1914

Mining methods and geology of the Boston Consolidated Mine at Bingham, Utah

James Leonidas Boucher

Department: Mining Engineering

MINING METHODS AND GEOLOGY OF THE BOSTON CONSOLIDATED MINE AT BINGHAM, UTAH.

BY

JAMES LEONIDAS BOUCHER.

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

BACHELOR OF SCIENCE IN MINE ENGINEERING

Rolla, Mo.

1914.

Approved by C.R. Forbes

Professor of Mining.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

INTRODUCTORY.

This thesis does not so much attempt a detailed report on the geology of the disseminated ores of Bingham Canyon as a more particular description of the underground methods of mining these ores, as well as studies in drilling, sampling etc. Steam shovel mining was studied to some extent but almost all the data for the following pages has been derived from the Boston Consolidated Underground Mine and the Old Utah Mine.

The Boston Consolidated, especially, has been studied for this mine is the largest and, at late date, was the only underground porphyry mine working, the Old Utah having been shut down on account of labor troubles.

The excellent report of Emmons, Keith and Boutwell on the Economic Geology of the Bingham Mining District, U.S.G.S., 1905, has been of the greatest assistance to the writer, and is used as an authority in the short description of the history and general geology of the district. For a fuller description of the general geology that report is referred to, as space for that is lacking here.

The data given in the special drilling information, tramming, sampling etc., was acquired by research work done by the author while in the employ of this company.

PART 1. GEOLOGY.

Geography.

The Bingham mining district is situated on the east side of the Oquirrh Mountains, in Utah, about equidistant from the north and south ends of the range. The Oquirrh Mountains form one of a large number of ranges which rise from the deserts and run in approximately north-south courses. They are about 30 miles long, the north end being touched by the south end of Great Salt Lake, and the south end dwindling and merging into the low rolling country. The peaks of the mountains have an elevation ranging from 9000 to 10000 feet.

Topography.

Bingham Canyon lies on the east side of the Oquirrh Mountains and runs in a general northeast course until it reaches Salt Lake Valley. The main crest of the Oquirrh Mountains borders the canyon on the west, and West Mountain lies at it's southern head. Several large gulches open into Bingham Canyon from the west and southwest, but none of importance from the east. The most important of these gulches is called Carr Fork. This Fork and the main canyon form a 'Y' between which lies most of the great disseminated porphyry deposit, (See map of geology of Utah Copper), which is being mined by opencut and underground methods.

Stratigraphy.

The strata in the Oquirrh Mountains consists in the main of quartzites, sandstones and limestones, with intrusive bodies of monzonite and monzonite porphyry, and extrusive flows of andesite, the latter being locally called porphyry. The stratified rocks are entirely of the Carboniferous Age, much the greater portion being the Upper Carboniferous. The age of the igneous rocks in this region is not known, except that they are later than Carboniferous. It is these rocks which contain the values (for which the Utah Copper mine) and in which we are most interested.

The monzonite and the monzonite-porphyry is the largest formation in the Bingham district except the Bingham quartzite. It forms many large and small irregular bodies in the mountains which lie east and northeast of West Mountain, a group about one mile wide and four miles long. The two largest of these are the one which lies at the head of Carr Fork and Bingham Canyon, and the one that reaches from Highland Bey to Upper Bingham.

The monzonite is usually a dark, gray-brown or black rock, whose surfaces weather gray or rusty brown. The gray aspect is due to the presence of feldspar, and the dark colors to the presence of biotite, horneblende, and augite. The rusty brown appearance is due to the oxidation of the iron bearing minerals; the decomposition of the feldspars also gives a whitish surface to the rock. The monzonite is composed principally of feldspar, with biotite, hornblende, augite and quartz. Magnetite, Pyrite, Chalcopyrite, Bornite, and a little Chalcocite are found in small grains widely distributed through the rock.

PART 2. HISTORY.

Little has been recorded of the earliest history of the district. It was a heavily wooded wilderness known only to the hunter and lumberman, and in the opinion of Brigham Young and his followers, the chief value of the locality lay in it's timber. Red pine abounded, and single trees often measured three feet in diameter.

Early in the fall of the year 1863, George B. Ogilvie, a Mormon farmer, found specimens of "mineral" in Bingham Canyon. He reported his discovery and located a claim known as the West Jordan claim. This was the earliest mining location in the state of Utah. Later the "West Mountain" mining district was formed. It took in the whole of the Oquirrh range, but was later split up into two districts, the West Mountain district and the Rush Valley district; the latter embracing all the western slope of the Oquirrh range.

