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BLUESTONE MINE

3/15/39

Owners Cleve Van Dyke and Hoval A. Smith - 387 E. Thomas Road
Phoenix, Arizona
Phone - 3-8311

(Conference with Smith)

Location south and southeast of New Cornelia holdings at Ajo and contains 2800 acres a portion of which is patented (See map).

Over $200,000 has been spent in acquiring property and development work mainly in sinking 14 diamond drill holes. Of these only #1 and #2 were put down thru the fanglomerate and reached the underlying monzonite as follows :-

	#1	#2
Depth to Monzonite	1500'	1668'
Total depth	2082'	2250'
Copper Assays of porphyry	28' @ 0.99% 87' @ 0.533 582' @ 0.240	162' @ 0.424 382' @ 0.28
Assay @ 1660'	0.50	0.51
Copper stains in overburden	1200'	1200'
Assay at bottom of hole	0.5	0.5

All ore oxidized to bottom of holes but some sulfides beginning to come in. Smith thinks that there should be an enriched secondary zone a short distance below the bottom of the holes and representing a zone which had been almost entirely eroded away from the top of the New Cornelia ore body which was not protected from erosion as was the Bluestone ground, therefore he expects to find a zone of rich chalcocite porphyry ore well above the 2000' level and claims that statements by Gilluly and others that any pay ore in this section would lie at depth of 4000-5000 feet are ridiculous and disproved by his drilling.

All other holes are still in the fanglomerate and most of them are only 500-600' deep and should be continued.

Former drilling was done on contract @ $3.50 per foot for 1st 1500' and then increase of 25¢ per foot for each 100' but Smith thinks that all future drilling could be done at cost of $3.00-$3.50 per foot to depth of 3000'.

There is a well on the property (see map) from which 35,000 gals. per day was pumped steadily for the drilling. It is excellent domestic water.

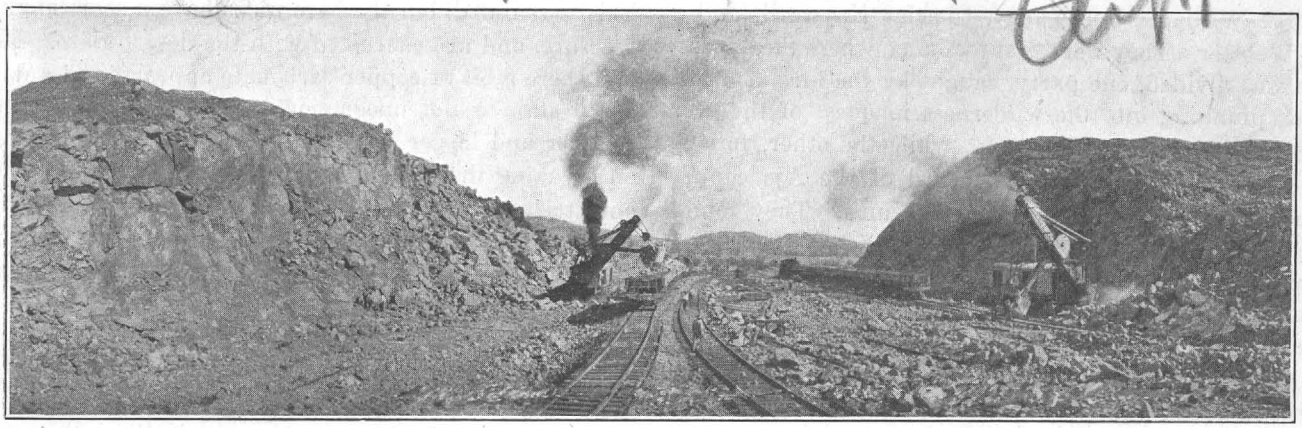
If holes were drilled at corners of 1000' squares for width of property 6000' (line of 7 holes east to west) and for 5000' south of line (5 more holes south of upper line) a total of 42 holes would be drilled to say depth of 3000' equals 126,000 feet of drilling which would probably cost $400,000. If pay ore (over 1% copper) should be found to have throughout this area (30,000,000 sq. ft.) it would represent about 2,400,000 tons for each foot of depth but could not be mined with profit unless the deposit were at least 100' thick which would represent 240,000,000 tons containing @ 1%, 4,800,000,000# of copper.

Nothing less than 1% could be classed as ore and so far there is no evidence that such a grade exists but it should be well worth while to deepen holes #1 and #2 for another 500' or more at cost of probably $5000 and if these passed thru pay ore a better opinion could then be formed as to the advisability of a more extensive campaign.

No terms were discussed but think Van Dyke and Smith would have to be reasonable.

New Cornelia ore body now said to have a reserve of 300,000,000 tons of plus 1% ore.

New Cornelia has now drilled to within 600' of the Bluestone line and it is reported that they have good ore in these holes although at depth of over 1000'.



CUT THROUGH COPPER MOUNTAIN. THE GAP REPRESENTS ORE REMOVED

Ajo Copper Mine—I

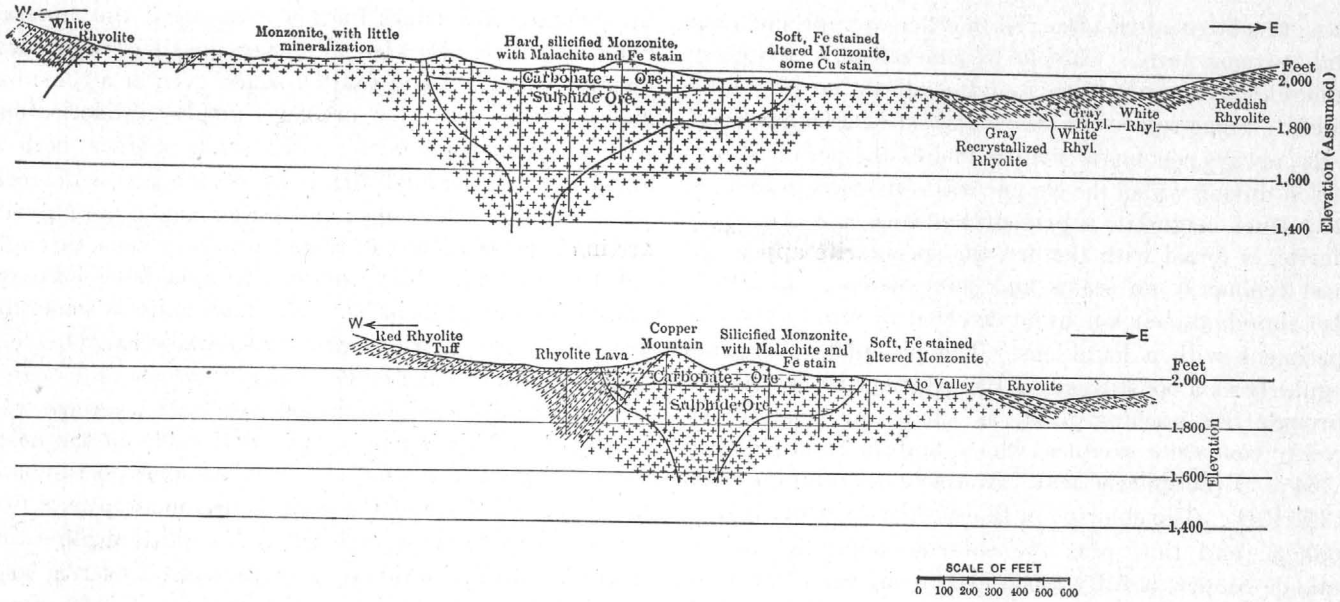
By COURTENAY DE KALB

At the town of Ajo, in the western end of Pima county, Arizona, is a copper mine now recognized among the great ones of the world. It is being worked by steam-shovels, and the ore is leached with sulphuric acid, after being crushed to ¼ inch. The monthly shipments of copper exceed three million pounds. The property is not yet completely developed, but 61,000,000 tons of ore averaging 1.51% copper has been definitely proved. This notable addition to the nation's available supply of that metal must be credited primarily to the courageous initiative and unflinching confidence of John C. Greenway. He was not alone in his conviction that Ajo would develop into a premier mine, for he was sustained by the mature judgment of L. D. Ricketts; but the least weakening of his own faith in the enterprise during the earlier period of development might have led to its abandonment. The degree of courage required may be inferred from the fact that Ajo labored under the burden of a history of successive condemnations by men of large experience in 'porphyry' mines. These were men who knew the characteristics of disseminated deposits; who understood the criteria of secondary enrichment; and they had even made tests by rather extensive drilling. In the end they withdrew, and nothing is more difficult than to resuscitate a mining district that has been investigated by competent engineers, supported by abundant capital, and then deserted as worthless. Moreover, Capt. Greenway, now major of engineers in France, whose military title was won as a Rough Rider in the Cuban campaign, faced a technical staff that was distinctly cold toward the Ajo mines. The first reports were not flatly condemnatory, but an adverse argument was involved in the faint praise given. He, however, was ambitious to sponsor a great disseminated copper property, and the features that had drawn his predecessors to look curiously at Ajo encouraged him to take the rather doubtful chances of success admitted by his advisers. In the end it proved that the earlier drilling had narrowly missed the important orebody, and that the expected enrichment did not exist, for the Ajo deposit has not been secondarily enriched. It consists of an upper zone of copper carbonate and a lower zone containing primary chalcopyrite and bornite. The difference in the copper content between the two is only 0.04%, with the higher proportion in favor of the carbonate. Acid leaching had been prevented by abundant calcite formed during a period of alteration that preceded the introduction of the copper, and sericite is so nearly absent that it can be detected only to a small extent by examination with the petrographic microscope. Thus it is evident that the Ajo deposit presents no analogies to the secondarily enriched 'porphyries' from which previous experience in disseminated copper ores had been gained. It was distinctly *sui generis*.

