CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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J. DANA SPERR
MINING ENGINEER

UNITED VERDE CONSOLIDATED COPPER COMPANY

Preliminary Report

Jerome, Arizona, September 28, 1916.

The Board of Directors,
United Verde Consolidated Copper Company,
Jerome, Arizona.

Gentlemen:

At your request I herewith submit a preliminary report on your group of claims. As soon as field work is completed, I shall submit a final report which will differ from the following principally in detail.

The location of the group would be described as on Copper Canon within the Squaw Peak Mining District, in Yavapai County, Arizona. This canon acquired its name from the many indications of copper to be found. These claims are located in the mountains about four miles to the west of Camp Verde. The main road from Camp Verde to Prescott crosses the group as shown on the map. A new road, also shown on the map, has been built from Camp Verde to the present camp site on the group. Equipment and supplies can either be brought in from Prescott over the County road, or hauled from the railroad at Clarkdale.

In general the topography of the country is characteristic of the mountain section of this part of Arizona. The hills on the group are usually regular and rolling in outline but cut by deep canons and narrow gorges which give some very precipitous slopes. This characteristic aids in

the study of the geology as the country rock is well exposed on the walls of the canons.

The claims are more or less covered with brush, pinon pine and cedar. The timber is only valuable for fire wood. Mine timber and lumber will have to be hauled in.

The group is well supplied with water by the stream in Copper Canon. A rough stream measurement gives me an estimate of 12 cu. ft. per minute as the flow of this stream. During the wet months the stream will probably yield several times that amount, but during the dry season I am informed it dwindles to much less than the present flow. A dam can easily be constructed across the canon at about the center to lower end of the group, which will give a reservoir capacity sufficient for all camp and mining purposes.

The development work so far consists in shallow surface work scattered over the various claims as shown on the map. The principal work has been done on the Rosebud, Pine, Poppy, Orient, Sunflower, Daisy, and Bellefleur claims.

On the Rosebud, copper bearing rock of highly metamorphosed porphyry has been developed by a shallow shaft and small open cut. Green and blue copper stains are found through the rock over a considerable area on this claim. On the Pine, an old tunnel in a granite porphyry discloses some disseminated copper in the form of chalcocite and chalcopyrite. On the Orient and Poppy Claims the cuts, tunnels and shafts in porphyry show green copper stains.

Considerable work has been done on the Belle-fleur claim by cuts, tunnels and shafts. Green, copper stained rock was found in the openings and on the surface where the washes have uncovered bed rock. The most important shaft or incline was full of water and could not be properly examined at the time of my visit. Mr. Mahurn, former owner of the group, claims to have uncovered copper sulphide in this opening at a depth of approximately forty feet from surface.

Other cuts on the group disclose mineralized seams and crevices in metamorphosed porphyritic rock, but none of them are extensive enough to aid in drawing any conclusions as to the possibility of developing commercial copper..

The Aster claim is the seat of a legend concerning a lost mine. The story goes that a rich gold mine was discovered by Mexicans in Copper Canon in the early days. A shaft and tunnel were used to develop the gold ore and the tunnel was also used to store bullion from this mine and from shipments from Mexico. At the time the Indians were bad a band of braves drove the Mexicans into the tunnel and caved the mouth by rolling big rocks down the hill. On the Aster claim is an old shaft which was walled up on four sides and evidences of an old tunnel caved at the mouth. Of course the natural conclusions would be the fiding of Mexican bones and stores of bullion, but unfortunately neither the shaft nor the tunnel has been cleaned out!

Considerable more field work will be necessary to satisfactorily work out the geology of this group. This report can do no more than contain a few rough statements of

general characteristics. The accompanying sketch will give a general idea of the structure. Apparently the rocks pitch steeply to the east and strike nearly north and south. Unfortunately the contacts are not sufficiently exposed to even approximate the true pitch of the formation. Going from west to east across the group I find the rocks exposed appear as shown on the sketch. At the extreme west side of the group, a nearly true granite is to be found. This seems to grade into a fine grained porphyry similar to the copper bearing porphyries of this district. Overlying this porphyry is a rock varying from fine to coarse grain which would be roughly classed as a diorite from field work.

This rock is highly metamorphosed in places, and may or may not be cut by porphyry dykes as it is possible that what appear to be dykes may be fractured zones of this rock which have been so highly altered as to give the general appearance of dykes.

The eastern edge of the group is covered with a recent sedimentary, grading from a coarse conglomerate to a fine grained rock heavy in lime. This is a bedded deposit well exposed by the canons cut through it. Some sections of this sedimentary show heavy copper stain, but the actual value of this deposit is entirely unknown.

The southern end of the group is capped by a basalt which occurs as a characteristic capping of the higher parts of mountains.

The only practicable method to prospect this group

is to put down a series of diamond drill holes to determine whether there are any commercial deposits of copper at depth. Future work would have to be based on the results of such diamond drilling. The commercial value of such drilling will depend on the geological conditions discovered. It is not to be expected that ore will be discovered by any shallow surface prospecting and money spent on such work at the present undeveloped stage would be merely wasted. The diamond drilling will determine whether it is advisable to do further development work, and also determine at what points such further work should be done.

The surface indications of copper are as satisfactory as might be expected but only deeper prospecting can determine the presence of commercial deposits. I unhesitatingly recommend diamond drilling as the most satisfactory method of carrying on this preliminary prospecting. However, I am not prepared at present to make any recommendations as to where this work should be done as it will require considerably more field work in the nature of topographical and geological surveying to arrive at final conclusions as to the most likely location of ore.

The surface indications are apparently, from the preliminary examination, most favorable along the metamorphosed or dyke zone cutting through the Sunflower and Bellefluer claims and within the porphyries on the western half of the group.

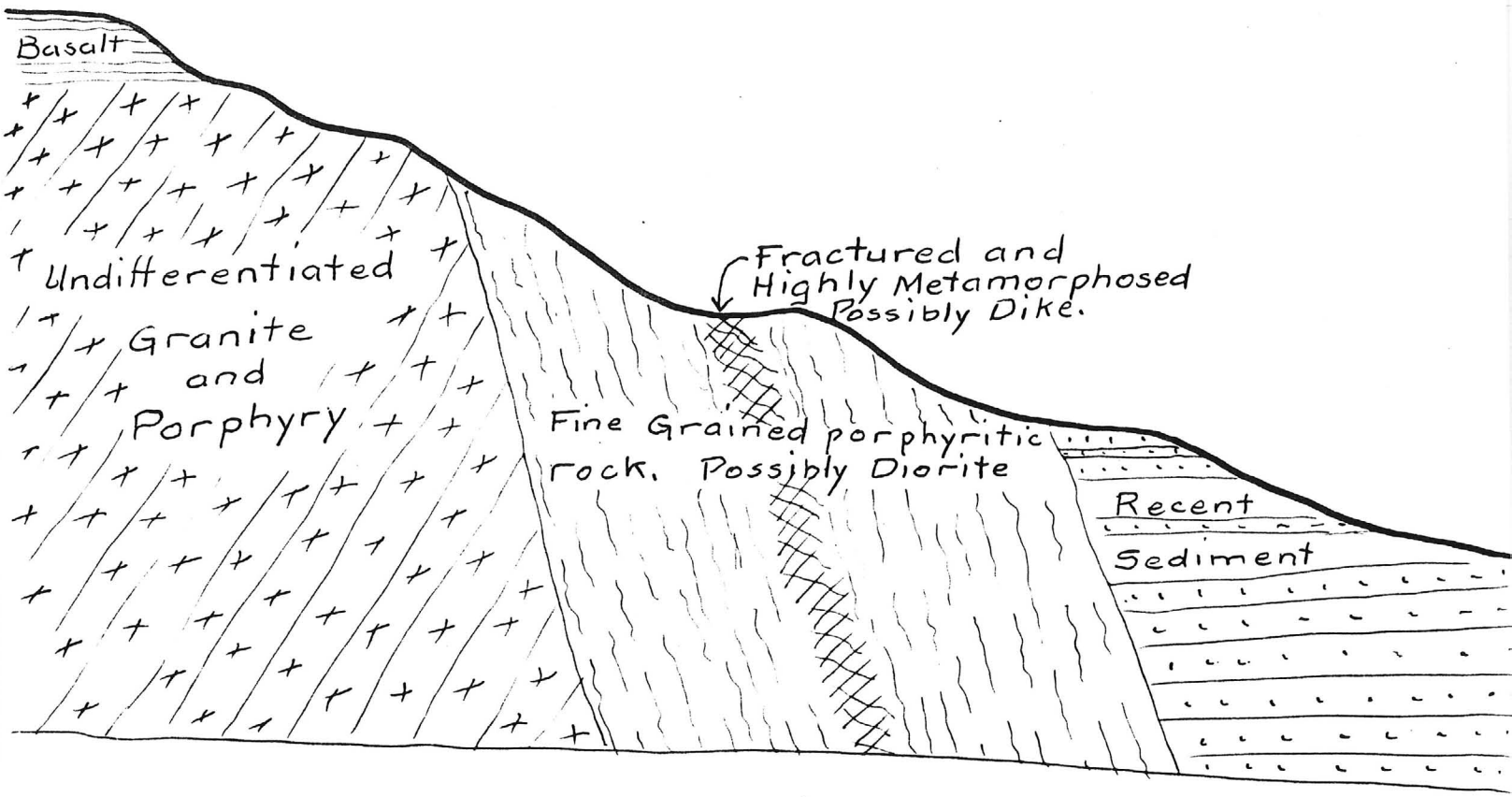
J. DANA SPERR
MINING ENGINEER

In concluding this preliminary report I may call your attention to the fact that as a general proposition ore is not found upon the surface in this district, but is more likely to be covered to considerable depth by barren rock, giving only the indications of copper, and whether there are actually commercial deposits, can only be determined by development work.

Respectfully,

J. D. Sperr

J. DANA SPERR
MINING ENGINEER



Ideal Cross-Section

NOTES

on

THE UNITED VERDE OPEN PIT

at

JEROME, ARIZONA

by

E. M. J. ALENIUS

A Brief History of an Unusual Mining Operation

FOREWORD

The "Big Hole" was the name miners gave to the United Verde Mine, for with its many shafts, raises, large stopes, and miles of drifts and tunnels it was one of the largest mines in the world and fully merited this distinction. Now the visitor can become familiar with the great extent of the mine by examining the model in the Douglas Memorial Mining Museum at the Jerome State Historic Park. But, only by comparing this with the actual "Big Hole" or the United Verde Open Pit to the north of the Town of Jerome, can its magnitude be fully appreciated.

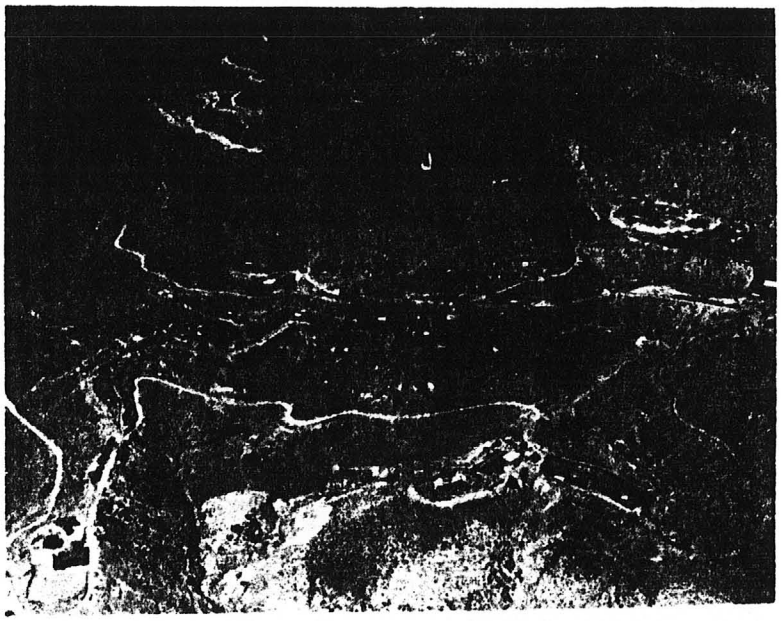
The United Verde Open Pit mining operation was unusual in all respects, for by its nature it presented conditions not found in other mining operations. This surface working stands alone by virtue of its existence and the means employed to recover its mineral wealth. To the best of my knowledge, no other surface mine operation can compare with the variety of situations encountered and the changing response to mining problems.. While development of the pit conformed to practises prevalent at the time, many changes and innovations occurred as operations progressed. During its twenty-two year lifetime, from 1918 to 1940, great improvements were made in drilling, blasting, loading and haulage methods. The United Verde Open Pit contributed to improvement of surface mining methods in a preliminary manner, great advances having been made since that time.