In 1864 the West Jordan Mining Co., was organized under the laws of California, and the Jordan tunnel, estimated to cost $60.00 a foot was then started. Prospecting and exploration progressed rapidly, but conditions were against developement on an extensive scale.

In 1864 placer gold was found in the gravels and in 1865 gravel washing was actively taken up. During the fall extensive lode mining yeilded a considerable profit. It is estimated that about $1,000,000 in gold was recovered from gravels in the early days. At present there is little or no placer work being done. In June 1868 the first carload of copper was shipped. Following this period the mining industry in the Bingham district continued to grow until at the present day it is said to be one of the greatest, if not the greatest, copper camp in the world.

History of Boston Consolidated.

The Boston Consolidated group originally embraced an extensive tract on the eastern slope of Muddy Fork, lying east and north of the Last Chance properties, and extending eastward across the head of Ross Fork on the main divide, into the Monzonite area of Copper Center Gulch.

It consisted of 51 claims, covering 350 acres. A 20 stamp mill was erected in 1882 and about 50 tons a day were reduced. Later the work of determining the practicability of working the porphyry on a large scale for copper was commenced. In 1902 a large mill was erected near Garfield and extensive operations commenced in the porphyry deposits.

At about the same time the Utah Copper Co. was formed, taking over the Wall properties at a price said to have been $7,000,000. In 1908 steam shovels were put in operation by this company, and just later a consolidation was made with the Boston Consolidated.

PART 3. MINING METHODS.

There are two general methods of mining the ore underground; one by the caving system and the other by what is locally known as the Boston Consolidated stoping method, a modified shrinkage stope method.

In locations where it is unnecessary to keep the surface intact the caving system was successfully used. In the use of this system the ore is blocked the size of which depends on the character of the ore and the size of the body to be stoped. Main drifts or entries are driven in from the main raise and sub drifts are driven off from these at right angles and parallel to each other (see map). The sub drifts are located about 150 feet apart, thus allowing many faces to be advanced simultaneously.

When the sub drifts are well advanced, cross cuts are driven at right angles to them, 30 feet apart, thus cutting the whole level into a parallel series of drifts, as shown in Fig. 1. From each of these cross drifts, at approximately every 20 feet, is driven a raise having a pitch of 45 degrees. These raises connect with an opposite one, driven in the next parallel cross cut, about 15 feet vertically above the top of the drift. Thus the whole series of raises is finally connected and the top allowed to cave. This caved material is drawn out of wooden chutes in each raise and trammed by hand to main raises which extend down to the main haulage level. From here it is drawn by electric locomotives through the transportation tunnel to the ore bins on the surface.

To insure the safety of the miner who is advancing the stope-raises, a deep "back-hole" is drilled, and if this pierces the stope or opposite raise, the other holes are drilled less deep. When all the raises are nearly connected to each other by widening at the top, a general blast is made which brings down the whole body of ore at once, breaking it fine enough to allow it to be drawn through the chutes. Few boulders occur, but if they do, they are easily broken up by blasting in the chute.

The principal trouble in this system is keeping open the drifts. Necessarily, when the great body of ore is loosened and allowed to cave, great weight is brought on the small pillars and tops of drifts. These are timbered with round poles and replaced as they are broken, the drift being kept open long enough to draw all the ore.

"Pulling the chutes", as the drawing out of the ore is called, is continued until the oxidized capping shows up, then they are abandoned.

Although somewhat dangerous, this was undoubtedly the cheapest and quickest method ever used underground. The main objection to it was that the ore was somewhat mixed with the capping near the final stage. To prevent this mixing, care was taken to draw the chutes evenly, which was accomplished by keeping tally of the number of cars drawn from each chute.

As has been stated before, this system can only be used where it is not neccessary to leave the surface perfectly intact, as it caves in as the mine progresses leaving a great "sink hole". At present the caving system is not used as it is imperative that the surface should not be disturbed owing to the railroads thereon.

Boston Consolidated Stoping System.

In order to keep a solid, undisturbed surface the Boston Consolidated Stoping System is used. As previously mentioned, this system is a modified shrinkage system in which the pillars are left standing to support the surface.

