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Item 15

STUDENT PRIZE AWARD CONTEST

NEVADA SECTION

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

FOREWARD

At a business meeting of the Nevada Section of the A.I.M.E., held in Reno on January 26, 1938, Mr. S. Power Warren offered to furnish prizes for a contest open to student members for the best papers on mining, metallurgy, geology, or allied subjects. Later Mr. A. N. Sweet joined with Mr. Warren in furnishing the prizes.

A Committee on Student Awards consisting of William O. Vanderburg, Chairman, Joseph F. Barton, and Ott F. Heizer was appointed to draw up the rules for the contest and judge the papers.

RULES

1. Judging. The papers are to be judged by three members of the Nevada Section of the Institute on the basis of:

(a) Originality of thought
(b) General interest of subject matter
(c) Composition and skill in presentation

2. Subject Matter. It is recommended by the Committe that the papers be based on actual observations and preferably that illustrations by line drawings instead of photographs.

Manuscripts should be in duplicate, typewritten, and double spaced.

3. Eligibility. Only Student Members of the A.I.M.E. attending the Mackay School of Mines are eligible to compete. A student who has applied for memberships in the A.I.M.E. will be considered a Student Member.

4. Time Limit. The contest closes on noon April 1, 1938. All manuscripts must be delivered to the Director of the Mackay School of Mine's office on or before this date.

Six papers were entered in the contest, four Senior students at the Mackay School of Mines and two Junior students. On May 6th, the committee announced the following winners:

First Prize: Brunton Compass
"The Dayton Consolidated Mill", Martin Smythe

Second Prize: Triple Aplanatic Lens
"An Unusual Summer in Nevada Mining Districts", John Burgess

The other papers submitted were:

"The Construction and Operation of a Small Sulfide Flotation Plant in Arizona and an Engineering Analysis of the Causes for Failure of the Gold Mining Venture", by Ellis H. Gates.

"Replacement in the Silver-Gold Veins at Rawhide, Nevada", by Eugene Grutt.

"Nevada's First Successful Placer Dredge", by Martin K. Hannifan.

"Starting at the Bottom in Nevada's Rio Tinto", by Henry A. Lang.

In its report the committee made the following comment on the papers:

"Your Committee feels that all the papers are meritorious and deserving of honorable mention, and the selection of the papers for first and second place was not an easy task. The Committee feels that the preparation of the papers by the Student Members of the A.I.M.E. will be a reward in itself by affording training and skill in the presentation of engineering subjects on paper".

Mr. Vanderburg presented the prizes to the winners at a meeting of the Nevada Section in Winnemucca on May 14th.

The officers of the Nevada Section are sorry all six papers are not available to mimeograph and mail to our members. The papers by John D. Burgess and Henry A. Lang were also submitted in a contest conducted by the "Explosives Engineer" where they both received honorable mention and were retained for publication by that magazine. Mr. Lang's paper appeared in the July number and Mr. Burgess' paper is expected to be published at a later date. At the request of the officials of the Mill Gulch Placer Mining Company, Mr. Hannifan's paper was not released for publication.

I wish to thank the students who took time out of a busy school year to prepare the papers for the contest. Also, I wish to thank the Committee on Student Awards for conducting the contest and judging the papers. I am glad to take this opportinuty to again thank Mr. Warren and Mr. Sweet who, by financing the prizes, made possible the first essay contest in our section. It is my hope that the results of the contest of 1938 are sufficiently encouraging to inspire some other member or group of members to furnish prizes for a similar contest in 1939

Wm. I. Smyth
Chairman, Nevada Section

THE DA YTON CONSOLIDATED MILL

By

Martin Smythe

April 1, 1938

INTRODUCTION:

The Dayton Consolidated mill is a 150 ton all-agitation all cyanidation plant located at Silver City, Nevada. Ore from the adjacent Dayton Mine, from the Keystone mines, located a mile away, as well as some custom rock, is treated at this plant. The ore from the Dayton mine is quartzose in character, and is largly made up of siliceous rhyolite. The valuable minerals occur principally as electrum with pyrite. T he ore from the Keystone mine is also siliceous in character, the v alues occurring with pyrite.

Most of the Dayton mill machinery came from the Flowery mill which operated for six years on the Comstock. Some of the equipment used in the Flowery came originally from the old Ophir Cyanide plant, and the rest came from the Yellow Jacket mill at Gold Hill, from the Mexican mill, from Rochester, and from Tuscarora. The present mill was erected in 1934 and has been in operation ever since.

CRUSHING:

Ore is hauled to the coarse ore bin by an ore train consisting of a 13 H.P. 200 D.C. electric trolley locomotive pulling three cars each of which has a capacity of two and a ha lf tons. The train hauls ore from a 46 ton Dayton ore bin, from a 65 ton Keystone ore bin, and from a 150 ton three compartment custom ore bin. These bins are all located along the surface haulage track of the Dayton mine.

Ore is fed from the thirty ton coarse ore bin to an Allis Chalmers jaw crusher. This 24 by 15-inch crusher is driven by a Westinghouse 50 H.P. induction motor. The ore is crushed to two inch size in this primary crusher. At this point lime is added.

The material from the jaw crusher is carried to a Bulldog gyratory crusher by means of a conv eyor belt. The $4\frac{1}{2}$ by 8-inch gyratory is driven by a General Electric 30 H.P. induction motor. The ore is crushed down to a half inch size in this intermediate crusher. The half inch ore next travels to a 300 ton fine ore bin on a long conveyor belt driven by a $7\frac{1}{2}$ H.P. induction motor. The ore system from the conveyor belt is cut by a bucket elevator sampler. These buckets empty into a Vezin sampler, where the final heads sample is obtained.

