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## PREFACE.

THE SILVER KING MINE of Arizona has become deservedly famous as one of the leading silver mines of the United States. It is one of the very few mines that have paid their way from the surface down without levying an assessment. It is extraordinary also for the peculiarities of the formation and the number and beauty of the minerals which it yields. It is worthy, therefore, of a description in detail. This I have undertaken to give in the following pages, constituting a monograph of the mine, written from a scientific rather than a mining or a financial standpoint. I have endeavored to describe the mine as it is, without especial regard to its money value, and particularly to fathom some of the mysteries of the formation of the ore so as to contribute something towards the growing knowledge of the origin of mineral veins and deposits. For the execution of the work I have not had unlimited time and resources. It has not been carried forward under the auspices of the government, or sustained by an appropriation from the public treasury, but every encouragement and facility that could be extended by the officers of the company has been received, and I am glad to add that I have been free to make my investigations and to write out my results in my own way.

The study of the mine was commenced at the request of Col. James M. Barney as early as April,

1880. Since that date I have made several visits to the mine and have watched its development from the 300-foot level to the 700-foot, the lowest level at this time. It has not been possible for me to undertake the chemical and microscopic examinations of the rocks which are certainly desirable. Some of the minerals are still under investigation, and I hope to be able to extend and complete some of the descriptions at a later date.

In the progress of the examinations, and in the preparation of the illustrations, I have had much direct assistance from the Superintendent of the mine and mill, which I desire to gratefully acknowledge.

JANUARY 1, 1883. W. P. B.

THE

# SILVER KING MINE.

## HISTORY OF THE DISCOVERY AND LOCATION.

The importance of the Silver King Mine in the history of mining in the United States, and particularly in the Territory of Arizona, lends more than the usual interest to the details of the discovery and location of the vein. The efforts to find the locality and to open up the mine date back into the period when the southwestern and central parts of Arizona were still in the possession of the savages, and the history of the mine is closely connected with the development of the region and its settlement by the white man. In fact, the Silver King has been an important, if not the leading factor in the reclamation of the Pinal region from the murderous Apaches. These hereditary, marauding savages dominated the whole region, and made it almost inaccessible to the hardy and daring prospectors who began to press outward from the frontier settlements on the Gila river towards its sources in the mountains.

The Pinal Mountains rising to the eastward of the broad plains of the Gila and Salt rivers stretch northwestward from the Gila to the higher ranges of the White Mountains, and to the plains of the Great Colorado. This range has many spurs and irregular outlying masses cut by cañons leading down to the Gila valley which, by reason of their extreme ruggedness and impassable nature, afforded an excellent refuge and secure hiding-place for the Apaches after marauding expeditions to the plains, or the destruction of helpless trains of immigrants. One of the trails most traveled by the Apaches led up the valley of the little creek, now known as Queen creek, and over the nearly vertical face of the mountain, within a stone's throw, almost, of the point where the Silver King Mine was afterward discovered. That the vicinity was the favorite resort and hiding-place of the savages is shown, also, by the fact that there are caves in the face of the cliffs overlooking the trail containing piles of ashes and fragments of Indian pottery.

In the year 1873 (?), when General Stoneman, the accomplished cavalry officer, now Governor of California, was commander of the military department of Arizona, it became necessary to adopt more vigorous measures than had been made for the repression of Apache raids. To this end General Stoneman moved with his command to the base of the mountains, near to the Apache trail, and established a camp. He then constructed a road, or mule trail, diagonally up the face of the mountains leading over into the higher table-lands and valleys of the Pinal Range. This pack-trail, since known as "Stoneman's Grade," is the main traveled route to the mining districts of Globe and Pioneer.

One of the soldiers, named Sullivan, employed in



cutting the trail, when returning from his work one evening, sat down to rest on a projecting rock, near the camp, and began picking up loose fragments of rock about him, amongst which there were some small but heavy, black, metallic-looking lumps. These, instead of breaking up when pounded on the stones, became flattened out, and were evidently metallic, somewhat resembling lead. This attracted his attention, but he did not fully realize the importance of his find. He, however, gathered a few of the lumps and went on to camp without saying anything about his discovery to his comrades. His term of service expiring soon afterwards, he was discharged from the service and made his way to the rancho of Charles G. Mason, on Salt river, near to the place where the town of Phœnix was afterwards located. Mr. Mason was one of the very few frontiersmen who braved the terrors of the Apaches and staked out a farm on the fertile bottom-lands of the river. Sullivan remained at the place some time and frequently showed the black ore (since familiarly known amongst the miners and prospectors of the region as "nugget silver"), to Mr. Mason, but without telling exactly where he had found it. Mr. Mason supposed that he would go back to the place and he no doubt expected to go with him and participate in the benefits of the discovery, but one day Sullivan suddenly disappeared and was not heard of for years after. He was supposed to have been killed by the Apaches, or to have perished on the desert, in the attempt, perhaps, to return to the place where he had found the rich silver ore.

The desire to find the place where Sullivan had discovered the "pure stuff," as the rancheros called the black nuggets of silver sulphide, led them to make several attempts to get there. Prospecting parties were formed at intervals for several years to prospect the Pinal Mountains, and these parties were often close upon the spot without knowing it. They even made a location only a mile and a half distant from the place, and called it the "Silver Queen." This was the first location made in the region, but no district was then defined by boundaries or organized by the appointment of a recorder. Later, the party extended their searches over the Pinal Mountains into the region now known as "Globe District." They made a location there known to this time as the "Globe Mine," and they gave the name to the district. The next year, 1875, Mr. Mason and one of his neighbors, Benjamin W. Regan, formed a party of five, consisting of themselves, William H. Long, Isaac Copeland and ——— ———, to go again to the Globe Mine, taking a train of animals to fetch out some of the ore. On their way back, March 21, 1875, they were attacked by Apaches and one of their party was killed. His body was taken to Camp Supply, at the summit of the Stoneman Grade, and was buried by his comrades in one of the old stone baking ovens used for baking bread by Stoneman's soldiers. When the survivors reached the foot of the Grade, near to the water and camp-ground, Copeland was sent to break off some of the croppings from projecting rocks at one side of the trail, and fetch them into camp two miles below. He went to the place indicated and soon after came hurrying into camp shouting, "I have struck it," and "it is good enough for me." The excited and hopeful prospectors gathered around him, and as the pieces of croppings holding the long-sought black silver ore passed from hand to hand they all said, "It



is good enough for us," and concluded that at last they had discovered the place where Sullivan had found the "black stuff," the nugget silver. But they were in no condition to remain at that time to explore the locality or to make their prize more certain and secure. Travel-worn, weary, and saddened by the loss of their comrade, and without provisions, they hastened on to the settlement on the Gila, at Florence, crossing the dreaded desert at night. The next day, jealously guarding their secret, they gathered supplies together and hastened back to the discovery-point. There, sure enough, they found the little black nuggets strewing the surface, and mineral stains, of many colors, including green and blue, in the substance of the rock. The long-sought treasure was found at last. Sullivan's discovery was no longer his alone. Standing upon the highest point of the mineral-stained rock they made the Silver King location, fifteen hundred feet long in an easterly and westerly direction, and six hundred feet wide in a northerly and southerly direction. This was on the 22d day of March, 1875. It was the initial location of the mining district now known as the "Pioneer Mining District." This district was immediately laid out, or designated, as twenty miles square, extending ten miles each way from the initial point of the Silver King location, with the bounding lines running north and south, east and west. This location, and the location of the claim, was properly made in accordance with the laws, and they were duly recorded in the county records at Florence, the county-seat.

The ownership of the location of the Silver King claim was then equally divided between the four survivors of the party of five, each holding one-fourth.

On the 30th June, 1876, Isaac Copeland sold his one-quarter to Charles G. Mason, and Wm. H. Long sold his one-quarter to Benjamin W. Reagan. On the 9th of January, 1877, Charles G. Mason sold his one-half to Col. James M. Barney, and on the 5th day of May, 1877, the Silver King Mining Company was incorporated under the laws of the State of California. On the 9th of May, 1877, James M. Barney and Benjamin W. Reagan deeded their entire interests in the mine to the incorporation.

The title to the mine is thus continuous and perfect, and is in accordance with the laws of the United States governing the occupation and working of mineral lands. The mine has been worked continuously, and since the incorporation to the present time, and it promises to be prominent as the leading silver mine of the country for years to come.

One day, two years ago, an aged man came slowly into the thriving settlement at Picket Post, and with great interest wandered about the Silver King Mill where twenty stamps were day and night merrily pounding out silver from the rock. The man was evidently in need of help, and soon went to the office of the company and announced himself as Sullivan, the old soldier, the original discoverer of the vein, and humbly asked for work. Although long before he had been given up as dead, and very few of his old acquaintances survived, he was identified beyond a doubt and was immediately taken into the company's service by the day. His story was briefly told as follows: On leaving Mason's rancho he crossed the wide deserts to the westward as far as the Great Colorado River, and beyond it into California. Being penniless, he had sustained himself by working as a farm



hand in California. Always hoping to obtain sufficient means to return to Arizona and secure the benefits of his discovery, he had labored on year after year, looking vaguely forward, and keeping the secret of the locality to himself, until one day he heard of the discovery of the rich deposit of silver by Mason and others. He was convinced that the place had been found, and that he had lost his chance of making the location for himself. Although without any ownership or right in the location, as made by Mason and his friends, and disappointed in his long-cherished hope, he could not resist a desire to return and see the result of the opening of the mine.

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# SILVER KING MINE, ARIZONA.

## SITUATION, ACCESSIBILITY, CLIMATE.

The Silver King Mine is situated near the base of the southwestern slope of the Pinal Mountain range in Pinal County, Arizona Territory, at an elevation of 3700 feet above the sea. The location overlooks the country to the southward as far as the Mexican line, and westward, the vast plain of the Gila and Salt rivers to Phœnix, and beyond. This plain, now comparatively treeless, sterile and desert-like, was once the seat of ancient civilization, as shown by the numerous ruins of buildings, and the profusion of fragments of pottery strewing the surface, but there is no evidence that the dwellers of the plain had ever discovered the wealth that lay hidden in the King Mountain.

The road from the mine leads for a few miles down the foot-hills and then over the nearly level plain for about 35 miles to Florence, on the Gila river, the County-seat of Pinal county. Beyond this town the road continues over the plain to Casa Grande station, on the Southern Pacific Railway of Arizona, 913 miles from San Francisco. The natural road, now also the county-road, is excellent at all seasons, and the drive from the railway station can be easily made in eight or nine hours. The mine may be reached from San



Francisco in 53 hours, or in 5½ days from New York, and at all seasons without embarrassment by snow, which renders so many of the important mines of the country comparatively inaccessible in the winter season.

The mill of the company is at the town called Pinal, on Queen creek, five miles from the mine. Pinal is at an elevation of 2400 feet above tide. It is connected with the mine by a good road, and by telephone. At Pinal, the offices of the Silver King and Florence Telegraph Company give direct telegraphic communication with the Western Union lines.

The climate of the region is salubrious, and is particularly delightful in winter, as severe frosts are unknown. The air is remarkably clear, the days are warm and the nights are cool and refreshing. In summer the great heat of the day is tempered by the dryness of the air, which promotes rapid evaporation from the skin, and keeps down the temperature of the body. There is no interference with mining or milling operations, or loss of time due to the climate.

A project for a railway leading northwards from the Southern Pacific Railway to the Silver King Mine, and beyond it, is now under consideration, and in all probability a road will be built in the near future. Such a road would not only make the mine accessible in a shorter time than is now required, but would reduce the cost of freight on machinery and supplies, and afford a cheaper outlet for the ores and bullion. The configuration of the country is especially favorable for railway construction, particularly as far as the foot-hills, for it is nearly all a continuous, level, gravelly plain, without streams or canyons, and requiring little or no grading.

## GEOLOGY.

The geological structure of the Pinal region is somewhat complex, but is very interesting. The whole country appears to have been covered, in comparatively recent geological time, with volcanic rocks, partly in a sedimentary form, as volcanic sandstones and conglomerates, and partly, and lastly, in a molten or lava-form. Considerable areas of these rocks have been swept away by denudation and erosion, leaving the older and foundation rocks exposed to view, particularly in the valleys and canyons, while remnants of the lava-flow cap the summits and in places remain as flat-topped mountains; as, for example, the mountain known as Tordilla, at Pinal, back of the mill.

The Pinal Range, above the Silver King Mine, is formed chiefly of Palæozoic strata with heavy beds of quartzite at the base, overlaid by massive limestones dipping eastwardly. These strata show along the Stoneman Grade as it ascends the mountain, and can be seen in greater thickness, probably not less than 3000 feet, by ascending Queen creek further to the southwest. Several miles further southwest, towards the Gila, the same series of limestones crop out in mountain masses, pitching at a higher angle eastward, and in some of the upper beds Spirifers have been found, which I refer to the Coal Measure series of the Carboniferous formation. In some places there is a large development of a coarse conglomerate of a red color.

Above the limestones at the King Mountain, as I denominate the highest summit above the mine, the volcanic outflows which form the capping, consist largely of pitchstone porphyry carrying obsidian,



geodes of quartz crystals, masses of chalcedony and of semi-opal.

Below the limestone and quartzite series, gneissic and hornblendic rocks of the Archæan age crop out and appear to be the foundation rocks on which the sediments rest unconformably. Still lower down the slope, the rocks become sienitic, and are then replaced by a distinctly-formed feldspar porphyry, with small white feldspar crystals, and an abundance of iron pyrites finely disseminated. The formation appears to have the position of a dike, cutting the other rocks, but it is extensive, and continues to and beyond the Silver King Mine. It may be regarded as the enclosing rock of the Silver King, though in one place, some 200 feet above the mine, there is a strongly-defined outcrop of a dense, hard porphyry with hornblende crystals and brilliant glassy feldspar forming a sienitic porphyry.

At the mine, and in it, the porphyritic structure generally becomes obliterated and the rock has more the appearance of a granular quartzite with a large amount of earthy admixture, and obscure fragmentary crystals of silvery mica. Examined alone, it would pass as a quartzite containing much clay and iron protoxide. In some places it is almost colorless, white and earthy, soft, easily cut or crushed, but shows distinct grains of quartz as large as peas. The larger portion of the rock below the open cut has a dark, greenish color, and is known by the miners as "dark porphyry." In some places it appears to be chloritic. This, with the light porphyry, is the ore-bearing rock of the mine. It is penetrated, as will be shown in detail in the following pages, by veinlets of quartz and by ore.

After carefully studying the rock in place and its environment by the unaltered crystalline porphyry, I am led to the conclusion that the rock of the mine is an altered porphyry, changed in its place contiguous to the solfataric outflow, the principal portion of the silica of the feldspar having been removed, going, perhaps to form the vein-stone of the ore. If, as seems probable, the rocks originally were charged with disseminated pyrites, as seen at some distance from the mine, it is now largely removed, and the pyrites may have exerted an important function in the precipitation of the ore as we now find it concentrated in veinlets and bunches. The altered porphyry appears to contain more iron protoxide than the unchanged rock. The feldspar porphyry below the mine is succeeded by a fine-grained grey granite, in places sienitic, and this again lower down the slope, towards the plain, by an extensively developed fine-grained mica slate formation. This formation is very ancient, and is lithologically and to all appearance the equivalent of the Taconic slates of Berkshire, Massachusetts, and the Vermont extensions. It is extensively developed in Arizona, and being one of the primal series of formations and fundamental bed-rocks of the territory, in and upon which such a variety of later formations are grouped, it deserves the distinguishing name of Arizonian slate, which I shall apply to it. It is extensively exposed to view along the sides of the Queen creek valley, west of the town of Pinal, where it may be seen in a highly contorted, twisted condition, traversed by innumerable veins of white quartz, also contorted, and often doubled back and forth upon themselves. This slate extends to the southwest, flanking the granitic masses of the Pinal range, and is there much

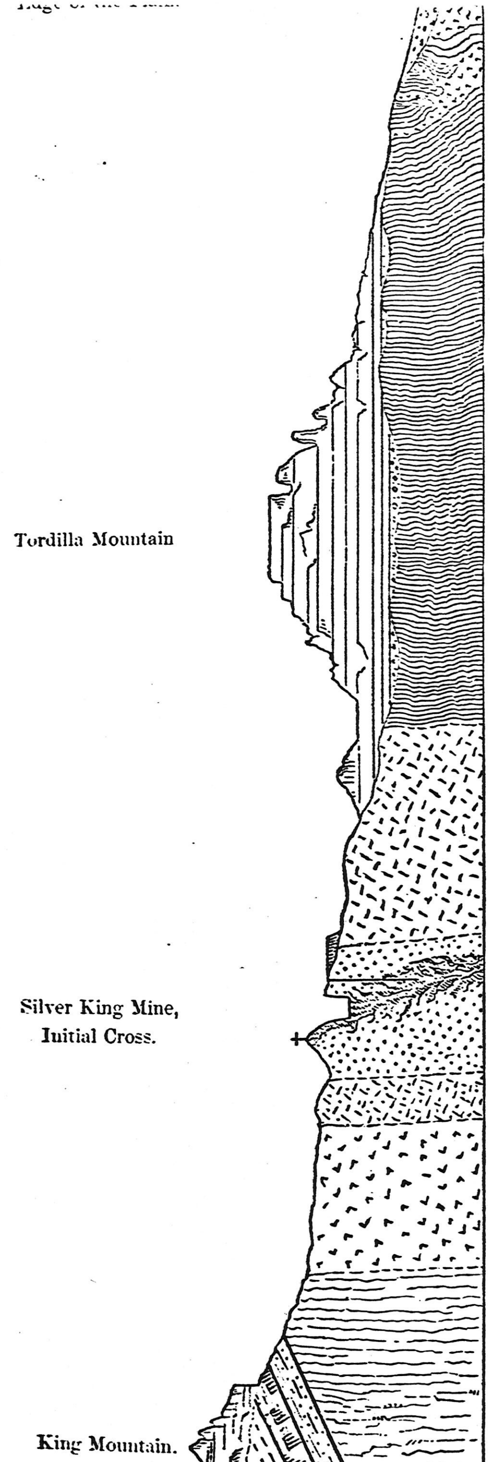


Fig. 1.—Geological Sketch-Section, Silver King Peak to the Plain, over the Silver King Mine.

traversed and broken up by granitic intrusions. This rock finally disappears, westward, under the post-tertiary formations of the Gila plains.

The sequence of the formations thus briefly noticed is shown on the appended sketch-section representing the summit of King Peak westward to the Gila plain. The central portion of the Arizonian slate is concealed from view by the horizontal sediments of Tordilla Mountain, opposite Pinal, but it crops out along the valley below it. About seven miles below Pinal the slate is penetrated by granitic intrusions, and is gradually replaced by granite.

The lower portion of Tordilla Mountain is formed of regular layers of compact white sandstone. It is suitable for building stone, and is quarried for that purpose. The same formation is developed along the Gila, but is there, in some places, tilted up at considerable angles.

---

## THE VEIN FORMATION.

The observer, standing upon the highest point of the Silver King location, the initial point of the mine, and of Pioneer District, looks below to the westward into the large open pit, or excavation, the result of the first working of the mine from the surface downward. This pit measures, approximately, 115 feet long by 92 feet wide and 120 feet in depth. (See the map and



the section.) It marks very nearly the limits of the ore-bearing ground, so far as it is yet known or developed at the surface and near it. The portions removed consisted largely of rock, the porphyry, so called, penetrated and seamed with interlacing veinlets of quartz, reticulating and crossing in every direction. These veinlets varied from the thickness of a sheet of paper to one-quarter of an inch or an inch in thickness, and were generally accompanied by ore in a medial position having quartz on each side of it next to the rock. The same conditions may be seen in the lower levels at the present time. In addition to these veinlets there are masses and bunches of ore, and apparently (at least in the upper levels), a central mass of quartz, a large and compact body, towards which the system of veinlets converged, or from which they may be said to radiate. This mass of quartz, of irregular dimensions, still exists in the region opened by the lowest levels of the mine, but it has not yet been thoroughly explored. This quartz appears to hold some direct relation to the deposition of the ore; the heavier bodies of ore, so far, having been cut below, or on the foot-wall side of the quartz body. It may be regarded as holding the relation of the chief veinstone to the ore, and as presenting within itself and together with the branching veinlets, the characters of a true fissure filling, although it has not the usual sheet-like or tabular form. It is, instead, a columnar or chimney-like mass, some eighty feet in diameter in places, but irregular and without longitudinal extension. In other words, this quartz-vein, instead of forming a sheet-like mass, or filling between parallel walls, with a length much greater than its breadth, is approximately *cylindrical* or columnar in its form, filling a nearly vertical, spirally-formed cavity, as if it had risen as smoke rises in a chimney, but circling about through the riven rocks until it reached the surface by many outlets.