The ore body is blocked out in blocks having a width of 120 feet, with the length and thickness depending on the limits of the ore. Anything over 1 to 5 per cent copper is considered ore. Parallel main drifts, 120 feet apart, are extended to the limit of the ore. From these at right angles, short "stub" drifts are driven in 30 feet, and the same distance apart.(See Fig. 2) At or near the ends of these short cross drifts raises are advanced having a pitch of 45 degrees, thus connecting with the opposite raise in the adjacent cross-cut.(See Fig. 3) When each of the opposite raises are connected, and a drift connecting all at the top is opened out, a series of "hog-backs" is formed, assuring easy drawing of the ore.

When the drift connecting the tops of all raises is completed and "widened" to 20 feet, the full width of the stope, the stope is said to be "opened out". When the stopes are opened out, manways are run up in alternate cross-cuts and kept open by means of 6" x 6" square cribbing. This manway is approximately four foot square in the clear and is kept even with the top of the stope.

The "opening out" of stopes is done principally by means of the water Leyner drills, and stoping is continued with Ingersoll and Waugh stopers. (See special drill information).

The stopes are kept 20 feet wide, a 40 foot pillar being left between parallel stopes. The machine man stands on top of the ore in order to drill the top; each day enough ore being drawn by means of chutes in cross-cuts, (See Fig. 4), to allow room enough for machines. Thus the stope is kept practically full of broken ore and the pillars remain intact. Only the surplus ore, made by increase in bulk when broken up, is taken out, as the companies later intend to strip the surface and take out the pillars and broken ore with steam shovels. It could, however, be very cheaply extracted by simply drawing the pillars and using practically a caving system.

As in the caving method, the ore is trammed by hand to convenient chute raises where it is conveyed to chutes on the transportation level below.

Comparatively little timber is required in this system. There is less weight on the drifts, consequently they are easily kept open, the only stope timbering being the manways. These stopes can be advanced to a height of over 200 feet, but over this distance it is not advisable to work them without running manway drifts from upper levels to stopes for ventilation and accessibility.

The timbers used in main chute frames are 10" x 10" with 6" x 6" braces and 3 x 12 lagging. (See Fig.4). Those used in keeping open the drifts are usually of 8" to 14" round timbers.

This mine is divided into five main working levels, stoping being advanced from each level, (See long cross cut section map), and connection being made with each by means of an adit to the surface, a main vertical raise, and a number of raises, having pitches varying from 50 to 75 degrees, used for ore chutes.

The main raise is divided in to two compartments, a ladder way and a cage compartment. The cage is used for hoisting timber from the main transportation level (sub. 1), to the levels above. It is equipped with a Sullivan air hoist having a six foot drum. The common laborers are not allowed to ride on the hoist.

The cars used for the hand tramming are steel "tub" cars, having a capacity of 14 cubic feet or about 1200 pounds. (See sketch). They are designed so as to dump at any angle, and have a short wheel base so as to take sharp curves and allow turning on steel plates.

The tracks have a grade of approximately .5 per cent, sloping from the stope chutes to the dump raises. This enables the men to handle the loads very easily, the cars being empty on the upgrade push. Twenty pound steel is used on the sub-levels where there is hand tramming.

In the main transportation level, three ten ton General Electric, 500 volt, D.C. locomotives are used for transporting ore from raises to surface ore bins. Steel, hopper bottom cars, having a capacity of five tons, are used, six cars making up a train. Sixty pound rails and No. 0000 copper wire hung from stulls or timbers at an average height of seven feet complete the haulage equipment.

The chutes from which the cars are loaded are equipped with steel sliding doors, the latter being raised by means of an iron hand wheel which turns a pinion gear, which in turn raises the door. Very little trouble is had with the ore "hanging up" in the chutes, usually not over a half stick of powder being necessary to clear it out.

The surface equipment consists of two ore bins, a double gravity tramway from the smaller wooden bin at the entrance of the transportation tunnel to the large circular steel bin several hundred feet below, a blacksmith shop, candle house, locomotive repair house and timber yards. The steel bin has a capacity of 4000 tons and empties into the railroad cars which are necessarily several hundred feet below the transportation tunnel. Both bins are unloaded by means of sliding chute doors which are opened with compressed air.

The average cost of underground mining at the Boston Consolidated during the year 1912 was 80.56 cents per ton, which includes 14.79 cents to cover the underground developement and churn drill prospecting.

SPECIAL DRILL INFORMATION.

Average number of machine drills sharpened per day,

-- 300.

Actual time required, -- No record.

Sharpened by drill sharpeners.

Number of men employed in sharpening,

-- One on each shift.