CRINDING AND CLASSIFICATION:

A belt feeder conveys material from the fine ore bin to the ball mill. The rate of feed is automatically regulated by chains which hang down over the fine ore bin chute. The chains are fastened to one end of a lever which lies under the feed belt. The other end of the lever consists of a roller which partially supports the feed belt and ore. If too much material is being fed onto the belt, the weight forces the roller down, causing the other end of the lever to be lifted, and the chains to drop down slowing the rate of feed.

Grinding in cyanide solution is carried out in two stages. The primary mill is a 6 by 5 foot grate discharge, belt driven, Allis Chalmers ball mill, powered by a 100 H.P. General Electric induction motor. Nine five-inch manganese steel balls are added to the mill each shift, and 100 lbs. of litharge are added per twenty four hours.

The ball mill discharge flows to a Dorr Duplex classifier, which is 176 inches long and 54 inches wide. The classifier sands are fed back to the ball mill, and the overflow is pumped by means of a Frenier sand pump to a second Dorr classifier. Caustic soda is sometimes added to this classifier to aid in the later settling. The sands from this second classifier pass to the secondary mill which is a 25 by 5 foot tube mill powered by a 75 H.P. Westinghouse induction motor. The mill consumes about 280 lbs. of Danish pebbles per day. A Frenier sand pump elevates the tube mill discharge to the second classifier. The overflow, from this classifier, flows down to the cyanidation section of the mill. A screen analysis of the overflow follows:

	Mesh	% Weight	Cumulative % Weight
Plus	48	1.2%	1.2%
	65	5.8%	7.0%
	80	7.4%	14.4%
	100	13.5%	27.9%
	150	23.65%	51.55%
	200	14.3%	65.85%
Minus	200	34.15%	100.0%

AGITATION THICKENING AND FILTERATION:

The overflow from the second Dorr classifier is discharged into a continuous slime thickener driven by a Westinghouse 3 H.P. induction motor. This thickener is 30 feet in diameter and 12 feet deep. The thickened pulp is pumped to the first of three Deveraux agitators by means of a Dorrco diaphragm pump. The agitators are 16 feet in diameter, 20 feet deep, and the blade propeller for each agitator is driven by a 5 H.P. electric motor. Sixty pounds of cyanide are added to the first agitator per day. The pulp ratio is one to one as it enters the agitation system, and the ratio is changed to 1½ to one by the addition of barren solution to the third agitator. A Dorrco pump carries the agitation pulp to the No. 2 thickener, which is of the same design as the first thickener.

The pulp from the second thickener is pumped by means of a Dorrco diaphragm pump to a 12 by 16 foot Oliver filter driven by a 7½ H.P. motor. The filter suction is supplied by a 10 by 14 inch duplex vacuum pump driven by a 35 H.P. electric motor. The pump was built by the Boak Gas Engine Company. Some barren solution is used as a wash on this filter. The filtrate goes to the No. 1 thickener; and the pulp goes to an agitator where it is re-pulped with barren solution. This pulp goes to a second 12 by 16 foot Oliver filter where it is given a water wash. This is the only place in the mill where water is added. The recovered solution is pumped to the No. 2 thickener, while the pulp is broken up by a log washer and passes out of the mill as tailings.

CLARIFICATION AND PRECIPITATION:

The solution circuit is designed to treat 400 tons of pregnant solution per day. The No. 1 thickener overflow is discharged into an 8 by 10-foot settling tank, from where it goes to a twenty leaf Merrill clarifying press. The pregnant solution then passes to a 8 by 10-foot clarified solution tank, and is next de-aerated by the Crowe vacuum process. The solution is then pumped, by means of a submerged centrifugal pump, to the zinc precipitation tank where twenty seven pounds of zinc dust are added per day. The precipitate obtained on the Butters leaf filter is dried in steam dryers, and is then melted into bullion in #400 graphite crucibles. The filtrate is used directly for wash water or else is pumped to a sump tank where it is stored.

CONSUMPTION OF SUPPLIES AND COST DATA:

The consumption of supplies per ton for the year 1937 was as follows: Balls 3.71 lbs; lime, 8.85 lbs.; cyanide, .641bs; zinc dust, .43 lbs.; ball mill liner, 1.35 lbs.; and pebbles, 1.26 lbs.

In 1937 this plant treated 53,978.953 tons of ore at a total cost of $1.551 per ton. The costs were distributed as follows: Labor, 35.5%; supplies, 46.8%; power, 17.7%. The costs per ton are given below:

