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Item 19

Papers Relating

TO THE

Geology, Mining, Metallurgy and Milling

OF THE

Comstock Orebodies of The United Comstock Mines Company

Prepared on the Occasion of the 126th Meeting
of the
American Institute of Mining and Metallurgical Engineers
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LIST OF PAPERS

The Geology of the United Comstock Mines

Gold Hill, Storey County, Nevada

By WILBUR H. GRANT *

The property of The United Comstock Mines Company lies in the east foot-hills of the Sierra Nevada Mountains. It is in the Washoe Mining District of Storey County, Nevada, where the famous Comstock Lode is situated. The property covers the south end of the Lode, commencing at the boundary line between Virginia City and Gold Hill, covering all the town of Gold Hill and extending south to American Flat. It is on American Flat that the main camp, or the new town of Comstock, the mills, shops, residences of employees, and the main haulage tunnel portal are situated.

PROPERTY

The property of The United Comstock Mines Company extends for a total length of about 10,300 feet along the Lode. This covers the south end of the main Comstock Lode, the Knickerbocker branch, and the junction of the Silver City branch with the Comstock Lode. Within the property, 5,000 feet of the main Comstock Lode is known to have been productive. Only 1,000 feet of the Lode at the north end of the property is thoroughly developed and 1,000 feet south of this is partially developed. This leaves about 3,000 feet of the known productive portion which has not been opened up by this company.

The north end of the property, or the Imperial mine, has been intricately developed by five main levels and numerous sub-levels. The Yellow Jacket ground to the south has been partially developed by the reopening of three old levels.

In addition to the above, the main haulage level is driven from the portal at Comstock for a total distance of 9,250 feet to the north end of the property. About 5,500 feet of this is in the footwall of the lode and parallel to it.

GENERAL GEOLOGY

Government geologists and engineers have determined at least fourteen rocks composing the country of the Washoe district. Of

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these, three are sedimentary, one is metamorphic igneous, five are essentially effusive or surface flow rocks and five are intrusive. Two of the intrusives are granitic and three are porphyritic. All of these are in a complicated relationship to each other. The exact relation of them is difficult to determine on account of the intense alteration by mineralizing solutions and surface leaching in the vicinity of the lodes. If a detailed study of the andesites, which have been differentiated by previous geologists, could be made, it is possible that several of them might be proved to be only phases of the same andesite.

This rock complex was fractured in a general North-South direction along three fairly well defined zones and these fractured zones subsequently intruded by mineralizing solutions. There is also a branch southeast of the Belcher Mine to Silver City, which is called the Silver City branch of the Comstock Lode. Another extends southwesterly from the Belcher and is called the Knickerbocker branch. The junction of these two is taken roughly to be the south end of the main Comstock Lode. The first fracture system east of the Comstock lode is called the Occidental or Brunswick lode, the next farther east, the Flowery lode. By far the greatest production has come from the main Comstock Lode, less has come from the Silver City branch, still less from the Occidental lode, less still from the Flowery lode, and least of all from the Knickerbocker branch.

The fissure zones in which the lodes form do not strike north-south in a straight line, but are composed prevailingly of two components. The average strike of one of these is N 45 E and one N 30 W. These components cause the lode to form in a twisted course, which has a resultant direction of magnetic north, or about N 14 E (astronomic), as exposed on surface.

As shown by development with depth, the main Comstock Lode tended to form along a true fault fissure with a northerly strike and an average dip of 43 degrees to the east. Branching up vertically from this prevailing portion of the Lode there were fractures into which ascending solutions penetrated and deposited some of the bonanza orebodies. The great Consolidated Virginia bonanza was one of this type. The outcrop of the Comstock Lode is a variable mineralization and replacement of the shattered rock in the wedge between the normal fissure and one of these vertical branches.

IMPERIAL MINE

As has been suggested, the ore in the Imperial mine has been developed above the main level in the wedge between the 43 degree easterly dipping Comstock Lode and a vertical branch. Instead of being perfectly vertical, it develops a crescent shape and forms a sharp east wall to the ore. At surface this east wall dips westerly; at a depth of about 300 feet it is vertical; below this it gradually bends into the normal 43 degree dip to the east. A pronounced fault gouge up to 10 feet or more in thickness follows this east wall of the ore. In the lower levels this gouge is dry and hard, while near surface it is wet and soft. The values grade to an uncommercial product westerly, so there is no sharp limit to the ore in that direction. This is an important feature in mining as any dilution of the ore by the caving in of the west wall will not reduce the grade of the general average perceptibly, as the west wall carries some values. The wedge continues to be mineralized back westerly to the main 43 degree easterly dipping footwall. In this portion some strong quartz with fair values has been found.

Only one rock has been found in the Imperial ground. This is an andesite which is highly altered by the mineralizing solutions and surface leaching. On the whole the mineralization is so intense that the original character of the andesite cannot be determined, but occasionally it is recognizable. Surface leaching appears to bring out the original character of the andesite where it has been thoroughly silicified. Some of the crosscuts back into the footwall show partly mineralized extrusive andesite breccia and some andesite tuff.

The gangue minerals are essentially quartz and calcite, the former prevailing. This mineralization varies from solid white quartz to stock work veinlets, to silicified andesite, to recognizable andesite altered by mineralizing solutions and leaching. All these types grade into each other but they are sufficiently distinct to enable a geologist to map four different classes of mineralization. These classifications are stope fills, rock in place more than half quartz, silicified andesite, and recognizable andesite somewhat silicified. There is no fresh andesite in the Imperial workings, but it is found farther removed from the mineralized zone. Associated with the primary gangue minerals are oxidized minerals, such as sulphates, consisting—in order of their abundance—of epsomite, gypsum, melanterite and lesser amounts of sulphates of manganese, aluminum, and copper, also kaolin and oxides of iron and manganese. On account of the low-grade character of the ore, metallic minerals are not easily recognizable. Pyrite is the most common with some argentite, halloids, and metallic silver. Most of the secondary metallic minerals are within 500 feet of surface, but even here they are intermixed with remnants of the primary sulfides.

From the portal to a point where the main haulage tunnel crosses the Knickerbocker branch of the Comstock Lode it is entirely within andesite, which is fairly fresh and gray to purplish brown in color. In crossing the Lode, the tunnel exposed only weak mineralization in soft,

Claims of Consolidated Imperial Group

	Tons (2,000 lbs.)	Average Value	Production
Imperial	223,047	$23.42	$ 5,224,672.75
Bacon	22,846	24.99	570,931.25
Empire	162,164	21.05	3,414,594.12
Eclipse	3,174	25.65	81,431.04
Trench			
Empire South			
Plato	797	19.71	15,728.47
Bowers	4,795	17.36	83,245.95
Piute			
J. Winters			
Consolidated	11,831	42.65	504,561.49
Consolidated Imperial	37,787	15.42	583,012.49
Challenge	1,943	22.56	43,839.05
Confidence	10,470	20.74	217,217.28
Burke & Hamilton	1,008	28.22	28,465.99
Totals and Average	479,862	$22.44	$10,767,699.88
Yellow Jacket Group			
Yellow Jacket	443,747	$29.29	$12,998,170.82
Kentuck	142,289	34.47	4,905,271.01
Crown Point	815,605	36.84	30,049,673.50
Belcher	702,236	46.52	32,672,166.29
	2,103,877	$38.32	$80,625,281.62
Segregated Belcher	4,961	$20.44	$ 101,466.81
Overman Group			
Trojan	12,810	$11.27	$ 144,392.81
Overman	77,623	18.18	1,411,489.06
Totals and average	90,433	$17.20	$ 1,555,881.87
Grand totals and average	2,679,133	$34.73	$93,050,330.18

PRODUCTION OF COMSTOCK MINES UP TO 1880, By BECKER

wet ground. A strong flow of warm water was encountered, which has continued uninterruptedly to date. This warm mine water is a valuable asset for milling, especially during the winter.

Farther along, after making the turn to a drift parallel to the Lode in the footwall, the tunnel pierced a complex of andesite intrusive into limestone and shale. The limestone was somewhat metamorphosed and silicified. This tunnel, therefore, will not only afford an exit for the ore, but furnishes warm water for mill operations and it is possible that sufficient limestone may ultimately be found which will contain enough soluble lime when calcined to be satisfactory for mill use.

In Monograph III, U. S. G. S., Becker has compiled the production of the principal Comstock mines up to June 30, 1880, including most of the mines now owned by The Comstock Mines Company. The valuable metals produced are practically all gold and silver. He has figured the value of gold at $20.67 and silver at $1.2929.

This compilation, submitted herewith, shows a total recorded bullion production of over $93,000,000. If there are added to this amount the production since 1880, which is relatively small, and the estimated unrecorded production, and this sum is converted to gross instead of bullion value, there will undoubtedly have been more than $100,000,000 produced from the ground now owned by this company.

It is interesting to note the proportions of the gold and silver in the ores of these mines.

	U. C. M. Co.		Becker	
	Gold	Silver	Gold	Silver
Consolidated Imperial	28.1%	71.9%	42.9%	57.1%
Yellow Jacket	31.0	69.0	31.9	68.1
Crown Point	31.5	68.5	42.5	57.5
Belcher	57.0	43.0	56.7	43.3
Lambert Tunnel	51.0	49.0		

The average grade of ore which has been produced from these mines is as follows:

Imperial Group	$22.44
Yellow Jacket	29.29
Kentuck	34.47
Crown Point	36.84
Belcher	46.52
Segregated Belcher	20.44
Overman	17.20
Average	$34.73

The above tables show that the grade of ore and gold content increase southerly from the Imperial mine. They reach their highest value at the Belcher mine and then both decrease as far as ore has been mined southerly. Statistics show that the highest proportion of silver in any ore shoot was usually found near the surface, the proportion of gold to silver increasing with depth. This need not, however, modify the above deduction, as both surface and deep ore are included in the production from each mine. For convenience of operation and to take advantage of the metal market, development and mining will progress from the Imperial ground southerly.

It has been found that the best grade of ore is in the old fills and much of the walls of the old stopes can now be mined at a profit. It is anticipated, therefore, that practically all of the ore to be mined above the main haulage level will be in the vicinity of the old stopes and that there will be barren stretches along the lode between these low-grade bodies. It is inconceivable that all bonanza pockets have been discovered and mined. Small pockets of such good ore will be taken out with the other ore by the method of mining that has been selected.