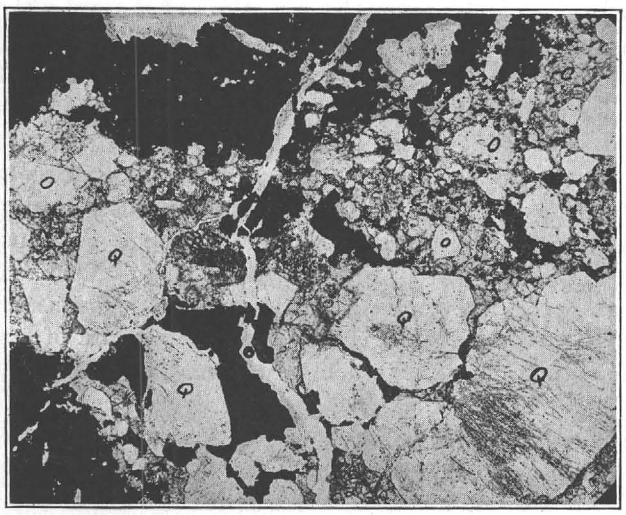
Part of the early history of Ajo has been given by Ira B. Joralemon.* He notes that, next to Santa Rita, New Mexico, it is the oldest centre of copper production in the South-West. Mr. Joralemon credits the first operation to the early 'sixties, but in reality the work began in 1855, and in the following year a shipment of high-grade ore was made to San Francisco by the Arizona Mining & Trading Co. This was a sort of company of gentlemen adventurers, organized in the spirit of true pioneering, with no more substantial objective than infinite hope in the possibilities of an unexplored country. The organizers were Major B. Allen, J. D. Wilson, William Blanding, A. S. Wright, and others resident at Los Angeles. An expedition was outfitted in that city in 1854, under the charge of E. E. Dunbar. It consisted of 20 men, among whom were F. Ronstadt, P. Brady, G. Kibbers,

*'The Ajo Copper Mining District,' Trans. A. I. M. E., Vol. XLIX, pp. 593-609.

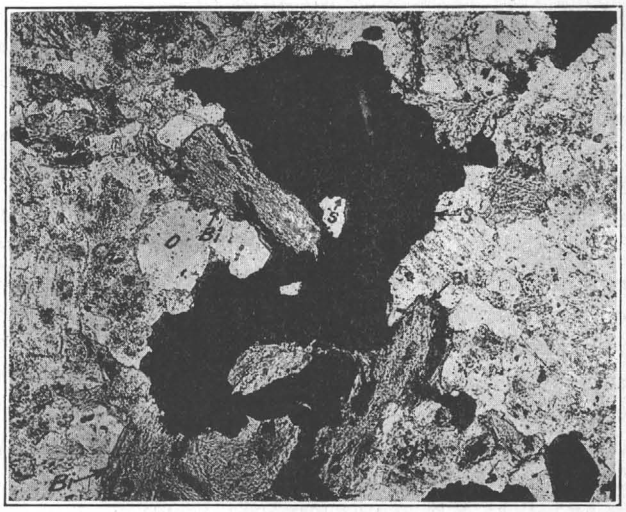
George Williams, Joe Yancy, Charles Hayward, and a Dr. Webster. They went first to Yuma, where the expedition was divided, one party, caught by the lure of a lost mine, plunging into the wilderness in quest of the ever elusive Planchas de Plata vein, while the other, following the trail to Tinaja Alta, heard of the Ajo copper mines 90 miles east-southeast from Yuma. They found these mines to be real, and soon established themselves in possession; but mining in Arizona in 1854 required familiarity with arms as well as with the pick. The new international line, as described in the treaty for the Gadsden Purchase, was still undetermined by survey, so the Mexican authorities undertook to wrest the mines away from the Americans, but they were defeated by effective resistance organized by Hayward. The first ores shipped came from excessively rich narrow deposits of cuprite and native copper, found near the contact between the intrusive monzonite and the older rhyolite, near the western end of the present workings of the New Cornelia Copper Co. Subsequently, rich narrow veins of chalcopyrite and chalcocite in the rhyolite were the source of ore that kept the district feebly and intermittently active for half a century. For a time the ore was hauled in ox-carts 400 miles across the desert to San Diego, and later it was taken to Yuma, to be floated down the Colorado river in barges to the head of the Gulf of California. From this point it was shipped to Swansea. The second period began about 1900, when a series of fiascos followed the attempts made by numerous companies to exploit the small rich deposits in the outlying region around the great mass of low-grade ore. Stamp-mills were erected, and patent processes for reducing and refining the copper were tried, among these being efforts to leach the ores with hydrofluoric acid. In 1909 a fresh venture was made, and this time by responsible people. The original New Cornelia Copper Co., one of the moribund concerns of the stock-promoting epoch, was taken under option by the General Development Co., and the holdings of the Rendall Ore Reduction Co. also were tested by a group of capitalists advised by Seeley W. Mudd. After a brief campaign of drilling both options were abandoned, but in 1911 Capt. Greenway took an option on the New Cornelia property for the Calumet & Arizona Mining Co. Instead of testing the low-lying areas around Copper mountain he directed his attention to the rugged group of hills that has proved to be the centre of mineralization. Mr. Joralemon describes these hills as being "highly stained outcrops." Whatever may have been the character of the central zone through which since then the steam-shovels have made a deep wide open-cut, the remainder of the area of 55 acres is surprisingly destitute of green coloration, except where broken in the course of exploratory work. The outcrop, however, is clearly marked; it consists of a number of low, barren, rocky hills surrounded by high peaks and ridges of gray granite and rhyolite. The prevailing tint of the encircling mountains might be described as pale grayish lavender. The copper terrain is distinguished by a warm russet hue, indicating an excess of iron. The form of the mineralized hills is rounded, but the bare rocks have a short angular fracture, and are encrusted with the desert glaze. Here and there a bit of copper carbonate appears, and a dark-green stain is not uncommon on sheltered faces of the rougher and larger blocks. A surprise comes, however, on breaking the rock with a hammer. No matter where one strikes it the stain of copper carbonate is revealed. It reaches up to the very crust of brown glaze that had obscured it; through every seam opened by the hammer, the green film penetrates. On breaking a few inches deeper the feldspars of the monzonite display a pale greenish tinge, and this minute coloration proves to be leachable, even without reducing the rock to a fine state of subdivision. Looking at the walls in the open-cut, as they are blasted down to feed the steam-shovels at their feet, the appearance is not that of ore but of rock merely permeated with greenish tints; and one recalls the common joke about a mountain stained with a copper cent. It seems, in fact, like mining a stain and making it pay. From this it must not be concluded that the ore is wanting in signs of richness. As finally broken ready for loading by the steam-shovel, the color of a pile of ore is dirty greenish gray, but on large blocks the seam-deposits are often thick and exceedingly brilliant in color. Turquoise-blue to verdigris-green are the prevailing shades. In places the incrustations are no more than a film, but more generally they constitute a scale of copper mineral that can be stripped with a knife, and many seams are found as much as an inch thick. This is in accord with the habit of the deposit. In monzonites that have not undergone profound alteration, such as sericitization or chloritization, the jointing developed in the final set of the rock is generally irregular; mineralization by sulphides follows the joint-planes, and, to a less extent, depending upon the degree of compression of the mineralizing gases, the sulphides invade the body of the rock, replacing primarily the ferro-magnesian minerals. This order is observed frequently, and it is seen in the Ajo deposit. The most striking feature to the eye, on examining the sulphide ore from the lower unoxidized zone, is the abundant deposition of the sulphides, both chalcopyrite and bornite, on seams and joint-planes. They form crusts and patches as well as crystalline flakes scattered quite regularly over the surface. Narrow veinlets of bornite and chalcopyrite suggest replacement of seams of segregated basic minerals, these being tightly coherent to the body of the rock, showing quartz often developed as prisms protruding into vugs. Cuprite occurs in the oxidized zone in the same manner; in fact, most of the recognizable cuprite is in veinlets cemented into the monzonite; some of the masses of cuprite would weigh a pound or more. Cuprite is also seen in such veinlets in the sulphide zone, where it is well crystallized, and of a dark color, but easily recognizable by the splinters that flash ruby-red by transmitted light. The copper sulphide is disseminated also, and appears to exist mainly as bornite. In the process of mineralization the volume removed has generally been in excess of that deposited, leaving the rock with a rough and minutely pitted sur-



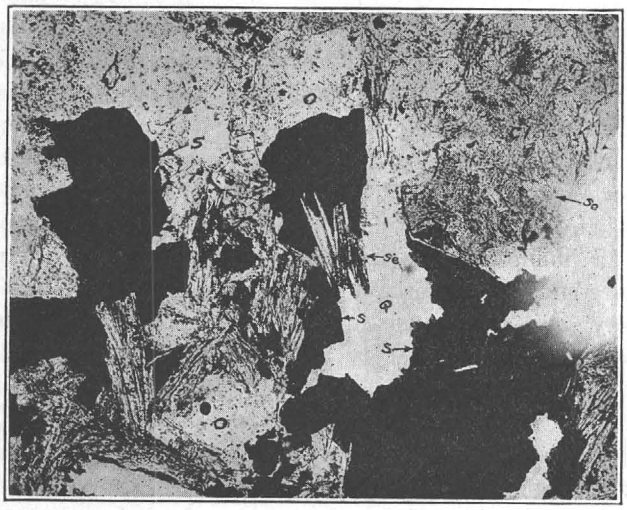
VERTICAL SECTIONS THROUGH NEW CORNELIA OREBODY



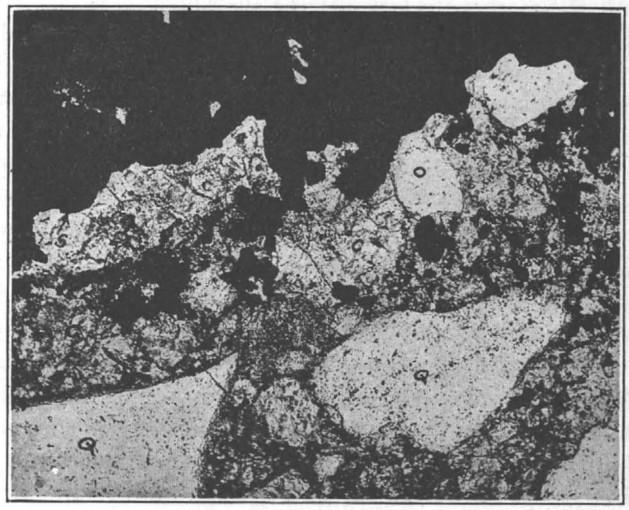
Calcite (C) replacing quartz (Q) and feldspar; sulphides (S) replacing all minerals. Note peculiar alteration of quartz. Mag. × 24.