Without here discussing the various theories which might be advanced to account for this peculiar impregnation of the rocks with rich ores of silver; whether the flow was from above downward, or the reverse, whether the quartz with the associated metals was extruded from the surrounding rock and found lodgement by replacement, or whether it was diffused by the penetration of fissures by solutions or gases, I prefer to adopt the explanation that there was an upward flow of heated water and steam which carried the metals into the fissures and left them there. The conditions as we find them are most clearly explained upon this hypothesis, and I believe are most vividly and truthfully represented to the mind by this conception of an upward flow of thermal water along a main central channel, like that of a deep-seated spring or geyser, now an extinct argentiferous solfatara.

If we examine the structure of the veinlets in detail we find them presenting the characteristics of fissure veins. They extend for long distances through the rocks and with parallel walls. They have regular veinstone and vein structure. The quartz forms on the opposite walls of the fissures in regular sheets, with "combs" of quartz crystals pointing inwards and holding the ore in bunches and sheets. Such inclusions of ore are still to be seen in the small veins at the summit of the croppings and in the levels below.

Some of the various forms under which the ores present themselves in the mine, and the sequence or order of deposition of the minerals may be shown to best



advantage by a few illustrative sketches and sections of the veins.

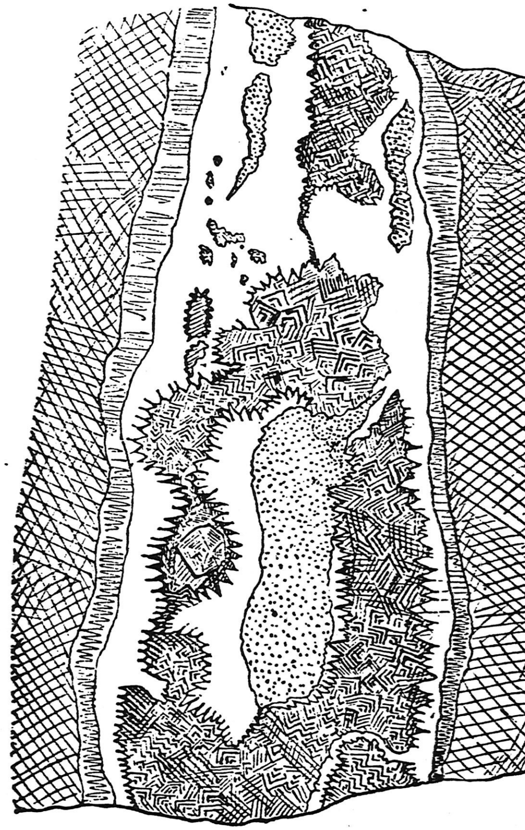


FIG. 2.—Section of a Vein, showing the structure.

1. Porphyry.
2. Compact quartz.
3. White crystalline quartz.
4. Ore filling, consisting of sphalerite, galenite and native silver, with some vuggs or cavities containing crystals of light-colored blende. Some irregular fragments of altered porphyry are enclosed in the midst of the vein.

3a. White crystalline quartz.
2a. Compact quartz.
1a. Porphyry.

Figure 2, of one-half the natural size of the specimen, shows a veinlet about four inches wide in the light-colored porphyry. We find first, next to the rock, a lining on each side of compact quartz, succeeded by white crystalline quartz and the ore, in the succession indicated.

Fig. 3. Section of a veinlet in dark porphyry carrying about two inches of dark-colored sphalerite (blende), confusedly crystallized. The paragenesis is as follows, and is chiefly remarkable for the brown-spar, which is not often found as a member of the series:

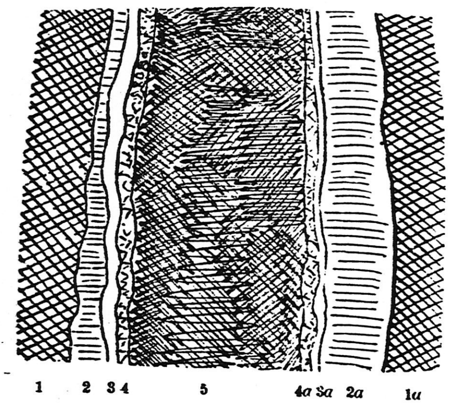


FIG. 3.—Section of a small Vein.

1. Porphyry.
2. Compact quartz.
3. White quartz.
4. Brown-spar or iron-spar with disseminated pyrites.
5. Central filling of compact ore. Blende chiefly.
4a. Brown-spar and pyrites.
3a. White quartz.
2a. Compact quartz.
1a. Porphyry.

Another fragment of a veinlet shows quartz more distinctly crystalline, with some copper pyrites be-



tween it and the porphyry, and a central ore-filling of massive blende and galena mingled together.

The ore occurs also in bunches in the rock with but little veinstone. A tendency to triangular forms is observable, and in several places I have noted veins joining together nearly at right angles, somewhat as shown by the figure annexed.

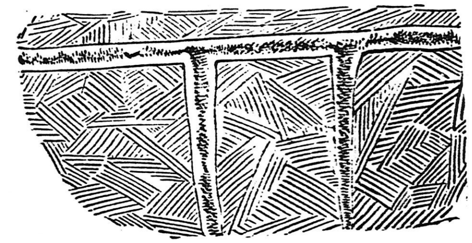

FIG. 4.—Example of reticulation of small veins, branching from one side in the green "porphyry."

This is an example of reticulation but not of crossing. The latter form is, however, common and may frequently be found in the masses of ore as sent out from the stopes, or better, in the freshly broken faces of the stopes. But irregularity of branching is the rule rather than any geometrical or symmetrical arrangement. The various appearances presented justify liberal illustration, and I would be glad to be able to add a few photographs of some blocks of the ore-bearing porphyry as taken from the dump.

The reticulation of the veins is seen to the best advantage at the surface, and particularly at the summit. There is at that point a very interesting example within the space of a few square feet, showing apparently two systems of veins of different ages, one system with a true north and south strike, and the other system having an east and west strike. They intersect at right angles, as shown on the appended sketch, from a drawing made upon the spot, and curiously at this initial point they form a true right-angled

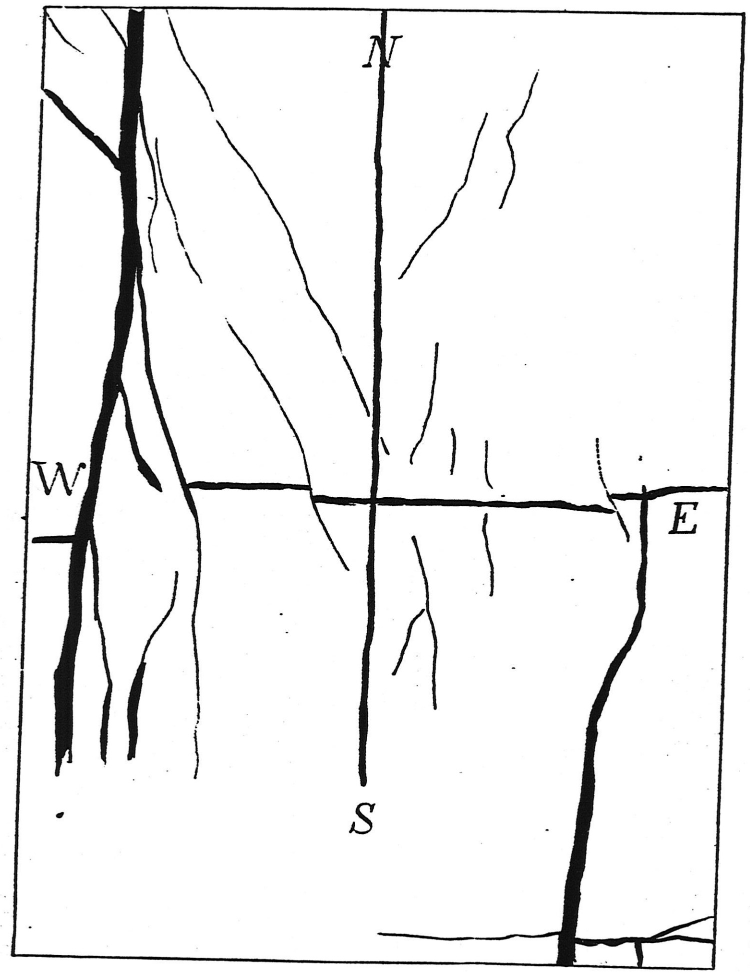


FIG. 5.—Sketch, showing the North and South and East and West systems of Veinlets, forming a Cross at the summit of Silver King Mine.

*cross*, the arms of which point north and south, east and west, marking in a very appropriate manner the



center of the district. I have deemed it worthy of a diagram or plat, illustrating, as it does, the reticulation of the veins and the complete mineralization of the mass of the rock. The east and west fissuring appears to be the older of the two, for the veinlets of that direction are cut through and are faulted for a short distance by the north and south veinlets.

It will be inferred from the preceding descriptions that the richest and most important accumulations of ore are not found in the main body of the quartz veinstone. Although the massive quartz does hold bunches of rich ore, it is not, as a rule, so rich and profitable to work as the rock adjoining it. The ore is more abundant in connection with the small branching veins in the outside rock than in the mass of the quartz itself. It must, however, be stated that the quartz body has not yet been fully explored, being merely cross-cut in the upper levels. It is my opinion, however, based upon what has already been shown, that contrary to the usual conditions in mines the chief body of quartz veinstone does not carry the best part of the ore. It appears rather to have been the main channel of the mineralization; the main artery or feeder to the thousands of veinlets branching from it into the wall rock, following the clefts and penetrating the substance of the rock, depositing and diffusing native silver and the sulphides throughout the whole mass of rock for an indeterminate distance on each side.

So far as explorations have extended, no distinct boundary line or wall to the ore has been found. The silver solutions appear to have found a congenial resting-place in the midst of the rock. We have, as the result, a form of mineral impregnation which may be classed as "*stockwork*," this name having been given to masses of rock so mineralized by small veins ramifying through them that they require to be mined *en masse*, and give broad excavations known as "*floors*." These are precisely the conditions found in the Silver King. The whole of the impregnated rock is blasted out and sent to the surface with but little selection or sorting. The "porphyry" and the veinlets go together and are crushed together, it being impossible to separate all the ore from the rock by sorting.

This extensive and varied mineralization, connected, as it appears to be, with a central solfataric mass of quartz, gives good evidence of being deep-seated. It is evidently not superficial, but has the appearance of a lasting ore-channel of great depth. There is no evidence of any weakening of the mineralization at the lowest level reached; on the contrary the lowest level is the largest yet opened except the Open Pit at the surface. The veinlets cannot be traced far on the surface, and it is difficult to show that they extend more in one direction than another. The formation seems to have a general dip to the westward, and this is the direction of the underlie of the ore-ground, as is shown in the chapter upon Development.

The solid white quartz of the upper levels has not yet been fully explored. It contains rich bunches of grey copper ore, generally in a very friable condition, almost in black powder, but rich in silver.

## MINERALOGY.

The mine is prolific of minerals and silver specimens of great beauty, highly interesting to mineralogists and collectors. There is, as usual, a great contrast between the surface ores and the ores from the lower levels. The surface ores are partially oxidized and decomposed, and are more earthy and less metallic in appearance than the ores from below. The rock enclosing them is also changed to a rusty brown color. The surface ores were, however, brilliant in the coloring, generally presenting masses of malachite-green, and of azure blue, due to the carbonate of copper, with small sheets and filaments of snow-white pure silver in beautiful contrast. Here, also, were the nuggets, generally in irregular nodular forms, with smooth surfaces, and jet black in color. Pyrites was rarely found. But when the mine was opened below the open-cut, the true mineralization of the mass was found to consist, generally, of sulphides—the sulphides of silver, of lead, of zinc, and of copper, disseminated, together with native silver, in the quartz veinlets through the rock.

The following list comprises the principal mineral species which I have found occurring in the mine: Native Silver, Stromeyerite, Argentite, Sphalerite, Galenite, Tetrahedrite, Bornite, Chalcopyrite, Pyrite, Quartz, Calcite, Siderite, Barite. Near the surface, in the decomposed parts of the vein, where the ores are partially oxidized and desulphurized, we find in addition, Horn Silver (Cerargyrite), Malachite, Azurite,

... copper, Cuprite, besides oxides and carbonates of lead, and possibly Embolite, the chlorobromide of silver; also the argentite, in pure black lumps.

I add notices in detail of some of the most interesting of the species.

*Native Silver.*—In the filamentous form, coarse and fine, very white, and striated as if made up of bundles of fine wire, and ranging in size from the size of a pin or knitting-needle to masses half an inch through, but solid and much twisted and gnarled. It is also finely filiform in long wires, in one instance twenty-four inches long, and in threads as fine as a hair or silk, filling cavities or branching from the coarser wires. It occurs, also, in sheet-like masses and plates, and in

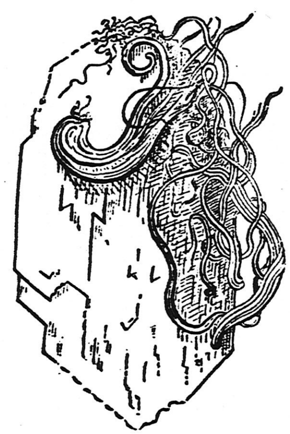

FIG. 6.—Wire Silver on Quartz.

thin films forming a regular continuous plating upon the surface of quartz crystals, especially when they occur imbedded in the argentite and stromeyerite. It is found similarly on the faces and cleavages of black zinc blende. Distinct crystals of the metal are extremely rare in the mine, and I have seen only one



small specimen of a brilliant white crust of silver lining a cavity, with a few octahedral crystals upon it. The filaments are often subdivided towards the extremity, and ramify like the tendrils of a vine, and they frequently bear aloft on their ends detached and beautiful crystals of calcite, the silver wires penetrating the crystals as if they were beads. So, also, they are found penetrating crystals of quartz and implanted at the base of the crystals, or at the end where the crystals were attached, especially when there are double terminations to the quartz crystals.

This native silver is remarkably pure. It has been shown by repeated assays to be from .990 to .997 (thousandths) fine. It does not blacken in nitric acid, and does not show a trace of copper or of gold by the usual tests. Fully one-third of the value of the product of the mine is in the form of native silver.

*Argentite.*—This species was the first found at the surface, and it continued to be found in working the mine down to the third and fourth levels, where it gave an unusual degree of value to the ore. It was easily recognized by its malleability, sectility, and its high content in silver, some of the early assays gave as high as 70 per cent. I find its color to be black, with a metallic lustre, especially when cut. It is perfectly sectile and cuts like lead. The specific gravity taken in distilled water at 60° is 6.828. A careful assay for the silver content yielded me 82.80 per cent. of silver. No copper.

*Stromeyerite.*—I place provisionally under this name the most peculiar and interesting of the mineral compounds found in the mine. It occurs massive, in blocks from an inch through to pieces weighing four or five pounds, but is more abundant in the third and fourth levels than below. It is generally penetrated by, or incloses, quartz crystals, and has a remarkably well-defined conchoidal fracture with brilliant surfaces. The lustre is highly metallic, splendent. Color, dark bluish-black, between graphite and anthracite coal. Streak brown, or reddish-black. Hardness about 3. Very brittle, but packs under the hammer. Specific gravity, 6.22. Soluble in hot nitric acid. Reacts for silver and copper. Contains 51.47 per cent. of silver, and about 30 per cent. of copper. Fuses quietly before the blowpipe. The determination of the amount of silver is the result of the assay, by myself, of a carefully selected sample. A sample not wholly free of included quartz, specific gravity 5.662, assayed for me by Mr. Aaron, at the mill, yielded 47.84 per cent. of silver and 29.86 per cent. of copper. No allowance in either case is made for cupellation loss.

*Galenite.*—Occurs coarsely crystalline and fine granular, but in the last-mentioned form it is confusedly mingled with blende, and perhaps tetrahedrite. The purer crystalline masses cleave with a very brilliant lustre and the surfaces are considerably curved, so much so as to look like surfaces of conchoidal fracture. This pure crystalline variety does not appear to be very rich in silver although occurring in close association with the metal. For the purpose of testing this question I selected some of the cleanest and purest cleavage fragments, apparently free from any other mineral, and had ten grammes assayed by Mr. Aaron. This quantity yielded only five milligrammes of silver, at the rate of 14.58 ounces per ton. In the large way the galena ore, so called from the preponderance of galenite, has been found to run from a value of $42 to $870 per ton. Large quantities of such ore in the



earlier history of the mine yielded in the vicinity of $800, in value of silver, per ton, but no doubt this was owing to the large amount of native silver and sulphide of silver mechanically enclosed with it.

*Tetrahedrite.*—Argentiferous grey copper. This species was more abundant in the upper levels than in the lower. It was found not only in the porphyry but in bunches in the midst of the large body of quartz above and in the third level. Assays of this species have yielded at the rate of $1200 to $1800 per ton, and even over 3000 ounces. In the year 1880 it was regarded as one of the most important ores of the mine. It now seems to be partly replaced in the lower levels by zinc blende.

*Bornite* and Chalcopyrite occur but sparingly and in small crystalline grains. Iron pyrites is frequently seen as a druse upon the filaments of silver, or coating some of the massive ore of blende and galena, or associated with the iron spar of the veinstone. Chalcopyrite, in small nodular masses, occurs also in association with the Stromeyerite, being apparently imbedded in the midst of the mineral.

*Sphalerite* (*zinc blende*).—This is an abundant mineral in the ore, and presents itself in a variety of forms; sometimes in beautiful transparent oil-green crystals and again in black masses without any crystalline facets except by cleavage. The crystals are so brittle and easily cleaved that it is very rare to get one with a single perfect plane. Some fragments before me appear to be compound dodecahedral crystals with re-entering angles, and hopper-shaped cavities. Films, or thin sheets of iron-sulphide—pyrite—can be seen with a glass implanted along the lines of cleavage.

This mineral is abundant, especially upon the seventh level of the mine, and is closely associated with the silver. The amount of silver which the crystals hold either in combination or mechanically entangled is variable. Clean crystallized fragments, of the dark color, after powdering and sifting, yield by assay from $170 to $220 in value per ton in silver. The metal is probably in mechanical combination, and experiments are necessary to determine whether the clean, clear blende carries the silver in any other form. The lighter olive-green variety has yielded by assay as low a value as from $26 to $42 per ton.

The ore as now concentrated and shipped contains nearly 18 per cent. of zinc, chiefly or wholly in the form of blende.

*Calcite.*—This species is not abundant in the mine and does not appear to play any important part in the combination of minerals or the formation of the vein. It is chiefly interesting by its occurrence in small crystals, impaled, or strung like beads, on the threads of silver. These crystals are in the form commonly known as "nail-head-spar," being obtuse rhombohedrons of the minus series, $-\frac{1}{2}R$, with the prismatic planes *i*, *i*, *i*, corresponding to Fig. 553, B., Dana's Mineralogy.

*Quartz.*—This is the chief veinstone of the mine and is found massive and crystalline, and milk-white, purple, amethystine, and also clear. The crystals are frequently found disseminated in the midst of the Stromeyerite, and apparently without attachment to a base. It forms combs and rosettes in cavities, and is sometimes in large crystals. One from the seventh level is six inches long and three and a half inches in diameter, and has imperfect terminations at each end, one end being cavernous, with many interrupted planes



and smaller implanted crystals at the side. The purple, or amethystine variety, is met with imbedded in the dark green ore-bearing rock, the porphyry of the miners, and is by them considered as a good sign for rich bunches of silver ore. It is usually in the central portions of white quartz. Some masses of calcedonic quartz, lining cavities, have been found in the dark green rock.

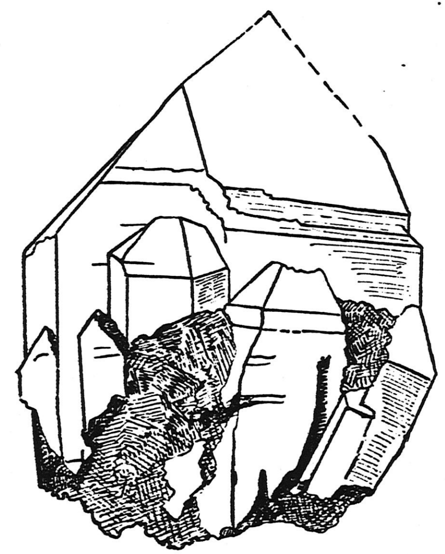

FIG. 7.—Quartz Crystal from the Seventh Level.

*Barite.*—Is found massive in bunches, and next to quartz it is the most abundant vein-stone or gangue, but is not as closely associated with the rich ore as the quartz. Much the larger portion is easily sorted out by hand and thus does not interfere with the concentration of the ore on the tables at the mill.