FUTURE POSSIBILITIES

A geological study of the property indicates that three-fifths of the length of the Lode within the property, which has been productive in the past, still remains to be developed above the main haulage level, with small possibilities on the branch veins above this horizon.

There is recorded in the history of the old operations that there are exposed bonanza orebodies below the main haulage level, which were abandoned on account of mine fires, etc., and never recovered. There is about 1,000 feet vertical distance between the main haulage level and the Sutro Tunnel, which contains the above described unmined portions of discovered bonanzas, and which has some possibilities of developing other small bonanza bodies and large bodies of fills and low-grade vein material, such as have already been developed in the Imperial workings above the main haulage tunnel.

There are indefinite possibilities below the Sutro Tunnel level. In Bulletin 735c, U. S. G. S., entitled "Bonanza Ores of the Comstock Lode", Edson S. Bastin concludes, after a detailed microscopic study of the ores, that: "Although the occurrence in the deep portions of the lode of orebodies comparable in size and richness to the great bonanzas of the past is not to be expected, yet the primary origin of some of the rich ores offers encouragement for deep development."

This in a few words gives a general survey of the geology of the United Comstock mines. There are many phases of the geology which might be elaborated upon and made of considerable interest to scientists, and other features which would be of great interest to mining investors. On account of the limited length of this paper, an endeavor was made to balance the essential features of each.

The mean ore shows about 15 pounds of salts per ton. On a 2000-ton milling basis the daily entry of salts to the mill will be 15 tons.

The tabulated analysis requires but brief review. The amounts of ferrous iron and manganese sulfates are serious with reference to the chemical consumption of cyanide. Indeed on several levels the amount of these salts would render the cyanide process impractical unless they were removed. The sulfates as a whole cause very high lime consumption and the aluminates with magnesium hydrates, formed by such reactions with lime, gelatinate and mingle with the ore and thereby seriously impair the settling, thickening and filtering properties of the ore pulps.

In a very general way the salts content of the ores increases with depth. The surface ores are lower in salts content and appear to have been leached downward.

As might be expected the ore is gypseous and mill solutions in this district are always saturated with reference to calcium sulfate.

TREATMENT

With this brief review of the ore properties I will now attempt a general description of our process designed to meet the various conditions described.

The ore is to be dry crushed to four mesh size, at which point the soluble matter in the ore is quickly and easily dissolved in warm water. This crushing is followed with a brief replacement wash in simple mechanical classifiers, using a minimum amount of warm mine tunnel water. The washing produces a filterable slime overflow and a sand discharge, which quickly drains to from 10 to 14 per cent moisture. The slimes are screened to remove wood and sent direct to thickeners where the aluminum sulfate and magnesium sulfate, dissolved out of the ore, act as flocculants and cause fairly rapid settlement of the slimes. The foul water in the thickener overflow is used in sluicing out the mill tailings.

The washer discharge sands are sent direct to regrinding units where the first contact of the ore with cyanide solution takes place.

The primary slime removed in the washing presents the most formidable metallurgical problem. It represents from 10 to 13 per cent of the total ore weight, and averages 50 per cent higher in value than the head ore. It is from 25 to 50 per cent true Brownian slime. The manganiferous ochres concentrate therein, accounting for its higher silver value, and it therefore represents our most refractory product. It is the highest cyanide consuming portion of the ore even after perfect washing. When overflowed at the washers at 80 mesh it is filterable, yet further grinding fails to yield higher solubility of the metals. When overflowed finer than 100 mesh, filteration becomes difficult and impracticable.

The thickened primary slime is sent to leaf type filters, where a loading of from three to four pounds of dry slime per square foot of filter surface can be made in from 28 to 30 minutes. The cakes thus made are washed, then transferred to stock mill solution and the retained moisture displaced with cyanide solution. Due to the higher initial cyanide consumption of this slime, a displacement of filtrate solution is obtained, very low in cyanide but high in value. This solution is precipitated and then discarded. The amount of displacement with mill solution is carried to a point which balances the moisture entry into the mill circuit, due to the moisture left in the washed ore from the washer's discharge. After replacement the cakes are discharged, pumped to agitators where the pulp receives preliminary treatments and from there it joins the secondary slimes in treatment, which will be described later.

The washed four-mesh ore, after regrinding, is deslimed in solution in bowl classifiers, which yield an overflow of secondary slimes and a deslimed discharge, which is sent to table concentrators. The secondary slimes are sent to thickeners and the discharge thereof, combined with the primary slimes, receive ordinary slime agitation treatment, solution replacements and filtration on leaf type filters before being discharged as tailings.

The tables produce a concentrate, which is sent to the concentrate treatment plant, a middling and concentrate to be returned for regrinding and a sand tailing, which is sent to the leaching plant. Hydraulic classification produces graded sands ahead of the tables and also cleanses the sands of any slime that might have escaped the bowl classifiers. The leaching sands are therefore doubly protected from the entry of slime.

The leaching plant operation will be ordinary, with possibly the added requirement of blowing the sands with low pressure air, similar to Homestake practice. The Comstock ores greedily absorb oxygen and it is evident that the soluble oxygen requirement of solutions is unusually important.

The concentrate treatment will consist of very fine grinding of the concentrate in a ball peb-mill, followed by classification of the ball-peb mill discharge on table concentrators. Only the finest slimed concentrate will thus succeed in passing to the concentrate treatment plant settlers. The middling and concentrate from these concentrators are returned for regrind. The thickening and agitation of the slimed concentrate will be continuous and cyanide strengths up to twenty pounds per ton of solution will be used. The plant is flexible, allowing three direct charges of solution. The concentrate offers little difficulty to direct treatment. Perhaps here a little lead salt, there a little mercury salt, combined with fine grinding, strong solution and moderate solution temperatures, is all that is required. Mercury will be introduced into the mill solutions with the working up of Gold Canyon Dredge sands with the concentrate. The presence of mercury is entirely desirable and beneficial.

After concentrate treatment the concentrate pulp is discharged to the regular slime plant and it receives its filtration and elimination in the tailings, mixed with the general slimes.

GENERAL

A general summary of the foregoing processes shows that in treatment the ore is split into six products, each product receiving a treatment peculiar to its needs, or is eliminated from treatment as the case may be:

Product	Approximate per cent of total ore by weight	Approximate relative value per ton ore heads taken as unity	Remarks
(1) Wood pulp	.30	None	Eliminated in washing
(2) Salts (with water of crystallization)	1.50	Trace	Eliminated in washing
(3) Primary slime	10 – 13	1½	Special treatment
(4) Secondary slime	30 – 50	½	Ordinary slime tr't
(5) Sands	40 – 60	¹/₅	Leached
(6) Concentrate	2 – 4	20	Special treatment

It is evident that the washing out of the primary slime removes from the grinding plant the usual high dissolution normally made in grinding, and this increases materially the dissolution effected in agitation and thickening. Advantage is taken of this feature in removing from the settling and agitation circuits the higher grade solution for precipitation. Before precipitation, however, this solution is passed through the leaching plant and concentrate treatment plant, thus stepping it up quite high in value before it enters the precipitation process.

Clarification is effected in part in the leaching plant and in part with baskets of filter leaves, which are separate but standard units, integral with the regular filter plant. The Crowe Vacuum process will be installed.

Melting will be conducted in an oil fired reverberatory furnace, similar to Mexican practice. The furnace will have a movable hearth and the wet, but fluxed, precipitate will be changed from cars through the roof of the furnace, thus reducing to a minimum the handling of precipitate.

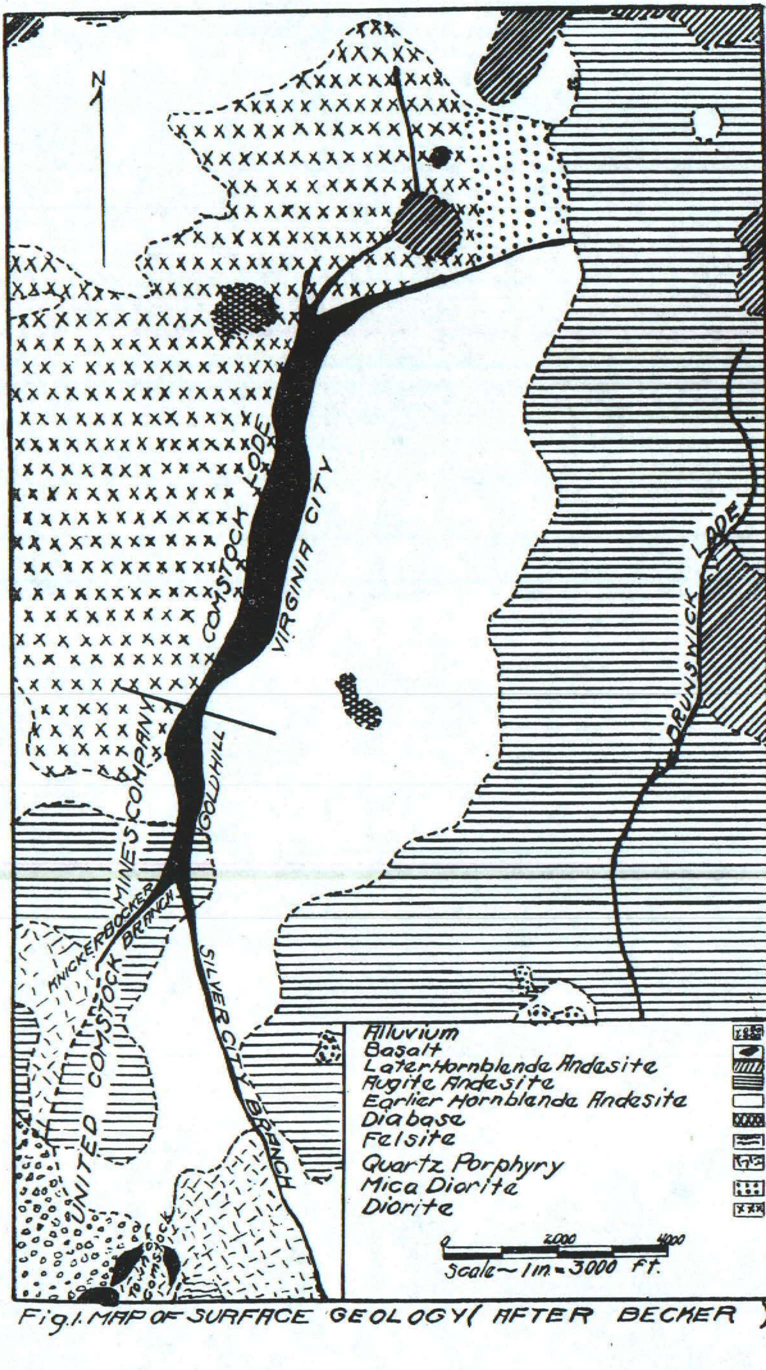


Fig. 1. MAP OF SURFACE GEOLOGY (AFTER BECKER).