Sulphides (S) replacing biotite (Bi); also chloritic alteration of biotite. Mag. × 71.



Bornite (black) replacing orthoclase (O); sericite (Se) replacing bornite. Chlorite (Cl); quartz (Q). Mag. × 91.



Calcite (C) replacing quartz (Q) and feldspars; sulphides (S) replacing all minerals. Mag. × 83.

THIN SECTIONS OF AJO SULPHIDE ORE

face; this is a feature observed in other examples of mineralized monzonite. Chlorite is general as a secondary mineral, having resulted from the alteration of biotite chiefly. Some siderite is also found; it is secondary, but is not always conclusively a product of the period of oxidation during which the copper was converted to carbonate. Much magnetite is present, and this, as well as specularite, is found with the ore, the specularite appearing most commonly on seams and joint-planes. Apatite is also abundant, but not to be detected in examination of specimens with a hand-lens. The phosphorus appears regularly as a constituent of the solutions in circulation through the leaching-plant, as shown by analyses of weekly composite samples, which contain from 0.162 to 0.184% of phosphoric acid. At times the solution holds 0.3% P_2O_5. The chlorine in the solutions is from 0.01 to 0.008%, and this, plus the chlorine deposited in the cathode copper, is fully accounted for by the chlorine in the water used for leaching, which carries 0.015%. The ore shows no chlorine whatever, hence the phosphorus is assumed to be present in the form of the fluo-apatite. The scarcity of sericite has already been noted, though it appears scattered rather abundantly through the mineralized rhyolite at the south-west end of the monzonite orebody.

The structural features of the deposit have been lucidly set forth by Mr. Joralemon,† who interprets the known relations of the monzonite as indicating a laccolith, over which the rhyolite is domed. Drill-testing, still in progress on the south-west side of the outcrop, beyond the point where the rhyolite is first seen shouldering over the monzonite, has penetrated to a depth of 1100 ft. and has not yet reached the monzonite. The drill-core, however, shows a great deal of native copper, so that it is apparently approaching near the zone of mineralization. This indicates, also, that the dip of the contact between the two rocks is becoming steeper. Whatever additional light this may throw upon the relation of the monzonite to the overlying rocks, it does indicate at least an approach toward its southern limit. Mr. Joralemon states that the monzonite laccolith, or 'batholith', which lifted the earlier rhyolite beds, is 10 miles long and of irregular width, varying from 1 to 4 miles, the direction of its major axis being N. 20° W. Toward the north the monzonite constitutes a series of high precipitous ridges, and in this portion of the exposure the facies is quite generally that of a coarse grano-diorite, with biotite prominently developed. Phases of more distinctly dioritic segregations are common, and Mr. Joralemon calls special attention to the fact that "diorite or diabase dikes cut both monzonite and rhyolite, but apparently have had no important effect on structure or mineralization." They are apparently complementary to the monzonite, thus accounting for the absence of secondary effects upon the parent magma. The dikes, however, have been pyritized, and their outcrops are very ruddy; the later fracturing through the monzonite, to which is ascribed the opening of avenues for the invasion of the mineralizing agents, is also seen following the dikes, and these narrow brecciated and faulted zones, even at a considerable distance from the orebody, display epidotization, with accompanying calcite and secondary silica, both in seams and throughout the body of the adjacent rock, while sulphides of copper and larger amounts of pyrite are in evidence. Many of these subsidiary veins throughout the otherwise 'dry' monzonite area have been explored by prospect-shafts. The monzonite is generally gray and hard, in which case considerable hornblende is usually present, but in other places it weathers to coarse, rough, granular particles, and is then highly stained with iron oxide. This is particularly noticeable on the north side of Copper mountain. A short distance north-northwest from the edge of the orebody the monzonite is profoundly saussuritized, and it may be said that alteration to saussurite and epidote is characteristic over a large part of the outlying area; this is true, at least, for a distance of a mile northward from Copper mountain, and it affects the diabase dikes as well as the grano-diorite. One of the surprising features of the orebody on its northern side, where a geological section can be readily traced by exposures, with the exception of about 200 ft. where obscured by 'wash', is the suddenness of the transition from mineralized to unmineralized ground. The limiting zone seems to be further defined by a more dioritic phase of the monzonite. The accompanying idealized sections, taken from Mr. Joralemon's paper, previously cited, show the chief features of the geology. The mushroom shape of the orebody is a unique characteristic, and the core of the deposit is the locus of a network of fractures, some of which reveal displacement, with slickensided walls. The nearly horizontal division between the carbonate and the sulphide ores conforms to the water-table, and the change from the oxidized ground at this level is abrupt.

Further information concerning the mineralogic character of the Ajo ore is available from a study of thin sections and polished surfaces, made by Z. K. Melcon at Stanford University under the direction of C. F. Tolman Jr. The minerals present in the ore from the sulphide zone, in the order of relative abundance, as determined by Mr. Melcon, are quartz, orthoclase, biotite, plagioclase, and magnetite. The quartz and orthoclase are prominently developed as phenocrysts, and the rock approaches more nearly the type of a granite-porphyry. Alteration has affected all the minerals, and even the quartz has not been immune. The orthoclase shows corrosion around the edges, while the body of the mass is converted into a gray substance consisting in an aggregate of minute specks that are probably kaolin. Biotite is universally altered, especially on the borders, to chlorite, magnetite, and leucoxene. The biotite was evidently unusually rich in titanium. The plagioclase was so readily attacked that only fragments remain; this mineral has chiefly suffered from calcitization, from which it may be inferred that it supplied much of the lime for the formation of the calcite. Sericite is a minor product of alteration, in places being

†*Loc. cit. supra.*

developed as well-shaped lath-like crystals, and again as minute aggregates. It replaces any of the rock-forming minerals, and is also found replacing both bornite and chalcopyrite. Secondary quartz, like the calcite, follows veinlets, and consists of small crystals occupying interstitial spaces. Bornite and chalcopyrite replace any of the other minerals, including the calcite and the secondary quartz. Preferably the sulphides replace the biotite, and even the smallest crystals of the mica show some bornite or chalcopyrite. The evidence points to the simultaneous introduction of the copper minerals. Fingers of bornite are found entering or enclosing chalcopyrite, and the reverse is equally common. Covellite is scarce, but it is seen in the unoxidized specimens closely associated with both bornite and chalcopyrite, taking the form of clusters of needles penetrating the other sulphides. It represents the only enrichment that has taken place. Chlorite is present as a persistent product of alteration from biotite, and is seen also as irregular masses.

The oxidized ores have been so deeply altered that their original constituents are no longer recognizable. The quartz is distinguishable, and to a less extent the biotite also. Limonite has resulted from the oxidation of the magnetite. The copper exists mainly in the form of malachite; next in abundance is chrysocolla; while cuprite is erratically developed, remaining to a large extent as a core in veinlets of malachite. An interesting fact revealed by the long campaign of leaching experiments is that no water-soluble copper has ever been found.

(To be continued)

Copper Production for 1917

The production of copper in 1917 was slightly less than in 1916, according to preliminary figures and estimates collected by B. S. Butler, of the U. S. Geological Survey, from all plants that make blister copper from domestic ores or that produce refined copper. At an average price of about 27 cents per pound the output for 1917 has a value of $510,000,000, as against values of $475,000,000 for 1916 and $190,000,000 for 1913.

The figures showing the smelter production from domestic ores represent the actual output of most of the companies for 11 months and the estimated output for December. The production of blister and Lake copper from domestic ores was 1,890,000,000 lb. in 1917, against 1,928,000,000 lb. in 1916 and 1,224,000,000 lb. in 1913.

The output of refined copper (electrolytic, Lake, casting, and pig) from primary sources, domestic and foreign, for 1917, is estimated at 2,362,000,000 lb., compared with 2,259,000,000 lb. for 1916 and 1,615,000,000 lb. for 1913.

According to the Bureau of Foreign and Domestic Commerce, the imports of unmanufactured copper of all forms for the first 10 months of 1917 amounted to 460,780,000 lb., as against 397,594,000 lb. for the first 10 months of 1916. The imports for the year 1916 were 462,335,000 lb. The exports of pigs, ingots, bars, plates, sheets, rods, wire, and other copper products for the first 10 months of 1917 amounted to 953,876,000 lb.; the exports for the first 10 months of 1916 were 655,473,000 lb. Similar exports for the year 1916 were 784,006,000 pounds.

At the beginning of 1917 about 128,000,000 lb. of refined copper was in stock in the United States. By adding this quantity to the refinery output of the year it will be seen that the total available supply of refined copper, exclusive of secondary copper, was about 2,490,000,000 lb. By subtracting from this quantity the exports for the first 10 months and the estimated exports for the last 2 months, and assuming no change in stocks, it will be seen that the supply available for domestic consumption in 1917 was materially less than the 1,430,000,000 lb. available in 1916.

The average monthly quoted prices of copper in 1916 and 1917 were almost exactly the same, 27.2 cents per pound. The average quoted price in 1916 was about 2.5c. more than the actual average price received. The actual price received in 1917 was probably nearer the average quoted price.

Arizona produced 687,800,000 lb., a slight decrease from the production in 1916, which was 694,800,000 pounds.

Montana produced 278,000,000 lb., as against 352,000,000 lb. in 1916.

Michigan produced 275,000,000 lb., an increase over the 269,794,000 lb. produced in 1916.

