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N E V A D A S T A T E B U R E A U O F M I N E S

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E A R L Y C O M S T O C K M I N I N G M E T H O D S

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Compiled by

MAX CROWELL, Field Engineer

NEVADA STATE BUREAU OF MINES

IN
COLLABORATION WITH

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Reno, Nevada.
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A TECHNICAL REVIEW

of

EARLY COMSTOCK MINING METHODS

by
Max Crowell

Field Engineer - Nevada State Bureau of Mines

Prospecting

On May 15, 1840 a wagon train made up of Mormons halted, at noon, in Washoe Valley. William Prouse picked up a tin pan and going to the edge of a nearby creek, began washing the surface dirt which upon panning showed a few glittering specks of gold dust. The dust was worth only a few cents, and was thrown carelessly aside a few moments later. The party moved on toward California, but due to the Sierra Nevada Mountains still being impassible the party returned to the stream and resumed prospecting.

John Orr, the son of the Mormon leader with a companion, Nicholas Kelly, worked up the canyon to Devils Gate where they found a gold nugget and they christened the canyon Gold Canyon.

The Mormon train left for the presumably richer placers of California. However, other emigrants entered the valley and continued the exploration of the new placer diggings. By the autumn of 1851 nearly 200 men were working the gravel in the Canyon with rockers and long toms and making from $5 to $10 per day to the man.

The placers in the Canyon were worked continuously until 1857. Meanwhile the average daily earnings had dropped from an estimated $5 in 1851 to about $2 in 1857 and it became evident that unless new discoveries were made the Canyon would be gradually abandoned.

Two young American brothers, Ethan Allen and Hosea Ballou Grosh beside placering made a persistent and well-planned effort for several years to discover the metal bearing ledges of the district that were probably the source of the placer gold. Their letters tell that they found several ledges and that one assay indicated $3,500 in silver to the ton. They knew, however, that it would require capital to treat the ore in the veins, but before they could raise the capital Hosea stuck a pick in his foot and died of gangrene on September 2, 1857. Allen died the following November when he was caught in a storm trying to cross the Sierras.

In January 1858 the Columbia Quartz Mining district was formed. The Pioneer Quartz Mining Company was formed and installed an arrastra to treat the gold ore from the ledges of the district. Ore was obtained from Pioneer Hill directly east of Devils Gate. The venture proved to be unprofitable and was abandoned.

As the payable gravel in the canyon was rapidly becoming exhausted, the attention of the miners was drawn to the hills at the head of the Canyon.

In the spring of 1859 James Finney and three other men prospecting in a gulch on the southeastern slope of Mount Davidson obtained a fair panning

from a soft iron stained outcrop. The prospecting showed a yield of gold dust of about 15¢ per pan, whereupon the men staked out four rectangular claims each 50 feet by 400 feet. Friends joined the men in staking claims and placering on the new discovery. With a little depth they first encountered fragmental quartz containing free gold and then into the rich gold bearing vein in place. Arrastras soon replaced pestal and mortar and mining replaced placering and Gold Hill replaced Gold Canyon as the mecca of miners.

In 1857 when the richer placer bars of Gold Canyon showed signs of exhaustion, the miners began to more thoroughly prospect the other ravines leading up from the valley. Thus it was that a group of miners were working in a canyon running nearly due east from the foot of Mount Davidson, later named Six Mile Canyon.

The placers of Six Mile Canyon consisted of a heavy clay which the miners had to puddle before they could separate the gold in their rockers and long toms. Puddling consisted of stirring the clay in a box or a hole in the ground filled with water by which means the clay was disintegrated making a thin pulp.

The gold dust obtained from the placer was lighter in color and less valuable than that obtained in Gold Canyon. However, working under the disadvantages of lower grade gold and the necessity of puddling, the miners were at first still able to earn from $5 to $12 per day per man. Due to the small flow of water in the Canyon during the summer months, it was necessary that the miners work higher up the Canyon nearer to the source of the stream. Thus it was that the miners in Six Mile Canyon were rapidly approaching its head.

Discovery

In the spring of 1859 Pete O'Riley and Pat McLaughlin began working well up at the head of Six Mile Canyon. They used rockers and found small pay and by June 1, 1859 they had gradually extended their operations up the slope of the hill. Here they had started a little cut and were washing the dirt taken from this in their rockers. Before they started the cut they were making only $1.50 to $2.00 per day with disappointing returns. In the cut their pay was even less.

Having but a small stream of water, it became necessary for them to dig a hole as sort of a reservoir in which to collect the water for use in their rockers. At a depth of about four feet, they struck into a stratum of an odd looking black dirt. As any change was welcome, they at once came to the conclusion to try some of the curious looking "stuff" in their rockers. The result astounded them as they found the bottoms of the rockers covered with gold as soon as a few buckets of the new dirt had been washed. However, as the gold was much lighter in color and weight than any that they had ever seen, they thought it a new and strange kind of base metal.

On the evening of the day on which the ground discovery was made, H. T. P. Comstock made his appearance on the scene. Comstock who was then looking after his Gold Hill Mines came up just as the lucky miners were making the last clean-up for the day. Comstock, who had a keen eye for all that was going on in the way of mining, saw at a glance the unusual quantity of gold that was in sight. After an examination of the strike, he coolly proceeded to inform the miners that they were working on ground that belonged to him. He asserted that he had sometime before taken up 160 acres of land at this point for a ranch; also that he owned the water that they were using in mining.

Suspecting they had been working in a decomposed quartz evin, McLaughlin and O'Riley had written and posted a notcie calling for a claim of 300 feet for each and a third claim for the discovery; which extra claim they were entitled to under the mining laws of the district. Comstock boisterously declared that they should not work there at all, unless they would agree to include himself and his friend Manny Penrod in the claim. The discoverers concluded that, rather than cause trouble, they would put the names of Comstock and Penrod in their notice of location. This being arranged to his satisfaction, Comstock next demanded that 100 feet of ground on the lead should be segregated and given to Penrod and himself for use of the water. He obtained this also.

John Bishop, who bought "Old Virginia's" interest in the sluices, gravel diggings, and water, managed to get in on the lead. He later sold his interest for $4,000.00 and shortly afterward the purchaser sold the same ground for $1,800.00 per foot.

The Ophir Claim was the first that was located as a quartz claim at any point on the Comstock lode, though as early as February 22, 1858, Old Virginia made a location on a large vein lying to the westward of the Comstock. At one time it was thought by some that this would prove to be the main lead of the range, and for a considerable distance below the surface, the Comstock vein dipped west toward it.

In a few weeks after the discovery had been made, O'Riley and McLaughlin were taking out gold at the rate of $1000 per day. This they were doing with rockers. Taking the harder lumps left on the screen, one man was able to pound out gold at the rate of $100 per day in a common hand-mortar.

The cut in the claim of McLaughlin and O'Riley was slowly opened. The prospectors had no idea of the black rocks which were mixed with the surface sand and threw them away with their other screenings. At a depth of four feet from the surface a seam of this black rock was uncovered from one to three inches in width, but increasing in size as its downward course was traced; this was looked upon as a hindrance to their work.

A few sample pieces of the black rock were carried out by visitors and reached Melville Atwood, a skillful assayer. The result of his assay showed a value per ton of $3000 in silver and $876 in gold. The richness of this sample was made known to James Walsh of Grass Valley, California, who set out at once with a party for the new district. They reached the district July 1, 1859 and determined the yellowish sand to be a rich chloride of silver, and the black rock was found to be a well defined vein of silver sulphides.

The indisputable richness of the ore had created widespread excitement, and every foot of the Comstock and of the parallel veins, was not only quickly claimed, but was doubly claimed in most instances. The locations generally overlapped each other - a circumstance that gave rise to the expensive litigation in which the principal mining companies were involved for the first four or five years.

Exploration and Development

The seam of black silver ore running through the claims of the Central and Ophir companies, formerly the claims owned by O'Riley, McLaughlin, Comstock and Penrod, had been rudely developed by digging large pits following its course downward; and the rich ore had been cut out with picks and raised to the surface. The quartz body was a broken seamy ledge 20 feet in width, inclosing a vein of sulphides from four to fifteen inches wide at the level reached by the pits in November 1859, 30 feet from the surface.

The Ophir Company employed ten miners at wages from $3 to $4 per day, and by November had sunk two inclined shafts to the 30-foot level, opening up the ledge at this point by a large excavation. The Central Company had an equal number of men employed and the bottom of their shaft had reached the same level.