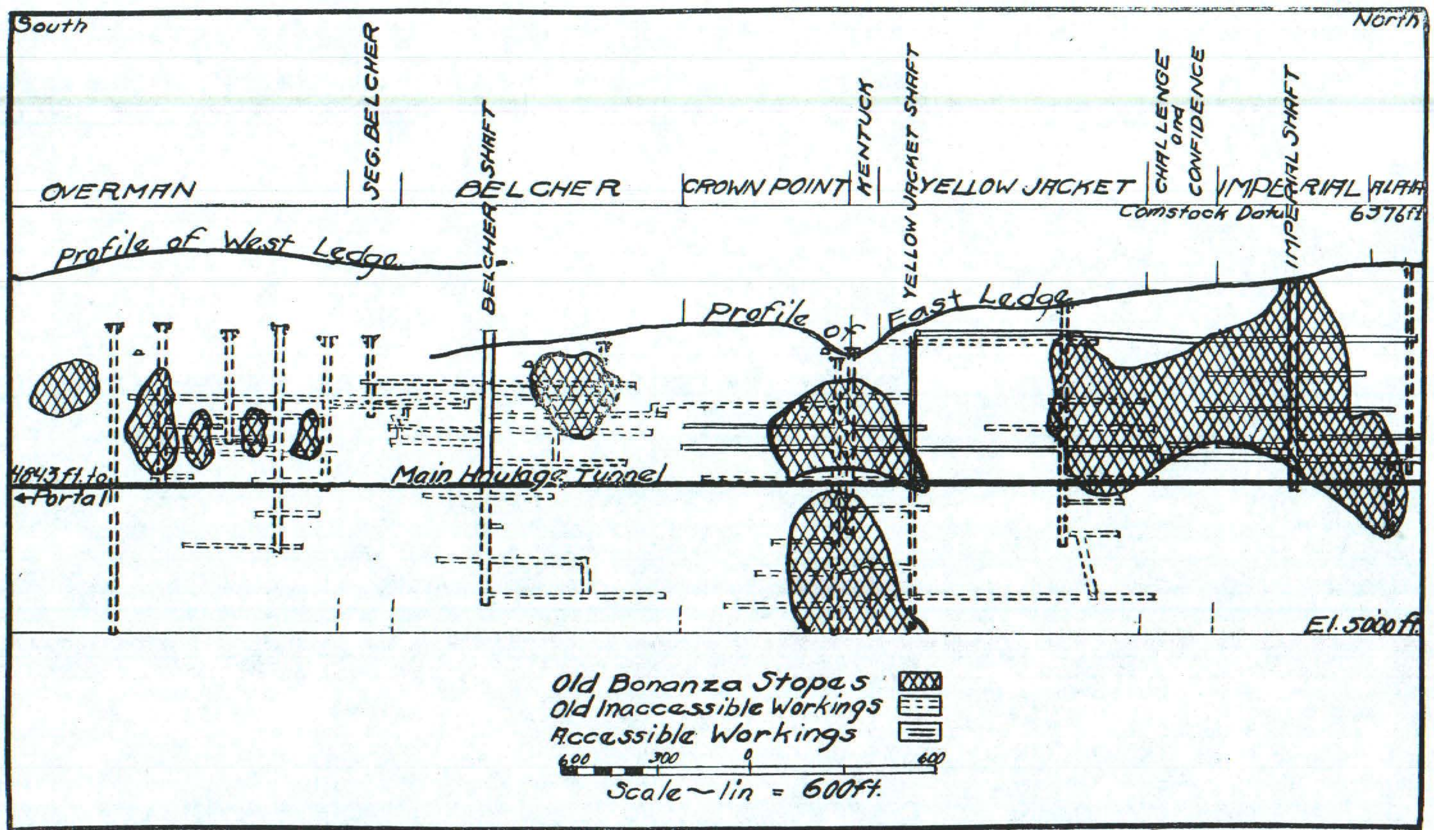


Fig. 2. LONGITUDINAL PROJECTION SHOWING OLD STOPES.

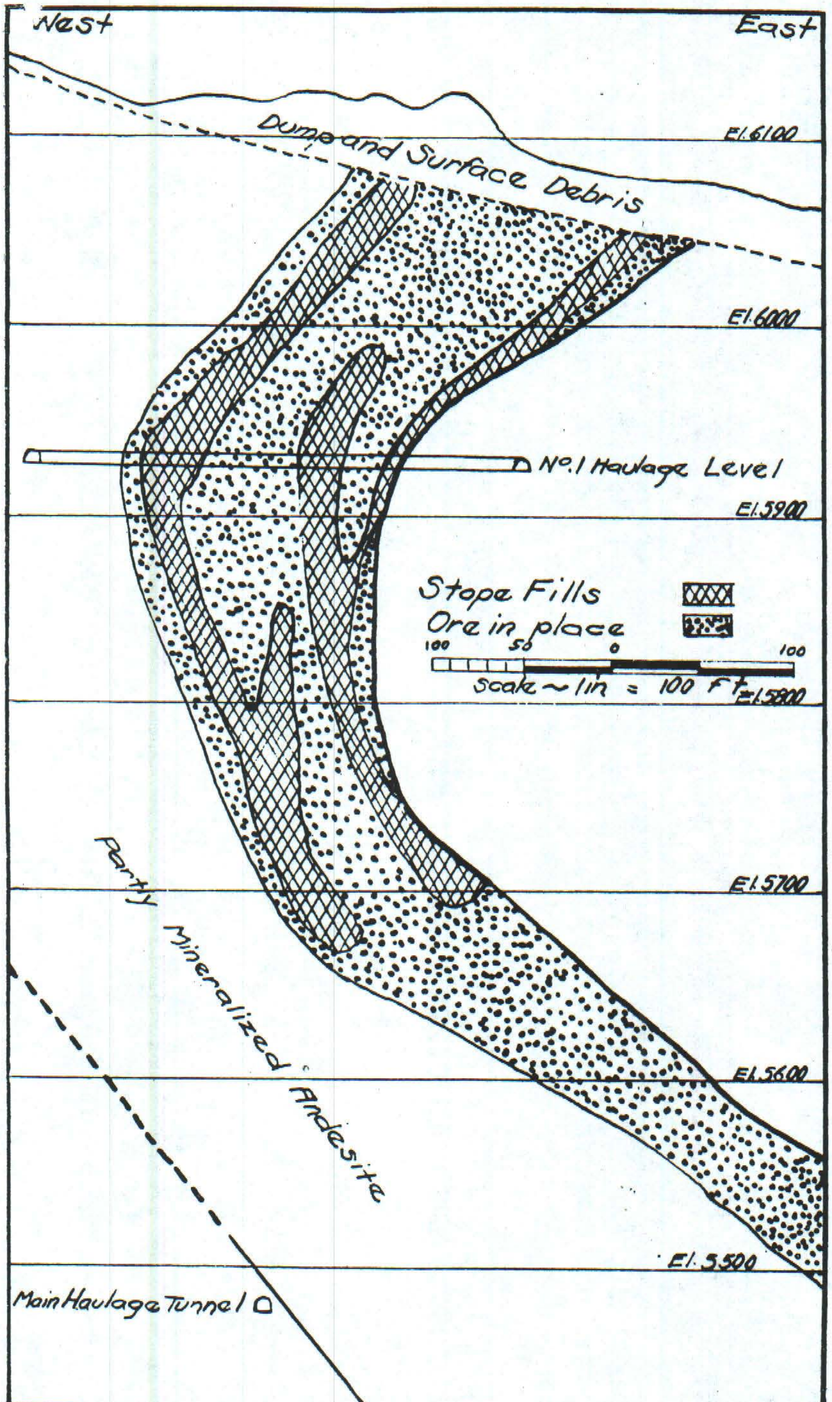


Fig 3. TYPICAL CROSS SECTION THRU IMPERIAL ORE BODY.