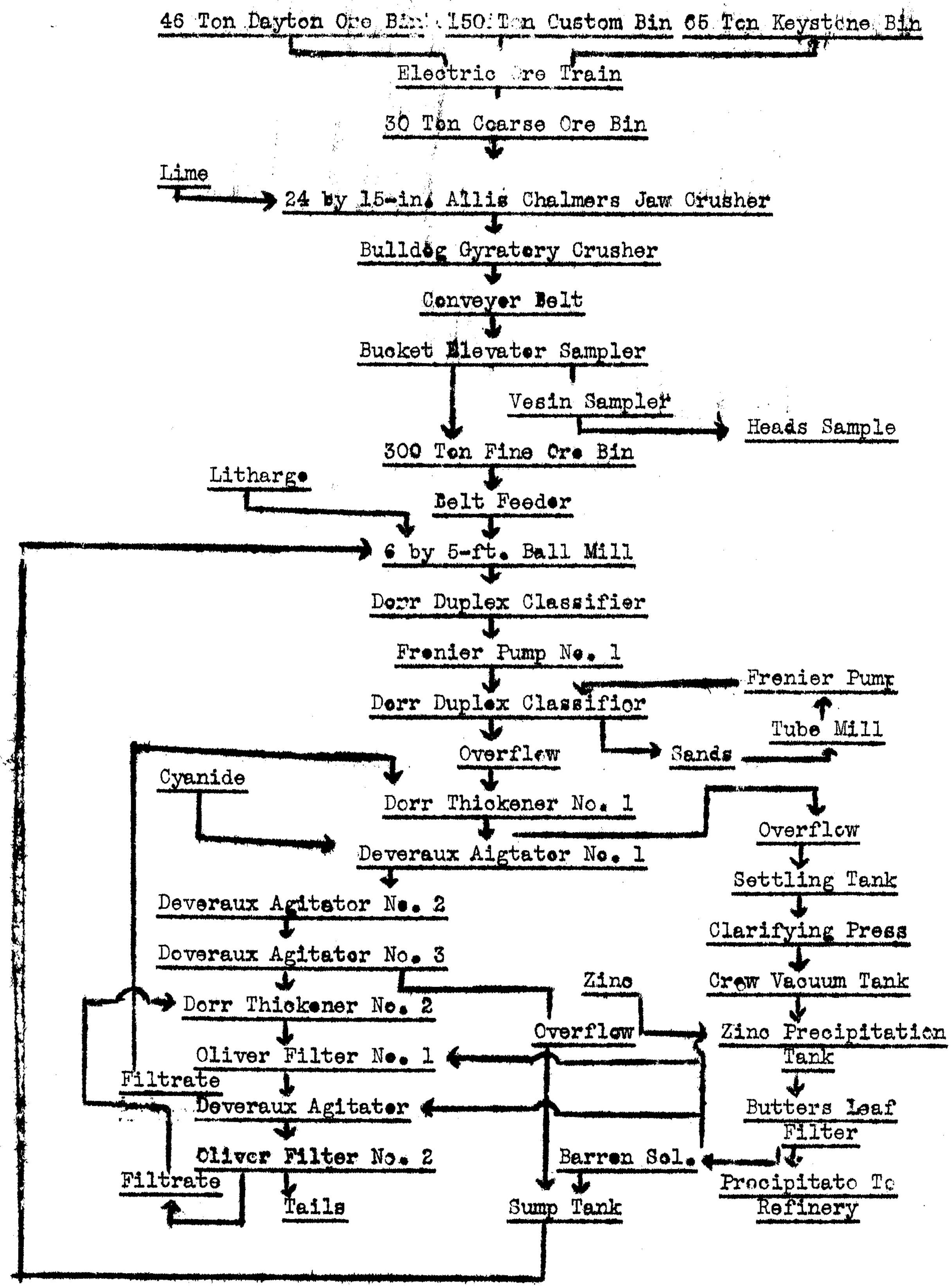
Coarse Crushing a nd Conveying	$0.195
Ball Mill Grinding	0.335
Tube Mill Grinding	0.169
Settling and Agitation	0.078
Filtering	0.135
Clarifying	0.048
Precipitating	0.071
Refining	0.027
Chemicals	0.224
Lubricants	0.017
Heating	0.068
Water	0.005
Lighting	0.003
Sampling	0.013
Assaying	0.026
General Charges	0.024
Supervision	0.070
Tailings and Disposal Expense	0.043
TOTAL COST PER TON	$1.551

The grinding duty in the mill was 6.3888 tons per hour, and the mill ran 96.3% of the possible running time. I did not obtain any assay data, but I understand that the recovery at this mill is very good.

ACKNOWLEDGMENT:

I wish to express my appreciation to Mr. Homar Gibson, general manager; Mr. William Henley, secretary; and Mr. Oliver Biddle, mill superintendent; for allowing me to make a study of the Dayton plant.

FLOW SHEET OF DAYTON MILL



THE CONSTRUCTION AND OPERATION OF A SMALL SULFIDE FLOTATION PLANT IN ARIZONA

AND

AN ENGINEERING ANALYSIS OF THE CAUSES FOR FAILURE OF THE GOLD MINING VENTURE

By Ellis H. Gates

The subject of this paper is the mining operations of a small gold property in Arizona. The observ ations I present were made during my employment as a flotation mill operator.