No systematic work was undertaken by any other companies during 1859, except by the Mexican Company, which by the end of October had just reached the sulphide vein. The development of these three mines was delayed for some time due to the influx of water at the 50-foot level.

In the numerous claims worked by the original locators, any man who was strong enough to swing a pick was accounted competent to sink a shaft or drive an adit. Hence in many workings the sides or roof were frequently caving in upon the unexperienced laborers, or again, the adit missed the line of the ledge in view, and the drifts and cross-cuts were crooked and ill-ventilate When two partners disagreed in regard to the best method of developing, their prospective vein, work begun on a given line by one shift of men would be abandoned shortly afterward by the next shift, who would open their cut in a new direction. Some claims were systematically developed, but the great majority were opened to suit the notions of the individual owners, and development was suspended or pushed according to the feeling of the hour.

The poor development of 1860 was serviceable in proving conclusively that organization and capital were essential to the profitable development of the great body of claims in the district. Informal associations with no means of insuring persistent work or equal apportionment of expenses were clearly ineffective. To supply this recognized need, mine owners began to incorporate as companies. By this plan of organization the work of mine development

was placed in charge of a single executive. The necessary funds for carrying on the development work were supplied by the levy of assessments or by the sale of reserved shares of the capital stock.

North of the Ophir mine, three companies were at work in the spring of 1862, washing away the hill soil with hydraulic streams. The Cedar Hill Float Rock and Surface Mining Company, the first to begin work, had a stream of only 50 feet head, but the Cedar Hill Float Rock and Surface Mining Company No. 2 and the Virginia City Hydraulic Mining Company had constructed a large reservoir fully 600 feet above their placers, and the water was conveyed through a flume to the desired point of use.

The hydraulic or surface mining was merely an incidental accompaniment of the great task of exploring the depths of the lode as a new era of development was coming into being. Shafts and drifts were cut without some reference to the lines followed in adjacent mines; connections were established systematically between adjoining levels. The old line of works were generally abandoned and operations were carried on through a new line of substantially constructed vertical shafts several hundred yards to the east of the lode croppings. Generally at 100-foot intervals, openings were made into stations with a floor surface of 100 square feet or more. From these stations cross-cuts were extended through the country rock until they reached the hanging wall of the lode and the cut prolonged, either partly or entirely, across the lode. From this cross-cut, drifts were extended lengthwise through the lode, and cross-cuts from these drifts at different intervals explored the lode more or less thoroughly. Winzes cut from one level to the other, cut at different angles, completed the schemesof exploration and secured more perfect ventilation throughout the mine.

When the shaft reached the hanging wall of the ledge, its course was commonly changed to conform with the dip of the ledge. This incline might be continued indefinitely or a new shaft cut from a point still farther to the eastward and the same plan of exploration adopted. Cross-cuts and drifts were extended from the incline levels as from the shaft. The disadvantage of hoisting the ore around the angle formed by the shaft and incline was offset by the expense of constructing a new shaft and of excavating cross-cuts to the hanging wall. The character of the rock through which the incline must pass and the comparative perfection of the vertical, generally decided the question in favor of the vertical shaft.

The new vertical shafts were divided into three or four compartments, the Curtis Shaft of the Savage Mining Company being an example of the better class. This contained a pump compartment 5 feet by 6 feet, two hoisting compartments, and one sinking compartment, by which the shaft was excavated, equal in size to the pump compartment.

The shaft timbering consisted of framed sets of square timbers, placed horizontally, 4 feet apart, and separated by uprights or posts introduced between them. Cross-timbers, for the partitions between the compartments, formed a part of every set. The whole was covered on the outside by a lagging of 3-inch plank placed vertically.

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The outer timbers of each set were 14 inches square and the posts, ten in number, were of the same size. The divider timbers were 12 inches square. The partitions were made of two pieces of timber, one above the other, at each set leaving open spaces of about 3 feet between the sets.

The method of putting shaft timbers in place while sinking was as follows: When sufficient ground had been excavated below the last set of timbers for putting in the lower set, the sill pieces, already framed for receiving the ends and having gains cut for the posts and ties, were lowered down and put approximately in place, being hung by chains to the last set already fixed above. The sill pieces were usually in two parts, each about 13 feet long, butted together in the middle without splicing or framing. The ends, cross-pieces and posts, were then fitted as nearly as possible into their proper places. This being done, several long, round iron bolts, each made in two parts with a tightening screw in the middle, were passed through the new set and the one or two above. Everything being milled approximately in its place by means of the tightening screws on the bolts by which it then hung to the set above, the lagging was then put in behind the timbers; and between the plank and the ground were forced wedges thus holding everything by lateral pressure.

Nearly all of the deep shafts of the Comstock mines required more or less timbering. A portion of the Yellow Jacket Shaft, passing through heavy ground was timbered with double sets--an outer set inclosing the ordinary single set. In 1870 several hundred feet of the shafts were retimbered with 14-inch timbers which were placed close to each other thus making a solid casing 14 inches thick.

In the Chollar Potosi shaft the sill pieces were made in two parts of unequal length, and in each succeeding set these pieces were so placed as to break joints.

A good understanding of the cost of shaft sinking may be obtained from the following cost of sinking a 7 by 26 foot shaft as shown by the Gould and Curry records:

225 feet from the surface	$ 70.21	per foot
200 feet next following	100.88	" "
200 " " "	135.34	" "
67 " " "	189.50	" "
187 " " "	324.99	" "
250 " " "	342.65	" "

Main working drifts were 6 feet high in the clear, from 3½ to 4 feet wide at the top and somewhat wider at the bottom, supported where necessary by timbers from 8 to 12 inches square. Temporary prospecting drifts and winzes were much smaller and generally left untimbered.

The tunnel sets were placed 2 to 6 feet apart according to the nature of the ground. Lagging placed several inches apart, was often preferred in heavy swelling ground, as the pressure broke in the pieces of scantling before affecting the stronger timbers of the tunnel. By picking down the intruding clay and relieving pressure, the more expensive timbers were saved.

The cost of tunneling in the Gould and Curry mine, the length of the tunnel being 1,465 feet is as follows:

Excavation	$ 10.87	per foot
Timber	2.13	" "
Lumber	.37	" "
Spiling	.55	" "
Framing and placing timber	.66	" "
Track iron and screws	.22	" "
Picks and drills	.39	" "
Powder and fuse	.21	" "
Candles	.45	" "
Air boxes	.23	" "
Total....	$ 16.08	per foot

Drilling and Blasting

During the "Early Comstock" period of mining, all rock drilling was accomplished by hand, either "single jacking" or "double jacking". In "single jacking" the miner would turn the drill with one hand while striking it with a 3½ to 4 pound hammer held in the other hand. The drill was usually 3/4 of an inch in diameter having a 1½ inch bit and the hole was usually bottomed at a depth of 3 or 4 feet with a 1 inch bit. The average rate of drilling was usually 1 foot per hour.

In "double jacking" one man turned the drill while another struck it with an 8 to 10 pound hammer. The drill was usually 7/8 to 1 inch in diameter having a 1 3/4 inch bit and the hole was usually bottomed at a depth of 6 to 8 feet with a 1¼ inch bit. The average rate of drilling was usually 1½ feet per hour.

Machine drills had been introduced in Europe in 1861 but were in their infancy and very inefficient. These drills could rarely drill to the depth of a foot without requiring repairs with a resulting cost above hand drilling.

The Burleigh drills, used in the Hossac Tunnel in Massachusetts were much better machines than the first drills, but still the average useful time before requiring repairs was only five days and as late as 1869 the average number of drills in the repair shops was double the number of those in use.

It was not until 1873 that the first Burleigh drills were put into successful use in the Crown Point mine. The Burleigh drill was first put into use in the Sutro Tunnel on April 25, 1874. The machine operated under 60 to 70 pounds per square inch air pressure, had a speed of only 300 blows per minute yet weighed 550 pounds. The labor cost with the drill was 33 per cent less than that of hand labor and the progress per foot was about three times as fast.

During the first six years after the discovery of the Comstock Lode, 1860 to 1865, approximately 57½ miles of underground workings were completed. This great amount of work accomplished by hand drilling can probably be credited to the high type of labor employed as well as to the soft character of the ground encountered. An idea of the type of labor employed may be gained from the report of the Unted States Commissioner of Mines and Mining made in 1866 which stated that 20 men in the Comstock mines could accomplish as much as 100 men in the mines of Mexico.

