# MINING METHODS AND PRACTICES AT THE IRON KING MINE, SHATTUCK-DENN MINING CORP. YAVAPAI COUNTY, ARIZ.

BY CHARLES A. KUMKE AND H. F. MILLE

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by

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2/ Manager, Iron King Branch, Shattuck-Denn Mining Corp.

## INTRODUCTION AND SUMMARY

This paper describes mining operations at the Iron King mine of the Shattuck-Denn Mining Corp. in Yavapai County, Ariz. It is one of a series being prepared by the Mining Division of the Bureau of Mines on mining practices and methods in various mining districts of the United States.

The mine and surface plant of the Iron King mine are situated in secs. 15 and 21, T. 13 N., R. 1 E., about 20 miles by State highway 69 east by southeast from the city of Prescott and 1 mile southwest of the mining town of Humboldt on the Prescott-Mayer branch of the Atchison, Topeka & Santa Fe Railroad (fig. 1). A 1-mile truck haul brings the mill concentrates (lead and zinc) to bins on a siding of this line at Humboldt; the silver-gold bullion is handled separately.

Some of the oldest residents in the vicinity of Prescott claim that the original location for the Iron King mine was made in 1880. The earliest recorded production was in 1906-1907. During the first World War the mine produced fluxing ore for the Humboldt smelter.

In 1936 the property was purchased under tax sale, and a mill (140-ton capacity) was erected in 1938. The capacity of this mill was increased to 225 tons the following year, and a cyanide plant was added in 1940 to treat mill tailings.

In 1942 the Shattuck-Denn Mining Corp. purchased the property. A new working shaft was sunk, mine development was speeded, and mill capacity was again increased.

The predominating formation of this district is a pre-Cambrian schist locally known as Yavapai schist. The Iron King deposit, which carries gold, silver, lead, zinc, and copper, occurs as a series of lenses in a sheared zone of the pre-Cambrian schist.

Down to the 600-foot level the ore was mined and drawn by the shrinkage method. The cut-and-fill method was adopted for the lower levels. Waste rock for stope fill was provided by block-caving an area on the 600 level.

Main haulage drifts were driven in the firm footwall, and crosscuts were driven across the mineralized zone at 100-foot intervals.

Grab samples taken from each car of every working place and channel samples cut every 5 feet in development work are considered sufficient for estimating ore reserves.

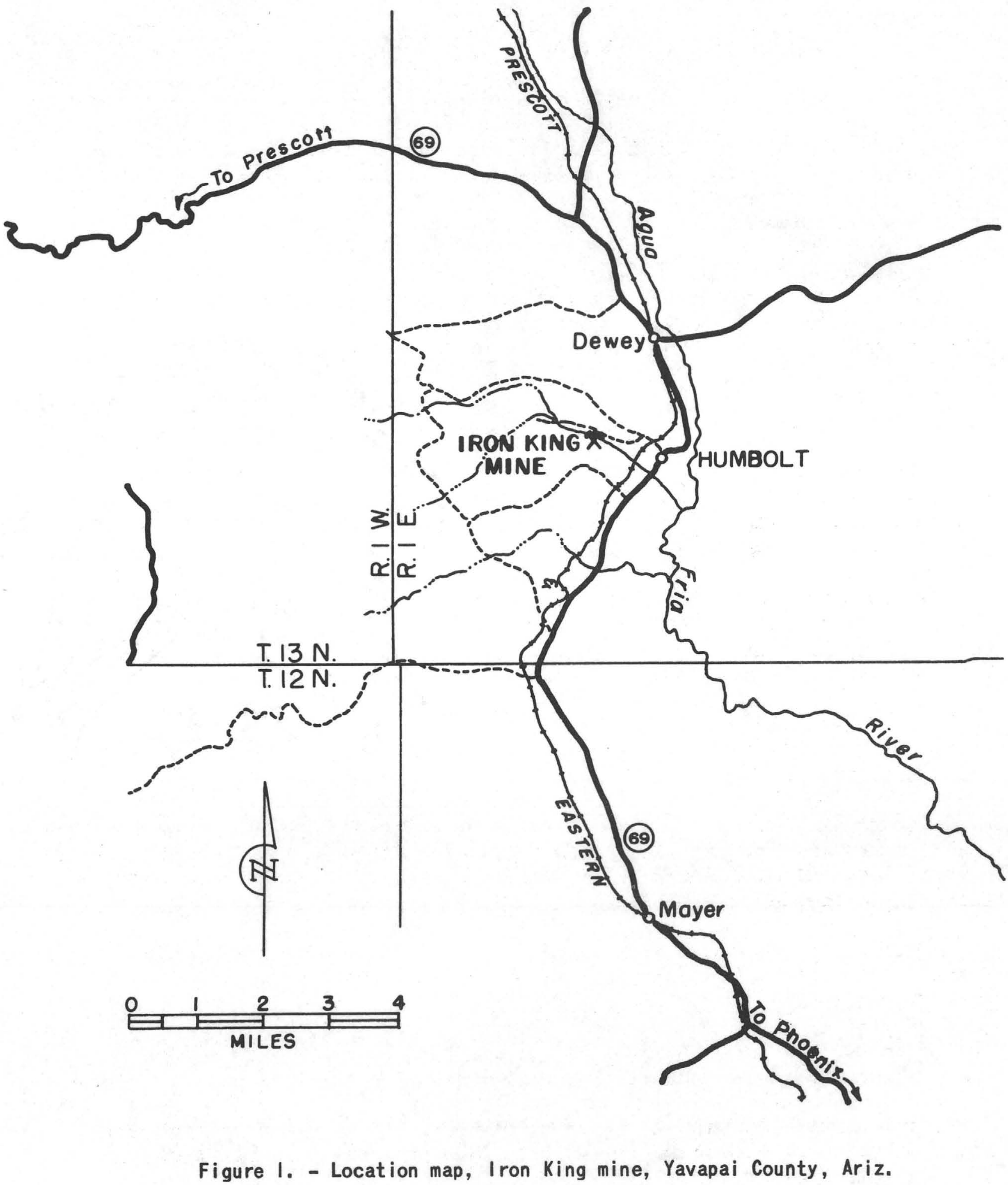


Figure 1. - Location map, Iron King mine, Yavapai County, Ariz.

The normal flow of water in the Iron King mine is 30 gallons per minute. This water is used by the mill but is not suitable for drinking or domestic use.

Employees live in nearby towns or in Prescott. Transportation by bus is provided for those of the crew who live in Prescott.

The crew is 100-percent trained in first aid, and part of the crew is trained in mine rescue and helmet work.

Total ore production from the Iron King mine to the end of 1948 amounts to 1,059,305 tons. The standing of the mine among Arizona gold-silver and lead-zinc producers in 1948 was:3/

Second in zinc production

Third in lead production

Third in gold production

Fourth in silver production

## ACKNOWLEDGMENTS

Acknowledgment is made to Thomas Bardon, president, and Normand Lamond, secretary and treasurer, of the Iron King branch of the Shattuck-Denn Mining Corp. for permission to publish this paper. Special acknowledgment is due H. F. Mills, resident general manager, for his valuable assistance as co-author of this paper and for furnishing information on wage scales, production figures, maps, photographs, and other data.

Special acknowledgment is also made to Elmer Tomkinson, mine superintendent, who was very helpful in conducting trips underground, through the mine surface plant, and in explaining the details of mining problems peculiar to this ore occurrence.

Interesting historical facts about the property prior to the Shattuck-Denn operations were obtained principally from the March 1944 issue of the Mining World.

## HISTORY

Some of the oldest residents in the vicinity of Prescott believe that the original location was made in 1880. Gold and silver were the metals most sought, and the few shallow surface workings probably proved disappointing, as the records say nothing about mining activities for the next 25 years.

The mine's earliest recorded production was made in 1906-1907, when the property was operated by a Reverend Blanchard. Evidently work was on a small scale and soon ceased.

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3/ Statement by H. F. Mills, general manager of the Iron King Branch, Shattuck-Denn Mining Corp.

During the first World War, the property was under lease to George Calvocoresses,4/ who hoped to obtain fluxing ore for his Humboldt smelter. When the smelter closed after the war, the Iron King mine was again abandoned.

In 1936 the property was purchased, under tax sale, for a few hundred dollars by Fred Gibbs5/ and associates, under the name of Iron King Mining Co., and in 1938 this company erected a mill (140-ton capacity) to produce a bulk flotation concentrate. The following year the mill was converted to selective flotation, and its capacity was increased to about 225 tons.

A cyanide plant was added in 1940 to treat mill tailings, and in 1942 the Shattuck-Denn Mining Corp. purchased the property. A new working shaft was sunk, and mill capacity was increased again. The property has been in steady production since 1942, and recently the first million-ton production mark was passed.

Most of the mine surface plant and the major portion of all mine workings are on the Bonanza claim (figs. 2 and 3). The property consists of 21 patented mining claims and 1 unpatented claim (fig. 4), as follows:

Patented claims (Survey 1774):

- Western copper
- Bonanza
- Sure Thing
- Eastern Copper
- Copper Chief
- Iron King
- Lime Rock
- Copper Platter
- Copper Prince No. 1
- Copper Prince
- Copper Mount
- Copper Van
- Copper Prince No. 2
- New Road
- Copper Reade
- Copper Peach
- Copper Princess
- Copper Road
- Copper Dyke
- Copper Produce

Patented claim (Survey 1885):

- Iron King Ex. No. 1

Unpatented (not shown on fig. 4):

- Iron King Ex. No. 2

4/ Formerly general manager of the Consolidated Arizona Smelting Co.
5/ Mining engineer, Prescott, Ariz.

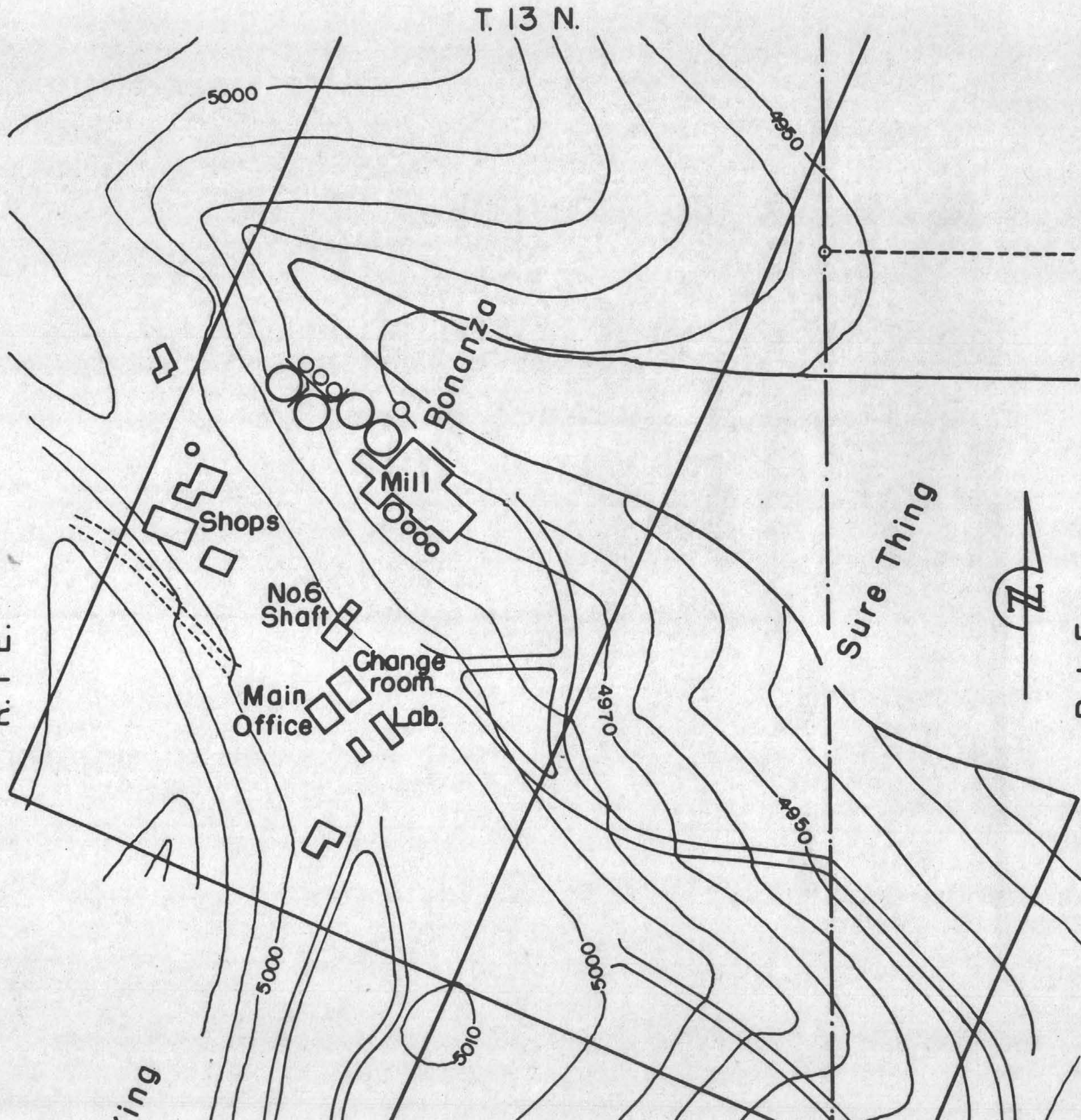



Figure 2. - Surface map of mine area.

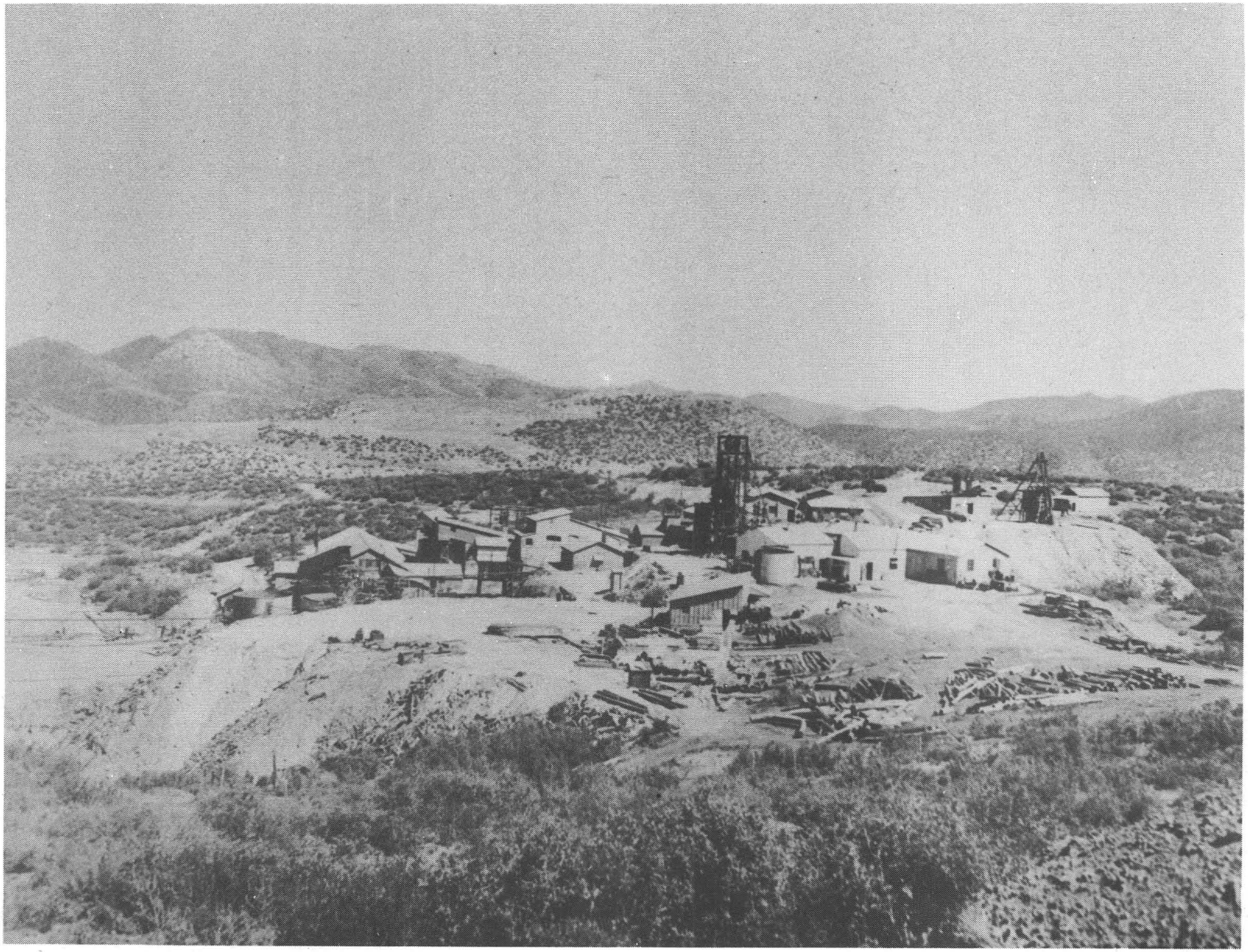


Figure 3. - View of mine surface area at No. 6 shaft.

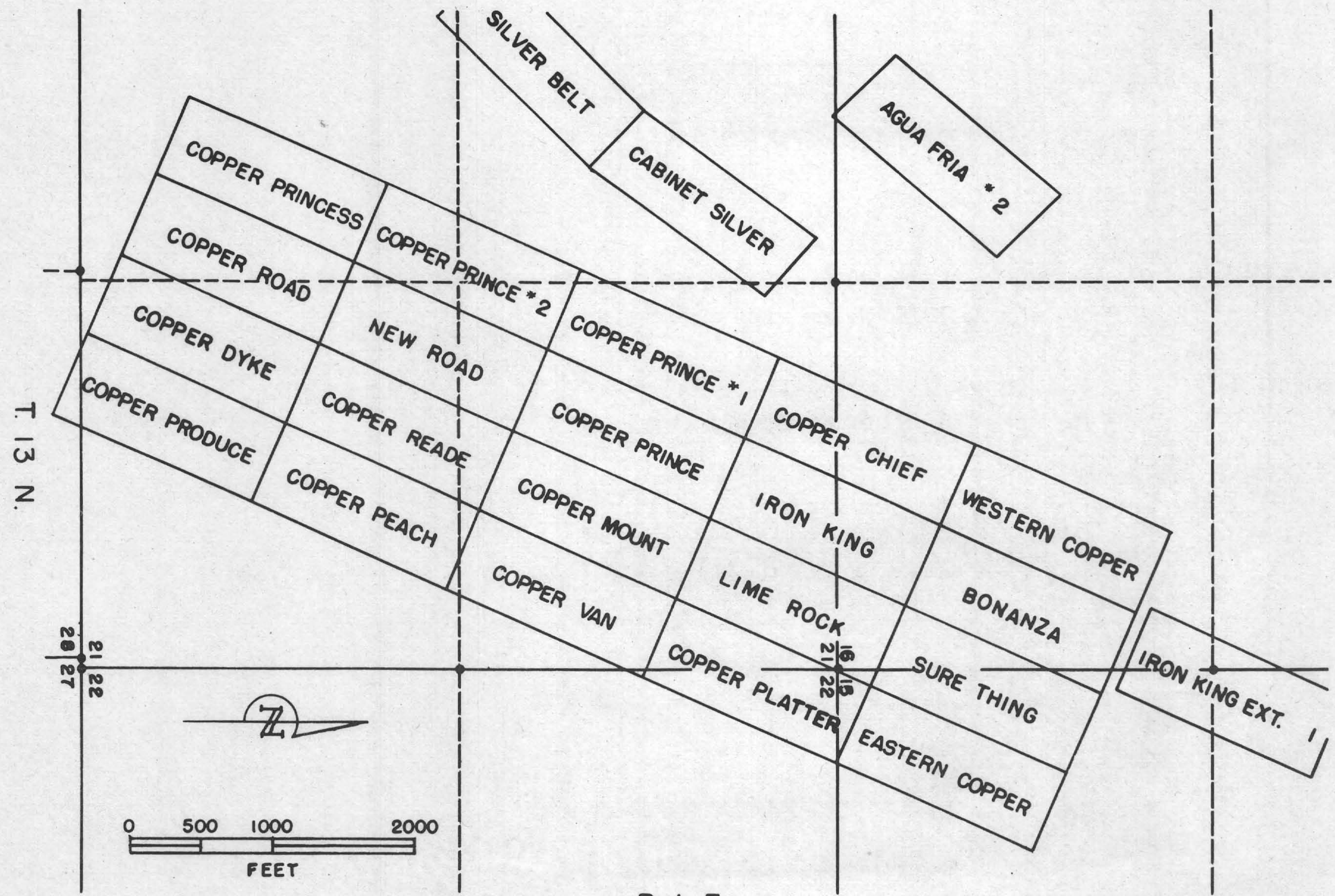



Figure 4. - Iron King group of claims (from plat of Mineral Survey No. 1714).