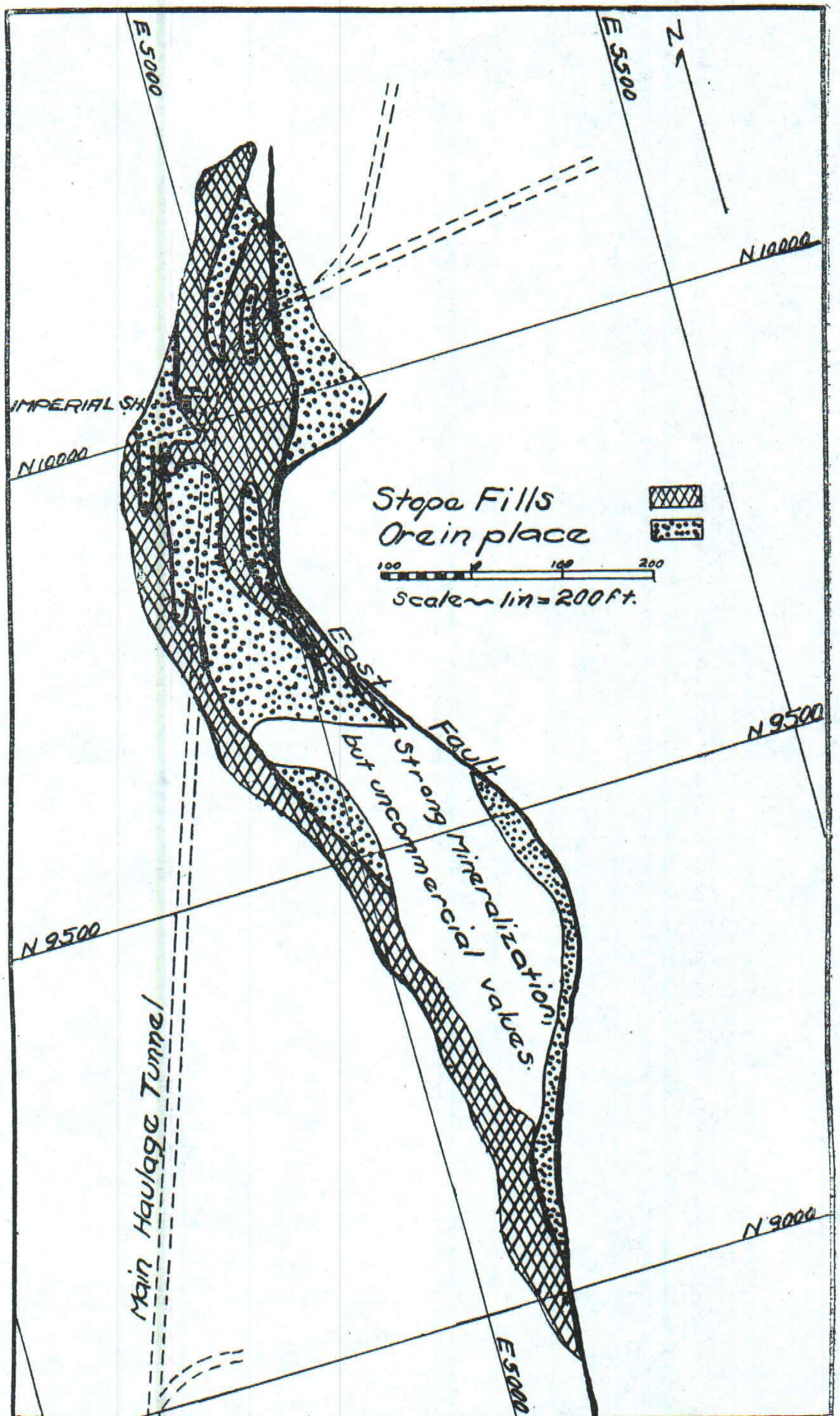


Fig 4. TYPICAL PLAN THRU IMPERIAL ORE BODY.

An Outline of the Proposed Mining Methods of the United Comstock Mines Company

By JOHN R. REIGART *

The property of The United Comstock Mines Company, at Gold Hill, Storey County, Nevada, consists of the so-called Gold Hill group of mines on the Comstock Lode. It embraces all that portion of the lode from the old Alpha mine, at the north end of Gold Hill southerly through the Globe group of claims, northwest of American Flat. Development work to date has been confined almost exclusively to the extreme northern portion of this area, namely the Yellow Jacket and Imperial groups, and this paper will deal with the mining methods planned for this section. The mill is situated on the east side of American Flat and is approximately two miles south of Gold Hill. A new town, known as Comstock, has been established there.

GEOLOGY

The selection of a method of development and mining has been directly dependent on the geological conditions which prevail within the area of operations. The lode proper in this section is a faulted zone, striking slightly east of north, in andesite. The vein consists of quartz and andesite which has been more or less completely replaced by silica. From an elevation of about 5,750 feet, downward, the vein dips 40 to 50 degrees to the east; above this elevation it steepens until at an elevation of 5,900 feet it is almost vertical. From the Yellow Jacket shaft northerly for 900 feet it continues vertically through to the surface. The attached section through crosscut No. 5 illustrates the general conditions which exist in this area. North of this point, or north of No. 12 crosscut, there is an overturn in the vein, and the vertical portion gradually bends to the east until a point is reached where the dip is as much as 45 degrees to the west. This condition is illustrated by Cross-section No. 3, which is through No. 14 crosscut.

In the vein there were several parallel enrichments which formed the bonanza veins originally mined, and now exist as ore-filled stopes. The westerly enrichment, commonly referred to as the "West Vein", and the easterly one, called the "East Vein", at various points merge into one. Where they do not, the intervening ground carries value

* Superintendent of Mines, The United Comstock Mines Company.

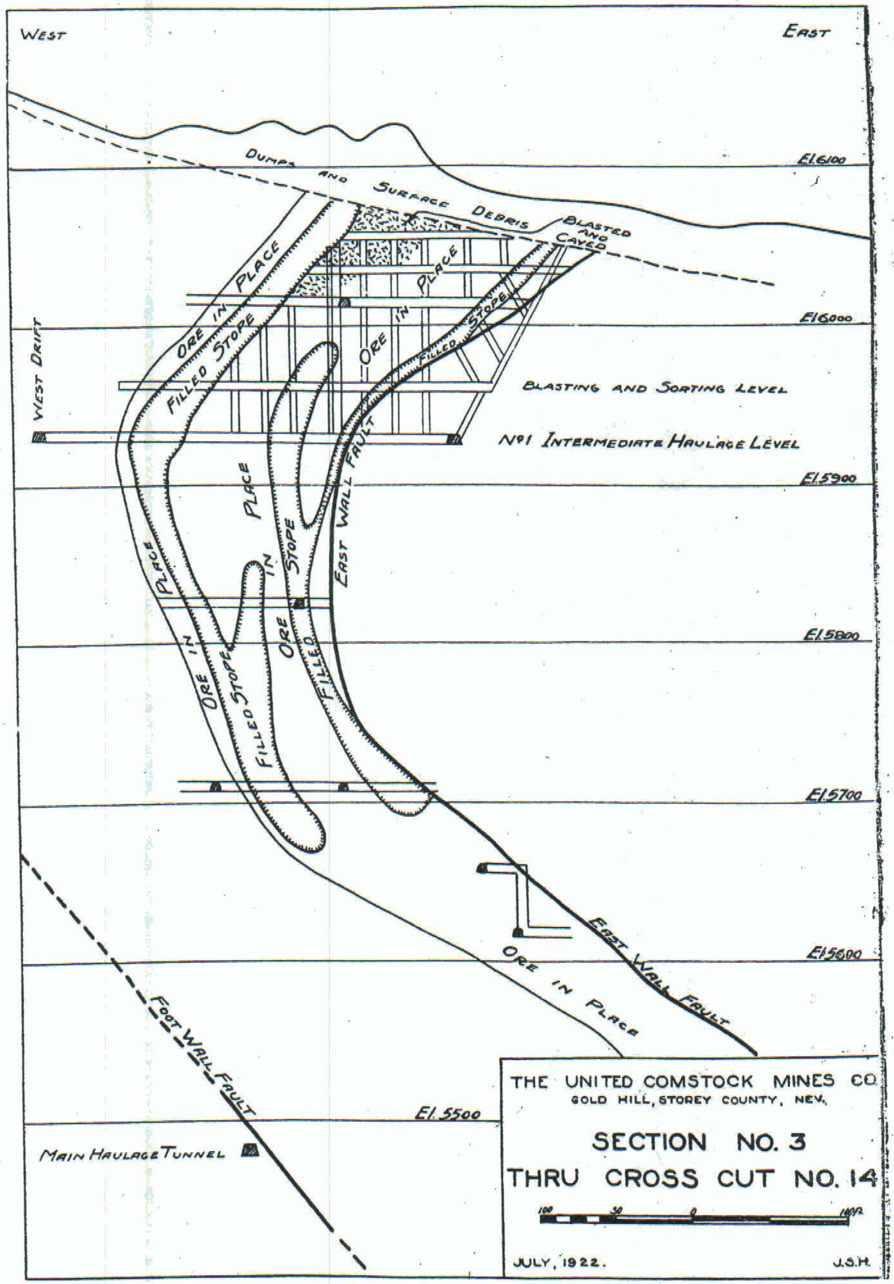
which will permit all or portions of it to be mined. The mineable portions are adjacent to the old stopes, forming a stope casing of varying widths.

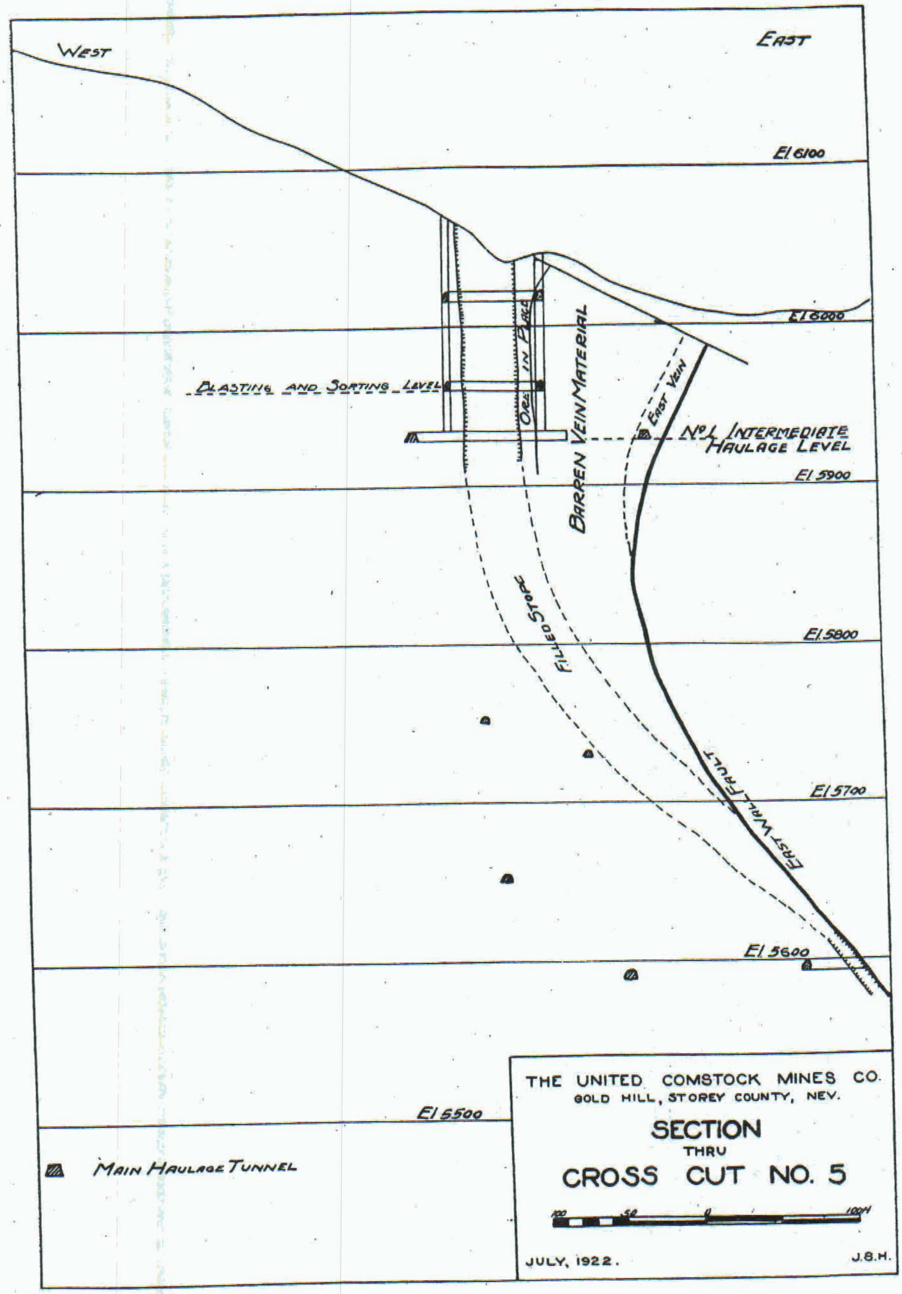
The wall west of the West vein, is an altered andesite, locally kaolinized, and containing an intricate network of small clay seams. On the east, the quartz is bounded by a distinct fault, marked by a band of dense, blue clay, beyond which the andesite is thoroughly shattered, highly kaolinized, and contains numerous clay seams. Both the east and west country rock adjacent to the lode require substantial timbering for either drifting or raising. Where dry, the ground gives little trouble after the timber is in, but the presence of even a small amount of moisture causes swelling and necessitates the use of top and side bridging and spiling.