## DEVELOPMENT.

The mine is now opened to a vertical depth of 830 feet below the initial point of the cross at the summit above the open cut. This includes the open cut and the sump 36 feet deep. The summit is about 80 feet above the level of the mouth of the main engine shaft. The shaft, exclusive of the open cut and the sump, is thus 714 feet deep. This shaft is vertical and is well and thoroughly timbered in the best manner from the top to the bottom. There are two compartments, each four feet in the clear, and fitted with guides and cages. It is in perfect order as shown by the smoothness with which the cages run. There is not sufficient water to require a pump; what there is comes from the 114 foot level and does not exceed 2000 gallons a day. It is hoisted by a tank fitted to the cage. A large sump-reservoir at the seventh level serves to hold it while accumulating.

There are seven main levels, as follows:

| Number. | Depth from Surface. |
|---|---|
| I. | 114.6 |
| II. | 256. |
| III. | 354.9 |
| IV. | 408. |
| V. | 570. |
| VI. | 612. |
| VII. | 714. |

An intermediate level, between the II. and the III., is at a depth of 302.9 feet below the surface.

The direction and length of these levels is best shown upon the map. They are generally curved and



consequently their full length is not shown upon the section.

*Level* I. passes through 80 feet of quartz and extends some 30 feet into the country-rock, or ore-bearing rock, beyond it. It has not been cross-cut, and cannot be considered to be a full test of that level of the mine. At the time it was run the distribution and the position of the ore were not as well understood as they now are.

*Level* II., 256 feet, passes through about 75 feet of quartz and shows very rich silver ore in detached bunches throughout its mass.

The next level below, the 302.9 feet, or intermediate level, follows the lower side of the quartz for 30 feet, and has a cross-cut extending at right angles for 50 feet, all in quartz. The underlying ore-ground back of the quartz has not been explored.

*Level* III., 354.9 feet, extends on both sides of the shaft, and has been driven around the quartz chimney so that the two levels started in opposite directions, are now connected. This level penetrated a large body of fine ore of high grade, rich in silver, underlying the quartz, upon which considerable stoping has since been done but without reaching, as yet, any definite limits of the ore. The shape and the extent of the excavation upon the sill-floor is shown upon the accompanying diagram. The size of the floor is approximately 63x43 feet, or 2700 square feet.

Each floor in succession upwards, to the 303-foot level, is smaller in area than the one below it. There are seven such floors or stopes from the sill-floor, on the III. level, to the upper one just under the 303 foot level. This opening upwards is one of the largest stopes of the mine, and represents an excavation in the aggregate of 97,921 cubic feet, which, taking 10 cubic feet to a ton, would represent about 9792 tons. I found the specific gravity of a sample of dark porphyry with some ore in it to be about 3, which would require about 10.7 cubic feet to weigh a ton. A considerable part of the rock-ore taken out should be

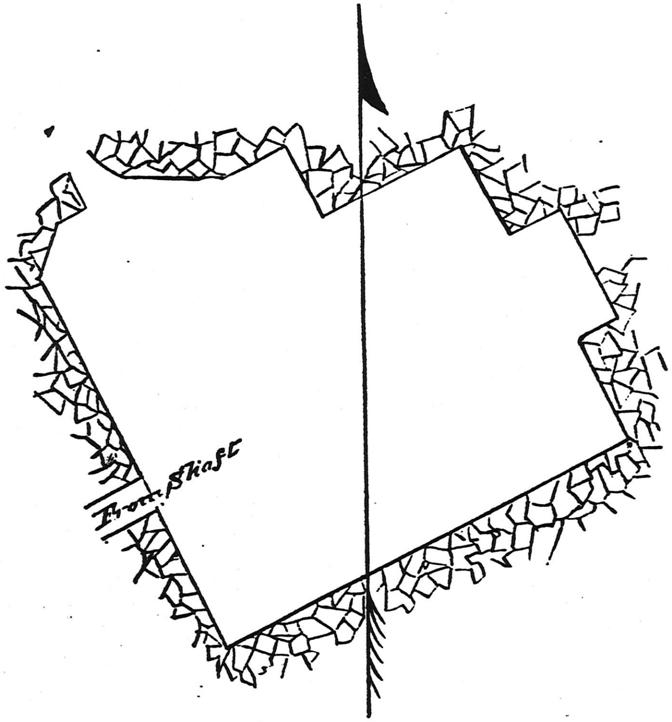


FIG. 8.—Plan of the Floor on Level III.

estimated at from 11 to 12 cubic feet to the ton. This stope has been one of the best of the mine Large quantities of silver sulphides were turned out of these floors and were rich enough to be sorted out by hand and shipped direct without being passed through the mill. The assays of ores from this stope were very



high, and for the roasted ore were from $250 to $400 per ton for months in succession. For the present, the work on these floors is not being prosecuted. They remain as they were a year ago. It is believed that the stopes may be considerably extended on the sides so as to extract a large additional quantity of ore from each of the floors.

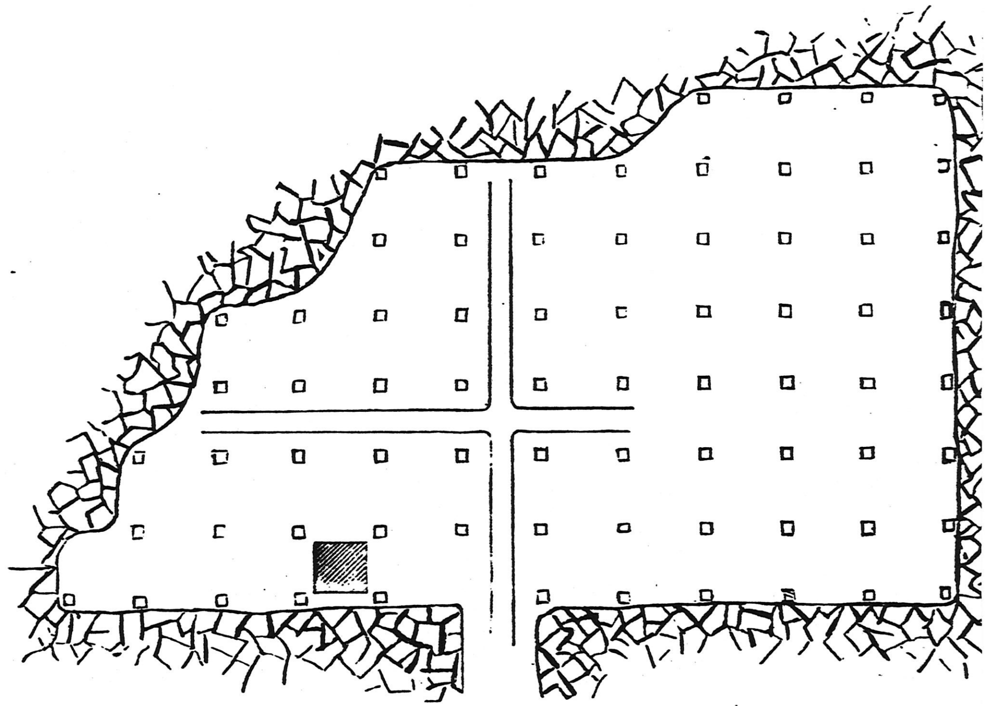

FIG. 9.—Plan of the Floor on Level IV.

*Level* IV. is excavated in the form shown upon the diagram. The distances between the timbers are 7 feet by 6.2 feet. A portion of the space is filled by waste. Stoping has been extended up to the 356 and above to the 300 foot level, as shown upon the section and in the foregoing description. A body of quartz, about eight feet thick, is cut in the extreme northwest corner.

The area of this sill-floor is 2557 square feet, and the cubic measurement of the stopes above it to the III. level are 133,788 feet, representing an extraction of 13,378 tons, as nearly as it can be calculated by measuring each floor. A portion of the excavated space for

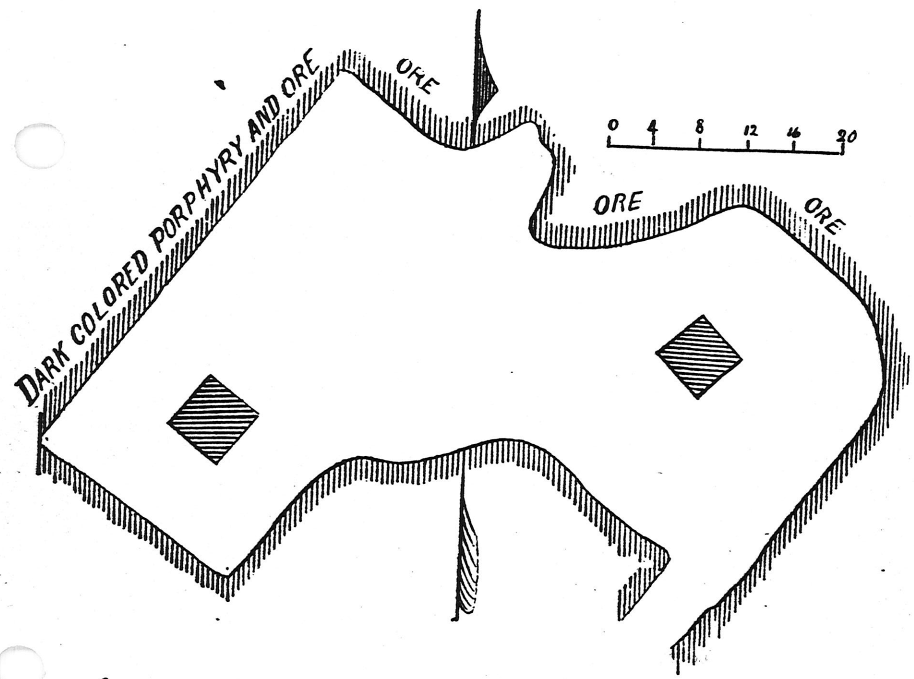


FIG. 10.—Plan of the Floor on Level V.

one and a half sets up is filled in with rock waste to aid in supporting the ground above. This work is now in progress. The waste is hoisted from the V. and the VII. instead of being sent to the surface. It is carefully piled between the timbers so that mining can be extended at will beyond the limits of the present excavations.



*Level* V. This level is but partially opened, as shown in the diagram of the sill-floor attached. It looks remarkably well, showing an abundance of ore on the north and the northwest sides of the sill-floor. The porphyry is very dark colored on the western side and appears to contain chlorite. Amethystine quartz and galena ore are abundant. The distances between the timbers are the same as on the VII. level, being 6 by 6 feet, by 8 in height.

The area of this excavation is approximately 3348 square feet. There are no stopes above; the ground is all standing up to the IV. The cubic measurement of the ore extracted is 28,458 feet, and the tonnage may be placed at 2845 tons. The sketch represents the position of the two winzes which connect this level with those above and below for the purpose of ventilation. One extends down to the VI. and the other up to the IV. The other levels are similarly connected. One or two of the winzes are shown upon the section. One is in the line of the shaft.

*Level* VI. This consists of a mere drift, extended 82 feet from the shaft on the northwest side to connect with a winze from the VII. level. It is also connected by winze with the V. level, above. No stoping has been done here, but the ground is ready to be opened out when required. The cubic measurement of the ground removed is as estimated by calculation of the dimensions of the drift at 3150 feet, equivalent to 315 tons. The direction of this drift is the same as that of the VII. level, directly under it.

*Level* VII., 714 feet. This is the lowest level in the mine and it is also the largest. It extends northwest from the shaft and is ore-bearing from the shaft to the extreme face. The limits of the ore are not yet ascertained. The faces around the excavation of the sill-floor are still in ore and are showing finely, especially at the bottom. The floor of the whole level is

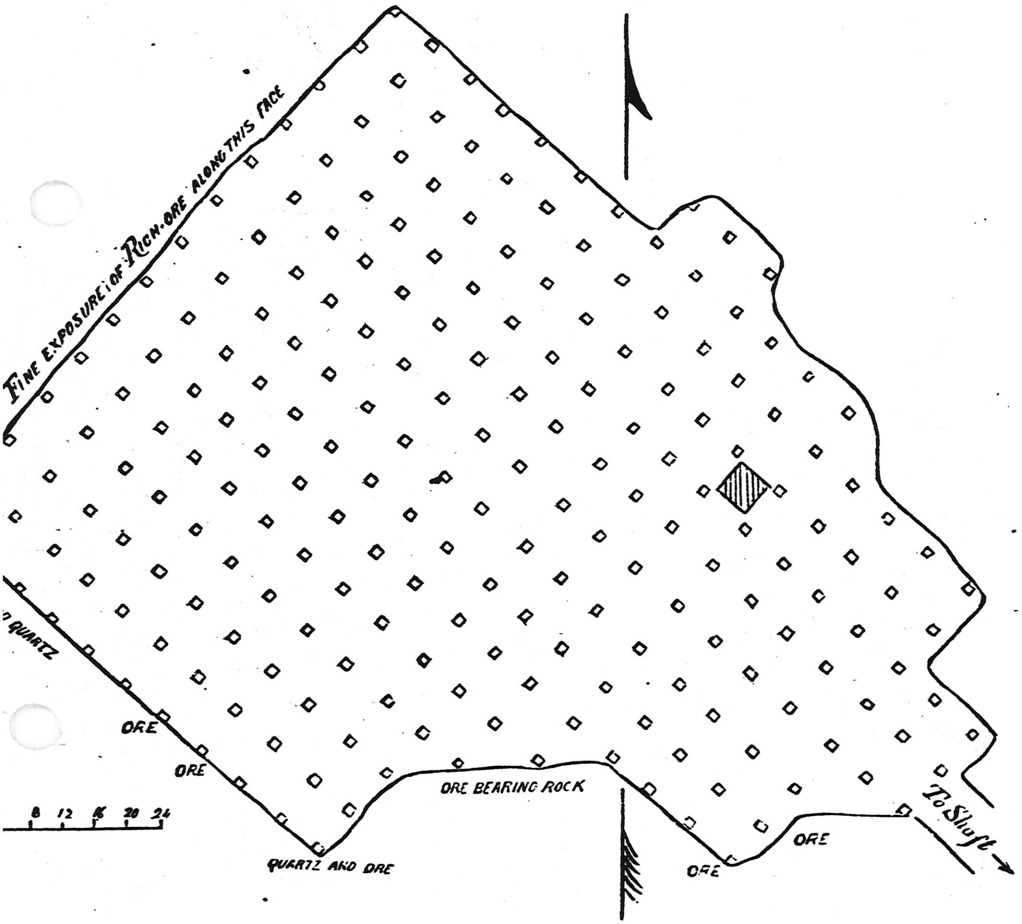


FIG. 12.—Plan of the Floor on Level VII.

said by the miners who worked it to be very rich. It is the most brilliant level of the mine and gives great promise for the extent and value of the ground below and above it. The distance between the posts is six



feet from center to center and the total area of the floor as now excavated is 5904 square feet. Stoping has been carried upwards three floors higher, or 32 feet above the sill-floor. The aggregate extraction from this level and the connected floors above, including the winze to the VI., is 166,228 cubic feet, or about 16,623 tons.

The aggregate extraction from the mine below the open cut, or rather from the 304-foot level to the VII., inclusive, may be summed up as follows, the extraction from each level and the stopes above it being recapitulated from the foregoing descriptions:

*Aggregate of Extraction from the Levels below the 300.*

| Levels. | | Cubic Feet. | Tons. |
|---|---|---|---|
| Number. | No. of feet deep. | | |
| III. | 354–303 | 97,921 | 9,792 |
| IV. | 408–354 | 133,788 | 13,378 |
| V. | 510 | 28,458 | 2,846 |
| VI. | 612 | 3,150 | 315 |
| VII. | 714 | 166,228 | 16,623 |
| | | 429,545 | 42,955 |

In calculating the number of tons, 10 cubic feet have been allowed to the ton. The pure dark porphyry, without ore, is found by experiment to have the specific gravity of 2.68, or 12 cubic feet to the ton.

The sump, 36 feet lower than the sill-floor of the VII., is reported to be in ore, thus proving the continuous existence of ore from the surface to the lowest point yet opened in the mine.

The strength of the ore-ground in the lowest level is very encouraging for the future of the mine below, and it indicates, also, that the upper levels may be more extensively opened to advantage. So far, there is nothing to indicate any giving out of the ore in depth. The changes of grade of ore from level to level are as likely to be in favor of higher grades of ore as of lower grades.

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## THE MAP AND SECTION.

The map of the underground work of the mine is drawn to a scale of 32 feet to the inch and represents the Open Pit and the successive levels in their relative positions with respect to the shaft as they would appear from a vertical point of view. The somewhat vortical form of the ore-channel makes it difficult to represent it, and causes the longer axes of the successive levels to be oblique to any one vertical plane. The lines of the sets of timbers vary in consequence, and are not always parallel, or one directly above the other. The drawing representing the upper levels, or to the III. inclusive, was made in 1880, and the other levels have since been added. The form of the third level sill-floor has been changed to conform to its present condition (December, 1882). The levels above it remain as they were in 1880.

The vertical section of the mine is upon the scale of 64 feet to the inch, or one-half the scale of the map. The position of the several levels and stopes with respect to each other made it necessary to adopt a certain line of section to which they could all be referred



by perpendiculars, as no one plane of section could be adopted which would pass through the longer axis of each level or floor. The line selected passes through the center of the shaft and lengthwise of the VII. level. This line corresponds very nearly to the direction of the long upper level. It is not indicated on the map. The distances of some of the levels from the shaft are necessarily fore-shortened, inasmuch as they are curved in some cases so as to run nearly at right angles with the plane of section. But the relative positions of the chief excavations are correctly shown. It will be seen that they show a gradual dip or pitch of the ore-formation to the westward at an angle of 68° to 70°, the underlie being about 250 feet in 800.

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## PRODUCTION OF THE MINE.

The records, if any exist, of the earliest workings of the mine before its incorporation, are very imperfect. It is therefore difficult to ascertain with precision the aggregate production. Much ore is known to have been taken out and sold before the incorporation of the Silver King Company. It is believed that the value of the ores so sold is not less than $1,000,000.

The production since the incorporation up to the end of 1881 (Jan. 1, 1882), was $1,973,458.68 gross, in value. It was estimated by the General Manager that 19,200 tons had been reduced and concentrated up to the 31st of December, 1879. The sale of ore for the same period amounted to $819,141.58.

The exceptionally rich character of the Silver King ore is best shown by the records of the shipments and sales, and by the assays of average samples. It varies of course in different parts of the mine. Some of the levels yield richer ore than others, as for example the III. and the IV., where an unusual amount of rich sulphide of silver was found. Before the construction of the railway from San Francisco to Arizona, at Fort Yuma, access to the mine and transportation to and from it were not only tedious but very expensive. The development of the mine was therefore not only retarded but it was impracticable to work ores of a grade that ordinarily would pay a handsome profit. During that period of isolation and inaccessibility the shipments were of necessity restricted to hand-sorted ore of high value, carefully selected, and averaging $1000 per ton, being such ores as would bear the great cost of extraction and transportation. All these extraordinary expenses have been gradually reduced, and since the completion of the railway through the Territory it has become practicable to ship ores of ordinary average grade with advantage. Much of the lower grade ore, which for a time was laid aside, has since been sorted over and concentrated.

It is now found most profitable to crush and concentrate the ore and to ship the concentrates for sale to reduction works. Considerable quantities have been sent to the Castle Dome Mining and Smelting Company, at Melrose, California, to the Selby Works, and to the Omaha Smelting Works.