Utah produced 245,000,000 lb., as compared with 232,000,000 lb. in 1916.

Nevada produced 110,000,000 lb., an increase over the 100,800,000 lb. produced in 1916.

Alaska, with a production of about 87,500,000 lb., showed a large decrease from the previous year.

New Mexico increased its production to 104,500,000 lb. from 79,800,000 lb. in 1916.

The production of California was considerably above the 43,400,000 lb. produced in 1916.

The production in Tennessee did not differ greatly from the production in 1916, which was 14,500,000 pounds.

Responding to the call to economize fuel a meeting of representative men was held at Albany, N. Y., and it was recommended that the use of stump-wood be encouraged. It was shown that the demand for such fuel had grown measurably in recent months, and that $3 worth of dynamite would break up the equivalent of eight cords of wood. Utilizing stumps helps to pay the cost of clearing 'cut-over' land, which is needed as virgin soil to increase our crops during the War.

Bleaching-powder is normally produced to the extent of 500,000 tons per year. The electrolysis of common salt has been largely developed to increase the supply of this material in the United States during the War. The result is that this country will hereafter be self-supporting as to this commodity.

Explosives

By F. H. MASON

Probably never before in history has such a vast quantity of explosives been detonated at one time as that which exploded accidentally—at least, we hope so—in the ill-fated 'Mont Blanc,' in Halifax harbor, razing the north end of the city, and leaving the work of destruction to be completed by fire. The horror of the catastrophe, people in San Francisco are perhaps better able to realize than the citizens of most other cities, for many of them have been through a somewhat similar experience. A few minutes after the 'Mont Blanc' and the 'Imo' collided 400 tons of trinitro-toluene and picric acid exploded. The terrific force of the explosion laid half of a city of 50,000 inhabitants in ruins, broke windows 60 miles away, and caused people on board a ship 40 miles at sea to think they had struck a mine. Much has been written since the 'accident' about the superior explosive qualities of trinitro-toluene, whereas, as a matter of fact, its explosive force is less than that of picric acid or trinitro-cellulose or some other nitro-explosives, but it has been selected in preference to them on account of its more stable qualities. When toluene is treated with nitric acid three nitro-derivatives can be produced; successive hydrogen atoms being replaced by nitrous acid, thus:

$$C_7H_8 + HNO_3 = C_7H_7NO_2 + H_2O$$
$$C_7H_8 + 2HNO_3 = C_7H_6(NO_2)_2 + H_2O$$
$$C_7H_8 + 3HNO_3 = C_7H_5(NO_2)_3 + 3H_2O$$

Trinitro-toluene is a yellow crystalline powder, melting at 79°C. When detonated with a fulminative cap it explodes with great violence and gives off dense black fume, whence the name 'black Maria' and 'coal box' that the soldiers have given to explosive shells charged with it. The products of combustion are, besides carbonic acid and nitrogen, carbon monoxide, free carbon, and hydrogen. Trinitro-toluene is often mixed with an oxidizing agent, generally ammonium nitrate, and sometimes aluminum dust, and small quantities of carbon are added. Trinitro-glycerine $C_3H_5(NO_3)_3$, on the other hand, is a self-contained explosive, that is, it contains more than enough oxygen for the complete combustion of its other ingredients; the products of the explosion are carbonic acid, nitrogen, and water, together with 4% of free oxygen.

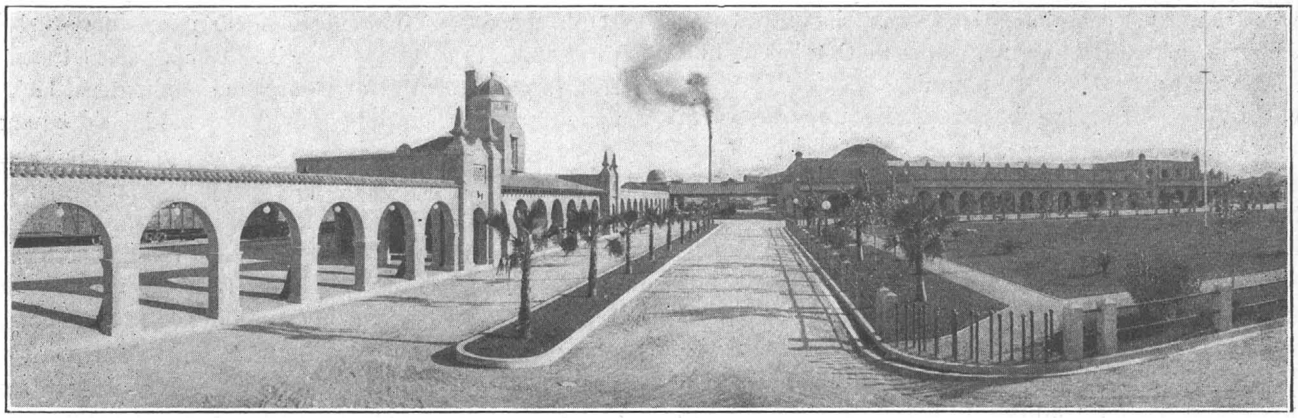
When phenol, or carbolic acid, is mixed with an equal weight of sulphuric acid and the mixture is gradually added to three times its weight of nitric acid, trinitrophenol or picric acid is produced. It is a lemon-yellow crystalline substance melting at 122.5°C. It was employed extensively under the names of lyddite and melinite for charging shells used in the South African war, but was found to be untrustworthy, sometimes exploding prematurely, and at other times not at all. Cordite is one of the most trustworthy explosives. It is made by mixing trinitro-glycerine and trinitro-cellulose together and dissolving them in acetone or some other common solvent. Five per cent of vaseline is added to increase the stability, and to lubricate the gun. When gelatinization is complete the substance is pressed through a die of the desired size, and the resulting 'cord' is wound on a reel and allowed to dry until the last trace of acetone has evaporated. In the case of thick cords, the drying operation sometimes takes as long as two months. Such accuracy is obtained in the manufacture of cordite that the plus or minus velocity is only 40 ft. in the prescribed velocity for rifles of 2380 ft. per second, according to the British regulations. Probably the most powerful explosive known is tetranitro-aniline and tetranitro-methyleaniline. The latter, under the less formidable name of 'tetryl,' is sometimes used as a substitute for fulminate of mercury in detonators. Recently, too, lead hydrazoate or triazide, PbN_6, has been employed for the same purpose.

Copper and Aluminum

The following data, prepared for the British Aluminum Co., are not generally accessible and may be useful to those having electrical and other problems to solve.

Property	Copper	Aluminum
Position in electro-chemical series	24	10
Melting point, deg. C	1100	655
Melting point, deg. F	2010	1210
Specific heat (water = 1)	0.094	0.212
Thermal conductivity (silver = 100)	73.6	31.3
Electric conductivity (silver = 100)	97.5	59.5
Co-efficient of linear expansion per deg. C	0.0000167	0.0000234
Specific gravity, rolled or drawn	8.89	2.71
Tensile strength in lb. per sq. in.	560,000–63,000	26,000–33,000
Tensile strength in kg. per sq. mm.	28–42	17–23
Ratio of tensile strength to weight (equal area)	1	1.62
Ratio of tensile strength (equal conductance)	1	2.65
Ratio of tensile strength (equal temp. rise)	1	2.12
Elastic limit of % of tensile strength	75	70
Modulus of elasticity in lb. per sq. in.	16,000,000	9,800,000
Modulus of elasticity in kg. per sq. mm.	11,200	6,905
Specific resistance in microhms per cu. cm. at 60° F. (15.5°) soft	1.690	2.770
Specific resistance in microhms per cu. cm. at 60° F. (15.5°) hard	1.725	2.870
Specific resistance in microhms per cu. cm. at 0° C. (32° F.) soft	1.595	2.610
Specific resistance in microhms per cu. cm. at 0° C. (32° F.) hard	1.650	2.70
Resistance of conductor 1000 yd. long, by 1 sq. in. cross-section, soft	0.02398	0.03932
Resistance of conductor 1000 yd. long, by 1 sq. in. cross-section, hard	0.02443	0.04070
Co-efficient of increase of resistance with temperature per deg. C	0.0038–0.0043	0.0032–0.00400
Co-efficient of increase of resistance with temperature per deg. F	0.0021–0.0024	0.0018–0.0022
Weight per 1000 yd. by 1 sq. in. nominal section (lb.)	11,700	3,520
Ratio of conductivities for equal area	1.0	0.61
Ratio of areas for equal resistance	1.0	1.64
Ratio of diameters for equal resistance	1.0	1.28
Ratio of weights for equal area	3.3	1.0
Ratio of weights for equal resistance	2.0	1.0

Picric acid is obtainable from the gum-resins secreted by certain plants. Thus, acaroid, black-boy, botany-bay, and grass-tree gums, yield picric acid upon treatment with nitric acid. This fact has not been utilized hitherto in a commercial way on account of the violence of the reaction, and the difficulty of controlling it, so as to secure a satisfactory output. Miller and Irlam have overcome this difficulty by treating the purified gum with limited amounts of acid, in the cold, or at temperatures not exceeding 40° C. Picric acid, nitro-phenol, and di-nitro-phenol are obtained by altering the quantity and temperature.