Nitroglycerin was discovered by Sobraro in 1856 and the Comstock mines were probably among the first to adopt it for under-ground rock blasting with hand drilling. Both black powder and liquid nitroglycerin were used for the purpose of blasting until the general adoption of dynamite that came after the invention of the machine drill. A. B. Nobel invented dynamite and the fulminate of mercury cap in 1867 and most of the Comstock mines were "experimenting" with this new explosive as early as 1868.

Method of Mining

At the 50-foot level the vein of black sulphides was only 3 or 4 feet wide, and could readily be extracted through a drift along its line, propping up the walls and roof when necessary by simple uprights and cap-posts. With depth the sulphide vein grew wider until, at a depth of 175 feet, it was 65 feet in width. The miners now were at a loss as to how to proceed, for the ore was so soft and crumbly that pillars could not be used to support the roof as in coal mines. They spliced timber together to hold up the caving ground, but these jointed props were too weak to withstand the pressure upon them, and were constantly broken. To insure the safety of the miners it was necessary to install "timber cribs" which consisted of building a pillar of timber from the foot to the hanging wall. This method of supporting the ground was very expensive due to the excessive amount of timber used and the time required in building of the cribs; consequently, it was very desirous that a new method of mining be devised that was suitable for the extraction of the type of ore bodies found on the Comstock Lode.

In 1860 at the request of a trustee of the Ophir Company, a young mining engineer, Philip Deidesheimer was authorized to inspect the workings of the Ophir Mine and to make such changes in the method of timbering as should seem to him expedient. After examining the vein he designed a system of timbering which proved to be exactly adapted to the requirements of the work. The plan was to frame timbers together in rectangular sets, each set being composed of a square base, placed horizontally, formed of four timbers, sills and cross pieces from 4 to 6 feet long, surmounted at the top by four posts,

from 6 to 7 feet high and cupped by a framework similar to the base. The cap-pieces forming the top of any set were at the same time the sills of the next set above. These sets could readily be extended to any desired height and over any given area, forming a series of horizontal floors. The spaces between the timbers were filled with waste rock or with wooden braces.

Mr. Deidesheimer's device of square set timbering would have obviated the chief practical difficulty encountered in the early development of the mines had it been uniformly applied which was not always the case.

When the snow on the slopes of Mount Davidson began to melt in the spring of 1862, the descending water softened the ground and rendered the earth non self-supporting. The roof and walls of the excavations gave way and many mines were completely closed. On the morning of July 15, 1863, half of the Mexican Mine, from the surface to the depth of 225 feet, caved in bearing the mass of crumbling rock and splintered wood past the limits of the mine into the workings of the Ophir Company.

Twenty months later on March 5, 1865 another great cavein, which was so violent that the engines were thrown out of place, rent the surface of Gold Hill. So great was the concussion of the atmosphere that fragments of rock were thrown more than 300 feet, up the Imperial shaft, against the roof of the hoisting works, with such force that they were instantly powdered.

The series of cave-ins served to show the mine superintendents that careful and well planned timbering should be exercised. By 1870 there had been developed a plan of stoping and timbering that rendered the mines safer to work in.

After driving two levels to the ore body, the top and bottom drifts were connected by a winze thus creating a circulation of air. Now that the stoping was begun, the work progressed upward; the ore, as fast as it was removed from place, was thrown down to the track level. The ore could generally be worked with a pick without the aid of powder, though blasting was sometimes required. The waste was sorted as well as possible and retained underground for the purpose of filling the excavated stopes. The waste rock mined to supply sufficient material for filling cost from $1 to $ 2 per ton. In 1870, $23 per ton ore was deemed worthless and was used for fill. For the purpose of fill, drives 30 or 40 feet long were driven into the country rock. These drives were securely timbered. At the end of any such drive, a chamber was excavated, about 10 or 12 feet high and 20 to 30 feet in diameter; the roof, during excavation was sustained by a few posts. When the chamber had attained the desired dimensions the slight supports were removed. The opening caved, supplying the material which was wheeled out and dumped into the slopes. As the loose material was removed more caving took place thus affording a supply for some time. The stopes were timbered by square sets which have been described before.

The timbers were usually 12 inch, square-hewn or sawed. They were framed with much care by hand so that the various parts fit snugly together.

In commencing the timbering of a stope, the ground sills were laid parallel with the direction of the stope, and were frequently timbers of sufficient length to furnish as the sill for several sets. The sills being laid and the cross

pieces adjusted in positions, the posts were raised and the cap timbers fixed in place. Wedges between the sets and the unexcavated ground were used to hold the timbers in place.

After a set of timbers had been introduced and put into place, a floor of 3-inch planking was laid upon it, to serve as a footing for the workmen in the space above.

In working a stope, the whole width of the workable ground was taken down at once and timbering supplied in its place, the advancing breast of the stope being carried forward from wall to wall.

As soon as the ground set was put in and sufficiently advanced in the direction of the stope, the next set above was placed on the first of those below; both then progressed at about the same rate, the lower floor being kept sufficiently in advance of the upper to furnish platform and working room for the men above. As the work progressed, one set or floor was raised above the other until the station above was reached.

When it became necessary to extract the ore as speedily as possible, they began at the same time, a floor on the level of the station and another floor halfway between the given station and the one above.

The following statement for the cost of timber and lumber consumed in the Savage Mine per ton of ore produced gives an idea of the average cost of timbering.

	1867	1868	1869
Extraction of ore	$ 0.63	$ 0.51	$0.42
Prospecting work	.12	.13	.16
Accessory work.....	.13	.24	.34
Improvements	.10	.06	.03
Total per ton	$ .98	$ .94	$ .95

Underground Transportation

The early appliances for removing the ore and waste rock were of the simplest kind. In some mines the ore and waste was carried out through the adits in hand cars, pushed by the miners over a tramway or wooden flooring. In the Mexican Mine the rock was conveyed to the surface in rawhide sacks, bound with a strap over the forehead. By 1870, however, underground transportation had developed in accordance with the other improvements on the lode.

The ore, as it was worked out was thrown down to the track level of the station below, either falling upon the floor of the drift or into a bin, whence it was loaded into a drift car and carried to the shaft where it was hoisted to the surface upon a cage.

The car in general use was made of wood and had a capacity of 1,600 to 1,800 pounds. The box was made of planks 1½ to 2 inches thick, lined with sheet iron and strengthened with iron bands on the outside. It was 3 feet 10 inches long, 2 feet wide and 2 feet 4 inches deep. The truck was a stout frame of four timbers, the two longitudinal pieces having their front ends beveled off to admit the car being dumped. The cast iron wheels were about 12 inches in diameter,

turning on the axles, which were fixed on the truck. The track was usually 18 or 20 inches wide and consisted of wood shod with iron. The front end of the car was hinged at the top to swing as a door for the discharge of the contents. It was closed by a button that could be turned up to confine the door or turned down to release it; the button was fixed on an iron rod passing under the car to the back and was controlled by the trammer. An iron rod at the back end of the car served to prevent the box from swinging on its pivot and was so connected with the rod on which the button was fixed that the door of the car could be opened and the box made free to swing to either side by the same movement on the part of the carman. The weight of the car was from 400 to 500 pounds.

Hoisting

For more than a year the ore from the Ophir and Mexican mines was brought up in rawhide buckets on the backs of Mexicans who climbed steps cut in logs placed at an incline from level to level.

In 1860 the Ophir company first raised ore with steam power by means of a rope wound around the shaft of their pumping engine, thus pulling a car filled with rock up the incline. In other mines the rock was raised to the surface in buckets through the shaft by means of a rope and windlass.

As the shafts grew deeper, the simple windlass was replaced by whims turned by horse power and small steam hoisting engines. By 1864 whims were used by the major mines on the lode. One horse turned the whim easily hoisting a bucket 50 feet with every revolution of the drum. The cost of operating a windlass by two men during three shifts of eight hours each was stated to be $24 while two drivers and two horses would hoist the same quantity of rock by means of a whim at a total daily expense of $12.

As steam power hoisting-engines gradually replaced the windlass and whim, iron framed cages from 4½ to 6 feet high were used instead of the clumsy iron buckets or skips. Wooden guide rails on the sides of the shaft compartments regulated the motion through the shaft. Round iron-wire ropes were substituted in some mines for hemp cables, but with indifferent success owing to the poor quadity of the material and the faulty design of the reel. In September 1863, the first flat iron-wire rope was made for the Sierra Nevada mine. It was woven in two coils, each 700 feet long, and was 4 inches in breadth by ½ inch in thickness. It was warranted to raise 10 tons, and was an important improvement upon the ropes in ordinary use, as it was less liable to slip on the reel. Cables of similar design, but made of braided steel wire, were adopted later by the majority of the mines.