Many pictures are included with this presentation so that the interested visitor to Jerome may have a better understanding of how the "Big Hole" was dug out, and what the problems were. Considering the nature and complexity of this mining operation, it is doubtful that any other mining venture will ever compare with the United Verde Open Pit in its wealth and challenging problems.

E. M. J. Alenius

Phoenix, Arizona

September 1966



Aerial view of Jerome, Arizona with the United Verde Open Pit at upper right. The Douglas Memorial Mining Museum and the United Verde Extension mine surface plant are seen at the lower right.

Aerial view taken in 1928 of the United Verde Mine showing the open pit, switchbacks and waste dumps across the upper part. The 500 level mine surface plant is seen at the lower right center.

UNIQUENESS OF THE UNITED VERDE OPEN PIT MINE

The nature of the United Verde orebody and the unusual conditions encountered may be considered unique in mining operations. The main features of distinction may be summarized as follows:

The ore at the United Verde Open Pit was high grade, some sulphides containing as much as 40 percent copper, some siliceous ore assaying at more than 200 ounces silver per ton and some oxide ore at more than three ounces gold per ton. Throughout the life of the pit operation, the ore averaged 3.49 % copper with 2.07 ounces silver and 0.07 ounces gold per ton. Economy of operation permitted mining of ore containing 1.00 percent copper, or $4.00 in total value per ton as conditions warranted.

The orebody consisted of minerals with entirely different characteristics containing basic sulphides (low silica content), siliceous sulphides, oxides, silicas, porphyry and schist (some altered by the fire). All of these required selective mining, based on mineral character and grade, for treatment by direct smelting, converting, concentrating, leaching, or for stockpiling. Moreover, by selective mining it was possible to effect great economy in the direct smelting process by controlling the silica content of the direct smelting ores to around 23 or 24 percent with an alumina content of about 4.3 percent. A noticeable distinction existed more or less at the 160 mine level, as the ores above were mainly oxides, and those below the 160 level, sulphides which had been enriched by transfer of copper from the oxides.

Not only were different mineral characteristics encountered in the orebody and the surrounding waste material, but great differences existed in hardness and fracture. The dense siliceous sulphides and the unaltered diorite waste rock presented problems in blasting, for drilling equipment then available was inadequate. On the other hand some of the very high grade sulphides with low

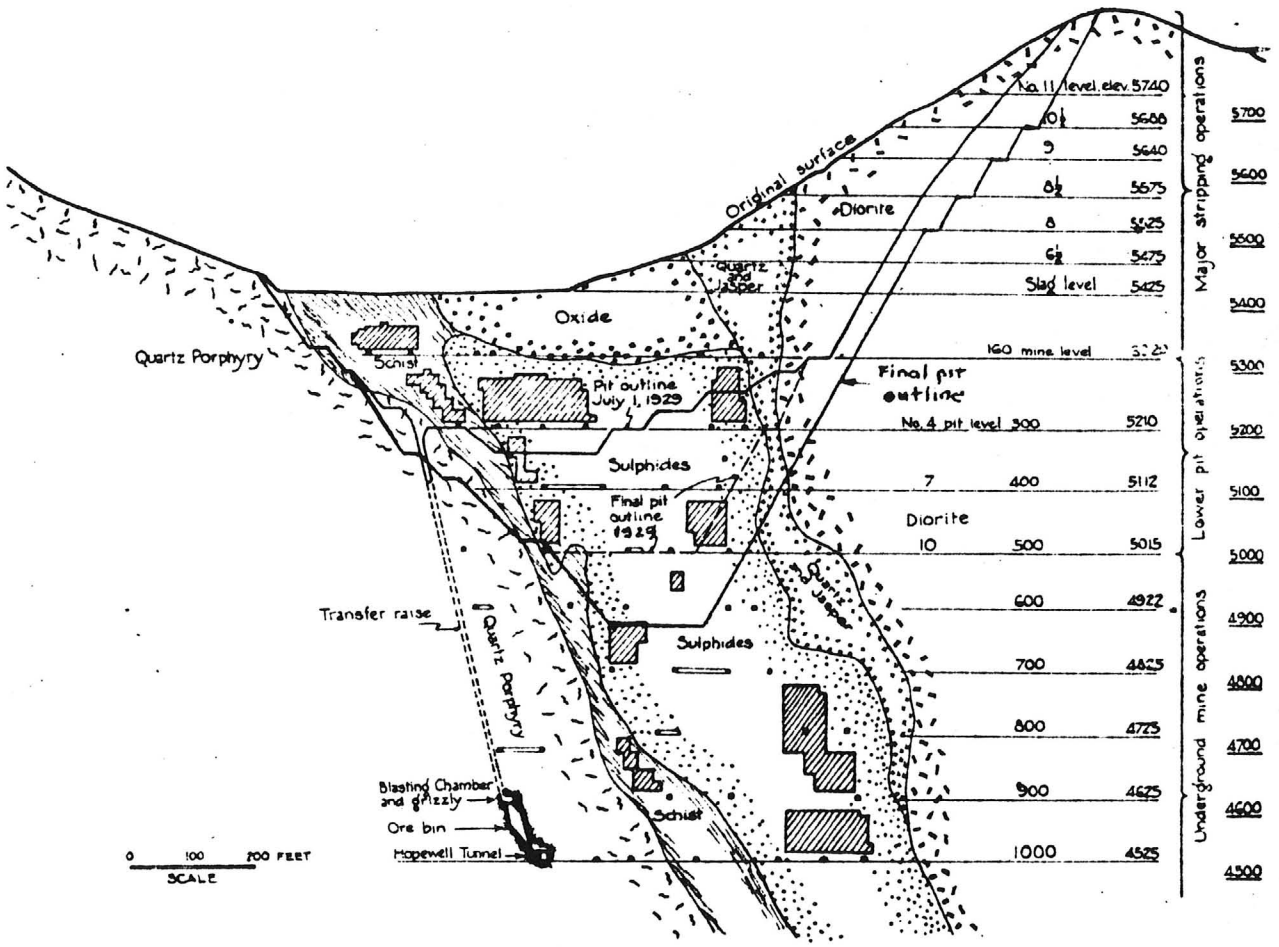
silica and iron content, and the high silica content converter ore in the oxidized zone required little blasting.

Open pit mining was resorted to when underground mining became impossible in the upper levels owing to portions of the sulphide mass having been on fire since 1893. As the ore was exposed the burning or hot material presented serious problems, particularly in blasting. One of the procedure for blasting this very hot ore will be discussed later.

Operations were conducted above old underground workings. Every drilling, blasting, loading and hauling operation required examination of old maps to avoid falling into old raises, drifts and open stopes. In some cases previous underground cave-ins resulting from the fire resulted in unreliable information. Moreover, as may be noted on the accompanying sketch, the slope on the orebody with its extensive underground workings under the diorite hanging wall on the northwest side weakened support of the overlying mass of diorite. This diorite wall or bank is first apparent to the visitor as the pit is approached from Jerome, or when his attention is directed toward the pit from the Douglas Memorial Mining Museum.

Shattering of this diorite bank by deep underground caving in 1929 required removal of additional waste rock during the depression years. Thereafter, constant scaling, trimming and vigilance were required to avoid injury to workmen and damage to equipment below the waste banks. At the termination of mining operations in the pit in 1940, the diorite bank along the northwest side was more than 600 feet high without a protective bench

All of these matters presented problems, but in spite of the fire, the need for selective mining and the hazards of caving, mining was conducted on a fairly regular schedule. As the pit deepened the danger of falling rock increased, but by continuous vigilance no one suffered injury from falling rock.



Typical section of the United Verde Open Pit as of July 1, 1929 showing the relationship of the complex ore body to the porphyry foot wall and the diorite hanging wall. This section is related to the underground workings as far down as the 1000 foot level to which material from the pit was dropped through transfer raises for disposal via the Hopewell tunnel system. The pit outline ~~as noted above~~ was moved back during the depression years as the hanging wall was weakened by underground caving above the 1200 level in 1929.

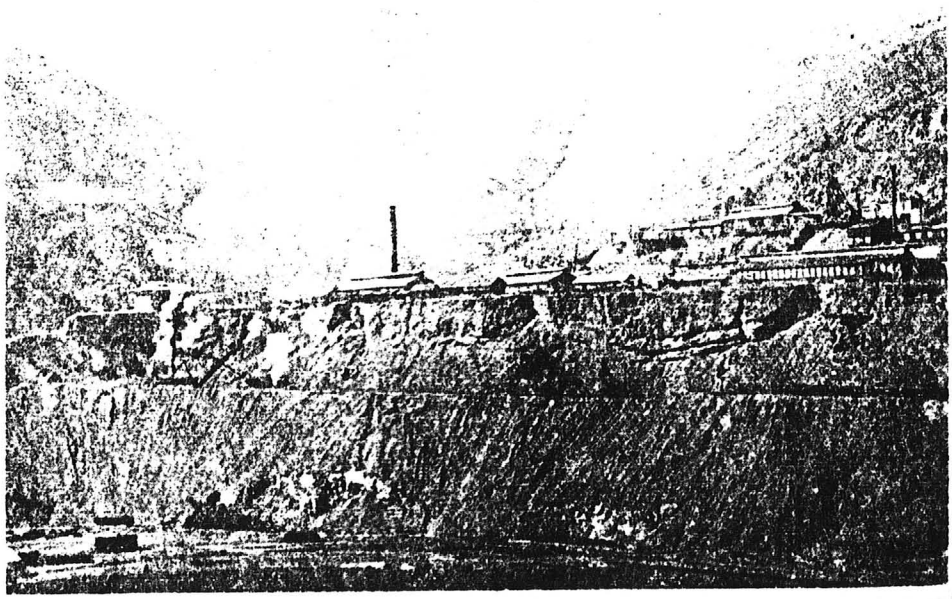
DEVELOPMENT OF PIT STRIPPING AND MINING OPERATIONS

Following purchase of the United Verde Copper Company by Senator William A. Clark of Montana in 1888, extensive development of the property was undertaken in the upper reaches of Bitter Creek Gulch north of the present town of Jerome. The gulch was filled in and the ground leveled off on the 50 foot mine or slag level. A smelter was erected on this site, which with the surrounding shops, offices and mine structures rested on top of the orebody. This orebody on the surface was roughly 800 feet wide and 1,000 feet long in area. Glory hole mining was undertaken in the rich oxide ores on the extreme south end outside the fire area. Slag from the smelting operations was dumped across the lower end of the gulch completely filling it for a width of more than 700 feet by 1915.