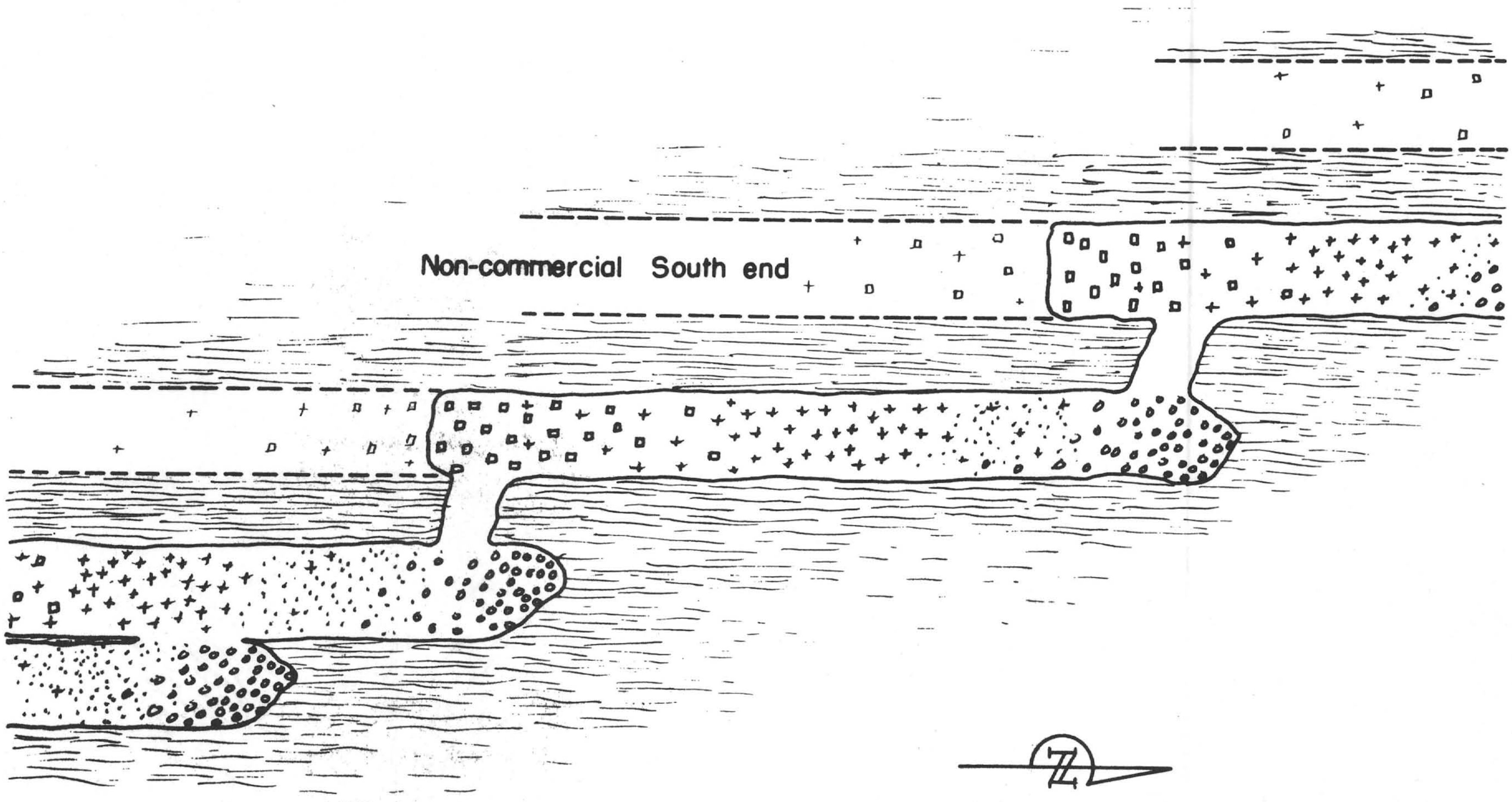



Figure 5. - Echelon pattern of ore shoots in mineralized zone.

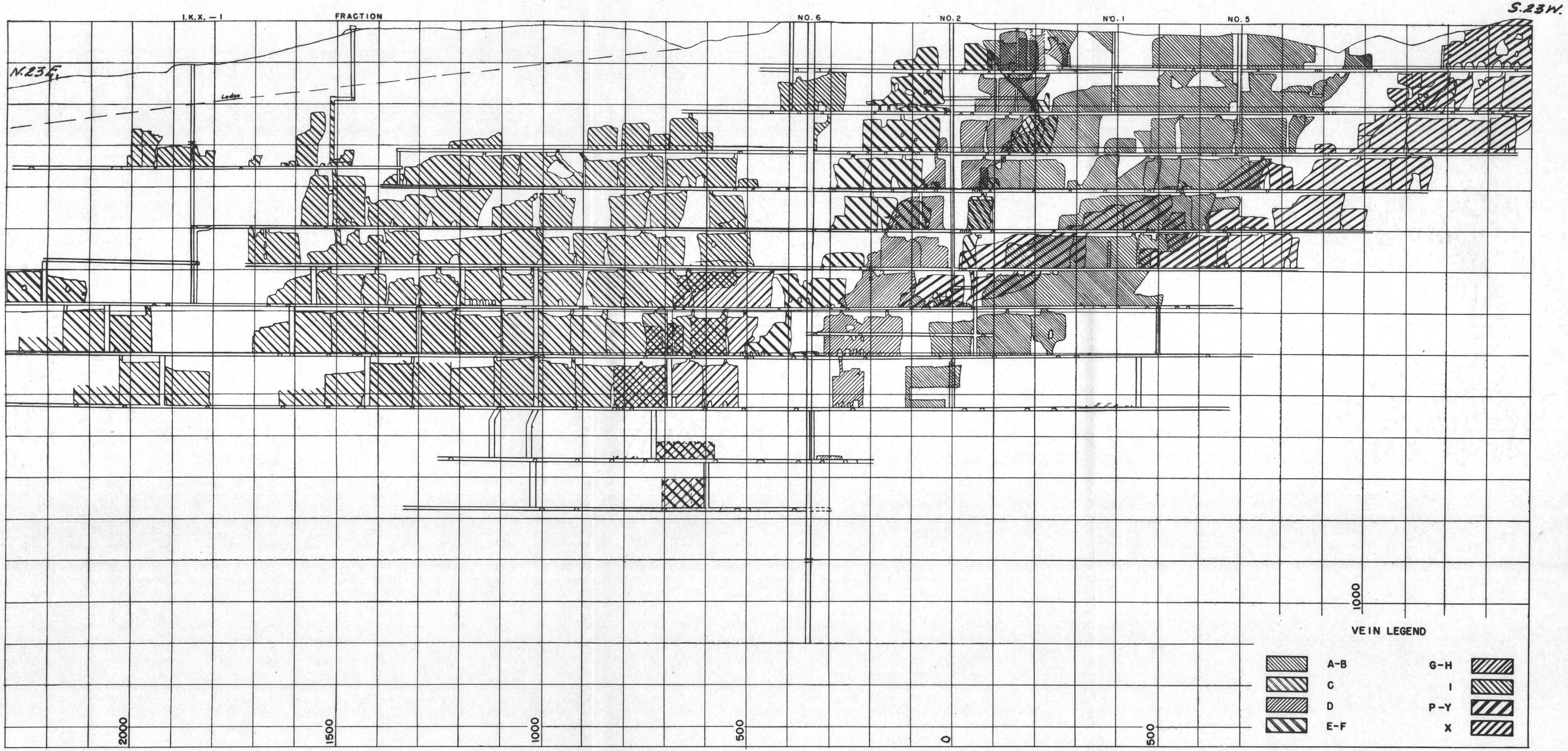



Figure 6. - Stope map, longitudinal projection, Iron King mine.

In the past, production was handled through the following mine shafts:

Shaft 1. This is the oldest shaft on the property. It was 100 feet deep, is now cribbed, and serves only for ventilation (fig. 6).

Shaft 2. This is a 2-compartment shaft 650 feet deep. There is no hoist at the shaft, but the headframe is still standing, and the shaft proper is in good condition. It serves as an emergency exit (fig. 6).

Shaft 3. Caved; no records.

Shaft 4. Caved; no records.

Shaft 5. A 2-compartment shaft 200 feet deep. It still has a headframe on it but is used only for ventilation (fig. 6).

Shaft 6. The entire present production comes from this 3-compartment vertical shaft. It has a steel headframe, and a station is being cut on the 1,300-foot level (fig. 6).

Extension shaft. This is the newest shaft, 1,500 feet northeast of shaft 6. It is a 3-compartment inclined shaft ($71^\circ$) equipped with a steel headframe. It is now being sunk from the 600 to the 700 level.

Since the Shattuck-Denn Mining Corp. acquired the property in 1942, annual production increased from approximately 80,000 to 146,000 tons in 1948.

## GEOLOGY[6]

On the northeast slope of the Bradshaw Mountains lies the Bigbug mining district, some mines being centered near Poland close to the Walker district. Other mines, mainly copper deposits, lie between Humboldt and Mayer. The Iron King mine lies 1 mile southwest of Humboldt.

The predominating formation of this district is a pre-Cambrian schist known locally as Yavapai schist. It is approximately 6 miles wide and extends from Bigbug Mesa down to the Agua Fria Valley. Its length is approximately 20 miles.

The Iron King deposit, which contains gold, silver, lead, zinc, and copper, occurs as a series of lenses in a sheared zone of the pre-Cambrian chloritic schist, which strikes N. $23^\circ$ E. and dips $75^\circ$ northwest. The ore shoots (sometimes referred to as veins) parallel the schist in strike and dip. They range in length from 60 to 800 feet along the strike and from 3 to 14 feet in width. A distinctive feature of the ore shoots is their echelon arrangement (fig. 5) throughout the entire proved length of the ore occurrence, a distance of approximately 3,500 feet. The over-all width of the echelon is about 75 feet.

6/ Based principally upon "Ore Deposits of the Jerome and Bradshaw Mountains Quadrangles, Arizona", by Waldamar Lindgren: U. S. Geol. Survey Bull. 782, 1926.

Another distinctive feature of the deposit is that the north end of each ore shoot marks the economic south end of the shoot immediately in the hanging wall. Crosscuts required in stepping over to the next ore shoot range from 2 to 10 feet through barren schist (fig. 5).

There is a definite zoning of minerals within each ore shoot. As the ore shoots advance southward, a white quartz appears gradually over the full width of the lens, indicating the approaching economic end of the ore shoot. Zinc sulfides disappear, lead sulfides remain about the same, and the amount of gold and silver increases slightly.

Each ore shoot of the entire echelon has an approximately 50-degree downward rake to the north. The wall rock is not impregnated appreciably by the ore minerals.

In general, the oxidized ore extends about 200 feet below the surface. The transition to sulfide ore occurs abruptly through a short, vertical range. The sulfides are fine-grained, and the ore is hard. Sphalerite and pyrite are interlocked, and their separation presents the principal milling problem. It is necessary to grind the ore fine to free the sulfides. The ore has an insoluble, tough, hard, and abrasive gangue that represents 10 to 60 percent of its total weight.

## EXPLORATION AND DEVELOPMENT

As is the custom in developing vein mines, the Iron King mine has been explored through shafts from which the levels were established at 100-foot intervals by drifting and crosscutting. Drifts have been driven along the vein, and raises have been extended above them to develop the ore and to prepare it for stoping. In recent years, diamond drilling also has aided in finding ore.

The regularity of the echelon pattern in the ore shoots and the definite zoning of minerals within each ore shoot simplifies exploration. The 50-degree downward rake to the north of all ore shoots facilitates reasonably close projection of where ore shoots will be found on the next lower level. The grade of ore (metal content) in each shoot is remarkably consistent from one level to the next.

Most of the development work on each level is completed when the sill floors of the ore shoots are prepared for cut-and-fill stoping. This method was adopted in 1946. Haulage drifts in the footwall and numerous crosscuts through the entire ore zone are required. Thus, it is almost impossible to overlook important ore. This phase of the work is discussed in greater detail under "Stoping."

There is no record or evidence that any ore was developed from surface prospect workings. The earliest formal development of the property was undertaken on the south end, approximately 1,000 feet south of No. 6 shaft, the present main working shaft. Ore was first mined from the oxidized zone above the 200 level. Below the 200 level, the workings abruptly entered sulfides. The sulfide ore from the next four levels on the south apparently

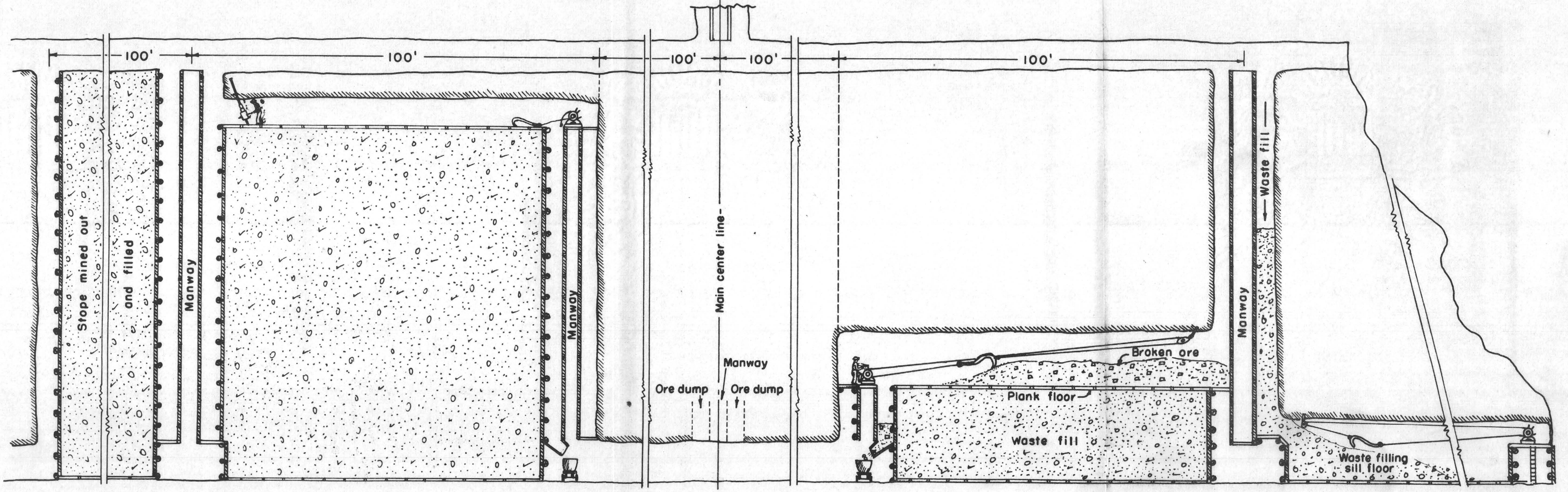



Figure 7. - Stoping method.

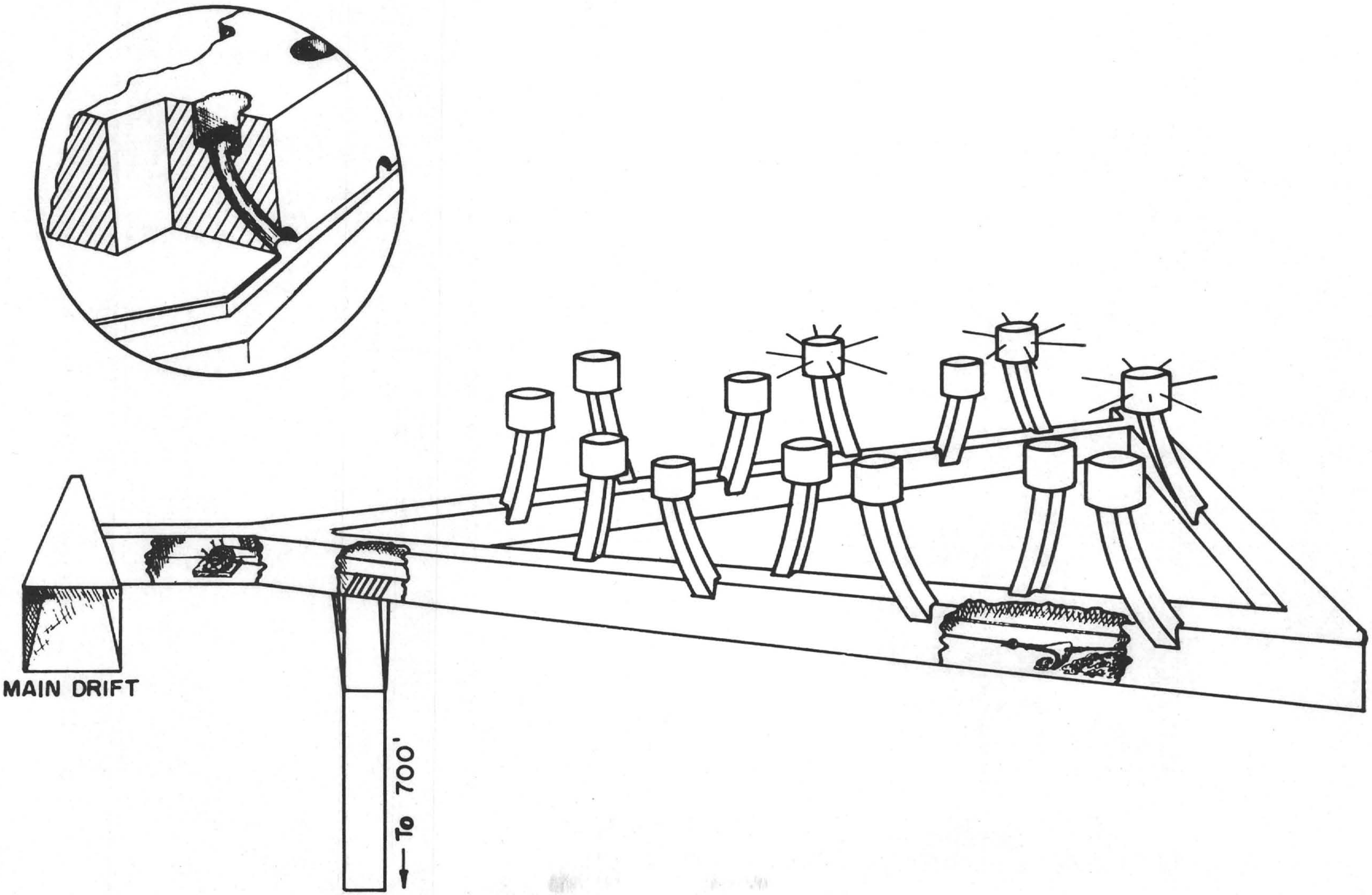



Figure 8. - Method of block-caving to obtain waste fill for stopes.

was mined through the No. 2 shaft until No. 6 shaft was in such shape that ore could be hoisted through it (fig. 6).