The loaded cars at the stations were put on to the cages and successively raised to the surface. As the cages in common use until 1871 had only one compartment, it was necessary to raise the cars singly. The average speed of hoisting was 700 feet per minute, and 400 tons in a day of 24 hours was esteemed an extraordinary amount to extract and raise to the surface through one shaft.

The cages in general in 1870 were constructed as simply as possible. The bottom of the cage was a simple platform formed of wrought iron bars firmly joined together and covered by a floor of wood with pieces of track on which to receive the car. The two sides of the cage were made of a stout frame-work of iron 7 or 8 feet high connected at the top by a central cross bar. Above this was a stem of iron which attached everything to the hoisting cable. The two sides of the cage were open.

The cage was guided by two vertical 4 by 6 inch strips of wood one on either side attached to the lining of the shaft. Attached to the cage on each side, near the top and bottom were iron flanges so made as to embrace the wooden guide rods.

The various devices applied for safety in case the cable or winding apparatus should break, differed a good deal in detail of construction. They generally depended upon a spring so fixed, with regard to the rod by which the cage was attached to the cable, as to be compressed while the weight of the cage exerted any strain upon the cable; but if the strain was relaxed, the spring was permitted to act upon some mechanical contrivance by means of which stout iron teeth were forcibly caused to grasp the guides along which the cage was moved.

Another appliance for insuring safety was one known as the Eccentric. This consisted of two round shafts which extended across the cage parallel to the center cross-bar. They were held by the frame of the cage in such a manner that they could revolve freely, and their ends were opposite the wooden guide posts. To each end of these two rods were attached eccentrics, which were circular pieces of cast iron supported in an off-center position by the shafts. That part of the circumference of the circle which was nearest to the point of support was smooth, but that which was more remote was furnished with teeth. Each eccentric rod was furnished with a chain, one end of which was fixed to the rod, and winding around it was attached at the other end by a bolt which passed through the cross bar. Between the head of the bolt and the cross-bar a strong steel spring was interposed, which when compressed caused the shaft to revolve in such a manner as to bring the teeth of the eccentrics into contact with the guides. The chains were attached so that while there was any strain in the cable, the eccentric teeth were turned away from the guides. If the strain in the cable was relaxed, the springs acted upon the shaft to turn the eccentric teeth toward the guides, thus preventing the fall of the cage.

The cage was sometimes furnished with a hood or covering of iron for the purpose of protecting the men from the danger of the cable in case of breakage, or other bodies falling in the shaft.

When the cage arrived at the surface it was kept at a fixed point, level with the floor at the landing, by supports on which the cage could rest. These supports consisted of four tappets, two on each side of the shaft, just below the floor. They were fixed upon a light iron shaft which could be partly revolved, turning the tappets upward entirely out of the path of the cage when the latter was to be lowered. The cage in ascending raised the tappets while passing; then they fell again into place and the cage was ready to descend again, it was first raised, the tappets were turned up out of the way by means

of a lever within reach of a lander, and held in that position until the cage had passed down.

While on the cage platform, the car was held securely in place, either by hooks fitting into staples in the body of the car, or by tappets which if fixed under the platform could be turned up so as to block the wheels of the car or turned down again to permit its exit.

The transportation of the men between the surface and the underground works was done entirely by the means of cages. No ladders were employed for this purpose.

The engines employed for hoisting in 1870 were in most cases horizontal, non-condensing engines.

The winding reels or drums were operated either by cog or friction gearing. As the depth of the mines increased, cog-gearing replaced friction-gearing. The friction wheel was attached to the drum in which the cable was wound. The brake-strap was usually a band of iron 4 or 5 inches wide, which encircled the rim of the drum and could be made to grasp it tightly, thus arresting the movement of the drum.

Where cog-gearing was employed the motion of the engine was imparted to the shaft carrying the drum by toothed wheel and pinion.

Many variations of hook-ups between the drum and the engines were made so as to allow hoisting in counter-balance and allow cages to be raised and lowered without changing the direction of the engines.

Flat ropes were wound on narrow reels, the width of which was not much greater than that of the rope. These reels were usually a central wheel of cast iron, 6 or 8 feet in diameter, to which was bolted a number of wooden arms, making the total diameter about 12 feet. They were sometimes cast with a rim for the application of a brake.

The sheaves were made of wood or iron 8 or 10 feet in diameter, and were supported by a gallows frame.

The position of the cage in the shaft was shown to the operator by an indicator, connected with the winding machinery. An indicator usually consisted of a dial, around the center of which a pointer revolved showing by means of points marked upon the circumference, the position of the cage in the shaft.

The cages in the shaft were hoisted, lowered, or stopped by the engineer in answer to signals communicated to him from below. These were usually given by pulling a bell-wire, hung in the shaft by means of which a gong or steel triangle was rung at the surface, the number of strokes indicating whether the cage was to be raised or lowered. In 1868 the Savage Company introduced a method of signaling by electric telegraphy. It gave satisfaction for a time, but was afterward given up owing to certain difficulties.

When the cage arrived at the surface, the loaded car was received by an attendant and disposed of according to its character. If the contents of the car

were milling ore, it was moved to an ore bin; if the car contained waste-rock, it was put on the waste dump.

Mine Drainage

When the inclines sunk by the Ophir, Mexican, and Central Mining Companies were advanced to a depth of 50 feet, water began to flow into the shafts so rapidly that further progress in depth was deferred. The accumulating water was drained out through small adits cut to the foot of the inclines from points below the croppings.

The Ophir Mining Company transported from San Francisco a small steam engine rated at 15 horse-power, the first on the lode. By the aid of this engine hoisting a tank fitted with a spindle valve at its bottom, their incline was continued along the dip of the ledge, while an adit was contracted for by the Mexican, California, Central and Ophir Companies to drain the ledge to a depth of 200 feet. Work upon this adit, the "Union Tunnel," was begun June 8, 1860 and pushed night and day until October 17, 1860. The lode was cut 155 feet below the surface. This adit 1,100 feet long, 4 feet wide and 5½ feet high was completed at a cost of $10,000 or $9 per foot. It was soon connected with the inclines and development was continued.

As the shafts progressed in depth, longer adits were cut to serve as drainways for the water. Small pumping engines were also set up at the principal shafts of the lode, 12 being in place at the end of the year 1862. By these combined methods, the mines were kept comparatively free from water until 1864.

In January 1863, a miner drove his pick through a clay seam in the Ophir mine and a spout of water followed the blow which caused the miners to flee for their lives. Fifty hours after its outburst, the water had formed a subterranean lake in the mine 21 feet deep, 30 feet wide and 100 feet long.

When the Best and Belcher Company started their new pump of 12 inch bore on April 26, 1864, the water in their main shaft was 30 feet deep and work had been suspended for sometime. The Crown Point Company gave up the attempt to lower the water in their shaft June 10, 1864. The Overman Company suspended operations during the same month, and in the Yellow Jacket Mine a body of water was tapped at a depth of 315 feet below the surface filling the workings to a depth of 20 feet.

The Ophir Company had just succeeded in pumping out the reservoir opened in January 1863 when on the 25th of December 1864 another great water-pocket was tapped filling the shaft to a height of 160 feet.

A cheap and effective method of freeing the mines from water was needed. The Gold Hill and Virginia Tunnel and Mining Company answered it by beginning the construction of a tunnel in the summer of 1863 to pierce the lode at a depth of 800 feet. In May 1864, it had been advanced 840 feet being 7 feet wide at the bottom, 6½ feet high and 6½ feet wide at the top. Due to a panic in mining stocks in the summer of 1864 the project failed. When a revival of the plan seemed probable, a new plan of extraordinary proportions was brought to the attention of the mining public.

By an act of the Nevada State Legislature, approved February 4, 1865, the Sutro Tunnel Company was incorporated, and the exclusive privilege granted for the ensuing 50 years to construct a tunnel extending from the foot hills of the Carson Valley to the Comstock Lode. The proposed length of this adit was 20,489 feet, and it would cut the lode at a depth of 1,633 feet and 8 inches below the nearest mine's workings.