As previously noted, the fire which started in 1893 in the upper levels made underground mining impossible in the sulphide mass. The fire later extended down to the 900 level and was sealed off by concrete bulkheads on the various levels affected. Caving in the fire area resulted in damage to the surface plant and was a constant threat. Open pit mining was decided upon as being the only way to recover the high grade ore in the upper levels. This entailed construction of a new smelter at Clarkdale beginning in 1912, a new surface plant on the 500 level, the Hopewell tunnel transfer system on the 1,000 foot level and the Verde Tunnel and Smelter Railroad. This railroad connected with the new branch line of the Sante Fe into Clarkdale, and served the smelter, Hopewell, the 500 level mine plant and the surface operations from the 300 level. These facilities have been abandoned for many years, but the remains can be seen from many vantage points in and around Jerome.

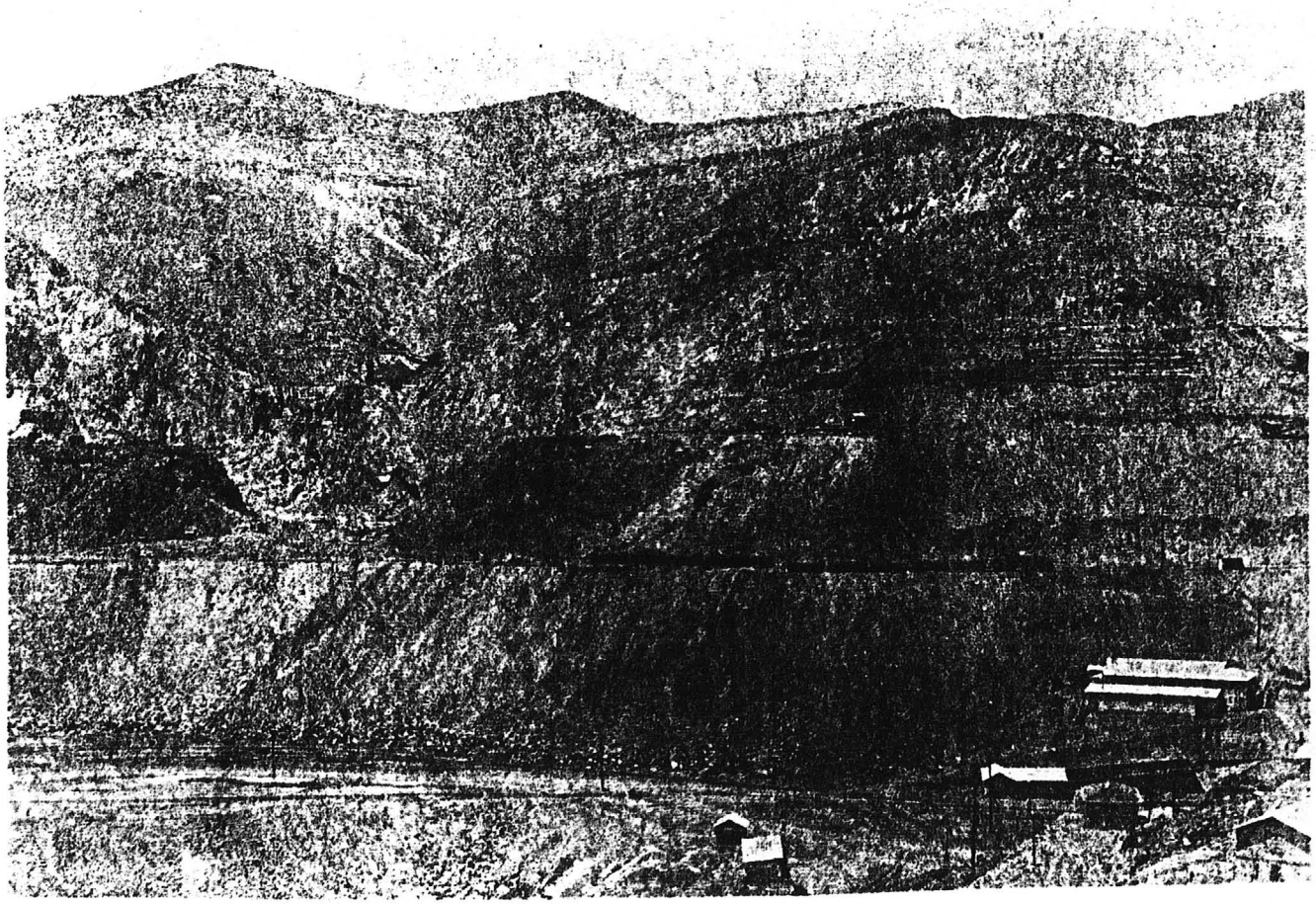
In 1915 the new smelter was blown in, and in 1918 stripping or waste removal for the open pit was started. A Marion 300, 8 cubic yard, full revolving steam shovel began cutting across the slag dump on the 160 level, and an Osgood 120, 4 cubic yard, railroad type steam shovel on the 300 level. Switchbacks for

standard gauge railroad haulage were constructed on the north side of the diorite hill with view towards cutting down the hill on benches 50 feet high so that a safe slope could be maintained above the mining operations below. In 1925, after some waste removal on intermediate benches, stripping was started on the top bench at elevation 5725. By this time the Marion shovel had cut rapidly into the orebody as the old surface structures were being demolished, removing rich oxide and siliceous ores, most of which was stockpiled on nearby dumps as they could not be smelted in quantity. Some waste was disposed of through glory holes and connecting raises for filling underground stopes, but the great amount of waste material was loaded into 25 cubic yard dump cars and hauled by switcher type steam locomotives to dumps for disposal. These waste dumps and switchbacks can be seen by driving north from Jerome a short way on the road to Perkinsville.



View of the surface plant on the 50 foot or slag level and pit operations taken late in 1919 showing the Marion 300 shovel cutting across the slag dump on the 160 level and the Osgood 120 shovel on the 300 level. Number 3 shaft headframe is seen on the right.

It became evident in the fall of 1924, as hard unaltered diorite was encountered on the upper benches, that stripping was falling behind the rapid advance of the Marion 300 shovel into the orebody. Beginning late that year as the diorite became exposed on the 160 level, six large tunnel blasts were resorted to on that level in order to expose more of the orebody. This resulted in leaving a bank above the 160 level without a break which in some places was more than 300 feet high when major stripping operations above the 160 level were terminated in 1927. Major stripping operations in that year were considered completed, a total of 809,000 cubic yards of ore and 7,274,000 cubic yards of waste having been removed above the 160 level.



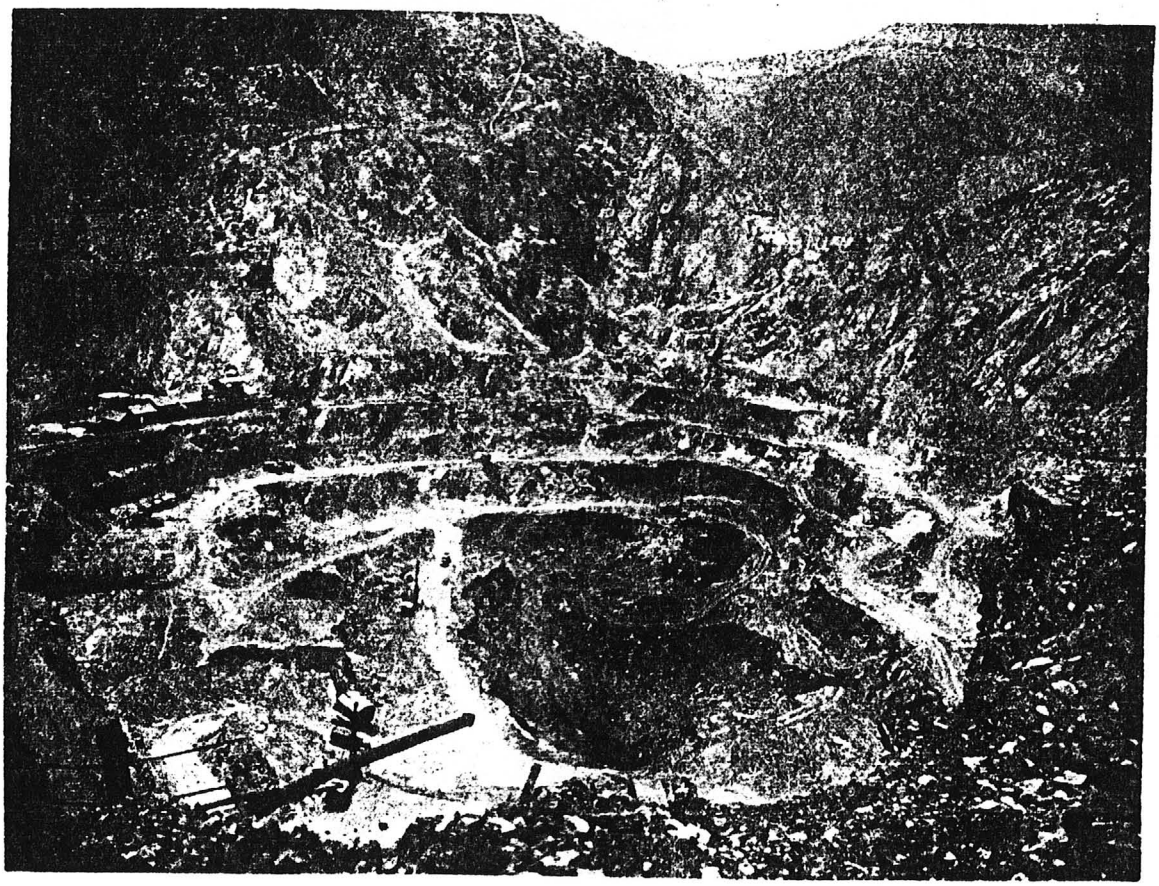
View taken in 1924 showing the cut into the orebody on the 160 level. The boom and dipper of the Marion 300 shovel are seen below the No. 4 shaft headframe. An Osgood 120 shovel is seen on the 5475 bench.

It was originally contemplated that mining below the 160 level would be done by glory hole methods, the material as broken dropping through connecting raises for removal on the 1000 foot level via the Hopewell system. However, the inability to mine selectively, the inability to properly locate transfer raises owing to the severity of the fire and old mine workings, uncertain and irregular production and hazards of operation indicated that glory holing was not feasible.

In 1925 it was decided to mine the orebody below the 160 level with small shovels working on benches about 30 feet high. Ore and waste materials could be separated by careful blasting and loaded into dump trucks for transportation to various transfer raises as could be put through, in and around the orebody. During the course of the lower level operations, nine transfer raises were available at one time or another, which permitted complete segregation of the various ore and waste materials.

Within a few years four 50-B, 1 3/4 cubic yard, Bucyrus-Erie alternating current electric shovels were put into operation. Beginning with a few World War I Liberty trucks having a 3 cubic yard side dump body, 10 ton capacity custom assembled trucks were later obtained, which at the time were the largest units available. From this initial use of trucks in mining operations, large haulage trucks have been developed and in many cases have completely eliminated rail haulage.

With the increasing demand for copper in the late 20's, mining increased at an accelerated rate, 1,055,684 tons of ore being mined in the pit during 1929. The break in the market late in 1929 caused mining operations to be sharply curtailed in 1930 and later suspended. Up to this time a total of 8,500,000 cubic yards of waste had been removed from the pit, permitting mining of 5,660,000 tons of ore averaging 3.22 percent copper with 2.51 ounces silver and 0.086 ounces gold per ton.

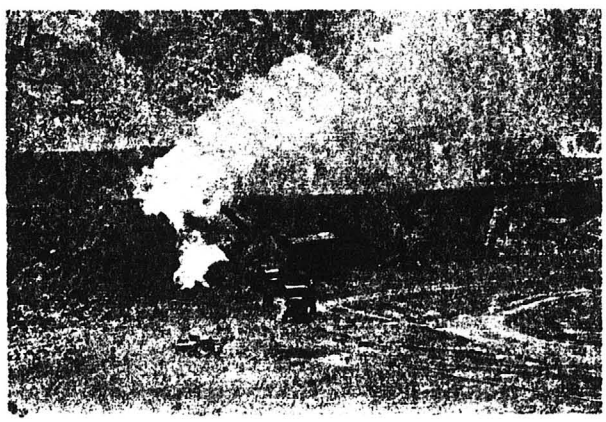


View from the 2475 bench looking southward into the pit in late 1929. The old glory hole workings can be seen at the upper center, the slime plant at the left center. At this time operations had progressed to the 2[illegible] level. The big slide of 1931 completely covered this lower bench.