Development and exploitation of the mine down to the 600-foot level through No. 2 shaft was not difficult. The walls stood well and permitted the ore to be mined and drawn by shrinkage stoping without perceptible dilution. There was good natural ventilation. The main shaft (No. 6) was downcast, and the air found its way to the surface through the old workings. It was not necessary to fill the stopes with waste.

## STOPING

As the mine was developed to the north to follow the downward rake of the ore lenses, the hanging wall became weaker, and it became evident that shrinkage stoping would have to be discontinued.

In 1946 cut-and-fill was adopted. It had been customary to extract all the ore on the main level or sill floor and then to maintain a timbered or overhead stulled and lagged haulage drift under the heavy broken ore of the shrinkage stope. This necessitated expensive timber repair work to keep open the main haulage drift under stoped areas.

A new plan was devised that provided for a run-around or detour haulage drift in the firm footwall of the mineralized zone. From this footwall drift, crosscuts are driven at 100-foot intervals across the entire mineralized zone. All the ore between these crosscuts is mined for a height of two floors. The bottom or sill floor is then filled with waste. The waste is contained by gob fences erected along the sides of the crosscuts through the mined-out sill-floor area. A manway with an open ore chute on each side is carried up over the crosscut as the stope advances. After every cut in the stope the ore is slushed into the chutes and drawn from them into the cars of the ore train, which is backed into the crosscut from the detour footwall drift (fig. 7). By this method, the maximum slushing distance is held to 100 feet, and the crosscuts through the ore zones at 100-foot intervals give complete assurance that no ore has been overlooked.

Detour drifts were first tried out in the hanging wall, but in some places the rock was broken and had to be barred down. For this reason the operation was transferred to the firmer footwall.

As several cut-and-fill stopes are worked simultaneously, it is essential that an adequate supply of broken waste be available at all times. This is accomplished by block-caving an area of barren schist over the north end of the 600 level (fig. 8).

A transfer raise (fig. 8) was driven up from the 700 level. It was branched just below the 600 level to serve two diverging crosscuts driven into the hanging wall of the level. These two crosscuts were driven on a 32-degree divergent angle for approximately 125 feet. Their ends were connected with a drift that completed an isosceles triangle pattern, which permitted spacing short finger raises so that the distance from one raise to the next was approximately 25 feet. The tops of these raises were slightly belled to permit drilling flared cut-off rounds, which, when blasted, undercut the entire block. The broken waste is drawn into the two diagonal drifts as needed and slushed to the transfer raise. A short cut-off stope also was run parallel to one side of one of the diagonal drifts to make caving of the block more certain.

This method of obtaining waste fill was successful in furnishing 4,000 to 5,000 tons per month. About 200,000 tons of waste fill has been drawn. There are grizzlies over the two branches of the transfer raise where the larger boulders are broken. To date, the number of large boulders has been small and no time has been lost in waiting for caving. Waste is always available for drawing and is being delivered into the operating stopes at a total cost of 30 cents per ton.

To facilitate the distribution of waste fill below the 700 level, a definite plan is followed. During development, major raises 5 by 15 feet, with a stulled and lagged manway in the center and open chutes on each side, are driven from each level to the level above at 400-foot intervals. The location of these major raises is staggered on succeeding levels. If on one level the raises are driven at 100, 500, and 900 feet, on the next level below they would be driven at 300, 700, and 1,100 feet. The first stopes on each level are started at the major raises (fig. 7), and 100 feet of stoping is carried to the north and south of each raise. As the stopes are mined above the sill floor, a 3-compartment raise similar to the major raises is carried up simultaneously at the opposite end of the stope (fig. 7). After every cut of ore, a slusher mounted on the manway of these raises scrapes the broken ore into the open chute adjacent to the manway on which the slusher is mounted. The broken ore travels from the major raise toward the new raise that is being carried up with the stope. To keep the ore clean, a plank floor is put down before a cut of ore is blasted. When the broken ore from a cut has been slushed into the ore chute, the plank flooring is taken up. The gob fence at each end of the stope is raised to hold the next run of waste, which is dumped down the waste chutes alongside the manways in the major raises. This fill material is then spread evenly over the stope with the same slusher and finished by hand shoveling, after which the plank floor is again put down and the stope is ready for drilling the next cut of ore. This cycle is repeated until the stope is completed and reaches the flooring under the waste-filled stope of the level above. If the level above has not been waste-filled over these stopes, and any ore remains on the sill floor above, it can be mined as a finishing operation.

When the two end stopes in a 400-foot block are completed, there is an open raise at each end of the unmined 200-foot center block. A manway with an open ore pass on each side is carried up with the stope at the main center-line position (fig. 7). A slusher hoist is mounted on this manway to scrape both ore and waste fill toward the center of this 200-foot block. The ore is disposed of through the ore passes carried up alongside the manway, and the waste fill is handled through the open raises at the north and south ends of the block.

It will be seen that through all the steps of the stoping operation the slusher is always mounted on top of advancing manways and never in open chutes through which waste fill is dumped.

The question may arise whether the extra cost involved in the footwall detour drifting and the additional crosscutting to reach the ore zone every 100 feet is justified. Experience has proved that the cost of this extra work is less than that of maintaining haulage drifts through waste-filled sill floors of stopes. Development is no longer hindered by closed haulage drifts that are being repaired, and the crosscuts insure thorough exploration of the ore zone.

## METHODS OF SAMPLING AND ESTIMATING TONNAGES AND VALUES

Because of the regularity and persistence of the ore shoots and the consistency of the values therein, there is no need for frequent very careful sampling in the stopes.

At every skip pocket for the ore-hoisting shaft, sample boxes are provided for each working place on each level. Before the cars are dumped a hand grab is taken from each car. At the end of every shift, all samples are sent to the surface for assay. This procedure applies to ore from drifts, crosscuts, raises, and that drawn from stopes. In addition, channel samples are cut every 5 feet in development work for examination and map records.

Twice a week, composite stope samples are prepared, and at the end of 2 weeks engineers compute the tonnage for each stope and apply the composite assay. When the calculated mine head for the month has been computed, it is compared with the mill head and adjusted to agree with it. Such corrections are usually slight.

Grab and cut samples from stopes and raises are considered adequate for closely estimating the values in ore reserves.

## MINE BUILDINGS AND EQUIPMENT

The Iron King mine has the following surface buildings (figs. 2 and 3):

Hoist house - compressors
Machine shop - warehouse
Blacksmith shop
Change house
Laboratory
Engineering - main office

Major items in the above buildings are:

Hoist, double-drum, electric, 250 h.p.
Hoist (supply), single-drum, electric, 75 h.p.
Compressor, air, electric, 1,400 cu. ft.
Compressor, air, electric, 900 cu. ft.
Lathe, 24-inch
Lathe, 14-inch
Drill press
Pipe threader

Bolt threader
Hacksaw, cut-off, electric
Oil furnace for conditioning drill rods
Hot-milling machine for detachable bits
Oil furnace for tempering detachable bits
Quenching machine (for bits)
Forging hammer, electric
Blacksmith forge

Mine (underground) equipment consists of:

7 small electric-battery haulage motors
8 shovel loaders
6 slusher hoists (air), 2-drum, 5 h.p.
6 slusher hoists (air), 2-drum, 7-1/2 h.p.
1 slusher hoist (air), 3-drum, 10 h.p.
1 slusher hoist (electric), 3-drum, 15 h.p.
10 drifter drills (1-1/4-inch round steel), 3-1/2-inch
10 Jackhammer drills (1-inch quarter-octagon steel)
32 Ingersoll-Rand No. 58 stoper drills (1-inch quarter-octagon steel)
40 ore cars, rocker-dump type, 1-1/2-ton
2 hoist skips, 2-1/2-ton, each with man cage suspended below

## VENTILATION

At no time in the past has mine ventilation presented a serious problem. The No. 6 shaft (fig. 6) and the old open workings on the south end were downcast, and the old open workings on the north end of the property were upcast. This natural flow was augmented by an exhaust fan over a ventilation raise north of the Bonanza claim. Recently, however, the new 3-compartment Extension shaft made connection with the north end of the 600 level and caused reversal of ventilation. The Extension shaft is downcast, and the No. 6 shaft is now upcast. The exhaust fan has not been used since ventilation was reversed. It is possible that with the approach of summer the flow of air will again reverse itself. This new condition is being watched closely, and it may become necessary to install a system of forced ventilation to keep the flow constant.

## WATER SUPPLY

The normal flow of water in the Iron King mine is 30 gallons per minute. It comes from the bottom levels and is cool and slightly alkaline. Water collected in sumps on the levels below the 900 and in the bottom of No. 6 shaft is pumped to the 900-level sump, where it is relayed to the surface by a larger pump. This water is used by the mill but is not suitable for drinking or for domestic use.

Water for domestic purposes and additional mill water are obtained from three company-owned wells on the Agua Fria River. From these wells the water is pumped 2 miles against a 600-foot head by electrically driven pumps.

## TRANSPORTATION

Ore is transported underground by small electric-battery locomotives and 1-1/2-ton rocker-dump type ore cars. Hoist skips of 2-1/2-ton capacity transport the ore to a 40-ton coarse-ore bin at the collar of the shaft. The ore is drawn from there on to a conveyor belt and is carried for 75 feet to a jaw crusher over the mill bin.

Mill concentrates are hauled by a contractor in 1-1/2-ton dump trucks to the railroad at Humboldt, a distance of 1 mile. All waste rock hoisted from the mine is disposed of by company 1-1/2-ton dump trucks.

Employees live in Humboldt, Mayer, and Prescott. Transportation by bus is provided at a nominal cost for those of the crew who live in Prescott (20 miles).

## SAFETY

Training in safety and first aid is supervised by the assistant superintendent. The crew is 100 percent trained in first aid. Class instruction in first aid is given at regular periods. Part of the crew is trained in mine rescue and helmet work. The company has six mine-rescue helmets, 1-hour machines. First-aid stations are maintained at every skip pocket in No. 6 shaft and stretchers are kept in the hoist house at the collar of the shaft.

A framed certificate of honor from the Joseph A. Holmes Safety Association hangs in the main office. It reads: "For operating an underground lead-zinc-copper mine without a fatality from October 26, 1939, to March 9, 1948, with an average of 115 men working 2,219,000 man-hours in the mining of 704,660 tons of ore."

## LABOR AND WAGES

Two shifts are worked at the Iron King mine. The day shift comes on at 8 a.m. and the night shift at 7 p.m. The interval between shifts allows the powder fumes from blasting to escape from the mine. There are 50 men on each mine shift. Of these, about half are on stoping and development. The remainder comprise motor crews, trackmen, timbermen, skip tenders, hoistmen, shop and surface men, bosses, and miscellaneous.

Classification and rates of pay for the mine crew are as follows:

TABLE 1. - Rates of pay as of October 1, 1948

| Classification | Day shift | Night shift |
|---|---|---|
| Cager | 11.20 | 11.68 |
| Diamond-drill operator | 12.00 | 12.48 |
| Diamond-drill helper | 10.88 | 11.36 |
| Grizzlyman | 10.24 | 10.72 |
| Handyman | 11.20 | 11.68 |
| Miner | 11.20 | 11.68 |
| Motorman | 11.20 | 11.68 |
| Mucking-machine operator | 11.20 | 11.68 |
| Mucker | 10.24 | 10.72 |
| Pipeman | 11.20 | 11.68 |
| Pipeman's helper | 10.88 | 11.36 |
| Pump man | 11.20 | 11.68 |
| Pump man's helper | 10.24 | 10.72 |
| Powder man | 10.88 | 11.36 |
| Skip tender | 11.20 | 11.68 |
| Shaft miner | 12.16 | 12.64 |
| Shaft jigger boss | 13.16 | 13.64 |
| Shaft repairman | 11.84 | 12.32 |
| Shaft timberman | 12.16 | 12.64 |
| Trammer (hand) | 10.24 | 10.72 |
| Timberman | 11.52 | 12.00 |
| Timberman special | 12.32 | 12.80 |
| Toplander | 10.88 | 11.36 |
| Trackman | 11.20 | 11.68 |
| Trackman helper | 10.88 | 11.36 |
| Tool nipper | 10.88 | 11.36 |
| Blacksmith | 11.83 | 12.31 |
| Blacksmith helper | 10.52 | 11.00 |
| Electrician | 11.51 | 11.00 |
| Electrician helper | 10.23 | 10.71 |
| Hoist engineer (double-drum) | 12.40 | 12.88 |
| Hoist engineer (single-drum) | 11.80 | 12.28 |
| Laborer (bull gang) | 10.00 | 10.48 |
| Mechanic | 11.51 | 11.99 |
| Tool sharpener | 11.80 | 12.28 |
| Truck driver | 10.24 | 10.72 |

All drifts and crosscuts are run 6 feet by 8 feet and are drilled and blasted by a miner (fig. 9). Average advance is 5 feet. The average round calls for 18 holes. A down-cut round is favored, but some regular V-cut rounds are drilled. Headings are mucked out on the shift following blasting. Mucking machines are used (fig. 10), and the motor crew services the headings with ore cars. The man operating the mucking machine is also a miner.

There are two miners on each shift in the large (5 by 15 feet) 3-compartment raises. Drilling is done with two stoper machines. Raise miners also do the timbering required in carrying up the manway. The muck from the blasted raise rounds is drawn by the motor crew. During December 1948

Figure 9. - Miner drilling drift round. Note line of separation between ore and schist (wall rock).

Figure 10. - Mucking machine in operation, sill floor.

the average advance for all drifts, crosscuts, and raises was 2.25 feet per man-shift, and for 1948 this figure was 2.01 feet.

Each stope is operated by two miners on each shift, who do all the work called for in a cut-and-fill stoping operation. They drill and blast, slush out the ore, take up flooring, raise gob fencing, apply waste fill, and lay flooring on the waste. Drilling is done with stopers and slushing with the smaller types of compressed-air slusher hoists.

All blasting, except in shaft sinking, is done with 45-percent gelatin dynamite. Black wrapped fuse and 6X blasting caps are used. In shaft sinking, a straight gelatin, 40-percent dynamite is used, and the rounds are detonated with electric blasting caps.

All drifting, crosscutting, raising and stoping is done under a bonus schedule (table 2). Drifts and crosscuts are carried 6 by 8 feet in size, and these rounds are drilled by one miner with a 3-1/2-inch drifter. From 14 to 18 holes are required to break the round, which is drilled 5 to 6 feet deep. An average round breaks about 5 feet net. The blasted round is mucked out with a shovel loader on the following shift by the driller's partner, who is also a miner.

In ore, the base requirement for advance in each round is 2 feet per man shift, or 4 feet for the 2-man crew. Engineers measure the advance every two weeks; they deduct 2 feet for every man shift worked, and the crew is paid $4 for each additional foot over the required base.

In waste rock, the base requirement is usually 2-1/2 or 3 feet per man shift, because the waste drills and breaks better than the ore. In exceptional cases in which conditions are unusual, the base requirement is set by the bonus engineer.

In stoping, the bonus schedule is more complicated (table 2). Measurements are in cubic feet mined for each period. Past experience has shown that, on the average, in making a complete cycle:

Laying plank floor consumes 12 percent of time,

Slushing ore consumes 43 percent of time,

Filling waste consumes 22 percent of time, and

Drilling and breaking ore consumes 23 percent of time.

TABLE 2. - New bonus schedule effective June 1, 1948

| Average width of ore, feet | Cost of stoping per cubic foot, cents | | | | |
|---|---|---|---|---|---|
| | Laying floor, 12 percent | Moving ore, 43 percent | Filling waste, 22 percent | Drilling ore breaking, 23 percent1/ | Total, 100 percent |
| Wider than 12 | 1.0 | 3.4 | 1.8 | 1.9 | 8.1 |
| 10 to 12 .... | 1.0 | 3.7 | 1.8 | 1.9 | 8.3 |
| 10 .......... | 1.0 | 3.7 | 1.9 | 2.0 | 8.6 |
| 9 .......... | 1.1 | 3.8 | 2.0 | 2.1 | 9.0 |
| 8 .......... | 1.1 | 4.0 | 2.1 | 2.2 | 9.4 |
| 7 .......... | 1.2 | 4.3 | 2.2 | 2.3 | 10.0 |
| 6 .......... | 1.3 | 4.6 | 2.3 | 2.5 | 10.7 |
| 5 .......... | 1.4 | 5.2 | 2.6 | 2.8 | 12.0 |
| 4 .......... | 1.6 | 5.9 | 3.0 | 3.1 | 13.6 |
| 3 .......... | 1.9 | 6.9 | 3.5 | 3.7 | 16.0 |

| | Cost per linear foot of work |
|---|---|
| Drifts and crosscuts (over base) ........ | $ 4.00 |
| Raises (timbered) ........................ | 12.00 |
| Shaft .................................... | 60.00 |
| Manway and chute ......................... | 6.00 |
| Gob fence ................................ | 3.85 |
| Single cribbed manway .................... | 3.85 |
| Untimbered raise (no staging) ............ | 3.65 |
| Untimbered raise (staging) ............... | 4.85 |

1/ Drilling and breaking price for shrinkage and cut-and-fill.

A price is set per cubic foot of ore in place in a stope according to the width of the stope. In stopes over 12 feet wide, the price has been set at 8.1 cents per cubic foot (see table 2). The price for drilling and breaking per cubic foot would then be 8.1 cents x 23 percent, or 1.9 cents. The price for slushing a cubic foot of ore would then be 8.1 cents x 43 percent, or 3.4 cents. Hence, if a stope crew had drilled and blasted a certain number of cubic feet of ore in a certain period, and had slushed all of this broken ore but had applied no waste fill to the stope, and had not put down flooring, they would receive 1.9 cents plus 3.4 cents, or 5.3 cents per cubic foot for the entire number of cubic feet measured for that period.

Crews working under the bonus schedule are furnished all necessary equipment and supplies. Any crew failing to earn a bonus in any period receives straight wages for that period.

