Mining in Bisbee

Chapter 5

The Art of Underground Mining

A look at the men, methods and machines

1880 - 1975

Slide 1

MINING IN BISBEE

THE ART OF UNDERGROUND MINING

A look at the men, methods and machines
1880-1975

Tramming Ore Underground
Bisbee
William Davidson White
Oil on panel, 14 x 20 inches
(undated, C-1923)

Part 5

University of Arizona
Mineral Museum Collection

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Slide 2

The beginning of mining at Bisbee

When mining began at Bisbee, every thing was done by hand, with the light of a candle. Except for the use of dynamite and the availability of steam power, things were done much as they had been done for centuries. The hammer, hand steel , pick and shovel were still the primary tools of the trade. Yet in the hands of an experienced miner, these tools were used in a most skillful way. Mining was, and remains, truly a skilled craft with many talented men engaged in its execution.

To be sure, this was hard work; work filled with danger for the careless or inexperienced; work often performed in harsh and difficult places. One had to endure the near darkness and the hardships of heat, of breathing stagnate and humid air. It was physically demanding to be a miner, but skill more than strength, made a good miner. The skill to drill for hours using a four pound hammer in most any position. The skill to shovel the heavy, broken rock quickly to make room for the next round to be drilled. The skill to "read" the ground and securely put in timber, thereby making the workplace safe for himself and all around him. The almost occult of skills - to know which way the ore was headed and follow it with a minimum of wasted effort. This was the miner at Bisbee. ~~~~~

The ores at Bisbee were soft and the encasing rock highly altered and often incompetent. Only the most massive of support timbering techniques could keep the ground open for mining. This required skilled miners, men with years of experience to extract the ore. It also placed huge costs on mining, as timber was costly and took time to install and too, it was labor intensive to maintain. This forced the mining of only the higher grade ores to cover these costs, but finding these ores was never easy at Bisbee.

Dr. James Douglas was slow to accept the use of geologist at Bisbee, in large part because he placed so much confidence in the experienced miner's ability to find ore. To be sure, this confidence was well placed, but as the mines deepened the clues to new ore were fewer and fewer and the larger smelter and was demanding more ore.

Slide 3

The mining cycle

A mining cycle is the complete set of defined tasks necessary to extract a full round of rock. In the case of the Bisbee underground this was: bar down any loose rock in the work area, muck the broken rock left by the previous shift, put in timber or other support where required, advance track in crosscuts, as well as air and water lines and ventilation, drill the round and blast. There are more than a few intermediate steps which must be performed, but these are the basics.

After the introduction of pneumatic drills, it was generally standard to complete the cycle in a single shift with a three or four man crew. With the advent of mechanized mucking equipment, a two man crew was almost always able cycle during a single shift.

This required timely service by a trammer then, in later years, by a motor crew to keep the raises pulled to the desired level or supplying empty cars to a crosscut. A number of others served in support functions as well.

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Much of the thoroughly oxidized ore mined at Bisbee was very soft and in many cases, claylike in nature. This material could often be mined with a just pick. When it was hard enough to benefit from blasting, very little powder was actually needed. In these cases, the mining crew just continued excavating, but was ever vigilant to make sure the back was supported.

This softness made mining a bit easier and faster, but this was more than offset by the threat of collapse and the amount of well-placed supporting timbers required.
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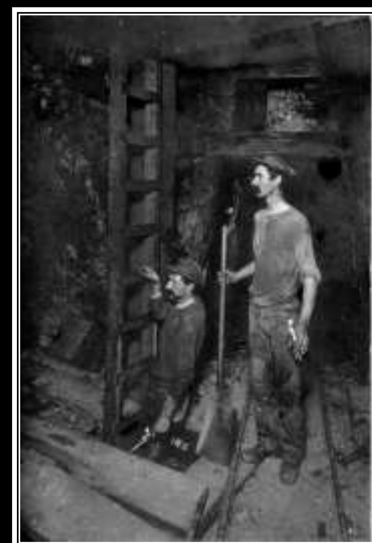
Ben Williams, the first superintendent of the Copper Queen, in the Czar Mine sitting on a ledge formed by the hard ore at the soft ore contact. The material in the upper part of the face could easily be removed by the use of a pick, while the lower would require drilling and blasting. (Douglas, 1900)

Graeme Larkin collection

The miner

Most people think anyone who worked underground was a miner. In truth, most were not. It is more of a collective term than a descriptive one. Who was the miner? What did he do? How did he do it and who helped him? These are basic questions whose answers will tell much about working underground and to see it was the true miner who led the way, in every respect. The miner was, and remains, a highly skilled craftsman in the art of moving rock, safely and efficiently. To do this ,much experience was needed. Today, as always, a person must spend four to five years working under the careful and instructive guidance of a well experienced miner to become truly proficient at the trade. This is not a job for either fools or the dim witted for they soon are either hurt or forced out by the miner who has little time to teach those who will not or can not learn. It is the miner who leads the team in the working face and woe to the foolish shift boss who thinks otherwise for he is doomed fail. ~~~~~



Graeme Larkin collection
Men at the top of a raise
C - 1908

The miner is a skilled worker in every sense of the word. He has years of experience in his job and knows it well. Both his life and income depend on his experience and abilities. A miner must have a quick understanding of the ever-changing work environment which he meets on a daily basis. Every foot of advance and every ton moved are different in some regard, often so subtle as to defy description, but the miner must recognize the change in an almost occult way, and adapt seamlessly. Only thus may he keep this inherently dangerous environment safe and therefore efficient and productive.

The miner had to understand the changing ground conditions under all circumstances. This was fundamental as from the very beginning to the very end; most accidents were related to the "fall of ground" - rocks falling from the back or rib. The miner had to always keep one eye on what was above him for his own safety and that of those working with him. He was, after all, the man in charge of the work happening at that point in the mine.

This man had to be sure that all loose rock had been remove before allowing anyone under the unsupported back. Sometimes a rock would sound loose then struck with the bar, but refuse to fall no matter how much effort was expended. These were all potential death traps and must be temporally supported. Then came the task of understanding when to put in the permanent timber, what kind of timber support and, most importantly, how to install it so that it will remain soundly in place after the blast he was to set off at shifts end.

Shoveling (mucking) the broken rock (muck) is not simple, most of all shoveling the heavy ore from a rough bottom. It took time to learn how to shovel and shovel quickly, as every step was dependent on the next. This was usually the task of the mucker, the miner's helper or more correctly his apprentice, but one the miner knew well, having performed it during his training.

Then, the timber or other support must be fully installed as it could not be put in place until all of the muck had been removed. This often called for hand picking to remove any spots which interfered with setting the post of other supports. Here too, the mucker became very involved as the miner was almost surely either involved in drilling or some other task.

He had to be an expert at drilling the blast holes, first by hand and later by machine. The rock face in front of him must be read and understood so that the holes were drilled to the best advantage. Something such as a ¼ inch crack or small break with clay could influence how the hole should be placed so as to not get the drill steel stuck or have the blast break out pieces too big to handle.

To be sure, standard hole patterns were used and to great effect, but the miner had to know when and how to modify them. He never, ever allowed the small remnant of a previous blast hole, a "bootleg" to be used, though the temptation was ever so great as starting the hole was always the most difficult part of the process. These bootlegs sometimes contained dynamite and a blasting cap which, for some reason, did not explode with the pervious blast, but were almost certain to explode under the pressure of drilling. More than one miner and his crew were either killed or badly hurt when this important safety rule was ignored.

Then comes the matter of loading the blast hole with dynamite in the right amount. Each hole was now charged, first with a stick of powder containing the blasting cap the crimped on fire fuse and followed by the right amount of dynamite. Too little would not break the rock and too much could blow out the timber, or worse yet, not completely explode and leave a potentially deadly trap for the next shift coming on. Sequencing the blast was so very important and the fuses which were all of the same length at the start had to be trimmed to have the center holes blast first, then the side holes followed by the top then the bottom holes. Each environment presented its own challenges, of course, and the miner had to know when and how to compensate for the different conditions.

After the fuses were lit, the miner and his crew would leave the work face and the blast which was soon to go off, but before they could leave the area, they had to count the reports from each individual hole as they went off. This was vital information for the oncoming crew, as they needed to know if unexploded dynamite was in the broken rock or face and if it was, they needed to take special precautions and find it before doing much else.

All the while and in all things, he had to both instruct and protect those entrusted to him as his crew. The effort was always worth the time as soon the crew would work together as one unit to the mutual benefit of all, as bonus was based on advance of the crosscut and raises while in stopes, the tons which passed through the chute at the bottom of the raise were the measured base for bonus pay.

These men who worked together so closely became "partners" devoted to each other underground and ready to sacrifice anything and everything for each other, even giving their lives to save or protect their Pard. This was universally true even for those for those men who did not like each other and would never speak to one another on the surface. Underground they were one; they were, after all, partners.

Who were the Miners?

For the most part, the men who followed mining as a career were a cross section of America's working men at any given time during Bisbee's near century of contributing to America's growth. Early on, many of the miners were immigrants - new to America bringing their skills from their lands of origin. Indeed, the most sought after miners before 1900 were the Cousin Jacks from Cornwall in England. These men were fabled for their skills as miners. And too, there came well experienced miners from Germany and Sweden as well as men from the copper regions of Northern Michigan and metal mines elsewhere in the U.S.

Good miners were never common – never, and they knew it, which bred in some a deep sense of independence and wanderlust. Oft times a good miner would flow with the seasons, south to Arizona in the winter and north to Montana or the mountains of Colorado in the winter. These fiercely independent souls, often called "tramp miners," were both the boon and bane of the mining companies. Their skills were desperately needed, but their free spirit and independent nature often caused them to quit over a minor matter, leaving the mine shorthanded. A stable workforce was highly desirable to the long-lived mines at Bisbee and much was done to make Bisbee a desirable place to live and work.

The strong social forces of the times did much to shape how the town was peopled. Bisbee was to be known as a "White Man's" camp, as noted by Brimsmaid in 1907, remain so for much of its life, reflecting the temper of the times that influenced Bisbee, the west and much of America. Chinese were never welcome in early Bisbee, an artifact of the California mining districts, while American Indians never lived near Bisbee, thus none were employed in the mines. A few small groups occasionally coming to camp near the top of The Divide where there was a source of good clay to make and sell their ever-popular ollas to the townspeople.

Also, in spite of its proximity to Mexico, Mexicans were relatively few in the town and the small number employed mostly worked in the smelter or other jobs as could be had. Both the miners and the mine management refused to allow Mexicans to work underground, in spite of the long and rich mining legacy of Mexico. The Shattuck and Arizona did employee Mexicans underground as did many of the small time leasers. For the Mexicans that did work for any of the mining companies in any capacity, differential treatment was practiced.

Over time, the composition of the work force changed, in large part by necessity. As more and more mines were developed in Bisbee, in Arizona and America as a whole, the pressure to find, train and, importantly, keep good mining men increased. Fortunately for the mining companies, this need was near-coincidental with increased immigration to the US from southern and central Europe. To be sure, the earlier arrivals and their descendants, largely from Britain, Germany and Northern Europe as a whole, were none too pleased with the influx of their ancestral advisories and kept them relegated to more menial jobs; as much as possible. Then came mechanization.

The owner, staff and a few residents of a Bisbee boardinghouse C-1900. In spite of the finery of the men seated, their rough hands speak of hard work, perhaps as miners.

Graeme Larkin collection

The advent of the pneumatic rock drill did much to alleviate the effects of the dire shortage of miners. Now, a reasonably strong and intelligent man could easily master the heretofore almost mystical art of efficiently drilling blast holes. Other improvements in the handling of broken rock, safety and mine ventilation did much to make the mines at Bisbee and elsewhere, places where most men could work, albeit the work was hard and, as the *Bisbee Daily Review* wrote about Bisbee in 1904, *"It is not a place for a person not in the best of health. But it is a place for men of good constitution. It is a place for men of nerve. It is a place for men who will work. … There are no drones in this hive of industry."*

Before 1910, most of the several thousand mine workers were single men, living in one of the numerous boarding houses cluttered about the canyon walls. A number of entrepreneurial women operated the boarding houses, usually providing little more than a bed and meals, perhaps laundry, but not the washing of the deeply soiled underground work cloths. Of course, there were also a number of other local businesses which catered to the needs and wants of the single miners.

Right: A C-1905 comic postcard depicting the abundance of boardinghouses and places to eat, while showing their very high cost for the time, as a miner earned $3.50 a day

The prostitute's "cribs," as they were called, are depicted in the center-right by three small houses with stairs.

Graeme Larkin collection

The staff of the Can Can Chop House, C-1891. Note the miner at the right, lunch pail in hand, which no doubt was filled at the Can Can. Many of Bisbee's restaurants offered such a service, as did most of the boardinghouses.

Graeme Larkin collection

1907 ad from the *Bisbee Daily Review* for miner's lunches from the English Kitchen restaurant

Graeme Larkin collection

Last night marked the final appearance of Bisbee's tenderloin as a blazing myriad of mahogany counters, foaming liquor, polished glasses and "smiling young man all dressed in white." They are all a thing of the past. Foolish young swains, inflamed by liquor, can no longer visit that district and spend what money they have in a wild debauch with the female denizens of the region, paying exhorbitant prices for what they drunkenly consume. If they want liquor in the tenderloin after this they will have to buy it down town themselves and carry it up there.

Then again, last night the bawdy-house orchestras sounded their farewell notes, the women hopped about in a farewell two-step and the dance hall doors were closed to open no more. The polished floors will either be left deserted or turned into parlor compartments.

While none of the places have closed as yet, it is known that over half the women of the district have left town. Most of the places will be operated as soft drink emporiums, with what women still remain here as adjuncts. But no more dancing and drunken hilarity.

Outgoing trains yesterday also carried away several bartenders, both up town and in the redlight district, who will "lose out" on account of the early closing and total abolition ordinance.

April 1, 1910 clipping from the *Bisbee Daily Review* noting the closure of the Red Light District.

Graeme Larkin collection

And too, it was largely this group of single men that gave life to the abundant gambling houses, salons, dance halls and brothels, for which Brewery Gulch is so justly infamous. In spite of this high-spirited living, little true violence resulted and Bisbee did not have need for a policeman until after 1902. In any event, by mid-1910, all the rowdiness came to an end by city ordinance with the forced closure of the dance halls and a prohibition of women working in any place where liquor was served.

The *Bisbee Daily Review* (1910) noted that many gamblers and women from the "tenderloin" district had left town ahead of the full closure to seek opportunity in other, friendlier places.

But Bisbee had changed in other aspects as well. More and more of the mining men were now married and truly, it had become a much more civilized place to live, largely due to the generosity of the Copper Queen. Still, Bisbee was to remain a "white man's" town for several decades more until the labor shortages of World War II forced a change on the camp.

To be sure, the social blending of the varying European groups working in and around the mines had been achieved in a most harmonious manner, though many watched in amazement as some of their neighbors left for Europe to defend the Serbian cause in 1914. And too, the revolution in Mexico that had its genesis a few years earlier in nearby Cananea, would cause fear and further suspicion among the Anglos about the Mexicans who lived in Bisbee.

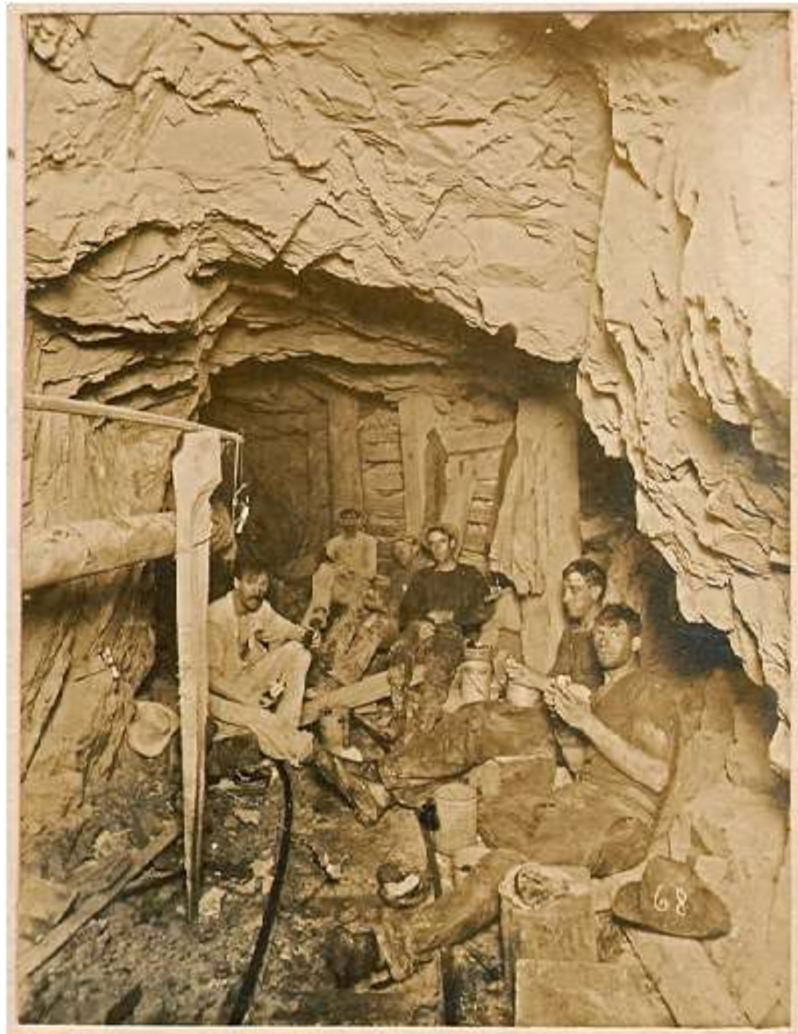
The last major migration to Bisbee was one that saw much of America involved. The farmers and others from Texas, Oklahoma Arkansas and such areas came during the early 1930s. World War II broke the policy of not allowing Mexicans underground. The manpower shortages caused by the conflict opened the door for these good men. They were to stay on and greatly contributed to Bisbee's success.