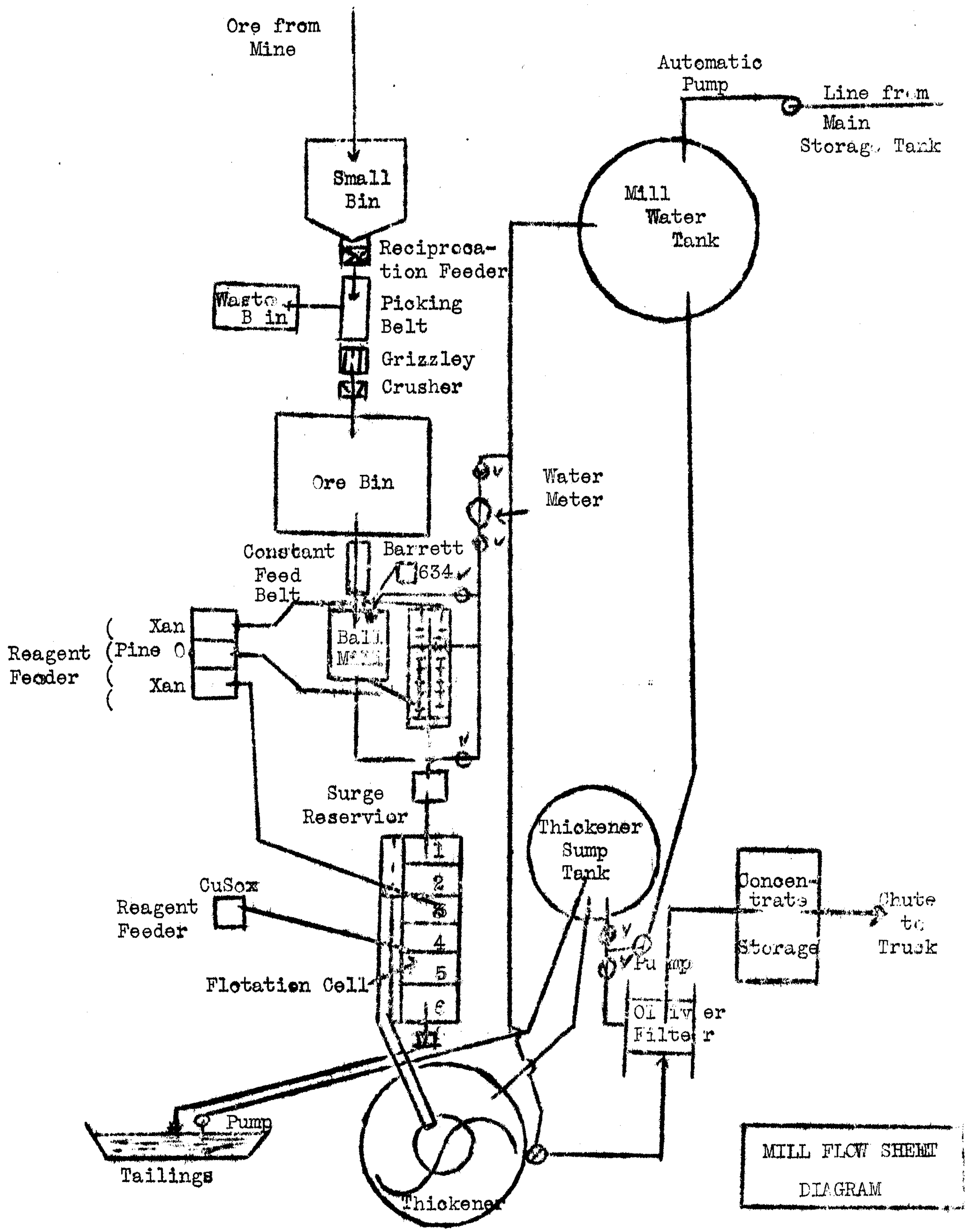
Primarily, this paper is meant to deal with a modern, smothly operating eighty-five ton flotation plant. I have set forth the most distinctive features in regard to the construction and operation of the plant.

Secondarily, and quite independent of the efficient mill operations, I am including a "post-mortem" analysis of the failure of the enterprise from an engineering point of view. As usual, the conditions causing failure were difficult to foretell, no matter how evident they afterwards appeared. I present very little that is new in such an analysis, but rather reiterate with yet another "concrete example" what has often been said in mining literature.

The mine is located in Arizona about half way between Prescott and Phoenix, and in a district that had, in the days before flotation, produced much gold from the shallow zones of oxidized sulfide-quartz veins.

The complete data on the character and treatment of ore and the mill equipment is summarized in the appendix.

The following diagram gives the classic flow sheet as adopted by the company for the concentration of sulfide minerals.



MILL FLOW SHEET DIAGRAM

FLOTATION PLANT

During my employment with the company the mill was my chief interest. The outstanding good quality of the plant was its smooth operation and freedom from metallurgical ills. It was a small plant designed for a capacity of eighty-five tons per twenty-four hours. Its flow sheet was simple but effective, and in general similar to most other plants of this type. However, the carefully designed details, not evident to the casual observer, make this plant remarkably easy to adjust and operate at maximum efficiency. After the first short trial run a technic of operating the mill was developed. All guess work and whims of an "individualistic" operator were discouraged. All variable factors such as pulp density, rate of ore, reagent, and water feed were carefully calibrated for any specific set of conditions likely to arise in the ore composition. As a result high recovery and efficiency of operation were consistently enjoyed--a contrast to the inexplicable ups and downs often met with the average small operation of this type.

While the following details are not new and could be advantageously applied to most plants, they apparently are not extensively used.

Details of Water Control to Ball Mill and Clasifier

The basic principle was the maintenance of a constant head or pressure of water behind the mill water feed. This constant pressure was accomplished as follows:

A large storage tank of about 35,000 gallons capacity was used as a reservoir. Beside the mill, a tall, narrow tank--in effect, a standpipe--was constructed. Water was pumped by a small electrically powered centrifugal pump into this tank, and was maintained at a constant elevation by an automatic pump switch actuated by a float. Water drawn from the standpipe was registered in the water meter before use in the mill. Three outlets for the water were provided on the discharge side of themeter. The hook up is shown in the accompanying water control diagram. Two main gate valves were fitted on either side of the water meter; the first was kept wide open at all times except when used in case of an emergency shut down; the second was the "total volume" control. It was calibrated by scratches on the handle.

Of the three water outlets, only two were fitted with valves. These two outlets entered either end of the ball mill. The third outlet was the classifier spray in the form of a horizontal pip perforated with large slots. The spray, not being fitted with a valve, was at all times capable of handling the excess water not used in the grinding unit. In this way, the volume of water was maintained a constant and with a uniform supply of ore feed, the density of the flotation heads remained constant. Yet at the same time, the density of pulp grinding within the ball mill could be precisely regulated by the two control valves at either end. Maximum grinding efficiency was thus easily maintained even when the ore varied from a clay like gouge to touch siliceous material, and the nicely balanced system was not disturbed. The result was a pulp of uniform density and particular size entering the flotation cells at all times.