Mr. Sutro succeeded in obtaining contracts in April 1866 from 23 of the principal mining companies. By these contracts the companies which signed the agreement bound themselves to pay the sum of $2 for every ton of ore extracted from their mine after the extension of the tunnel was within their boundaries. It was provided that the tunnel should not be less than 7 feet in height and 8 feet in width in the clear, with a grade of not less than 1 foot to the 100 feet. The privilege was granted to the companies of transporting men, ore, waste, timber, tools, and other materials through the tunnel on the payment of stipulated sums.

To guarantee the completion of this drainway within a reasonable term of years, the Sutro Tunnel Company contracted to secure subscriptions amounting to $3,000,000 before the 1st of August, 1863.

Mr. Sutro had difficulty in securing the required subscription. He went before the United States Congress and had his rights confirmed and in addition obtained certain mineral rights to the veins he might cut in driving the tunnel. Mr. Sutro did not have time to fulfill his contract and the companies would not grant him an extension. Due to the installation of better pumps, the mines were holding their own against the water and some thought that the mines were getting below the surface water level. This condition plus the power of the Bank of California banking interests defeated the project for the time being.

The pumps usually employed from 1865 to 1870 were either lifting or force pumps. In a complete set of deep pumps the two kinds were combined, the former being applied to raise the water from the bottom of the shaft to a height adapted to the capacity of a single pump, and the latter to force the water thence upward to the point of discharge.

The motion of the plunger was imparted to it by a pump-rod, a continuous piece of timber, which was suspended in the shaft along side the outflow pipe, and to which the plungers were attached. The pump timbers 8, 10 or 12 inches square were joined to each other by splicing so as to form a continuous piece.

The motion of the rod was communicated to it from the engine by means of an oscillating "bob", established at the surface. The pumping engine driven by means of the pinion, the pump wheel to which was attached one end of a pitman. As the wheel was set in revolution by the engine, the pitman received a reciprocating motion, the length of the stroke being determined by the distance of the wrist pin from the center of the wheel. The other end of the pitman being connected to the king-post of the "bob", caused that to oscillate, giving the pump-rod in the shaft an upward and downward motion.

The length of the stroke varied from 3 or 4 to 6 or 8 feet, and the number of strokes per minute varied from 3 or 4 to 10 or 12. The ordinary working capacity of the pumps employed was about 250 gallons per minute.

In the Gould and Curry Mine, work in the lower levels had been suspended in 1866 owing to the water encountered, and during 1867 a new pumping engine was at work. Even in the spring of 1868 the influx was still so great that it was necessary to put in additional pumps. In June of the same year it was reported that four pumps were still in constant operation.

Exploration in the Ophir mine had been practically abandoned, since 1865, owing to the entering floods of water. During the autumn of 1867, the Company decided to sink a new shaft and cut the lode at a lower point. Water was encountered when less than 50 from the surface, and it was soon found necessary to put up a pumping engine which, in conjunction with the hoisting tanks could raise 300 gallons per minute. The pumps were of 10" diameter with a 6-foot stroke, giving an estimated capacity of 24 gallons per stroke. With the pump making from 6 to 8½ strokes per minute, it was possible to continue the work. On June 10th, the shaft being 287 feet deep, two 12-inch plunger pumps were substituted for the two 10-inch pumps then in use, the pumps raising 1,000 tons of water every 24 hours. In October, 1869, a water chamber was cut, and the flood rose constantly in the shaft, though the pumps were worked at their full capacity and were discharging 20,000 gallons hourly. On the 6th of November, the water was 270 feet deep in the shaft, covering the lower pumps, which soon ceased to work. A new engine was set up to raise two boiling tanks holding 800 gallons, and early in December, with pumps and tanks in full operation, the fight was renewed more and more until April 1, 1870, when the shaft was drained. On January 2, 1872, when the new superintendent, Philip Deidesheimer, assumed charge of the mine, three 12-inch plunger pumps and one 10-inch pipe were in service and 146,000 gallons of water were raised daily from a depth of over 1,200 feet. The direct and indirect costs to the Ophir Company caused by the presence of water in their mine was estimated at $6,000 monthly.

Since 1867 Mr. Sutro had been endeavoring with tireless energy to raise money for the prosecution of his proposed tunnel. He succeeded in September, 1871 in obtaining a subscription of $650,000 to the stock of the company which increased shortly afterward to $1,450,000. Work at the tunnel was immediately pushed on an enlarged scale. As many laborers as could be employed to advantage were engaged; the necessary machinery was bought, and the project became the greatest mining enterprise in America.

Mine Ventilation

During the earlier years of work on the Comstock Lode little or no difficulty was experienced in effecting free ventilation of the mines, the underground works being in communication with the surface either by adits or connected shafts in such a manner as to insure easy circulation of air.

As the depth increased and work had to be done at points not reached by the ordinary circulating currents of air in the mine, various simple and well-known means were employed to supply fresh air to the laborers. One of the simplest and most efficient appliances for that purpose used in the Gould and Curry

was the water blast, consisting of a wooden box-pipe standing in the shaft some 200 feet high and connected at the bottom with an air pipe. The object of the blast was to supply air to the laborers in the end of drifts. The top of the box pipe was open and a finely divided shower of water was caused to fall into the box carrying down with it a volume of air. The bottom of the pipe dipped into a box 2 or 3 feet long and 15 inches deep, in which the water was allowed to stand above the bottom of the pipe, and from which the excess escaped through a sliding gate. Connected with the water pipe just above the box was the air pipe leading to the point to which fresh air was to be forced. The air coming down the standing pipe with the water, and having no other means of escape, was driven along the horizontal air pipe and delivered to the desired point.

In 1870 the deeper mines found the lack of good air and the increased heat sources of much trouble/and were forced to more costly means of ventilation. For this purpose the air was forced down into the mines by means of a Root's Blower. At the Ophir mine a No. 5 machine was used, the drum being 4 feet long. It was driven by a small engine and was calculated to run 300 revolutions per minute.

For conveying the air down the shaft and along the drift a square, wooden box-pipe was used. When these blowers were first introduced the conveying pipes were made of galvanized iron; but this material was not proof against the corroding influences of the water in the shafts. Air-boxes of pine wood were used next, but the tendency of this wood to split and crack caused them to leak very badly. The best material in use in 1870 for this purpose was the redwood of California. The air-box was made of dressed lumber 1½ inches thick, and was about 12 inches square in horizontal section. The four sides of the box were tightly joined together with tongue and groove and the ends of the sections of the pipes were connected by letting the lower end of the upper section into the upper end of the lower section. An iron band was put around this joint which was well packed and then covered with a thick coat of paint. The pipe was supported by clamping it to the timber sets in a corner of the pumping compartment. The cost of this air pipe in place was about $1.50 per foot. The cost of the blower used at the Ophir mine was $700.

Underground fires had broken out in previous years, but had been extinguished without loss of life. Thus, in March 1866, afire in the 260' level of the Empire mine, had spread with such swiftness that the men at work in this and neighboring mines were driven to the surface by an overpowering volume of smoke and gas. Powerful engines threw streams of water down the shaft, but the climbing flames reached the surface. For hours the shaft was a reeking pit but the fire died out finally, two days later, for want of fuel to feed upon. Seven months later another fire was discovered in an upper level of the Ophir mine, alarming the miners by the dense smoke which poured forth, but soon extinguished by their prompt action. Thus in April 1869, when the warning cry of fire was heard in the Crown Point mine, it was not considered dangerous. The fire originated in the 800- foot level of the Yellow Jacket mine on April 7. When the timbers had burned away unnoticed, the supported rock fell and expelled a blast of fould air and smoke through connecting drifts into the shaft of the Crown Point and Yellow Jacket mines. It was the hour when the shifts were changing so that fewer men were at work in the mine than usual. Dense volumes of black smoke began to rise up the Kentuck, Crown Point, and Yellow Jacket mine shafts, and the alarm was given.

All possible efforts were made by superintendents and miners to rescue the doomed men. As soon as the smoke cleared away somewhat from the Yellow Jacket Shaft, owing to a strong draft which began to go down that mine and up the Crown Point Shaft, small parties of miners and firemen went down repeatedly into the burning pit and at 10 o'clock the first bodies were removed.

Thirty-four miners were dead and missing. About midnight it was decided to descend through the 900 foot level of the Yellow Jacket mine into the lower levels of the Crown Point mine, and with the aid of a blower furnishing air in the lower levels, they succeeded in bringing out several of the missing miners.