World War II also brought to Bisbee a number of "Soldier Miners," men excused from the regular army to support vital war industries. Many were Blacks, a first for Bisbee, but to avoid problems seen elsewhere, they were all assigned to the Uncle Sam Mine. In the end, there were no problems in the mines. They did their job, but found Bisbee not to their liking. While a number of other soldier miners stayed on after the war, few Blacks chose to remain.

Irrespective of where they may have come from, the men adapted to the work and life in the mines at Bisbee. Here, like mines everywhere, there were two things a man never went underground without – his light and his lunch. The work underground was incredibly demanding and a substantial lunch was a must.

While most men worked in pairs, lunch was usually eaten with most of the men working nearby and in a common place, sitting on a lagging (a plank that was 2"X12"X6'). It was common to blast missed holes or the occasional boulder in the stope or crosscut during lunch; leaving the area to eat allowed time for the smoke to dissipate.

For most miners, lunch was a moment of rest, but some worked on; food in hand while drilling. For many it just another three or four sandwiches to wash down with tepid coffee (we ate a lot and there were few fat miners). A few had wives that were exceptional cooks. These lucky chaps were the envy of the rest at lunch. The Cousin Jacks favored the English pasty, a treat most enjoyed, and with the entry of those of Mexican heritage came tamales and burritos, all eagerly sought by the other miners when shared, something not uncommon. Indeed it was common for someone to bring special food to share with his lunchtime friends.



Postcard view of a lunch break underground at Bisbee C-1910. The setting – a dry drift- in a mining area is so typical as is each man with a lagging or block to sit on.

Graeme Larkin collection

Great care was taken with any food to be discarded with most going back to the surface in the lunch pail or into a raise or chute, away from the lunch spot. This was important as rats had entered the mines during the earliest of years and followed the miners to depth as the mines advanced. While never too numerous, they would soon spoil a lunch area if food were left around. This is not to say that the mines were septic because there were a few rats and in some places there were roaches around. Quite the contrary, while very industrial in nature, they were reasonably clean.

To be sure rats would show up at lunchtime because a few miners would feed them scraps in a playful manner. The end to the rats in the mines at Bisbee came with the protracted strike in 1967-1968. They simply died of starvation during the eight months of inactivity. The roaches, however survived and were present in small numbers, scattered throughout the mines to the end, but rarely where the men eat.

As was so prevalent during these times, many miners used tobacco. A few chewed others smoked. Except for a short period during the 1950s and early 1960s, only “role your own” type cigarettes were allowed, with Prince Albert tobacco the most commonly used filling. Factory made (tailor made) cigarettes were not permitted because of the fire hazard they created. When left unattended or discarded, a tailor made cigarette would continue to burn, potentially setting fire to timber. A roll you own was hard to keep lit and would go out almost instantly when thrown away.

On the whole, the miners at Bisbee were good men, hard working men and well paid for their labors, who saw their jobs as opportunities to better their lot in life. That is not to imply in any manner that the lot of an underground miner at Bisbee was ever bad. In the context of the times, indeed it was very good, far, far better than most had known in the place they had called home before coming here. As miners and craftsmen many stayed in the mines the whole of their working life. Good people all.

Postcard image of an ethnically diverse group of miners at the Cole Mine C-1905. Men who appear to be of central and southern European are alongside men who seem to be of northern European origin and American, such as the engineer with the lace boots at the far left. The man with the oil lamp on his hat near the center may well have come to Bisbee from mining areas in the east or mid-west, as this style of lamp was common in the mines of these areas but rare at Bisbee.

Graeme Larkin collection

Following photo is of Run 3 at the Cole mine in 1972 being honored for their excellent safety performance (a run is an area under the supervision of a given shift boss). These were all good men and great miners. At one time or another, I worked alongside of most of the men in this photo.

Graeme Larkin collection


SAFETY

Slide 5

The mining crew and support

The crew at any given mining face included the miner, the shoveler (later called the mucker) and a drill helper. This crew make up was largely the same until the 1930s when mechanical mucking so improved the loading efficiencies that two men could do all that was required to cycle in a shift. Other support was always necessary , most particularly, the timely removal of of loaded mine cars by trammers and later, the motor crew. It was always the miner who directed the process while working along side the others and performing those often ardious task which required more skill and experience such as drilling and timbering.

Among the others who provided direct support to the miner and crew at the working face were:

Shift boss	Tool nipper	Powder monkey
Electrician	Cager	Timberman
Survey crew	Ventilation engineer	Pipe and track repairman

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Graeme Larkin collection
Mining crew at a crosscut face drilling and mucking
C - 1908

For every miner at the face, there were a surprisingly large number of support personnel working in the mine just to make sure that he, the miner, had everything he needed to get the ore broken and out. After all, this was "what put the ink on the paycheck" as the men were fond of saying. In addition to those listed, a great many more were involved in the surface shops making and/or repairing the miner's tools and equipment or getting the timber framed and other consumable materials ready for delivery to the mine yard. The logistics of running a mine are complex.

It may seem odd to have the shift boss listed as a service person when he was indeed the miners direct supervisor, but it was the shift boss' first responsibility to make sure the tools, materials and support the mining crew needed were available when and where needed. He alone had the authority to order tools and timber or send in the motor crew or see that the electrician kept his works as close as needed. The shift boss would make every working place on his run twice daily to be sure things were going well. He also checked on potential problems and helped the miner plan a bit, but he seldom dared to tell the miner how to do anything.

Even though the shift boss was almost always a former miner, and probably a good one, the miner at the face knew his working place better. Any shift boss who tried to tell a good miner
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how to do his job very often, was soon looking for a new miner as the guy he was so busy try to instruct quickly took offence and would quit, figuring he was a better miner than this "know-it-all boss" and why should he take instructions from someone who knew less than he did. As good miners were always very hard to find, few shift bosses made this mistake often, for the mine superintendent would soon decide that it was far easier to replace a mediocre shift boss than it was to replace a couple of good miners. He was right.

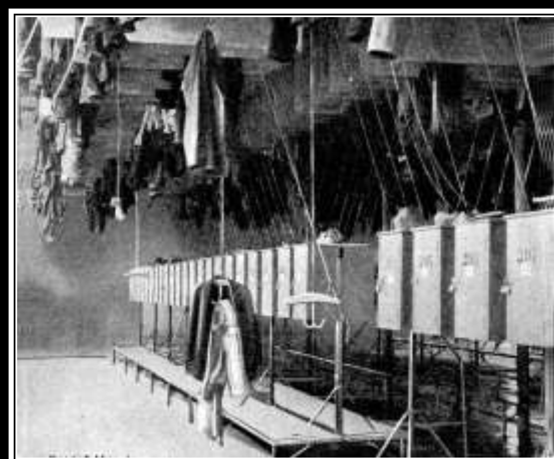
Slide 6

Starting the day – the change room

For most, the day began by changing from "street clothes" into "diggers", those work clothes, washed only weekly, at most, and now stiff from the combination of mud, sweat and mine water . At the end of the last shift, they had been placed, wet from work, on a hook and pulled high, into the rafters of the change room, or "dry" as it was often called, to dry out before the next shift. Even though the diggers were dry at the start of the shift, they smelled of the mine and of hard work. Caked drilling mud often flaked off the cloths as they were put on to start another shift.

Change rooms were in use in Bisbee before 1890, but it was only after 1900 that they became what we know today with warm showers and secure lockers for the valuables.

Next, it was off to get the daily allotment of candles, carbide or the assigned electric cap lamp, depending on the era. Then to the time keepers office to get the brass and report for work ~~~~~



Graeme Larkin collection

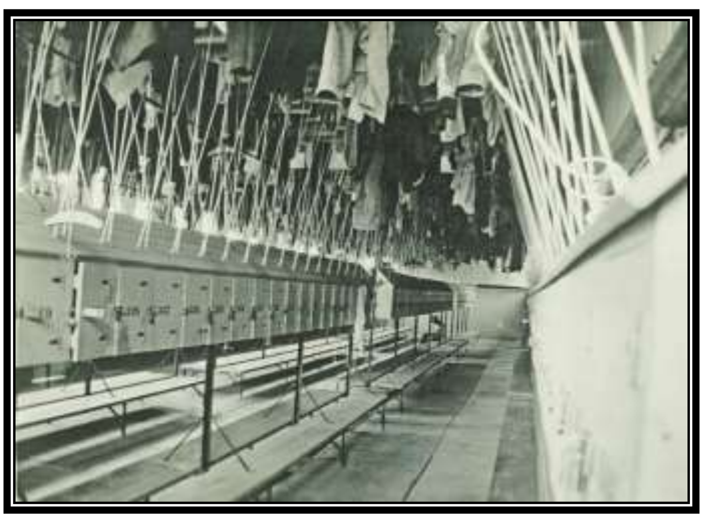
Sacramento mine change room - 1915

Mine change rooms at Bisbee were truly well kept. After all, it was here that the transition from one world to another took place and the mining companies had long cared about the workers cleanliness and health, so good showers were provided in a warm and clean environment. The deep appreciation of industrial hygiene which evolved in the first decade of the 20th century placed a new emphasis on the design of mine change rooms and the companies at Bisbee were industry leaders in providing for the workers.

However, long before it became standard to provide change rooms for miners, Dr. Douglas had displayed his concern for the men by providing this necessary facility. Given that none of the homes in early Bisbee had access to water in any quantity, much less running water. These were essential. Early on, mine water was used for the showers and while generally good for this use, on occasion it was less than perfect. Stories of showers in yellowish, smelly mine water were not altogether rare. This was particularly true when the water level in the storage tank was low as mud always settled out of the mine water, no matter how clean it looked, and collected in the tank bottom.

Change room attendants were always around to clean up the mud, gravel and grim after each shift came or went. These were usually older miners who could no longer keep pace with the demands of the work underground or men who were permanently or temporally disabled as a result of an accident in the mine.

Showers in the Czar Mine change room C -1919



General view of the Czar Mine change room C -1919

Slide 7

Reporting for work

After getting his light, the miner went to the window of the "time keeper's" office to pick up his brass, a coin-like piece stamped with his payroll number and kept on a large board placed in a conspicuous spot for easy visual reference.

When the brass was given the miner by the time keeper, this indicated he had reported for work . The process was often referred to as "brassing out." The brass was used to keep track of men who were underground. If the brass was not on the board in the time keeper's office, it was assumed he was underground.

The employee was to return the brass to the time keeper at the end of the shift thereby indicating he was out of the mine. This was referred to as "brassing in." The whole process was a simple, but important safety measure ~~~~~

Obverse and reverse of a custom struck brass of the Shattuck & Arizona Copper Company
C – 1915
Graeme Larkin collection

Typical brasses for an employee of the Copper Queen Branch
pre-1920 (L) post-1920 (R)
Graeme Larkin collection

Typical brass for a supervisor or engineer of the Copper Queen Branch
C – 1970
Graeme Larkin collection

For safety reasons, every person who went underground had to pick up his personal brass token from the time keeper to show that he had reported to work and was underground. This coin-like piece, which was stamped with his payroll number, was all important in keeping track of the man. A shift boss could tell by a glance of the board if all of his crew had reported for work and, at the end of the shift, if they had all come out of the mine, as the miners returned their brass to the time keeper before entering the change room at the end of the shift.

The careless miner who did not return his brass at the end of the shift caused turmoil, as his boss and others went looking for him. If he was found in a local drinking establishment, instead of dead or injured in the mine, he would soon wish he were indeed injured in the mine as he was publically chastised and humiliated. Few repeated this grievous "sin."

Underground, these were occasionally used to indicate who was working in a hazardous area. Working in a fire area or behind a water door, are examples. Outside of the fire area or water door, every man would hang his brass on a board placed for this purpose, before entering and collect it when leaving. This allowed the shift boss to know that everyone was out before he would have the water door closed and bolted before the blast in an area where large volumes of water might be hit.

Supervisors such as shift bosses and the technical staff like engineers, surveyors and geologist had their individual brass as well, but in place of a number, their initials were stamped.

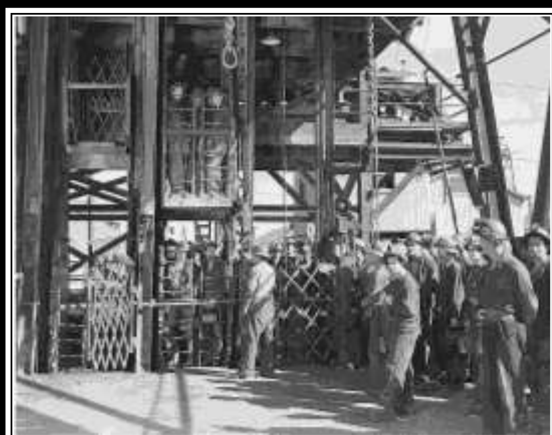
Man tag board from the Dallas
Mine 1975
Queen Mine Tours collection

SLIDE 8

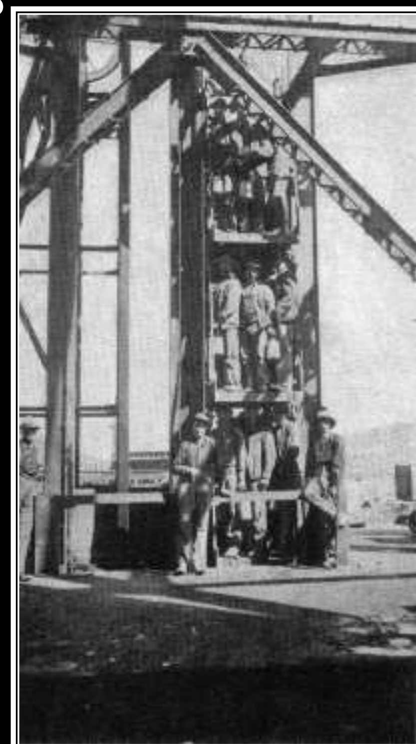
THE CAGE RIDE INTO THE MINE

MINERS ENTERED THE CAGE ACCORDING TO THE LEVEL ON WHICH THEY WERE WORKING. NINE TO 12 MEN SQUEEZED INTO EACH DECK, LUNCHBOX AND LIGHT IN HAND. NINE OR MORE MEN, IN WORK CLOTHS WHICH HAD NOT BEEN WASHED FOR DAYS. THOSE FEW WHO SELDOM OR NEVER WASHED THEIR DIGGERS WERE VERY UNPOPULAR AT THIS MOMENT, EVEN THOUGH THE CAGE RIDE WAS FOR 3 MINUETS OR LESS. THREE MINUETS PACKED THIS CLOSE WAS ENOUGH.