Details for Constant Ore Feed

The company was partial to equipment of maximum simplicity and ruggedness For the ore feed, a slow moving belt was adopted. The belt was powered by a rheostat controlled variable speed motor that gave a 20% variation in speed. The belt fed from an adjustable discharge chute situated beneath the ore bin. The opening of the chute

chute was so arranged ~~that minimum~~ difficulty was encountered from clogged and ore hung ups. The belt discharged the feed onto a steeply inclined chute loading into the mill. In the bottom of this chute an outlet fitted with a trap door was installed. The trap door was a steel plate hinged along its center horizontal axis and fitted with a handle. Below the trap, a platform balance was installed. A tarred box was placed on the platform, and by a twist of a handle, the entire feed was diverted into the box. By recording the seconds taken to raise the beam (set at 50 lbs.) and referring to a graph, the tonnage per 24 hours could be quickly calculated. The tonnage rate was checked and adjusted by the rheostat every 30 minutes. In this way very constant feed was obtained.

Measurement of Pulp Density

It was found that the pulp density determination at the classifier overflow was the most direct indicator of the well being of the grinding circuit. A careful check of the density was therefore made every 30 minutes throughout each shift. In order to facilitate the making of these rapid determinations, the single device of weighing a unit volume of the pulp was used.

A small conical flask with a narrow neck was made of galvanized iron and calibrated for a volume equivalent to one pound of pure water. A small spring scale with a five pound capacity was used and the needle set to register zero when the flask was weighed empty. The weight reading on the scale for each pulp sample filled to the proper mark on the flask was taken as the specific gravity of the pulp direct.

In general, all calculations required were reduced to the simplest possible arithmetic to reduce errors and promote rapidity and ease of measurements.

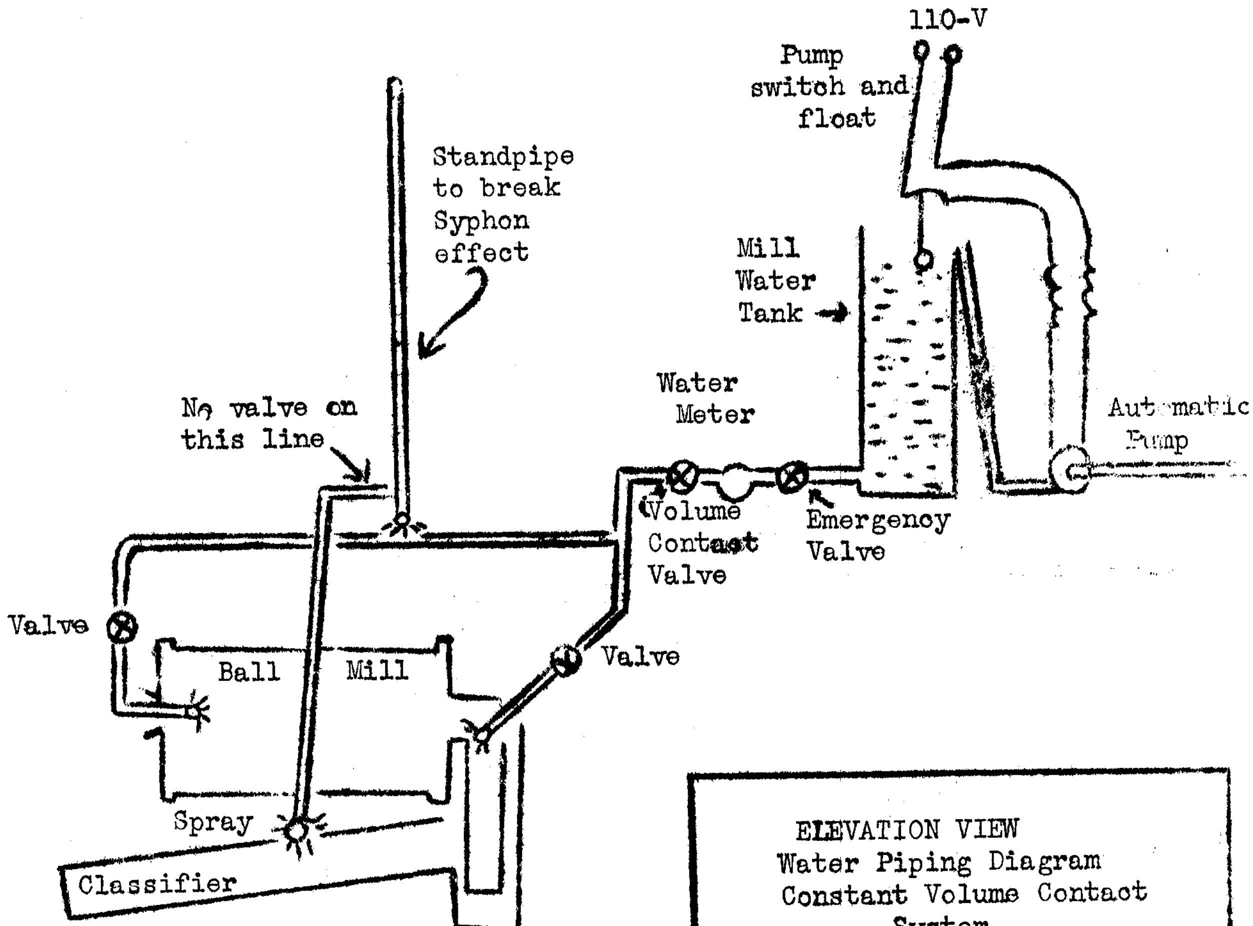
AN ANALYSIS OF THE FAILURE OF THE ENTERPRISE

Since my position was that of a flotation operator, I did not know the company's policy and plans. Perhaps important factors unknown to me may bear a good share of the responsibility for the failure of the enterprise. I am presenting only the facts which were evident by the nature of the problems the company encountered and which were available to interested persons.