The mill of the company is at Pinal, five miles from the mine, and twenty stamps are kept constantly running. The amount crushed per day ranges from 50 to 57 tons. In the month of November last 1532



tons were crushed, being an average of a little over 51 tons a day. The stamped ore, wet, flows to eight Frue concentrators which are made to "handle" the entire product. For the same month of November the total product of concentrates was 78.944 tons, being 5.2 per cent. of the amount of ore stamped; the tailings, by difference, amounting to tons 1453.056, or 94.8 per cent. These tailings contained, by assay, $4.95 per ton in value of silver, and the concentrates,

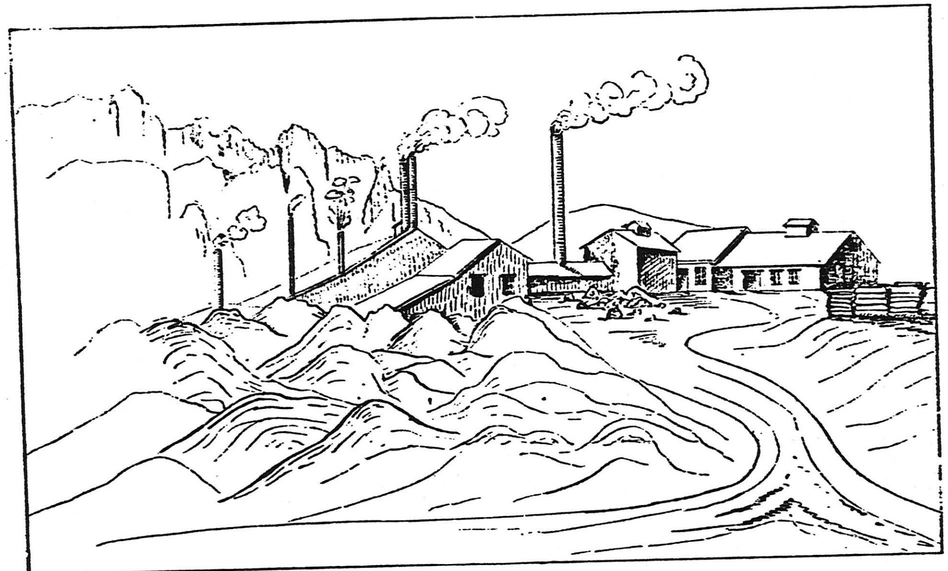

FIG. 13.—Outline View of the Mill at Pinal. Piles of Tailings in front.

by assay, contained $1094.15 in value per ton in silver, being a total value of $86,377.01, which deducted from the gross valuation, by assay, of $93,574.56, shows a loss of $7197.55 in value, or 7.69 per cent.

The battery samples for the period averaged $61.08 in value.

There is unusual difficulty in the way of obtaining closely correct samples of the concentrates owing to the amount of native silver they contain. Samples taken from the same lot, and in the same way, will often give very different results. Great care has to be exercised to take every particle of the bottom layer of dust next to the rubber cloth upon which the powder is mixed.

These concentrates are dried and sacked for shipment in strong canvas sacks. The average content in lead as determined from many shipments is 21½ per cent. and of zinc 18 per cent. The chief value is in the native silver disseminated in the stamped mass in the form of irregularly shaped scale-like fragments.

At the time of my first visit to the mine, in the spring of the year 1880, desiring to check the statements of the value of the ore-bearing rock by assays entirely under my own control, I took four samples, as follows:

I. On 356 foot level. Along drift for 10 feet, corresponding to the part sent to mill.

II. On 356 foot level. Face of drift for 10 feet.

III. On 304 foot level. Quartz and "Horse-flesh" copper ore with some "yellow copper."

IV. On 256 foot level (second). Large pieces of quartz, with some grey copper and yellow copper.

I took these samples to Messrs. Huhn & Luckhardt, of San Francisco, for careful assay and received the following returns, as per the original certificate, a copy of which is subjoined:



## RESULTS OF ASSAYS.

San Francisco, May 15, 1880.

Sample No. 9876—Marked "No. I." Silver King. One parcel of ore. The whole was crushed and pulverized, and an average sample proved to contain — Gold, none; Silver, 114.23 ounces=$147.69 per ton (2000 lbs.).

Sample No. 9877—Marked "No. II." Silver King. Small sack of ore. The whole was crushed and pulverized, and an average sample proved to contain — Gold, none; Silver, 243.05 ounces=$314.24 per ton (2000 lbs.).

Sample No. 9878—Marked "No. III." Silver King. Small sack of ore. After being crushed and pulverized, an average sample proved to contain—Gold, none; Silver, 77.99 ounces=$102.13 per ton (2000 lbs.).

Sample No. 9879—Marked "No. IV." Silver King. Small sack of ore. The whole was crushed and pulverized, and an average sample proved to contain—Gold, none; Silver, 14.58 ounces=$18.85 per ton (2000 lbs.).

The seventh level yields beautiful masses of native silver, associated with stromeyerite and blende. Specimens have been sent forward since my last visit in December, and are equal to any seen in the upper levels. The area of the excavation has been extended, and full details are given in the Annual Report of the Superintendent, dated January 1, 1883.

Since then some important additions have been made to the facilities for crushing and delivering ore to the mill, and to the plant for concentrating.

A large crushing mill has been erected at the mine, where the ore is passed through a large-sized Blake rock breaker, and is stored in bins with chutes and gates, so that it is loaded direct into the wagons to be taken to the mill at Pinal.

The batteries have been changed so as to deliver from both sides, and four additional Frue tables will be set up. It is expected that with these improvements the daily product can be increased to seventy-five tons of concentrates.

The outline sketch of the surface work at the mine represents the new building for the crusher approximately, as when the sketch was made the foundations only had been laid.

WILLIAM P. BLAKE.

MILL ROCK, NEW HAVEN, CONN.,
March, 1883.

ARIZONA DEPT. OF MINES & MINERAL RES
STATE OFFICE BUILDING
416 W. CONGRESS, ROOM 161
TUCSON, ARIZONA 85701

Silver King Mine

From

U.S.G.S. Bulletin 540

Copper Deposits Near Superior, Arizona

by

F. L. Ransome

## The Silver King Ore Body

The mine is filled with water and therefore could not be examined. Blake's article already referred to contains the only original description of the ore body, although Ransome[1], who visited the mine in 1912, has given a con-

1. Ransome, F.L. - Copper Deposits Near Superior, Arizona U.S.Geol. Survey Bull. 540 pp. 139-158, 1914.

cise summary of this description in addition to some material collected by himself during his visit. The following is from Ransome's article:

The ore body formerly cropped out at the top of a little hill about 75 feet high, composed of much-altered yellowish-brown to greenish-gray porphyry. Stoping was carried to the surface and a crater-like pit from 100 to 125 feet in diameter marks the site of the former outcrop. Here and there in the porphyry walls of the pit may be found small veinlets of rock, partly oxidized silver ore, but, so far as can be seen from the surface, the ore body was not determined by the inter-section of two or more persistent fissures. It apparently was a compact plexus of veinlets in-closed in comparatively unfissured porphyry. Blake's description and the maps of underground workings show that the ore body was a stockwork about 130 feet in maximum diameter, with a general dip of 70°W. The stockwork was disposed about an irregular core or axis of milk-white quartz, containing some bunches of rich ore but as a whole comparatively barren. This material is abundant and conspicuous in the mine dump and evidently constituted at times the bulk of the waste.

The following description is from Blake's original article:

The portion removed from the open pit consisted largely of rock, the porphyry, so-called, penetrated and seamed with interlacing veinlets of quartz, reticulating and crossing in every direction. These veinlets varied from the thickness of a sheet of paper to one quarter of an inch or an inch in thickness, and were generally accompanied with ore in a medial position, having quartz on each side of it next to the rock. The same conditions may be seen in the lower levels at the present time. In addition to these veinlets, there are masses and bunches of ore, and apparently (at least in the upper levels) a central mass of quartz, a large and compact body, toward which the system of veinlets converged, or from which they may be said to radiate. This mass of quartz, of irregular dimensions, still exists in the region opened by the lowest levels of the mine, but it has not yet been thoroughly explored. This quartz appears to hold some direct relation to the deposition of the ore: the heavier bodies of ore, so far, having been cut below, or on the foot-wall side of the quartz body. It may be regarded as holding the relation of the chief veinstone to the ore, and as presenting within itself, and together with the branching veinlets, the characters of a true fissure-filling, although it has not the usual sheet-like or tabular form. It is, instead, a columnar or chimney-like mass, some eighty feet in diameter in places, but irregular and without longitudal extension. In other words, this quartz-vein, instead of having a width much greater than its breadth, is approximately cylindrical or columnar in its form, filling a nearly vertical, spirally-formed cavity.

If we examine the structure of the veinlets in detail, we find them presenting the characteristics of fissure-veins. They extend for long distances through the rocks, and with parallel walls. They have regular veinstone and vein structure. The quartz forms on the opposite walls of the fissures in regular sheets, with "combs" or quartz crystals pointing inward and holding the ore in bunches and sheets. Such inclusions of ore are still to be seen in the small veins at the summit of the croppings and in the levels below.

The ore occurs also in bunches in the rock with but little veinstone. A tendency to triangular forms is observable, and in several places I have noted veins joining together nearly at right angles.

It will be inferred from the preceding descriptions that the richest and most import nt accumulations of ore are not found in the main body of the quartz veinstone. Although the massive quartz does hold bunches of rich ore, it is not, as a rule, so rich and profitable to work as the rock adjoining it. The ore is more abundant in connection with the small branching veins in the outside rock than in the mass of the quartz itself. It must, however, be stated that the quartz body has not yet been fully explored, being merely cross-cut in the upper levels. It is my opinion, howev r, based upon what has already been shown, that, contrary to the usual conditions in mines, the chief body of quartz veinstone does not carry the best part of the ore. It appears rather to have been the main channel of the mineralization: the main artery or feeder to the thousands of veinlets branching from it into the wall-rock following

Silver King Mine

From

Geology of the Silver King Area

Thesis

by

Frederic W. Galbraith

Economic Geology

Discovery of the Silver King Mine

There are three published accounts[1,2,3] of the discovery

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1. Raymond, R.W. - Eighth An. Rept. of the Mineral Resources West of the Rocky Mtns. 1876.
2. Blake, W.P. - The Silver King Mine of Arizona. Tuttle, Morehouse, and Taylor. Printer, New Haven, 1883.
3. Clark, Chas.M.- The Discovery of the Silver King Mine.

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of the Silver King mine all of which are in essential aggreement. As territorial geologist Blake examined the property at various times, and as he is known to have been an accurate and keen observer, the following story is based upon his published material.

In the middle of the 19th Century, while the settlements along the Gila River were slowly growing and spreading, the mountainous areas, now included largely in Pinal and Gila counties, were still in the possession of the Apaches. These marauding savages dominated the whole region, and made it almost inaccessible to the prospectors who began to press outward from the frontier settlements on the Gila River toward its source in the mountains. The country is rugged, the flanks of the Pinal mountains having been cut into innumerable small ridges and spurs by the intermittent streams flowing south and west into the low lying Sonoran Desert. One of the trails most frequented by the Apaches led up over the steep limestone cliffs about two miles north of the present town of Superior.

In 1873, when General George Stoneman, later to become Governor of California, was commander of the military department of Arizona Territory, it became necessary to expend every possible effort in an attemp to stop Apache raids. To this end, he established a camp at the base of the mountains close to the Apache trail and began the construction of a road known as the Stoneman Grade up the face of the cliffs, which became the main route of travel between the Globe mining districts and the valleys of the Salt and Gila Rivers.

A soldier by the name of Sullivan, engaged in the construction of the Grade, was attracted by some heavy, black lumps of metallic material, which flattened instead of breaking up when pounded on the rocks. He gathered a few specimens, but said nothing of his find. When his term of service expired soon afterward, he made his way to the ranch of Charles G. Mason near the present city of Phoenix, where he frequently showed the black ore, since known as nugget silver, but without revealing where he had found it. Sullivan suddenly disappeared, and it was supposed that he had been killed by Apaches while trying to return to the place where he had discovered the rich silver ore.

In 1874, Mason and some of his fellow ranchers began to organize preospecting trips to locate Sullivan's find. The first discovery of importance was the Silver Queen, now known as the Magma mine, and soon afterwards the Globe mine was located to the east which gave its name to the Globe

Mining District.

In 1875, a party consisting of Mason, Benjamin W. Reagan, William H. Long, and Issac Copeland, returning from the Globe district with a pack train of samples for assay camped just off the road at the base of the Stoneman Grade where more of the black nuggets were found. This float was followed up the slope of a small conical hill nearby to the outcrop of the ore at the top. On March 22, 1875 the initial location was made, duly recorded, and the Pioneer Mining District laid out. Assays by Tom Price of San Francisco established the value of the ore, and active mining began.

## Development and Production

The development and production of the Silver King mine has been admirably treated by Tenney.[1] The following account is a condensation of his material.

1. Tenney, J.B. - Unpublished manuscript.

In his report on the mineral resources of the Rocky mountains, Raymond states that by the end of 1875 the shaft was down 42 feet and a 12 foot drift had been driven from the bottom. The shaft started in ore and was sunk along a network of stringers ranging from 3 to 18 inches wide in "granite." The gangue material in the stringers was quartz and the ore minerals were cerargyrite(the chloride of silver), argentite, and native silver. This ore when sorted ran $20000.00 a ton. A small furnace of the cupel type was erected at Florence by Cury and Hughes to treat the ore. Pig lead for collecting the silver was obtained from the Mowry mine in the Patagonia mountains, which lie 150 miles to the south near the International Boundary between Arizona and Mexico. Five hundred pounds of selected ore obtained from the first 14 feet of the shaft yielded over 5 dollars a pound. The total production from the shaft and drift was estimated at $50,000.00 /10,000/

When the news of the discovery reached San Francisco, mining experts representing the Comstock interests were sent to negotiate the purchase of the property, and in 1876 the mine was sold to a corporation known as the Silver King Mining Co. Further development was begun and a small stamp mill and amalgamation plant was erected five miles from the mine at Pinal, on Queen Creek. Most of the ore was shipped without milling, only the lower grade ore being treated.

In 1879, Arthur Macy, E.M., was appointed superintendent. Due to the exhaustion of the free milling ore it became necessary to change the method of treatment, which was done in 1882. The ore was crushed at the mine in a Blake crusher and sent to the concentrator at Pinal. There it was further crushed by a battery of 20 stamps and concentrated over 12 Frue Vanners. The concentrates were sent to the Dome Mining and Smelting Company, Melrose, Calif., the Selby Works at San Francisco, and the Omaha Smelting Works. In 1883 the mill treated from 50 to 57 tons a day with a concentration ratio of about 20 to 1. The average grade of the heads was

$61.08 in silver, and the reported extraction was 92.31 per cent. In addition to silver the concentrates assayed 21½ per cent lead and 18 per cent zinc.

Active prospecting of adjoining ground closely followed the success of the Silver King mine. In 1883 fourteen groups were being actively worked and three mills had been erected, the largest being the amalgamation plant of the Windsor Consolidated Company. In 1884 this mill was leased by the Silver King Company to treat a part of the ore not amenable to concentration. The mine was developed to a depth of over 800 feet and most of the ore was being obtained from the 700 and 800 foot levels. The grade had fallen to $43.00 for concentrating ore and $46.40 for that treated by amalgamation.

The last year of profitable operation was 1887. The grade of the ore had fallen to 21.08 ounces per ton for the concentrated ore and 32,47 ounces for the ore amalgamated. Lixivation was tried on some ore high in copper from the 800 foot level, and some old tailings were reconcentrated. The costs reported by the superintendent for 1887 were as follows:

| | |
|---|---|
| Mining------------------------ | $10.97 per ton |
| Milling and Roasting---------- | 9.69 " " |
| Total--------------- | $20.66 per ton |

During the first half of 1888 the company operated at a loss and the president, Mr. H.H. Noble, reported a debt of $75,000. An assessment was levied, and a drastic reduction was made in operating costs which were lowered from $40,000 to $5,000 a month. By December the indebtedness had been paid and the company had a balance of $74,000 in the treasury and sufficient ore in sight to run to January 1,1889.

Prospecting in 1889 and 1890 failed to find commercial ore, and the mine was closed in January 1891. It was reopened in September of the same year after 44,000 delinquent shares had been called in. In October a strike was made in a new shaft to the east of the old workings. This ore was developed in 1892 but the company was again in debt. Ten stamps were moved from Pinal to the mine and a small production of concentrates was made during the remainder of the year. With the decline of the price of silver in the early part of 1893 the mine was again closed.

The property was reopened by the superintendent, Mr. W.S. Champion, in the fall of 1895, work being confined to the new shaft. He reported finding a pocket of ore worth $40,000 at a depth of 75 feet. The mine was again closed in 1896.

From 1876 to 1896 the company declared dividends of $1,950,000., the last dividend being paid in 1887. A total of $300,000 in assessments was levied from 1888 to 1895, making the net operation profit $1,650,000. The dividends were paid on 100,000 issued shares and the assessments were collected on 56,000 shares.

In 1916, after the successful exploitation of the neighboring Silver Queen mine by the Magma Copper Company, the property was acquired by the Silver King of Arizona Mining Company, a Delaware corporation, with A.W.Hildebrand of

New York as president, and John Fowler as manager. In 1917 the old main shaft, 987 feet deep, was unwatered and repaired. Small high grade ore bodies overlooked by the former operators were mined on the 120 foot level. A small flotation mill was completed in 1918 to treat this ore and low grade dump material. About 35 tons a day were treated with a reported extraction of 90 per cent. A small vein on the 400 foot level yielded some rich ore that was shipped to the smelter, and shipments of concentrates continued intermittently to July, 1919. At that time the management claimed to have 10,000 tons of ore developed averaging over $20,000 per ton.

In July 1919 a new shaft, financed by a $500,000 bond issue, was started 150 feet northwest of the ore chimney. The old shaft was kept unwatered and ore from the 120 and 400 foot levels was treated at the mill. In October a cross-cut from the old shaft on the 400 foot level connected with the 415 foot levels of the new shaft.

In January of 1920 a reorganization was effected whereby the capitalization was reduced to allow for further financing. Shaft sinking continued until June, 1920, when a depth of 635 feet was reached. A cross-cut on the 615 foot level extended to the old workings. The company went into bankruptcy shortly afterwards and a reorganization as the Silver King Mine Incorporated was effected but no further work was done. The total ore treated from 1916 to 1920 amounted to 12,546 tons averaging approximately $20.00 a

18 $/ton

ton in silver. The concentrates contained from 1000 to 1980 ounces of silver, 20 per cent lead and from 7 to 8 per cent copper.

The Silk shaft apparently sunk in the early days of the camp, is located 450 feet to the northwest of the new Silver King shaft, and is reported to be over 1000 feet deep. The writer has heard numerous stories about this shaft from old timers in the district but as no authentic account of the operation has been located, it seems inadvisable to include the unverified material here.

At the present time the Silver King property is owned by Mr. Bat Gays, of Superior, Arizona, who has carried on a little prospecting to the east of the old workings.

Production of the Silver King

(Figures compiled by J.B.Tenney)

| Year | Price | Ounces of Silver | Gross Value |
|---|---|---|---|
| 1875 | 1.24 | 40,323 | $ 50,000 |
| 1877-79 | 1.16 | 706,157 | 819,142 |
| 1880 | 1.15 | 439,689 | 505,642 |
| 1881 | 1.13 | 574,049 | 648,675 |
| 1882 | 1.14 | 714,912 | 815,000 |
| 1883 | 1.11 | 533,787 | 592,503 |
| 1884 | 1.11 | 429,559 | 476,811 |
| 1885 | 1.07 | 764,832 | 818,370 |
| 1886 | .99 | 656,566 | 650,000 |
| 1887 | .98 | 709,134 | 694,951 |
| 1888 | .94 | 319,149 | 300,000 |
| 1889 | 1.00 | 55,000 | 55,000 |
| Total 1875-1889 | | 5,943,157 | $ 6,526,094 |
| 1918 | 1.00 | 37,000 | 37,000 |
| 1919 | 1.12 | 126,892 | 142,119 |
| 1920 | 1.09 | 65,872 | 71,800 |
| 1928 | .58 | 3,000 | 1,755 |
| TOtal 1918-1928 | | 232,764 | $ 252,674 |
| Grand Total | | 6,175,921 | $ 6,778,768 |

Silver King
Pinal Co.

# REPORT

—OF THE—

# SILVER KING MINING CO.,

JANUARY 1, 1881.

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SAN FRANCISCO:
A. L. BANCROFT & COMPANY,
721 Market Street,
1881.

ARIZONA DEPT. OF MINES & MINERAL RESOURCES
STATE OFFICE BUILDING
416 W. CONGRESS, ROOM 161
TUCSON, ARIZONA 85701

ARIZONA DEPT. OF MINES & MINERAL RESOURCES
STATE OFFICE BUILDING
416 W. CONGRESS, ROOM 161
TUCSON, ARIZONA 85701

# Silver King Mining Company.

Location:

Pioneer District, Pinal County,

Arizona Territory.

Principal Office:

Safe Deposit Building, 328 Montgomery St.,

San Francisco, California.

Capital Stock, - - - - - $10,000,000

divided into

100,000 Shares of $100 each.

## Directors.

JAMES M. BARNEY, B. A. BARNEY,
WILLIAM H. STANLEY, GEO. L. WOODS,
J. L. JONES.

## Officers.

GEO. L. WOODS, - - - - - - - *President.*
B. A. BARNEY, - - - - - - - *Vice-President.*
JAMES M. BARNEY, - - - - - *Treasurer.*
AARON MASON, - - - - - - *Superintendent.*
JOSEPH NASH, - - - - - - *Secretary.*
JAMES M. BARNEY, *General Manager.*

# PRESIDENT'S REPORT.

OFFICE OF THE SILVER KING MINING CO.,
328 MONTGOMERY STREET,
SAN FRANCISCO, CAL., January 11, 1881.