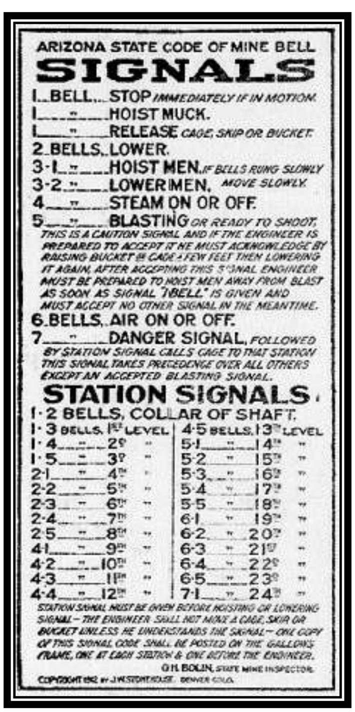
EACH CAGE TYPICALLY HAD THREE DECKS YET, TO LOWER A FULL SHIFT OF SEVERAL HUNDRED MEN, MOST OF 20 MINUTES WAS NEEDED AT THE DEEPER MINES ~~~~~



GRAEME LARKIN COLLECTION
LOWERING THE NIGHT SHIFT AT THE JUNCTION MINE - 1953



GRAEME LARKIN COLLECTION
MINERS ON A THREE-DECK CAGE GARDNER MINE C - 1915



ARIZONA STATE CODE OF MINE BELL

SIGNALS

1 BELL ... STOP IMMEDIATELY IF IN MOTION.
1 " ... HOIST MUCK.
1 " ... RELEASE CAGE, SKIP OR BUCKET.
2 BELLS ... LOWER.
3-1 " ... HOIST MEN. IF BELLS RUNG SLOWLY
3-2 " ... LOWER MEN. MOVE SLOWLY.
4 " ... STEAM ON OR OFF.
5 " ... BLASTING OR READY TO SHOOT. THIS IS A CAUTION SIGNAL AND IF THE ENGINEER IS PREPARED TO ACCEPT IT HE MUST ACKNOWLEDGE BY RAISING BUCKET OR CAGE A FEW FEET THEN LOWERING IT AGAIN. AFTER ACCEPTING THIS SIGNAL ENGINEER MUST BE PREPARED TO HOIST MEN AWAY FROM BLAST AS SOON AS SIGNAL "1 BELL" IS GIVEN AND MUST ACCEPT NO OTHER SIGNAL IN THE MEANTIME.
6 BELLS ... AIR ON OR OFF.
7 " ... DANGER SIGNAL, FOLLOWED BY STATION SIGNAL CALLS CAGE TO THAT STATION. THIS SIGNAL TAKES PRECEDENCE OVER ALL OTHERS EXCEPT AN ACCEPTED BLASTING SIGNAL.

STATION SIGNALS.

1-2 BELLS, COLLAR OF SHAFT.

1-3 BELLS,	1ST LEVEL	4-5 BELLS,	13TH LEVEL
1-4 "	2ND "	5-1 "	14TH "
1-5 "	3RD "	5-2 "	15TH "
2-1 "	4TH "	5-3 "	16TH "
2-2 "	5TH "	5-4 "	17TH "
2-3 "	6TH "	5-5 "	18TH "
2-4 "	7TH "	6-1 "	19TH "
2-5 "	8TH "	6-2 "	20TH "
4-1 "	9TH "	6-3 "	21ST "
4-2 "	10TH "	6-4 "	22ND "
4-3 "	11TH "	6-5 "	23RD "
4-4 "	12TH "	7-1 "	24TH "

STATION SIGNAL MUST BE GIVEN BEFORE HOISTING OR LOWERING SIGNAL — THE ENGINEER SHALL NOT MOVE A CAGE, SKIP OR BUCKET UNLESS HE UNDERSTANDS THE SIGNAL — ONE COPY OF THIS SIGNAL CODE SHALL BE POSTED ON THE GALLOWS FRAME, ONE AT EACH STATION & ONE BEFORE THE ENGINEER.

G.H. BOLIN, STATE MINE INSPECTOR.

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The use of the cages in hoisting men and materials was a matter of great concern from a safety stand point. After all, the lives of many men were at risk. To address the risk associated with this task, the State of Arizona established a code of mine bell signals in 1912 whereby the cager who loaded the men and materials on the cage, could communicate with the hoist engineer on when and how to precede.

By way of example and using the chart at the left, if the cager on the surface wanted to lower the cage load of men to the 1800 level, he would ring 5–5–3–2 on the shaft bells indicating the destination was the 1800 level and that men were being lowered. As the mines became deeper, this chart was modified.

Slide 9

Underground – now to work

Once on the level, it was usually a reasonably short walk to the working place . In a few rare instances such as the Denn being worked from the 2966 Campbell and the Cole interior, man-cars pulled by trolley motors were used to transport the men to the area. It was then a climb into a stope, raise to start the real work.

Graeme Larkin collection
Walking to the working face, Campbell mine - 1950

First there was safety. All loose rock must be barred down and temporary support placed where necessary and this varied for the different environments – stopes, raises or crosscuts

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Graeme Larkin collection
Barring down , 2966 level Campbell mine - 1973

Graeme Larkin collection
Boarding man cars, 2966 level Campbell mine - 1950

Miners leaving the cage to board a man car on the 2966 level Campbell Mine – 1950. Graeme Larkin collection
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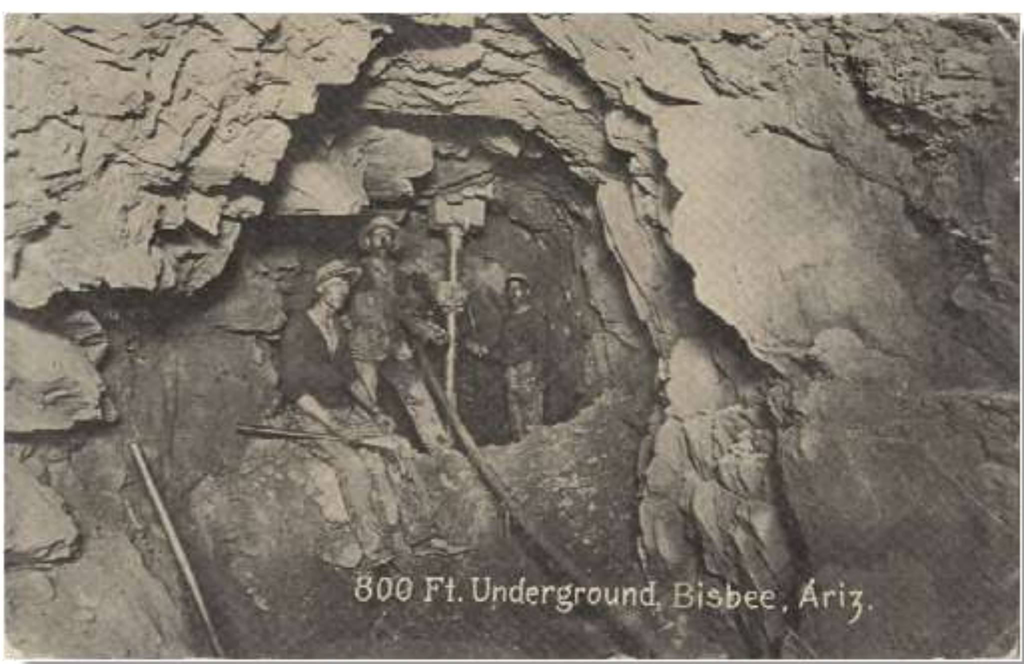
SLIDE 10

A NEWLY BLASTED FACE WAITED FOR THE MINERS COMING IN

BLASTING WAS ALWAYS CARRIED OUT AT THE END OF THE SHIFT TO ALLOW THE POWDER SMOKE TO CLEAR DURING THE CHANGING OF SHIFTS. THUS, A FRESH MUCK PILE WAS USUALLY WHAT A MINER SAW WHEN HE AND HIS PARTNER ARRIVED AT THEIR WORK PLACE.

THE FIRST THING THE MINER AND THE MUCKER WOULD DO WAS TO VISUALLY CHECK THE AREA FOR HAZARDS SUCH AS LOOSE TIMBER, ROCKS ON THE MUCK PILE WHICH MIGHT ROLL DOWN AND OBVIOUSLY LOOSE ROCK IN THE BACK (CEILING). AFTER DRILL WATER BECAME WIDELY AVAILABLE IN ABOUT 1910, IT BECAME STANDARD PRACTICES TO THEN THOROUGHLY WET DOWN THE MUCK PILE FROM A SAFE POSITION. THIS WAS FOR DUST CONTROL AND TO REDUCE THE EFFECTS OF ANY RESIDUAL POWDER SMOKE. FOLLOWING THIS, THE RIBS (WALLS) AND BACK WERE WASHED TO EXPOSE LOOSE ROCK. THEN THE BARRING DOWN OF ANY LOOSE ROCK BEGAN. THIS TOO WAS DONE FROM A SAFE POSITION.

ONLY AFTER ALL LOOSE ROCK HAD BEEN REMOVED FROM THE BACK AND RIBS DID THE MINERS VENTURE INTO THE NEWLY BLASTED AREA TO START THE PROCESS OF SUPPORTING THE BACK AND RIBS, WHERE NEEDED. ~~~~~~



A 1910 era postcard showing the muck pile in a crosscut that has been partially mucked and the drill setup.

As the miners drilled out the face, the mucker (left) was to finish mucking the broken rock into mine cars.
Graeme Larkin collection

Slide 11

Booming out for safety

In squareset stopes and crosscuts where timber support was needed, temporary support was provided by 10"X10" timber "booms" hung in iron hangers and pushed a full set ahead then the cap for the next set, along with the back lagging was placed on this temporary support. This provided a safe back to muck and drill under. Only after all the muck was removed were the permanent posts and side lagging installed.

The photo at the right shows a miner cleaning the face under boom support. Note the number 3^{4} on the cap, indicating a copper grade of 3.4% for the previous face. Also, note the air hose at the right used to cool the area with compressed air

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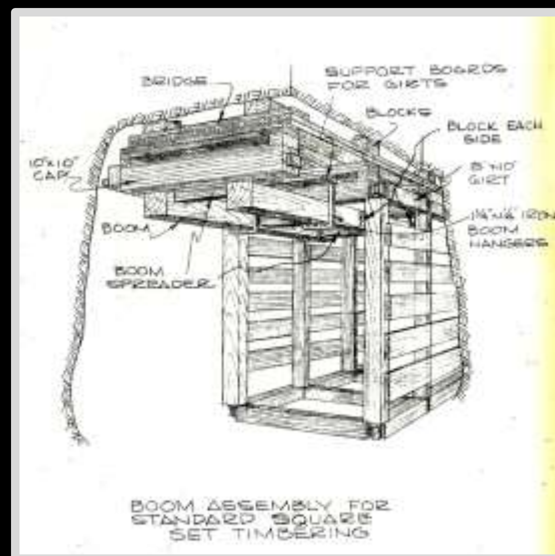
Graeme Larkin collection
Cleaning the face under boom support in a crosscut C - 1915



Graeme Larkin COLLECTION
Illustration of how to boom out in a squareset stope - 1955

It will come as no surprise to learn that the most common accident underground was falling rock. This was called "fall of ground" and every precaution was taken to prevent such events. Much of the rock mined at Bisbee was oxidized by the near-surface decomposition of pyrite. This alteration generally made the ground soft and unable to stand without constant support.

To be able to muck out and make room for supporting post required the miners to work under a potentially bad ceiling or "back", as they call it. The most common approach was to use large timber booms with planking (lagging) as shown above until the post could be set.
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Collapse of the 400 level Czar Mine station due to a lack of timber maintenance - 1964
Graeme Larkin collection

Fall of ground along a fault zone, which should have been an obvious threat and thus timbered - 1904. These are among the most treacherous types of failures as there is often no warning of an impending collapse.
Graeme Larkin collection

Below: Collapse of a stope due to a lack of adequate backfilling coupled with a natural weakness of the rock caused by void formation along pre-existing calcite lined subsidence cracks.
Graeme Larkin collection

Moving the broken rock in stopes

For the first 50+ years, all mucking was done by hand. In stopes, raises were closely spaced and as much as possible, rock was blasted directly onto an inclined chute which connected to a vertical raise from the level below. This is illustrated in the drawing at the right. Any ore that remained, was hand sorted before mucking, with as much waste removed as possible to use for back fill, then the ore was shoveled into the raise

Where the distance was too great, the ore was first hand sorted. Then the ore was shoveled into wheelbarrows and run over a plank path to dump in the chute. If the distance to the chute was more than 50 feet, mine cars on rail were used to hand tram the ore. This improved productivity by increasing the amount of ore trammed at a time.

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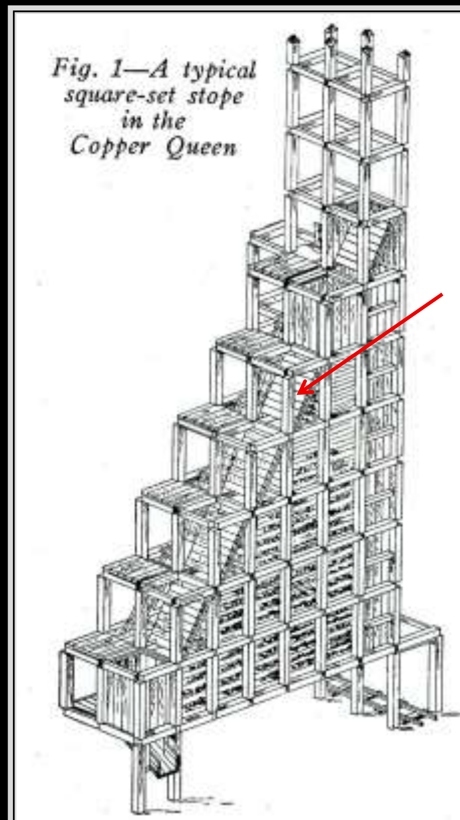

Graeme Larkin collection

Squareset stope timbering - 1912

In many cases, the soft ore was just mined by pick and shoveled in to the chute after removing all of the obvious waste. Hand sorting was an important part of the mining process at Bisbee until the advent of mechanical loaders which was coincidental with relatively high wages.

Gob walls made from waste manually sorted from ore in a stope, 5th level Southwest Mine

Graeme Larkin collection

The sorting took place because it was deemed to be cheaper to pay for the labor to remove the waste than to move the worthless rock to the surface, transport it to Douglas and then smelt the waste. This process raised the grade of the material sent to the smelter substantially. It had the additional benefit of
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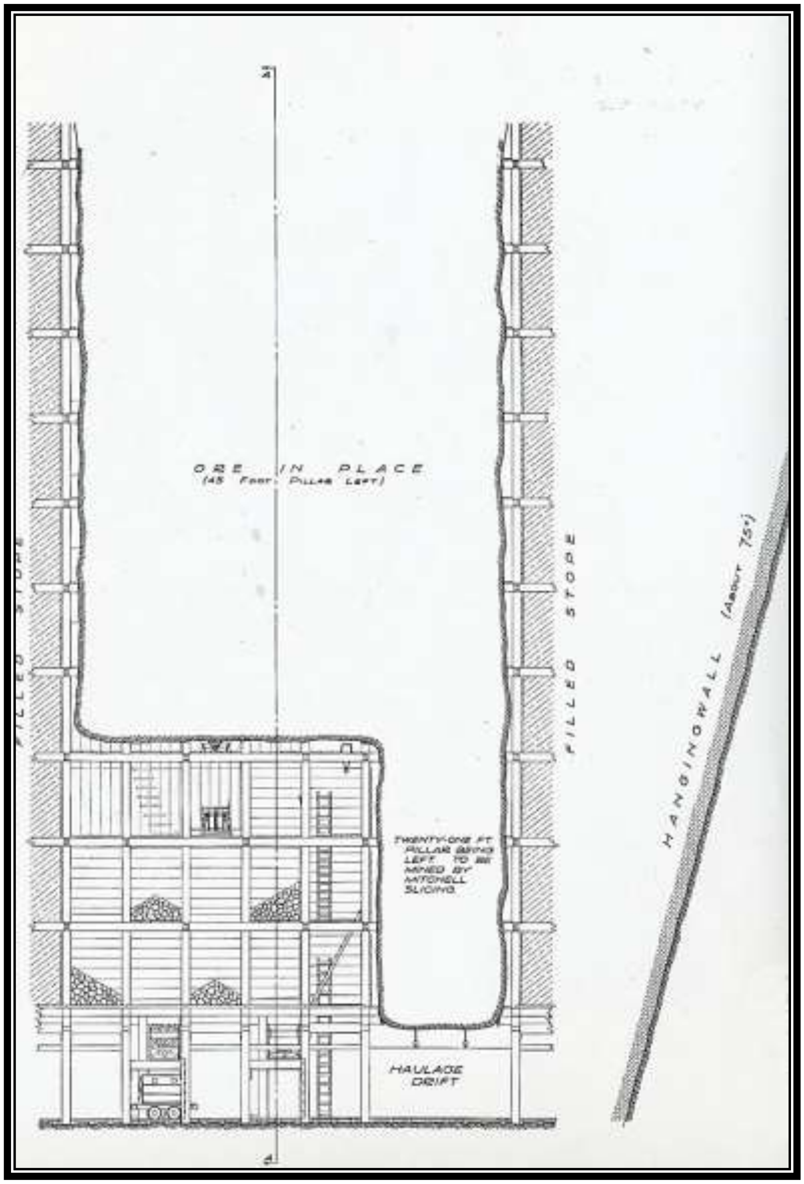
making the culled material available for backfill (gob) in the stopes which was vitally important for this type of mining.

All open spaces of any size had to be backfilled, as their eventual collapse would cause the nearby ground to shift, crack and become unstable and thus dangerous to mine. As shown in the illustration below, mining between two correctly filled stopes to recover ore pillars was practical.