Coal and coke used per day, -- 60 pounds.

Air blast for forge furnished by compressor.

Average time estimated to set up drill in drift,

-- 1-1/2 hours.

Average footage drilled per machine shift in drifts,

-- 32 feet.

Length of shift, -- 8 hours.

Kind or machines used, -- Water Leyners and 2-1/2 inch Sullivan pistons.

Number of set-ups made, -- generally two.

Average total footage drilled in stopes per shift,

-- 975 feet.

Kind of machines used in stopes, -- Ingersoll, Leyner and Waugh stopers.

Feet drilled,per machine shift, -- 65 feet.

Cubic feet free air used per day in drilling, -

-- 2000 cu. ft. per minute.

Average number of drills used per shift,

-- 16 pistons and 16 hammer drills.

b ____

AVERAGE RECORD OF DRIFTING.

Nature of ground, -- Medium hard porphyry.

Shifts worked, -- 31 of 8 hours each.

No. of men on each shift, -- 2.

Approximate hours spent in drilling, -- 5.

Powder used, -- 539 lbs.

Position of primer, -- Center and near bottom.

Feet advanced,-- 117.2

No timbering.

Size of drift, -- 5' x 6'.

Kind of machine, -- Sullivan 3-1/4" piston.

Spring cut holes, once in awhile, if in hard ground.

AVERAGE RAISE RECORD.

Nature of ground, -- Monzonite porphyry, dry and requiring no timbering.

Shifts, -- 31 of 8 hours each.

No. of men on each shift, -- 2.

Approximate hours of drilling, -- 4.

Powder used, -- 1035 lbs.

Feet advanced, -- 155.

Machine used, -- Ingersoll stoper.

Approximate time putting in stulls,4' x 5',-- 1 hr.a day.

TRAMMING RECORD.

There was no shoveling done from rock bottom except in cleaning up the drifts.

Average number of cars trammed from a certain drift by a man shoveling from a plate into a car and tramming 600 feet to chute using a 2' x 3' x 2' car, --

10 cars in 8 hours.

Average numberoof cars of the above size trammed from stope chute to another chute, --- 40.

Oil used on 30 muckers cars and 12 motor cars per month, -- 111 gallons.

Average length of tramming by hand in mine,

--- 100 feet.

Size of shovel used in mucking,-- #2 short handle, square pointed and holding about 16 pounds.

TONNAGE AND COMPRESSED AIR DATA.

The following is from a record kept during the month of March 1913.

No. of drill shifts (day), -- 31.

No. of drill shifts (night),-- 31.

Average air pressure at compressor, -- 80 lbs.

Total wet tons produced, -- 57,265.

Average daily tonnage, -- 1,847.

No. working days per month, -- 31.

Average number of men per day, -- 181.

Average number machines daily and air used, - as follows-

Day Shift.	No. Machines.	Cu. Ft. Air.
#7 Leyners	.51	47
#9 Leyners	3.51	424
2-1/2 pistons	5.19	400
Hammer drills	10.55	800
Comp. air pumps	2.	80
Drill sharpener & forge	1.	125
Air hoist	1.	340
Head house gravity tram	1.	100
		2,316

Night Shift		
Hammer drills	.68	48
2-1/2" pistons	9.74	660
	23	708

The following is a record collected from the office and by personal observation by the author during the month of June 1918.

TONNAGE RECORD.

Tons of ore from stopes, ------------------11,290

" " waste " " ------------------none

" " ore from developement,------------- 8026

" " waste " " -------------------none

Nature of rock mined,--medium dark, hard Monzonite porphyry.

No ore hoisted.

System of mining, -- modified shrinkage stopes.

LABOR RECORD.

Kind employed,-- American, Greek, Austria, Fin.

Average No. men in stopes,--

Breaking ore --------------82 men per day.

Shovelling ore to chutes --none

Tramming " " " ---87 " " "

Filling -------------------none

Timbering --

Stope manways ---------11 men per day

Stope chutes ----------11 " " "

Total -----------------------191 men per day.

Average No. men in developement.

Advancing, -------------------28 men per day.

Mucking & tramming,,-----------32 " " "

Timbering, -------------------4 " " "

Total --------- 64 men per day.

Average No. misc. men underground,- 33 men per day

" " " " on surface, --20 " " "

FEET OF DEVELOPEMENT.

Shaft, -----------none.

Drifts & Xcuts ---2629.5 ft.