*To the Stockholders of the*
*Silver King Mining Co.*

GENTLEMEN: In compliance with a duty imposed upon me as President of the Board of Directors of the Silver King Mining Company, I submit to you my annual report.

The management of the business affairs of the Company during the past year has been most successful in every way, and can but prove highly satisfactory to the stockholders.

The ore yield, considering the circumstances, has been very large; and the developments and explorations only confirm that which was before apparent, that the mine is permanent, and that the ore is of exceeding richness. No mine on the continent makes a finer showing, or has a more promising future, than the Silver King.

In my last annual report I mentioned that the mill and machinery, then in operation, were inadequate, and that it was deemed advisable by the Board to add thereto a ten-stamp mill, and a requisite number of Frue concentrators, in order to work the mine to better advantage, and on a scale commensurate with its importance.

Such additions were made, and the machinery is now, and for some time past has been, in operation, producing splendid results.

The payment of a monthly dividend has been resumed, and it is believed will be paid uninterruptedly for years to come.

The condition of the Company is excellent, it could not be better. One thing only has occurred to mar a record which would otherwise be perfect.

It becomes my duty to report to you, that during the incumbency of E. B. Booth as Secretary of your Company, an unauthorized over-issue of stock was made by him, amounting in the aggregate to four hundred and fifty shares, and delivered by him to William H. Boothe at his request, under the promise, as he has informed the Board of Directors, that the original shares, in lieu of which these four hundred and fifty shares were issued, should be delivered up to him for cancellation, but which were never so delivered up nor canceled; all of which stock, the Board of Directors have been informed and believe, was sold and delivered into the hands of innocent third parties before such over-issue was discovered.

Confidential relations must necessarily exist between persons associated together in business with mutual interests. The President had unlimited confidence in



the Secretary. Transfers of stock, in a company like yours, must be, and necessarily are, rapid and continuous. It is practically impossible for the President to be *always* present and personally supervise the issuance and cancellation of each and every certificate of stock which may change hands in the course of trade; hence at times it has been expedient for the President to sign certificates in blank, relying upon the integrity and faithfulness of the Secretary to discharge his duties aright. It was so in the instance in question.

Immediately after making the discovery of this over-issue, the Board of Directors, at a meeting called for the purpose, authorized Col. James M. Barney, the General Manager of the Company, to purchase, at the lowest market value, four hundred and fifty shares of stock, an amount equal to the over-issue, for cancellation, which purchase was made, and the stock canceled. The like will not occur again.

For a more detailed statement of the business affairs of the Company, I refer you to the reports of the General Manager, Superintendent, and Secretary, copies of which are herewith transmitted for your inspection.

Respectfully,

GEO. L. WOODS,

President.

# GENERAL MANAGER'S REPORT.

SAN FRANCISCO, CAL.,
January 11, 1881.

*Messrs. The Directors and Stockholders of the Silver King Mining Co., 328 Montgomery Street, San Francisco, Cal.*

GENTLEMEN: I submit this, my report as General Manager of your Company for the year 1880.

At your last annual meeting an increase of the reduction works was decided upon, and it has been done.

We now have a twenty (20) stamp mill, six (6) Frue concentrators, two (2) large engines and boilers, and new pumps; also, three (3) roasters, new dryer, pulverizer, furnace, and a full line of tanks, etc., for lixiviating. The second and third roasters are now being put in place.

At the mine new hoisting works of the best quality have been erected.

From mine to mill (five miles) a telegraph line has been built, and telephonic communication established.

The late heavy rains have somewhat delayed the setting up of the last lot of machinery, but all will be in place and under cover by March 1, 1881, and perhaps



sooner. We shall then turn out a good lot of bullion, which hereafter will be the principal product of the newly adopted mode of reduction. On thorough examination and careful tests we found the ore in the 110, 252 and 304-foot levels would not concentrate satisfactorily, and we prepared to work it by lixiviation, as after exhaustive experiments we found that to be the proper method. While putting in the necessary machinery, the Superintendent opened the 356-foot level, which, like the ore in the old works, would concentrate, and for several months past we have been reducing the ore by both methods, successfully. The 408-foot level, opened in December, 1880, and which is to date the deepest one in the mine, so far as opened, shows a small percentage of concentrating ore, but all of excellent quality for lixiviating, so the impression is strengthened that we may soon lay aside the concentrators and reduce entirely by leaching.

Ottokar Hofmann gives you an exhaustive report on this subject, to which you are referred, and which is most interesting to us all.

The cost of all the improvements at mine and mill has been large, but they are well worth it, and are a good investment, as the result shows.

The present condition of the mine and mill, and in fact of everything pertaining to the affairs of the Company, are No. 1, and it is hard to see how they could be bettered.

Several lawsuits have been commenced against the Company during the year. Competent counsel is retained, and they will be properly defended. I do not

The style of timbering adopted is the same as that used in the California and Consolidated Virginia, and is, I am thoroughly satisfied, by far the best.

In the three hundred and fifty-six (356) foot-level I found a very high grade ore, which has been opened out to an extent of 84x56 feet. This ore I have been working at the Company's mill since June last. While opening out this, I came upon a body of ore which could not be worked on the concentrators; accordingly, after consulting with Col. James M. Barney, General Manager, and by and with his advice and approval, I placed in the mill one roaster, with tanks, vats, and all the appurtenances needful for lixiviating. The process having now been fairly tested, and having proved entirely satisfactory, I have ordered two more roasters, with boiler and engine complete; these I expect to have in operation in sixty (60) days. A description of the process, and of the machinery used, made by Mr. O. Hofmann, who is employed by the Company to work the ore, accompanies this report.

There is now upon the ore dump, which I have recently had constructed at the mine, two thousand (2000) tons of ore, which will average about two hundred (200) dollars per ton. This ore can be satisfactorily worked by the lixiviating process, but not upon the concentrators.

The four hundred and eight (408) foot level is now forty-two (42) feet in ore showing about the same characteristics as that in the level above, excepting that there is less concentrating ore, more heavy spar, and an increase in native silver.



The ore worked by lixiviation has averaged two hundred and eight (208) dollars per ton, that by concentrators one hundred and fifty (150) dollars per ton. The latter, up to the month of June, was taken from the old workings, which have been temporarily abandoned.

Within the last year, in addition to the machinery for the lixiviating process, I have added to the mill ten (10) more stamps, two (2) concentrating tables, an assay and smelting office, and storehouse. A suitable building for the Company's office, with a large safe for books, papers, and bullion, has also been secured.

Within the same period, the price paid for hauling ore from mine to mill has been reduced from two dollars and fifty cents ($2.50) to two dollars and twenty-five cents ($2.25) per ton. This contract expires on April 1, 1881.

Wood at the mine costs ten (10) dollars per cord, most of it being hauled eighteeen (18) miles; that for the mill is brought twelve (12) miles, and the price paid is from six (6) to seven (7) dollars per cord.

The wages of men, both at mine and mill, remain the same as last year.

I have paid up all the indebtedness of mine and mill to date, except the income tax, which is not due until February 1, 1881, so that on this, the first day of the new year, the Company can announce itself free from all liabilities in the Territory.

Permit me, in closing this report, to extend my hearty thanks to the General Manager, Directors, and

Secretary, for the many kindnesses extended to me during the past year.

I remain, gentlemen,

Very respectfully,

AARON MASON.

# METALLURGIST'S REPORT.

ASSAY OFFICE, SILVER KING MINING CO.,
PINAL, ARIZONA TERRITORY,
January 1, 1881.

*Aaron Mason, Esq., Superintendent of the Silver King Mining Co.*

DEAR SIR: I take pleasure in submitting to you the following report, regarding the reduction of the Silver King ore by the lixiviation process at the Company's mill.

THE ORE

Which is subjected to the lixiviation process is very base, and consists of the following silver-bearing minerals:

1. *Native Silver*, in close contact with Fahlore, Zincblende, and in some instances with Galena. It is brittle enough to be pulverized in the battery; is of a bright white color and 975 thousandths fine, the impurity being copper; contains no gold.

2. *Silver Copper Glance*, with 70.3 per cent., or 20457.3 ounces per ton, silver; 9.8 per cent. copper; 17.4 per cent. sulphur.

3. *Antimonious Fahlore*, containing over 3000

ounces of silver per ton. This mineral is the most important constituent part of the ore.

4. *Zincblende.*

(*a*) *Zincblende,* found in large and perfect, transparent crystals of a lustrous green color. This is the poorest of the silver-bearing minerals of the Silver King, but is highly interesting from its beauty as a specimen. It contains only 10.2 ounces of silver per ton.

(*b*) *Brown Zincblende* occurs more in solid masses and in large quantities, frequently intersected with wire silver, and contains 97.7 ounces of silver per ton.

(*c*) *Black Zincblende* is more scarce, and contains 40.8 ounces of silver per ton.

5. *Peacock Copper Ore,* with 450.62 ounces of silver per ton.

6. *Galena,* containing antimony, and with from 29 to 185 ounces of silver per ton.

7. *Copper Pyrites.*

8. *Iron Pyrites.*

The gangue consists of Quartz, Heavy-spar, and some Porphyry.

The average value of the ore, as it was delivered from the mine to the mill during November and December, proved to be two hundred and eight dollars and twenty-six cents ($208.26) per ton. This I ascertained by daily samples and assays.

THE WORKING OF THE ORE.

*Roasting.*—The ore is crushed wet, dried on a kiln, mixed with ten (10) per cent. of salt, and charged into



a large revolving furnace, lined on the inside with bricks; the furnace is sixteen (16) feet long and five (5) feet ten (10) inches in diameter, inside the lining; there are four (4) doors for charging and discharging, and a fire-place on each end of the cylinder. This latter arrangement differs from the common construction of these furnaces, which are provided with only one fire-place; but I found it necessary to attach a second fire-place, in order to obtain a uniform roasting. On account of the heavy-spar, fahlore, and galena, the ore cakes very easily, and in order to avoid this, and a loss of silver, the ore has to be roasted at a very moderate heat; but this would be impossible to do with only one fire-place, as the ore would either not have heat enough at the farther end from, or too much at the nearer end to, the fire.

After the charge of ore is in, the furnace is set in slow-revolving motion, and fire kept in one of the fire-places, the flame traversing the furnace, and smoke and gases escaping through the opposite fire-place and flue into the dust chamber. After a lapse of one hour, fire is made in the other fire-place, the dampers reversed, and flame and gases allowed to pass through the furnace in the opposite direction. This changing of the fire is kept up at hourly intervals, till the charge is roasted.

This system of fire-places and flues proved to be of great advantage, by obtaining a very uniform roasting, the ore from both ends being chloridized up to the same percentage, while in the old construction the ore from the further end shows from five (5) to ten (10) per cent. less chlorination.

Glancing over the above list of minerals, of which the Silver King ore is composed, the base and rebellious nature of the ore is apparent. The worst feature of the ore is the simultaneous presence of antimonious fahlore and zincblende, by which great chemical loss of silver is caused in roasting. There are cases in which the loss in roasting has been as high as fifty (50) per cent. By actual experiment with the furnace, I found the loss in roasting Silver King ore to be thirty-eight (38) per cent., if the same is subjected to the common way of roasting; but I succeeded, by applying steam during the time while chemical action takes place, in reducing the loss to a minimum, and not exceeding two (2) per cent. The use of steam in roasting had been recommended by Mr. Pattera, of Joachimsthal, Bohemia, and its beneficial and powerful effect I demonstrated with Silver King ore, to the advantage of the Company. I do not hesitate to assert, that without the application of steam, the Company's ore could not be treated successfully, as the loss in roasting would be enormous. It is true, the use of steam costs more fuel and a delay in roasting, but the advantage gained is so great, that these questions can not be taken into consideration.

The furnace is charged with about three and a half ($3\frac{1}{2}$) tons, and the time required for roasting is from twelve (12) to fifteen (15) hours, according to ore and fuel. This long time is caused by the low heat at



which the ore has to be roasted, and the large amount of zincblende contained in the ore.

The average chlorination of the ore, as ascertained by assay of sixty-seven (67) furnace charges, proved to be 94.4 per cent., while in some cases it came as high as 96.8 per cent.

### LIXIVIATION.

After the ore is discharged from the furnace, it is moistened with water, and elevated to a hopper, whence, by means of cars running on a track above the vats, it is charged into the lixiviating vats. There are five (5) of these vats, each ten (10) feet in diameter and three (3) feet deep, provided with a filter bottom, and an outlet under the same for the escape of the solution. As soon as one vat is charged with the proper amount of ore, a stream of water is allowed to enter on the top, which, in passing through the ore and escaping under the filter bottom, dissolves and carries off the base metal chlorides. After these are removed from the ore, a stream of hyposulphite of lime is applied, which dissolves the chloride of silver.

The solution containing the silver is now conveyed to the precipitation tanks, where it is precipitated with a solution of sulphide of calcium, which chemical is prepared on the premises, by boiling lime, sulphur, and water, and, besides the salt used in roasting, is the only chemical consumed in the process.

The silver, when precipitated, settles as a sulphide of silver on the bottom of the vats, the clear solution of hyposulphite of lime is drawn off by means of four (4) outlets, at different levels of the vat, and conveyed to a lower tank (pump-tank), whence it is pumped up to the reservoir and ready for re-use. This solvent is prepared only once, as the sulphide of calcium, by precipitating the silver, changes into the hyposulphite, or the chemical used as solvent for the chloride of silver. and if proper care is taken increases in strength and volume, which is actually the case at the Company's works, where we are obliged, from time to time, to let part of it flow into the waste, as it increases beyond our use.

When enough sulphide of silver has accumulated on the bottom of the precipitation vats, it is discharged through an outlet close to the bottom, and conveyed, by means of troughs, to a system of filters, and the solution strained from the silver. This, however, leaves the precipitate in too wet a condition to be convenient for the subsequent operation. The use of a press I had found by former experience impracticable. In order to overcome this drawback and save fuel, I planned a centrifugal filter, acting on the principle of the sugar centrifugal machines, by which the precipitate will be strained and dried in a very short time. This machine will soon be in operation.

The precipitate from the filters is charged into a small reverberatory furnace, to burn off the surplus sulphur. During the operation the precipitate diminishes a great deal in volume, and when finished is covered with wire of silver, moss-like, and contains eighty-three (83) per cent. bullion. The burned precipitate is charged into crucibles, melted with iron and borax, and poured into moulds. This finishes the manipulations.



The bullion is from eight hundred (800) to nine hundred (900) fine.

The average value of the tailings during November and December, or the time the lixiviation process has been in smooth working order, proved to be eleven dollars and seventy-nine cents ($11.79) per ton. This is the average of sixty-five (65) assays. In some instances, however, the tailings did not contain more than five dollars and sixty-five cents ($5.65) per ton.

The men employed at present are:

Three (3) Roasters at four dollars ($4).

Three (3) Helpers at three dollars and fifty cents ($3.50).

Two (2) Leachers at five dollars ($5).

Two (2) Helpers at three dollars and fifty cents ($3.50).

One (1) Assayer at five dollars ($5).

One (1) Helper at three dollars and fifty cents ($3.50).

One (1) man preparing the chemicals at three dollars and fifty cents ($3.50.)

The result of the lixiviation process having proved to be satisfactory, two more roasting furnaces are under way.

By using three furnaces the production of bullion will be trebled, while the expenditure in labor will be only slightly increased, as only a few more helpers will be required. The same roasters can attend to all three furnaces. The present vats are sufficient for the increased roasting capacity.

The three (3) roasting furnaces in operation, the precipitate will be melted in a German cupelling furnace, as crucible melting will be too expensive and slow for the quantity of silver precipitate. This furnace is under construction, and a Dodge's small pulverizer has been procured to pulverize the salt.

I remain, very respectfully,

Yours,

OTTOKAR HOFMANN,

Metallurgist and M. E.

# SECRETARY'S REPORT.

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SILVER KING MINING CO.,
ROOM 19, 328 MONTGOMERY STREET,
SAN FRANCISCO, January 11, 1881.

*To the President and Board of Directors of the Silver King Mining Co.*

GENTLEMEN: In compliance with the by-laws of your Company, I beg to present herewith the accompanying annual report for the year 1880.

Your obedient servant,

JOSEPH NASH,

Secretary.

ARIZONA DEPT. OF MINES & MINERAL RESOURCES
STATE OFFICE BUILDING
416 W. CONGRESS, ROOM 161
TUCSON, ARIZONA 85701

## STATEMENT OF THE ACCOUNTS OF THE SILVER KING MINING COMPANY,

### FOR THE YEAR ENDING DECEMBER 31, 1880.

### RECEIPTS.

| | |
|---|---|
| In Treasury, December 31, 1879 | $ 3,444 50 |
| Sales of Concentrations | 437,174 24 |
| Sales of Ores | 37,073 27 |
| Sales of Bullion | 31,394 20 |
| Rebates on Railroad Freight | 4,283 14 |
| Bills Payable | 73,517 33 |
| | $586,886 68 |

### EXPENSES.

| | |
|---|---|
| MINE ACCOUNT: Salaries and Wages | $ 84,962 60 |
| Supplies and Machinery | 28,727 93 |
| Portage | 25,194 50 |
| Freight per Rail: On Concentrations and Ore | 26,408 90 |
| On Supplies and Machinery | 22,244 34 |
| Freight per Wagon: On Machinery and Supplies to Oct. 1, 1880 | 5,806 79 |
| On Concentrations and Ore, to Oct. 1, 1880 | 3,658 69 |
| On Concentrations, Ore, Machinery, and Supplies, from Oct. 1 to Dec. 31, 1880 | 9,287 44 |
| Taxes | 1,648 85 |
| Real Estate | 4,750 00 |
| Team | 550 00 |
| Petty Expenses | 357 93 |
| MILL ACCOUNT: Machinery and Supplies | 62,906 55 |
| Salaries and Wages | 49,896 08 |
| Freight per Wagon on Machinery and Supplies | 5,008 23 |
| Taxes | 600 00 |
| Real Estate | 450 00 |
| Petty Expenses | 34 00 |
| Drayage, Sampling and Assaying | 3,725 66 |
| Expense—Salaries, fees, rent, stationery, printing, advertising, etc. | 8,371 79 |
| Law Expense | 1,500 00 |
| Insurance | 1,142 00 |
| Furniture | 480 00 |
| 450 Shares of Stock purchased | 4,521 90 |
| Dividends—Nos. 10 to 12 inclusive | 75,000 00 |
| In Treasury, December 31, 1880 | 159,652 50 |
| | $586,886 68 |

Silver King Mine

From

Arizona Bureau of Mines Bull. 156

on this level is weaker than on those above. The wall rocks are highly silicified, and the vein contains minor amounts of pyrite, chalcopyrite, and sphalerite. Mineralization is strongest where both walls are diabase. Westward the vein feathers out and becomes indefinite; at a point 900 feet west of the shaft it could not be located.

### Silver King Mine

*Operations and production:* The Silver King mine, about 2 miles north of Superior, was worked almost exclusively for silver, but its ores contained also important quantities of base metals which were not recovered. Under present-day metallurgy, those ores might have yielded substantial amounts of zinc, lead, and copper.

Production of the Silver King mine has been reported[16] as follows:

| Years | Ounces silver | Value |
|---|---|---|
| 1875-89 | 5,943,157 | $6,526,094 |
| 1918-28 | 232,764 | 252,674 |
| Total | 6,175,921 | $6,778,768 |

During 1876-96 the mine was operated by Silver King Mining Company which paid $1,950,000 in dividends to the end of 1887. Most of the ore was milled at Pinal, on Queen Creek at the base of Picket Post Mountain. In 1883 this mill treated about 50 tons per day, with a concentration ratio of nearly 2 to 1. The average grade of the heads was $61.08 in silver, and the reported extraction was 92.31 per cent. In addition to silver, the concentrates assayed 21.5 per cent lead and 18 per cent zinc.[17]

As stated by Ransome,[18]

> Some idea of the character of the ore during a rather late stage in the activity of the mine is obtainable from the company's report for 1887, wherein it is stated that Mill No. 1, employing wet crushing and concentration, treated 2,699 tons of ore with an average content of 21.08 ounces of silver to the ton. The product was 577.813 tons of first-class concentrates averaging 83.4135 ounces of silver to the ton and 31 per cent of lead. Of the total silver contents, 53.95 per cent was native silver. In addition the mill turned out 1,261 tons of second-class concentrates carrying 31.77 ounces of silver to the ton, chiefly combined in zinc blende and galena. Mill No. 2, in which chloridizing, roasting, and pan amalgamation were employed, treated 8,840 tons of first-class ore, 1,914 tons of second-class concentrates, and 3,875 tons of old tailings.