The prevailing country rock was a solft micaceous schist. The schist was apparently a fair aquifer and a ready conductor of water along its cleavage direction. The main vein dipped with the schist at about 45 degrees. The hanging wall tended to sluff in heavy slabs necessitating considerable timber and lightly loaded rounds in the stope to prevent excessive ore dilution. The relatively low grade vein average from one to five feet in thickness, but the ore, as blocked out at the start of operation, was calculated to be sufficient value and quantity to pay expenses and the return of capital invested. Geologically, the vein was uniform, and of a fairly continuous nature. It was reasonable to suppose it would continue for some distance in length and depth beyond the development work.

Water Supply Failure

The first serious difficulty brought forcibly to our attention at the mill was that of the water supply gradually falling short. Water data used in the mill design was based on a specific quantity of water the mine was "making" per day during the period of development.



ELEVATION VIEW
Water Piping Diagram
Constant Volume Contact
System

The mine was located in a desert region, the mine sump being the only convenient water supply. Ground water of the region was replenished only by short, violent cloud bursts in the summer, and light intermittent rains and snow during the winter. Because of the small drainage area above the mine and the steep stream gradient, the greater part of the water was lost in the runoff before it could replenish the underground water by seepage.

In spite of the water bearing qualities of the schist, the local water table was lowering under the continual drain of the mine sump over a prolonged mining operation. The only practical remedy seemed to be the installation of a long pipe line and costly wells in a more favorable location.

At this critical time, the company was unable to easily bear the sudden, heavy expenditure of developing new water sources. The mill running time was cut to two shifts per day, pumps were installed on the tailings ponds, and all possible efforts were made toward economizing on water.

DIFFICULTIES IN MAINTAINING TONNAGE QUOTA

As previously mentioned, sufficient tonnage of valuable ore was blocked out to satisfy the company's engineers of the safety of their investment in the metallurgical plant, but unforseen troubles and knotty problems began to arise in the new stopes. The flatness of the vein angle allowed the soft hanging wall to seriously dilute the broken ore. It was necessary to hold the wall by numerous well placed stulls. Too heavy rounds in the stopes had to be avoided to keep the ore clean. The narrow sloping vein was difficult for the men to set up machines and work. A high cost per ton of ore was naturally the result. Furthermore, because of these difficulties, the number of places in the stopes from which ore could be taken at one time was limited. The daily tonnage quote for the mill was difficult to maintain, and sometimes impossible even when the mill ran only two shifts. The mining method found most successful was the "over hand" open stoping method.

Insufficient Development for Future

The financial backers apparently did not look with favor upon the company spending their finances for development of future ore until the mine was on a profit making basis. This meant a gradul depletion of the ore reserves at a mining cost higher than estimated. The result was a stalements; the company could not pay off their obligations on the basis of lower profits unless new ore was developed, the financiers would not consent to the additional development work.

The mill was completed in August, 1936, and the property was closed January, 1937.

APPENDIX

The character and treatment of the ore, and the mill equipment are listed as follows:

CHARACTER AND TREATMENT OF ORE

Composition and Properties of Ore

Mineral Compositions

Gold bearing minerals:	(black sphalerite (pyrite (chalcopyrite (galena
Gangue: Predominating Minerals:	(quartz (limestone (silicified schist
Small amounts:	(magnetite (garnet (wolfenite

Specific gravity of mill heads averages 2.7 to 2.9

Hardness and Grinding Qualities:

Ore for the most part is friable and easily pulverized. Occasionally large percentages of silicified schist which is tough and refractory occur as ore. This material causes a considerable reduction in capacity of the ball mill, and a tendency toward overgrinding of the more friable minerals. By checking the particle sizes of the classifier overflow, and by a careful regulation of pulp density and rate of pulp flow through the mill, this condition can be avoided to some extent.

Maximum particle size for efficient separation:

Ore testing laboratory determinations show that grinding to 65 mesh will liberate the gold bearing minerals.

Flotation Reagents

Collectors:	(Amyl Xanthate (Pentasol Xanthate (Barrett No. 634
Frothers:	(Yarmour Pine Oil (Barrett No. 634 (froth stiffener)
Activating Agents	(Copper sulfate (for sphalerite)
Depressing Agents	(Sodium Silicate (deflocculation of SiO_2 and silicates)

Water Supply

pH.... 8.4 — Mine water contains copious amounts of calcium and magnesium salts.

MILL EQUIPMENT AND DETAILS OF INSTALLATION

Grizzley: Bars set at 3/4" openings -- installed ahead of crusher.

Crusher: Blake Type 8" x 10" Jaw crusher. 3/4" set.

Ball Mill: Allis-Chalmers 5' x 5' Cylindrical
Capacity 85 tons from 3/4" to minus 65 mesh.
Powered by 60 HP Electric motor.
R. P. M. 30
Central Discharge.

Classifier: Mechanical type. Dorrco Duplex.
17 strokes per minute per each rake.

Flotation Units:
Denver Sub-A Farenwalf type.
Number of cells 6.
Total power (Electric) 6 HP

Thickener for concentrates:

Denver Thickener 8' x 8' Steel tank
Rakes -- continuous curved spirals ~~tuo~~ rakes in number.
Discharge -- effected by diaphram pump.

Oliver Filter for dewatering concentrates:

Cylinder 4' diameter.
Oscillating agitator paddles.

Reagent feeder:

Denver Equipment Company 3 cell.
Drip feeders made from buckets.

Water storage tanks:

Main water storage reserve 35,000 gals.
Mill tank 8,000 gals.
Outfitted with pump and automatic switch to keep constant water head above mill.
Thickener sump tank - to receive clear water from the overflow for reuse.

Automatic samplers:
Heads) Sampled pulps ahead and after
Tails) flotation cells.
For coarse material ahead of ball mill.

Apparatus determination of pulp density:

Spring scales and calibrated cup for pulp density determinations. Taken half hourly.