HAULAGE LEVELS

To deliver the ore to the mill a tunnel was driven in the footwall, or west wall, sufficiently near the lode so as not to make crosscutting to it excessive, and at the same time far enough away to avoid its being endangered by subsequent mining operations. This tunnel is 9,250 feet from the portal to the north end and has a cross-section of 8 ft. x 8 ft. 6 in. in the clear. The first 3,500 feet was in ground requiring little or no timbering, but from this point in, with the exception of a few short stretches, the tunnel had to be timbered. At the north end, the tunnel is 700 feet below the surface and approximately 1,000 feet above the Sutro Drainage Tunnel level. It is run on a 0.5% grade in favor of the load and a ditch has been carried on the west side for its full length. All the water passing through this ditch will be diverted to the mill. The equipment consists of 60-lb. rail, laid to 30-inch gauge, and solid bottom cars, of ten-ton capacity, which will be handled by two eight-ton trolley locomotives operated in tandem. The cars will be dumped at the mill coarse-ore pocket by a rotary dumper, operated by compressed air and handling four cars at a time.

To mine the ore above the elevation of the Main Haulage tunnel, three intermediate haulage levels will be driven, dividing, vertically, the area to be mined into four sections. These three intermediate haulage levels will be from 175 to 190 feet apart. The upper haulage level is now being driven, as it is the ore above this that will be first attacked. This level is an adit at an elevation of 5,930, which is the elevation of the collar of the Yellow Jacket shaft. This fact has aided the speed with which the development work could be carried on, as it gave an outlet on the surface near the Yellow Jacket shaft, and obviated the necessity of doing a great deal of the work through shafts.


West
East
Dumps and Surface Debris
Blasted and Caved
El.6100
El.6000
El.5900
El.5800
El.5700
El.5600
El. 5500
Ore in Place
Filled Stope
Ore in Place
Filled Stope
East Wall Fault
West Drift
Blasting and Sorting Level
No1 Intermediate Haulage Level
Place
Ore in Place
Filled Stope
Ore in Stope
Filled
Ore in Place
East Wall Fault
Foot Wall Fault
Main Haulage Tunnel
THE UNITED COMSTOCK MINES CO.
GOLD HILL, STOREY COUNTY, NEV.
SECTION NO. 3
THRU CROSS CUT NO. 14
100
50
0
100ft
JULY, 1922.
J.S.H.


West
East
El 6100
El 6000
Ore in Place
Barren Vein Material
East Vein
Blasting and Sorting Level
No. 1 Intermediate Haulage Level
El 5900
Filled Stope
El 5800
East Wall Fault
El 5700
El 5600
El 5500
Main Haulage Tunnel
THE UNITED COMSTOCK MINES CO.
GOLD HILL, STOREY COUNTY, NEV.
SECTION
THRU
CROSS CUT NO. 5
100
50
0
100 Ft
JULY, 1922.
J.B.H.

ORE PASSES

To drop the ore from the upper haulage level to the Main Haulage level, ore passes "C", No. 5, No. 15, and No. 19 are being driven between these levels. Their locations are shown on the accompanying plain view. These are 9 x 8 ft. over all and divided into a chute compartment and manway. The manway is 2 ft. x 6 ft. 4 in. in the clear and the chute compartment 4 ft. 6 in. x 6 ft. 4 in. in the clear. All are cribbed with 10 x 10 timber and between the cribbing 10 in. blocks have been driven, with the ends projecting into the chute compartment 3 to 4 in. beyond the line of the cribbing. These blocks are designed to protect the cribbing from wear. On the manway side of the chute, port holes with covers are provided every 10 or 15 feet, for barring in case the ore should hang up.

DEVELOPMENT AND MINING

The accompanying plan shows the method of developing the upper haulage level and the location of the raises through which the ore as mined will be transferred to this level. The ore from the raises will be transferred to the ore passes by two-ton Granby type cars and storage battery locomotives. It will be seen from the plan view that the general layout of this level consists of two drifts, one on the west side and one on the east side of the orebody. From the west, or footwall drift, crosscuts are turned off every 55 feet and on the northern end connect through to the east, or hanging wall, drift. All of the ore passes from the main haulage tunnel connect with the footwall drift.

A sub-level is being opened up 25 feet above the first haulage level, and all raises are driven to this sub-level. They are then offset the width of the raise and continued through to the surface, on the south end, and to the hanging wall, where possible, on the north end. Grizzlies are to be installed over these raises at this sub-level, and all large chunks will be blasted here. The timbers from the old stopes will also be removed and handled at these same grizzly chambers.

The southern portion of the orebody will be mined as a milling pit as long as the side walls will stand to permit using this method with safety. The portion to the north will be blocked out starting 25 feet below the top of the ore, in pillars approximately 25 feet square. These are to be drilled and blasted, but only sufficient ore drawn off to permit working on the unmined pillars. As this work is going on, a second sub-level, 25 feet below, will be developed, on which the same process will be carried out. This will give 50 feet of broken ore up to the hanging, and an endeavor will be made to maintain this thickness of broken ore to protect against dilution in subsequent mining. It is expected that the next or 3rd. sub-level can be carried down 35 feet, 50 feet, or farther, and drawing off from the old stopes and the new pillars will then be regulated by the amount which can be taken and still keep the top of the ore horizontal. The southern portion, which will first be mined as a milling pit, will later be attacked along the same lines.

The ore must be drawn as evenly as possible and to do this much the same system as is in use at one of the porphry coppers will be followed. This embraces the making of frequent cross-sections, and in estimating the ore in place, and by regulating the daily product from the various raises to keep the top of the ore as nearly level as possible.

The methods outlined above will undoubtedly have to be modified in various ways to meet conditions as they arise.

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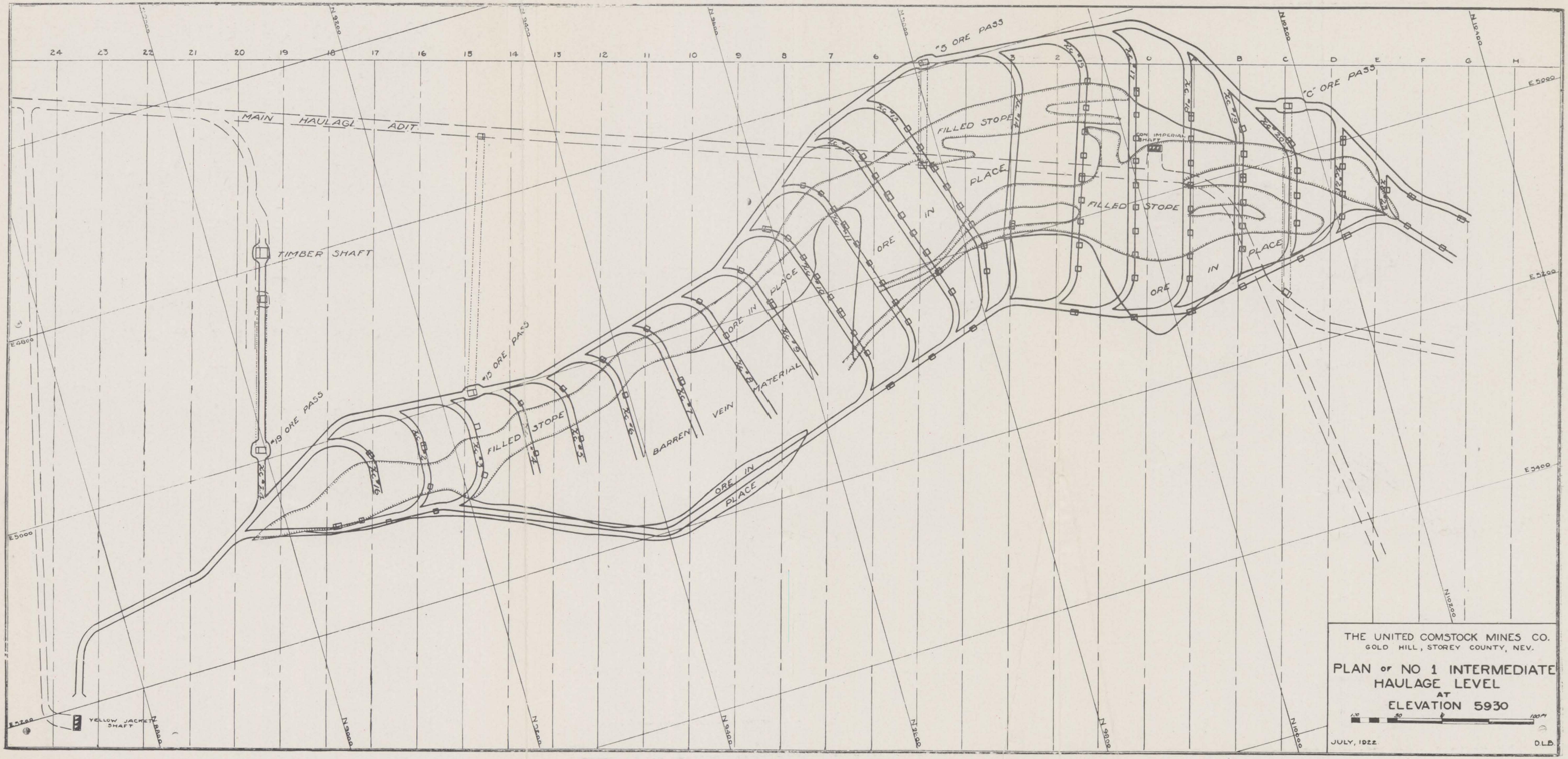


MAIN HAULAGE ADIT
TIMBER SHAFT
#19 ORE PASS
#15 ORE PASS
#5 ORE PASS
"C" ORE PASS
FILLED STOPE
FILLED STOPE
FILLED STOPE
ORE IN PLACE
ORE IN PLACE
ORE IN PLACE
ORE IN PLACE
ORE IN PLACE
BARREN VEIN MATERIAL
CON IMPERIAL SHAFT
YELLOW JACKET SHAFT
E 4800
E 5000
E 5200
E 5400
THE UNITED COMSTOCK MINES CO.
GOLD HILL, STOREY COUNTY, NEV.
PLAN OF NO 1 INTERMEDIATE
HAULAGE LEVEL
AT
ELEVATION 5930
JULY, 1922
D.L.B.