FIRE IN THE EXPOSED OREBODY

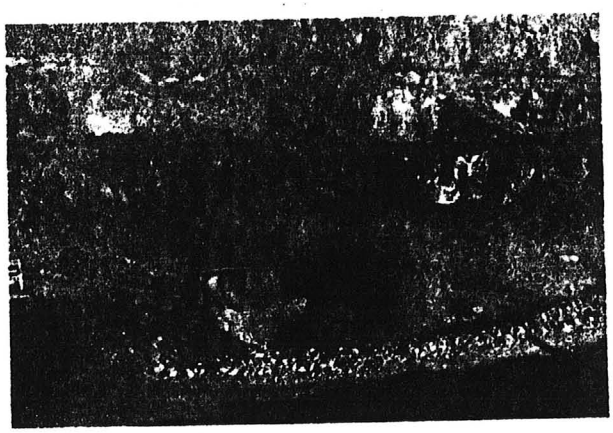
Between 1924 and 1927, after the ore was exposed by the initial 100 level cut, the pit was filled with smoke from the burning ore and old timbers in the underground workings. At times when there was no breeze visibility was limited to 500 feet. On some occasions the heat of the burning ore caused shovel dippers and truck bodies to glow a dull cherry red during night operations. The big problem was in blasting this hot ore. After a mishap in 1924 procedures were developed for controlling blasting in the hot ground. Not only was the problem

of burning ore confined to the surface, but in handling the hot material through the transfer raises and in disposal via the Hopewell tunnel system. Only a small amount of burning ore was placed in a transfer raise at a time, being mixed with material not on fire. The underground fire was brought under control beginning in 1927 when tailings from the concentrator in Clarkdale were pumped through the bulkheads which sealed off the fire area on the underground levels. The effectiveness of this procedure warranted construction in 1928 of a plant adjacent to the pit for making slimes (finely ground sand suspended in water).



Loading burning ore with 6-B shovel on [illegible] level in 1926.

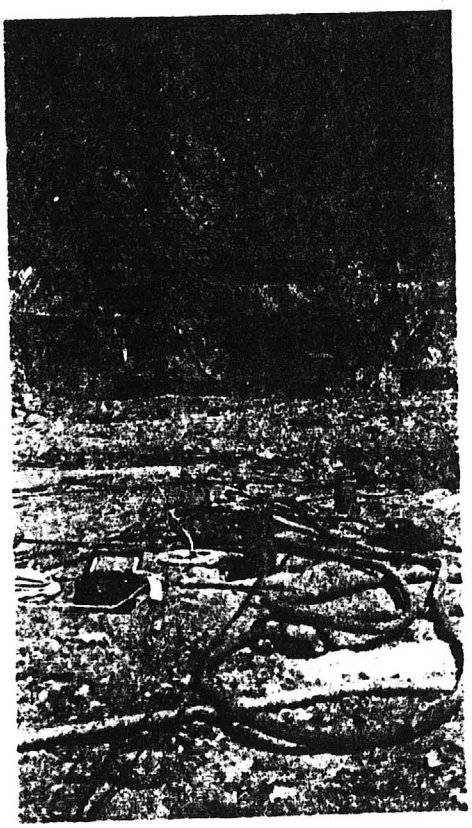
Close up of shovel digging into burning sulphide ore.



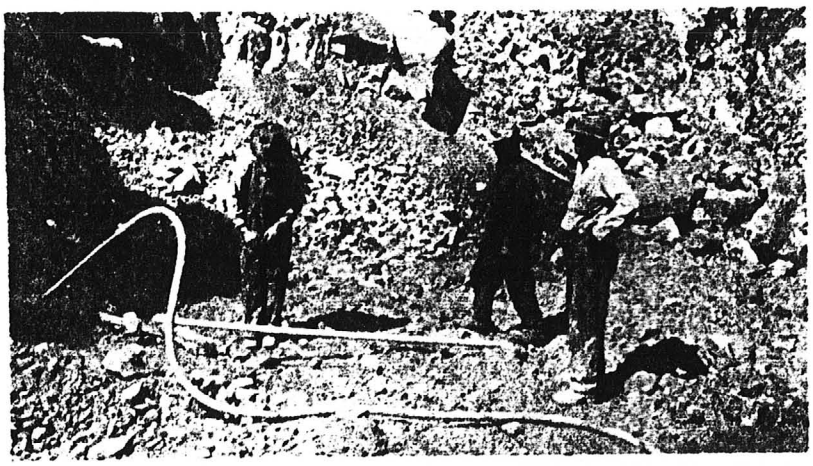
View after dumping load of burning ore into a transfer raise.

BLASTING HOT GROUND

As the cut on the 100 level was being extended into the orebody, hot ground was encountered. After a misha, occurred in loading a hot hole for blasting, ground temperature was taken as a precaution in all holes were heat was apparent. An attempt was made to cool the hot holes before loading by running water or air into the holes, or by placing wet sand in the holes. When the temperature could be reduced below 120°F. for a substantial time, it was considered safe for loading. However, when the burning sulphide mass was encountered below the 100 level, the range of mercury thermometers bid not permit measurement of the extreme heat and it was necessary to use a potentiometer with an iron-constantan thermocouple for obtaining temperatures in the holes. Many holes could not be cooled. The accompanying pictures illustrate means taken to blast very hot ground.

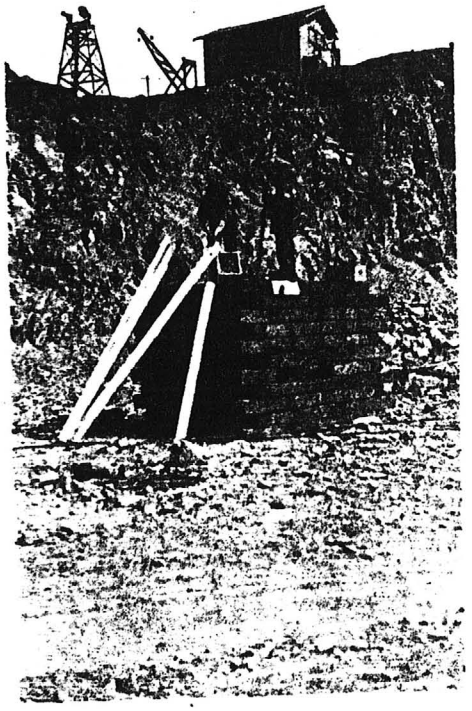


potentiometer with an iron-constantan thermocouple being used to measure temperature in churn drill hole. An attempt is being made to cool several holes by blowing air into them. The highest temperature measured in any hole was 760° F. Two 1 ½-yard shovels, trucks and an electric churn drill are seen operating in the background.

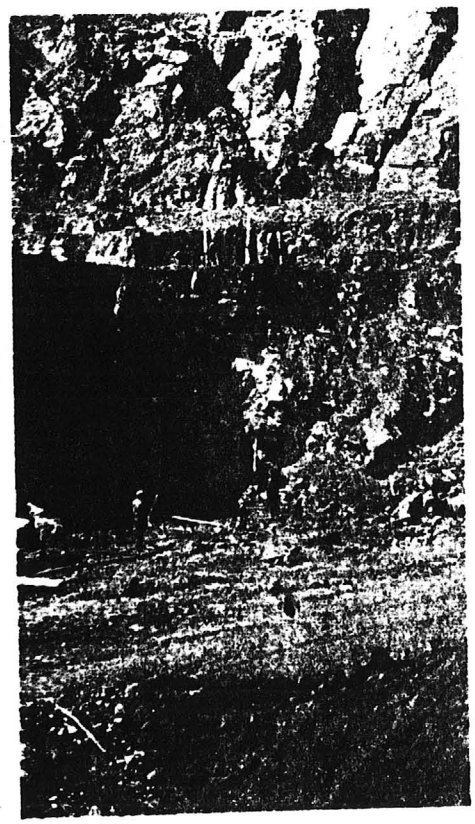


Connecting electric detonators in preloaded paper tube cartridges for blasting air drilled toe holes in very hot ground. One hole is being cooled down by blowing air into it. Note that tubes are supported off of the hot ground.

Blasting crew ready to insert insulated dynamite charges into toe holes as soon as the signal is given. All detonators have been connected except to main blasting circuit. Shot was fired as soon as men were in clear. Note 50-B electric churn drills on benches above. Ground was broken pricipally by blasting churn drill holes, but owing to ground irregularities, hard spots frequently remained which required blasting air drilled toe holes.



Preparing cartridges for six inch churn drill holes. The five inch diameter cardboard tube with walls one-half an inch thick was filled with explosives and double primed with electric detonators. Loading is being done on top of a blasting shelter made of old railroad ties. Note the stand at the upper left supporting electric flood lights. These floodlights located around the pit were used for night operations. At times continuous operation was conducted on a three shift basis.



Ready to insert insulated cartridges for a combination shot of churn drill and toe holes. The large cartridges were carefully lowered into the holes by means of an attached wire. The fractured diorite hanging wall above the 160 level can be seen at the top of the picture.

DEPRESSION YEARS AND ADDITIONAL STRIPPING

At the beginning of 1931, pit operations had been drastically curtailed. Work was confined mainly to supplying a small amount of waste for stope filling in the underground mine which continued operating until the summer of that year. However, the breaking up and caving of the diorite hanging wall in March resulted in resumption of waste stripping in the summer of 1931. During the following years and continuing several years after the resumption of open pit mining in January 1935, more than 6,000,000 cubic yards of waste were removed from the surrounding pit walls.

Stripping operations were resumed one hundred feet above the old upper stripping bench in order to include all the fractured ground resulting from subsidence of the diorite hanging wall. This subsidence will be discussed later. Thus, the top of hanging wall was cut back to an elevation of 6,000 feet above sea level, as compared with the previous high mark of 5,820 feet. In so doing, some overlying sediments of sandstone and limestone were removed.

Stripping operations were carried down progressively on benches 50 feet high to the 5525 foot level, in order to remove weight from the fractured hanging wall. Below the 5525 level, stripping was confined mostly to removal of the fractured and caved material from the big slide. This caved material was not uniform, and many large fragments, some as big as a house, had to be dislodged and broken up before loading. This was done under a bank 200 feet high under extremely hazardous conditions, the slope requiring constant scaling and trimming.

An unusual situation was noted in the lower part of the caved material, for it found to be cemented together, Presumably, this resulted from fumes arising from the underground fire area precipitating solids in the displaced diorite rock which bound it together. This material was difficult to break up until it was discovered that a generous amount of water would loosen the cementing agent..