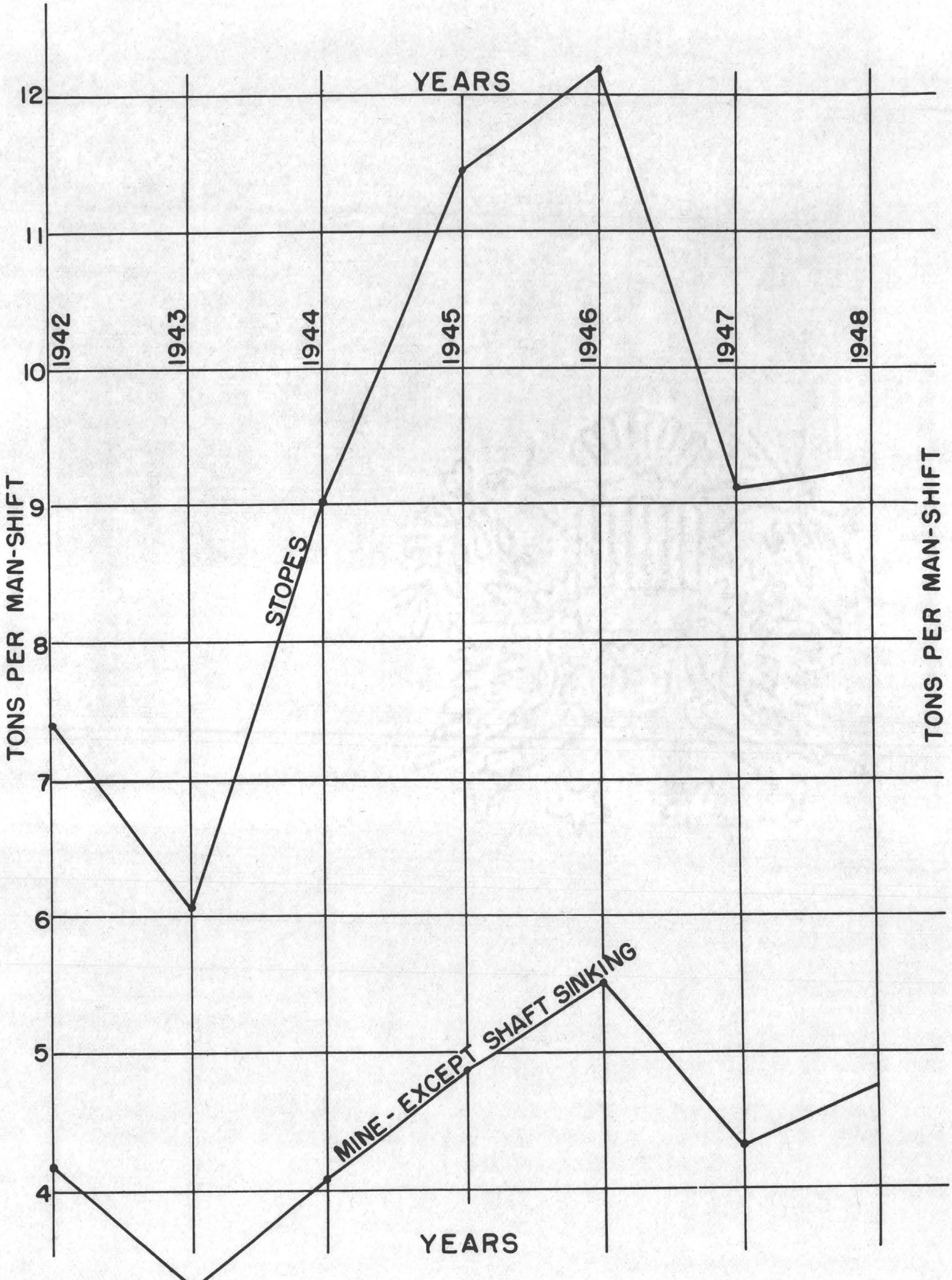



Figure 11. - Tons per man-shift, Iron King mine.

## PRODUCTION AND COSTS

Total ore production from the Iron King mine to the end of 1948 amounts to 1,059,305 tons (table 3). The figures given for the years prior to 1938 are probably approximate. Since 1942, when the Shattuck-Denn Mining Corp. acquired the property, production has increased steadily.

Table 4 gives the tonnage produced from each vein on and below the 400 level. A close study of tables 3 and 4 will reveal the persistency of the ore shoots and the consistency of the values. There has been a slight decrease in the gold and silver content in depth. Lead values have remained about the same, and there has been a perceptible increase in zinc. The standing of the Iron King mine among Arizona gold-silver and lead-zinc producers in 1948 was:7/

Second in zinc production.

Third in lead production.

Third in gold production.

Fourth in silver production.

Output per man shift is shown in figure 11. Just previous to the change-over from shrinkage to cut-and-fill stoping, the tons-per-man-shift figure for all men working in stopes was 12.2, and for all mine employees, exclusive of men on shaft sinking, it was 5.6. By the end of 1947, when the change-over was completed, the tons-per-man-shift figure for stopes was 9.1 and for the mine it was 4.3. This drop results from the necessity of applying waste fill to the stopes after every cut of ore. There was a slight increase in tons per man-shift during 1948.

Sinking costs in No. 6 and the Extension shafts amount to 40 cents per ton of ore produced, and it costs 50 to 60 cents per ton of ore produced to keep up ore reserves.

During 1948 development costs amounted to 59 cents per ton of ore produced, and the direct stoping cost for 1948 was $2.24 per ton. The total mining cost for 1948, including indirect costs and depreciation, was $6.36 per ton, and the total milling cost was $2.61 per ton, making the total over-all cost $8.97 per ton.

---

7/ See footnote 2.

TABLE 3. - Estimate of Iron King production (mined ore)

| | | Assay | | | | | Contents | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons | Oz. Au | Oz. Ag | Units Pb | Units Zn | Units Cu | Oz. Ag | Oz. Ag | Units Pb | Units Zn | Units Cu |
| Previous to mill (1906 to 1938) .. | 78,452 | 0.200 | 4.00 | 2.0020 | 4.00 | 0.30 | 15,690 | 313,808 | 156,904 | 313,808 | 23,535 |
| Oct. 1938 - Dec. 31, 1938 ........ | 13,477 | .172 | 3.41 | 1.500 | 4.00 | .25 | 2,317 | 45,938 | 20,215 | 53,908 | 3,370 |
| 1939 ............. | 70,227 | .141 | 3.88 | 1.333 | 4.17 | .25 | 9,911 | 272,604 | 93,634 | 292,701 | 17,556 |
| 1940 ............. | 65,812 | .140 | 4.05 | 1.28 | 5.48 | 1/.25 | 9,239 | 266,497 | 94,553 | 361,022 | 16,453 |
| 1941 ............. | 69,159 | .140 | 4.80 | 1.68 | 5.51 | 1/.25 | 9,720 | 331,746 | 116,002 | 380,855 | 17,290 |
| 1942 ............. | 88,200 | .132 | 4.45 | 2.00 | 6.00 | 1/.25 | 11,659 | 392,458 | 177,005 | 529,278 | 22,050 |
| 1943 ............. | 73,721 | .124 | 4.17 | 2.15 | 6.84 | .149 | 9,167 | 307,465 | 158,219 | 504,765 | 11,036 |
| 1944 ............. | 99,164 | .095 | 3.11 | 1.82 | 6.87 | .213 | 9,460 | 308,567 | 180,583 | 681,193 | 21,191 |
| 1945 ............. | 117,287 | .111 | 3.72 | 2.24 | 6.89 | .194 | 13,068 | 436,506 | 262,982 | 807,809 | 22,764 |
| 1946 ............. | 115,615 | .113 | 4.04 | 2.48 | 7.30 | .210 | 13,065 | 467,387 | 286,714 | 843,766 | 24,289 |
| 1947 ............. | 122,368 | .125 | 4.36 | 2.53 | 6.92 | .168 | 15,297 | 533,642 | 309,744 | 846,266 | 20,591 |
| 1948 ............. | 145,823 | .117 | 3.71 | 2.35 | 6.53 | .155 | 17,036 | 540,548 | 342,706 | 952,405 | 22,651 |
| Total ........ | 1,059,305 | .128 | 3.98 | 2.076 | 6.20 | .210 | 135,629 | 4,217,161 | 2,199,261 | 6,567,776 | 222,776 |

1/ Estimate

TABLE 4. - Record of Iron King stopes up to November 1948

| Vein | Level | Tons | Value, Au and Ag | Assay, percent Pb | Assay, percent Zn |
|---|---|---|---|---|---|
| A | 4 | 23,523 | $ 7.82 | 1.25 | 6.85 |
| | 5 | 15,781 | 6.40 | 1.61 | 8.60 |
| | 6 | 13,940 | 6.04 | 1.65 | 8.67 |
| | 7 | 11,015 | 3.96 | 2.02 | 9.97 |
| | 8 | 12,734 | 5.27 | 1.21 | 6.47 |
| | 9 | 5,537 | 5.84 | 1.08 | 5.65 |
| | | 82,530 | 6.20 | 1.47 | 7.76 |
| C | 4 | 541 | 7.69 | 1.0 | 4.0 |
| | 5 | 1,739 | 8.28 | 1.5 | 4.0 |
| | 6 | 1,254 | 10.38 | 1.5 | 3.0 |
| | 7 | 707 | 10.53 | 1.6 | 4.3 |
| | | 4,241 | 9.22 | 1.46 | 3.76 |
| D | 4 | 6,155 | 8.97 | 1.5 | 3.7 |
| | 5 | 8,097 | 12.32 | 1.5 | 3.0 |
| | 6 | 12,539 | 12.59 | 1.4 | 3.67 |
| | 7 | 8,113 | 10.51 | 1.6 | 4.1 |
| | 8 | 11,514 | 7.36 | 1.64 | 4.67 |
| | 9 | 3,183 | 3.45 | 1.56 | 6.37 |
| | | 49,601 | 9.96 | 1.53 | 4.03 |
| E-F | 4 | 14,997 | 7.00 | 1.75 | 5.11 |
| | 5 | 11,903 | 7.69 | 1.61 | 5.03 |
| | 6 | 3,930 | 5.32 | 1.50 | 3.50 |
| | 7 | 5,243 | 2.97 | 1.50 | 6.70 |
| | 8 | 5,108 | 2.60 | 2.29 | 5.38 |
| | 9 | - | - | - | - |
| | | 41,181 | 5.92 | 1.72 | 5.17 |

| Vein | Level | Tons | Value, Au and Ag | Assay, percent Pb | Assay, percent Zn |
|---|---|---|---|---|---|
| G, H, I | 4 | 30,661 | $ 6.75 | 2.64 | 7.00 |
| | 5 | 43,022 | 5.94 | 2.52 | 7.58 |
| | 6 | 52,300 | 7.02 | 2.55 | 6.94 |
| | 7 | 82,412 | 7.06 | 2.41 | 5.88 |
| | 8 | 125,404 | 7.21 | 2.61 | 6.99 |
| | 9 | 113,195 | 7.15 | 2.81 | 7.58 |
| | | 446,994 | 6.99 | 2.61 | 6.99 |
| P-Y | 4 | 5,788 | 6.56 | 1.07 | 7.43 |
| | 5 | 10,674 | 11.12 | .69 | 4.97 |
| | 6 | 16,260 | 6.82 | .95 | 5.27 |
| | 7 | 11,579 | 6.23 | 1.45 | 7.62 |
| | | 44,301 | 7.67 | 1.04 | 6.13 |
| X | 4 | 12,529 | 6.80 | 1.89 | 6.82 |
| | 5 | 7,411 | 4.82 | 1.64 | 8.19 |
| | 6 | 7,973 | 4.76 | 1.46 | 8.12 |
| | | 27,913 | 5.70 | 1.70 | 7.56 |
| All veins on: | 4 | 94,194 | 7.20 | 1.87 | 6.43 |
| | 5 | 98,627 | 7.26 | 1.90 | 6.76 |
| | 6 | 108,196 | 7.32 | 1.93 | 6.45 |
| | 7 | 119,069 | 6.76 | 2.18 | 6.33 |
| | 8 | 154,760 | 6.91 | 2.41 | 6.73 |
| | 9 | 121,915 | 6.99 | 2.70 | 7.46 |
| | | 696,761 | 7.05 | 2.20 | 6.71 |

Iron King

Cross Section Book

376

# KEUFFEL & ESSER CO.

DRAWING MATERIALS

SURVEYING INSTRUMENTS.

NEW YORK.

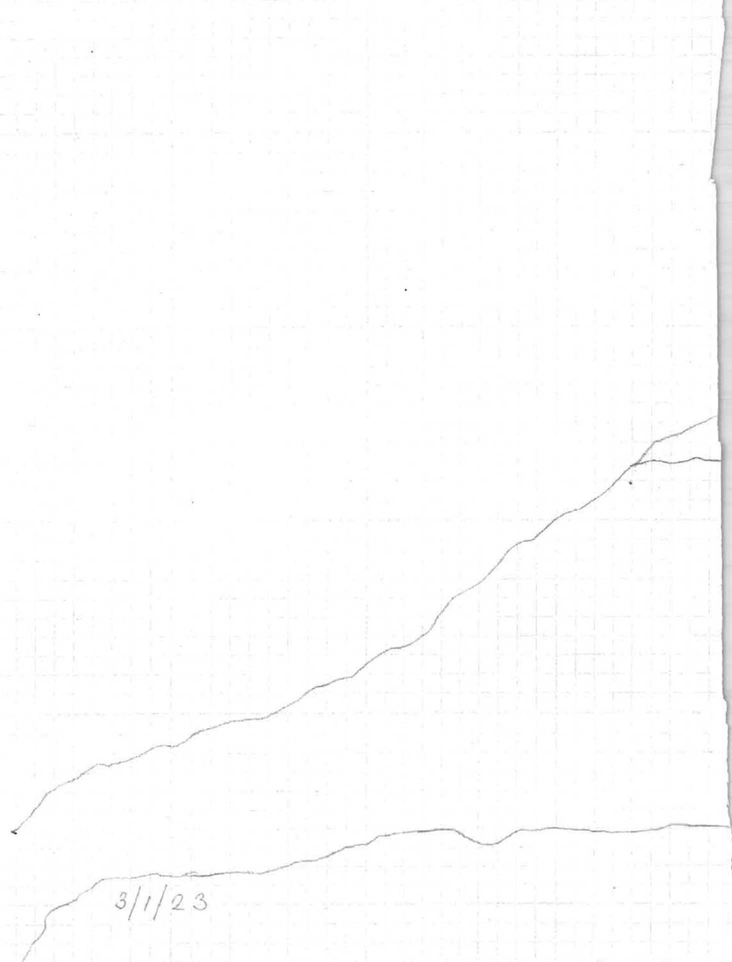
Iron King Mine

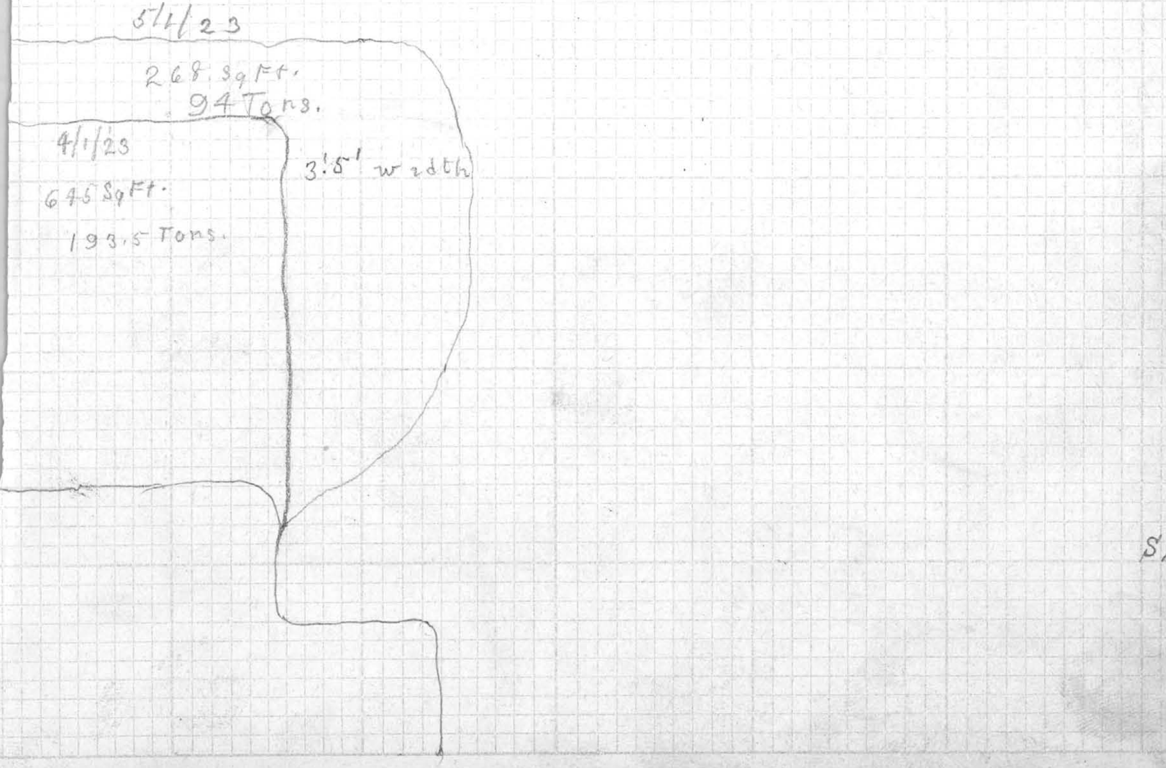
3/1/'23

Page 9 - 210 S. Stope & Drifts
" 11, 13, 14 - 210 N. "
15 - 352 stope
16 - 310 Exten & Raise.
17 - 400 Drift.

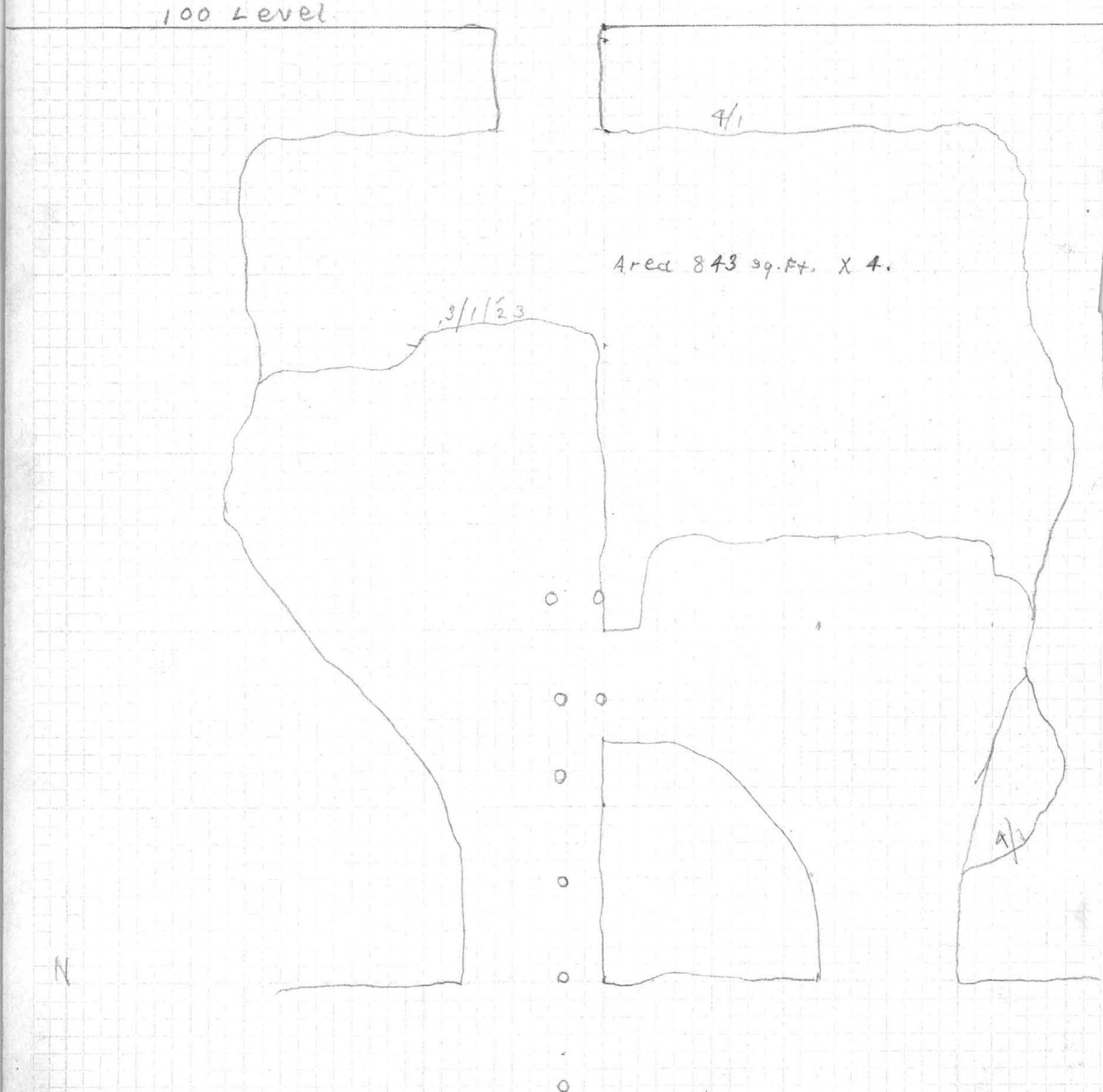
# 211 Stope

N.