RAILROAD STATION AND PLAZA, AJO, ARIZONA

Ajo Copper Mine—II

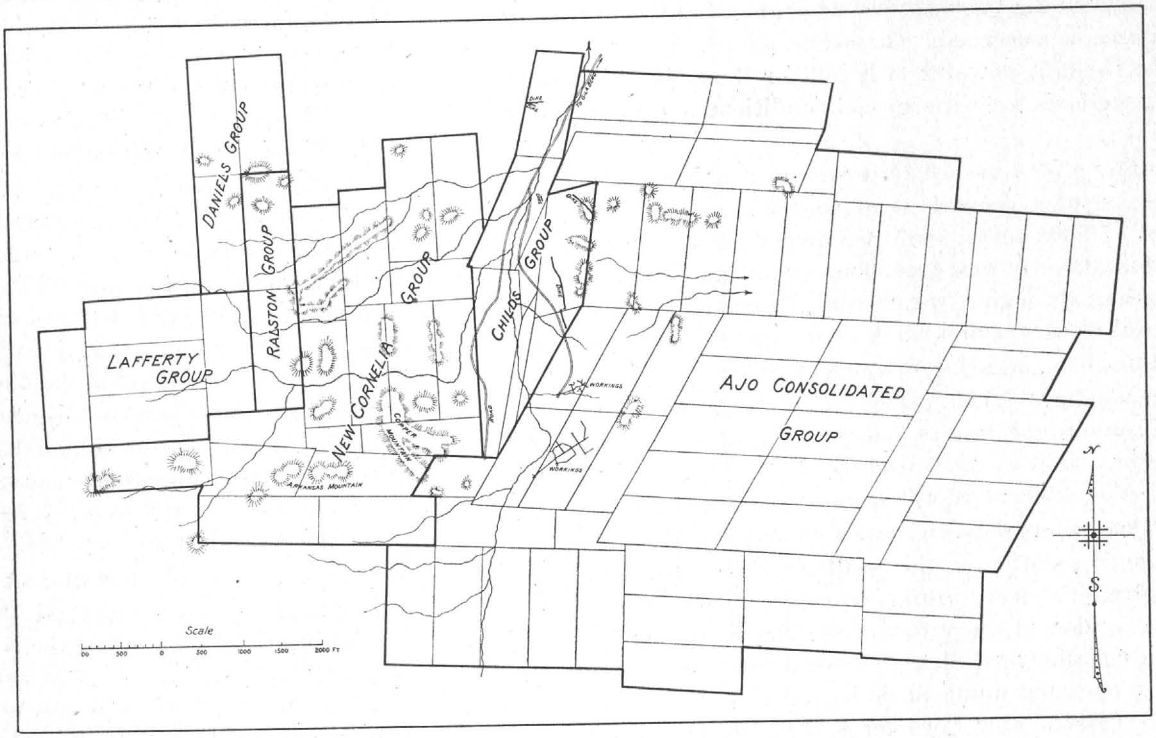
By COURTENAY DE KALB

EXPLORATION. The Ajo deposit was developed by diamond-drilling, done by the E. J. Longyear Co., of Minneapolis, on contract. The diameter of core at the beginning was 1⅛ in., and was the same at the bottom of the holes. The average depth of the holes was 300 ft., and in the centre of the deposit they extended to a depth of 1000 ft. The rods were pulled every 5 ft. and core-samples taken. The total sludge from each 5-ft. section was also collected in barrels and settled. The water was decanted, the whole of the sludge being dried and quartered down to a sample of about four pounds for assay. The entire area was surveyed into blocks 200 ft. square, and a drill-hole was sunk at each corner. Mr. Joralemon states that, "Owing to the thoroughly fractured uneven nature of the rock, the recovery of core was low, and neither core nor sludge-samples alone were satisfactory. To obtain an accurate assay-value for the ore developed, the length of core for every 5-ft. advance was measured, and on the basis of this length of core the sludge and core-assays were combined to give a final value, which represented all the material removed from the hole during the 5-ft. advance." After developing with drills for a period of six months the results were checked by test-pits 4 by 6 ft., sunk with the aid of windlasses. This work was done by Mexican and Indian labor. Every tenth bucket windlassed from the pits was taken as a sample. After the pits were completed they were again sampled in 5-ft. sections by channeling. Eighty-four diamond-drill holes were sunk; they ranged from 200 to 1000 ft. in length, aggregating 23,097 ft. of hole. These were checked by 77 test-pits, amounting in all to 3955 ft., of which 3600 ft. was in carbonate ore. In addition to this the sulphide ore was explored by 1513 ft. of drifts. The estimate based on the data obtained in this way was as follows: 11,954,400 tons of carbonate ore assaying 1.54% copper, and 28,303,600 tons of sulphide ore assaying 1.50%. Of this amount 32,481,200 tons was available by steam-shovel mining, leaving only 7,776,800 tons of sulphide ore, of an average copper content of 1.40%. The unoxidized orebody will be removed ultimately by caving. The central part of the deposit is available without the necessity of stripping overburden, since the copper extends in undiminished quantity to the very surface. Around the edges, however, are patches of overlying rock that represent a total of 3,308,000 tons that must be stripped. This overburden assays above 0.63% copper, and is not necessarily waste. As Dr. Ricketts once said to me while looking over the vast tailing-pile at Cananea, "The stuff is useless for anything today except to serve as a fairly good dam for our settling-pond, but some wise metallurgist in future will extract the copper from it; the waste of this generation is the wealth of the next."

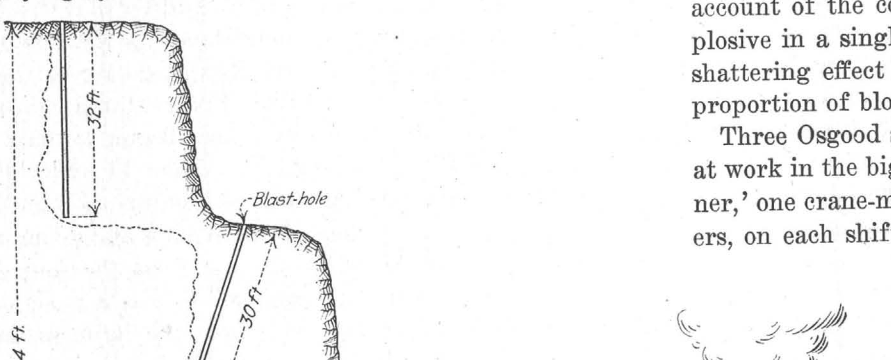
As soon as this exploration and development had been completed, the New Cornelia Copper Co. was organized with a capital stock of 1,200,000 shares of $5 par each, the capital being increased later to 1,600,000 shares, of which 1,201,600 were issued. An issue of $4,000,000 of 6% mortgage convertible bonds was authorized also, and the Calumet & Arizona Mining Co. subscribed to $3,100,000 of these at par. When the 'C. & A.' was listed on the New York Stock Exchange the circular issued to the public stated that the holdings were 90 patented claims aggregating 1629 acres, with 15 mill-site claims comprising 74.94 acres, and that the property drilled had shown 40,000,000 tons of ore having an average copper content of 1.51%; it also declared that the average monthly production would be 3,000,000 lb. of copper. This has now been completely realized, although the plant has barely passed the point of 'tuning up.' Operations started as recently as May 1917, and the necessary changes are not yet complete. In August the output was 2,200,000 lb. of cathode copper; and in October it had been brought up to 3,260,000 pounds.

On July 28, 1917, the board of directors issued a call to the stockholders for proxies, authorizing an important move for expansion. It was announced that the production in June had been 1,093,000 lb. of copper from the leaching-plant, and 225,876 lb. from ores shipped to the smelter at Douglas. The opinion was expressed that "there will not be any material difficulty in maintaining a recovery of at least 80% of the copper content of the ore." Then follows the statement that the opportunity had presented itself for adding to the ore-reserves of the company by the purchase of 7 patented and 52 unpatented mining claims, amounting to 1150 acres, covering an extension of the orebodies already owned. The circular set forth: "Part of this new ground has been explored by the former owners by 5500 ft. of drifts and raises, and by drilling, and the estimate of tonnage of ore in the explored part is 21,000,000 tons, averaging 1.55% copper. The character of these ores is identical with our old ores, the major portion being sulphides. We have not been able to check fully all the work, but have checked important parts by new drill-holes, and have examined the records and made numerous assays of samples furnished from the drillings, all of which were done by the same reliable contractor who drilled our old territory, so that we feel entirely satisfied of the value of the property to the New Cornelia Copper Co." The terms of the purchase were to deliver to the owners of the Ajo Consolidated Copper Co. 200,000 shares of New Cornelia stock, and notes of the company for $500,000 due in 6 and 12 months, respectively, with interest at 4%. The apparently simple ease with which a development company was able to convince a great corporation, mainly with its own development records and samples, and to obtain so large a sum in notes and gilt-edged securities, for a mine that represented a total capital expenditure of probably $700,000, finds explanation in a number of circumstances. The circular gives one of them: the same drilling-contractors had done the work, and their reliability had been demonstrated previously to the New Cornelia Copper Co. The employment of the same contractors that had served the one logical buyer of the mine displayed good business judgment. In the next place, the New Cornelia Copper Co. had finished its campaign of development, and had worked out the essential geological relationships before serious exploration on the extension was undertaken; in other words, the New Cornelia company had shown the reasonableness of expecting ore in a direction that if known in 1911 would have enabled them to avail themselves of a proffered option on this area at a price of only $300,000. Finally, the owners of the Ajo Consolidated Copper Co., namely, James Phillips Jr. and associates, placed the control of their development campaign in the hands of a capable manager, James P. Gaskill, in whom the heads of the New Cornelia Copper Co. had confidence as an engineer and as a man of integrity. To meet the requirements of this purchase the New Cornelia company increased its capital stock to 1,800,000 shares. It may seem that the directors paid heavily for what some might deem lack of foresight, but the argument will not hold. To be sure, money would have been saved by accepting the earlier opportunity, but a considerable amount of spot-cash was demanded by the original owners at that time, and this would have increased the initial outlay at a moment when the entire project rested on hope, restrained by the discouragement of previous investigators. The argument, in fact, might be turned the other way: the old Ajo Copper Co. which later sold its interests, together with such rights as had been held by the Rendall Ore Reduction Co., to James Phillips and his associates, who then organized the Ajo Consolidated Copper Co., might have obtained a larger sum in the end by offering the property to the New Cornelia on such liberal terms as would have postponed all payments until the first nut had been cracked. Until the faith of Capt. Greenway, Dr. Ricketts, and their comrades, had been vindicated by the drill on Copper mountain, it was wise to defer expenditures looking toward expansion; equally was it a matter of sound business policy to take over the property after their own development and that of their rational neighbors had shown that a reserve of 520,800,000 net pounds of copper, together with an area offering possibilities of many times the amount by further development, could be purchased for 0.29c. per pound of net recoverable copper on a basis that, as the circular stated, "need not defer the time when payment of dividends can be commenced."