Pumps: Centrifugal pump for tailings water return.
Operated at 30 gals. per minute against 100' head and 300' of 1" pipe resistance.
(Approximate data. No figures on power consumption)

Pumps: Centrifugal pump for tailings water return. Operated at 30 gals. per minute against 100' head and 300' of 1" pipe resistance. (Approximate data. No figures on power consumption)

Thickener sump tank pump

Automatic mill tank pump

Storage bins:

Ore. Square bin. Approximately 50 ton capacity free flowing ore (ore included in the inverted cone above discharge). Bin installed between crusher and ball mill.
Total bin capacity 150 tons.

Small bin between mine hoist and crusher 15 ton capacity (approximately)

Waste bin: below picking belt to receive discarded material.
Flat iron sheathed floor for drying and storing concentrates for shipment.

Feed belts:
Picking belt from small bin to crusher Fitted at small bin discharg with reciprocating plate feeder.

Ball mill feed belt powered by variable speed motor. Rate of feed controlled rheostate.

Mill buildings-
Steel framed.
Galvanized iron sheathed
Concrete floors and foundations.
Ample floor space for uncrowded work.

Power:
High voltage from local power company
Transformer reduction to 440-220-110 volts.

REPLACEMENT PHENOMENA IN THE SILVER-GOLD VEINS AT RAWHIDE NEVADA

By Eugene Grutt

Rawhide, Nevada is located in north-central Mineral County about six miles from the Churchill County line, and about 50 miles south-east of Fallon, Nevada.

Although the first mineral locations were made in 1906, it was not until the "boom" of 1908 that mining was started. According to the U.S. Bureau of Mines records Rawhide has produced in excess of $1,500,000 from lode and placer mines.

Rocks and Mineralization

The country rocks, for the most part, are tertiary rhyolites, andesites, and rhyolite-breccias and tuffs. Most of the rocks originated as flows.

The mineralization is of the epithermal type as is clearly shown by the mineral veins. The veins show symmetrical colloform bending, vugs, comb structure and replacement, all of which are epithermal characteristics. According to Lindgren[1] the temperatures attending this type of mineralization are generally less than 200° C, and the pressures are usually under 100 atmospheres.

Events Leading To Ore Formation

In the formation of mineral veins of the type found in Rawhide, there are definite stages in the formation that can be traced. The first step is the intrusion of a magma into the earth's crust. The intrusion is generally closely followed by a period of fracturing or faulting around the intrusion, which fracturing may produce structures favorable for the later deposition or ore. The ore itself is deposited from solutions ascending through these structures, forced upward by some means not clearly understood. The solutions are composed of magmatic and ground waters containing products of magmatic differentiation, and when the physico-chemical conditions are favorable, these rising thermal solutions deposit their load of gangue and ore-making elements in the form of various minerals.

The hydrothermal solutions change in acid and base content through the period of activity. There is also a change from high temperatures at the beginning of hydrothermal activity to lower temperatures in the last stages.

As to the exact character of the solutions in which the minerals are transported there is considerable disagreement. Lindgren[2] holds that the solutions, which are acid in nature at their source, are rapidely neutralized by the wall rocks through which they pass until finally they become alkaline, and that the hydrotherm veins are formed from alkaline solutions. Bowen[3] says that most ores are likely deposited from acid solution, and that their transportation is no problem in these solutions. Frondel[4] thinks that native gold can be carried in either alkaline or acid solution, but in the alkaline solutions he shows that the action of colloids plays an important part.

In any event, as the rising solutions change in composition, they give rise to a rather definite paragenesis. Replacement is caused by this hydrothermal change. Minerals stable under one condition may become unstable as the solutions change in character or composition, and the early minerals may be completely re-placed by later ones. These replacement phenomena are exellently shown in two quartz veins at Rawhide.

Burn's Hill Quartz Vein

In a vein on Burn's Hill unusual pseudomorphs of quartz after calcite have been developed.

The paragenesis of this vein is as follows:

1--Banded chalcedony

2--Vein quartz containing small amount of pyrite and arsenopyrite.

3--Calcite

4--Replacement of calcite by quartz

5--Alunite

This vein averages about twelve inches in width, between rhyolite walls, and fully two-thirds of the vein consists of banded chalcedony and massive quartz. Pyrite and some arsenopyrite occur as small crystals disseminated through the massive vein quartz. The calcite was deposited on the quartz in crystals of the aregentine variety, which is a calcite developed parallel to the basal plane in the form of thin hexagonal plates (Fig. 1). The crystals arranged from one-half inch to three inches in diameter. They were arranged in various positions and in general only about one half of the crystal plate was developed. They were intimately intergrown and formed a cellular lacy structure. Later quartz completely replaced the calcite with the development of thousands of minute quartz crystals on both sides of the original calcite plate (Fig. 1). Each crystal developed perpendicular to the plane of the plate growing with the utmost economy of space. These quartz crystals are about .1 mm. in diameter and .5 mm. long. The pseudomorph plates average about 2 mm. in thickness which is probably considerably thicker than the original calcite plate.

The replacement of the calcite was due to its becoming unstalbe under changing conditions. Graton thinks that the replacement of carbonates in epithermal veins indicates a change from alkaline to acid solutions. Calcite would be readily dissolved in acid solutions.

There are two possible modes of origin of the alunite. It could have been formed by ascending acid solutions or by reaction between ascending alkaline solutions and descending aicd solutions. Either mode of origin is possible in this vein.