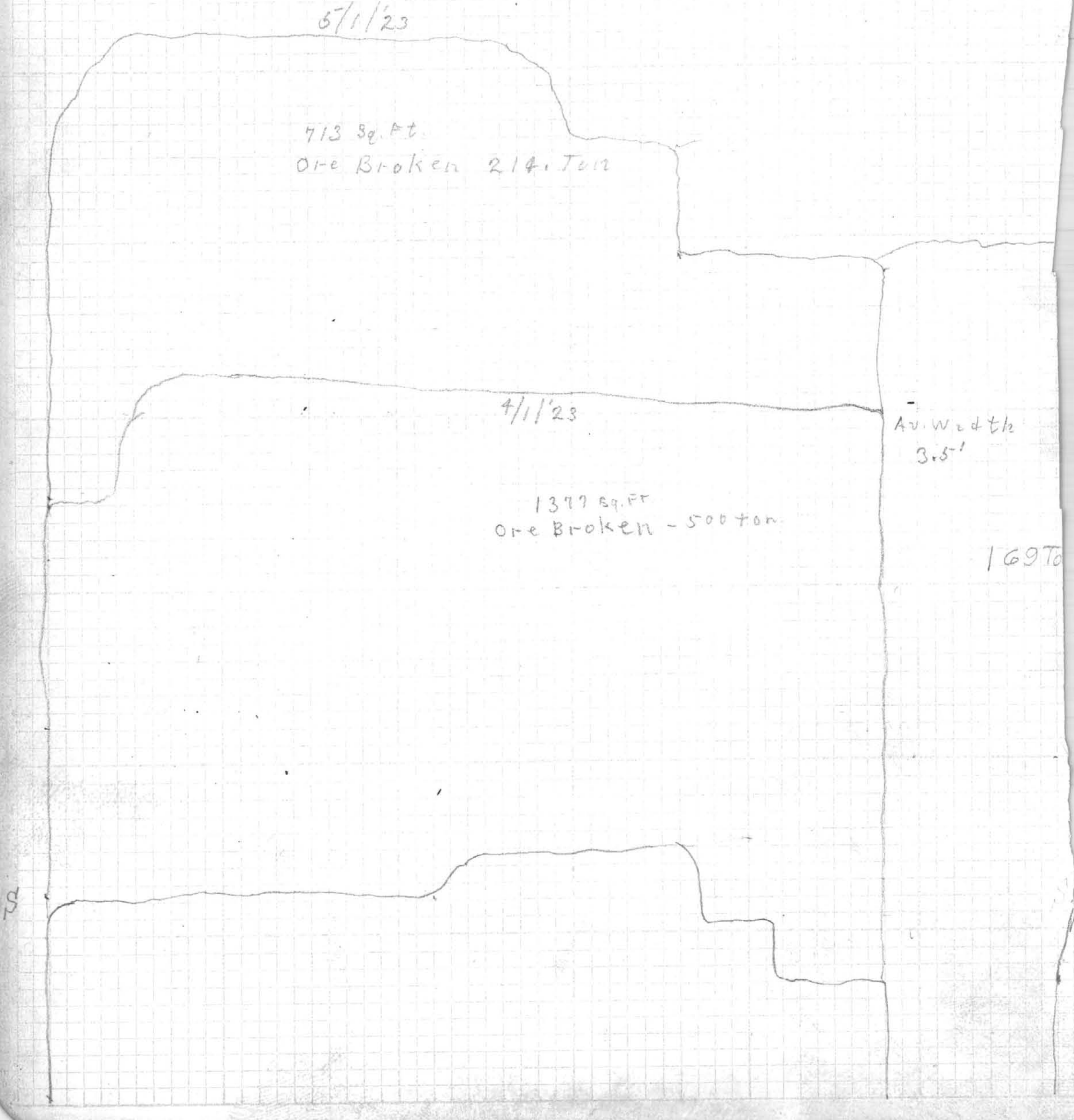



5/4/23
268 Sq Ft.
94 Tons.
4/1/23
645 Sq Ft.
193.5 Tons.
3.5' width
S.

251 Stope

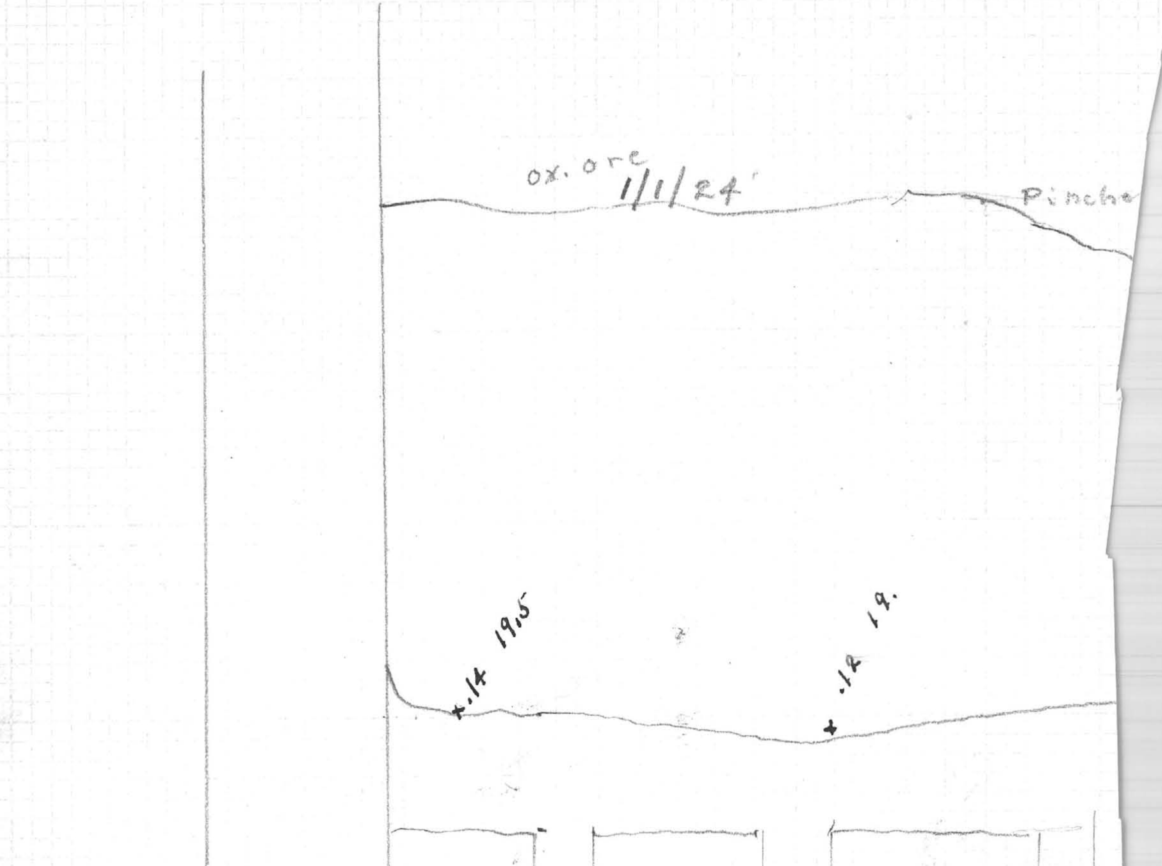


# 252 Stope.


6/1/'23
713 Sq. Ft.
Ore Broken 214. Ton
4/1/'23
Av. Width
3.5'
1377 Sq. Ft
Ore Broken - 500 ton
169 To
S

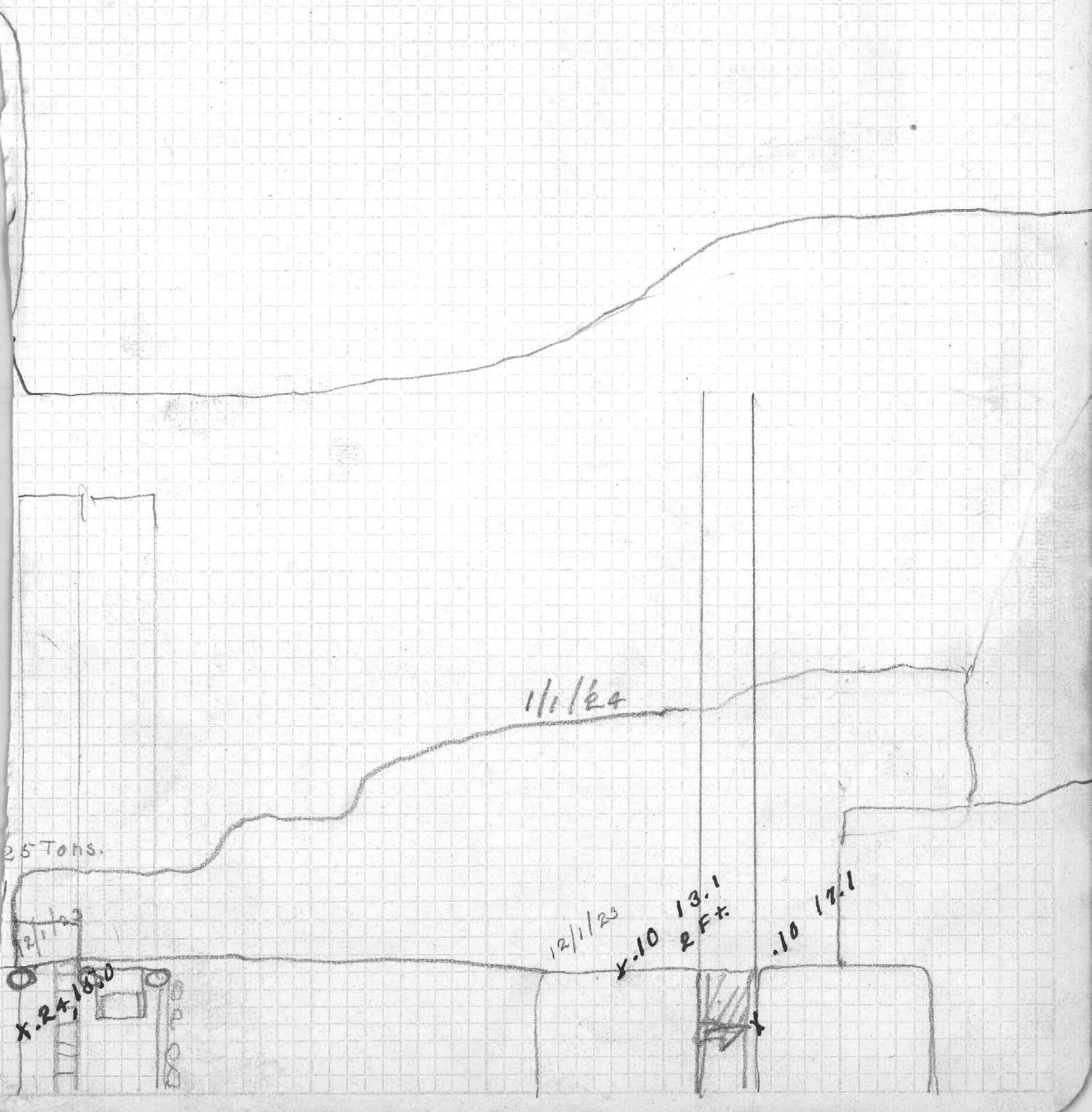

6/1/23 vein Pinched to 1' going North & 8" in back

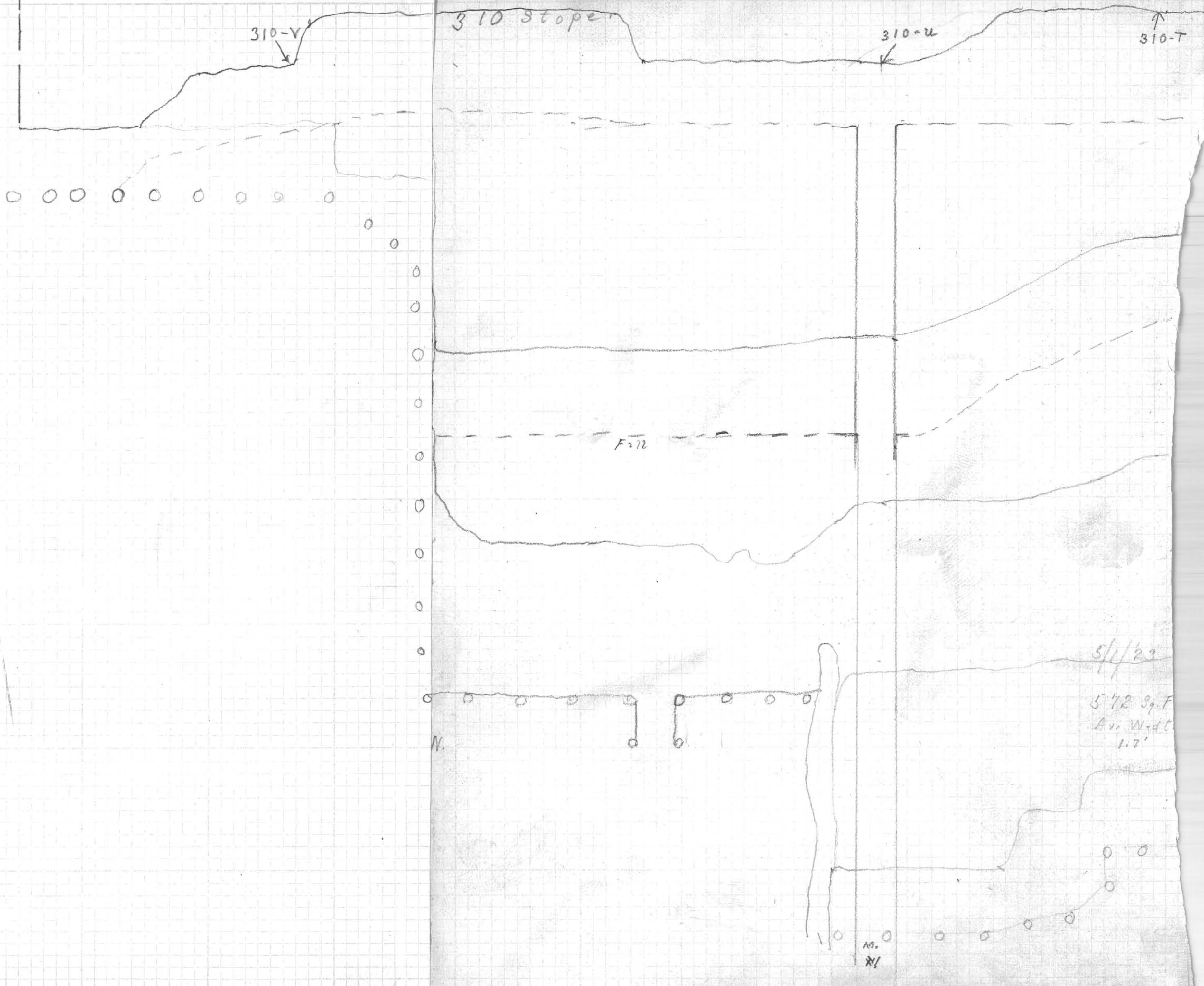
N.