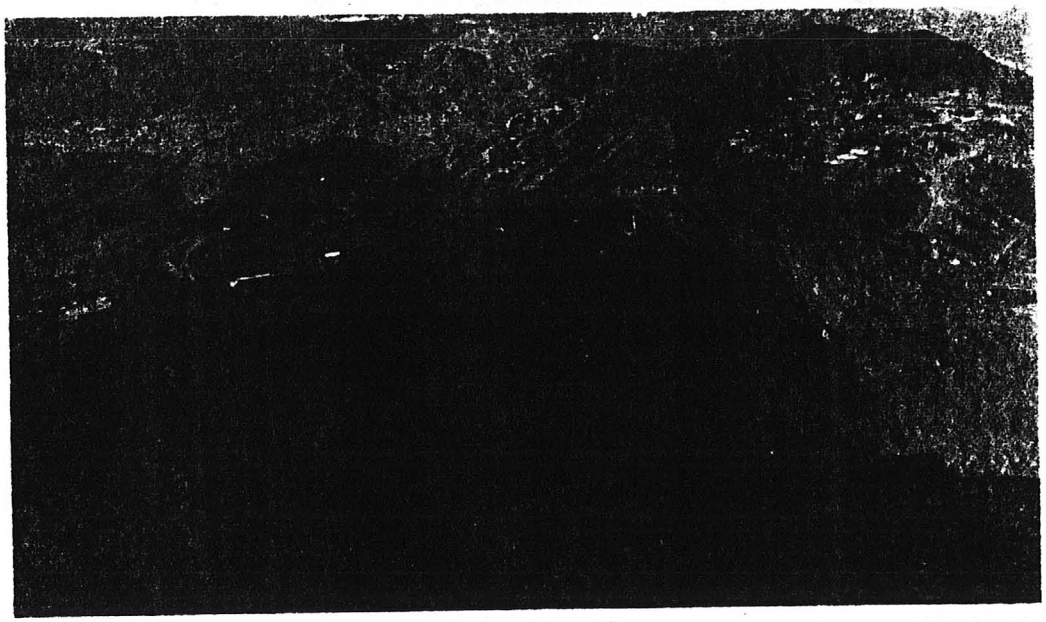
Trackage was relayed on the old switchbacks and waste dumps, and the old steam locomotives and dump cars put back into service. The old steam shovels were not used, for during the few previous years, many improvements had been made in power shovels. Two Bucyrus-Erie 120-B, 4 cubic yard, electric shovels with Ward-Leonard control were obtained. This type of shovel operated at less than one-third the cost of the old steam shovels. These modern shovels were the first of this type to be used in Arizona. As construction of switchbacks to the two upper levels was impractical, a small gasoline powered shovel, a gasoline locomotive and 10 yard dump cars with the necessary trackage were hauled or moved up on a road constructed for that purpose.

A cut was made into the pit in 1934 from the 300 level to facilitate removal of waste below the 100 level by means of direct rail haulage. This also permitted direct loading of ore on two benches without the necessity of transfer through raises and the Hopewell tunnel system when mining was resumed. This cut was later widened out for providing desirable waste for underground stope filling. It is from this level, which is skirted by the road leading from Jerome to the old Mine Office buildings, that the extent of the "Big Hole" can be seen to the best advantage. With permission one can look down deep into the pit from this level, operations having been terminated at the 630 mine level or 330 feet below. Now the hole has been partially filled by caving and leasing operations, so the full depth is not apparent. It is said that one standing in the center of the lowest level and looking up, could see the entire rim of the pit and see stars shining in the daytime.

THE BIG SLIDE OF 1931

In June 1929, mining operations in the pit had progressed to below the 300 level, and were being conducted on a 24 hour, 3 shift basis. At about 4:00 A.M. on June 30th, those working in the pit were alarmed by very sharp noises, resembling explosions. The bottom of the pit in the center section adjacent to the diorite wall gave way and dropped as much as four feet. At the same time a rupture of the diorite wall occurred, extending across a width of more than 300 feet, upward and beyond the upper edge of the northwest diorite wall which at that time was more than 650 feet above the lowest pit level. This ruptured section dropped more or less as one mass, only small amounts of rock, about 25,000 tons, falling away from the fractures. Immediate action was to move men away from the fractured area, and wherever possible to move equipment away from the danger area. Operations were discontinued and a survey was initiated to determine the extent of the caving and its effect on continuing mining operations.

The investigation disclosed that early on the morning of the previous day, underground workmen on the upper levels had reported ground giving away above the 1200 level. As most of the workings above had been sealed off owing to the fire in the upper orebody, the extent of the caving was not realized and no warning was given to those in charge of pit operations. Close examination of the fractured area on top of the hill disclosed that displacement of about three feet had occurred, there being more than 12 distinct fractures on the surface. No further movement of the pit floor was evident. It was decided that the loosened mass had dropped as far as possible owing to caved material filling the open spaces in the underground workings, and provided support for the loosened mass. The cause of this subsidence was attributed in part to heavy surface blasting in previous years, to weakening of underground support by the slimes which had been pumped into the underground fire area for choking off the fire, and to weakening of support by continued burning in certain areas.



View of the fractured area on the surface showing displacement of the diorite hanging wall, 650 feet above the 370 level on which mining operations were being conducted. Sunshine Hill and 500 level townsites may be seen in the upper center and right. Tracks of the Verde Tunnel and Smelter Railroad may be seen extending as far as Hopewell in the distance.

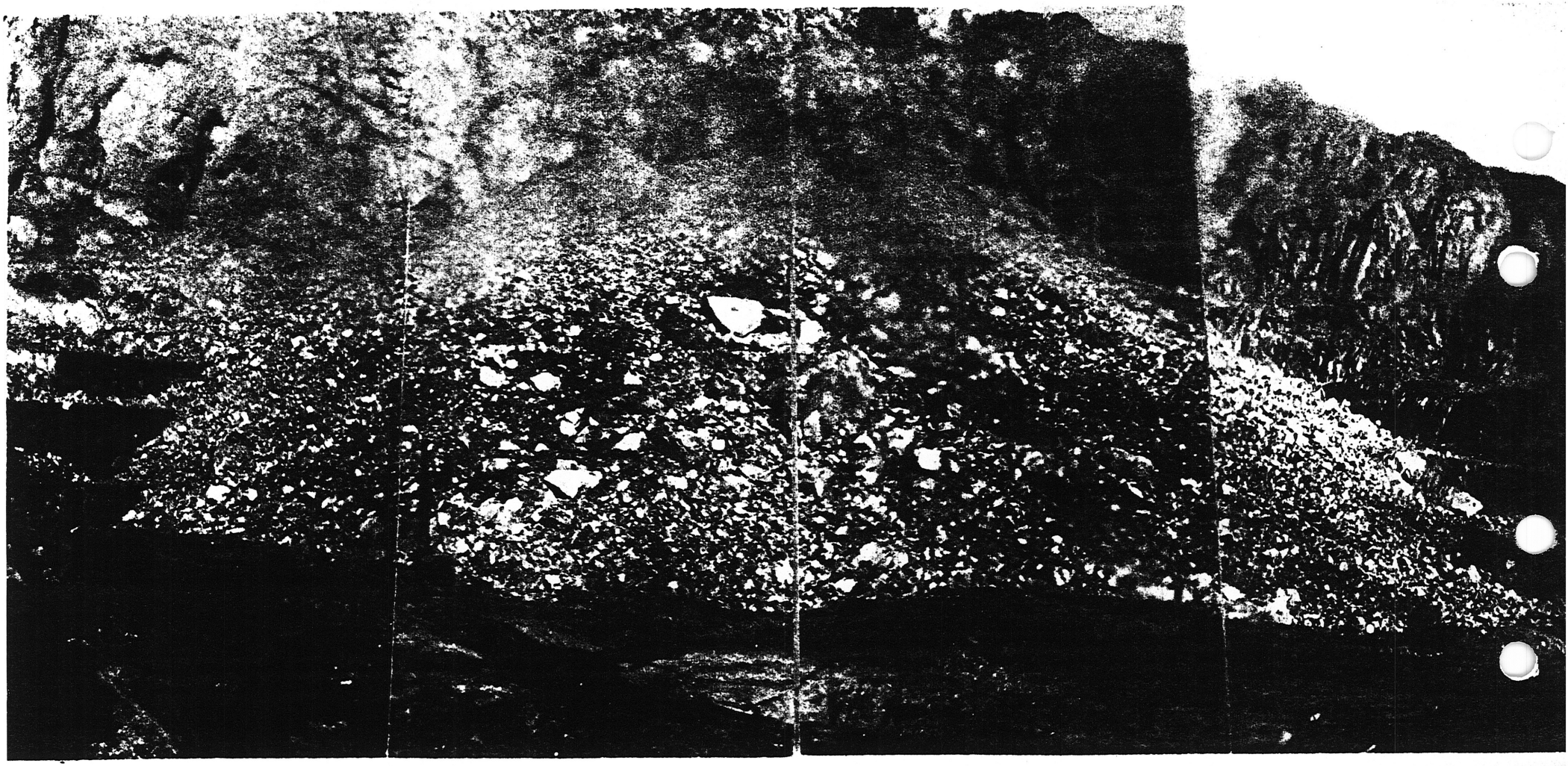
Material continued to fall away from the fractured bank, in no great amount, but enough to make operations in the pit hazardous. In a few days, it became evident that no great fall would occur. Scaling and trimming of the bank was initiated, permitting mining on the far side. Further rockfalls ceased in a few days and the slope was placed under constant surveillance when operations were resumed. On Sundays, all equipment was moved away from the fractured slope so that scaling and trimming could be conducted.

A program for observing the fractured ares was undertaken, twenty or more monuments being set in concrete, in and outside of the fractured area on top of the hill. Surveys were made at periodic intervals thereafter, to determine

vertical and horizontal dispacement by which total movement was determined. This information was recorded on a time-movement graph, which indicated the rate of movement. The rate of movement was uniform for eighteen months, after which an increase was noted. By extending the movement line in a curve, it was predicted that the mass would give away in the twentieth month. So it did, sloughing of rock from the fractured area began a week before and increased at an accelerated rate until the displaced mass gave way with a tremendous roar and clouds of dust in March 1931. It was estimated that more than 1,000,000 tons of waste diorite rock fell into the pit below. As operations in the pit had been practically suspended at that time, no injury to personnel or damage to euipment resulted.

The method of predicting when a fractured wall would fail by plotting the time and movement, was also successfully employed to predict another fall of rock in March 1936, when about 400,000 tons fell into the pit from the wall on the southwest.

The big slide or cave of March 1931, resulted in the decision previously noted, to remove additional stripping from the hanging wall, and so provided employment for many during the depression years. The overall cost was much lower than it would have been in previous years, for costs for labor, materials and supplies were at rock bottom during the depression. This additional stripping also made it possible to extend mining operations down to the 630 level, instead of the 500 level as previously contemplated.



View of the caved material from the big slide of march 1931. The pile of broken diorite rock was about 600 feet wide, covering the lowest working bench at the 5175 level, the crest being about 300 feet higher. More than 1,000,000 tons of rock caved off the hanging wall, some of the fragments being big as a house.

RESUMPTION OF PIT MINING OPERATIONS

The removal of waste during the depression years and the improved price of copper permitted resumption of mining in January 1935. The extreme heat encountered in previous years was never a problem after mining was resumed. Burnt schist ores required special handling until milling procedures were revised to accomodate them. On February 18, 1935, control of the United Verde Copper Company passed to the Phelps Dodge Corporation. Shortly thereafter the decision was made to forego underground mining until pit operations were well towards completion in order to eliminate the possibility of more fracturing and caving of the diorite hanging wall. Pit mining proceeded at an accelerated rate, and for two and one-half years, practically all ore processed was mined in the pit, amounting to more than 2,500,000 tons having an average grade of 3.92 % copper, with 1.44 ounces of silver and 0.046 ounces of gold per ton. While copper prices were low and fluctuated during this period, it is conservatively estimated that the value of the ore produced from the pit in these first thirty months of Phelps Dodge ownership amounted to more than $25,000,000.

Production in the pit declined rapidly after 1937 as the working benches became restricted by the surrounding slopes. Pit mining was carried down to the 630 level or more than 1,100 feet below the highest point on top of the hill when operations were terminated in April 1940. A total of more than 4,050,000 tons of ore were removed after mining was resumed in the pit, averaging 3.83 % copper, with 1.45 ounces of silver and 0.050 ounces gold per ton.