Illustration of mining an ore pillar between two gobbed stopes - 1939.
Graeme Larkin collection



Mining on top of gob in a stope, C - 1910. The hole in front of the drill is the top of the gobbed stope.
Graeme Larkin collection

Slide 13

Crosscut mucking was all by hand

There was no alternative to moving everything by hand in the crosscuts, but several things were done to make it easier. Crosscuts were always driven with a very slight inclined grade, about 5 ½" per 100 feet (0.55% grade). This allowed for the free draining of any water which might be hit. Mucking in water was very hard work. This simple step eliminated the problem.

It was also difficult to muck off of the rough bottom of the crosscut. This problem was solved by placing planks or later, a steel sheet on the crosscut bottom before the blast and then, set the blast to throw as much of the muck as possible onto this smooth surface.

Graeme Larkin collection
Hand shoveling broken rock in a crosscut - 1920

An added benefit of having much of the broken muck away from the face was that drilling could start before the mucking was anywhere near complete. This would expedite the whole process as the miner could drill while the mucker loaded the broken rock into cars

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In the 1904 photo to the left, a steel sheet (often called a turn-sheet, as mine cars could be easily turned on such a sheet of steel) has been set on the track to receive the broken rock from a blast in a crosscut. This greatly facilitated the shoveling and made for a faster cleanup.

Graeme Larkin collection
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Slide 14

Raise mining was the simplest for mucking

Before every blast, an inclined bulkhead was constructed to direct all of the broken rock into the chute side of the raise to be pulled on the level below. Little or no rock remained to be moved by hand. The hard work in driving a raise was barring down through the small opening in the bulkhead then installing the support timber. Ground conditions and ultimate use for the raise dictated the timbering technique to be used.

Cribbed raises were either in bad ground where more support was needed or where there was a long term need for the raise. Six post raises were much cheaper and were used for stope development, when ground conditions permitted, as the timber would easily tie into squaresets in the future stope

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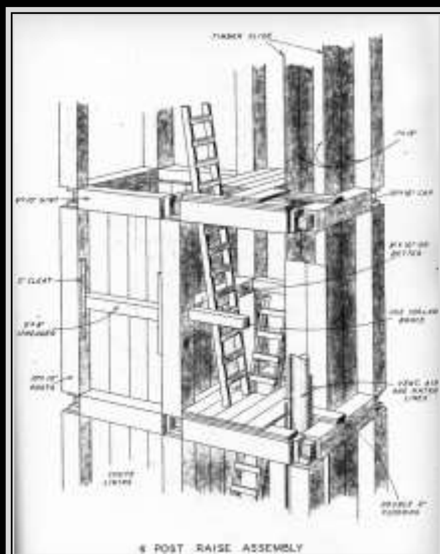
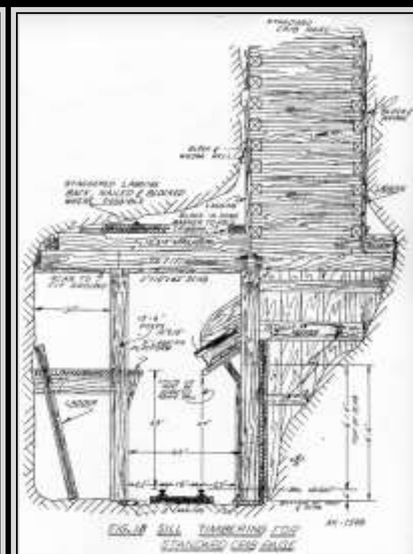
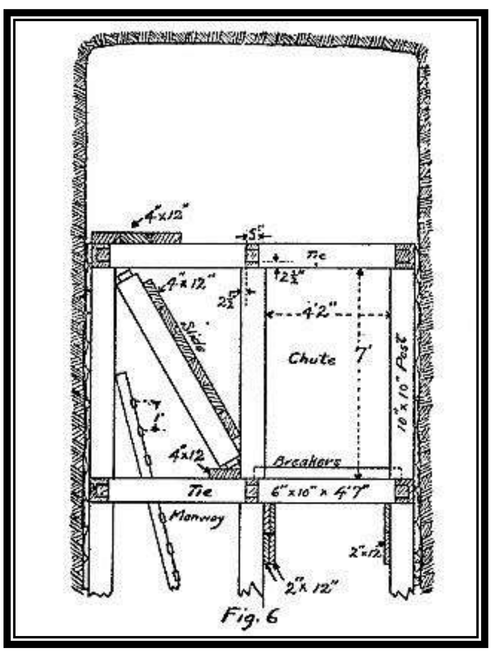


Graeme Larkin collection
Six post raise timbering plan
1955



Graeme Larkin collection
Cribbed raise timbering plan
1955



Driving raises was difficult work, which required highly skilled miners. Keeping the raise perfectly aligned so as to arrive at the desired point some 100 feet above, required frequent survey work. Timbering to meet the future requirements for the use of the raise and ground conditions was vital.

While gravity moved almost all of the broken rock from the blast to the chute over the slide (see illustration to the left), baring down loose rock and setting the next ring of timber was both hard physical work and required skill.
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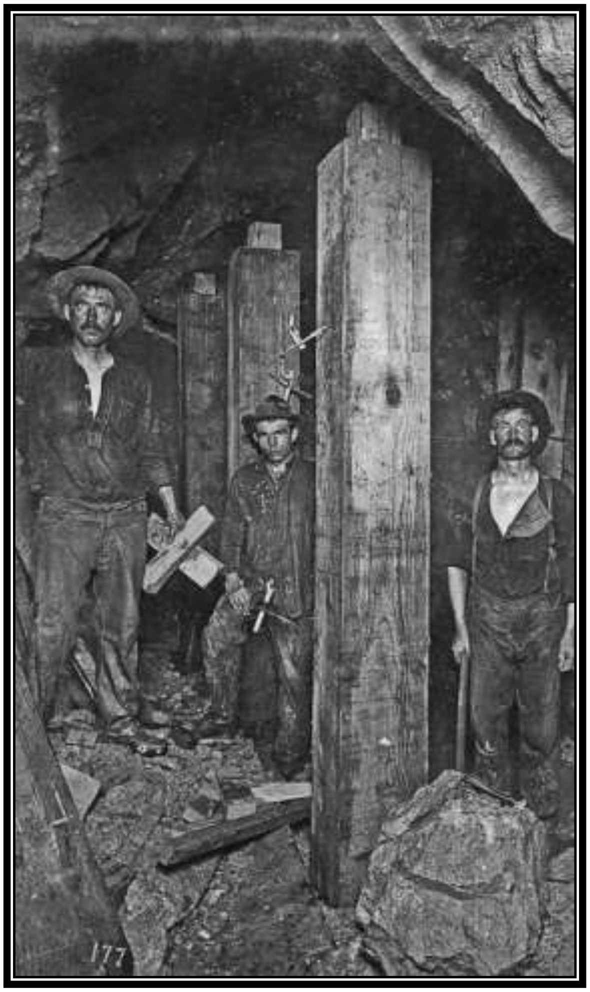
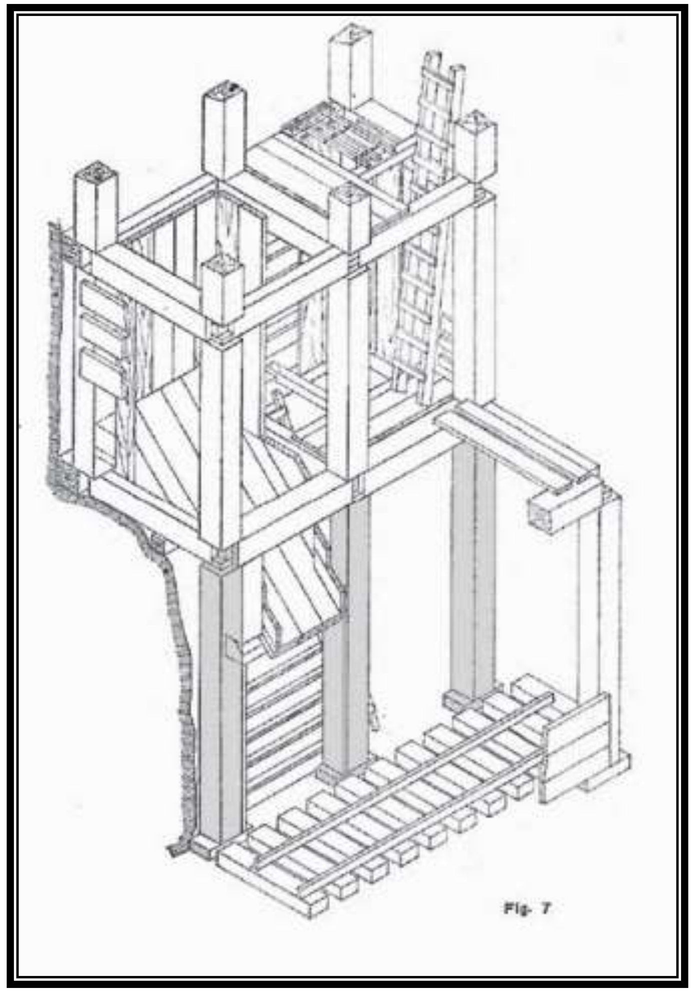




Left: Standing the three, 12" X 12" posts on the level preparatory to advancing a raise. To this point, only a single round has been taken out of the crosscut back. C – 1910

Right: The illustration of the sill timbering scheme for a standard six-post has these three posts shown in the photo shaded for reference.

Graeme Larkin collection

Shaft Sinking

During the many years of mining at Bisbee, dozens of vertical shafts were sunk, some to great depth. In most cases, the challenges were the same – advance as rapidly as possible while keeping the shaft true, something not easily done, especially in bad ground.

Generally speaking, shafts were started small in size, with hand or animal power used to hoist the broken rock. Timber support for the shaft walls and to guide the cages varied with the ground conditions, but was always carefully placed and protected. Advance in a small shaft might be as little as a few feet pre day, due to space constraints, while a large shaft may make ten or more.

Water made sinking ever so much more difficult. First, working in perpetual rain is hard, but worst of all is hand mucking the broken rock in water. It is more than twice the work, as the resistance to shoveling by the water is trying indeed. Air movement is nil with out help, making for a humid and altogether unpleasant environment.

Sinking of the Cochise Shaft C-1902. Note the tripod headframe and the horse whim for hoisting of rock. The miners are in wet gear telling of water and the plank extension of the headframe is to enhance natural ventilation, suggesting a hot work environment.

Three men riding the sinking bucket at the Dallas Shaft C-1902. Graeme Larkin collection

This was the typical manner to enter and to leave a shaft during development. Here too, the vertical boards to the right have been placed to form a chimney-like duct to enhance natural air circulation.

Right: A hand-operated windless over a small Prospect shaft on Bucky O'Neil Hill - 1914
Graeme Larkin Collection

Early on at Bisbee, shafts were used to explore for possible ore occurrences, as there were almost no recognizable surface indications. Thus, many were started in modest fashion, perhaps with just a windless or a tripod head frame or a small with wooden head frames. These were replaced or enlarged with depth if mineral was found. The shaft size would be increased if exploration was promising.

The head frames and hoists would be changed as the shaft was deepened or enlarged, as more substantial support and efficacy of hoisting would be required. In a few rare instances, steel head frames were in place from the start, such as at Campbell, Galena and Warren mines where much more was understood about the geology below.

Above: The small wooden head frame at the Dallas Mine as sinking was being initiated C- 1902.
Graeme Larkin Collection

The wooden headframe at the Junction Mine is being overbuilt by a large, steel headframe which will replace it when complete. A new hoist was also added, 1906.
Graeme Larkin Collection

A map of a part of the 1600 level of the Junction Mine with the 200' diameter shaft pillar clearly marked as a circle. C-1950
Graeme Larkin Collection

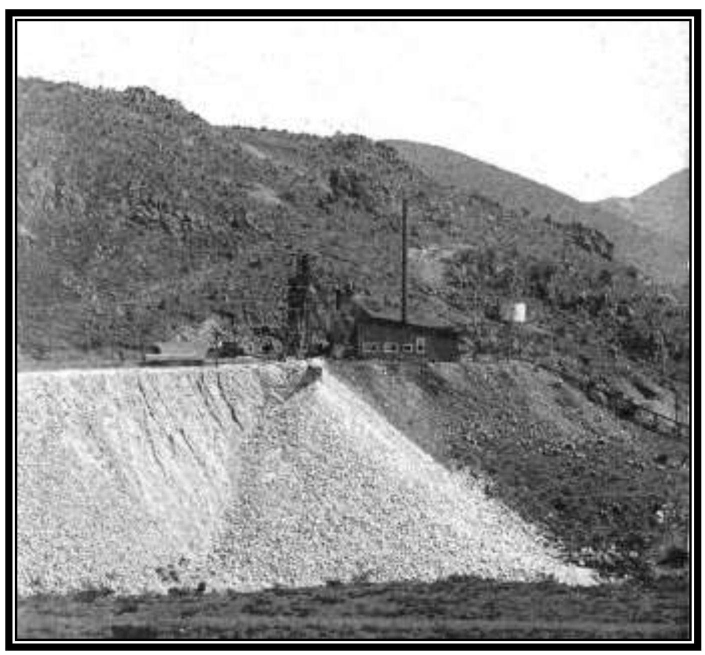
Adding additional compartments to the shaft was needed to allow for reasonable production to be achieved. Often, the shaft size was enlarged by working it as a raise, mining up to take advantage of gravity. Several shafts at Bisbee were developed largely or entirely by driving raises form existing underground workings, sometimes from several levels simultaneously. The Holbrook number two, Campbell and Sunrise shafts were all developed by raising. Clearly, this required accurate survey work to be sure that all of the individual segments were correctly aligned.

Ideally, when ore was found, it was located in the drifts and crosscuts driven from the shaft. This was almost always necessary to protect the structural integrity of the shaft by not mining too close. Typically, a 200 foot diameter shaft pillar was defined and considered sacred until the mine was ready for closure. The Holbrook Shaft cut ore when it was being sunk and while the ore was left in place, the soft, plastic supergene clays associated with the ore made it impossible to keep the shaft timbers Aligned. A second Holbrook Shaft was raised nearby to replace this important access point.

The first years of the 20th Century saw a good many new shafts sunk in the Warren Mining District. The C & A undertook several, while the Shattuck, Denn, Saginaw and other shafts were eagerly developed by their owners, seeking ore below the thick limestone cover.

The Copper Queen deepened the Spray, Gardner, Lowell Dallas mines and sank the Sacramento Shaft at much the same time. In all cases, this was serious work and great care was taken in developing and supporting the shafts.

At the Briggs Shaft of the C & A, huge amounts of water were hit during sinking, which slowed the advance while the area was drained both by aggressive pumping and through workings advanced from the Junction Mine. At the Denn Shaft, much the same happened and work was often stopped until the water was either pumped out or drained, again into the junction.