In 1916 the property was acquired by Silver King of Arizona Mining Company. The old shaft, 987 feet deep, was unwatered, and a new shaft was sunk to a depth of 615 feet. A small flotation mill treated 12,546 tons of ore and dump material during 1916-20. Its concentrates contained 1,000 to 1,980 ounces of silver per ton, 20 per cent lead, and 7 to 8 per cent copper. Subsequently

[16] Ariz. Bur. Mines Bull. 151, p. 144.
[17] Ariz. Bur. Mines Bull. 151, p. 142.
[18] F. L. Ransome, Copper deposits near Superior, Arizona: U.S. Geol. Survey Bull. 540, pp. 139-58 (1914).



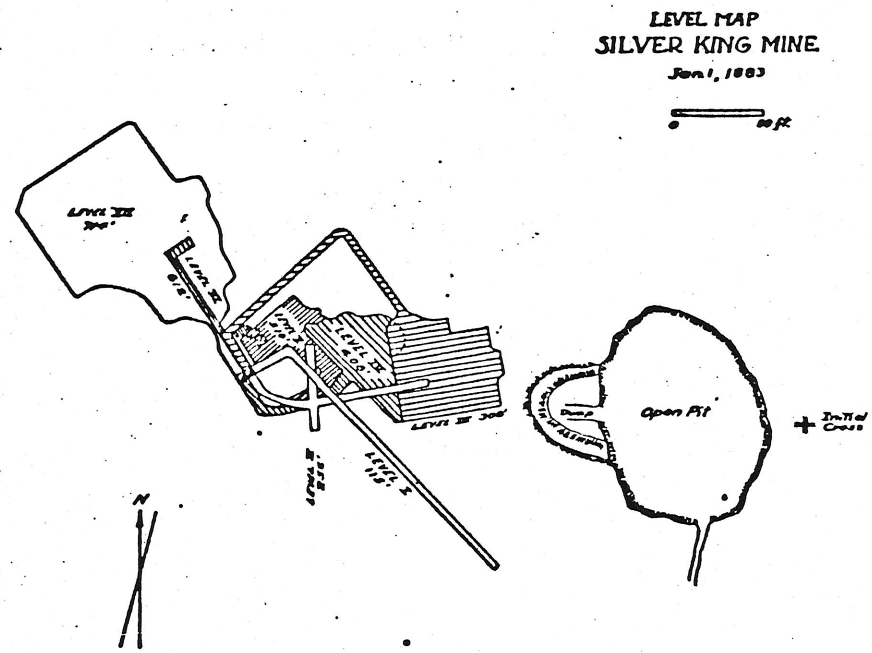



Figure 30.—Map of Silver King mine levels (after Blake).

the property was acquired by Bat Gays who has carried on small-scale operations. Several shipments have been made from the dumps. During 1945-46 some of the area was prospected by diamond drilling.

*Geology:* The Silver King porphyry, in which was developed the Silver King ore body, crops out as an irregular mass approximately 2,500 feet long from east to west by 1,200 feet wide. It was intruded into the southeastern part of a much larger stock of quartz diorite.

The pit marking the former outcrop of the ore body shows brecciated quartz and porphyry. Extending N. 60°-70° E. from the breccia mass is a steeply northwestward-dipping fissure which was mineralized for a few hundred feet along its strike. Evidence for other structural control of the breccia mass is not readily apparent; alluvium and mine dumps conceal most of the area north, south, and west of the pit, and the mine workings are not accessible.

*Ore body:* Blake published an original description of the Silver King ore body and a map (Fig. 30) of the workings as of 1883.[19] Ransome gave a summary of Blake's report together with data collected by himself.[20] Quoting from Ransome,

> The ore body formerly cropped out at the top of a little hill about 75 feet high, composed of much-altered yellowish-brown to greenish-

[19] W. P. Blake, The Silver King mine of Arizona. New Haven (1883).
[20] F. L. Ransome, work cited, pp. 156-8.

gray porphyry. Stoping was carried to the surface, and a craterlike pit from 100 to 125 feet in diameter marks the site of the former outcrop. Here and there in the porphyry walls of the pit may be found small veinlets of rich, partly oxidized silver ore, but so far as can be seen from the surface, the ore body was not part of a vein, and there is nothing to suggest that it was determined by the intersection of two or more persistent fissures. It apparently was a compact plexus of veinlets inclosed in comparatively unfissured porphyry.

Blake's description and the maps of underground workings show that the ore body was a stockwork about 130 feet in maximum diameter, with a general dip of 70° west. The stockwork was disposed about an irregular core or axis of milk-white quartz, containing some bunches of rich ore but as a whole comparatively barren. The ore consisted of altered porphyry traversed in all directions by innumerable veinlets carrying stromeyerite, tetrahedrite, galena, sphalerite, chalcopyrite, and pyrite in a gangue of quartz with some barite. Blake makes the interesting observation that stromeyerite and highly argentiferous tetrahedrite with more or less argentite were the most important constituents of the ore on the upper levels, whereas argentiferous sphalerite had become the principal ore mineral on the seventh level.

Other minerals listed by Blake were native silver, native copper, cuprite, oxidized lead minerals, bornite, calcite, and siderite.

The paragenesis of the minerals has been described in detail by Galbraith,[21] who noted that sphalerite was the most abundant sulfide mineral, and galena the next most abundant.

Ransome's[22] conclusion was:

> Various explanations are given locally for the failure of this interesting deposit below the 800-foot level, some stating that the ore body was faulted, some that the ore changed in character and grade. The latter is probably true. The worked-out part of the deposit appears to have been a striking example of deep downward enrichment. If so, the time may come when the old mine will be reopened and its low-grade ore utilized.

[21] Ariz. Bur. Mines Bull. 151, pp. 146-154, 2 pls.
[22] F. L. Ransome, work cited, p. 158.

## CHAPTER VIII.—LEAD AND ZINC DEPOSITS IN THE GLOBE-MIAMI DISTRICT, ARIZONA[1]

BY NELS P. PETERSON[2]

### INTRODUCTION

The Globe-Miami district is in the northern foothills of the Pinal Mountains about 90 miles by road east of Phoenix, Arizona. It is almost entirely within the Inspiration and Globe quadrangles as mapped by the U. S. Geological Survey in 1945. The topography of the district is fairly rugged, the altitude ranging from 3,400 feet at Miami to 5,060 feet on Needle Mountain near the southern edge of the Inspiration quadrangle.

[1] Published by permission of the Director, U. S. Geological Survey.
[2] Geologist, U. S. Geological Survey.



The columnar section of sedimentary and volcanic rocks in the district is illustrated in Figure 31. The oldest rock of the region is the Pinal schist, a complex of metamorphosed sedimentary rocks of early pre-Cambrian age. Also of pre-Cambrian age, but much younger than the Pinal schist and separated from it by a major unconformity, are rocks of the Apache group. All formations of the group are represented in the district, but in most places the Mescal limestone and much of the Dripping Spring quartzite were removed during the period of erosion preceding the deposition of the Troy quartzite of Cambrian age. Another period of intense erosion following the Cambrian period removed the Troy quartzite in most parts of the district and cut still deeper into the rocks of the underlying Apache group.

The Martin limestone of Devonian age rests either on Dripping Spring quartzite or on small remnants of Troy quartzite. The Mississippian Escabrosa limestone and Pennsylvanian Naco limestone overlie the Martin limestone with no apparent disconformity, although beds of upper Mississippian age are absent throughout the district.

There is no record of sedimentation between the Pennsylvanian epoch and the deposition of the Tertiary (?) Whitetail conglomerate, but widespread igneous intrusions occurred during this interval. A thick flow of dacite younger than the Whitetail conglomerate covered the entire region. In later Tertiary and Quaternary time the Gila conglomerate was deposited as great coalescing alluvial fans and stream deposits filling valleys and spreading more thinly over much of the higher parts of the region.

All the rocks of the district are cut by a complex pattern of faults which Ransome[3] aptly described as "regional brecciation." The deformation of the rocks by faulting appears to have been continuous from pre-Cambrian time until after deposition of the Gila conglomerate when many of the largest displacements of the rocks occurred.

Diabase magma in great volumes was intruded into the earlier rocks probably during Mesozoic time. The diabase forced its way between beds of sedimentary rock as sills and occupied many of the faults. Great blocks of strata, particularly those of pre-Cambrian and Cambrian age, were pushed apart and in places completely enveloped in diabase.

Several other intrusions of igneous rocks, ranging from granodiorite to quartz monzonite, took place probably during late Mesozoic and early Tertiary time. The latest of these is the mass of Schultze granite, which underlies the southern part of the district, and numerous smaller bodies of granite porphyry which may be offshoots of the main Schultze granite mass. The mineralization of the district is most nearly contemporaneous with the Schultze granite and the granite porphyry and is probably genetically related to them.

[3] Ransome, F. L., Geology of the Globe copper district, Arizona: U. S. Geol. Survey Prof. Paper 12, p. 99, 1903.

> imately cylindrical or columnar in its form, filling a nearly vertical, spirally-formed cavity.
>
> If we examine the structure of the veinlets in detail, we find them presenting the characteristics of fissure-veins. They extend for long distances through the rocks, and with parallel walls. They have regular veinstone and vein structure. The quartz forms on the opposite walls of the fissures in regular sheets, with "combs" or quartz crystals pointing inward and holding the ore in bunches and sheets. Such inclusions of ore are still to be seen in the small veins at the summit of the croppings and in the levels below.
>
> The ore occurs also in bunches in the rock with but little veinstone. A tendency to triangular forms is observable, and in several places I have noted veins joining together nearly at right angles.
>
> It will be inferred from the preceding descriptions that the richest and most important accumulations of ore are not found in the main body of the quartz veinstone. Although the massive quartz does hold bunches of rich ore, it is not, as a rule, so rich and profitable to work as the rock adjoining it. The ore is more abundant in connection with the small branching veins in the outside rock than in the mass of the quartz itself. It must, however, be stated that the quartz body has not yet been fully explored, being merely cross-cut in the upper levels. It is my opinion, however, based upon what has already been shown that, contrary to the usual conditions in the mines, the chief body of quartz veinstone does not carry the best part of the ore. It appears rather to have been the main channel of the mineralization: the main artery or feeder to the thousands of veinlets branching from it into the wall-rock following the clefts and penetrating the substances of the rock, depositing and diffusing native silver and the sulfides throughout the whole mass of rock for an indeterminate distance on each side.

Through the courtesy of Mr. Bat Gays, owner of the Silver King mine, level maps made by Mr. Starbird, resident engineer for the Silver King of Arizona Mining Company, were examined by the writers. These maps show the stoped area of the ore body to have the following dimensions:

| Level | North-South (ft.) | East-West (ft.) |
|---|---|---|
| 250 | 100 | 100 |
| 400 | 80 | 50 |
| 500 | 60 | 50 |
| 600 | 80 | 70 |
| 800 | 180 | 100 |

## MINERALOGY

**General statement:** Although the Silver King mine was worked exclusively for silver, the most abundant minerals are those of lead, copper, and zinc. The most important of the base metal minerals are sphalerite, chalcopyrite, tetrahedrite, galena, and bornite. Much of the tetrahedrite contains a small amount of silver, but with this exception stromeyerite and native silver were the valuable constituents of the ore. Chalcocite, covellite, cuprite, azurite, and malachite are present in smaller amounts.

**Hypogene minerals:** *Pyrite:* Pyrite occurs in only a few of the specimens studied, generally as small, rounded remnants in chalcopyrite, by which it has been replaced most extensively. In sections where pyrite is in contact with sphalerite, the two minerals exhibit smooth boundaries with no marginal relations which



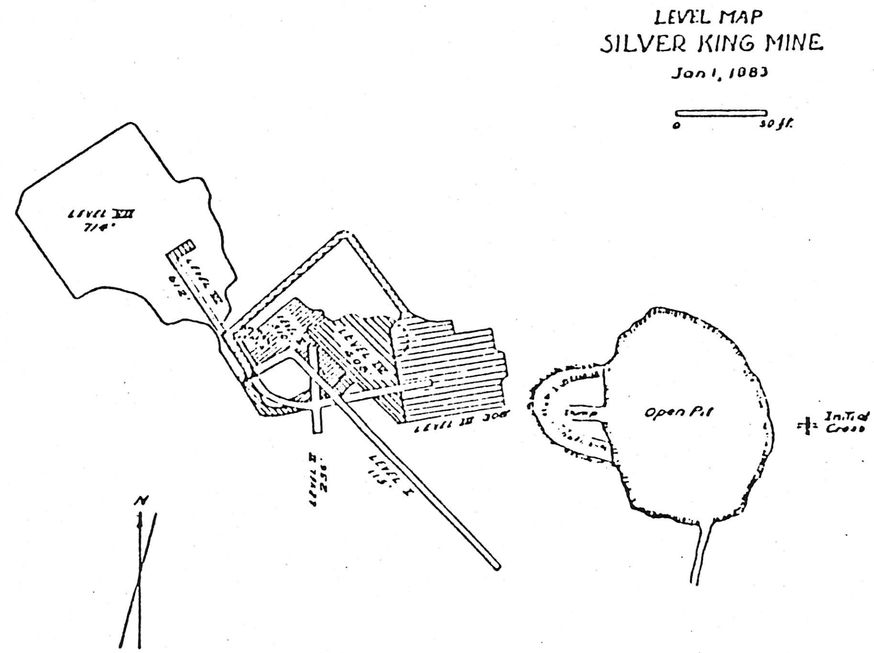



Figure 12.—Map of Silver King mine levels (after Blake).

can be interpreted. In the Magma mine pyrite is the earliest sulfide and is followed by sphalerite. By analogy, the same condition is believed to exist in the Silver King area.

*Sphalerite:* Sphalerite is the most abundant sulfide mineral. In hand specimen much of it is light colored and translucent; in polished section it is medium gray and gives a weak reaction for iron. Sphalerite, like the other hypogene minerals of the ores, is present largely as open-space filling. However, it replaces quartz to a much greater degree than any of the other sulfides. It is in turn replaced by the other sulfides, particularly galena, with which it is almost invariably associated.

*Galena:* Next to sphalerite, galena is the most abundant sulfide. It is intimately associated with sphalerite, which it replaces along cleavage cracks. The galena in many places shows mutual boundaries with chalcopyrite and tetrahedrite, but it is later than these minerals. It selectively replaces tetrahedrite, as shown by its numerous tiny tonguelike projections into tetrahedrite and a multitude of small residual masses surrounding the larger areas of that mineral. Microchemical tests of the galena showed no silver.

*Chalcopyrite and tetrahedrite:* Chalcopyrite and tetrahedrite, the most abundant copper minerals, are present in about equal

In the breakdown of the tetrahedrite molecule the sulphide of antimony has been removed leaving the sulphides of copper and silver, some of which appear as the double salt $Cu_2S.Ag_2S$ (stromeyerite).

Guild recognized that this structure might also be formed by replacement of chalcocite by solutions rich in silver or replacement of stromeyerite by solutions rich in copper.

Textural evidence of supergene origin for the stromeyerite has already been mentioned. In addition, blue chalcocite, believed to be supergene, occurs abundantly in the stromeyerite-chalcocite mixture, and veinlets of this mineral are associated with the replacement of bornite by stromeyerite. Many specimens of fine-grained stromeyerite contain supergene covellite, and only in these specimens were malachite and azurite observed.

*Massive chalcocite:* Although supergene massive chalcocite was observed in only three of the polished sections studied, its mode of occurrence indicates that it was an important constituent of the sulfide ores in upper levels of the mine. Where seen, it constitutes a large portion or all of the sulfides in the specimen. Microscopically, it is distinctly lighter blue than the supergene massive chalcocite from the Magma mine previously described by Short.[68] The mottled character of the Magma ore is present to a slight degree only, but the rounded gray patches described by Short and believed to represent "ghosts" of replaced bornite are readily seen; the difference in color is probably due to incomplete removal of iron. The chalcocite is fine grained, and nitric acid does not bring out the cleavage structure of individual grains as it does on coarse-grained hypogene chalcocite from other localities. This chalcocite has been derived, in large part at least, from hypogene copper sulfides. It replaces chalcopyrite and tetrahedrite, both of which appear as remnants throughout the chalcocite, and tetrahedrite has been replaced by the chalcocite along fractures. Bornite has been almost entirely replaced by chalcocite. It is present as halos surrounding remnants of chalcopyrite (Pl. XXXIII *A*), but rarely tiny areas of bornite alone may be seen. The bornite might be considered an evanescent transitional phase in the replacement of chalcopyrite, but a similar relationship between bornite and stromeyerite, already described, suggests that the bornite is hypogene and a remnant rather than a product of replacement. Furthermore, in many specimens chalcocite replaces chalcopyrite without bornite halos, and the bornite presents an exceedingly hazy or fuzzy boundary toward the chalcocite but a clear, sharp boundary toward the chalcopyrite. Inclusions of bornite in the chalcopyrite contain no chalcocite.

*Blue chalcocite:* This mineral, determined by Posnjak, Allen, and Merwin[69] to be chalcocite containing a small proportion of

[68] Short and Ettlinger, op. cit., pp. 202-3.

[69] Posnjak, E., Allen, E. T., and Merwin, H. E., The sulphides of copper: Econ. Geol., vol. 10, p. 526, 1915.



covellite in solution, is observed sparingly in several specimens. It is derived from both chalcopyrite and bornite, which it frequently replaces along minute fractures (Pl. XXVIII *C*). By analogy with covellite, it is believed to be later than the massive chalcocite.

*Covellite:* Covellite is less common than blue chalcocite. The mode of occurrence of the covellite is identical with that of blue chalcocite, replacing chalcopyrite and bornite along minute fractures. Nowhere in the specimens studied was covellite observed as a product of oxidation of massive chalcocite, and therefore the sequence of formation of massive chalcocite, blue chalcocite, and covellite is not illustrated. In the Magma mine, however, covellite is later than massive supergene chalcocite,[70] and as blue chalcocite is believed to be incipient covellite, the minerals are believed to have been formed in the order described. Supergene covellite also replaces hypogene stromeyerite.

*Chalcopyrite:* A second generation of chalcopyrite is supergene, but it is not abundant. It is intimately associated with supergene covellite and appears as tiny veinlets in bornite, which it has replaced along open fractures and in tongues branching outward from such fractures.

*Native silver:* Native silver is intimately associated with massive chalcocite and in places makes up about 30 per cent of the specimen (Pl. XXXIII *A*). Guild[71] has described the relationship as follows:

The silver is arranged in beautiful filiform structure, the branches of which envelope individual chalcocite grains, some of the finer filaments even extending into fracture and cleavage cracks of the chalcocite. In places the whole design is roughly oriented with reference to cleavage directions of chalcocite. All of these features are well brought out by etching with potassium cyanide solution. The areas showing the structure described grade into stromeyerite, where the native silver disappears altogether, or is confined to borders, veinlets or clumps of more or less rounded outline. The causes responsible for the filiform structure now become clear. Stromeyerite has been broken down into chalcocite and native silver. The chalcocite has crystallized into definite grains of varying size. The silver in recrystallizing has formed around these grains, extending everywhere into the minutest cracks. The silver is also recrystallizing in cracks and along borders of other minerals, both gangue and ore.

*Cuprite:* Cuprite was observed in only one specimen, but there is no doubt that its supergene origin is later than that of chalcocite and native silver. It replaces these minerals as tongues extending into the residual areas, and at one place it has filled an open fracture extending through chalcocite and native silver.

*Azurite and malachite:* Azurite and malachite occur as pockets of small, well-formed crystals in the walls of the open pit. In

[70] Short and Ettlinger, op. cit., pp. 203-4.

[71] Guild, F. N., A microscopic study of the silver ores and their associated minerals: Econ. Geol., vol. 12, pp. 323-4, 1917.

Az Bur of Mines Bull
#151



other hand, their presence may indicate that oxidation took place before the beds were tilted.

Six shoots of gold ore within a horizontal distance of 1,600 feet have been found on the Carlton tunnel level. All bodies of ore on this level are associated with one or more east-west faults, and very few such faults were found between the ore bodies. Evidently east-west faults acted as channelways for the ore solutions.

In the lower levels only one ore shoot has been found. It is a continuation of the general zone, 100-300 feet broad, mined near the collar of the inclined shaft and cropping out northeast of the Holt tunnel portal. East-west faults were found near this shoot on most levels, but at many places within it mineralization has obscured the faulting.