200

210-S. Stope 9
and
Drift
210 S. Extension

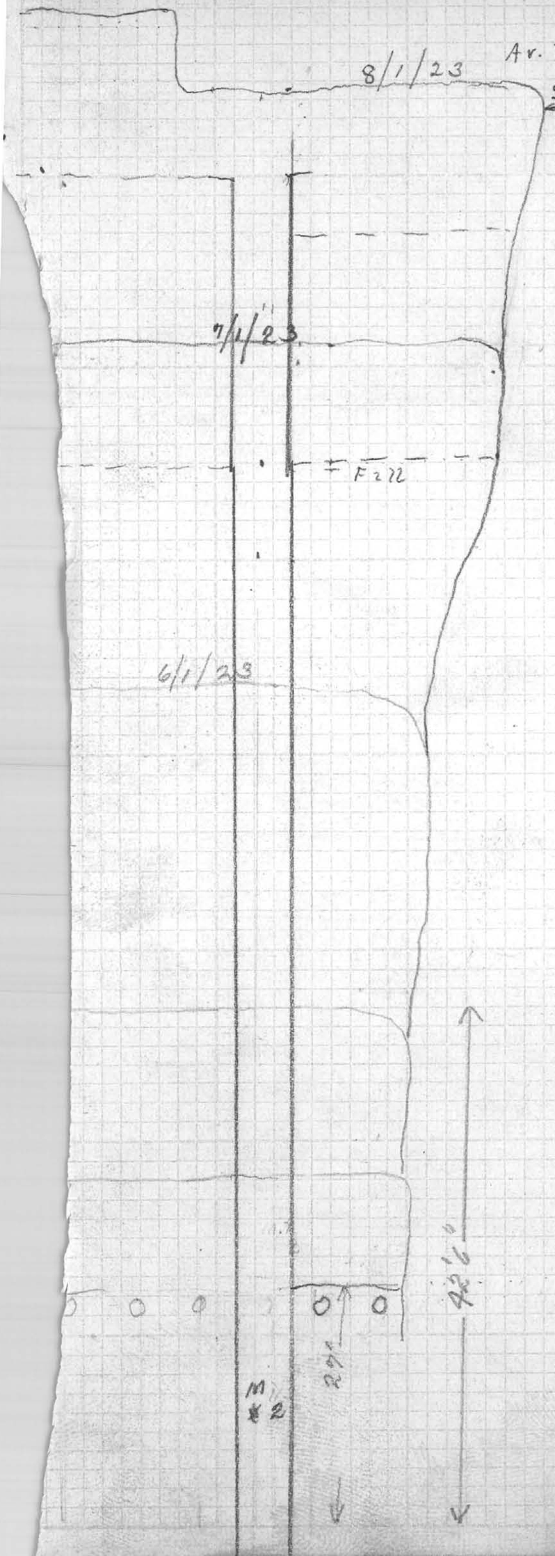


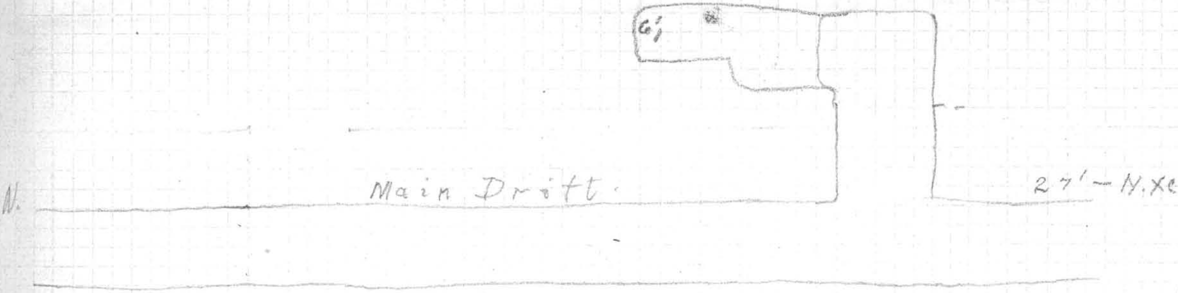


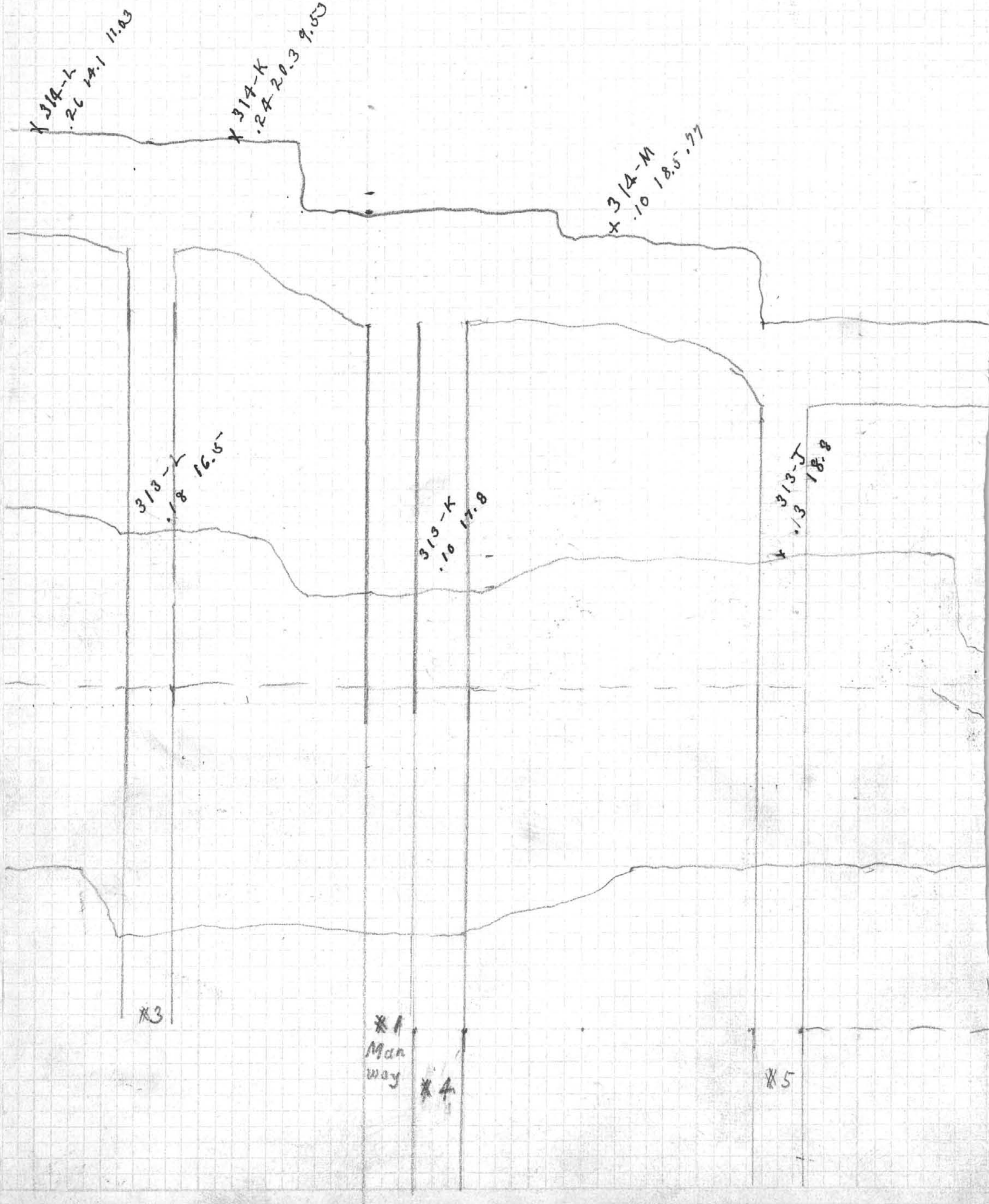
310 Stope
310-V
310-U
310-T
N.
5/1/23
572 Sq. F
Av. Widt
1.7'
M.

See Page 13

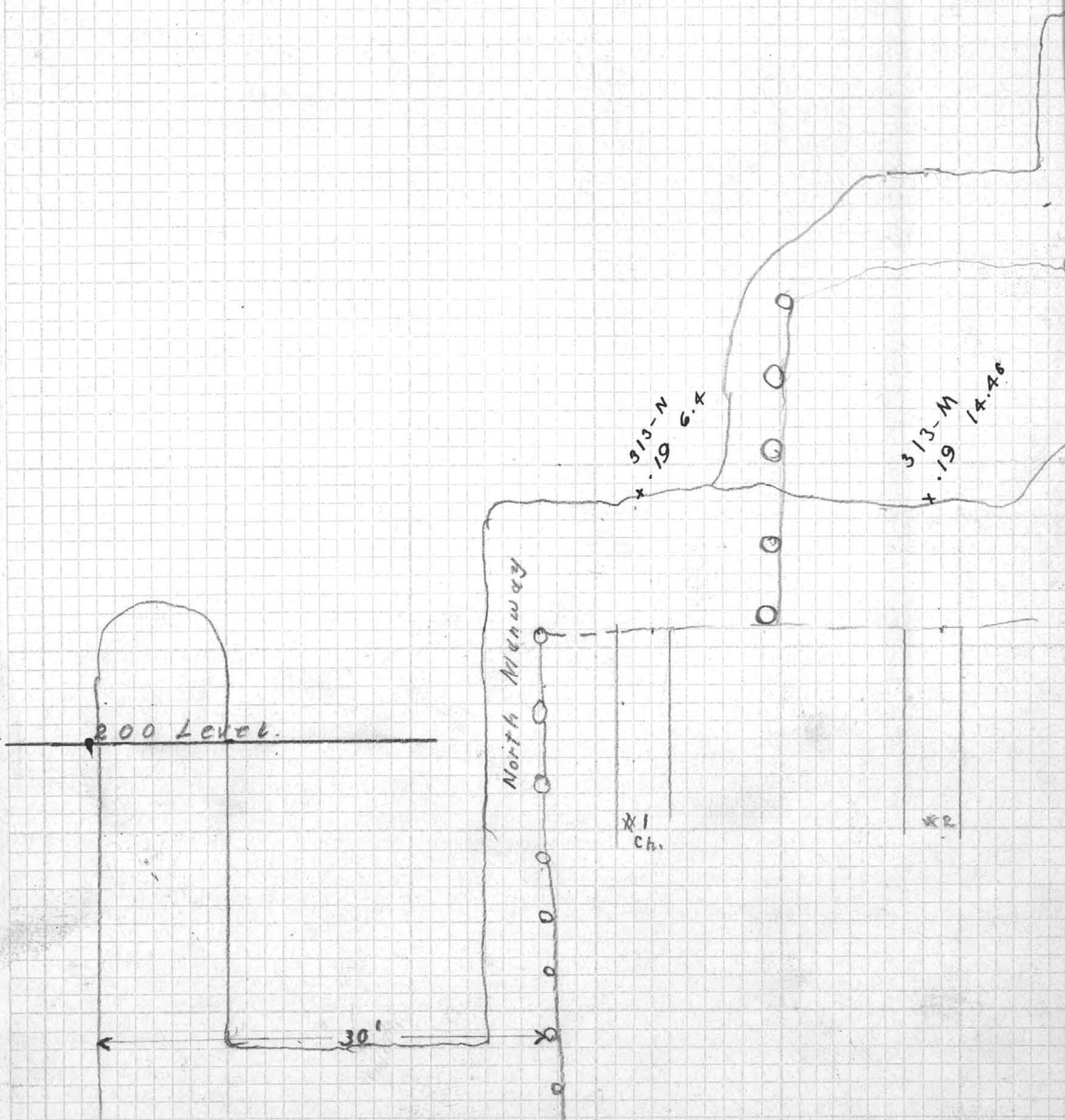
Av. Width = 2.02. (ORE)



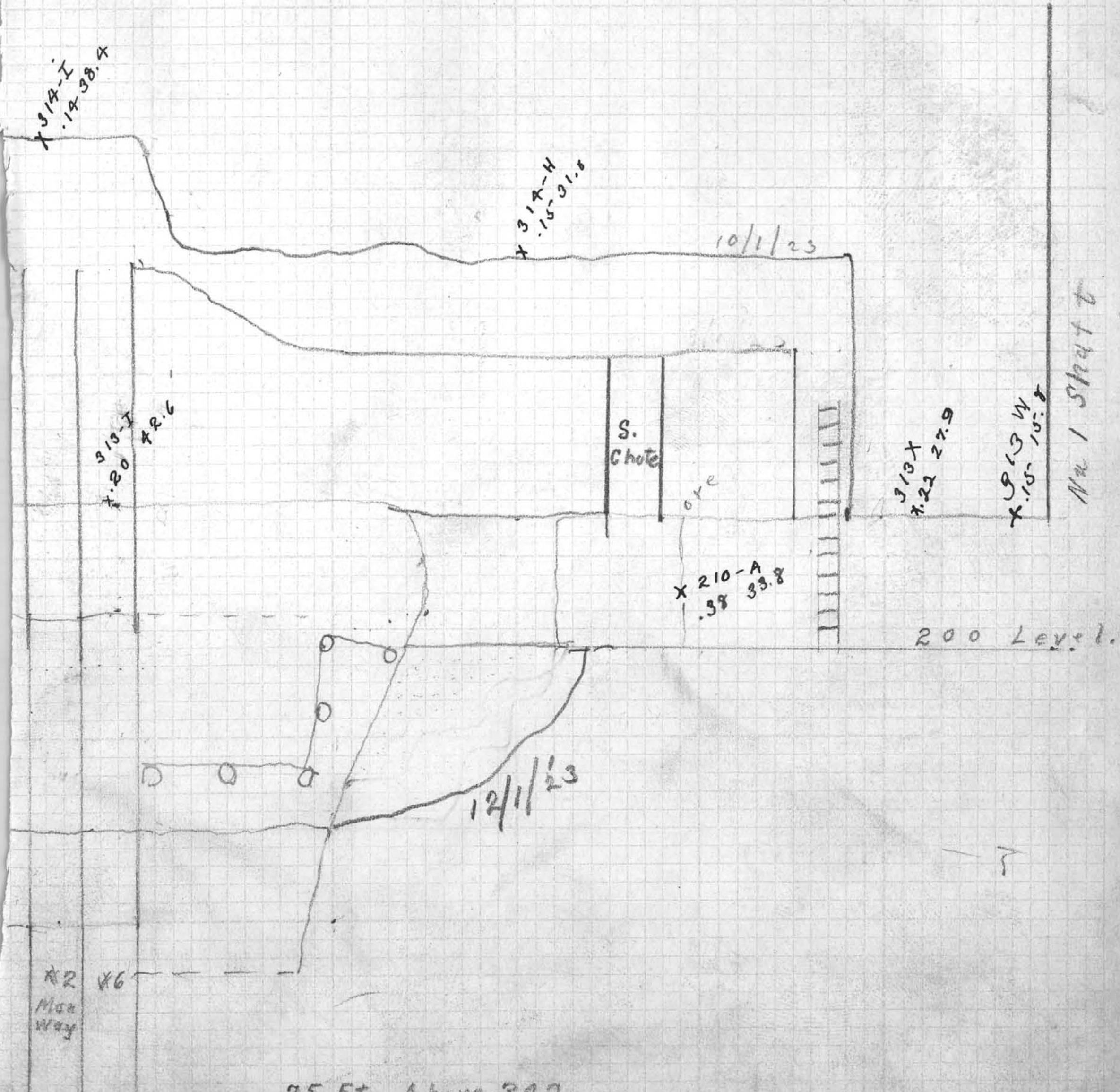

6'
N.
Main Drift.
27' – N.Xc



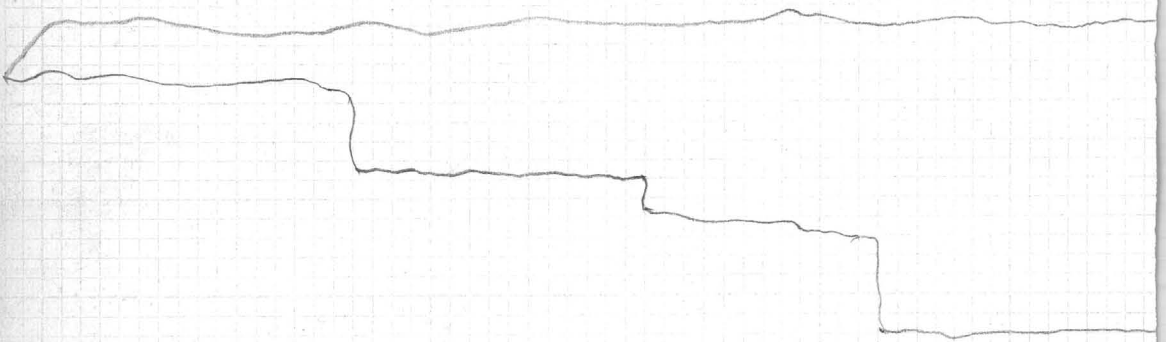
x 314-L .26 24.1 11.03
x 314-K .24 20.3 9.53
x 314-M .10 18.5 .77
313-L .18 16.5
313-K .10 17.8
x 313-J .13 18.8
#3
#1 Man way
#4
#5

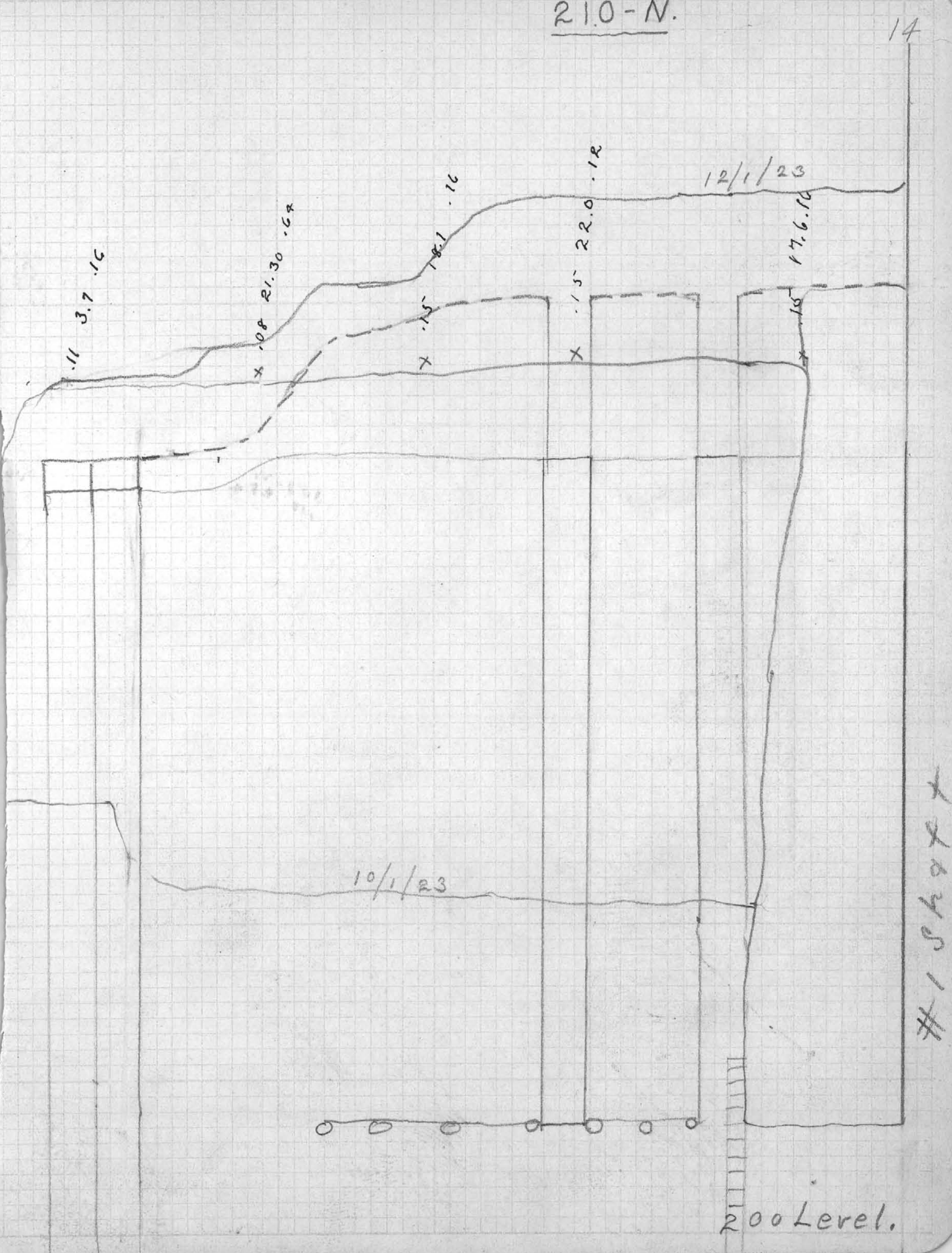

313-N
.19 6.4
313-M
.19 14.46
North Manway
200 Level.
#1
Ch.
#2
30'

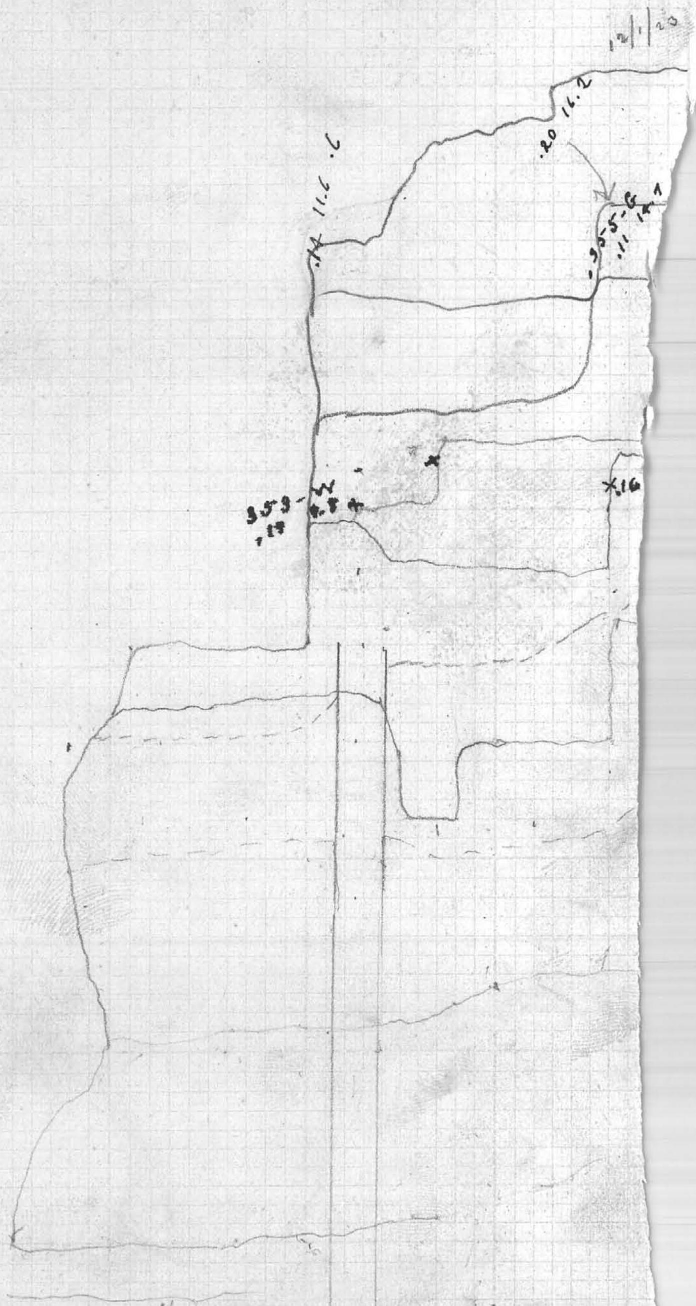
See page 14.