THE MINING OPERATIONS are relatively simple. A standard-gauge service-track 4000 ft. long extends from the level of the upper floor of the crusher-house to Copper mountain. It enters the orebody through a cut, and divides into two tracks, serving steam-shovels on each side of a great open-cut across the mass of carbonate ore. The width of the open-cut is over 200 ft., and the maximum height of face against which the steam-shovels are advancing is 125 ft. The cut is about 2000 ft. long, and as it widens it will take an irregular slice over 66 acres; 750,000 tons have already been excavated and sent to the metallurgical plant. The mining is under the superintendence of Fred R. Eckman, a man trained to efficiency in the hard but expansive school of the Lake Superior iron mines, in which the American practice of mining 'in the large' chiefly has been developed. The accompanying sketch illustrates the manner of attack. Near the bottom is drilled a series of holes to serve as 'lifters,' each 45 ft. deep, and inclined at an angle of 22° from the horizontal. Next comes a series drilled on a bench about 75 ft. above the bottom, bearing into the wall. These holes are 30 ft. deep and break to a lower bench above the lifters. A third series is drilled vertically to a depth of 32 ft., and 18 ft. back from the edge of the ore-face. The holes in each series average about 18 ft. apart horizontally. Ingersoll-Rand air-drills are used, taking air at about 70 lb. pressure, and 3½-in. drill-steel is employed for starting the hole, drawing down to 1⅛ in. at the end. The hole is then sprung with 40% dynamite, this being repeated twice, and consuming 1½ boxes of powder. The chamber is then loaded with four cases of 25% dynamite. This is now being replaced to a considerable extent with black powder. For each pound of total powder used four tons of ore are broken. The larger masses are block-holed, employing jack-hammers. The block-holing would not seem to be a serious matter, since the No. 24 gyratories in the crusher-house will take pieces of ore 8 ft. long by 4 ft. in the other two dimensions, and the steam-shovels will load blocks of that size; but the character of the rock has resulted in an excess of large masses over the amount originally estimated, and the labor-shortage makes it difficult to obtain a sufficient force of drillers. Therefore, the full quota of 5000 tons of ore daily is at present difficult to deliver to the crushing-plant.



MAP OF CLAIM GROUPS AT THE AJO MINES



METHOD OF BLASTING HIGH BANKS

It is proposed to drill holes on the high banks in future with Cyclone churn-drills, set about 15 ft. back from the edge in which charges of Trojan powder will be fired. On account of the concentration of a large quantity of explosive in a single charge, it is expected that a superior shattering effect will be obtained, thereby reducing the proportion of block-holing to the total tonnage broken.

Three Osgood steam-shovels, with 4-cu. yd. shovels are at work in the big open-cut. A crew consists of one 'runner,' one crane-man, one fireman, and four Mexican helpers, on each shift. Four trains of 8-ton side-dump cars are constantly in service hauling the ore to the crusher-house.

At the south-west end of Copper mountain underground work is in progress along the contact between the monzonite and the rhoylite, under the charge of George Harmson. A shaft has been sunk 60 ft. deep, and a drift extended under the mineralized rhyolite, which at this point averages about 4% in copper that is present as minutely disseminated silicate and carbonate. The ore is broken around an open pit and drawn to the loading-chute through a mill-hole in the bottom of the funnel-shaped opening. It is estimated that 81% of the Copper mountain orebody is available for mining by steam-shovel, but this will involve working downward below the level of the ore-railroad by spiral benches.

The ground rises from the site of the metallurgical works, so that drainage of the pit will be easy to a depth at which open-cast work will cease. The mine is ideally situated for economical operation, and presents no difficult engineering problems so far as the original New Cornelia area is concerned. The extension of the deposit under the rhyolite, however, will call for the adaptation of caving methods to fit the special conditions there presented.

The building of a branch railroad was a necessity for the operation of a property that was to start with the treatment of 5000 tons of ore per diem. Surveys were made at first directly west from Tucson, a distance of 135 miles, passing through a region containing undeveloped agricultural resources, and many copper prospects in the Coyote, Comobabi, and Quijotoa ranges, where important developments have taken place. This would have afforded a route connecting at Tucson with the El Paso & Southwestern railway and leading to the smelters at Douglas. The alternative was to build over open plains between the scattered basin-ranges 43 miles northward to Gila Bend, a station on the Southern Pacific railway. This involved the least initial expenditure, which was important in view of the outlay of $4,000,000 needed for erecting a metallurgical plant. The railroad cost $700,000, and is operated under an independent organization styled the Tucson, New Cornelia & Gila Bend Railway Co., of which one-half the capital is held by the Calumet & Arizona Mining Co. In the title lies a suggestion of the ultimate construction of the line through to Tucson, which would appear logical.

An Impression. The approach to Ajo is over a typical Arizonan desert-plains depressed between surrounding ranges in the form of vast basins, overgrown with creosote in the lower portions, and adding bayoneted yuccas and opuntia cacti toward the heads of the clino-plains. The color of the landscape in the broad perspective is green, suggestive of an abundance of verdure, which, however, is not confirmed by the barren ground near at hand over which the creosote bushes are seen to grow far apart in a kind of distant association with each other. The mountains are mostly gray, except where remnants of the basaltic lava-flows form black frowning mantles over the older rocks. At one place a great fault has involved the underlying formation as well as its lofty burden of lava, and along the fractured zone is a broad band of iron-stained outcrop that makes a brilliant display. These lavas once covered the Ajo ore deposit, and a few iron-stained fragments still endure on its higher points. Erosion swept the cap of lava away until the ore was left exposed to the sun. The purplish peaks of altered rhyolite are visible from the train, rising behind the brown hillocks of ore, while toward the north swings the grayish lavender range constituting the extension of the grano-dioritic mass of which the orebody is in a favored differentiate. The town and the works spread around the entrance to the amphitheatre, in the centre of which is Copper mountain. The place looks like a city, and so indeed it is, built at the command of the copper barons with the magic of money, industrial purpose, and proved resources. The train halts in front of a station of unexpected beauty. No suggestion of what the West calls a mining 'camp' was here; it was like coming to a fashionable resort for tourists. The sky was of Algerian brilliancy, and the air was soft and exhilarating. The beautiful double colonnade and Moorish towers of the station aided the delusion of being in northern Africa. The richly-colored arches extended for the distance of a city-block on either side of what one hesitates to call a 'ticket-office' when surrounded by so much æsthetic charm. Through the arches was a vista of a deep-green plaza, the carefully tended lawn rising gently toward a low tower surrounded and almost concealed by flaming oleanders; and along the other side of this remarkable plaza, which would make the cities of San Antonio or San Diego envious, is a continuation of Moorish structures and broad colonnades. It presently appears that here is concentrated the activity of the town. It is a civic centre in an unusually real and delightful sense; at the Plaza is found the post-office, and the offices of the local civil authorities, the stores, cafés, and chocolate-shops, the 'movies,' and all that makes up the round of business and pleasure of the community. Whatever one may need, just as in a Spanish city, he will find at the Plaza! There is where people meet, where they find refreshment, and listen to the band in the limpid Arizona nights while the children romp upon the electric-lighted green, for in some way, which means with the aid of a generous purse, the New Cornelia Copper Co. has found it possible to dispense with the customary disheartening injunction to "keep off the grass." In a spirit of delightful democracy the children of the staff and of the laborers mingle in their play for a while under influences that make for a better understanding between them all. It was a costly bit of luxury for a mining company to offer all this before it had begun to make a profit from its enterprise, and the vision to undertake such extraordinary welfare-work is credited to a member of the directorate, a man of fine feeling and generous sympathies, now mourned as one lost from the council-table, the late Chester A. Congdon. It was a practical thing to do, for it meant relief from the ugliness and despair of the customary 'mining camp' with its glare of barren clay and sand, its piles of rusting tin-cans, and its spiritual vacuity; it meant refreshment, re-invigoration of body and mind, and the conservation of self-respect through respectable and cheering surroundings. Thus it has proved as good an investment as some of the new mills, and lead-lined pumps, and other accessories introduced to help in the mining of ore for profit.

Ottawa, Canada, now claims the largest gold refinery in the world. The Ottawa mint was recently enlarged, and is now capable of treating 250,000 oz. per week by a chlorine process. Since the beginning of the War Canada has handled one billion dollars' worth of bullion for the British government and the Bank of England.

The Ajo Copper District, Ariz.

SYNOPSIS—Geographical position, history, geology and development of the New Cornelia copper property in southern Arizona, controlled by the Calumet & Arizona. No overburden; upper carbonate zone with sharp change to chalcopyrite and bornite zone. Grade uniform, about 1½% monzonite intrusion in rhyolite. By drilling, test-pitting and drifting about 40,000,000 tons developed. Larger part will be handled with steam shovel. Problems of treatment, railroad connections and water supply in a fair way to be settled.

The Ajo copper mining district lies in southwestern Arizona, about 30 miles north of the Mexican line, 125 miles west of Tucson and 43 miles south of Gila Bend, the nearest railroad point. The Little Ajo Mountains rise a few hundred feet above wide desert valleys, and the camp itself lies in a small basin on the east side of the range, separated from the open desert by low hills. Its elevation above sea level is about 1900 ft. In the center of the basin the brilliantly stained rocks of Copper Mountain rise 150 ft. above the village. The scanty supply of water is obtained from wells in the desert and from prospect pits in the camp. The nearest abundant source of water is the Gila River, 50 miles north.