Not all of the ore above the 630 level was recovered by pit mining, as the pit slopes by necessity extended into the ore zone. Underground mining, beginning on a small scale in April 1937, was terminated in 1953. A few years later, leasers started mining ore remaining above the 630 level and at the present time are continuing mining in the south ~~end~~ wall of the pit.

SUMMARY OF OPERATIONS

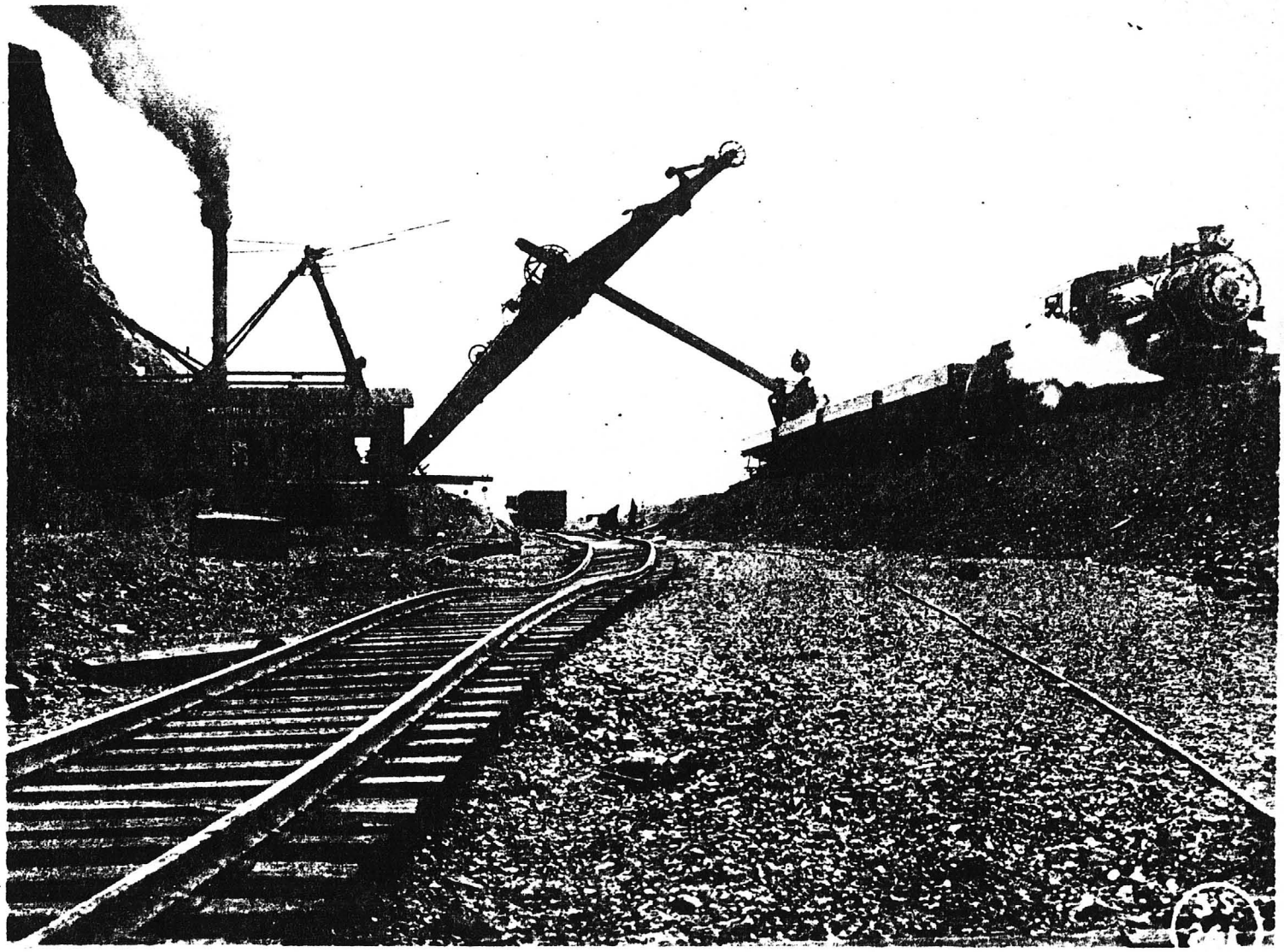
During the life span of the United Verde Open Pit, from 1918 to 1940, many changes occurred, not only in operating methods and equipment in the Jerome pit, but in surface mining operations in general. The United Verde Open Pit operation contributed to these changes, even though it was unique as a surface operation. For many years, uncertain conditions prevailed in developing and operating the United Verde pit, but when mining was resumed in 1935, operations progressed smoothly, firm and systematic operating procedures having been established.

The lifetime period on the United Verde pit was also a period of feast or famine in the copper industry. As the price of copper fluctuated, it was reflected in speeding up or shutting down operations. All operations were shut down in 1921 for a year and a half, and all mining operation for four and a half years during the depression. Actual pit mining was accomplished in not more than fifteen years.

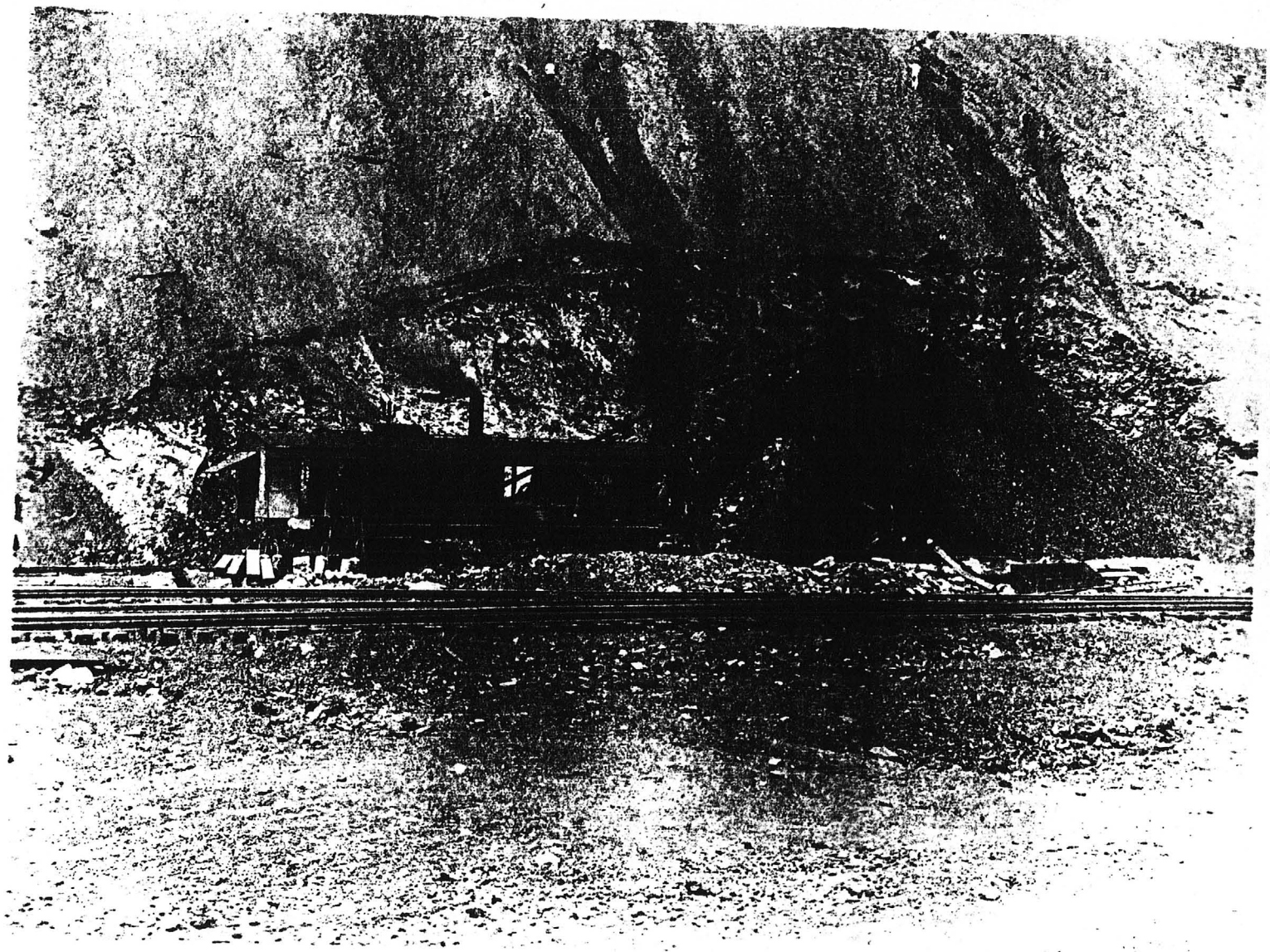
It has been noted that 9,708,923 tons of ore were mined from the pit. In addition several million tons of waste with low copper content were placed on designated dumps for leaching. Disregarding copper produced by leaching, production from the pit roughly amounted to:

674,000,000 pounds copper, 20,000,000 oz. silver and 686,000 oz. gold, conservatively valued at more than $100,000,000. This was indeed, a whole lot of wealth to come from a hole in the ground.

The story of the United Verde Open Pit is not complete without paying tribute to the loyalty and skill of the men who made it possible. From the scaler, dangling at the end of a rope on the high bank, down to the drillers, powdermen, shovel crews, truck drivers and others working below, a fine spirit of cooperation and accomplishment existed. No task was ever too difficult, in spite up the unusual conditions under which these men worked. These brief notes are an attempt to present the general aspects of operations at the United Verde Open Pit, the many details of which can only be found in the memories of those who made the operation possible.

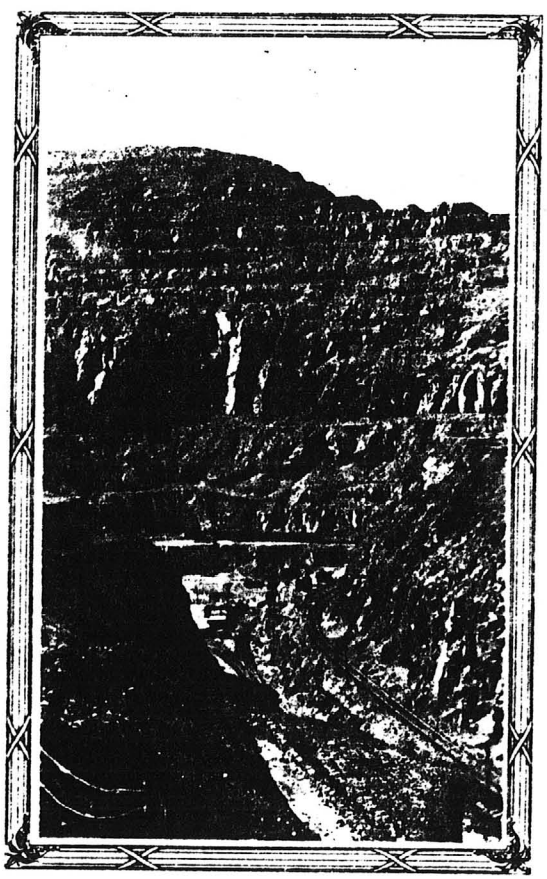


The Marion 300, 8 Yd. coal fired steam shovel loading slag into 25 Yd. dump cars with a six wheel, switcher type, steam locomotive during 1919. This full revolving shovel was procured on a priority basis during WWI, it having been built for work at the Panama Canal. The shovel was mounted on four rail type heavy duty trucks, which enabled it to move on very heavy sections of track laid by a ground crew of four men. The shovel crew consisted of four men, an engineer, craneman, oiler and fireman, a far cry from the one man operator on today's shovels. The shovel was equipped with two boilers which were later modified to use fuel oil.