75 Ft. Above 300

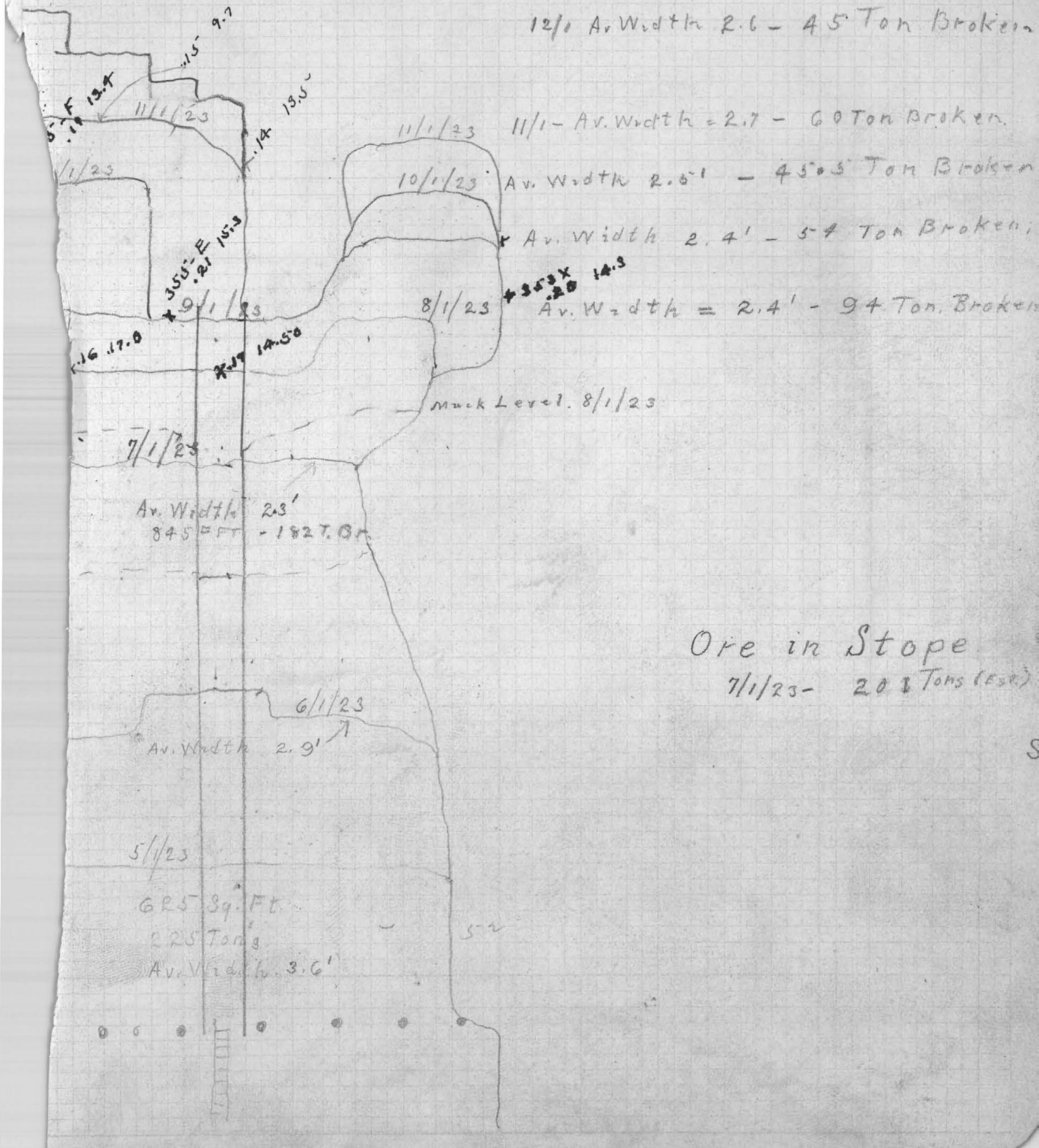



210-N.
12/1/23
.11 3.7 .16
.08 21.30 .64
.15 18.1 .16
.15 22.0 .12
.15 17.6.16
10/1/23
#1 Shaft
200 Level.



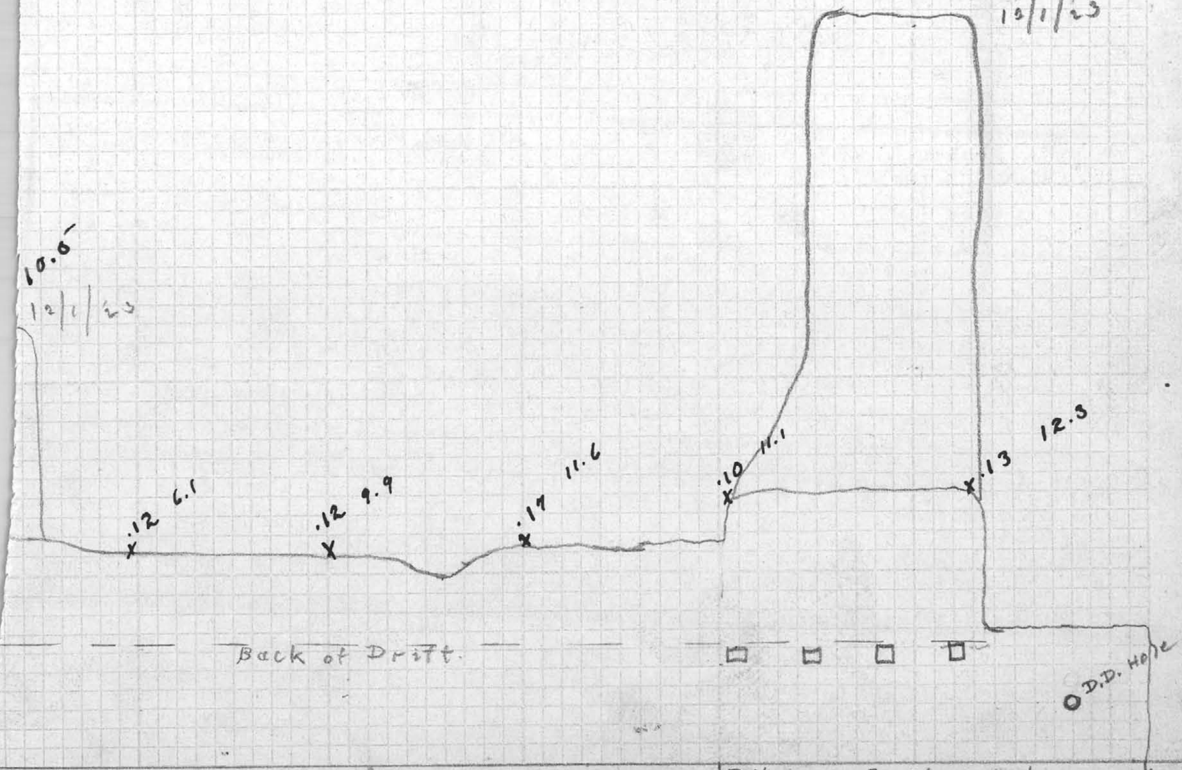

N.

133' 1/2 x.e


12/1 Av. Width 2.6 - 45 Ton Broken
11/1 - Av. Width = 2.7 - 60 Ton Broken.
11/1/23
10/1/23 Av. Width 2.5' - 45.5 Ton Broken
Av. Width 2.4' - 54 Ton Broken.
8/1/23 Av. Width = 2.4' - 94 Ton. Broken
Muck Level. 8/1/23
11/1/23
9/1/23
7/1/23
Av. Width 2.3'
845 ☐ Ft - 182 T. Br.
6/1/23
Av. Width 2.9'
5/1/23
625 Sq. Ft.
225 Tons
Av. Width 3.6'
Ore in Stope
7/1/23 - 201 Tons (Est)

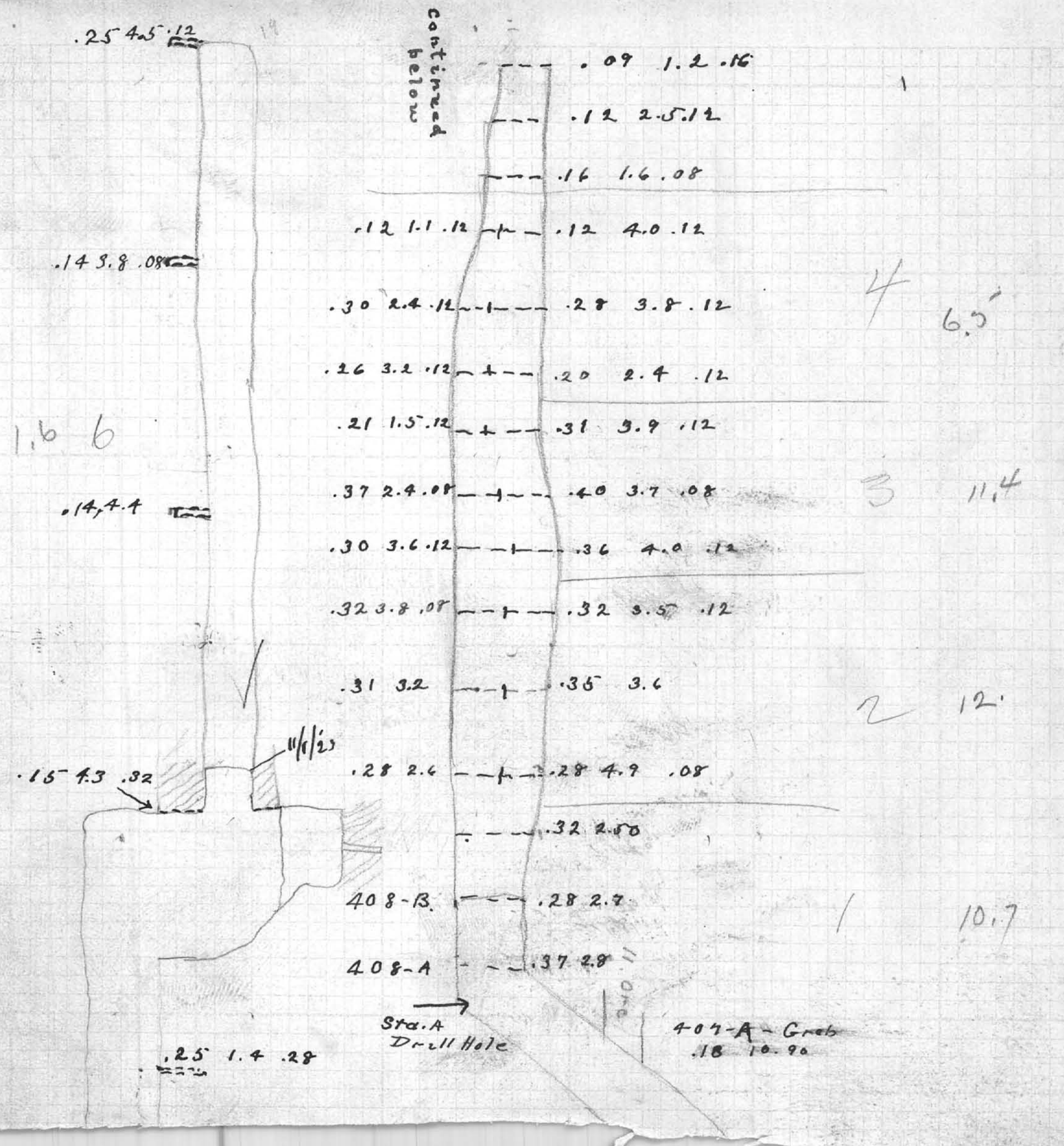

.11
12.9
.14
13.3
.14
12.1
.15

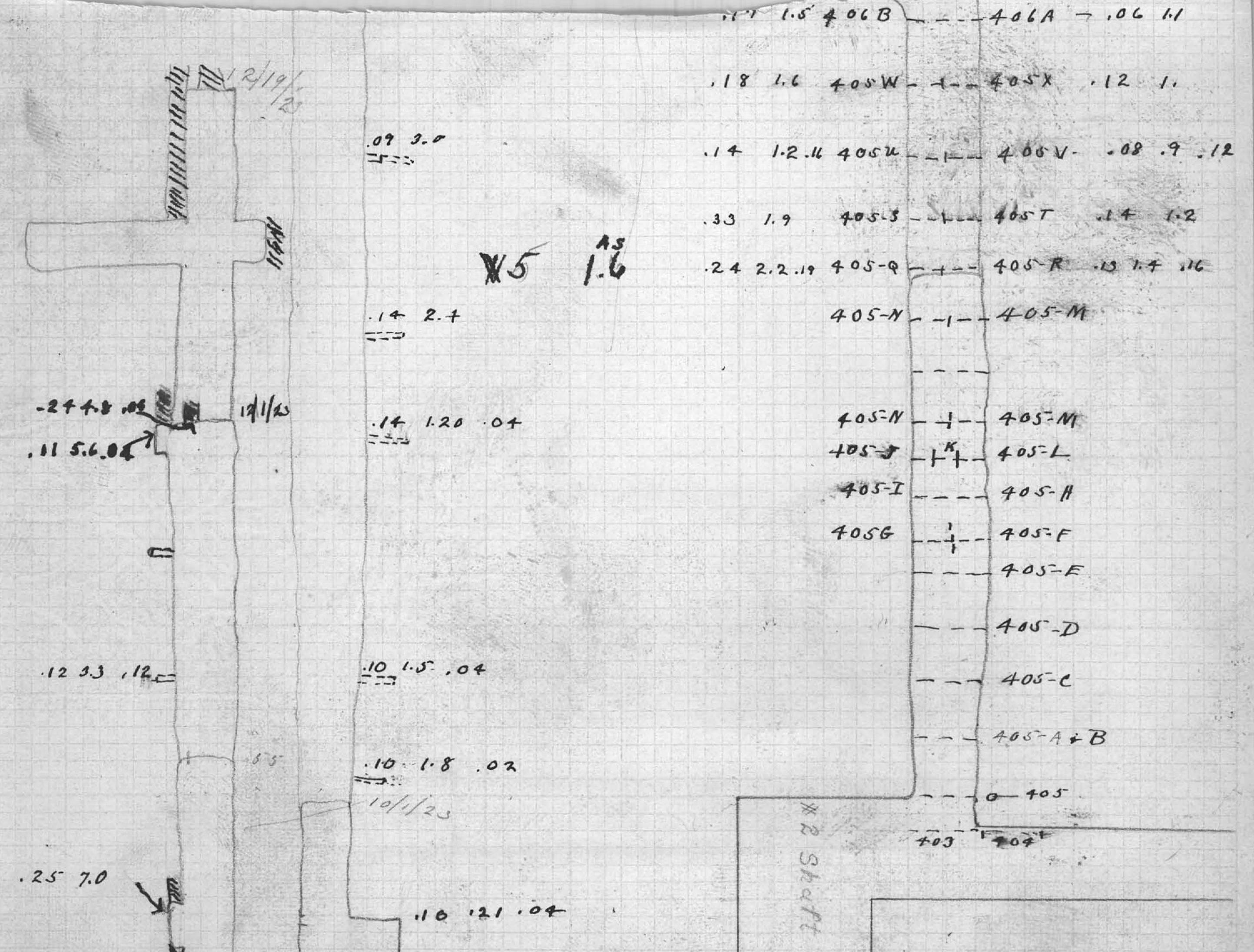
310 EX.