## SILVER KING MINE

### EARLY HISTORY

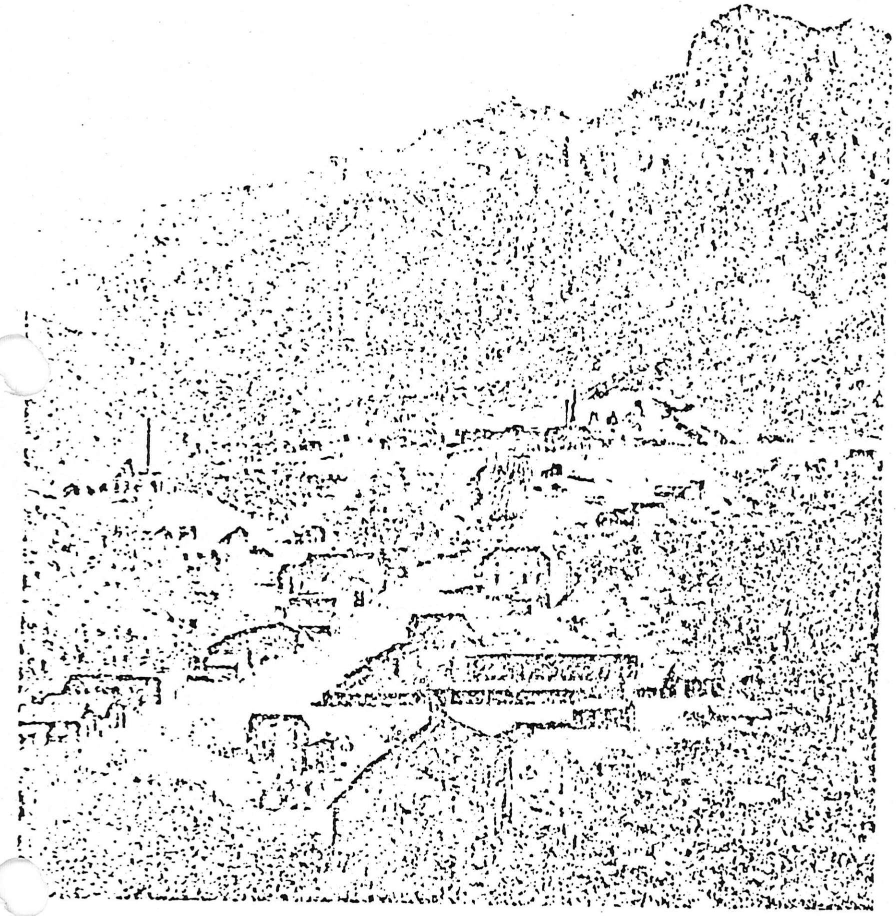
The three published accounts[24] of the discovery of the Silver King mine essentially agree. The following is based upon material published by Wm. P. Blake who, as Territorial Geologist, examined the property at various times.

In the middle of the nineteenth century, while settlements along the Gila River were slowly growing and spreading, the mountainous areas in Pinal and Gila counties were still in possession of the Apaches. These marauding savages dominated the whole region and made it almost inaccessible to prospectors who began to press outward from frontier settlements into the mountains. The country is rugged. One of the trails most frequented by the Apaches led over the steep limestone cliffs about 2 miles north of the site of Superior.

In 1873, General George Stoneman, later Governor of California, was commander of the military department of Arizona Territory. In a campaign to stop Apache raids, he established a camp at the base of the mountains close to the Apache trail and constructed a road, the Stoneman Grade, over the cliffs. It became the main route of travel between the Globe mining districts and the valleys of the Salt and Gila rivers.

A soldier named Sullivan, engaged in construction of the grade, was attracted by some heavy, black lumps of metallic material which flattened when hammered. He gathered a few specimens but said nothing of his find. When his term of service expired soon afterward he went to the Charles G. Mason ranch, near the site

[24] Raymond, R. W., Eighth ann. rept. of the mineral resources west of the Rocky Mts., 1876.
Blake, W. P., The Silver King mine of Arizona. Tuttle, Morehouse, and Taylor, Printers, New Haven, 1883.
Clark, Chas. M., The discovery of the Silver King mine: Ariz. Min. Jour., vol. 8, no. 9, pp. 11, 26, 1924.



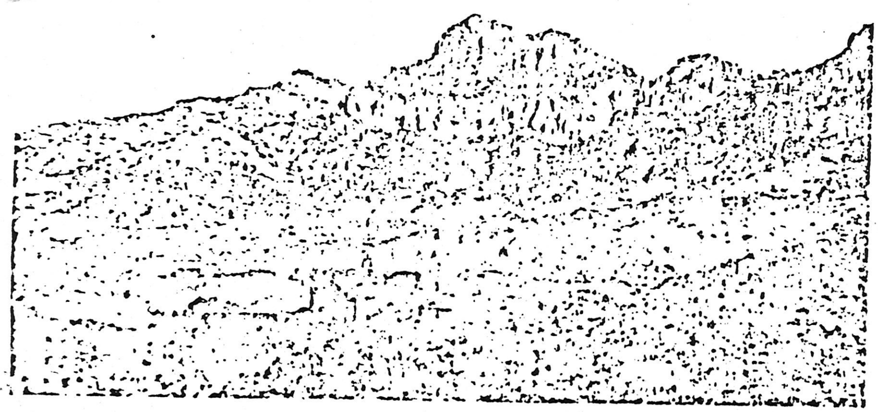


Plate XXIX.—*A*, Silver King in 1880's; *B*, Silver King and King's Crown, 1935



of Florence, where he frequently showed the black ore. This ore has since been known as nugget silver. Sullivan suddenly disappeared, supposedly killed by Apaches while returning to his discovery.

In 1874 Mason and some fellow ranchers organized prospecting trips to locate Sullivan's find. Their first discovery of importance was the Silver Queen, now known as the Magma mine. Soon afterward the Globe mine, from which the Globe mining district derived its name, was located.

In 1875 Mason, Benjamin W. Reagan, William H. Long, and Isaac Copeland, returning from the Globe district with a pack train of samples, camped near the base of the Stoneman Grade and found more of the black nuggets. This float was followed up a small conical hill near by to the outcrop of ore at its top. On March 22, 1875, the initial location was made, and the Pioneer mining district laid out. Assays by Tom Price, of San Francisco, established the value of the ore, and active mining began.

### DEVELOPMENT AND PRODUCTION*

In a report on the mineral resources of the Rocky Mountains, Raymond states that by the end of 1875 the shaft was down 42 feet and a 12-foot drift had been driven at the bottom. The shaft started in ore and was sunk along a network of stringers ranging from 3 to 18 inches wide in "granite." The gangue material in the stringers was quartz, and the ore minerals were cerargyrite, argentite, and native silver. This ore, when sorted, ran $2,000 a ton. To treat the ore a small furnace of cupel type was erected at Florence by Cury and Hughes. Pig lead for collecting the silver was obtained from the Mowry mine in the Patagonia Mountains 150 miles south. Five hundred pounds of selected ore from the first 14 feet of the shaft yielded over $5 a pound. The total production from the shaft and drift was estimated at $50,000.

When the news of the discovery reached San Francisco, mining experts representing the Comstock interests were sent to negotiate purchase of the property, and in 1876 the mine was sold to the Silver King Mining Company. Further development was begun, and a small stamp mill and amalgamation plant were erected at Pinal, on Queen Creek, to treat the lower-grade ore. Most of the ore was shipped without milling.

In 1879 Arthur Macy was appointed Superintendent. Exhaustion of the free milling ore necessitated a change in method of treatment in 1882. The ore was crushed at the mine in a Blake crusher and sent to Pinal where it was further crushed by a battery of 20 stamps and concentrated over 12 Frue vanners. The concentrates were sent to the Dome Mining and Smelting Company, Melrose, California, the Selby Works at San Francisco, and the

*Abstracted from unpublished manuscript by J. B. Tenney

Omaha Smelting Works. In 1883 the mill treated 50 to 57 tons a day, with a concentration ratio of about 2 to 1. The average grade of the heads was $61.08 in silver, and the reported extraction was 92.31 per cent. In addition to silver, the concentrates assayed 21.5 per cent lead and 18 per cent zinc.

Active prospecting of adjacent ground closely followed the success of the Silver King mine. In 1883 fourteen groups were worked and three mills, of which the largest was the amalgamation plant of the Windsor Consolidated Company, had been erected. In 1884 this mill was leased by the Silver King Company to treat ore not amenable to concentration. In the same year the mine was developed to a depth of more than 800 feet, and most of the ore was obtained from the 700 and 800 levels. The grade had fallen to $43.00 for concentrating ore and $46.40 for amalgamation ore.

The last year of profitable operation was 1887. The grade had fallen to 21.08 ounces per ton for concentrating ore and 32.47 ounces for amalgamation ore. Lixiviation was tried on some ore high in copper from the 800 level, and some old tailings were reconcentrated. Costs reported by the Superintendent for 1887 were as follows:

| | |
|---|---|
| Mining, per ton | $10.97 |
| Milling and roasting, per ton | 9.69 |
| Total | $20.66 |

During the first half of 1888 the company operated at a loss, and the President, H. H. Noble, reported a debt of $75,000. An assessment was levied, and operating costs were lowered from $40,000 to $5,000 a month. By December the indebtedness had been paid, the company had a balance of $74,000, and sufficient ore was in sight to run until January 1, 1889.

As prospecting in 1889-90 failed to find commercial ore, the mine was closed in January, 1891. It was reopened in September of that year after 44,000 delinquent shares had been called in. In October a strike was made in a new shaft east of the old workings. This ore was developed in 1892, but the company was again in debt. Ten stamps were moved from Pinal to the mine, and a small production of concentrates was made during the remainder of the year. With the decline of the price of silver early in 1893, the mine was again closed.

In the fall of 1895 the Superintendent, W. S. Champion, resumed work in the new shaft. He reported finding a pocket of ore at a depth of 75 feet worth $40,000. The mine was again closed in 1896.

From 1876 to 1896 the company declared $1,950,000 in dividends, of which the last was paid in 1887. A total of $300,000 in assessments was levied from 1888 to 1895, making the net profit $1,650,000. The dividends were paid on 100,000 issued shares, and assessments were collected on 56,000 shares.



In 1916, after successful exploitation of the neighboring Silver Queen mine by the Magma Copper Company, the property was acquired by the Silver King of Arizona Mining Company, a Delaware corporation, with A. W. Hildebrand, of New York, as President, and John Fowle as Manager. In 1917 the old main shaft, 987 feet deep, was unwatered and repaired. Small high-grade ore bodies, overlooked by the former operators, were mined on the 120 level. A small flotation mill was completed in 1918 to treat this ore and low-grade dump material. About 35 tons a day were treated, with a reported extraction of 90 per cent. A small vein on the 400 level yielded some rich ore that was shipped to the smelter, and shipments of concentrates continued intermittently to July, 1919. At that time the management claimed to have developed 10,000 tons of ore averaging over $20 per ton.

In July, 1919, a new shaft, financed by a $500,000 bond issue, was started 150 feet northwest of the ore chimney. The old shaft was kept unwatered, and ore from the 120 and 400 levels was treated at the mill. In October a crosscut from the old shaft on the 400 level connected with the 415 level of the new shaft.

In January, 1920, the capitalization was reduced to allow further financing. Shaft sinking continued until June, 1920, when a depth of 635 feet was reached. A crosscut on the 615 level extended to the old workings. The company went into bankruptcy shortly afterward, and a reorganization as the Silver King Mine, Incorporated, was effected, but no further work was done. The total ore treated from 1916 to 1920 amounted to 12,546 tons, averaging approximately $20 a ton in silver. The concentrates contained 1,000 to 1,980 ounces of silver, 20 per cent lead, and 7 to 8 per cent copper.

The Bilk shaft (Pl. XXIX *A*, left) is 450 feet northwest of the new Silver King shaft. It is reported to be over 1,000 feet deep and connects with the lower levels of the Silver King mine. The shaft was sunk during the early days by interests outside of the Silver King Mining Company. Observing the westward pitch of the Silver King ore body, owners of the Bilk assertedly hoped to intersect the Silver King pipe in depth where it passed beyond the side line of the Silver King claim.[60] No mention was made of the apex law.

In 1940 a pipe line was laid from the Bilk shaft to provide an auxiliary water supply for the Magma mine.

In 1941 the Silver King property was owned by Mr. Bat Gays, of Superior, Arizona.

Pinal, on Queen Creek at the base of Picket Post Mountain, was first settled in 1877 during construction of the Silver King mill. As Silver King Wash had insufficient water for milling, the site chosen for the mill was on the north bank of Queen Creek, near

[60] Hamilton, Patrick, The resources of Arizona, 1884.

its junction with Silver King Wash, about 5 miles west of Silver King. The settlement first was called Picket Post but was named Pinal upon establishment of its post office.

Pinal grew rapidly and by 1884 had a population of about 600,[61] with several stores, a bank, two hotels, several saloons, a church, and a school. The newspaper *Pinal Drill* was established by J. DeNoon Reymert, a lawyer, and was maintained for several years prior to 1884. In 1887 the population was about 400.[62]

A telephone, one of the earliest in the territory, connected Pinal with Silver King, and a telegraph connected Pinal with Florence, the county seat.

The settlement of Silver King, around the mine, had during the eighties a population of about 500,[63] with three stores, two hotels, a post office, a school, and several saloons. Present local tradition gives for both camps a much greater population.

PRODUCTION OF SILVER KING MINE
(Compiled by J. B. Tenney)

| Year | Price of silver | Silver (oz.) | Gross value |
|---|---|---|---|
| 1875 | $1.24 | 40,323 | $ 50,000 |
| 1877-79 | 1.16 | 706,157 | 819,142 |
| 1880 | 1.15 | 439,689 | 505,642 |
| 1881 | 1.13 | 574,049 | 648,675 |
| 1882 | 1.14 | 714,912 | 815,000 |
| 1883 | 1.11 | 533,787 | 592,503 |
| 1884 | 1.11 | 429,559 | 476,811 |
| 1885 | 1.07 | 764,832 | 818,370 |
| 1886 | .99 | 656,566 | 650,000 |
| 1887 | .98 | 709,134 | 694,951 |
| 1888 | .94 | 319,149 | 300,000 |
| 1889 | 1.00 | 55,000 | 55,000 |
| Total (1875-89) | | 5,943,157 | $6,526,094 |
| 1918 | 1.00 | 37,000 | 37,000 |
| 1919 | 1.12 | 126,892 | 142,119 |
| 1920 | 1.09 | 65,872 | 71,800 |
| 1928 | .58 | 3,000 | 1,755 |
| Total (1918-28) | | 232,764 | $ 252,674 |
| Grand total | | 6,175,921 | $6,778,768 |

SILVER KING ORE BODY

The Silver King mine is filled with water and therefore is inaccessible for examination. Blake's article[64] contains the only original description of the ore body, although Ransome[65] has given

[61] Hamilton, Patrick, op. cit.
[62] Bancroft, H. H., History of Arizona and New Mexico, 1889.
[63] Bancroft, op. cit.
[64] Blake, Wm. P., op. cit.
[65] Ransome, F. L., Copper deposits near Superior, Arizona: U.S. Geol. Survey Bul. 540, pp. 156-58, 1914.



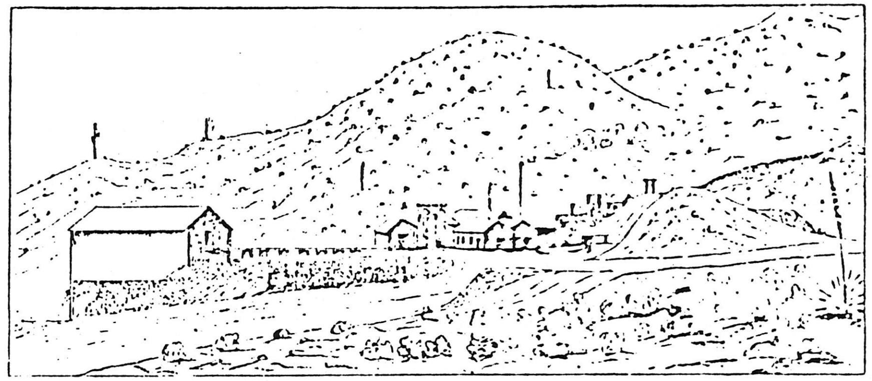


Plate XXX.—Silver King mine and crusher (after Blake).

a concise summary of Blake's description in addition to data collected by himself. Quoting from Ransome:

> The ore body formerly cropped out at the top of a little hill about 75 feet high, composed of much-altered yellowish brown to greenish gray porphyry. Stoping was carried to the surface and a crater-like pit from 100 to 125 feet in diameter marks the site of the former outcrop. Here and there in the porphyry walls of the pit may be found small veinlets of rich, partly oxidized silver ore, but, so far as can be seen from the surface, the ore body was determined by the intersection of two or more persistent fissures. It apparently was a compact plexus of veinlets inclosed in comparatively unfissured porphyry. Blake's description and the maps of underground workings show that the ore body was a stockwork about 130 feet in maximum diameter, with a general dip of 70° W. The stockwork was disposed about an irregular core or axis of milk-white quartz, containing some bunches of rich ore but as a whole comparatively barren. This material is abundant and conspicuous in the mine dump and evidently constituted at times the bulk of the waste.

The following description is from Blake:

> The portion removed from the open pit consisted largely of rock, the porphyry, so-called, penetrated and seamed with interlacing veinlets of quartz, reticulating and crossing in every direction. These veinlets varied from the thickness of a sheet of paper to 1/4 inch or an inch in thickness, and were generally accompanied with ore in a medial position, having quartz on each side of it next to the rock. The same conditions may be seen in the lower levels at the present time. In addition to these veinlets, there are masses and bunches of ore, and apparently (at least in the upper levels) a central mass of quartz, a large and compact body, toward which the system of veinlets converged, or from which they may be said to radiate. This mass of quartz, of irregular dimensions, still exists in the region opened by the lowest levels of the mine, but it has not yet been thoroughly explored. This quartz appears to hold some direct relation to the deposition of the ore: The heavier bodies of ore, so far, having been cut below, or on the foot-wall side of the quartz body. It may be regarded as holding the relation of the chief veinstone to the ore, and as presenting within itself, and together with the branching veinlets, the characters of a true fissure-filling, although it has not the usual sheet-like or tabular form. It is, instead, a columnar or chimney-like mass, some 80 feet in diameter in places, but irregular and without longitudinal extension. In other words, this quartz-vein, instead of having a width much greater than its breadth, is approx-

polished sections, the minerals occur as stains along minute fractures in quartz gangue.

*Anglesite:* In one specimen anglesite replaces galena, forming a network of tiny veinlets in open fractures.

Gangue minerals: *Quartz:* At least 95 per cent of the gangue is quartz. It occurs in two forms, one a rather fine-grained crystalline variety and the other as euhedral crystals extending from walls of the fine-grained gangue (Pl. XXXII *B*). Hand specimens as well as thin sections show both varieties of quartz to be later than the Silver King porphyry in which the ore body was formed. Open spaces left after deposition of the quartz were the most favorable locations for deposition of ore minerals.

*Barite:* In the specimens studied, small amounts of barite occur in two generations—

1. Earlier than the ores, as open-space filling in the quartz.
2. Later than ores, numerous narrow veinlets cutting through the sulfides. The later generation is much less common than the earlier.

*Calcite:* Calcite was infrequently observed as narrow veinlets in the quartz gangue. Its age relative to the barite was not determined, but it is assumed to be younger, since in other districts most calcite is generally considered to be later than the latest barite.

## MINES IN THE BELMONT SUBAREA

### EARLY HISTORY

Some mining, largely of manganese-stained vein outcrops, was done in the Belmont-Queen Creek area before 1900. This ore, mined for its silver and gold, was treated in a custom stamp mill near Pinal. After construction of the Silver King Mining Company's mill, this older mill was closed, for at the new one provision was made for roasting the ore, a process which aided materially in recovery of the precious metals.

Most of the present claims were located shortly after 1900 by Henry Thomson, C. H. Smith, A. C. Norris, A. J. Daggs, John Sandal, and many others. Organized prospecting, begun in 1912, has been carried on intermittently.

### MINERALIZATION

Two favorable horizons for ore deposition, the Troy-Martin contact and the upper portion of the Escabrosa, have been recognized.

**Troy-Martin contact:** The Troy-Martin contact is known as the L. S. and A. contact, from the Lake Superior and Arizona mine



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occurs throughout along
ern part of the Belmont
developed in the quartz
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fault was not determine
The brecciated quartz
along which solutions c
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**Escabrosa ore horizo**
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by iron and manganese
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faults through the und
and limestone. Upon r
Escabrosa limestone t
posits. Because of the e
bodies dip eastward, w
ing of small magnitud
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**Oxidation and enrich**
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malachite, and azurite.
ent in most of the ore.
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Microscopic examin
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of enrichment which
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mineralization.
Chemically, sufficien
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## ORE BODY OF THE SILVER KING MINE.