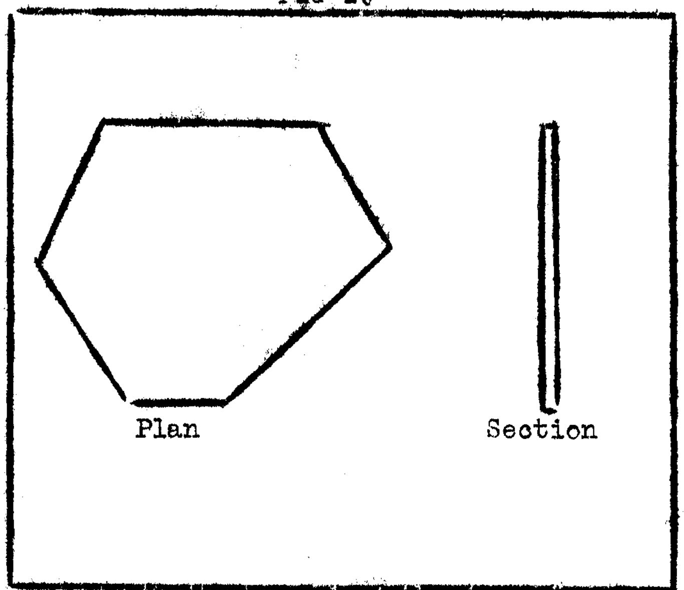
There was no gold or silver mineralization in this vein.

Murray Hill Vein

The Murrary Hill Vein shows replacement phenomena similar to the Burn's Hill vein, but a more complete paragenesis is shown. The pseudomorphic nature of the ore is strikinly displayed in many specimens, and the relations can be easily detected. The vein varies from one foot to two feet in width.

The paragenesis is as follows:

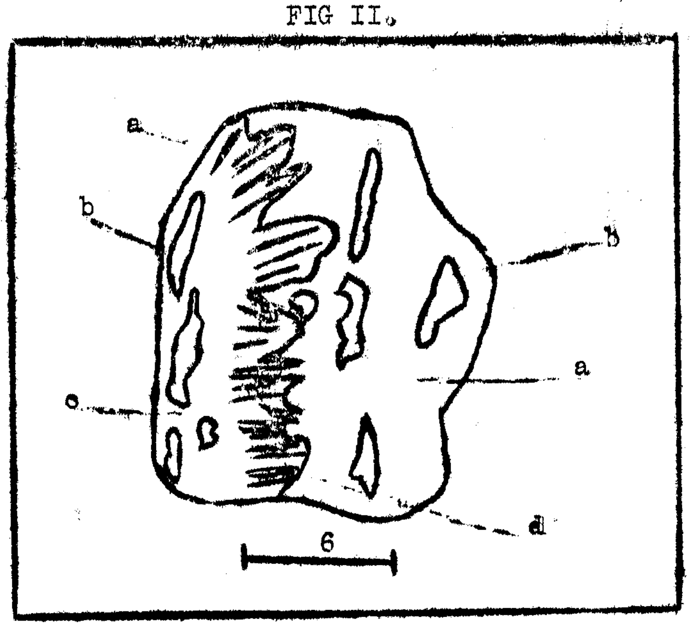
FIG I.



A pseudomorph plate from Burn's hill

(Actual Size)

FIG II.



A specimen Murray hill silver ore

a-- Vein quartz
b-- Vugs
c-- Quartz pseudomorphs
d-- Mineralized quartz

1--Barren vein quartz

2--Calcite

3--Replacement of calcite by quartz

4--Quartz containing pyrite and argentite along
with a little free gold

5--Barren vein quartz

The first stage, the introducing of massive vein quartz, was a prominent one, as approximately two-thirds of the vein is composed of it. This quartz is quite barren, and it shows vugs in many places.

The pseudomorphs of quartz after calcite show that the next mineral, calcite, was of the argentine variety. A close resemblance to the Burn's Hill pseudomorphs in shape is at once evident. On Murray Hill, however, the calcite did not grow in the open comb structure, common to all of the Burn's Hill material, instead sheaves of flat plates have been compactly developed. The traces of the individual blades are traceable for as far as four inches in places. The next step saw the formation of quartz pseudomorphs after calcite, with the calcite being completely removed. Simultaneous with the replacement of the calcite by quartz was the period of ore deposition. This mineralization is shown by a band of quartz containing dark patches of argentite and pyrite along with a small amount of free gold. The band of mineralized quartz varies from 1/8 inch to one-half inche in width, and is deposited in most cases directly next to and between the sheaves and individual plates of pseudomorphs (Fig. 2).

As evidenced by the narrow band of mineralized quartz the period of ore deposition was short. The last stage was the introduction of barren vein quartz.

Discussion

The Burn's Hill vein because of its unusual crystals is an interesting occurrence, but no conclusions about ore depositions can be reached. The Murray Hill vein, however, shows such definite boundaries of ore mineralization that one conclusion about this vein seems quite probable. The calcite appears to have controlled ore deposition.

The close relationship between the pseudomorphs and the mineralized quartz shows that the replacing and the ore bearing solutions were probably of the same state, and that some connection exists between the replacement of the calcite and the deposition or ore. The deposition of ore along the sheaves and between the calcite plates is too consistent to have been accidental.

If the replacement of the calcite is to be regarded as being done through the changing of solutions from alkaline to acid, and if replacing and mineralizing stages are to be regarded as the same, then the ore carrying solutions are probably of acid nature. The calcite exerted a neutralizing effect on the solutions as it was replaced by quartz. This action undoubtedly exerted strong control on the ore deposition.

REFERENCES

1--Lindgren, W.: Mineral Deposits, 4th ed., p 210

2--Lindgren, W.: Am. Inst. Min. Met. Eng., Tech. Pub. 713, p 360 ,1936

3--Bowen, N. L.: Ore Deposits of the Western States, p. 126, New York, 1933

4--Frondell, G.: Econ. Geol., Vol. 33, p. 16-17

5--Graton, L.C.: Ore Deposits of the Western States, p. 190, New York, 1933.