History of the District

Next to Santa Rita, N. M., the Ajo district is said to be the first southwestern copper district worked by Americans, high-grade material having been hauled out in the early '60s. A good many stock companies at one time or another have been organized on the strength of the surface showings. In the fall of 1911, the Calumet & Arizona took an option on all available stock of the New Cornelia Copper Co., one of the reorganized companies that had attempted to work the district. The C. & A. started prospecting by diamond drilling, following this with test pitting, and with drifting in the sulphide zone. The work resulted in the outlining under the iron- and copper-stained outcrop of a low-grade copper orebody covering an area of about 55 acres, and reaching a known maximum depth of over 600 ft. below the surface. Following this development, James Phillips, Utley Wedge and others, under the name of the Ajo Copper Co., took an option on the property of the Rendall Ore Reduction Co., and the U. S. Smelting, Refining & Mining Co. took an option on the Childs group of claims between the New Cornelia and the Rendall properties. The United States company gave up its option after sinking a few churn-drill holes; the Phillips interests, however, still hold their property, but without doing any development work.

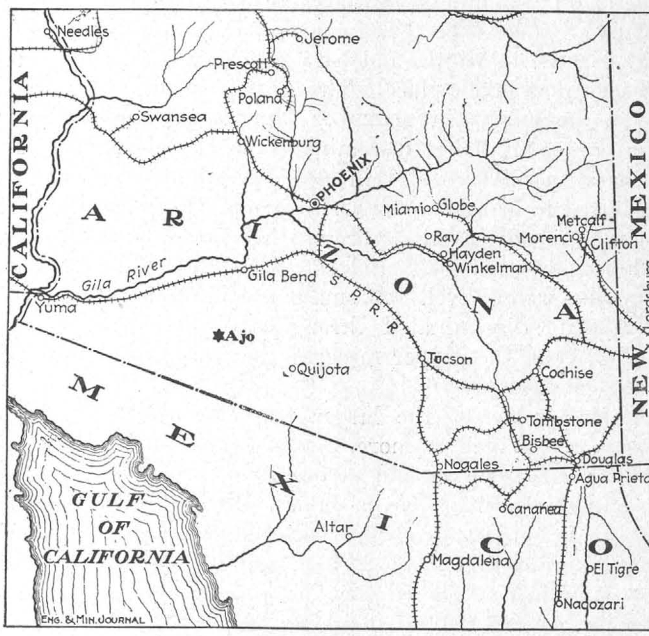
Geology

Except for a conglomerate, the regional rocks are igneous. The earliest formation exposed consists of rhyolite, breccia and tuff. An intrusion of monzonite porphyry cuts and uplifts the rhyolite. This porphyry, in the character of its minerals and its crystallization, varies a good deal locally. Following the monzonite are dikes of diorite or diabase, probably allied with the Tertiary flows, which cover much of the surrounding desert region. The more recent conglomerate is a coarse aggregate of rhyolite and monzonite fragments, which may be earlier or later than the Tertiary flows just mentioned. It is evidently the result of rapid erosion of the mineralized rhyolite and monzonite of Copper Mountain.

The only great alteration of the rock other than that accompanying the mineralization is found along the rhyolite-monzonite contact, where fine-grained monzonite and recrystallized rhyolite are difficult to distinguish.

Structure

The monzonite laccolith or batholith uplifted the rhyolite bed into a dome which was eroded in fairly recent times. The intrusion is eight to 10 miles long and one to four miles wide with its long axis extending N 20° W. The northern part forms high hills north of the basin; the southern end forms Copper Mountain. The copper orebody is found at the southern end of the intrusion, where the monzonite plunges beneath the rhyolite. On the top of Copper Mountain, small remnants of the rhyolite lie flat; on the west the rhyolite dips to the southwest and on the east to the southeast at about 20°. The southerly pitch of the rhyolite beds is fairly steep; all contacts are irregular. There are many inclusions of rhyolite within the monzonite and irregular intrusions of monzonite break up through the rhyolite, especially to the east of Copper Mountain. The diorite and diabase dikes cutting both monzonite and rhyolite seem to have little effect on structure or mineralization.



Key Map, Showing Situation of Ajo Camp and Railroad Facilities

Both the monzonite and the rhyolite near it are thoroughly shattered by fracturing in all directions. Although some fractures are accompanied by considerable gouge and may be faults of importance, most of them can be traced only a short distance and are probably contraction fissures. While in any one portion of the porphyry there is generally a well marked direction of strongest

Condensed from a paper prepared for the Salt Lake meeting of the A. I. M. E. by Ira A. Joralemon, geologist of the Calumet & Arizona Mining Co., Bisbee, Ariz.

fracturing, in the mass as a whole no such generalization can be made. The somewhat idealized east-west sections show the most important points in the geologic structure.

The Disseminated Orebody

The mineralization has formed a low-grade disseminated copper deposit, together with higher-grade veins in the monzonite and narrow rich veins in the adjoining rhyolite. The disseminated orebody is roughly pear-shaped in outline, with its neck toward the south; its outline agrees almost exactly with that of Copper Mountain and the silicified iron-stained hills to the north of the mountain. While the area of the orebody is about 55 acres, its depth varies from less than 50 ft. below the surface on the outskirts to an unknown depth of more than 600 ft. in the center. In vertical section the deposit would resemble a mushroom.

The disseminated sulphide is chalcopyrite and bornite. Within the limits of the orebody the monzonite is shattered by a network of fractures; of these the larger often run about N 20° W parallel with the axis of the intrusion, but others have all possible directions. Along many of these there exist quartz veins running from 1/4 in. to 1 ft. in width, and between the veins much silicification has taken place. The sulphides were introduced with the quartz in seams or films along the fractures and in small flakes disseminated in the porphyry. In general, a mixture of vein and disseminated material is required to bring the ore up to grade. In the main part of the orebody, pyrite is present in small quantities only. Chalcocite is rarely found except in thin films just below the water level. A small and variable amount of magnetite disseminated through the ore is apparently earlier than the copper minerals and may be an original rock constituent.

Along some of the larger fractures sulphide seams widen to an inch or more, and several of these close together will form a band of ore 10 to over 100 ft. wide, running from 3 to 5% in copper. In general, the grade of ore is subject to abrupt changes, the richer portions being found in the more thoroughly fractured part of the monzonite. The bands of rich and lean material follow in general the fracturing in the vicinity. The rich bands are so narrow and irregular as to prohibit economical sorting, and the whole mass has to be considered as low-grade ore.

Sulphide Primary

It seems clear that the sulphide ore is primary and not the result of enrichment by descending solutions. Variations in grades are due to differences in the intensity of the original mineralization, a fundamental distinction between this orebody and most of the other disseminated copper deposits that are being mined.

Boundaries

The boundaries of the orebody are commercial. Toward the southwest it extends to the rhyolite contact, and in some places the rhyolite is mineralized sufficiently to form commercial ore, but it is generally under 1% and not commercial. To the east the change from ore to lean material is not so much the result of a decrease in mineralization as it is of a change from copper sulphide to pyrite, together with a decrease in the amount of silicification and an increasing prevalence of the dioritic type of monzonite. To the west and northwest, the change from ore to lean material is caused by a decrease in mineralization all around. Where the bottom has been found, the ore gives place to less fractured and less silicified monzonite containing little copper sulphide. Occasionally, a sudden change to a more acid and a more basic variation of porphyry is accompanied by a drop from ore to lean material. The association of ore with coarse-grained monzonite is noticeable, but it seems probable that these are coördinate results rather than cause and effect and depend on conditions existing at the top of the intrusion.

Surface Alterations

The result of alteration by surface waters, unlike those in other low-grade copper districts, has resulted in the formation of malachite, limonite, hematite and a little chrysocolla. The rock is still hard, although the feldspar is somewhat kaolinized. The prevailing color is a deep red-brown, due to staining by iron oxide, although brilliant copper staining can be seen in places. Probably over 85% of the copper in this oxidized zone is in the form of malachite. Some disseminated sulphides are found in hard ores between fractures, but these are relatively unimportant. As in the sulphide zone, values vary greatly and rich and lean bands alternate. Along large fractures some softening and leaching is found, with less copper in the adjoining harder rock. But more usually, the variation in value is not accompanied by any change in the degree of alteration of the rock. The general copper content from top to bottom of the oxidized zone is constant, and is almost exactly the same as that of the underlying sulphide zone.

Sharp Demarcation

The bottom of the oxidized zone is almost a horizontal plane lying about 20 ft. below the deepest arroyos and 150 ft. below the highest hills, and this plane of demarcation agrees almost exactly with the present ground-water level. The transition from carbonate to sulphide is abrupt; less than 5 ft. of material whose classification is doubtful, is usually shown by the drill cores, although along large fractures bands of carbonate and sulphide ore may alternate over a distance varying from 15 to 20 ft. vertically. Nor is there any appreciable enrichment at the top of the sulphide zone except for a few local exceptions. This abrupt change on a horizontal plane will greatly simplify both mining and treatment of the ore.

Rich Veins in Rhyolite

The low-grade orebody just described was not what first attracted attention to the district; this was rather the existence of rich veins in the surrounding rhyolite. These vary in width up to 6 ft. and carry malachite, cuprite, chalcocite and bornite. They are associated usually with dikes of monzonite, which themselves are frequently mineralized up to 2 or 3%. In one or two places, lenses of this disseminated ore in monzonite dikes accompanying veins reach a width of over 50 ft. and promise to yield a good tonnage. The development has not yet been carried far enough to show their ultimate importance.

Proving the Orebody

To develop the New Cornelia property, the ground considered as probably ore-bearing was coördinated with east-west and north-south lines at 200-ft. intervals and drill holes were sunk at the intersections; the actual drilling was conducted by the E. J. Longyear Co., of Minneapolis, Minn., and the sampling was done under the direction of Calumet & Arizona representatives. Not a great deal of core was obtained, and both the core and the sludge were therefore assayed and the results combined in the proper ratio by the use of a chart furnished by the Longyear Co.[1].

