2	1.56
N	1	.80
O	1	.80
P	1	.80
	128	100.00

Conclusions.

From table 7 (page 15) it will be seen that almost 70% of the drills used were discarded because of the fact that the cutting edge was worn (shown opposite "A" in first line). Of these, nearly two-thirds were 6 foot, 8 foot, and 10 foot drills, which meant that these drills received the greatest wear. True enough, they were used more regularly than the shorter and longer sizes, but after going into the matter, it was found that the rapid wear was due to two reasons. These were(1) shortage of 6 foot, 8 foot, and 10 foot drill steel, thus causing those lengths to be sharpened more frequently; (2) a non-uniform heat treatment during sharpening. The former was remedied by increasing the number of steels to twelve each per machine. This increase permitted the steels to be used one day, sharpened the next and to lie idle for the two succeeding days.

The non-uniform heat treatment of the steels during sharpening was due to the fact that on dark days, the steels appeared hotter, when taken from the fire, than they really were. The result was that the proper temper was not obtained. The suggestion which was offered at the time this report was made (but which has not yet been carried out) probably would have remedied this fault, viz., the installation of an oil-burning forge. Since the heat thus obtained would be more uniform and by timing the bit while in the forge, a uniform temper could be obtained on dark days as well as light days and the bits would stand up better, the miners could spend more time drilling (instead of packing drills around) and in the end would benefit all concerned.