Streams of water were kept constantly playing on the heated rock of the walls. Fresh air was pumped into the drifts by blowers and new flames would be started. For 72 hours steam was forced into the mines. On April 12 a stream of water was thrown down the Crown Point Shaft in order to purify the air as much as possible and after several attempts more bodies were removed.

Upon the failure of the desperate attempt to extinguish the re-kindling flames, steam was again injected until the 14th of April, and three days later the Yellow Jacket Shaft was reopened. During the days immediately following, all passages connecting the Crown Point and Kentuck mines were carefully closed with bulkheads. On April 23 ore was hoisted from the upper levels of the Kentuck mine; but on May 3rd, it was found necessary to close both the Kentuck and Crown Point Shafts as the fire between the 700 and 600-foot levels seemed to be gaining. When the shafts were reopened, May 18, 1869, work could be resumed by degrees. Even six months later men working in the upper levels of the mines would occasionally drive their picks into a recess where brands were still smouldering; and once several miners were asphyxiated by a sudden influx of gas while extracting ore.

Milling and Marketing

In 1858 a few rude attempts were made to crush the rock cropping near the canyon and extract their metallic contents. A small association, named the Pioneer Quartz Company located several lodes. An arrastra was built to reduce the quartz. Four or five tons of rock were hauled down into the ravine and put into the arrastra. The two mules attached to the beam walked around in a beaten circle for 3 weeks and succeeded in pulverizing about 1/10 of the rock. At the end of this time, the resulting amalgam was retorted and 3½ ounces of bullion were obtained which was sent to Sacramento and a return of $42 was made. The project was given up.

As the hole on the Ophir claim was dug deeper, a harder stratum of earth was cut which could not be washed to advantage in the rockers. They had crushed the clotted masses with picks and sledge hammers, but the work was too laborious and they determined to procure an arrastra. Accordingly on June 24, Joseph Osborn and John D. Winters were given a 2/6 undivided interest in 1,400 feet of the Ophir claim in consideration for the supply of two arrastras and two horses.

The first consignment of ore from the mines was carried to San Francisco by James Walsh and Henry Comstock, who arrived August 30, 1859. They sold their freight, 3,151 pounds in all, for $1.50 per pound without difficulty. This success induced the owners of the Ophir claim to ship their rich ore to San Francisco as rapidly as it could be extracted and before November 1, 1859, 38 tons had been shipped. The gross yield of this ore when crushed and smelted was $112,000 so that

the profits of the Ophir Company were very large although the expense of the reduction was $412 per ton and the freight charges were $140 per ton

During the same season 41,400 pounds of ore were shipped to San Francisco by the Central Company; the gross yield was fully $50,000.

It was known at the outset that the mines could not be opened with success unless a cheap method of reducing the ore was devised. Reduction by smelting was the most effective process, but this was barred, except in the case of the richest ore, by the cost of fuel, labor and transportation. Some ore had been reduced in arrastras, but that method was slow at the best.

Almarin B. Paul, a mill owner of Nevada, California, had been strongly urged by his friends to build a mill in the vicinity of the mines and attempt the reduction of the ore from the ledges. He visited the district in August 1859 and took back with him to his mill in California sample rocks of ore. After a few careful experiments in reducing this selected quartz, he determined to undertake its reduction on a large scale. He persuaded some friends to unite with him in subscribing the requisite capital and the Washoe Gold and Silver Mining Company was formed in March 1860.

Paul began at once to build the proposed mill. The ore could not be reduced without water. A shaft was sunk to a depth of 50 feet and a cross drift cut in the bed rock 100 feet in length, and the well was filled with water. Contracts were secured from owners of claims to crush and reduce 3,000 tons of ore at from $25 to $30 per ton if the quartz would yield a surplus profit to the owners.

In order to obtain this concession Mr. Paul was obliged to pledge the completion of his mill in 60 days from June 12, 1860. The mill machinery had been ordered and the completed castings were forwarded by steamer to Sacramento and from that point by wagon train over the Sierras. The cost of transporting the mill from San Francisco ranged from 13 to 25¢ per pound. Lumber was $60 per M at the saw mill and more than doubled that when delivered. The mill was completed and began to crush ore on the 11th of August.

The first ore worked was five tons of refuse rock previously discarded as too low in values to work. The mortar of the battery was surrounded by a wire bolting cloth, through which the ore crushed dry was washed in a misty cloud by the fall of the stamps, dropping on a platform outside. Here the powder was dampened sufficiently to admit of its removal in shovels to the pans, where it was mixed with water and mercury; the heap thus formed was ground by the revolving mortars. Each pan held about 300 pounds of ore and 40 pounds of mercury, and with each charge a pint of salt and a few ounces of copper filings or copper sulphate were used. Water was conducted to the pans by pipes leading from a tank heated slightly by the exhaust steam from the driving engine. The copper cross-boards in the pan were scraped twice a day, and the amalgam collecting at the bottom of the pan was drawn off at intervals through a discharge hole. When a sufficient quantity of this was thus obtained, it was strained through a buckskin sack until the liquid mercury was pressed out and a pasty mass left in the bag ready for retorting. Placed in a closed iron vessel over a fire, this paste was steadily heated until the remaining mercury passed off in vapor through a pipe into a condensing chamber.

The process was watched with natural anxiety. The five tons yielded $84.56 or an average return of $16.91 per ton. This product from refuse ore was accounted satisfactory, and Paul proceeded to crush and reduce 10 tons of average rock which yielded $55.07 per ton.

Interest in the work was then awakened throughout the camp and many companies wished tests run. The Washoe Gold and Silver Mining Company at once contracted for the building of another large mill of 64 stamps at a point near Gold Hill, the new works being completed January 4, 1861 at a cost of $150,000.

Soon the number of mills in process of erection was totally out of proportion to the quantity of ore so far known to exist. Seventy-six mills running 1,153 stamps, with an estimated crushing capacity of 1,200 tons daily, were erected before the end of the year 1861, and 20 more were planned or being built.

Much money was wasted by the adoption of imperfect mechanical devices and unsuitable processes. Mills were furnished with expensive machinery which failed, upon trial, to reduce ore cheaply or effectively. Money was lavishly expended in the construction and equipment of mills belonging to wealthy mining companies as if drawn from an inexhaustible supply.

The mill of the Ohpir Company was put up in Washoe Valley at a point 12 miles west from their mine. The buildings erected here covered an acre of ground. Besides the main edifice, an immense building was put up for the use of the patio process, which was here employed for a time on the poorer class of ores. The cost of the entire plant amounted to $1,000,000. Besides the crushing mill, carrying 36 stamps, several furnaces for roasting or chloridizing the ores were provided, the Frieberg in connection with the patio process having been practiced here. Rows of huge barrels used for amalgamation and extending the whole length of the mill, were kept in ceaseless revolution. A hundred tons of ore were worked here daily, independent of that disposed of by the patio method.

Up to April 1, 1862 when the mill closed, 21,000 tons of ore had been quarried from the Ophir Mine, but only a slected proportion of 3,000 tons had been reduced. The bullion production was $980,000. If the actual expense of delivering the 21,000 tons on the surface were set at $7 per ton, the sum of $349,200 must have been paid for the reduction of 3,000 tons including freight and office expense.

The official report of the Ophir Mill is as follows:

Amount received for ore and bullion.....	$ 980,000
" expended on capital account //.....	300,000
" " for working expenses	559,200
" paid for dividends.....	100,800
Balance on hand	20,000

The extraordinary mill of the Gould and Curry Company was, however, the most conspicuous monument of inexperience and extravagence ever erected in the mining district. The site for their structure was a small flat at the junction of Six and Seven Mile canyons. The spot was a rugged one, the cost of clearing the ground and preparing for the foundation of the main building having amounted to more than that expended on any mill in the territory. The massive walls laid for the reception of the main edifice, which was 250 feet long with 2 wings 75 feet in length, were constructed of hewn stone. The engine to run the mill was of 150 H. P. There were eight batteries of five stamps, each capable of crushing 40 tons of ore per day. The services of 75 men were required, working in relays day and night.

This company, like the Ophir, entertaining at first a great distrust to the Paul or pan process, employed at the outset the Veatch plan of amalgamation which involved the use of numerous deep tubs, the system being a mixture of the German, the pan and the patio process. Later the pan process was employed altogether. The total cost of the Gould and Curry mill was over $1,250,000. After a successful career of a few years, the current expenses began to drag heavily on the company, and the mine itself giving out, brought operations to a standstill.