Raises ---------- 469.5 ft.

Winzes ----------none

Stations & pockets none

Total ----- 3099.0 ft.

Pounds of dynamite used in stoping, --46100

Pounds of dynamite used in developement - 18400

Total ------------------ 64500

Timber used in stoping.

Sawed lumber ---------------- 108497 board ft.

Round poles ----------------- 3354 linear ft.

Timber used in developement.

Sawed lumber ---------------- 22459 board ft.

Round poles ----------------- 971 linear ft.

Number of candles used per man per shift of 8 hrs. - 4.

Electric lights are used in main drifts and stations.
Machine drill shifts in stoping ----------1241.

" " " " developement ----- 773.

Pounds of machine drill used ------ no record kept.

METHOD OF SAMPLING.

All drifts are sampled in blocks of ten feet, one sample being taken on each side of the drift. A groove about 3/4" deep and two to four inches wide is cut along the side of the drift and parallel to the top, care being taken not to cut through any streak of unreasonable richness such as are occasionally found in small fault planes etc.

The sample taken weighs about five pounds. It is carefully labeled with the number and location of the drift, and a record kept by the sampler. The ore is assayed for copper and iron by the mine assayer and a check sample sent to the mill assayer. The results are placed on assay maps of each level which are scaled off to correspond with the location from which the sample was taken.

All the extracted ore is sampled by means of the grab method, a handful being taken out from each mine car as it is dumped from the ore bin.

The table following shows method by which the average assay is obtained.

ORE BIN SAMPLE - July, 1913.

Date	No. Cars	Percent Cu.	Percent x No. Cars.
1	134	2.00	268
2	210	1.95	409
3	130	2.00	260
4	--	---	---
5	181	2.00	362
6	236	1.75	413
7	228	1.80	410
8	222	1.65	366
9	230	1.60	368
10	229	2.00	458
11	158	1.55	245
12	110	1.55	245
13	101	130	131
14	160	1.30	208
15	145	1.65	239
16	95	1.40	133
17	103	1.55	160
18	87	1.05	91
19	145	1.45	210
20	165	1.30	214
21	165	1.65	272
	3234		5462

Date	No. Cars	Percent Cu.	Percent x No. Cars.
	3234		5462
22	145	1.20	174
23	150	1.31	196
24	144	1.40	201
25	160	1.53	245
26	150	2.00	300
27	135	1.49	201
28	170	1.26	214
29	190	1.44	274
30	205	1.44	195
31	225	1.26	283
	4908		7745

$$\frac{7745}{4908} = 1.57$$

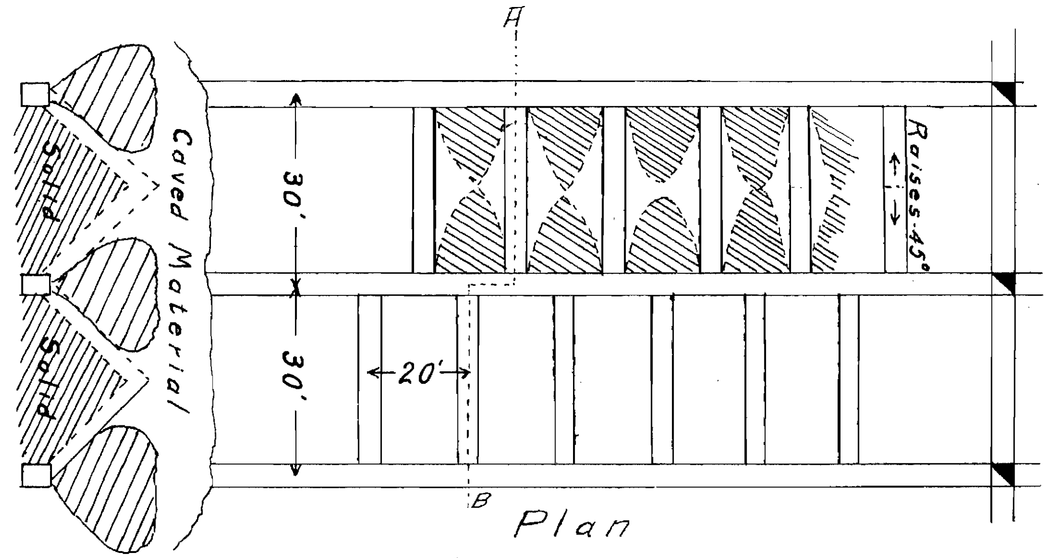
Therefore, 1.57 = average assay for the month.