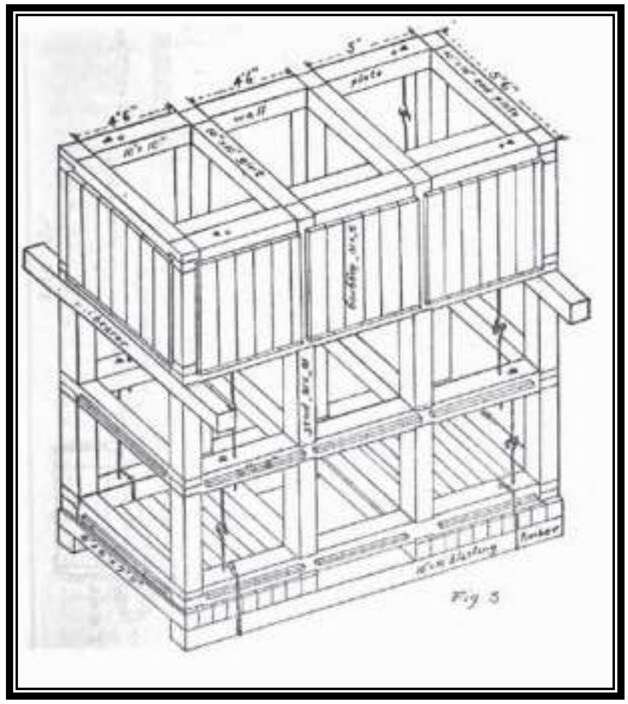


THE SACRAMENTO SHAFT AS IT WAS BEING SUNK IN 1904. NOTE THE STARK DIFFERENCE IN THE LIGHT COLORED, FRESH PORPHYRY ROCK ON THE DUMP IN CONTRAST WITH THE DARK GOSSAN OF THE OXIDIZED SURFACE MATERIAL.
GRAEME LARKIN COLLECTION

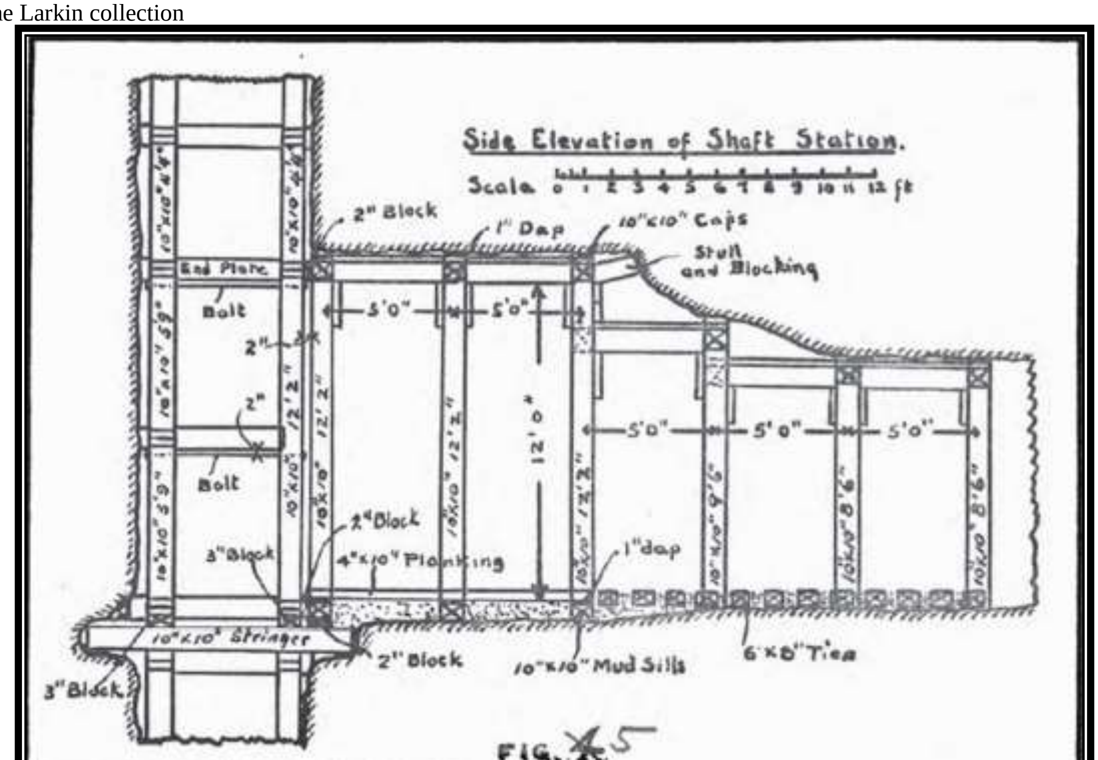
In Later years, the Copper Queen would face the difficulties of large flows of water at the Warren Shaft, while the nearby Cochise & Calumet Mine (C&C) had been reopened and developed with the hope of finding water.

Examples of shaft timbering and station development as practiced during the deepening of the C&C were included in the "*Practical Mining Course*" by Phelps Dodge (1920) are presented here as they so typify most that was carried out under similar conditions at Bisbee.

The Gardner Shaft was wet, always wet, as can be seen in this C-1910 postcard view of men in rain gear on the cage.
Graeme Larkin collection

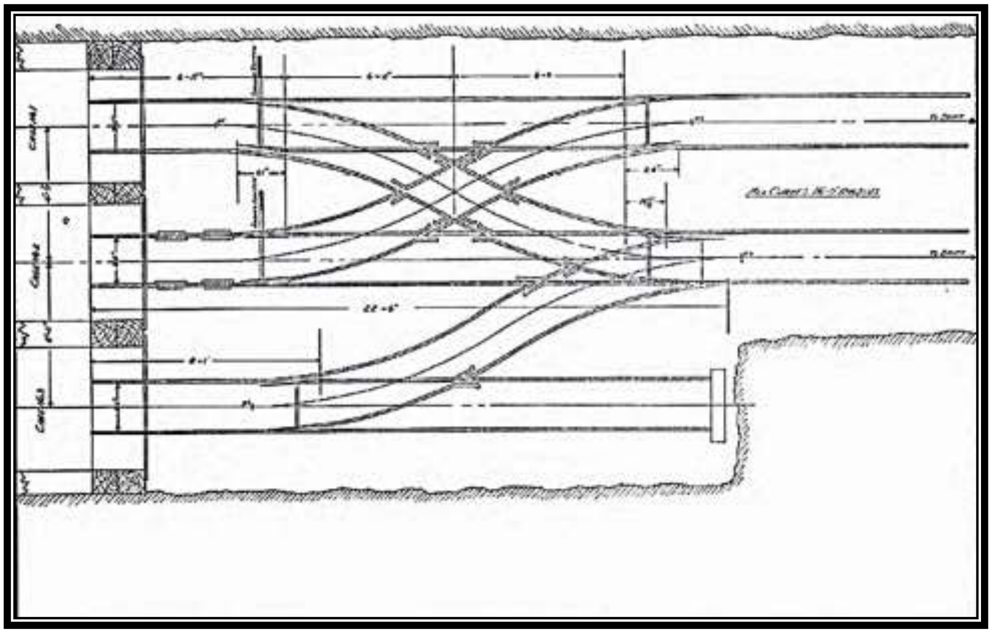


Above: Shaft timbering for the three-compartment, C&C Shaft using steel "J" bolts as shaft timber hangers to support the sets as downward advance is made.
Graeme Larkin collection

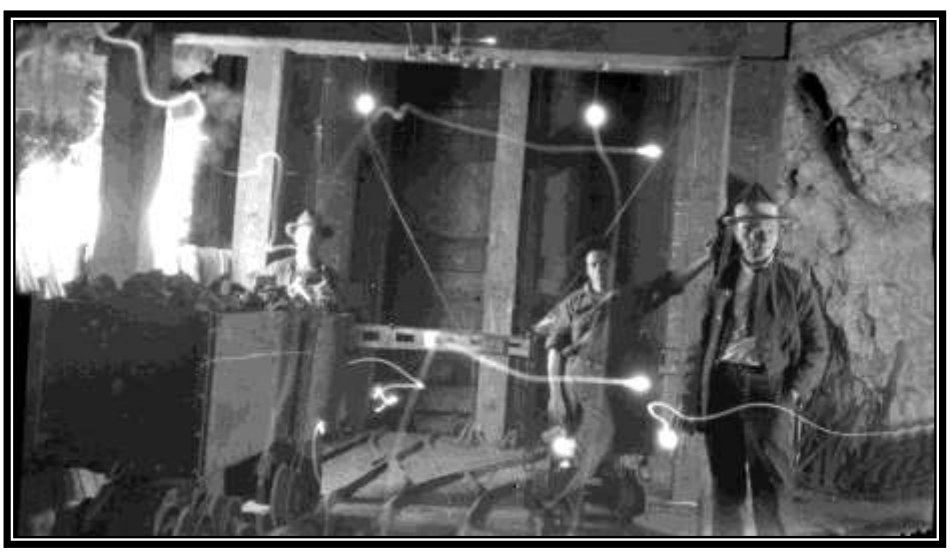


Station development and timbering as implemented in the C & C Mine – 1920. Here, steel bolts are used to maintain the desired shaft dimensions by holding the vertical post in compression against the end plates in the open space of the station.
Graeme Larkin collection

Both the C & A and the Copper Queen began to use concrete and steel linings in their principle shafts and the Denn followed suite. By 1950 the only production shaft that was not concrete lined was the Cole. However, the several ventilation shafts such as the Saginaw and Boras remained as timbered shafts.



Mine rail layout for a three compartment shaft. This layout allows for easy movement of mine cars to or from any compartment.
Graeme Larkin collection



Station off of the Cole Shaft with a mine rail layout very similar to that illustrated above, even though only two compartments were used for hoisting at the time -1913.
Graeme Larkin collection

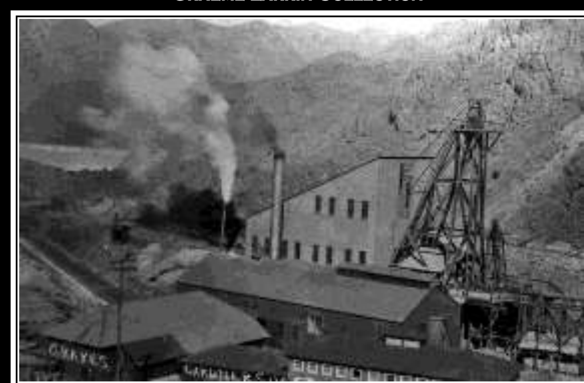
Slide 16

The evolution of hoist and headframes

With the discovery of ore came the need to have adequate surface facilities to hoist the ore and waste from the mine and to handle the ore, dispose of any waste rock as well as provide for support shops and facilities.

Spray Shaft Complex with enclosed head frame/hoist house, ore bins, and rock waste area C-1905.
Graeme Larkin Collection

View in the Junction Hoist House - 1934, with the man hoist (1 & 2) in the foreground, skip hoist (3 & 4) in the middle ground and the service hoist (5) in the far right
Graeme Larkin Collection

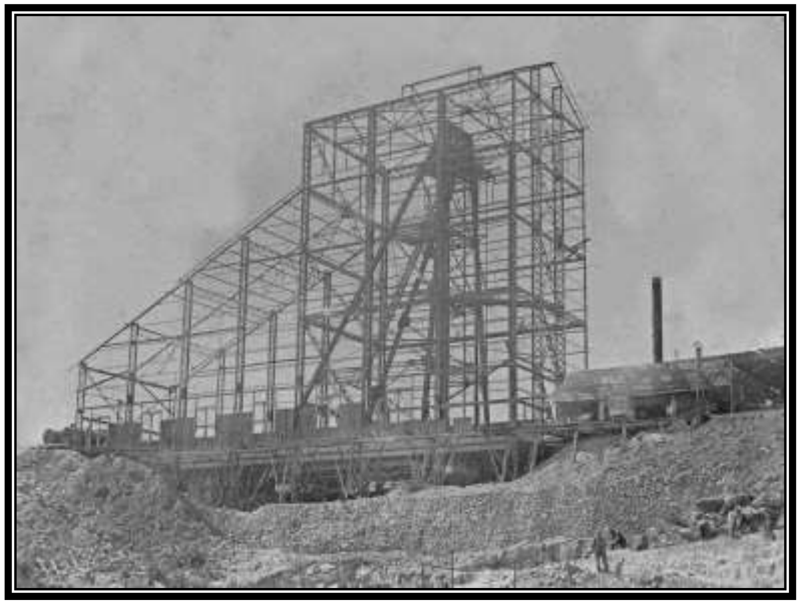


Gardner Shaft complex – open head frame, hoist house and shops C-1906.
Graeme Larkin Collection

While modest head frames and small hoist were adequate for exploration, their small size was an impediment to successful mining.

Mining has always been a volume business – the greater the volume, the lower the costs. From the earliest of days at Bisbee, the need to maximize the tonnages handled was apparent. Thus, as the mines expanded, the facilities related to getting the rock to the surface were improved and enlarged.

Small wooden head frames were replaced with well designed, massive steel structures, capable of supporting forces of the hoist cable and the loaded cages or skips.



Construction of the Spray hoist house, enclosing the newly-built steel head frame. C-1901
Bisbee Mining & Historical Museum collection

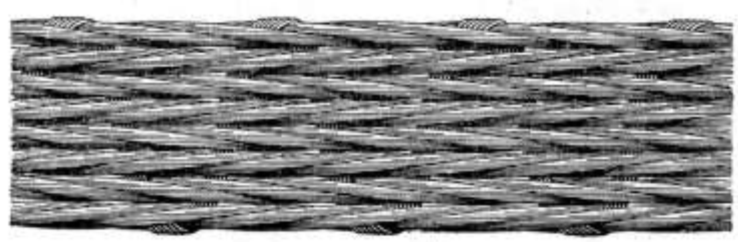
For unknown reasons, the first head frames built at Bisbee were enclosed structures, with the hoist in the same building as the head frame, something common in the frigid copper country of northern Michigan, but seemingly out of place in Arizona. The Czar, Holbrook and Spray mines, all Copper Queen properties were so designed. With time and probably for reasons of improving ventilation, all were later opened, with only the hoist remaining under cover.

By 1910 a number of fine and substantial steel head frames were added to the landscape. These included the Irish Mag, Junction, Oliver, Hoatson and Briggs of the C & A, the Shattuck was added as well, while the Copper Queen built the Gardner, Sacramento, Lowell and Spray. The Spray was the only and last enclosed head frame after 1900. Also, Copper Queen also built the Holbrook Number 2, but of wood, as the centralized hoisting of muck at the Sacramento had been adapted.

Centralized hoisting of ore and waste was introduced with the advent of motorized haulage. No longer did each shaft need to host all of its ores and no longer did the shafts have to be close ± 500 feet to make hand tramming practical. The Junction and Sacramento shafts were both enlarged to five compartments and concrete lined to accommodate the additional tonnages.

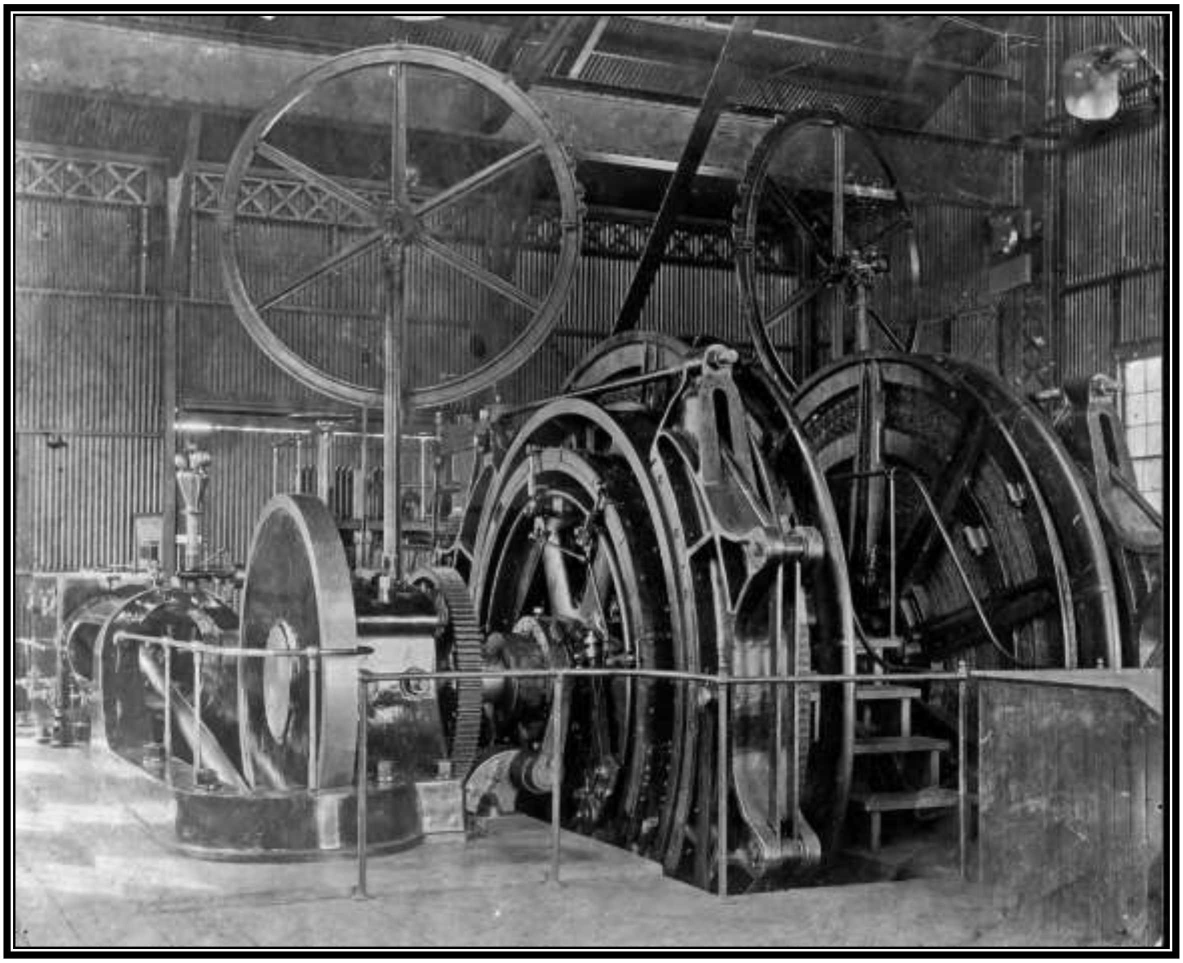
In later years, haul distances and substantial elevation differences combined to make it more practical for each of the operating mines to hoist their own ore. The Campbell, Cole and Dallas shafts had long been equipped ore pockets for quick and efficient skip loading.