18

A General Study of United Comstock Metallurgy

By A. J. Weinig *

The ores now developed and considered for delivery to the United Comstock Mills are to be derived from depths under 700 feet from the surface and will be obtained in part from mine fills, containing timber in all stages of preservation, and in part from the mining of virgin ore.

The haulage tunnel, which intercepts the ore deposit, has developed some warm water of sufficient purity for milling purposes.

NATURE OF THE ORE

In general the average ore may be classified as an oxidized quartzose vein matter, containing a variable amount of clays and ochres and some valuable sulfides and other minerals. The valuable metals are essentially gold and silver, existing in a ratio of about one of gold to forty of silver, by weight. The ores contain a large amount of organic matter and are rather unusual in that inorganic salts are also present in abundance.

The ores vary from soft to very hard, but as a mean they possess a high coefficient of grinding resistance. This is reflected in a practical way in that local operating mills are motored for two horsepower per ton daily capacity for crushing and grinding equipment alone.

The settling and thickening properties of the ore are usually good, provided the ore is naturally free of soluble constituents or has been washed free of them. Local operating mills manage well with five square feet settler area per ton of ore per day on clean or washed ore, even when grinding to 200 mesh.

The sulphides are mainly pyrite with smaller amounts of argentite and its alteration products, which usually contain copper. The pyrite shows irregular inclusions of alabandite, argentite, quartz, gypsum, gold and silver. The free metal inclusions are very small and exist as minute skeleton forms in crystallites and microlites. The inclusions of argentite are both irregular and in crystal form. Pyrite is often entirely enclosed in gypsum crystals. Indeed crystalline pyrite has been observed even in stalactites and stalagmites com-

* Superintendent of Mills, The United Comstock Mines Company.

posed of water soluble salts that have leached from the ore and deposited in the mine drifts.

The gold exists in the ore almost entirely free, though alloyed with considerable silver and some copper. Allusion has already been made to its association with pyrite, but gold also exists in the interstices of the quartz crystals as minute spongy grains, very often containing numerous irregular inclusions of quartz, all of which frequently show extinction together when under the polarizing microscope.

The silver with the quartz exists mainly as argentite and its derivatives. Some silver is free, usually in wire form, some is present as chloride and some traces are soluble under conditions which might lead one to believe it combined as sulfate.

Silver, in an insoluble form associated with manganiferous ochres, is present, but mainly so in surface ores where peroxidations are most pronounced. Some of this silver is rendered soluble with simple selective reduction treatment and some is relentlessly unyielding until all of the manganese has been reduced and the ore completely bleached.

CONTENT OF IMPORTANT SALTS

The large amounts of soluble matter in the ore are mainly due to the presence of the sulfates of iron, manganese, zinc, copper, sodium, potassium, calcium and magnesium, with some rare earths in very small amounts. The accompanying analysis, made by Mr. M. F. Coolbaugh,* shows in a general way the more important salts content of the ores from the various mine horizons. The level number roughly indicates the depth of the horizon below the ground surface. The amounts of constituents are represented as pounds per ton of ore.

Analysis of ore by M. F. Coolbaugh, showing content of important salts.

Pounds per ton of ore Constituents	Surface Tunnel Yellow Jacket	360 Level Yellow Jacket	200 Level Imperial	300 Level Imperial	400 Level Imperial	470 Level Imperial
$FeSO_4$	.054	1.206	2.724	2.580	3.428	6.80
$Al_2(SO_4)_3$	.014		.630	1.032	.844	1.340
MSO_4		.0614	.802	.1260		.786
$MnSO_4$	.124	.445	1.522	.566	.626	1.136
$CaSO_4$	.700	9.304	4.758	3.050	4.322	4.186
$MgSO_4$	1.300	5.180	6.638	5.664	6.854	11.928
$CuSO_4$		Trace	Trace	Trace	Trace	.020
Total solids	2.234	16.282	16.218	12.426	15.700	26.062
Total water	25.800	20.420	31.400	16.600	17.400	29.800

* Manager Research Department, The Metals Exploration Company.

The mean ore shows about 15 pounds of salts per ton. On a 2000-ton milling basis the daily entry of salts to the mill will be 15 tons.

The tabulated analysis requires but brief review. The amounts of ferrous iron and manganese sulfates are serious with reference to the chemical consumption of cyanide. Indeed on several levels the amount of these salts would render the cyanide process impractical unless they were removed. The sulfates as a whole cause very high lime consumption and the aluminates with magnesium hydrates, formed by such reactions with lime, gelatinate and mingle with the ore and thereby seriously impair the settling, thickening and filtering properties of the ore pulps.

In a very general way the salts content of the ores increases with depth. The surface ores are lower in salts content and appear to have been leached downward.

As might be expected the ore is gypseous and mill solutions in this district are always saturated with reference to calcium sulfate.

TREATMENT

With this brief review of the ore properties I will now attempt a general description of our process designed to meet the various conditions described.

The ore is to be dry crushed to four mesh size, at which point the soluble matter in the ore is quickly and easily dissolved in warm water. This crushing is followed with a brief replacement wash in simple mechanical classifiers, using a minimum amount of warm mine tunnel water. The washing produces a filterable slime overflow and a sand discharge, which quickly drains to from 10 to 14 per cent moisture. The slimes are screened to remove wood and sent direct to thickeners where the aluminum sulfate and magnesium sulfate, dissolved out of the ore, act as flocculants and cause fairly rapid settlement of the slimes. The foul water in the thickener overflow is used in sluicing out the mill tailings.

The washer discharge sands are sent direct to regrinding units where the first contact of the ore with cyanide solution takes place.

The primary slime removed in the washing presents the most formidable metallurgical problem. It represents from 10 to 13 per cent of the total ore weight, and averages 50 per cent higher in value than the head ore. It is from 25 to 50 per cent true Brownian slime. The manganiferous ochres concentrate therein, accounting for its higher silver value, and it therefore represents our most refractory product. It is the highest cyanide consuming portion of the ore even after perfect washing. When overflowed at the washers at 80 mesh it is filterable, yet further grinding fails to yield higher solubility of the metals. When overflowed finer than 100 mesh, filteration becomes difficult and impracticable.

The thickened primary slime is sent to leaf type filters, where a loading of from three to four pounds of dry slime per square foot of filter surface can be made in from 28 to 30 minutes. The cakes thus made are washed, then transferred to stock mill solution and the retained moisture displaced with cyanide solution. Due to the higher initial cyanide consumption of this slime, a displacement of filtrate solution is obtained, very low in cyanide but high in value. This solution is precipitated and then discarded. The amount of displacement with mill solution is carried to a point which balances the moisture entry into the mill circuit, due to the moisture left in the washed ore from the washer's discharge. After replacement the cakes are discharged, pumped to agitators where the pulp receives preliminary treatments and from there it joins the secondary slimes in treatment, which will be described later.

The washed four-mesh ore, after regrinding, is deslimed in solution in bowl classifiers, which yield an overflow of secondary slimes and a deslimed discharge, which is sent to table concentrators. The secondary slimes are sent to thickeners and the discharge thereof, combined with the primary slimes, receive ordinary slime agitation treatment, solution replacements and filtration on leaf type filters before being discharged as tailings.

The tables produce a concentrate, which is sent to the concentrate treatment plant, a middling and concentrate to be returned for regrinding and a sand tailing, which is sent to the leaching plant. Hydraulic classification produces graded sands ahead of the tables and also cleanses the sands of any slime that might have escaped the bowl classifiers. The leaching sands are therefore doubly protected from the entry of slime.

The leaching plant operation will be ordinary, with possibly the added requirement of blowing the sands with low pressure air, similar to Homestake practice. The Comstock ores greedily absorb oxygen and it is evident that the soluble oxygen requirement of solutions is unusually important.

The concentrate treatment will consist of very fine grinding of the concentrate in a ball peb-mill, followed by classification of the ball-peb mill discharge on table concentrators. Only the finest slimed concentrate will thus succeed in passing to the concentrate treatment plant settlers. The middling and concentrate from these concentrators are returned for regrind. The thickening and agitation of the slimed concentrate will be continuous and cyanide strengths up to twenty pounds per ton of solution will be used. The plant is flexible, allowing three direct charges of solution. The concentrate offers little difficulty to direct treatment. Perhaps here a little lead salt, there a little mercury salt, combined with fine grinding, strong solution and moderate solution temperatures, is all that is required. Mercury will be introduced into the mill solutions with the working up of Gold Canyon Dredge sands with the concentrate. The presence of mercury is entirely desirable and beneficial.

After concentrate treatment the concentrate pulp is discharged to the regular slime plant and it receives its filtration and elimination in the tailings, mixed with the general slimes.