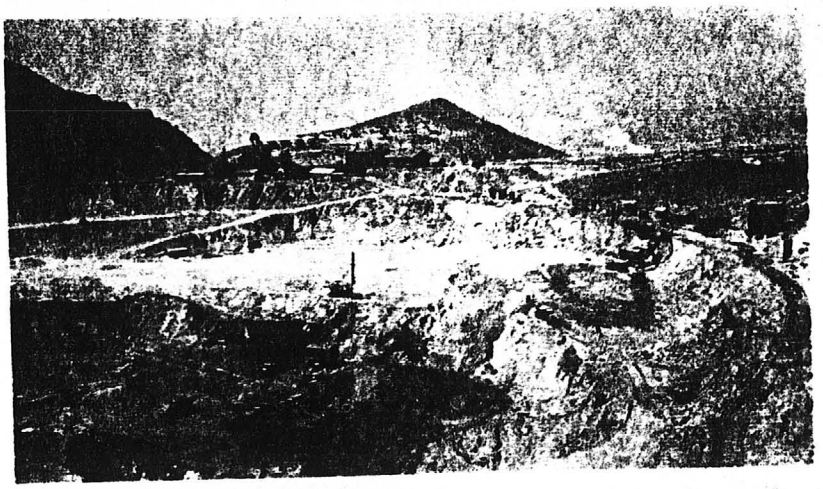


The Osgood 120, 4 yd. railroad type steam shovel operating on the 300 level loading slag in 1919. This was the largest size of this type of shovel built. The shovel moved along on track, only the boom and dipper swinging, the front end being supported on jacks. These shovels were later modified to use fuel oil, and by providing caterpillar trucks for independent moving, one at the rear and one at the end of each supporting jack arm. Carbide lights for night operation are stacked on the ground behind the shovel.

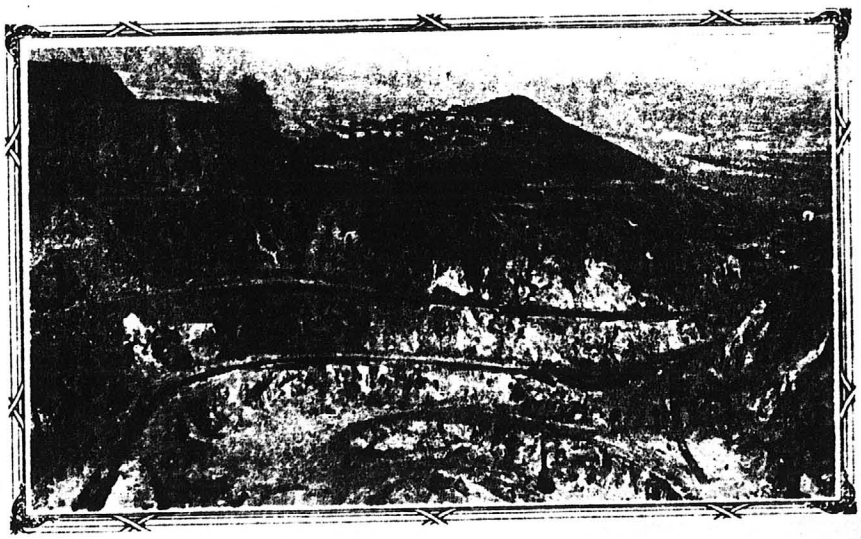
Stripping operations late in 1925. An Osgood shovel is working on the 5175 elev. bench, another on the 50 foot level or 5425 elev. bench. A 1/2 yard utility steam shovel is cutting through a pile of broken rock from a tunnel blast on the 160 level, elev. 5525, for extending the loading track. The Marion 500 shovel on the lower right is down for repair. The top of the diorite bank at this time was at elev. 5800.



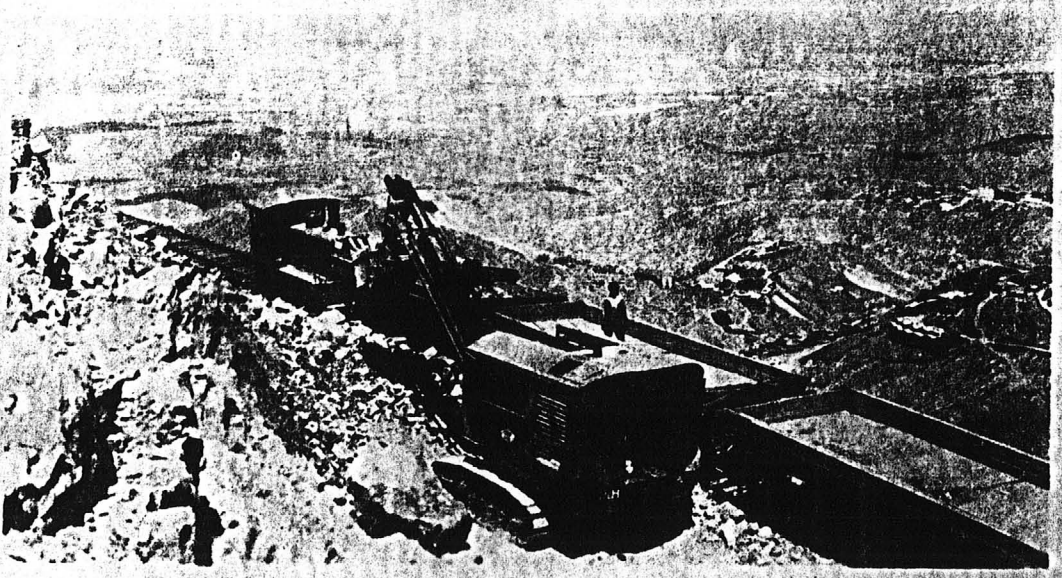
View of the diorite wall in October 1925, looking throught the cut from to 300 level. The top of the bank was at elev. 6000. A series of benches, 50 ft. high, extended down to the 5425 elev. bench. Below that a bank 200 ft. high remained above the 160 level bench. which was about 150 ft. above the ore cars waiting to be loaded on the 5178 elev. bench. At this time the difference between the top of the cut and the lowest working bench was some 820 feet.



View of the pit in June 1928 looking northeast. The pit surface plant and The idle Marion 300 shovel can be seen on the 160 level with Sunshine Hill in the background. Smoke from the Clarkdale smelter can be seen in the upper right, below which is a tank for mill tailings which were initially used for choking off the underground fire. Electric 1 3/4 shovels, an electric churn drill and rocker type, side dump trucks may be seen, the lower ones on the third bench below the 300 level at elev. 5240. One truck has just dumped a load into No. 8 transfer raise.



Same view of pit in October 1929. With the construction of a cut into the pit on the 300 level, the pit surface plant was moved down to that level. Trackage entered the pit on two grades, one to the 3d bench, elev. 5240, the other to the 5th bench, elev. 5178. On the left, a 120-B, 4 yd., shovel can be seen waiting for a waste train to come in. Below it, another 120-B shovel is loading ore into 100 ton V. T. & S. R. R. cars for direct shipment to the smelter which can be seen in the upper right.



View of equipment used on upper two benches when stripping was resumed in 1931, showing the 3/4 Yd. P & H gasoline shovel, the gasoline locomotive and 10 Yd. dump cars. The Douglas Memorial Mining Museum can be seen down below in the right center.

View taken in December 1931, showing the Bucyrus-Erie 120-B, 4 Yd. electric shovel cutting into the caved rock on the 160 foot level.

STORY OF THE UNITED VERDE AND THE UNITED VERDE EXTENSION

According to the Phelps Dodge Corporation's Annual Report for 1951 there were then only a few months more life in the United Verde Mine which, at the time it was owned by Senator Clark was probably the richest mine that was ever worked under individual ownership. From the date of its purchase by William A. Clark in 1888 to the end of 1935, the mine had yielded 20,346,000 tons of ore, from which 1,979,105,400 pounds of copper have been extracted, together with 971,735 ounces of gold and 34,358,390 ounces of silver. The gross value of this output, after transportation, refining and marketing, was slightly more than $350,000,000. This indicates an average grade of better than 17 dollar ore, and the United Verde Mine ranks among the "bonanza" mines of the State, as distinguished from the "low-grade porphyry" mines.

History *

The United Verde Mine, the chief mine of the Jerome or Verde Mining District, is at Jerome, in Yavapai County in north-central Arizona. Jerome is on the northeasterly slope of the Black Hills. The mean altitude is about 5,200 feet, and the smelter towns of Clarkdale and Clemenceau are in the valley about 2,000 feet lower. The Verde Tunnel and Smelter Railroad connects Jerome with Clarkdale, which is on a branch of the Santa Fe.

The first mining claim to be located in the Jerome District was that of Albert Sieber, a noted Scout, in 1877; he named it the Verde because of the green carbonate stain. However, Al Sieber located none of the original United Verde claims. The first claims in the original United Verde group were located on February 17, 1876, as follows: Venture No. 1 North by John O'Dougherty, John P. Kelly

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* Rickard's "A History of American Mining".
Paper by Louis E. Reber Jr. in Arizona Bureau of Mines, Bull. # 145.
Joralemon's "Romantic Copper".
H. V. Young, longtime employee of the old United Verde Copper Company and Phelps Dodge Corporation.

and Josiah Riley; Venture No. 1 South by Edward O'Dougherty, John D. Boyd and A. B. O'Dougherty. By 1880 the district had acquired fame enough so that the Phelps Dodge Company sent Mr. Douglas to examine it. He reported that there was a little copper ore, but the long 175-mile wagon haul to the Santa Fe Railroad discouraged him from recommending exploitation. During these early days the United Verde Mine was worked on a small scale and shipments of high-grade gold-silver ore were made from the surface workings.

In the summer of 1882, Fred Thomas, a San Francisco engineer, obtained an option on the Wade Hampton and nine other claims and two millsites which comprised the original United Verde grant. The Wade Hampton had been located in 1877 by M. A. Ruffner and Angus McKennon. With the help of George Treadwell (who later developed the Great Treadwell Gold Mine in Alaska),Thomas organized the United Verde Copper Company. Its secretary was Eugene Jerome, for whom the growing town was named. The Governor of the Territory, F. A. Tritle, maintained an active interest in the company until Clark took over in 1889. Thomas built a fifty-ton furnace and turned out nearly $800,000 worth of copper in the first year, and paid $62,000 in dividends. Then the price of copper dropped and the mine had to shut down. Even 20 or 30 percent ore was of no value in such a remote camp when copper sold for less than 10 cents a pound.

Dr. Douglas visited the United Verde a second time in 1887, after the first little smelter had been in production and the railroad was then only 45 miles away. He was sufficiently impressed with it to enter into negotiations for an option. The terms he offered were opposed by Charles Lennig, the principal creditor of the United Verde, and in January 1888, the deal went on the rocks. In the same month W. A. Clark took his option.

In 1888, W. A. Clark came down from Butte with his smelter man Joe Giroux. Clark took a lease on the United Verde and bought it the following year. The development work he carried on soon proved that the 10 to 20 percent copper glance

ore was two hundred feet wide and six or eight hundred feet long.

In 1894 Clark built a twenty-seven mile narrow-gage railway to connect with the new Santa Fe running south from Ash Fork to Prescott. With a new smelter and roast heaps like those at Rio Tinto to burn the sulphur out of the ore, the United Verde was soon one of the great copper mines. As the grade of ore dropped with increasing depth of the mine, new equipment and larger tonnage kept up the yield of copper and the profits. In the thirty years before he died, Senator Clark made $60,000,000 out of the mine that Thomas had bought with so much difficulty for $50,000.

The smelter which Clark built was unfortunately placed over the mine workings and became endangered by the settling of the ground; moreover, the site was inadequate for the desired expansion of the plant. In 1912, the building of a new smelter was started in the valley, at Clarkdale. It was completed in 1915. At this time the Santa Fe built a branch of standard gage to this point. 1919 marked the beginning of open-pit operation. In 1931 the United Verde purchased the Verde Central and in 1935 the Phelps Dodge Corporation purchased the United Verde.