The evolution of the mine hoist had much to do with the advances in steel metallurgy. Stronger steel allowed for development of safe, round cables and wide, steel shaft mounted hoist drums.



An example of flat cable. Approximate width - four inches.

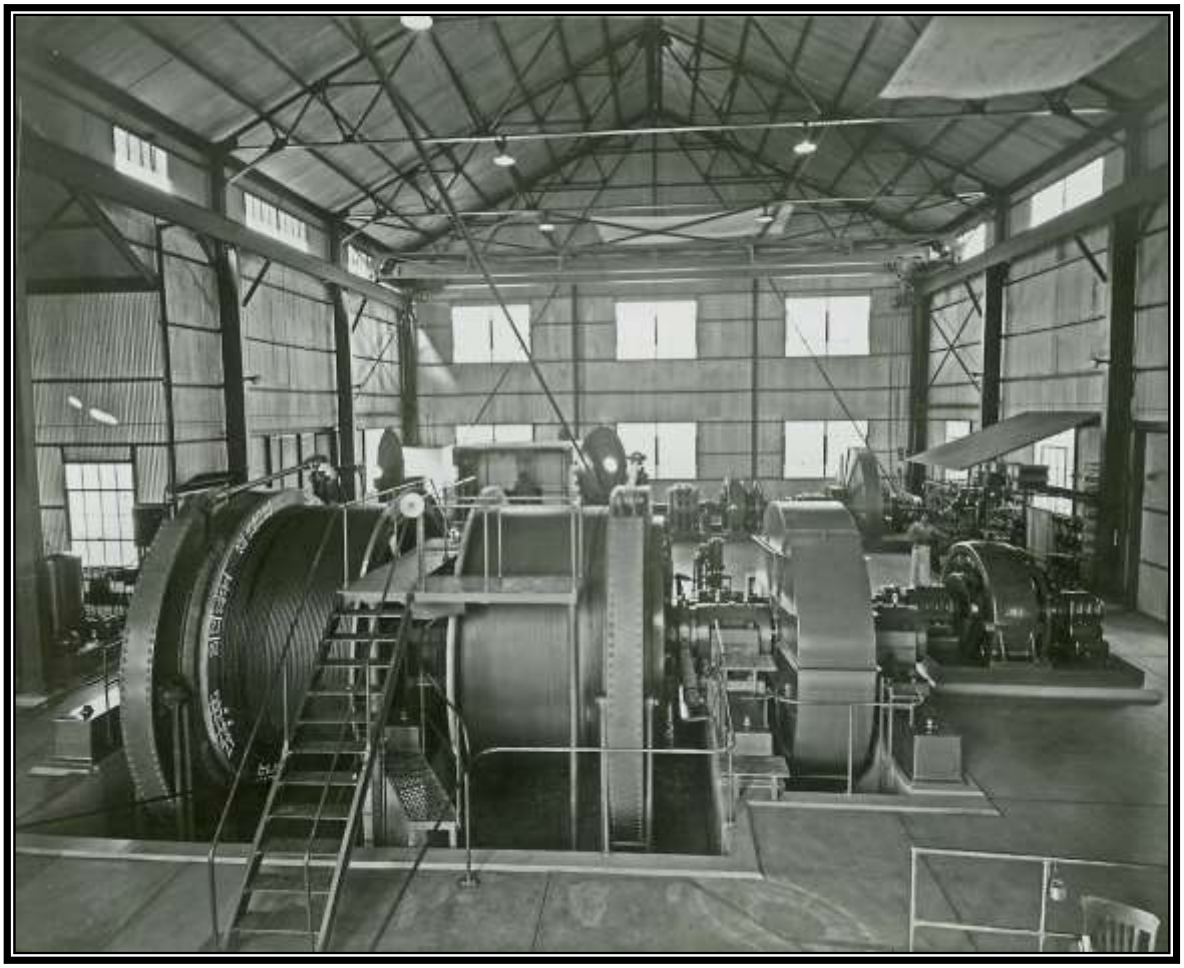
The first large hoists at Bisbee were all of the flat cable type with reel-like drums. Flat rope (in mining, cable and rope are used interchangeably to describe what should be called “wire rope”) was composed of numerous smaller, multi-wire cables crossing each other and sewn together by multiple, parallel strands of soft steel wire.



Flat rope hoist at the Gardner Mine when it was just installed -1904. As is typical for double drum hoist, one side is overwind, while the other side is under-wined.
Graeme Larkin Collection

The early hoists were largely steam driven and each mine had its own steam plant with a number of large boilers to drive the hoist and later, air compressions and electrical generators were also steam power. When electricity replaced steam as the most economic form of power, this hoist was converted to compressed air. By 1938, a small electrical powered round cable, drum hoist had replaced this magnificent unit.

While round cable, drum-type hoist were introduced early at Bisbee, few were truly serious hoist and most were used for light duty work such as men and material movement. By 1934, Phelps Dodge had installed large, fast skip hoist in both the Campbell and Junction mines. These were electric driven and, like most electric mine hoist, operated on DC current because it was possible to better control the hoist. Thus each hoist house had adequately sized motor-generator (MG) sets to convert the incoming electrical power to DC. An MG set can be seen in the very back of the below photograph.



The large Allis Chalmers, grooved drum hoist for the number three and four hoisting compartments at the Junction Shaft, soon after instillation was complete 1934.
Graeme Larkin Collection

Slide 17

Moving broken rock was all done by hand

The innovations which came to mining in the early part of the 20th century were great improvements, but mining remained a very labor intensive industry. If the blasted rock could not be moved by gravity, it had to be moved by hand. Everyday at early Bisbee, several thousand tons of ore and waste were hand shoveled into mine cars. It was an never-ending cycle. This illustration depicts a mine car being loaded with a hand shovel with the trammer standing by to push the car to some collection point when full or if waste, to dump it as gob into a nearby stope as fill.

Graeme Larkin collection
Dumping a mine car into a raise - 1939

Trammer, Bisbee
Oil on panel, about 14 x 20 inches (1923).
University of Arizona Mineral Museum collection

Slide 18

The trammer

Keep the rock moving! This was the job of the trammer . In addition to the cars hand mucked, h e also loaded cars with ore from stope chutes. Pulling chutes was not a simple task as they often hung up with the sticky oxide ores of the time. It was hard work to fill the cars. He then pushed them to the shaft for hoisting to the surface. His was a job which required little skill, just brawn. It was rewarded however, as trammers were paid the same as miners

Graeme Larkin collection
Loading a car at a chute
C - 1905

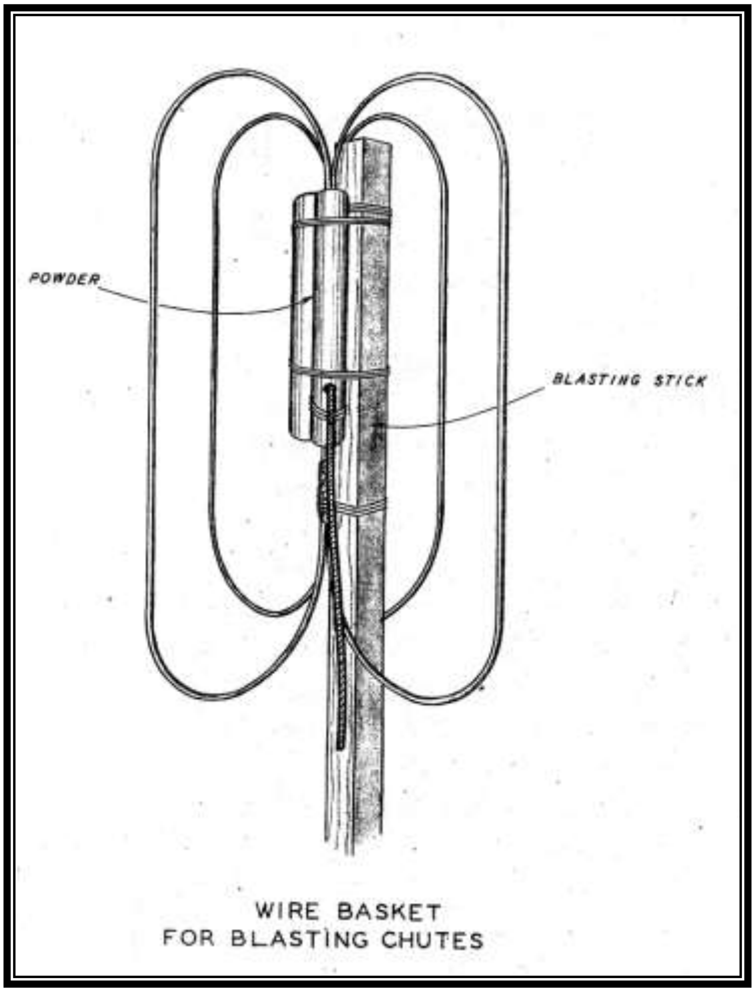
Graeme Larkin collection
Clearing a hung chute
C - 1915

Graeme Larkin collection
Tramming a loaded car
C - 1915

The trammer was the lowest position in the mines in terms of required skill and was back-breaking work. All shift long, he loaded and pushed the full cars to the shaft for hoisting and returned an empty car to the chute to start over again. Because it was so labor intensive, the tram distance was an important consideration and every effort was made to keep this distance at a manageable distance of less than 300 feet in one direction.

However, loading cars at chutes was not usually a simple task. The oxide ores were high in clay like minerals and would often just hang in the chute, apparently defying gravity and would only fall with much prodding with a long steel bar or eventually with a long pipe connected by hose to the compressed air line, called a blow pipe. In the worst of cases, dynamite would be attached to a long wooden blasting stick and placed in the chute to blast the muck free. This was always a last resort effort, but not altogether uncommon.

When the sticky ore finally would fall, it often did so suddenly and with great force, spilling over the chute door. Looking into the chute as shown above was a very dangerous and forbidden practices as one never knew when the muck might fall. The only thing worse was to climb into a hung chute for any reason. More than a few did and most never had a problem (including the author –dumb), but some were less fortunate.



Safety drawing of a wire basket for blasting chutes - 1955
Graeme Larkin collection

In the sulfide stopers, the hard boulders of ore would jam together and move only with great effort by the trammer as he poked and pried with the long steel chute bar. When the boulders broke loose and fell, it was a tense moment for the trammer as his bar was thrust about wildly by the heavy, falling rocks. Injuries were not altogether uncommon because of this.

In the above postcard view, the chute door is open, but no muck is coming out No doubt it was wet (as can be seen) and sticky. His face is mud covered, except where protective goggles (removed for the photograph) were in place. Loading cars in this very common condition was dirty, difficult and very hard work. C - 1910
Graeme Larkin collection

Using a bar to prod wet, sticky muck from a chute. Note the use of a "loading board" between the man and the muck in the car. It was a safety feature to protect the loader from injury if a large rock rolled out with some force.
C - 1915
Graeme Larkin collection

Slide 19

Mules are brought in to aid in moving muck

Hand tramming was efficient to about 300 feet, one way. Beyond that, it was too time and labor intensive and too, only a single car could be moved at a time. The introduction of mules for haulage more than doubled the efficient tram distance and three to four cars could be moved at a time. Now that's improvement! The mules were well treated as any important and expensive tool was cared for. They were not overworked, well fed and the "mule barns" where they were stabled were always dry and warm ~~~~~

Graeme Larkin collection
Mule pulling four "A" style cars
C – 1910

Graeme Larkin collection
"Mule barn, 1500 level, Junction mine
1973

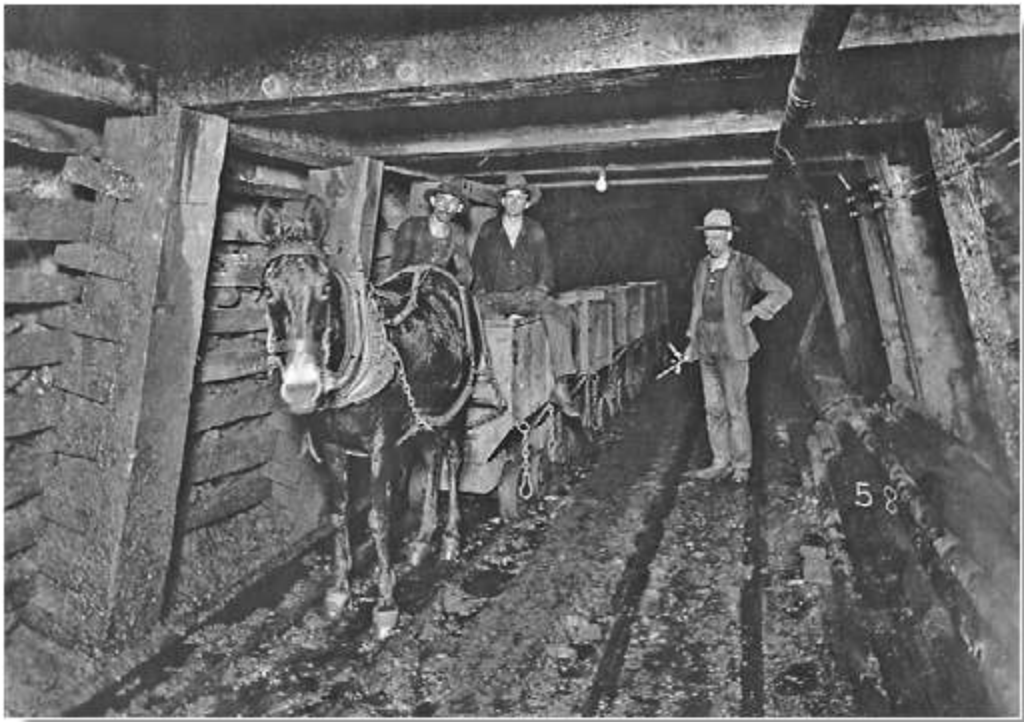
A postcard view of a mule barn in a dry and well lit area. C - 1910
Graeme Larkin collection

The introduction of mules into the mines in 1907 for haulage made an important contribution to the efficient movement of material. . A number of trammers were replaced by these great animals, thus reducing costs and allowing lower grade ores to be mined. While it was to be an intermediate step, as trolley motors soon followed further improving haulage. Still, it would be 1930 before the last mules left the mines as they were useful in the small, older workings.

Mules were expensive animals and always treated with care, every effort was taken to assure their wellbeing. Both large companies had full time veterinarians on staff to take care of these important animals.   They were well-fed, receiving hay and oats daily. More than one miner was found to have his lunch pail filled with oats to take home, attesting to the quality.

To enter most of the mines, the mules had to be well trussed and partially sedated. Getting such a large animal down a shaft safely was no simple task. The Southwest Mine the only mine that had a cage to allow a mule to enter, but even here they were blindfolded and tied to the cage to keep them quiet.

A well trussed mule that has just been unloaded from a cage. Note the sand on the turn sheet to protect the animal when laid-down.
C - 1913
Graeme Larkin collection



Postcard view of a mule pulling six empty cars. C – 1910. The double track, timber type and stored pipe suggest the photo was taken on a shaft station.
Graeme Larkin collection

Local lore among the non-miners had it that the mules were kept underground until they became blind due to the darkness. This was untrue, as there were lights present in many places in the mines and all mule barns were well lit.

There are numerous humorous tails of miners and mules interacting. Given that both miner and mules are traditionally stubborn and slow to yield gave a good deal of credence to the stories.

Slide 20

The motor replaces the trammer and the mule

Electric trolleys (motors), were introduced in 1908 and gradually replaced tramming by both man and animal. By 1930, all mule haulage had been replaced by motors and hand tramming was uncommon. The early motors were small -2 ½ tons in weight - and lacked the power to pull more than just a few of the large gable bottom cars then in use. They were soon supplanted by 5 and 8 ton units, which met the needs

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Five ton motor in the Gardner mine soon after this size was introduced C – 1912
Graeme Larkin collection

Graeme Larkin collection
2 ½ ton motor hauling "gable bottom" style cars, C – 1910

Graeme Larkin collection
Loading a "gable bottom" type car from a stope C - 1910

Motor size matter a great deal for the long hauls required when the Sac was made the central hoisting shaft for the CQ. The smaller motors were unable to meet the need as their pulling power (draw bar capacity) was but the equivalent of three to four of the newly introduced 1½ ton capacity gable bottom, side dump cars. Hardly enough to keep the chutes pulled and pockets full.

Larger motors of several different brands and sizes were introduced and the five ton units were able to pull just over twice of the load the smaller motors. The eight ton motors pulled almost four times the load. These units continued to serve the mine well until closure. Only a very few larger motors were ever used and these for long, regular hauls. On the 1400 Cole to Dallas run, a 15 ton motor with a 24 inch rail gage was used with great success pulling a six car string of five ton capacity Granby style cars on a consistent waste haul.

Interestingly, the area where this motor was used had three rails. One set on 18 inch gage for normal traffic and the other with the 24 inch gage for the large motor and cars.