BIBLIOGRAPHY.

1. Economic Geology of the Bingham Mining District,- Emmons, Keith & Boutwell, U.S.G.S., 1905 --

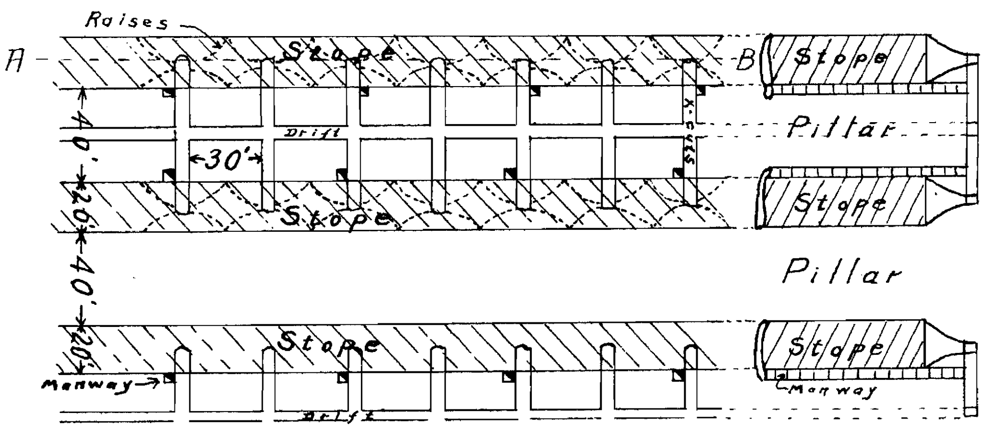
2. Data collected by author during the year 1915, while employed by the Utah Copper Co.

INDEX.



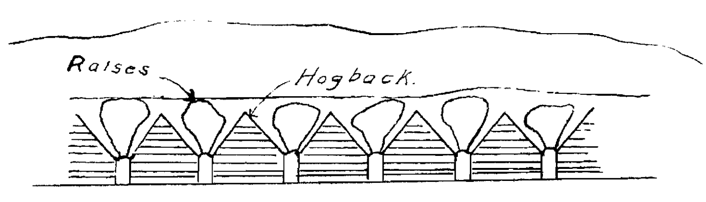
Cross-Section on AB.   of Caving System

Fig. I.