The development of the United Verde Extension Mine, beginning in 1899, makes a story in itself, and it has been very interestingly told by T. A. Rickard in his "History of American Mining". The data for this story was obtained from Ira Joralemon's "Romantic Copper". Joralemon was given credit by Rickard for having recommended the venture to Mr. James Douglas (the son of James Douglas of Copper Queen fame), and Major A. J. Pickrell.

* Just below the "Big Hole" (United Verde Mine) is a great fault. The rock east of this Jerome fault has slid down toward the Verde Canyon for half a mile. As a result, the limestone and lava that were laid down on an ancient erosion surface long after the orebody was formed are high up on top of the mountain west of the fault and of the United Verde, and far down toward the canyon east of

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* Joralemon's "Romantic Copper".

them. Under these comparatively recent rocks east of the fault, the older schist that contains the ore is buried six hundred feet deep. The fault cut off the greatly enriched top of the United Verde orebody, together with the enclosing rock, and slid it two thousand feet down an equal amount to the east. Erosion then exposed the roots of the ore west of the fault. The former top of the orebody, now east of the fault, remained safely covered and hidden by the limestone and lava. The dip of the fault was to the east, under claims owned by George Hull, a Jerome Pioneer. In 1899, he formed the United Verde Extension Mining Co., and induced a New York broker, named Louis Whicher, to sell a lot of stock and to sink a shaft through the lava on the Little Daisy claim.

In the next twelve years Whicher and his associates raised and spent nearly half a million dollars on the Verde Extension. Only a few streaks of ore resulted from the investment and the Little Daisy was finally shut down.

Among Verde Extension's stockholders was a fine old southern gentleman, Major Andrew Jackson Pickrell, who still had faith in the property, and persuaded his friend James S. Douglas to become interested in it. The latter, with his friend Geo. Tiner of Pittsburg, sent an engineer to examine the Verde Extension. It was recommended as a good gamble, and Douglas and Tiner started development. $200,000 went into the ground with no results. They decided to risk another hundred thousand. Two years after they started work, a crosscut on the 1,200 foot level found five feet of 45 percent copper glance, and they started to sink again.

In 1916, after a four-year campaign of development, the fourteen hundred level electrified the mining world by cutting 300 feet of 15 percent ore. It was the faulted top of the Great United Verde orebody and its richest spot. A vertical side-line agreement with the old company prevented a complicated apex suit that might have ruined the Verde Extension. Under Clark's very nose, Jim Douglas and his friends took out over 42 million dollars in dividends. The ore-body was finally exhausted in 1938.

Rickard paid the following gowing tribute to James S. Douglas for the part he played in this successful venture:

> * "M any of the richest mines in the world have been the cause of great financial loss to the public because they were over-valued on the stock exchange and their shares were bought at inflated prices. The "Bonanzas" have been as much a source of regret as the "borrascas"; the genuine enterprises, by being grossly exaggerated, have done as much harm to the pockets of innocent folk as the calculated frauds. The U.V.X. has been free from anything of the kind; not much stock was sold at the high quotations, because the principal holders retained their stock even when, in 1916, it went up to $52 per share. Mr. Douglas, I may add, sold none of his stock until 1928, when he sold some, most of which he bought back later. The whole business has been clean from start to finish; it has justified the claim of Agricola that "mining is a calling of peculiar dignity."

Ore Mineralization **

*** "The United Verde ore zone, as developed in the United Verde Mine, consisted of a very irregular pipelike body of massive sulphide and rock. In plan the mineralized zone ranged from more than 500,000 square feet to less than 300,000 square feet, with an average of near 400,000 square feet. The massive sulphide itself had an average cross section of approximately 250,000 square feet. Pyrite, quartz, carbonate minerals, and some sphalerite (locally insignificant quantity) formed the sulphide gangue. Black chlorite rock (black schist), with some quartz porphyry, is the predominant rock gangue. The mineralization is very clearly of the replacement type. Although other sulphides were present, the copper content of the ore as a rule depended on the abundance of chalcopyrite with about one-seventh of the volume of the mineralized zone as commercial copper ore."

The ore zone in the U.V.X. Mine probably represents a segment from over 2,000 feet above the top of that exposed in the United Verde Mine. Probably a large part of the chalcocite ore was a fairly good grade before enrichment. As in the highest levels in the United Verde, there was probably a smaller-than-average area of mineralization, with a higher-than-average proportion of chalcopy-

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* Rickard's "History of American Mining", p. 379.
** L. E. Reber's Article in Arizona Bureau of Mines Bull. #145.
*** Paul Yates.

rite. The intensity and extent of the secondary enrichment in the U. V. X. Mine formed an almost unique deposit of chalcocite that placed the mine in the front rank of high-grade copper mines.

Mining, Milling* and Smelting

Several methods of underground stoping have been employed in the United Verde mine: horizontal cut-and-fill, incline cut-and fill; square-set and fill, shrinkage and fill, and glory hole. In 1918, open-pit operation was started, and was completed in 1940. Since then, underground mining was employed chiefly in removing the pillars left in the mine.

The system of ventilation was complete and modern and has been fully described by Tally in his paper on mine fires. Owing to several expensive mine fires it was found necessary to devote much attention to this subject. One fire, on the 400-foot level, burned for over twenty years. Mining in the fire zone was conducted under the plenum system, by which air under pressure is introduced into the workings. As far as possible the fires were isolated by bulkheads. In order to reach the burning sulphides, steam shovels were introduced in 1918 to remove 15,977,807 cubic yards of overburden, which permitted the mining down to the 600-foot level of some 9,708,923 tons of ore said to average 3.47 percent copper, 2.07 ounces silver and .07 ounces gold.

Most of the copper-bearing mine water was formed during the progress of natural surface drainage through the oxidized zone and through old filled stopes above the 500-foot level. Before and during early Pit operations these waters were the source of profitable copper precipitate. All ore hoisted through the No. 5 shaft was dumped into storage bins above the 1,000-foot level. Trains of 40-ton ore cars were hauled an average distance of 8,900 feet through the Hopewell tunnel to a crushing plant which was originally at the tunnel's mouth but later moved to Clarkdale near the new smelter.

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* Milling method described by Kuzel & Barker in U.S.B.M. Information Cir. 6343.

A concentrator, designed by H. Kenyon Burch and United Verde's chief engineer, J. E. Lanning, was constructed near the crushing plant, and began operations in 1927, handling 1,000 tons of ore per day. The General location of the concentrating plant was such that tailings could be delivered by gravity through a pipeline to a very desirable location for tailings disposal. The plant was also located favorably with respect to all services such as railroad, water, power and the like. The Verde Tunnel & Smelter Railroad, owned by the corporation, hauled the ore from the Hopewell Tunnel, a distance of six miles to the crushing plant. The water supply had its source in springs, artesian wells, and a tunnel under the Verde River. Power was available from the smelter power plant, the generators therein being operated on waste-heat steam from reverberatory furnaces. The smelter power system, however, is interconnected with the Arizona Power Co.

The primary breaking was done by 48" x 36" jaw crushers, followed by 48" vertical disk crushers and 56" x 24" rolls crushing to minus $\frac{1}{4}$" size. The maximum size piece of ore received at the crushing plant was about 17 inches. The product of the Jaw crushers was minus 4-inch size, and of the disk crushers minus 1-inch size. Conveyors and elevators were used throughout the plant for transporting the ore to each machine.

As initially constructed, the mill consisted of two units consisting of 8' x 12' ball mills and mechanical flotation machines. Hunt flotation machines were also used experimentally. Auxiliary thickeners, classifiers and pumps were employed in each unit of the plant, and the capacity of the plant varied from 1,000 to 1,600 tons per day, depending upon the degree of grinding required.

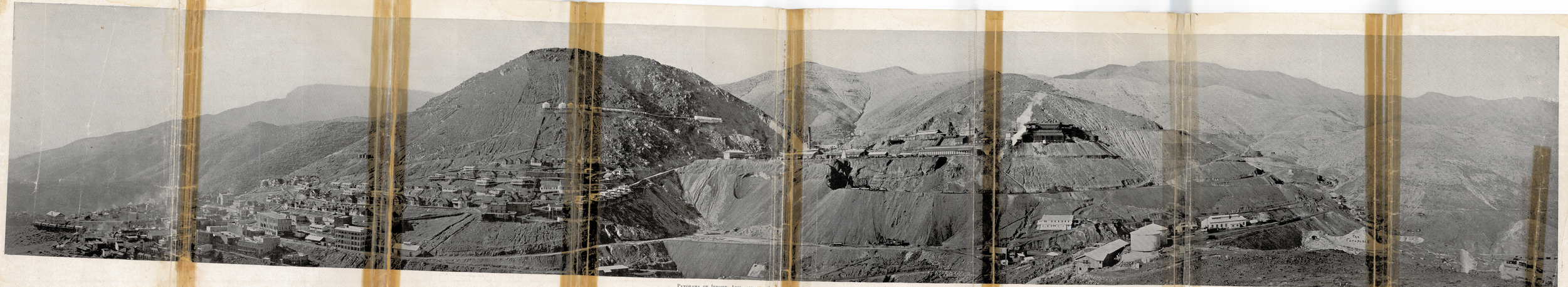
The ore treated usually contained about three percent copper, and consisted chiefly of the schist ore, and at times the massive. Lime was used in the mill to neutralize deleterious soluble ore salts and for pyrite depression. Although an extraction of over 91 percent of the copper was obtained, constant experimenting and research were carried on by a competent metallurgical staff.

The concentrate, after filtering, and containing about 15 per cent copper, 5 percent silica and 30 percent iron, was conveyed to the roaster-charging conveyor system of the smelter. The latter, built at Clarkdale in 1915, had a capacity of 5,000 tons of ore a day. It consisted of a crushing plant and sampler; a calcining plant of 21½ foot Wedge furnaces with dust chambers and a Cottrell precipitating plant, six 100 foot reverberatory furnaces; four 48 x 320 inch blast furnaces; seven stands with eight shells of Great Falls converters; and necessary pumps and compressors. The smelter has been described by L. A. Parsons in Mining & Scientific Press Oct. 16, 1920 and June 25, 1921.

Conclusion

Mining operations were terminated at the United Verde Branch on March 23, 1953. The United Verde Mine had produced over two and three quarter billion pounds of copper, which with gold and silver values, was worth about 475 millions of dollars. The U. V. X. Mine has produced over three-quarters of a billion pounds of copper, which, with gold and silver values, was worth over 125 millions of dollars. Of course, most of this grand total of six hundred million dollars was turned back to the state and nation in the form of wages, purchase of supplies, and taxes. However, probably one hundred and twenty-five million dollars was the profit returned to the investors, or a little over 3½ cents per pound of copper produced. For the seventy years of production, this was a return of less than two million dollars per year. With a probable capital expenditure of twenty million dollars for plant and development, the average return for the investment was less than ten percent, which can be considered only a fair return on what at many times must have been a hazardous proposition.

April, 1957



Panorama of Jerome, Ariz., and the Surface Plant of the United Verde Copper Co.

Exhibit "B"


Mingus Mountain Elev. 7700 ft.
U.V. Glory Hole
No. 4 Shaft
HILL COPPER CO.
UNITED VERDE COPPER CO.
U.V. Ore Bodies
Main North Fault
Tessy Shaft
U.V. Extn. Ore Body East of Fault
U.V. Extn. Ore Body
No. 3 Shaft
Trend of U.V. Cop. Co. Ore Bodies
Trace of Fault
JEROME VICTOR EXTENSION
JEROME HERCULES
United Verde & Pacific R.R.
Flat View
A.&A. Shaft
ARKANSAS & ARIZONA