Three trolley motors of varying size on the 1600 level of the Junction Mine, C – 1916. This was a main haulage level where ores from the Briggs and Hoatson mines as well as the Junction stopes on this level were all collected and brought to the Junction Shaft for hoisting.
Graeme Larkin collection

Several styles of storage battery locomotives were used successfully in the mines as well. The small "Mancha" trammers was common, while the eight ton locomotive, such as that show at the left were less common.

A eight ton storage battery type locomotive pulling a string of "K" cars in the Campbell Mine c-1970.
Graeme Larkin collection

Slide 21

Drilling by hand was both hard work and an art

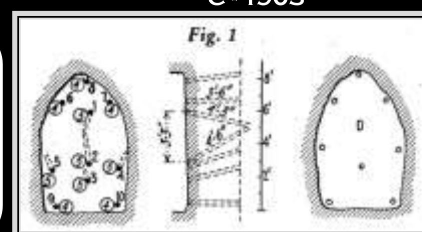
From the beginning of mining here, until 1905 all drilling for blast holes was done by hand. In crosscuts, raises and stopes, men worked all day long, for several days to completely drill a round consisting of as many as a dozen holes up to 4½ feet deep.
In crosscuts and raises, the constrained space had one man drilling while the more open areas in a stope often allowed for two or more men to drill at he same time. Soft oxides could be drilled by using a hand auger. The auger was a helical shaped piece of steel about 4 feet in length

Graeme Larkin collection
Hand drilling in a crosscut
C - 1903

Graeme Larkin collection
Single jack, hand drilling in a stope
C - 1903

Hole pattern for hand drilling in a crosscut -1910

Graeme Larkin collection



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Before all of the muck from the previous blast had been removed, drilling would start because it took so long to drill a round. A hand driller was at the top of the skill level of the day. Good hand drillers were rare indeed and the best were typically Cousin Jacks (miners of Cornish descent). Hour after hour of hitting the chisel-shaped drill steel with a four pound hammed was hard work. Holes had to be drilled at all angles making the task ever more difficult, miss hitting the steel with the hammer and it your hand that was hit with obviously painful results.

After every blow, the steel was rotated a bit to make the hole round and to keep from sticking the steel in the rock. The first steel used was both the widest and shortest. Steels were changed on about six inch intervals with each successive steel used slightly smaller at the bit part to make certain that the next steel would follow the previous.

Holes were not randomly drill. The pattern and the inclination of the holes were vitally important to assure that the blast accomplished its goal of breaking the rock while maintaining the opening size, shape, direction and inclination. To be sure the nature of the rock to be broken played an important role in the hole placement and number. If the rock was hard and competent, more holes were required. When timber support was to be required, the pattern in the back was
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such that a more or less flat back would be left to facilitate placing the timber. Raw (untimbered) crosscuts had a hole pattern which would yield an arched back for natural support.

Hand augers were extensively used in the soft, claylike ores to drill holes in material which was a bit harder than a pick could easily remove. Only one or two sticks of powder were placed in these typically wide-spaced holes to break this material. More often than not, augers were just used to make shallow hole to allow for the proper placement of timber.

Hand auger used for drilling blast holes C – 1910
Queen Mine Tours collection

Slide 22

Blasting used dynamite

Dynamite was available from the very beginning of Bisbee and was used as the principal blasting agent for more than 80 years. Fire fuse with a blasting cap was by far the preferred way to initiate a blast in the underground mines.

The blasting cap was attached to the end of the fuse by the miner by crimping it with a special pliers-like tool or a hand operated machine when done on the surface in bulk.
A hole was made in the stick of powder and the fuse inserted, then it was put into the blast hole.
Other sticks of powder without primers were then put in the hole as well.
The fuses then trimmed to varying lengths to control the blast and the fuse ignited
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Graeme Larkin collection
A primed stick of powder
1939

Graeme Larkin collection
Fully loaded round in a crosscut ready to light C - 1900

The use of dynamite to blast was something learned. Among the first things learned was that more powder did not usually mean a better blast. Well placed and well-timed ignition was far more important. In fact, the hole was not even usually filled with dynamite.

The first stick placed in the hole contained the blasting cap or primer as it is frequently called. The cap had been crimped onto a length of fire fuse either by the miner or a powder monkey well ahead of time to save the miner some time as well as assure uniformity. This primed stick was pushed to the back of the hole and lightly tamped, to assure that it would stay in place, with a long, wooden stick, called a loading stick. This was done with some care as blasting caps are far more sensitive to rough treatment than dynamite. Other sticks were then placed in the hole with each somewhat tamped into place with the loading stick. Finally an inert material, tamping, (paper, wrapped sawdust) was put in the hole on top of the powder to help control the blast and gas emissions.

The fire fuse used was all of the same length for a given blast. This fuse had a definite burning rate measured in feet per minute. When all of the holes were loaded, the fuse was cut to determine the blasting sequence, the shorter the fuse, the sooner the hole would go off. The fuse
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was ignited by candles at first then carbide lamp and finally by a hot wire sparkler like device called a “spitter”.

In a blast, center holes were always shot first and they threw a small amount of rock out to develop an open space for the remainder of the holes to break to, Lastly, the bottom holes (lifters) would fire to throw the broken rock back from the face to allow for easier mucking from the steel sheet as well as provide space for drilling to begin as soon as possible.

Empty 50 pound *Giant Powder* dynamite box from 1890.

Graeme Larkin collection

Right: Number six size blasting caps as used at Bisbee – 1930.

Right: Apache Powder ad - 1926

Graeme Larkin collection

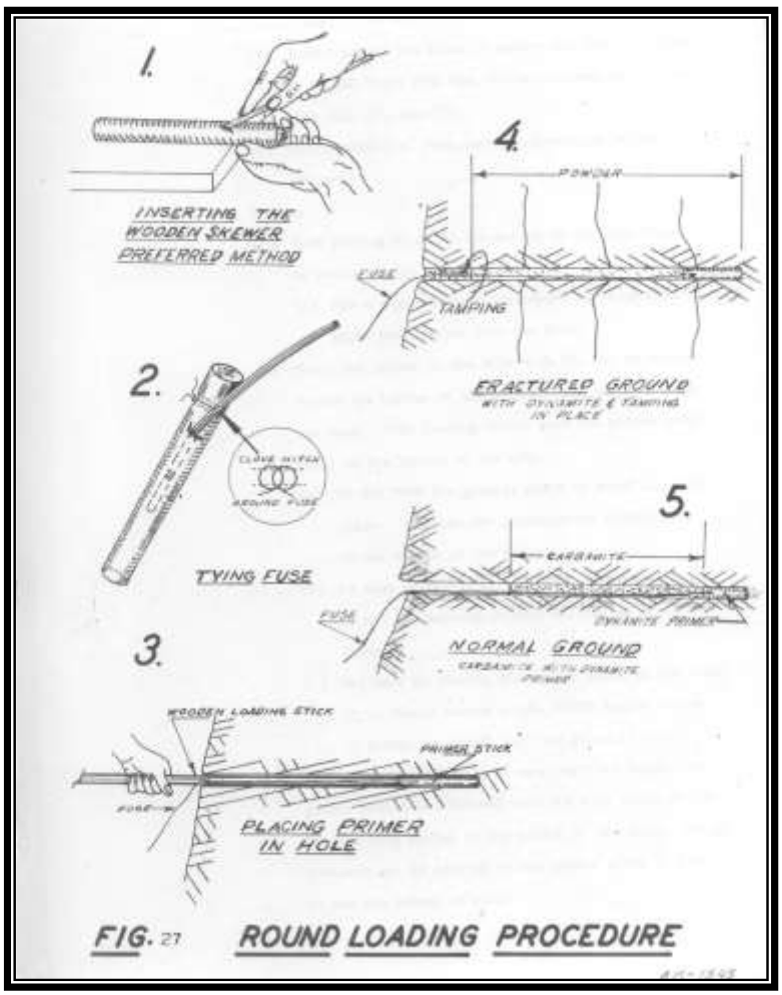
From 1923 onward, Apache Powder Company dynamite was the most commonly used explosive in the underground mines at Bisbee.

Two empty 50 pound boxes and a roll of fire fuse and a pair of cap crimpers.

Graeme Larkin collection

While dynamite was a safe explosive, it was expensive and the nitroglycerine in the dynamite and the smoke following a blast caused intense headaches, if one were overexposed. In the early 1960s, dynamite was largely replaced by a blasting agent manufactured by Apache Powder and marketed under the trade name of "*Carbamite*." This blasting agent was an oxygen-balanced, free flowing mixture of blasting grade ammonium nitrate with approximately 6% No.2 fuel oil. The oil contained a dye which gave the product a distinctive red color so as to be readily visible when a hole misfired or the product spilled. The blasting agent was loaded via a pneumatic venturi tube to suck the material from the sack and fill the blast hole using modest air pressure.

Dynamite was still used – one primed stick per hole – to detonate the Carbamite and if there was water around or the ground badly fractured, dynamite was used exclusively. Typically reluctant to accept anything new, the miners quickly adapted to using the new blasting agent as it was quick and easy to use and the problem of "powder headaches" largely disappeared.



Procedure for loading blast holes with dynamite and/or Carbamite as indicated by ground conditions. Phelps Dodge, 1968

Missed holes – the greatest explosive related danger a miner faced!!! Sometimes and for various reasons one or more holes in a blast would not fire or only partially fire. These were missed holes, often hidden in the short raiment of a drill hole, or "bootleg" from a previous blast. You never drilled into a bootleg – never.

While the miners took every precaution to prevent a misfire, they still were common. The miners loaded the blast holes with care, assuring the fire fuse was undamaged and well placed with no sharp bends or kinks. Blasting caps well placed in the first stick of powder and all subsequent sticks tamped into contact with the first stick. The miners carefully lit the fuses and were sure they were burning before walking a safe distance to wait and count the reports as each hole fired – one-by-one. All recognized missed holes were reported to the shift boss and was carefully noted on the "Missed Hole" board; prominently placed on every station.

Safety cartoon C-1960 illustrating the risk of drilling into a bootleg.

Graeme Larkin collection

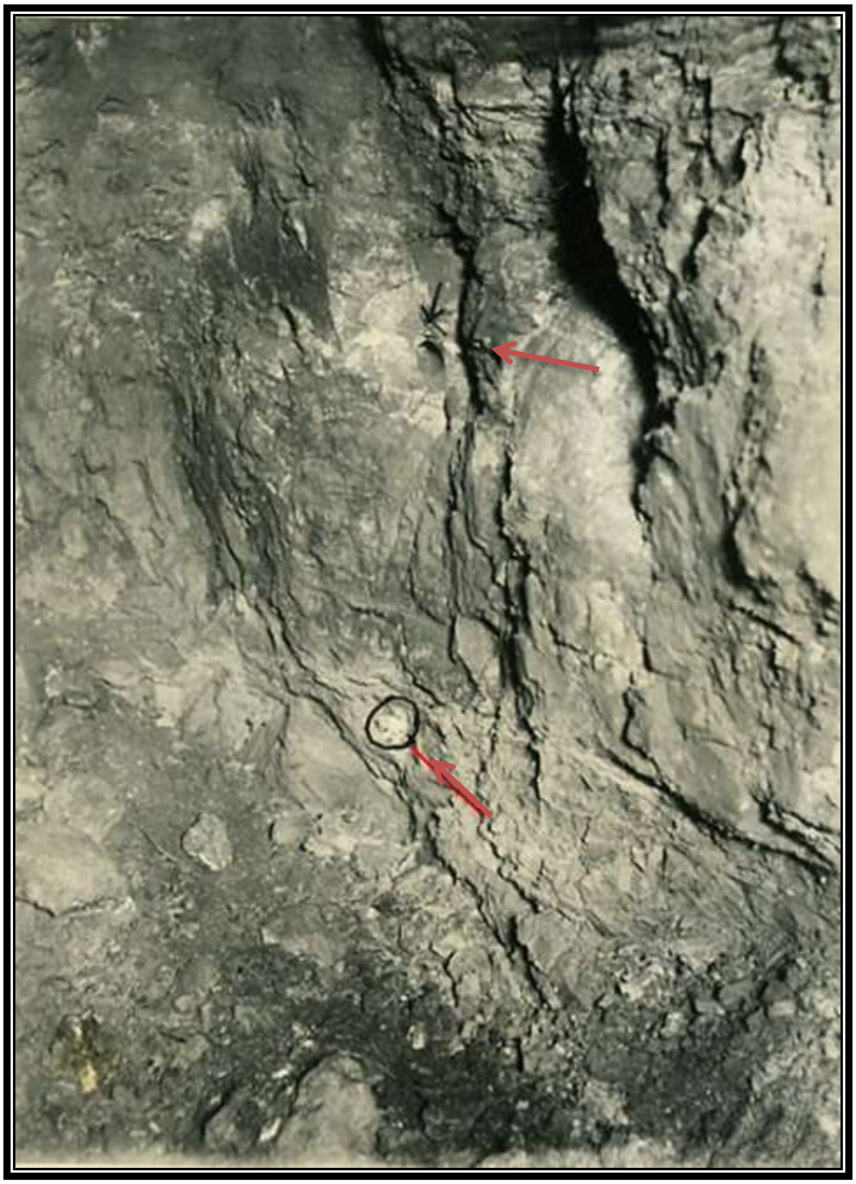
The on-coming shift would check the Missed Hole board on the way to their working place. Even if no missed hole was reported, precautions were taken. First the face and muck pile were thoroughly wet down and inspected. As mucking progressed, further inspections were made. Most often, nothing was found.

If a missed hole was found or known to exist, the miner was faced with the troublesome, but relatively safe task of either cleaning out the residual powder using a long copper "spoon" made from the heavy trolley wire. Copper was used because it was no-sparking and thus a bit more safe around the sensitive blasting caps. Alternatively, using a new primer and stick of powder, the miner could try to blast the hole, usually at lunch time. Both were standard and safe approaches but time consuming.

It was equally dangerous to hit a missed hole with a pick while digging. More than a few men had the extremely unfortunate experience of doing so. Some were killed, some blinded, but all were badly hurt as were those nearby. These types of accidents were totally avoidable.

A safety photo C-1915 taken where a man was killed from drilling into a missed hole. Note that the drill column was blasted off the bracing blocks.

Graeme Larkin collection



A safety photo C-1915 of missed holes that were completely cleaned around. The bulge in the wall is a clear indication that the blast was incomplete and that missed hole are almost certainly present.
Graeme Larkin collection

Slide 23

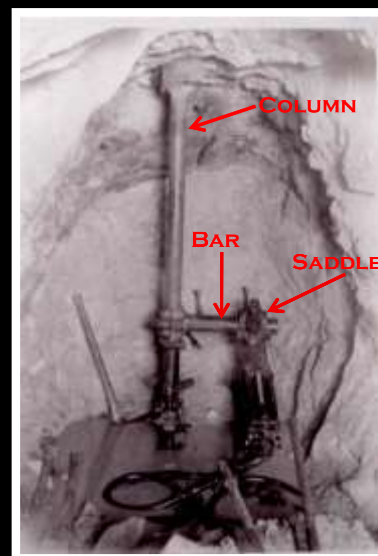
Drilling changed first

Drilling blast holes by hand was the most labor intensive part of the mining process and it required the highest skill level. Truly skilled hand drillers were never abundant, thus the need to develop an alternative was evermore pressing as there was almost always a shortage of hand drillers. Pneumatic drills filled this need at Bisbee early in the 20th century.

These heavy, column mounted machines made drilling faster and less skilled men could now perform this vital task.

The clearly staged photo at the near right (drill is set 90° to the way the column is blocked; an unsafe position to work) shows an early, dry drill. Note the substantial dust below the large holes drilled in the face of the crosscut.

Graeme Larkin collection
Early bar and column setup
C - 1908



Graeme Larkin collection
Bar and column with drill
C - 1915

Miner assisted by a mucker removing the heavy drifter from the column setup in the Campbell Mine – 1939.

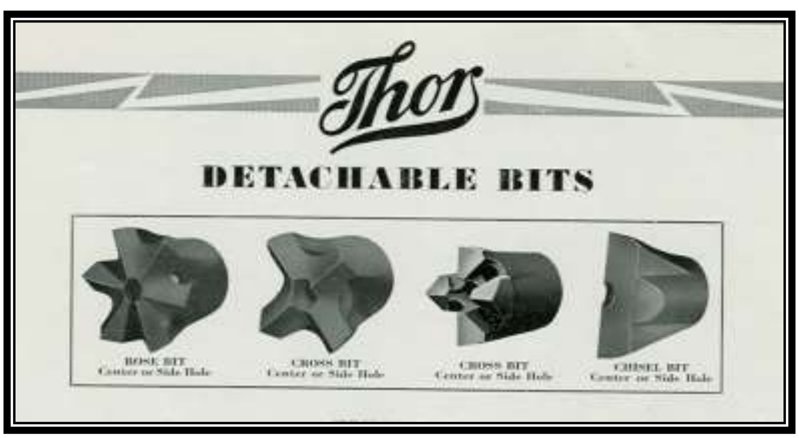
Graeme Larkin collection

The first pneumatic drills (called drifters or Leyners) were very heavy and two men were needed to mount or move the drill on the column Because of the weight and need for stability these machines were, by necessity, mounted on stout columns with adjustable, horizontal bars which supported the drill in a saddle which allowed for some positioning of the drill The columns were secured by tightening massive bolts on the base which put pressure on wooden blocks at both the top and bottom.