The Silver King mine was well described by W. P. Blake[1] 30 years ago, but his original publication is not readily accessible. Accordingly, although the present paper is concerned mainly with the copper deposits, and although the old mine, being full of water, could not be reexamined, a brief descriptive summary of the conditions under which the ore occurred will perhaps be of sufficient interest to warrant its inclusion here.

The eruptive mass which incloses the ore is a quartz diorite porphyry or closely related rock. It presents some rather noticeable variations, which Blake distinguished as "porphyry," "sienite," and "granite," although they appear to be merely facies of one intrusive body which is probably of Mesozoic age.

The ore body formerly cropped out at the top of a little hill about 75 feet high, composed of much-altered yellowish-brown to greenish-gray porphyry. Stoping was carried to the surface and a crater-like pit from 100 to 125 feet in diameter marks the site of the former outcrop. Here and there in the porphyry walls of the pit may be found small veinlets of rich, partly oxidized silver ore, but, so far as can be seen from the surface, the ore body was not part of a vein, and there is nothing to suggest that it was determined by the intersection of two or more persistent fissures. It apparently was a compact plexus of veinlets inclosed in comparatively unfissured porphyry.

Blake's description and the maps of underground workings show that the ore body was a stockwork about 130 feet in maximum diameter, with a general dip of 70° W. The stockwork was disposed about an irregular core or axis of milk-white quartz, containing some bunches of rich ore but as a whole comparatively barren. This material is abundant and conspicuous in the mine dump and evidently constituted at times the bulk of the waste. The ore consisted of altered porphyry traversed in all directions by innumerable veinlets carrying stromeyerite, tetrahedrite, galena, sphalerite, chalcopyrite, and pyrite in a gangue of quartz with some barite. The minerals named were noted in 1912 on the dump, but Blake lists and describes also native silver, argentite, bornite, calcite, and siderite. Bornite, chalcopyrite, and pyrite are said to have been comparatively rare. Blake makes the interesting observation that stromeyerite and highly argentiferous tetrahedrite with more or less argentite were the most important constitutents of the ore on the upper levels, whereas argentiferous sphalerite had become the principal ore mineral on the seventh level. Native silver, associated with stromeyerite and sphalerite, was abundant on that level, according to the same

[1] Description of the Silver King mine of Arizona, New Haven, 1883, 48 pp., with illustrations.

observer. He also describes the metallic minerals as occurring generally along the medial plane of the veinlets, a characteristic that is verifiable in specimens collected on the dumps in 1912. Apparently the deposit was not deeply oxidized and veinlets seen in the open pit in 1912 showed sulphides present with cerargyrite, malachite, and azurite. Blake notes also native copper, cuprite, "oxides and carbonates of lead and possibly embolite, the chlorobromide of silver; also the argentite, in pure black lumps."

From the fact that water is now flowing from the collar of the No. 2 shaft the original water level was probably close to the surface. The quantity of water pumped to keep the mine clear near its maximum development in 1887 was 10,941 gallons a day.[1] Blake states that at the time of his visit (1882 or 1883), when the mine was 714 feet deep, only 2,000 gallons a day was pumped, all of which entered the mine at the first or 114-foot level.

In the early stages of development, before there was a railroad in Arizona, some rich ore was shipped under great disadvantages. Blake states that some of this carefully sorted ore averaged $1,000 a ton, and as late as 1887 the superintendent, Mr. Arthur Macy, reported assays up to 447 ounces of silver to the ton in ore consisting chiefly of tetrahedrite. Subsequently two 20-stamp mills were built at Pinal, 5 miles from the mine. Some idea of the character of the ore during a rather late stage in the activity of the mine is obtainable from the company's report for 1887, wherein it is stated that mill No. 1, employing wet crushing and concentration, treated 2,698.75 tons of ore with an average content of 21.08 ounces of silver to the ton. The product was 577,813 tons of first-class concentrates averaging 334,135 ounces of silver to the ton and 31 per cent of lead. Of the total silver contents, 53.95 per cent was native silver. In addition the mill turned out 1,261.55 tons of second-class concentrates carrying 31.77 ounces of silver to the ton, chiefly combined in zinc blende and galena. Mill No. 2, in which chloridizing, roasting, and pan amalgamation were employed, treated 4,840.08 tons of first-class ore, averaging 32.47 ounces of silver to the ton of roasted pulp, 1,913.51 tons of second-class concentrates, and 3,875.34 tons of old tailings with an average content of 12 ounces of silver to the ton. The superintendent states that whereas previously the ore treated in this mill had carried 50 per cent of its silver in native condition, the proportion for the year covered by the report had fallen so notably and the bullion, not withstanding an extraction of over 96 per cent of the total silver, had become so base that he had stopped this method of treatment and was experimenting with an old lixiviation plant previously used.

[1] Report of the Silver King Mining Co. for 1887, San Francisco, 1888.

Various explanations are given locally for the failure of this interesting deposit below the 800-foot level, some stating that the ore body was faulted, some that the ore changed in character and grade. The latter is probably true. The worked-out part of the deposit appears to have been a striking example of deep downward enrichment. If so, the time may come when the old mine will be reopened and its low-grade hypogene ore utilized.

Silver King Mine

Silver King Mining District

Pinal County, Arizona

By

Rene G. von Boeck

June, 1983

– [illegible] w/ [illegible] –

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INTRODUCTION

This report was written at the request of Mike Guzman Jr., Vice President of Guzman Construction Company of Globe, Arizona. It is a summary from data provided by Mr. Guzman and from published literature. No field work was done for purposes of this report. The writer is familiar with the property and has visited it on sevaral occasions while working for a mining company. No information obtained for that company is included in this report unless the same has been released to the property owner and it is in Guzman Construction files. Some geological interpretations and inferences for exploration potential are the sole responsability of the writer. They are based upon available data and personal knowledge of the property.

Copies of portions of literature dealing with the mine are attached in the appendix.

LOCATION

The Silver King Mine is located 2.5 miles north of Superior, Pinal County, Arizona, in section 24, Township 1 South, Range 12 East, Gila and Salt River Meridian. The mining claims under control of Guzman Construction Co., which contain the mine and adjacent areas cover portions of sections 10, 11, 13, 14, 23, 24 and 26 (see Index Map and Fig. 1).

The mine is reached by driving west from Superior on U.S. highway 60 for approximately one mile, thence turning right on a graded road (Silver King Road) and travelling north-northwest for 4.5 miles to the mine site. The surrounding claims are accessible by jeep trails and on foot from these trails. The graded road is open all year. The jeep trails are often washed-out by heavy rains.

## LAND STATUS

Guzman Construction Company controls 60 unpatented lode mining claims over the Silver King Mine and adjacent areas (Fig. 1). The corners of all the claims have been re-established and new monuments have been placed at all the corners. Some of the claims were reportedly acquired through leases, while others have been located by members of the Guzman family. All the claims have been properly recorded and, on the date of this writing, are being maintained in compliance with State and Federal Laws.

Most of the area surrounding the Guzman Construction claims is adversely owned. To the south are claims owned by Magma Copper. To the east is a group of claims controlled by Fisher Watt Mining Company. The rest of the area contains claims or groups of claims under various ownerships. They are all presumed to be valid claims, but no title search has been done at this time.

Some patented claims are scattered through the area but none are owned by Guzman construction. These patented claims include three that are adjacent to the Silver King Mine workings. Two of them, Bilk and Mowry, belong to Magma Copper. The other, 1st. Extension of The Silver King Mine, belongs to Jeff Smith.

HISTORY AND PRODUCTION

The Silver King Mine is one of the early bonanza deposits mined in Arizona. It was discovered in 1875 by a group of prospectors.[1] Since that time it had a continuous production through 1889. During that period it produced 5,943,157 ounces of silver with a gross value of $6,526,094. From 1918 to 1920 there was another period of production which yielded 229,764 ounces of silver with a gross value of $250,919. In addition to silver, the mine produced undisclosed amounts of copper, lead and zinc. Some of these metals may not have been recovered in the early years of production.

The mine has been idle since 1920. Sporadic attemts to mine have been made since in the most accessible portions of the mine The only recorded production of these later attempts are 3,000 ounces in 1928. Most recently, in 1981, Guzman Construction Co. set up a small leaching operation treating crushed dump material. The operation was short lived. It was set up when the price of silver was high, but the sudden drop in price forced the operation to a halt. The small recovery plant is still in place and it is apparently functional.

AREAL GEOLOGY

Rock formations in the area range from Precambrian to Tertiary and include: Precambrian schist and sediments, Paleozoic sediments, Cretaceous and Tertiary intrusive igneous rocks, and Tertiary and Quaternary volcanic rocks and clastic sediments.[2] (Fig. 2). Significant rock units present are as follows:

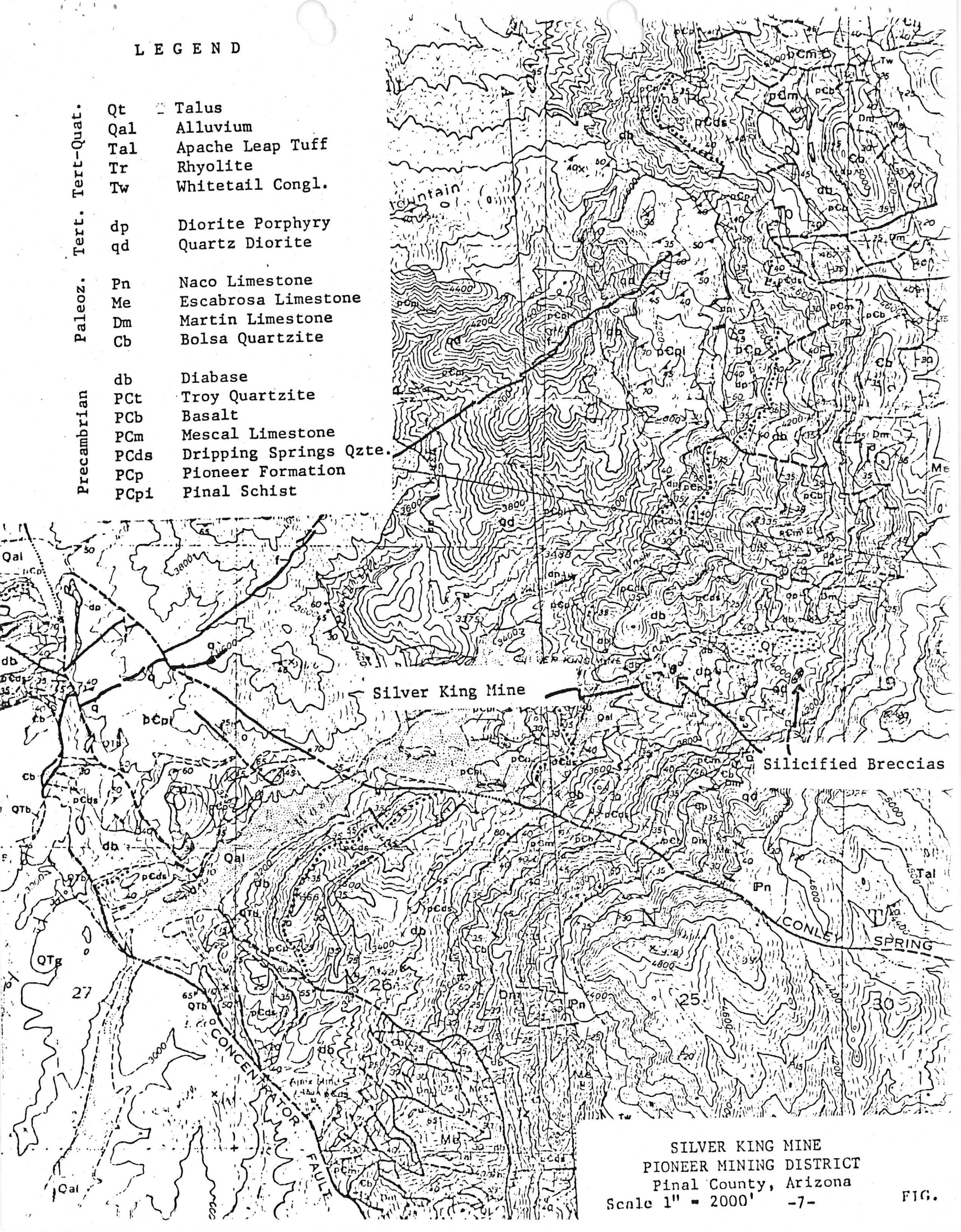
| | | | |
|---|---|---|---|
| | (Qt) | Talus | |
| Quaternary | (Qal) | Alluvium | |
| | | | Unconformity |
| | (Tal) | Apache Leap Tuff | |
| | (Tr) | Rhyolite | |
| Tertiary | (Tw) | Whitetail Conglomerate | |
| | | | Unconformity |
| Cretaceous or | (dp) | Diorite Porphyry | |
| Tertiary | (qd) | Quartz Diorite | |
| | | | Unconformity |
| | (Pn) | Naco Limestone | |
| | (Me) | Escabrosa Limestone | |
| | (Dm) | Martin Limestone | |
| | | | Disconformity |
| Paleozoic | (Cb) | Bolsa Quartzite | |
| | | | Unconformity |
| | (db) | Diabase | |
| | (PCt) | Troy Quartzite | |
| | (PCb) | Basalt | |
| | (PCm) | Mescal Limestone | |
| Upper | (PCds) | Dripping Springs Quartzite | |
| Precambrian | (PCp) | Pioneer Formation | |
| | | | Unconformity |
| Lower | | | |
| Precambrian | (PCpi) | Pinal Schist | |

The reader is referred to published literature e.g. U.S.G.S. GQ-818 (ref. 2) for detailed description of the various rock units listed.

The Tertiary Whitetail conglomerate and volcanics have been deposited over east dipping Paleozoic sediments. The volcanics cover

# LEGEND

| | | |
|---|---|---|
| Tert-Quat. | Qt | Talus |
| | Qal | Alluvium |
| | Tal | Apache Leap Tuff |
| | Tr | Rhyolite |
| | Tw | Whitetail Congl. |
| Tert. | dp | Diorite Porphyry |
| | qd | Quartz Diorite |
| Paleoz. | Pn | Naco Limestone |
| | Me | Escabrosa Limestone |
| | Dm | Martin Limestone |
| | Cb | Bolsa Quartzite |
| Precambrian | db | Diabase |
| | PCt | Troy Quartzite |
| | PCb | Basalt |
| | PCm | Mescal Limestone |
| | PCds | Dripping Springs Qzte. |
| | PCp | Pioneer Formation |
| | PCpi | Pinal Schist |




SILVER KING MINE
PIONEER MINING DISTRICT
Pinal County, Arizona
Scale 1" = 2000'

FIG. -7-

an extensive area to the east and form a west slopping scarp above the contact with the sedimentary rocks.

All Pre-Tertiary rocks are intruded by a Laramide complex consisting of a quartz diorite pluton, which in turn is intruded by a smaller quartz diorite porphyry stock. These two stocks have economic significance for they contain the Silver King ore body and at least one other mineralized breccia.

Structurally the area is cut by east-west normal faults which are, in most cases, cut by more extensive north-south and northeast trending faults. The density of faulting increases towards the south. Almost all the east-west trending faults in the district are at least weakly mineralized. Calcareous sediments adjacent to the vein systems along these faults are hosts to replacement mineral deposits. In the case of the Magma vein, several copper ore bodies have formed in the Martin, Escabrosa and Naco Limestones.

## GEOLOGY OF THE SILVER KING MINE

The Silver King Mine deposit is contained within a breccia pipe intruded into a stock-like mass of siliceous quartz diorite porphyry. The stock at the outcrop meassures about 2,000 ft. from east to west and 1200 ft. from north to south(dp in geologic map). This body is intruded into a much larger quartz diorite stock (qd). The contacts between these rocks, where exposed, are well defined. The quartz diorite contains less silica and tends to weather more easily than the quartz diorite porphyry, thus producing weathering and color contrasts. The breccia pipe at the outcrop, shows a reddish tan color anomaly due to alteration and oxidation of sulfides.

The breccia pipe itself is composed of light colored diorite porphyry fragments cut by small and irregular dikes of dark porphyritic rock. It has not been established whether this dark rock is a later intrusive injection or an alteration product. Mineralization is present in both dark and light colored rocks. The shape and nature of the mineralized body is no obvious at the outcrop, which has been greatly disturbed by mining. The following is a description of the deposit by Ransome:[3]

> The ore body formely cropped out at the top a little hill about 75 feet high, composed of much-altered yellowish-brown to greenish-gray porphyry.... Here and there in the porphyry walls of the pit may be found small veinlets of rich, partly oxidized ore, but, so far as can be seen from the surface, the ore was not part of a vein, and there is nothing to suggest that it was determined by the intersection of two or more persistent fissures. It apparently was a compact plexus of veinlets inclosed in comparatively unfissured porphyry.
>
> ...maps from underground workings show that the ore body was a stockwork about 130 feet in maximum diameter, with a general dip of 70° W. The stockwork was disposed about an irregular core or axis of milk-white quartz, containing some bunches of rich ore but as a whole comparatively barren....The ore consisted of altered porphyry traversed in all directions by innumerable veinlets carrying stromeyerite, tetrahedrite, galena, sphalerite, chalcopyrite, and pyrite in a gangue of quartz with some barite....Blake makes the interesting observation that the stromeyerite and high argentiferous tetrahedrite with more or les argentite were the most important constitutents of the ore on the upper levels, whereas argentiferous sphalerite had become the principal ore mineral on the seventh level. Native silver associated with stromeyerite and sphalerite, was abundant at that level, according to the same observer....

> Various explanations are given locally for the failure of this interesting deposit below the 800-foot level, some stating that the ore body was faulted, some that the ore changed in character and grade. The latter is probably true....

No much more has been learned since Ransome wrote about the deposit in his 1914 report although some work was done at the mine after that date. The old shaft which has a depth of 987 feet was dewatered and a new shaft to a depth of 615 ft. was sunk. The production from 1918 to 1920 mentioned earlier in this report came as a result of this later work. The new shaft was not sunk any deeper presumably because the Company went into bankruptcy in 1920. Ore produced probably came from upper levels.

## ECONOMIC POTENTIAL

The Silver King Mine has been shut down for a long period of time. Except for what can be recovered from dumps and shallow mineralization, no ore is accesible from the old mine workings. As an exploration target the property has good potential for additional silver ores in the breccia pipe and for porphyry copper mineralization within the igneous stocks. Of most immediate interest is the silver mineralization potential. Porphyry copper mineralization is of low priority at this time of low prices and low demand.

Silver Potential: Galbraith has used data from old mine maps and constructed a stereogram of the Silver King ore body (see Appendix).

If the tonnage of rock in this body is calculated using the dimensions given by Galbraith it gives a total of approximately 550,000 tons. Production to 1928 is given in ounces per ton. Assay values for the ore that produced the silver are not available in the literature or available data except as follows: Some mention is made for production in 1883 with ore going to the mill with heads of 61.08 opt Ag; in 1884 mention is made of ore having a metal content of 43 to 46.40 opt Ag; in 1887 ore to the mill was running from 21.08 to 32.47 opt Ag; for the period 1918 to 1920 the heads are given at 18.7 opt Ag.

For calculation of tonnage mined to yield the silver produced the following silver values will be assumed: 1875 to 1883 - 55 opt, 1884 to 1886 - 40 opt, 1887 to 1889 - 25 opt, and 1918 to 1920 - 18 opt. These values are realistic but should not be taken as the true values. They are being used here to estimate the potential ore that was not mined or is left in dumps or underground. The tonnage of ore mined using the above values is 159,500 tons. What remains in place or broken underground or in dumps is the difference between the original ore in place and the ore mined. This difference is 390,500 tons. The silver content of the remaining mineralized material is not known but should be assumed to be less than 18 opt Ag, with values in copper, lead and zinc in addition to the silver.

Whether or not the Silver King ore body continues at depth or has lateral extensions can be determined only by exploration. A silicified brecciated zone containing pyrite is present in quartz diorite about 2.000 ft. east of the Silver King ore body. This breccia is outside of the Guzman Construction claims but points out that other potential targets may exist in the area.

Porphyry Copper Potential: Both the quartz diorite and the quartz diorite porphyry show widespread quartz and sulfide veining, and alteration is locally intense. This alteration is mostly propylitic to weak phyllic, with local potassic alteration in the vicinity of the breccia pipe at the Silver King Mine. The alteration pattern and widespread sulfide mineralization (pyrite and rare chalcopyrite) are evidence of a potentially larger sulfide body that may contain economic concentrations of disseminated copper mineralization.

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