Test-Pitting and Drifting

After six months of drilling, test-pitting was begun for the sake of checking the drilling results. The pits were about 4x6 ft. in size, sunk with windlass and hand drills, Mexican and Papago Indian miners being employed. The work was done on contract, and after practice, the men became so efficient that up to a depth of 50 ft., test-pitting was cheaper than diamond drilling. During the last year of development, test pits were sunk 50 ft. deep on the coördinate points in advance of the drilling, in order both to expedite the work and to decrease the drilling cost.

Samples

Every tenth bucket hoisted from each hole was taken for a sample and large samples were thus obtained for every round shot. Then after the pit was completed, it was resampled in 5-ft. sections by cutting a rectangular vertical groove 3 in. deep by 6 in. wide, so as to give about a 500-lb. sample for each 5-ft. section. These channel samples averaged about 0.15% lower than the bucket samples, and were taken for the final samples of the pit.

In the sulphide ore the pits encountered water, which made sinking so slow that only a few hundred feet was done in the sulphide zone. However, to check more thoroughly the drilling results in the sulphide and prove a constant grade of ore between drill holes, drifts were run on coördinate lines from the bottoms of two of the deepest test pits and raises were put up from these drifts to check the drill holes. For the sake of giving accurate samples the material broken in each round was hoisted separately, dumped on an iron plate, and every tenth shovelful taken out for the large sample to be cut down later.

Extent of Work Done

Up to September, 1913, when development work was stopped, 84 diamond-drill holes had been bored, varying in depth from 200 to 1000 ft., and giving a total footage of 23,097. Of these 19 were stopped in ore. In all, 77 test pits were sunk with a total footage of 3955; of this, 3606 ft. was in carbonate ore and 349 in sulphide; 1059 ft. of the test-pitting checked drill holes in carbonate ore; 175 ft. checked drill holes in sulphide, and 2721 was done in advance of drilling. The drifting in the sulphide ore amounted to 1513 ft. and the combined sinking and raising on drill holes in sulphide ore was 317 ft.

Results of Development

The sinking, drifting and raising checked the drilling accurately. The channel samples of the test pits in carbonate averaged 0.005% lower than the corresponding diamond-drill samples; the test pits and raises in sulphide averaged 0.05% lower than the diamond-drill samples; and the drifts in sulphide averaged 0.26% higher than the assay value of the blocks through which they were run, as indicated by the drill holes at the corners of the blocks. In calculating the ore, drill samples were used wherever drilling was done, and channel samples of test pits were used where sinking was done in advance of drilling. The estimate of the ore developed is as follows:

	Tons	Copper, Per Cent.
Ore estimate:		
Carbonate	11,954,400	1.54
Sulphide	28,303,600	1.50
Total	40,258,000	1.51
Available by steam shovel:		
Carbonate	11,954,400	1.54
Sulphide	20,526,800	1.54
Total	32,481,200	1.54
Not available by steam shovel:		
Sulphide	7,776,800	1.40
Rock which must be removed to make steam-shovel tonnage available:		
Rock in carbonate zone	708,400	0.65
Rock in sulphide zone	2,600,000	0.63
Total rock	3,308,400	0.63

The gold and silver content is low, generally amounting to less than 15c. per ton. In computing the tonnage, no material running under 1% in copper was included. The estimate of ore available for steam shoveling depends on the assumed maximum grade of track in approaches and pits, and on amount of lean rock in the sides and bottom of the pit which it will pay to remove in order to get access to the ore. It is likely that the proportion removed by steam shovel will be greater than that indicated in the table. Not only will there be no stripping expense, but the absence of overburden precludes the possibility of lowering grades by the admixture of barren material. Both tonnage and content of copper, therefore, should come out closely to the estimate.

Plans and Problems

Three problems will arise in connection with the exploitation of the New Cornelia copper property. These are the questions of treatment, water supply and railroad communication. The question of treatment has been pretty well worked out.

As for water, two deep wells were drilled in the large valley northeast of Ajo, and water was found in both at a depth ranging from 550 to 750 ft. By means of a boiler plant and compressor, the water was raised from one of these drill holes with an air lift having a capacity of about 175 gal. per min. Pumping at this rate did not exhaust the water in two weeks. In view of such a flow from an 8-in. drill hole, it seems reasonably sure that a shaft with a little drifting will furnish an ample supply, and such a shaft has been started.

As for the railroad, preliminary surveys have been made both from Gila Bend, on the Southern Pacific, and from Tucson, the junction point of the Southern Pacific, and the El Paso & Southwestern systems. The respective distances are 44 and 130 miles. Both lines would lead through a gently sloping desert country and should be constructed at a cost of less than $20,000 per mile. The route has not yet been selected.

The orebody already developed will supply a 4000-ton mill for over 26 years, or a 6000-ton mill for over 18 years. Indications are that the life of the mine will be greatly lengthened by the development of a large tonnage of deep ore along the fracture zone in the center of the orebody. For the next quarter of a century, the Ajo will be one of the greatest copper districts of the Southwest.

[1]See "Eng. and Min. Journ.," Mar. 21, 1914.

Holcomb Valley Mining District

SPECIAL CORRESPONDENCE

The old but interesting mining district of Holcomb Valley, in California, has been more active than in several years. The Gold Mountain mine, at Doble, is running its 40-stamp mill with a newly constructed cyanide plant. It is operated by a group of young men, ex-departmental officials of the Chino Copper Co., under a lease and option of purchase. The title is vested, I believe, in Captain J. R. De Lamar and T. H. Oxnam; Mr. Oxnam's son is exercising general supervision of the property on behalf of the owners and is also superintending the extraction of ore.

Gold Mountain Mine

This mine has had many vicissitudes. It was owned in early days by E. J. (Lucky) Baldwin, who built a 30-stamp mill on the property, which was destroyed by fire before it had run any great length of time. Prof. John A. Church held it under option for some time. During this period, Charles Rolker built and operated a 5-stamp prospecting battery below the present mill.

Many years later, Captain J. R. De Lamar purchased the property, erected the mill previously spoken of and ran for some little time, suspending operations in 1902. Since that period several mill runs were made, the last of which, about three years ago, was carried out by T. H. Oxnam, to determine definitely if plate amalgamation would alone answer. This question was answered in the negative.

The Mine and the Deposit

At the present time the mine is worked principally from a series of three gloryholes or opencuts, connected by mill holes with one of the tunnel levels. A comparatively small force of men can keep the mill supplied with ore now, but as the top of the ore bins in the mill is only 7 ft. lower than the mouth of the tunnel, and as there are about 1000 ft. of track, delivery of ore to the mill when the upper reserves are exhausted, will prove somewhat more expensive or inconvenient. For this reason, the choice of this mill site, where the hill side is practically all mill site, is open to criticism. The assay plan of the mine shows the ore to be somewhat spotted, but in large sections the value, low-grade at the best, is fairly well maintained. T. H. Oxnam, in his mill run, confined his work to a paystreak of quartz on the foot-wall side. This was of higher grade than the mass itself. Occasionally in this, I am informed, free gold could be seen, which is a rare occurrence in the mass of iron stained "quartzite," forming the main body of ore and said to be 500 ft. wide at the apex of the formation, where work is now going on.

I inclose "quartzite" in quotation marks, for I have some reason to believe that the rock is a highly acid rhyolite. It was classified as quartzite, however, by Professor Church and the miners who came here from Delamar, Nev., noted a great similarity to the quartzite ore of that mine and dubbed it accordingly. This rock covers a large area south and west of Gold Mountain. At Hollonet and Bear Valleys, the sheetings have been thin and are now represented by débris. At several points, this rock has been found to lie upon shale. At the Gold Mountain mine, there are shales and intrusive rocks of porphyritic texture on the foot wall, but the true foot is considered to be a mica schist. This I have not observed in the workings of any other prospects.

The concentration of values at Gold Mountain seems to be in a region of faulting, shearing and shattering. The value is in the cleavage planes largely, which are stained or coated with iron oxides. The gold in the mass is probably derived from the decomposition of pyrite, which I have not seen in an undecomposed state. Promising looking specimens from another section of the field containing pyrrohotite, were found to carry no gold. The ore seems a typically good cyaniding ore, and the double process of cyaniding and plate amalgamation should give a fairly high percentage of extraction. While the surface ore contains an iron-stained clay, the mass itself should produce little true slime; at the present time, however, there is considerable colloidal matter in the battery pulp.

The Mill

At the mill a pronounced innovation consists of the use of a Janney classifier, the several products of which are delivered directly to separate tanks. The sand tanks are equipped with Butters distributors. For the slimes there are two mechanical agitators and one settler. It is stated that frequent shutdowns have occurred from the limited settling capacity.

The cost of mining ore is estimated at 50c. per ton and the total cost of operations at $2. As the assay value seems to be considerably in excess of this latter figure, a reasonably high extraction should return a working profit, when the disadvantages of working a plant which is in part old and in bad condition and in part new and untried, are overcome. As the orebody is large, a success by the present lessors will mean future working on a much larger scale with a more modern plant.

Water for steam and milling purposes is obtained from Baldwin Lake, a shallow sheet of water one-half mile from the mine and several hundred feet lower than the mill supply tanks. Twelve years ago this lake went completely dry, but as Bear Lake Reservoir is only four miles distant from the west end of Baldwin Lake, and as Holcomb Valley, three miles away, at no great difference of elevation, is itself a natural reservoir, there will probably be no great difficulty at any time in extending operations.

Placer Operations

Wood for fuel is abundant. Cedar is commonly used. There is also good pine on the neighboring forest reserve for what mine timber is required. A sawmill is running in Holcomb Valley. Holcomb Valley was one of the last large placer camps in California. It was discovered by Holcomb, a hunter, at the outbreak of the Civil war, and attracted many miners from the Kern River district, and indeed from camps further north. The field of operations was over three miles long and a maximum of one mile wide. The rim of the main channel and tributary gulches were mainly worked. The great quantity of water to contend with and the rough nature of the bedrock, consisting of great boulders of granite, effectually prevented work on bedrock, while every indication was that the channel would be exceedingly rich if ever worked. I am informed by a placer miner who has had considerable experience in working the rim gravel in the last few years, that this will run in specially good