GENERAL

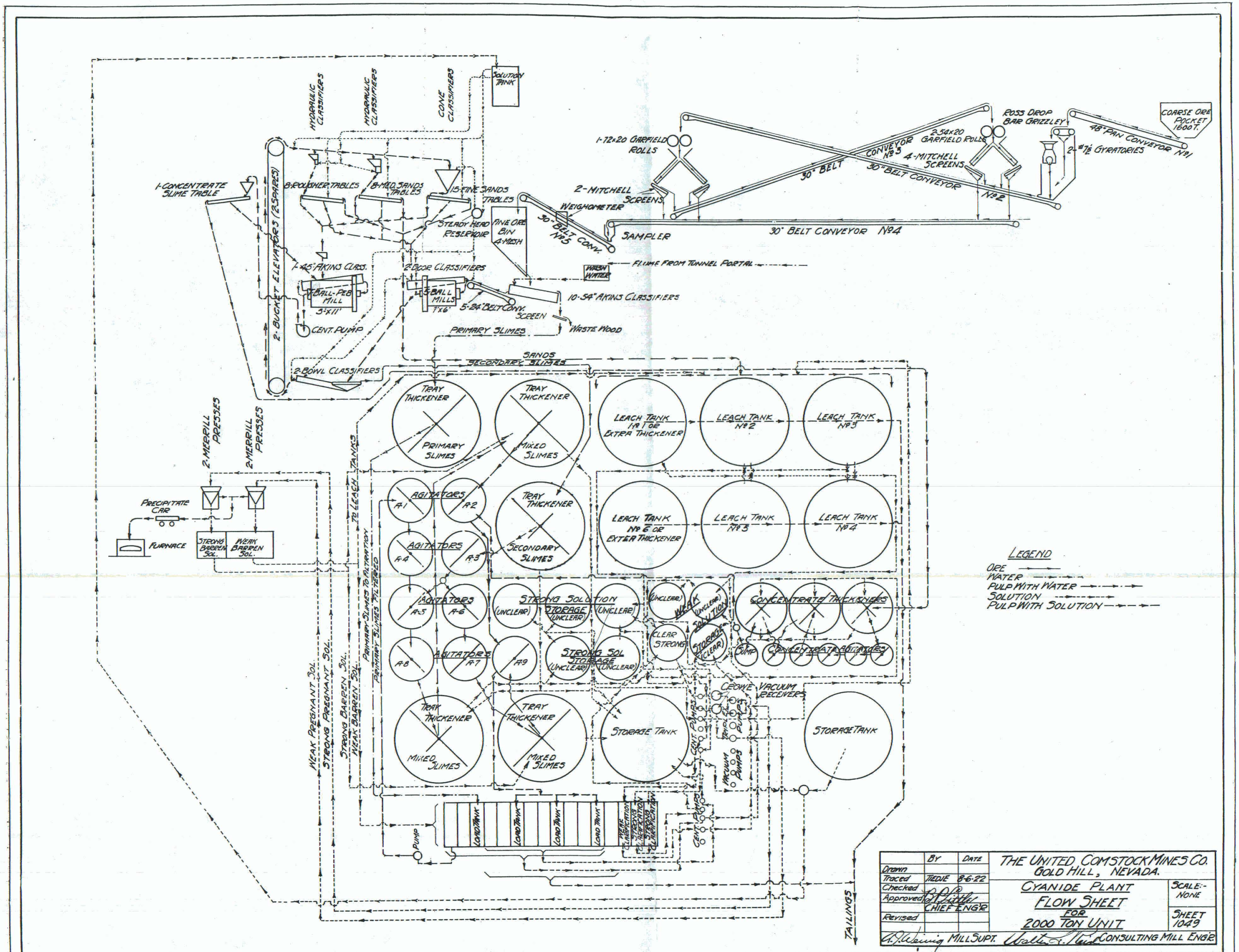
A general summary of the foregoing processes shows that in treatment the ore is split into six products, each product receiving a treatment peculiar to its needs, or is eliminated from treatment as the case may be:

Product	Approximate per cent of total ore by weight	Approximate relative value per ton ore heads taken as unity	Remarks
(1) Wood pulp	.30	None	Eliminated in washing
(2) Salts (with water of crystallization)	1.50	Trace	Eliminated in washing
(3) Primary slime	10 – 13	1½	Special treatment
(4) Secondary slime	30 – 50	½	Ordinary slime tr't
(5) Sands	40 – 60	⅓	Leached
(6) Concentrate	2 – 4	20	Special treatment

It is evident that the washing out of the primary slime removes from the grinding plant the usual high dissolution normally made in grinding, and this increases materially the dissolution effected in agitation and thickening. Advantage is taken of this feature in removing from the settling and agitation circuits the higher grade solution for precipitation. Before precipation, however, this solution is passed through the leaching plant and concentrate treatment plant, thus stepping it up quite high in value before it enters the precipitation process.

Clarification is effected in part in the leaching plant and in part with baskets of filter leaves, which are separate but standard units, integral with the regular filter plant. The Crowe Vacuum process will be installed.

Melting will be conducted in an oil fired reverberatory furnace, similar to Mexican practice. The furnace will have a movable hearth and the wet, but fluxed, precipitate will be changed from cars through the roof of the furnace, thus reducing to a mininum the handling of precipitate.


THE UNITED COMSTOCK MINES CO.
GOLD HILL, NEVADA.
CYANIDE PLANT
FLOW SHEET
FOR
2000 TON UNIT
SCALE:- NONE
SHEET 1049
BY
DATE
Drawn
Traced TIEDIE 8-6-22
Checked
Approved
CHIEF ENG'R
Revised
MILL SUPT.
CONSULTING MILL ENG'R.
COARSE ORE POCKET 1600 T.
48" PAN CONVEYOR Nº1
2-#7½ GYRATORIES
ROSS DROP BAR GRIZZLEY
2-54x20 GARFIELD ROLLS
4-MITCHELL SCREENS
30" BELT CONVEYOR Nº2
30" BELT CONVEYOR Nº3
1-72x20 GARFIELD ROLLS
2-MITCHELL SCREENS
WEIGHOMETER
SAMPLER
30" BELT CONVEYOR Nº4
30" BELT CONV. Nº5
FLUME FROM TUNNEL PORTAL
WASH WATER
FINE ORE BIN 4-MESH
10-54" AKINS CLASSIFIERS
SCREEN
WASTE WOOD
5-24" BELT CONV.
3-BALL MILLS 7'x6'
2-DOOR CLASSIFIERS
STEADY HEAD RESERVOIR
15-FINE SANDS TABLES
8-MED SANDS TABLES
8-ROUGHER TABLES
CONE CLASSIFIERS
HYDRAULIC CLASSIFIERS
HYDRAULIC CLASSIFIERS
SOLUTION TANK
1-CONCENTRATE SLIME TABLE
2-BUCKET ELEVATORS (2 SPARES)
1-45" AKINS CLASS.
BALL-PEB MILL 5'x11'
CENT. PUMP
PRIMARY SLIMES
SANDS
SECONDARY SLIMES
2-BOWL CLASSIFIERS
TRAY THICKENER
PRIMARY SLIMES
TRAY THICKENER
MIXED SLIMES
LEACH TANK Nº1 OR EXTRA THICKENER
LEACH TANK Nº2
LEACH TANK Nº3
AGITATORS
A-1
A-2
TRAY THICKENER
SECONDARY SLIMES
LEACH TANK Nº6 OR EXTRA THICKENER
LEACH TANK Nº5
LEACH TANK Nº4
AGITATORS
A-4
A-3
AGITATORS
A-5
A-6
STRONG SOLUTION STORAGE
(UNCLEAR)
(UNCLEAR)
(UNCLEAR)
WEAK SOLUTION STORAGE
(UNCLEAR)
(UNCLEAR)
CLEAR STRONG
(CLEAR)
CONCENTRATE THICKENERS
A-8
AGITATORS
A-7
A-9
STRONG SOL STORAGE
(UNCLEAR)
(UNCLEAR)
SUMP
CONCENTRATE AGITATORS
OLIVER VACUUM RECEIVERS
TRIPLEX PUMPS
VACUUM PUMPS
CENT. PUMPS
TRAY THICKENER
MIXED SLIMES
TRAY THICKENER
MIXED SLIMES
STORAGE TANK
STORAGE TANK
LOAD TANK
LOAD TANK
LOAD TANK
LOAD TANK
WEAK CLARIFICATION
STRONG CLARIFICATION
PUMP
CENT. PUMPS
TO LEACH TANKS
PRIMARY SLIMES TO FILTRATION
PRIMARY SLIMES FILTERED
WEAK PREGNANT SOL.
STRONG PREGNANT SOL.
STRONG BARREN SOL.
WEAK BARREN SOL.
2-MERRILL PRESSES
2-MERRILL PRESSES
PRECIPITATE CAR
FURNACE
STRONG BARREN SOL.
WEAK BARREN SOL.
TAILINGS
LEGEND
ORE
WATER
PULP WITH WATER
SOLUTION
PULP WITH SOLUTION

Design and Construction of the United Comstock Mills

By Walter L. Reid *

The United Comstock Mines Company is a subsidiary of The Metals Exploration Company. Its properties were acquired in June, 1920, and the work of designing and constructing plants for the treatment of its ores was assigned to the engineering staff of The Metals Exploration Company.

The men directly in charge of this work have been:

Walter L. Reid, Consulting Milling Engineer;

A. J. Weinig, Metallurgist;

Lee L. Fillius, Superintendent of Construction;

B. P. Little, Chief Draftsman, in charge of Engineering Office;

Robert McF. Doble, in charge of Power and Electrical Engineering.

Tests made at the instance of former owners of these properties had developed the recommendation that an all sliming in cyanide solution practice be adopted. An inspection of actual milling operations in the Comstock District, supplemented by a special mill run of 100 tons, gave rise to the belief that the prevailing practice of grinding to 90% through 100 mesh in cyanide solution was not necessary nor justified by results; and further, that this practice occasioned a too high cyanide consumption measured by the value of the ores. Laboratory tests confirmed this conclusion, and demonstrated the presence in the ores of soluble salts, which proved to be the cause of the large consumption of cyanide.

PRELIMINARY TESTS

A plant for testing 1,000 pound lots of ores was then installed at the mines. Tests there conducted demonstrated the necessity of a preliminary washing of the ores in water to remove the soluble salts before the application of cyanide solutions.

One example of the results so obtained will be of interest. Two lots of 1,000 pounds each were treated, one without preliminary washing, the second with washing of the ores before treatment by cyanide. The results were as follows:

* Consulting Milling Engineer, The Metals Exploration Company.