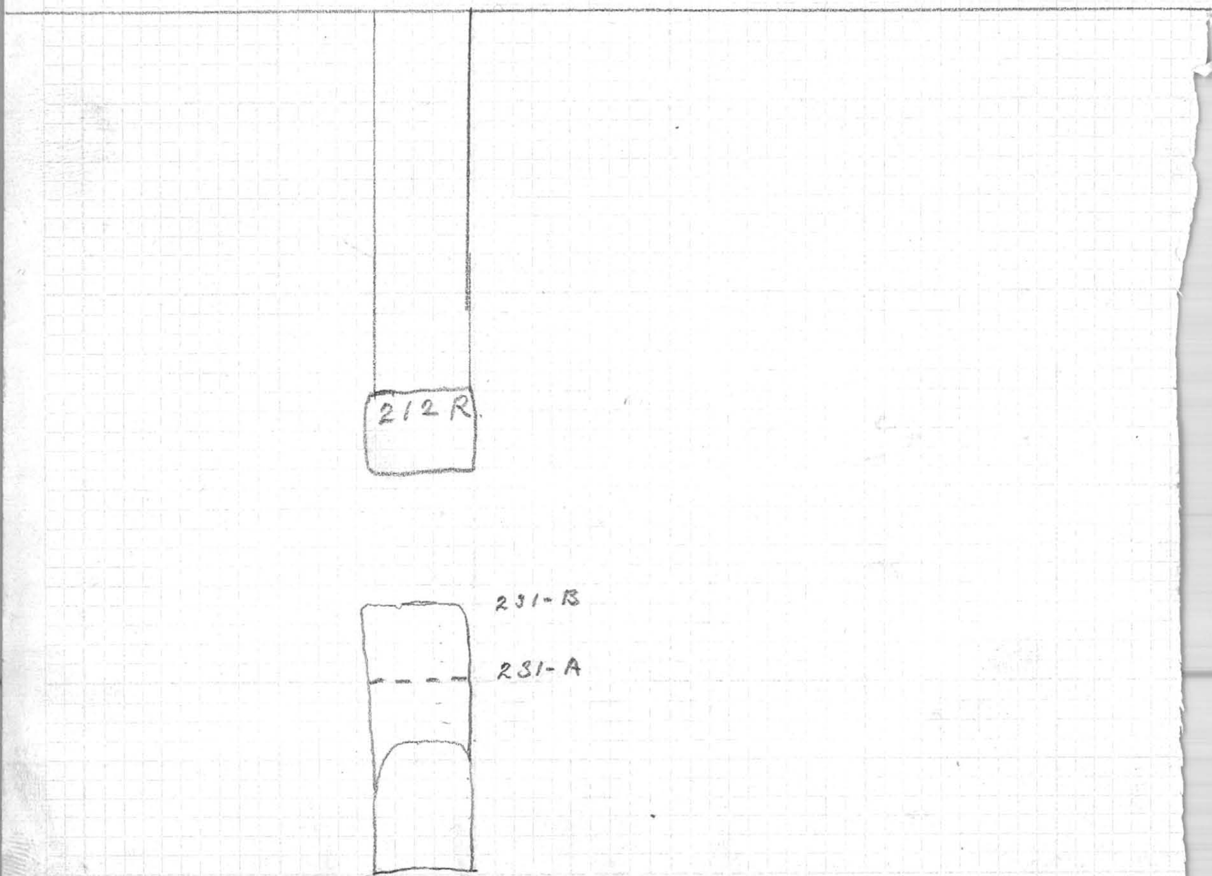



2 Veins - Ft. 2' ore, 2.1' Waste, 1.4' ore

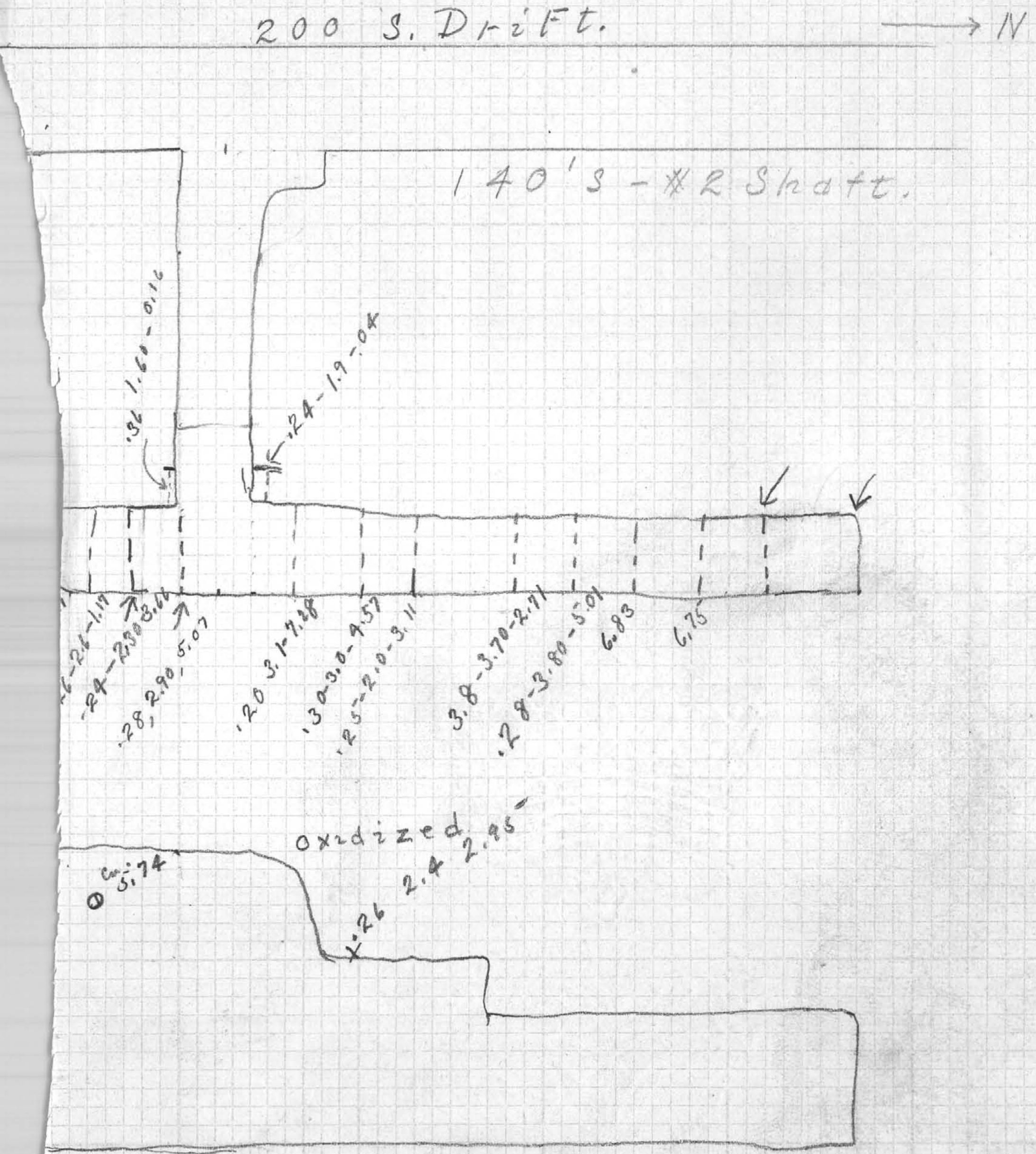
400. S. Drift.

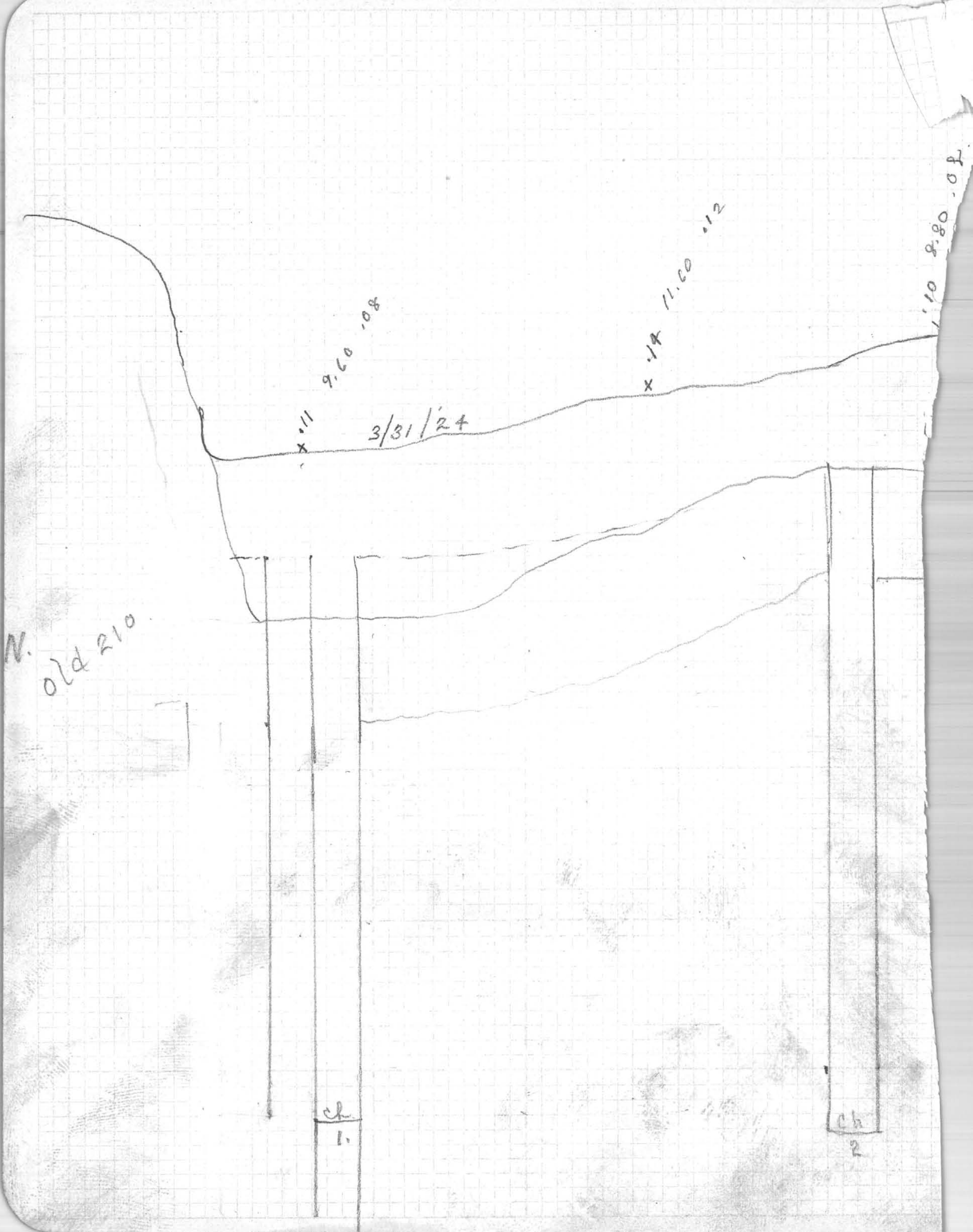

continued below
.25 4.5 .12
.09 1.2 .16
.12 2.5.12
.16 1.6 .08
.12 1.1 .12
.12 4.0 .12
.14 3.8 .08
.30 2.4 .12
.28 3.8 .12
4
6.5'
.26 3.2 .12
.20 2.4 .12
1.6 6
.21 1.5 .12
.31 3.9 .12
.37 2.4 .08
.40 3.7 .08
3
11.4
.14, 4.4
.30 3.6 .12
.36 4.0 .12
.32 3.8 .08
.32 3.5 .12
.31 3.2
.35 3.6
2
12'
11/1/23
.15 4.3 .32
.28 2.6
.28 4.9 .08
.32 2.50
408-B.
.28 2.7
1
10.7
408-A
.37 2.8
Sta. A
Drill Hole
407-A - Grab
.18 10.90
.25 1.4 .28


1.5 406B
406A → .06 1.1
.18 1.6 405W
405X .12 1.
.14 1.2 .11 405U
406V .08 .9 .12
.33 1.9 405S
405T .14 1.2
.24 2.2 .19 405-Q
405-R .13 1.4 .16
405-N
405-M
405-N
405-M
405-J
K
405-L
405-I
405-H
405G
405-F
405-E
405-D
405-C
405-A & B
405
403
404
#2 Shaft
N.
#5 1.6
As
.09 3.0
.14 2.4
.14 1.20 .04
.10 1.5 .04
.10 1.8 .02
10/1/23
.10 121 .04
5 2.6 S.-Sta.A
12/19/23
12/1/23
.24 4.8
.11 5.6 .04
.12 3.3 .12
.25 7.0

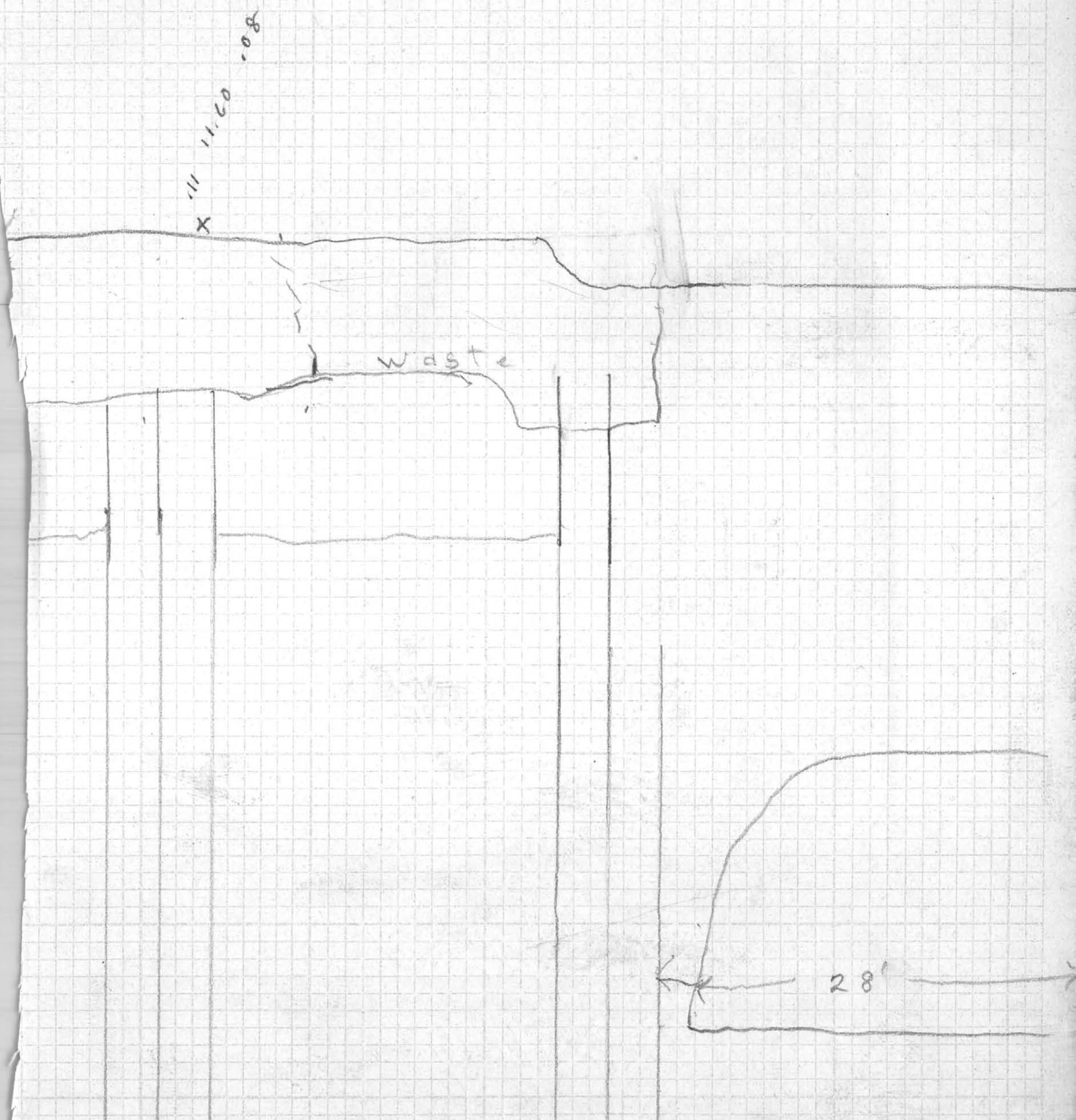

212 R
231-B
231-A

212 X Cut


200 S. Drift.
→ N
140'S - #2 Shaft.
.36 1.60 - 0.16
.24-1.9-.08
.24-2.30 8.66
.28, 2.90, 5.07
.20 3.1-7.28
.30-3.0-9.57
.25-2.0-3.11
3.8-3.70-2.71
.28-3.80-5.01
6.83
6.75
oxidized
2.4 2.95
x.26
Cu 5.74


N.
old 210
x .11 9.60 .08
3/31/'24
x .14 11.60 .12
Ch
1.
Ch
2

210 Ext.



Pitch of top of slope 20°
me Cl admit [illegible]

S 45° E

l 30' & for pitch

22' w [illegible] dip

N 50 E for 105

& 45' S, 55 W

Then [illegible] 9' w [illegible]

[illegible]

[illegible] 50 E

d 13.5

&

S 50° W.

d 19' on [illegible]

[illegible]

Card [illegible] Mtg [illegible]

20' [illegible] f8 & Ball

Bring Card [illegible]

[illegible]

[illegible]

---

[illegible] a / [illegible]

3 dys [illegible] / [illegible]

[illegible]

---

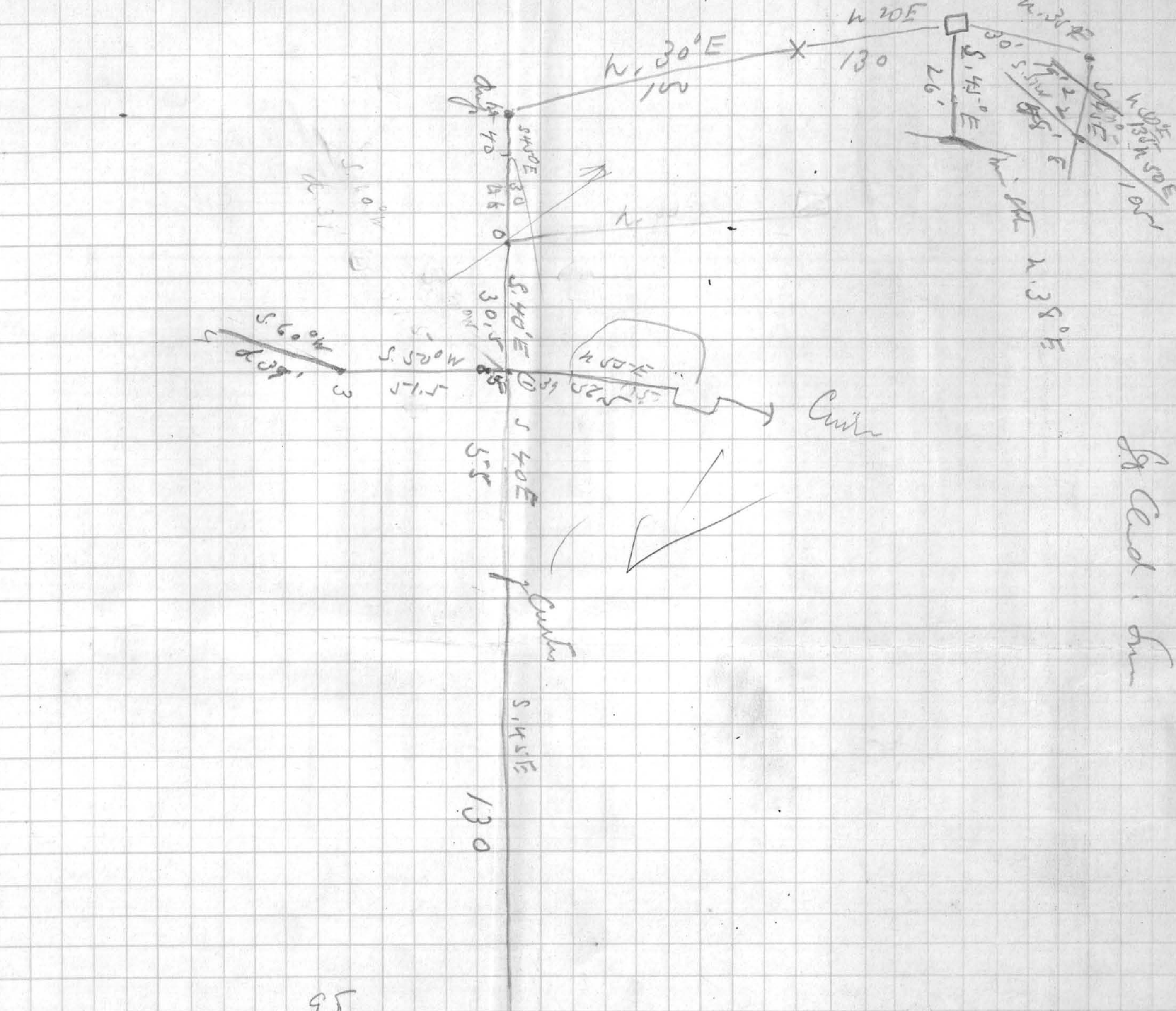
[illegible] El [illegible]

[illegible]

[illegible]

Send [illegible] Club 4 [illegible]

[illegible]



N. 30°E
100
N 20E
130
S. 60°W
S. 52°W
51.5
S. 40°E
S. 45°E
130
N. 75°E
40
S. 45W.
N. 45E
95
54
58'
252'
N. 55E
56.5
10
15

# Survey Notes

## Storm Cloud Lower workings. 6/18. 37

O, on Lion adit dump.
O to 1, (portal of Lion adit, S. 45°E d = 40'
(10' to toe of slope)

To Then first Shaft.
O to X N 30°E. d. 100'
X to S.W. corner of shaft N 20E d/ 130'

Shaft (north corner) to the Clem vein in surface
S. 45°E, d. 26'
Strike of the Clem vein = N. 38°E

fm N.e corner of shaft N. 35°E dist 30'
to edge of the Clem shaft
Shaft is 9'x5' (long way Ne-SW.

North corner of shaft to the Clem adit portal
N 35°E dist 30'.

McClean adit, Portal to breast S. 45°E, d. 30'

Breast back to McClean vein drift 8',
drift N 50 E, 105' & S. 55 W. 48'

McClean drift & ~~other~~ Harlan drift 13'
Harlan drift N. 50°E drift 13.5'
" " S. 50° W. " 19'

Harb drift to portal 9'
Ore stoped in Harlan, [inserted: bottom] drift for length of 15' & to
depth 4', dip of vein 80° toward cliff