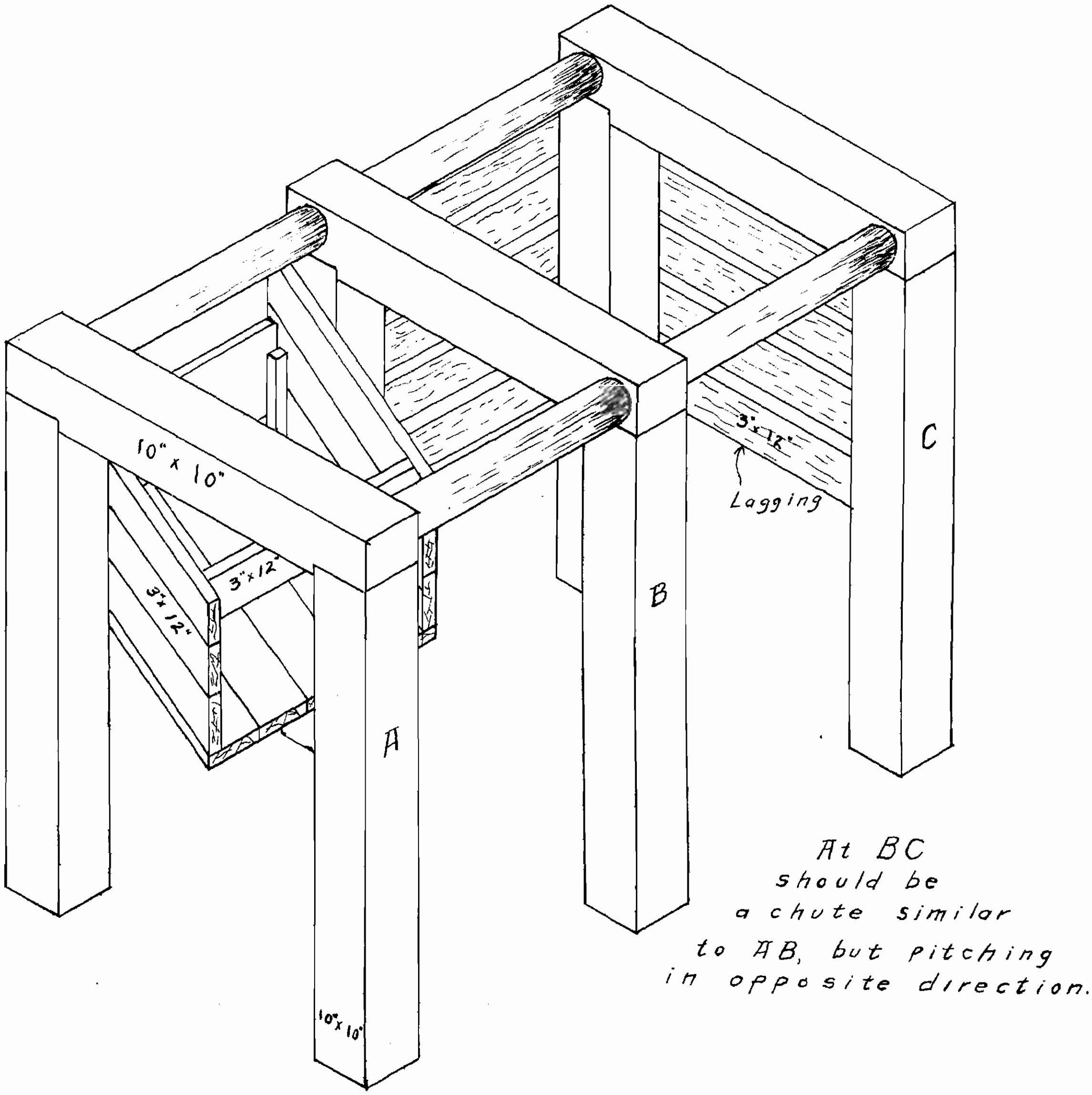
Plan of Shrinkage Stopes

Fig. II.



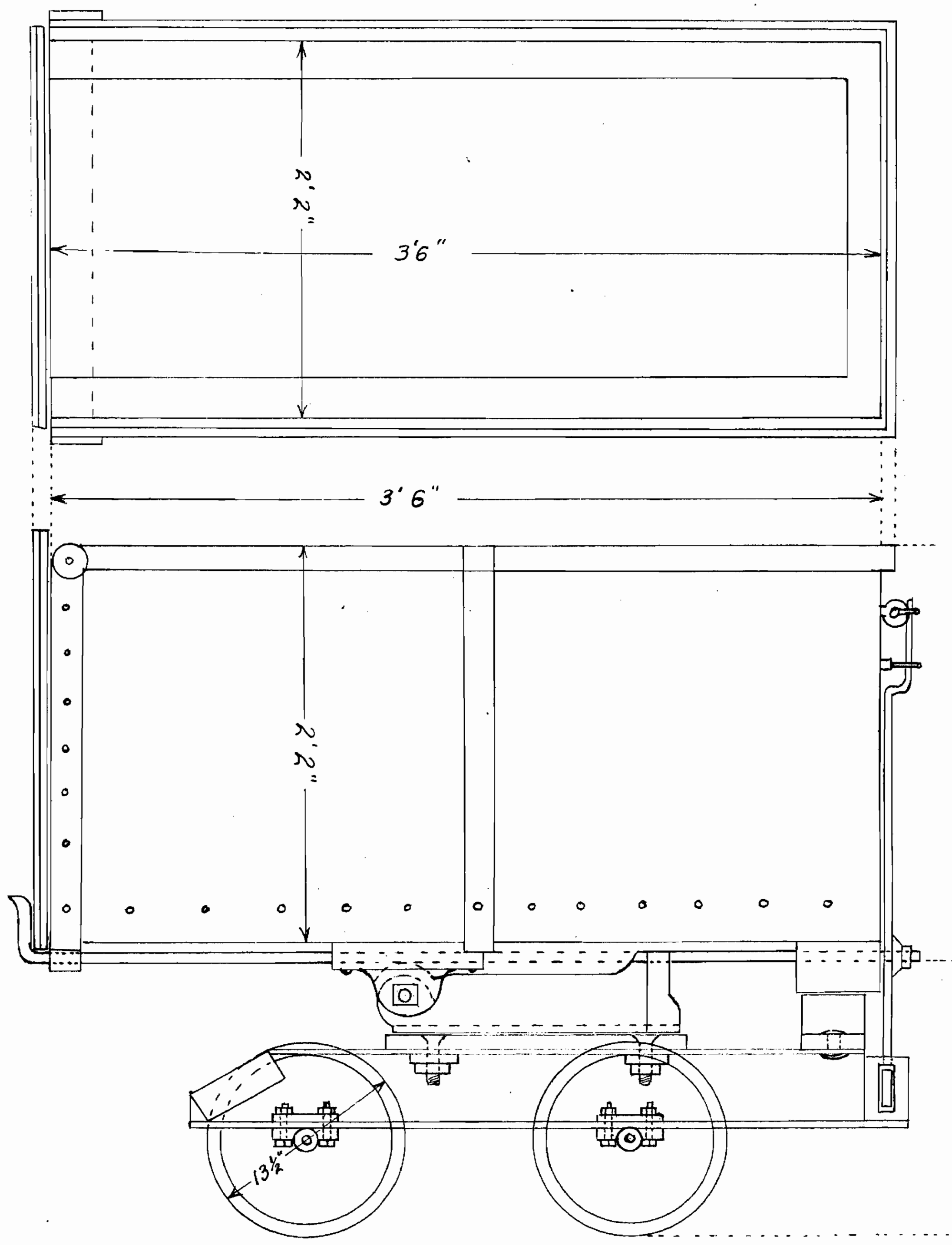
Section on AB. of Fig. II.