First Test (without washing)—

Cyanide Consumption	4.06 pounds
Lime Consumption	22.70 pounds
Extraction of values	89.0 %

Second Test (with washing)—

Cyanide Consumption	0.68 pounds
Lime Consumption	6.52 pounds
Extraction of values	91.60 %

Further tests proved that the salts were readily soluble when the ores had been reduced to all through one quarter inch mesh, thus establishing the work to be done in the dry crushing department. It was also demonstrated that fine grinding need be conducted only to pass between 16 and 40 mesh, instead of 100, materially reducing installation and operating costs. Under this practice it also proves possible to leach approximately 60% of the mill feed, and through concentration, in advance of all cyanide treatment, to concentrate approximately 40% of the values in the ores to 2½% of their original tonnage, thereby confining the extremely fine grinding to a small quantity of concentrate, which is given intensive treatment.

A full year was devoted to further ore tests, to the selection of mill equipment and to the design of necessary mill buildings. Ground was broken on July 1, 1921. The construction of the plants was considerably delayed by an unusually severe winter.

THE MILLING PLANT

The milling plant consists of the coarse crushing plant, the fine grinding and concentration plant, and cyanide plant. There are eight auxiliary buildings; the ore pocket, conveyor gallery, substation, machine shop, plate or blacksmith shop, warehouse, precipitation and refinery building, and assay office with testing plant.

The coarse crushing plant is a reinforced concrete structure throughout, 192 feet in length, 46 feet in width, and 89 feet in extreme height. It contains a pan conveyor (number one); three, 30-inch, belt conveyors, each driven by an individual motor; two Allis Chalmers No. 7½ Gates gyratory crushers; one set of Power Mining & Machinery Company, 72-inch, Garfield rolls, driven through a counter shaft by a 200 horsepower motor; two sets of 54-inch Garfield rolls, one driven through a counter shaft by a 150 horespower motor and one by a 200 horsepower motor of an older type; six Mitchell vibrating screens, and sampling plant for continuous cutting out and reduction of sample. All of these are served by one twenty-ton hand power crane, running the length of building and out to the shops and railroad spur.

Rolls and conveyors are arranged in close circuit with the Mitchell screens. The product of the Mitchell screens drops on the third belt conveyor, known as conveyor number four; this in turn is fed to number five conveyor, which runs at a right angle to number four through a conveyor gallery, 250 feet in length, thence over weightometer into fine ore bins of 3,200 tons capacity.

From the feed to number five conveyor a sample of 150 pounds will be cut at intervals of one minute, making a cut of 80 tons from each 2,000 tons. This sample is automatically fed through the sampling plant, consisting of one set of rolls and one special Vezin sampler, thus cutting the sample down to 3,000 pounds. This is retained in a bin for further reduction by rolls, thence through a Vezin sampler, followed by a sample grinder, to obtain 400 pounds of sample to be cut further by hand. The reject from the sampling plant is continuously fed to number five conveyor.

FINE GRINDING PLANT

The fine grinding plant is a reinforced concrete structure, 240 feet long, 89 feet wide and 23 feet extreme height, containing ten 56-inch Akins classifiers for primary wash to remove soluble salts; five 7 x 6 Allis Chalmers ball mills, each direct connected, through herringbone gears to a 150 horsepower motor; one 5 x 12 ball pebmill for regrinding concentrate; one small 3 x 6 ball mill for grinding lime; two Dorr classifiers for returning middling to ball mills; two 15-foot Dorr bowl classifiers; also feeder belts from bins to Akins classifiers, and from Akins classifiers to ball mills. The overflow from the bowl classifiers, consisting of the secondary limes, is sent direct to the cyanide plant thickening department.

A twenty-ton crane is arranged over the ball mills, the crane-way running over the supply yard and into the machine shop. This crane-way is at right angles to the crane-way of the coarse crushing plant, and loads can be interchanged from one crane to the other.

The upper floor of this building contains 32 Deister Machine Company Plat-o tables, which are fed by two elevators, (each arranged with a duplicate for spare) which carry the over-size from the Dorr bowl classifiers.

The tables make a concentrate which is reground by the ball pebmill in circuit with two tables and flows to the retreatment tanks. A middling is returned to the ball mills and the sand tailing flows to the leaching tanks.

The elevators lift 65 feet. They are fitted with 30 inch belts and are driven by individual 30 horsepower motors, direct connected to the elevator head shafts through a Fawcus herringbone gear speed reducer, which reduces the speed from 900 to 26 r. p. m. The gears are enclosed and run in oil, and have a flexible coupling on each side of the gear sets.

TANK HOUSE

The tank house is a steel frame building 325 feet by 296½ feet in plan, centre to centre of column lines, covering 96,600 square feet or 2¼ acres. A bay 36 feet wide extends along the west side and contains the Moore filter plant. In the remainder of the building interior columns are placed at each corner of 64 feet bays (except that exterior bays are 66½ feet). The tallest of these interior columns is 74 feet 11 inches from the bottom of the base plate to the upper gauge line of the roof truss. Intercepting main trusses extend from column to column. These carry intersecting trusses dividing each bay into three panels. This arrangement allows the use of 60-feet thickeners and storage tanks without interference from building columns. The roof is designed for a 40-pound snow load per square foot, and for a maximum wind load of 20 pounds per square foot, with 16,000 pounds per square inch maximum fiber stress in tension members, reduced in the usual ratio for compression members. The total weight of columns, roof trusses, wall girts, etc., (exclusive of Filter Bay Crane girders) is 441 tons, or a trifle less than 9.2 pounds per square foot of area. This was selected from a number of tentative designs considered as it was the most economical arrangement by over 200 tons. The roof is sheathed with 1¾ inch tongued and grooved Oregon pine, attached directly to steel purlin, and covered with 20-gauge galvanized corrugated steel. One-third of the side wall area is Fenestra steel sash, 17,500 square feet being used. The wall proper will consist of 28-gauge galvanized plain sheets attached to the steel frame. Between this and the outside wall of 24-gauge corrugated galvanized sheets will be placed two layers of tarred building paper, each layer weighing 15 pounds per 100 square foot. The sheets are fastened together at close intervals with stove bolts and galvanized rivets, and the outer sheets attached through the inner plies to the steel frame with the usual galvanized steel wire clinch nails. It is expected that this insulation will give a satisfactory radiation factor and not appreciably increase the fire hazard.

The building contains forty redwood tanks, arranged as follows: Six, 60 feet in diameter by 16 feet in depth, for leaching; five, same dimensions, fitted with trays for double deck thickener mechanisms; two, same dimensions, for solution storage tanks; nine, 30 feet in diameter by 24 feet in depth, fitted with Dorr agitator mechanism; five, 30 feet in diameter by 24 feet in depth, and four, 20 feet in diameter by 25 feet in depth, for various solution storage; also three, 35 feet in diameter by 6 feet in depth, fitted with Dorr thickener mechanism, and five, 15 feet in diameter by 20 feet in depth, fitted with Dorr agitator mechanism. The latter thickeners and agitators compose the concentrate retreatment plant. The wood sheathing in the roof and the tanks are the only wood in the plant.

The tanks rest on concrete sills placed directly on the reinforced concrete floors of the building. All pipe connections and outlets from these tanks are carried in tunnels or culverts, running under the floor, there being 2,600 feet of these tunnels. The runways or operating floors around tanks and superstructures carrying shafting and mechanisms have structural steel supports, with precast concrete slabs for floors and walkways. There are 260 tons of interior structural steel in addition to 441 tons contained in the building frame as mentioned above, making a total of 700 tons of structural steel used in the tank house. There are 46 miles, or 88 tons, of tank hoops.

The filter plant consists of 16 concrete tanks, 27 feet in length by 9 feet in width by 11 feet in depth, each with three hoppers in the bottom to insure rapidity and ease of draining. These are cast as one monolithic block. The tanks are fitted with 12 baskets, each containing 62 leaves 6 feet by 8 feet and are served by two electric cranes of 40 tons capacity. These are arranged for a complete transfer of basket from tank to tank in two and one-half minutes.

The tank house is conveniently arranged for the gravity flow of the pulp throughout, except for one transfer of the primary slime by pump (containing a minimum proportion of the granular pulp) from the filters to the agitators and so arranged as to confine practically all pumping to clear solutions. Attention has been given throughout to the application of direct connected motors, except where belt driven are more convenient of operation.

Precipitation is accomplished by the zinc dust method, using four 32 frame 52 inch Merrill presses with Crowe vacuum.

Eight miles of pipe was used in the interior of the tank house, or a total of ten miles for the mill operations through the buildings described, exclusive of the water service lines outside.

PRECIPITATION AND REFINING

The precipitation and refinery building is a reinforced concrete structure throughout, 112 feet in length, 32 feet in width and 24 feet in height, to the eaves. One-half of the first story forms two rectangular tanks; above these is the floor supporting the four Merrill presses, the remainder of the building being devoted to the refinery containing a reverberatory furnace for melting, and a vault for bullion storage. The doors and windows are guarded with heavy grate bars.

OTHER BUILDINGS

The machine shop is 32 feet high to the eaves and has a floor area of 50 feet by 30 feet. The easterly 30 feet is under the ball mill, supply yard craneway and the machine shop has a 15-ton hand power crane, on this runway, for its own use. The floor and side walls for a height of 4 to 6 feet (to window sill horizon) are reinforced concrete, above which as a reinforced concrete skeleton frame with panels mostly filled with Fenestra steel sash, a few panels being closed with corrugated galvanized steel. The shop is so arranged that work can be handled into large machines by crane.

The plate shop is separated from the machine shop by the rigging bay of the coarse crushing plant; a space 32 feet by 50 feet in which the spare roll shafts will be overhauled and fitted with new shells.

A 30-inch gauge track (mine gauge) extends lengthwise through the supply yard, machine shop, across the rigging bay and through the plate shop, and connects to the mine track system.

The plate shop is 32 feet wide, 48 feet long and 19½ feet high to the eaves. The construction is the same as that of the machine shop.

The warehouse is a solid concrete building 32 feet by 96 feet by 13 feet high to the eaves, situated on a railroad spur. It contains a storekeeper's office and is provided with cases containing 3,000 receptacles for small items of stock. There are 1,000 square feet of floor space for storage of larger items. The warehouse is surrounded by a concrete platform 8 feet in width and 4 feet above the yard level.

The assay office and testing plant is a two-story building 38 feet by 66 feet; the first story consists of reinforced concrete and contains equipment for testing, and sample grinding machinery. The second story consists of a steel frame covered with metal lath and cement plaster, inside and out. It contains the furnace room laboratory and mill superintendent's office.

The total motor installation for the 2,000 ton milling and treatment plant is 2,800 horsepower.