By 1870 the milling had become quite standardized and was known as the Washoe Pan Amalgamation process. The ore was crushed wet in five stamp mortars to a fineness ranging from 20 to 40 mesh; the crushed ore was then settled in square vats on the pan floors; the finest of the slime was settled in a reservoir outside the mill. The pulp, after settlement, was charged into fast running grinding pans holding a charge ranging from one to two tons; the pans were either steam-jacketed or arranged to take live steam into the charge. The density of the pulp was such that the quicksilver was kept in suspension while the pans were in motion. The chemicals used were bluestone and salt. The treatment lasted from three to six hours in the pans, which were finally discharged into settlers(a pan of slower motion, to which large quantities of water were added) to insure the settling of the quicksilver with its gold and silver. The pulp was slowly discharged from the settlers, and the quicksilver recovered and strained to secure the gold and silver amalgam, which was then ground in a clean-up pan to remove all impurities, restrained and retorted; the resulting crude bullion was melted into bars of fine metal.

The equipment was as follows: For ten stamps of 900 to 1000 pounds each, four standard two-ton pans were required, together with two settlers and a slow motion clean-up pan, retort, assay office, etc. The actual horse power required was 60, but to provide for extra rock breaking service 75 horse power was generally provided.

Such a mill would treat from 30 to 40 tons of ore per day at a cost ranging from $3 to $7 per ton depending upon the loss of mercury, cost of water, power, etc. In the treatment of the ore such a mill would use 50,000 gallons of water per 24 hours, about 50% of which could be reused.

Mining Districts

In January 1858 some of the miners organized a quartz mining district called the "Columbia Quartz Mining District." They set up their mining laws as follows:

Article 1. There shall be elected one Justice of Peace, one constable, and one recorder of this district for the term of 6 months.

Article 4. The duty of the recorder shall be to keep in a well bound book a record of all claims which may be presented for record, with the names of the parties locating or purchasing, the number of feet, where situated and the date of location or purchase; also to return a certificate for such claim or claims.

Section 7. Evidence of record of claims shall be considered title in preference to claims that are not recorded, nor shall the recorder record more than one hill, dry gulch, or ravine claim in the name of an individual unless the same has been purchased.

Section 8. All claims shall be properly defined by a stake at each end of the claim, with the number of members forming said company and the number of feet owned.

Section 9. All claims shall be worked or the notice renewed in 60 days from the date of record, and no claim shall exceed 200 feet square, hill claims excepted, which may be reduced to 50 feet front.

Section 10. The recorder shall be allowed the sum of 25¢ for recording the claim of each individual or member of a company.

Section 11. No Chinaman will be allowed to hold a claim in this district.

Section 12. This district shall include all the territory from the meridian of Johnstown to Steamboat Valley.

Section 13. All quartz claims shall not exceed 300 feet in length, including the dips and spurs.

Section 14. Any person or persons discovering a quartz vein shall be entitled to an extra claim on all veins he or they may discover.

Section 15. All persons holding quartz claims shall actually work to the amount of $15 to the claims within 90 days from the time of locating.

Section 16. All persons holding quartz claims and complying with section 15 shall hold the same for the term of 18 months as actual property.

Section 17. All quartz claims shall be duly recorded within 30 days from the time of locating.

Section 18. No person shall locate more than one claim on a vein discovered.

Section 19. Any and all persons locating for mining purposes shall have the same duly recorded within 10 days from the time of locating.

Section 20. Resolved, that the above rules and regulations shall be signed by the citizens of the district and all who may locate hereafter.

No one seemed to pay any attention to these laws and on September 14, 1859 it was decided to organize a new mining district termed the"Virginia Mining District" with the following mining laws:

Article 1. All quartz claims hereafter located shall be 200 feet on the lode including its dips and angles.

Article 2. All discoverers of new quartz veins shall be entitled to an additional claim for discovery.

Article 3. All claims shall be designated by stakes and notices at each corner.

Article 4. All quartz claims shall be worked to the amount of $10. or three days work per month to each claim, and the owner can work to the amount of $40 as soon after the location of the claim as he may select, which amount being worked shall exempt him from working on said claim for six months thereafter.

Article 5. All quartz claims shall be designated and known by a name and in sections.

Article 6. All claims shall be properly recorded within 10 days from the time of location.

Article 7. All the claims recorded in the Gold Hill record and lying in the Virginia District shall be recorded, free of charge, in the record of the Virginia District, upon the presentation of a certificate from the Recorder of Gold Hill District, certifying that said claims have been duly recorded in said district; and said claims shall be recorded within thirty days after the passage of this article.

Article 8. (Stricken out by the meeting).

Article 9. Surface and hill claims shall be 100 feet square and be designated by stakes and notices at each corner.

Article 10. All ravine and gulch claims shall be 100 feet in length, and in width extend from bank to bank, and be designated by a stake and notice at each end.

Article 11. All claims shall be worked within ten days after water can be had sufficient to work said claim.

Article 12. All ravine, gulch, and surface claims shall be recorded within ten days after location.

Article 13. All claims not worked according to the laws of this district shall be forfeited and subject to relocation.

Article 14. There shall be a recorder elected to hold his office for the term of 12 months, who shall be entitled to the sum at 50¢ for each claim located and recorded.

Article 15. The recorder shall keep a book with all the laws of the district written therein, which shall at all times be subject to the inspection of the miners of said district, and he is furthermore required to post in two conspicuous places a copy of the laws of said district.

The Workmen

When miners were employed by the different companies in the district, they were commonly expert men, trained in the mines of England, California, or Mexico.

The usual wages for miners were from $4 to $5 per day, and mill hands recieved from $4 to $6. Much of the early mining work was done by contract, the profits of the miners varying with the character of the rock encountered. The usual price paid per foot of linear excavation in ordinary drifts or adits was $5. Powder fuse and drills were furnished by the workmen, but the requisite timbering was commonly supplied by the employers.

On May 30, 1863 the Miner's Protective Association was organized and $4 was decided upon as "a fair day's pay for a day's work". The miners were peaceful when one mine cut the day's wage to $3.50, but they put on a demonstration with much laughter and good will; however, there was enough seriousness and business-like manner that the wages were raised back to $4 per day. The union had won its point but only to lose its glory soon. The superintendents continued to pay $4 per day and gradually weeded out the union men and replaced them with non-union men. The union men saw the disadvantage of belonging to the union. Many miners accordingly ceased to pay their monthly dues and withdrew from the organization. The superintendents seeing that opposition was effectively prostrated and the time was ripe for the change reduced the pay of the miners to $3.50 per day in the spring of 1865. Many of the discontented miners left the district.

If the cost of extraction and reduction had not been cut down, work in a number of the mines would have been carried on at a less in 1866. The rich sulphides of the Mexico and Ophir mines, yielding $3000 to the ton, had been soon exhausted, and the bonanza of the Gould and Curry Company whose milling ore was worth $104 per ton in 1862, furnished $36 per ton ore in 1866. While the cost of extraction in 1862 was $12 per ton and cost of reduction was $44 per ton, these items had fallen in 1866 to $7.86 per ton and $13.57 per ton respectively, for the miners in the service of the Gould and Curry Company were extracting 1.13 tons of ore daily per man. The high cost of labor was offset by energy, skill, and machinery, and the relative cost of production was low.

Another miners' union was organized on the 4th of July, 1867. Provision was made for the care of its members during temporary illness by an allowance which in no case could exceed $80 annually to one person, and an appropriation of $80 was made to defray the funeral expenses of the deceased member. They constrained the mining companies of the district to pay every person employed in underground labor of any kind at the rate of $4 for every eight hours' work.

The union was successful in keeping the wages up until the closing of the mines a few years later.

Ownership and Legal Battles

Although Comstock proclaimed the value of his pretended discovery, he was persuaded to make over his interest in the ledge to a shrewd speculator, without any tangible security. The deed and transfer was drawn and signed, but Comstock was laughed at when his action was known, and he began to think how he might get his mine back again. The speculator was induced to allow a jury of miners to sit in judgment upon the validity of his deed from Comstock. The jury was composed of Comstock's friends, who had indistinct notions of proceedings in equity, but a clearly defined dislike to the new-comers from California who were fast taking control of the district.

Comstock did not long keep possession of the claim. Mr. James Walsh had been quietly testing the silver ore on the ledge and had satisfied himself fully of its remarkable richness. He obtained a bill of sale from Comstock for his interest in the 1,400 feet of the united claims as well as other property of less value for the sum of $10 in cash and the agreement to pay the remaining sum of $10,990 at a later date.