Fig. III.

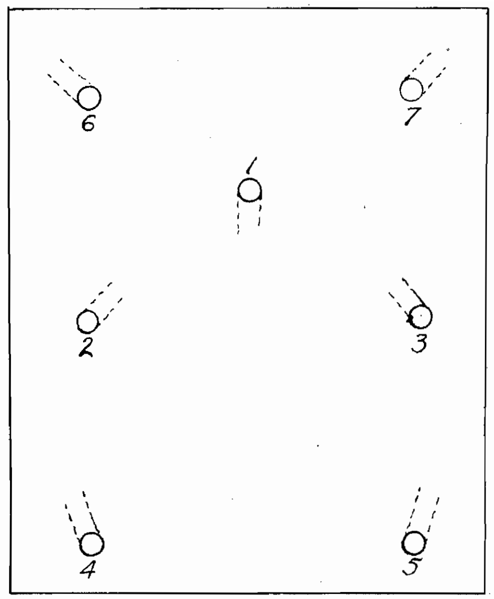


Method of Building Chutes.

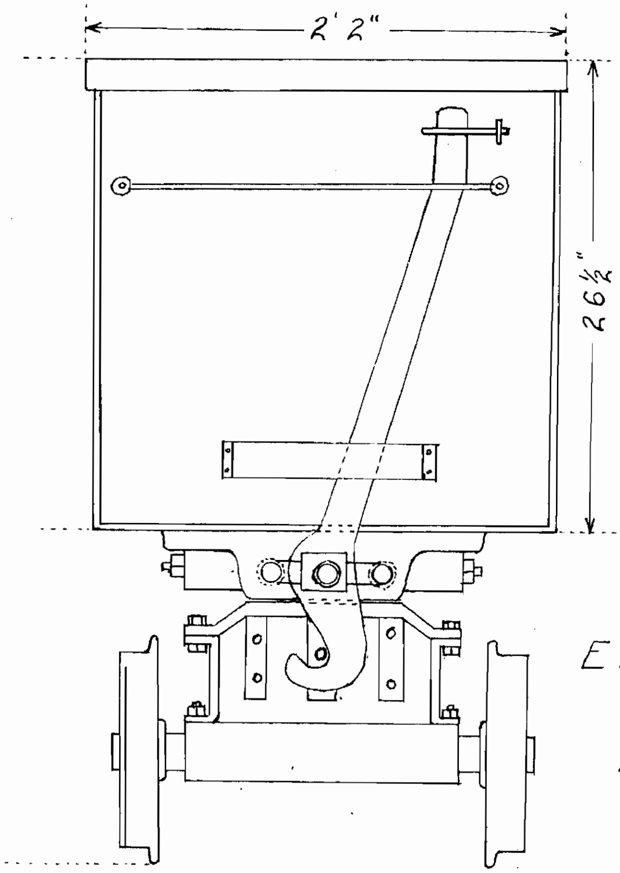
Fig. IV.



Mine Car used for Tramming.



Holes in a 5'x7' drift.



End-View of Mine Car.