The sale was completed and additional interests were bought up as well by Walsh and others, so that before the spring of the following year, none of the original holders of the first location on the Comstock ledge, with the exception of John D. Winters, retained their shares. Five-sixths of the location were sold for $70,601 or about $60 per foot. The purchasers and subsequent assignees united with John D. Winters in an informal association, which was organized under a corporation charter in April 1860 as the Ophir Gold and Silver Mining Company.

An organization named the Central No. 1, held possession by purchase of the northern 150 feet of the Corey Claim, and the 100 feet reserved by Comstock and Penrod had been transferred on payment of $9,500 to Gabriel Maldanado and Francis J. Hughes, who constituted what was called the Mexican Company.

Informal associations with no strong ties of union and no means of insuring persistent work or equal apportionment of expenses were clearly ineffective. To supply this recognized need, mine owners began to unite as incorporated companies. By this plan of organization, the conduct of the business of the company was provided for in the election of a board of directors. The necessary funds for carrying on the work were supplied by the levy of assessments or by the sale of reserved shares of the capital stock. The Ophir Company was the first to organize in this manner on the 28th of April 1860, with a capital stock of 16,800 shares whose par value was $300. Other associations followed suit in quick succession, and the most promising claims were soon owned by stock companies.

During the early existence of the mining camp no serious controversy as to ownership had arisen. One claim appeared as good as another, but before the close of the year 1860, work upon the principal claims had reached a point where collusion was inevitable.

By the law of the miners the first locators were entitled to the exclusive possession of the section of the ledge included in their claims, with all its spurs and angles throughout the whole extent, or as far below the surface as they and their assignees were disposed to develop it. Planes drawn perpendicular through boundary lines running at right angles with the general strike of the ledge as determined by survey, marked the separation of the different claims. If then, there was only one ledge, and the croppings on each side of it were adjudged to be spurs and angles instead of distinct bodies, the locators along the line of that one ledge were the lawful possessors of the ore deposits throughout the entire basin and eastern hill slope. Thus there arose the single ledge theory supported by the well-organized companies on the lode and the many-ledge theory supported by the poorer prospectors on what they thought to be parallel veins.

A party of miners, holding the "Middle Lead" as it was termed, lying to the west of the Ophir Companies ground was the first of the parallel claims to develop a rich ore body, and the deposit was at once claimed by the Ophir and Mexican properties.

John Cradlebaugh, a pioneer lawyer, opened court at Genoa. Excitement over the "Middle Lead Case" and other pending suits was at fever heat, and more than one shot was fired at important witnesses.

When the case was called 300 or 400 men, armed to the teeth, were present at the trial. The room was crowded with excited partisans, and an unguarded expression might at any moment bring a collision which would cover the floor with bleeding bodies. In the face of this prevailing harmony, the jury persistently refused to agree upon a verdict.

The next case of interest on the docket was the suit brought by the Savage Mining Company to recover possession of ground on their claim held by a party calling themselves the Bowers Company. The Savage Company had their claim by virtue of a location made and recorded July 4, 1859. The Bowers Company had located their claim May 1859 and recorded it on July 2, 1859.

For a time the two companies worked on the disputed claim without collision, but in April 1860, the Bowers Company, thinking that their rights were infringed upon, built a rude stone fort on the ground, laid in a stock of provisions and ammunition and a garrison of 30 armed men defied dislodgement. The Savage Mining Company in order to recover the ground, brought suit against them for trespass. The weight of evidence was overwhelmingly in favor of the plaintiffs, but the jury returned a verdict for the defendents. Subsequently, one of the jurors made an affidavit that his decision was bought for the sum of $250 and a portion of the ground in dispute.

Before the end of the year 1861, eighty-six companies, with an aggregate capital stock of $61,500,000 were organized to work the mines of the Comstock.

Pressure was brought to bear on the superintendents of the mines by the stockholders to extract and consequently mill more ore. At least $1,000,000 profit was lost to the stockholders by inefficient and extravagent mills due to their own greedy haste.

Yet the ore was so rich, yielding an average return of $80.44 per ton in 1863 and $73.48 per ton in 1864, that in spite of these drawbacks, dividends amounting to $2,908,800 were declared during these two years. As the Gould and Curry Mine had paid in so short a time considerable more than the par value of its capital stock (4,800 shares at $500) and more than 15 times the amount actually invested by the stockholders, assessments 1, 2, 3 and 4, aggregating $187,200, its owners did not trouble themselves about the comparatively unimportant item of current expenditures. They scarcely noticed that the expenses of the company were $5,940,297 or more than twice the amount of profits declared in dividends and more than two-thirds of the receipts from all sources or $8,809,271.

But this extraordinary outlay was not wholly chargeable to the mining and milling accounts, as the expenses incurred in contesting adverse claims to the mine were considerable.

Upon the opening of the First District Court in February 1862, the multitude of suits which had been accumulating during the past twelve months were eagerly pressed for trial. Every claim of any value in the district was in litigation; the single ledge theory was passionately combated, rights of rival locators were asserted and the confusion was worse confounded by the vagueness of the notices of location and the lack of trustworthy records. Trespasses, fraud, and perjury were the natural outcome of the insufficiency of the mining regulations and the laxity with which they were enforced. The trials were overrun with black-mail and bribery, and witnesses were manufactured by wholseale with testimony to suit the requirements of the case. Attack on miners by miners from other mines was a common occurrence along with the wrecking of machinery and filling up of shafts--anything to win the case.

After many expensive trials in which the juries would not decide, it was thought much cheaper to consolidate the two companies in conflict over the same ground. No sooner were the trials over and the consolidations completed than a period of general depression gripped the camp. The rich superficial deposits of the Gould and Curry, Ophir and Savage mines had begun to show plain indications of exhaustion.

In 1863 William Sharon went to Virginia City to establish a branch of the Bank of California. The bank and the capitalists associated with it already controlled the principal mines, and Sharon soon devised a way by which he and a few others became the owners of a majority of the mills as well. Quite a number of men had built what are termed "Custom mills"; that is, they had no mines of their own but worked ore for any company that would furnish it. Most of them, however, had involved themselves and were in need of financial aid; therefore, Sharon, as manager of the branch bank, generously came to their assistance. But no sooner had they secured a loan than their supply of ore was cut off, and as a matter of course their mills in due time fell into the hands of the bank. These properties, however, did not go into the assets of the bank. They were taken out by Mr. Sharon and his friends and organized into the Union Mill and Mining Company, which from then on became an instrument for absorbing the wealth of the Comstock mines. If a mine had a rich body of ore, more than an equal share of waste rock was mixed with it to feed to the mills. If the ore was poor, the stockholders were assessed to make up the deficit in the cost of production.

However, the Bank of California bought the mills during very dark days on the Comstock. In 1869 all the known bonanzas were nearly exhausted. The Yellow Jacket Mine production had fallen from $2,677,488 in 1867 to $682,004 in 1868; the Empire Mine had paid no dividends since 1867. Of the productive mines, all showed a falling-off in 1868 except the Savage and Overman. The Savage mine declared a dividend in 1869 amounting to $90,000 contrasted with $1,560,000 paid in 1868.

At the close of the year 1870, a number of mines of the lode were producing considerable quantities of low grade ore, but few were paying dividends. The Savage Mining Company had paid its last dividend in June 1869, the Kentuck in March 1870, and the Gould and Curry a return of $48,000 in October 1870. The approaching exhaustion of the Hale and Norcross and the Yellow Jacket ore bodies must have been foreseen, as both companies ceased the payment of dividends in April 1871 and August 1871 respectively. The Chollar Potosi alone had a rich undeveloped ore-body in sight which yielded a profit of $1,946,637 in dividends to the stockholders during the year ending May 31, 1871. It was a dismal outlook, when two comparatively obscure men, J. W. Mackay and J. G. Fair, both practical miners and familiar with every inch of the lode lifted them out of all their difficulties.

J. W. Mackay and J. G. Fair, in conjunction with J. Q. Flood and W. S. O'Brien of San Francisco, wrested the control of Hale and Norcross from Mr. Sharon and his friends in 1868 and quickly turned it from an assessment to a dividend-paying mine.

This new period which was to follow, termed "The Big Bonanza" period, was to show many new developments as interesting as those in the "Early Comstock" period described herein. These two periods together made the Comstock the outstanding world leader in advanced mining methods and machinery from 1860 to 1880.

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