The drills were noisy beyond belief and the early ones were dry machines which generated clouds of dust. Both the noise and dust were very real health hazards. Progress had brought with it new problems which were overcome in a few years, but more than a few miners suffered from long term exposure to the very fine dust.

Ad for drill steel showing both the conventional steel with the bit formed on the steel as well as steels which could accommodate screw-on, detachable bits - 1949

Graeme Larkin collection



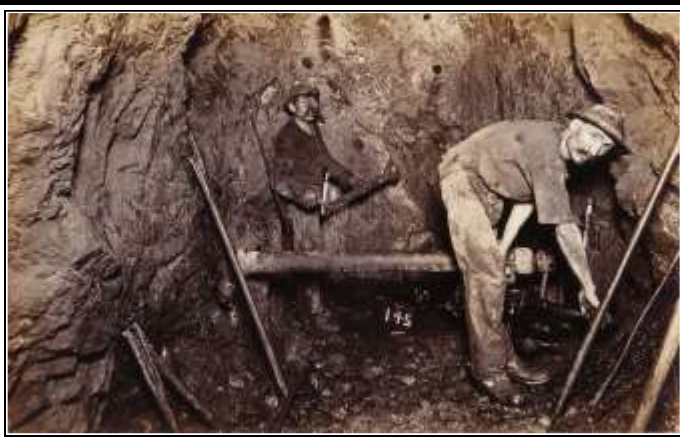
Ad for screw-on, detachable bits -1949

Graeme Larkin collection

Slide 24

Drilling became easier in stopes and raises as well

The column mounted drills were adapted for use in stopes with great success. Vertical drilling, such as in raises was done using stoper drills. These were much smaller and lighter than the column drills and employed a piston to apply the needed pressure against the rock during drilling. These were non rotating drills and the miner had to continually move the drill back and forth to provide rotation. The early dry machines covered the miner with fine dust which also filled his lungs and caused "miners consumption" - silicoses.



Graeme Larkin collection
Early bar and column setup in a stope C - 1908

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Graeme Larkin collection
Stoper drill in use C - 1915

Early stopers were a mixed blessing at best. To be sure, they made drilling in a vertical or near vertical position much, much easier. Now, however, choking clouds of dust were made by these dry machines. All of the dust fell directly back on the miner and he was forced to breathe the fine rock particles.

For the most part, this fine rock dust was just a temporary irritation, but where there was any quartz or other forms of silica in the rock, this dust became potentially lethal, over time. The fine grained silica particles lodged in the lungs and the body reacted by trying to reject them by surrounding them with liquid. With continued and extended exposure, the lungs became scared and partially filled with fluid, making breathing difficult. Because this was so very similar to the – then very common tuberculosis (consumption), and as it was largely restricted to miners, it earned the name, "miners' consumption", a simple name for a horrible industrial disease which killed so very many. Soon these drills were known as "widow makers" as they sent many a man to an early grave and left many widows.
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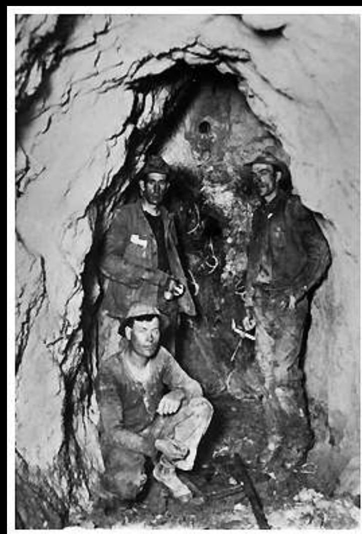
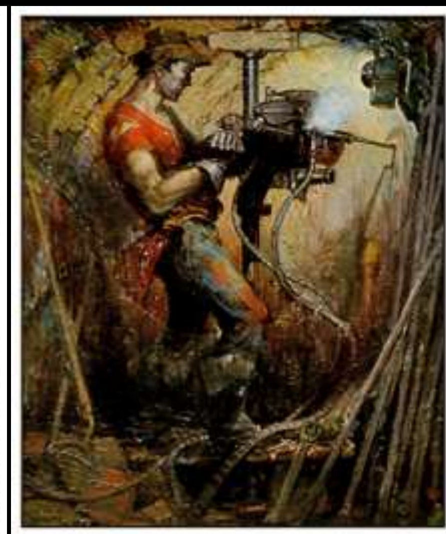
1914 advertisement featuring the type of stoper used at Bisbee.
Graeme Larkin collection

Slide 25

Each blast would now give more length to the working

Machine drill holes were much larger in diameter and could be drilled deeper. Thus each blast would now give nearly six feet of advance instead of just three - four feet. Hole placement and alignment were still important to accommodate the rock conditions





Drilling at the Working Face, Bisbee
William Davidson White
Oil on panel, 14 x 20 inches
(undated, C -1923)

University of Arizona
Mineral Museum collection

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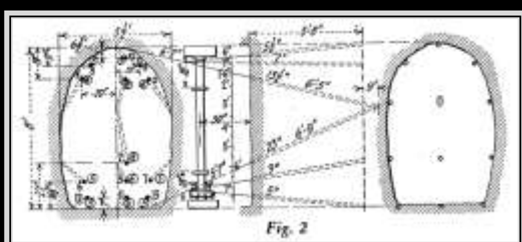
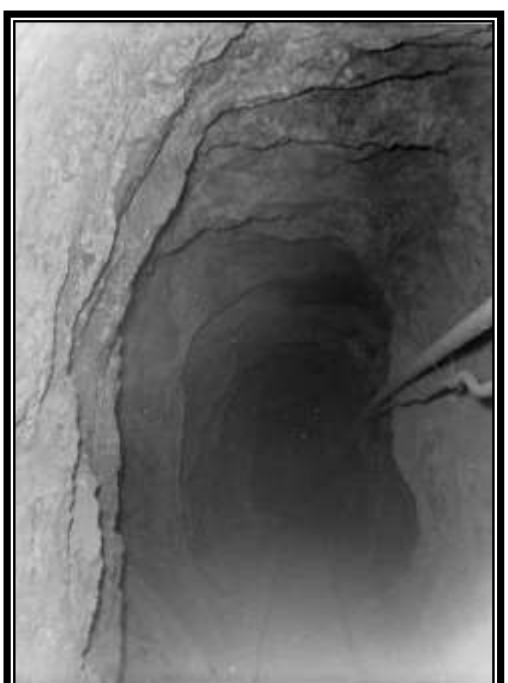


Graeme Larkin collection
Hole pattern for column mounted drill
1910

Fully loaded round in a machine drilled crosscut (above)
C - 1915
Graeme Larkin collection



In the photo at left, each of the bumps in the back and ribs reflects the length of crosscut advance per blast – just over five feet. This was drilled by a column mounted machine in the 1912 – 1915 era. Its height and width suggest that it was driven with long-term use in mind.

Crosscut on 4th level Southwest Mine -1957
Graeme Larkin collection
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Slide 26

Smaller, hand held drills were used as well

As the drills improved in power and became lighter, hand held drills became practical for use in some applications including crosscuts and stopes in cases where softer ground conditions allowed sufficient pressure to be applied by the miner using his body. These hand held machines were quite adaptable to varying conditions and were cheaper. For these reasons, they were favored by leasers

Driving a drift, Bisbee
William Davidson White
Oil on panel, 14 x 20 inches
(undated, C -1930)

University of Arizona
Mineral Museum collection

Graeme Larkin collection
Hand held drill in use C - 1915

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Hand held drills or, pluggers as they were called, were used very early on in a number of areas. They were largely restricted to the softer ground as they lacked the power of the larger and much heavier column mounted machines. And too, they were always used to drill downward or horizontally as the piston in the drill depended on gravity to aid in delivering the needed force.

These drills were quite versatile and cheaper than their mounted kin, thus they were very much preferred by the always budget conscious leasers. Their smaller size made them perfect for the typically small spaces they worked. However a day of holding one of these drills was quite tiring. Someone came up with the idea to drill the first hole in the back of the working face, put an eye bolt in it, run a rope through the eye bolt and suspend the drill, adjusting it as necessary. Doing this, the miner only had to push the drill forward and not support its weight as well.

What an idea!! It made drilling with these little machines so much easier. Local lore has it that a Mexican miner working for a leaser came up with this idea, in any event, it was forever called the "Mexican set up" as a drill mounted on a column was called a set up. This was used in the mines into the early 1960s, long after the leasers left the mines.
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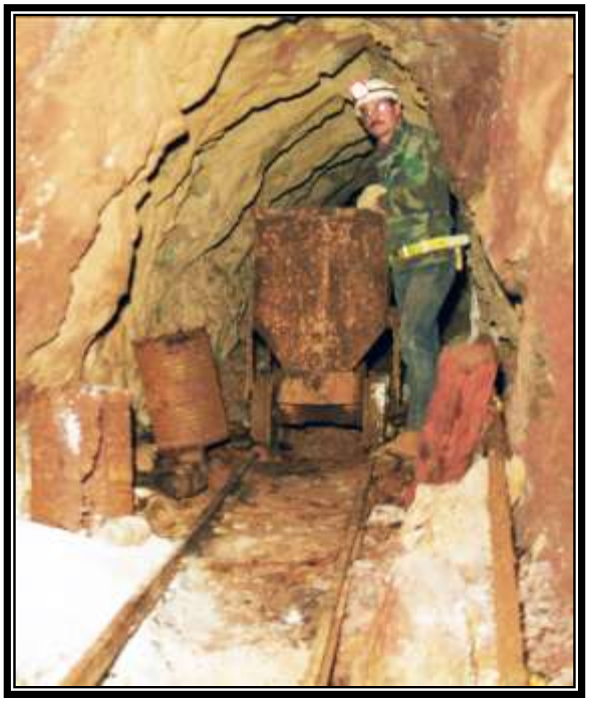
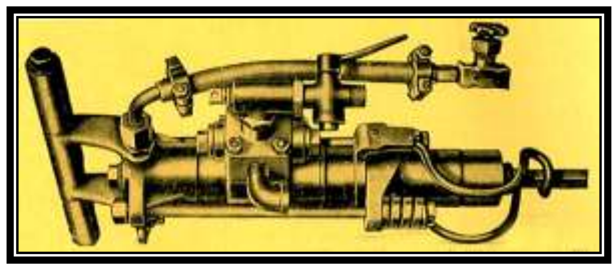


Crosscut on 5th level Southwest Mine
Graeme Larkin collection

This exploration crosscut was developed using handheld, plugger drills in the 1930s by leasers. The drill type is indicated by the short distance between blasts (3 feet) as shown by the bulges in the left rib.
The small size indicates it was not expected to see anything other than hand tramming and modest use.



Cochise brand plugger drill ad (top) and an example below, both C - 1920
Graeme Larkin collection

Slide 27

The move to machine drilling was seen as important

The move to machine drilling was such an important innovation that most mining companies wanted to show they too employed this new technology and were, by association, more efficient and therefore more profitable.

The stock certificate vignettes from all three of the big players at Bisbee carried images which depicted some form of machine drilling. This continued for years after the application of these devices was commonplace

Vignette of the Calumet and Arizona - 1909
Graeme Larkin collection

Vignette of Phelps Dodge -1952
Graeme Larkin collection

Vignette of the Shattuck Denn - 1925
Graeme Larkin collection

The design of stock certificates was and indeed, remains an art. One where the company is attempting to send a message of stability, strength and profitability so as to be able to pay dividends and increase the share value. For mining companies in the early part of the 20^{th} century, it was common to have mining scenes as the vignette and many of the companies working at Bisbee did just this.

This practice changed somewhat about mid-century when more art-based illustrations began to appear.

Slide 28

Drilling equipment continued to be improved

The dual boom jumbo, which held two drills, was introduced in 1948 for use in crosscuts. It was a track based cart held in place by a pair of pneumatic pistons. Vertical and horizontal adjustments were made with a "come along" type chain hoists. Certainly primitive by today's standards, but it was a huge improvement. These were used until mining came to an end.

Graeme Larkin collection
Setting up a dual boom jumbo in the Campbell mine -1950

Jackleg drills were a God send to the stope miner. They were much lighter and could be used most any place. A controllable piston leg allowed rapid vertical adjustment and applied the necessary pressure against the rock as well. They were first introduced in the very late 1950s and continued in use to the end ~~~~

Graeme Larkin collection
Drilling with a jackleg on the 2833 level Campbell mine -1973

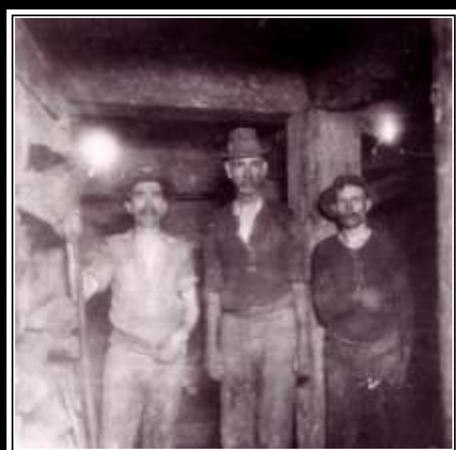
Ad from Phelps Dodge showing the use of a jackleg drill underground at Bisbee -1970

Graeme Larkin collection

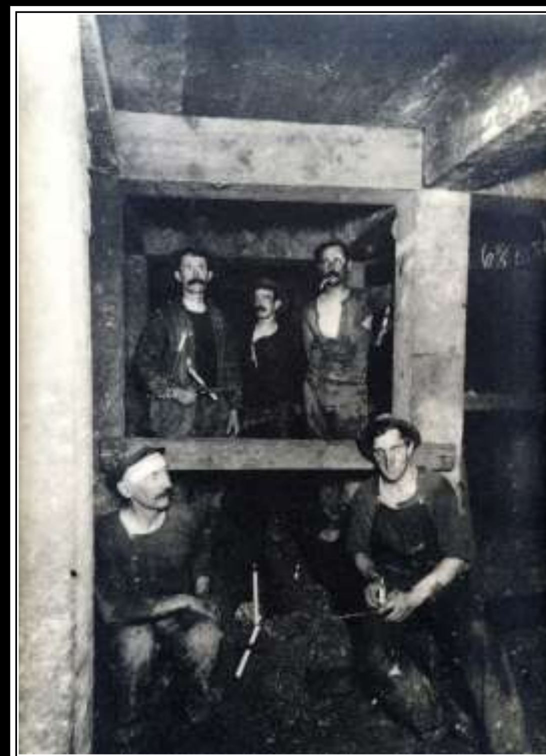
Slide 29

The evolution of individual mine lighting
---- candles ---

Nothing is so important to a miner as his personal light - in this world of absolute darkness. For the first 30 years, miners at Bisbee labored in the dim light of one candle pre man. These were clipped in forged, steel candle sticks with a loop handle and a spike end to stick in timber and a hook to hang on a rock. This feeble source of illumination was all that was available until 1910. ~~~~~



Candles in candle sticks in use - in a square set stope (far R) and while gobbing a stope Note how the high humidity has given an aurora effect to the candle light C - 1905 Graeme Larkin collection



Stearic acid candles were preferred as the incorporation of this, now common, additive made the wax harder and the candles burn longer, thus they were better suited to the typically rough treatment. Of course, the longer burning aspect was important to the mine owners who had to buy the candles for the miners.

Mining candle box, candles and candle holder, all C – 1895
Graeme Larkin collection

Mining candle box, C – 1895
Graeme Larkin collection

Miners at the Spray Shaft, C – 1895. Note the number of candles evident in the pockets of the men on the left. Candle wax is visible on the clothing of several of the men as well.
Graeme Larkin collection

The evolution of individual mine lighting
---- Carbide lamps ----

The introduction of carbide lamps began in 1910 and the transition from candles was complete by 1915. These lamps produced from 10 to 12 times the light of a single candle. The benefits of more light are obvious – improved safety, and better production. They were cheaper to use than candles. Fire danger was reduced, as burning candles, set on timber and forgotten, were the single greatest cause of fires at Bisbee. The Copper Queen had a lamp manufactured for its mines by Justrite in 1912 which is marked "Copper Queen" ~~~~~

Graeme Larkin collection
Men using cap lamps re-railing an "A" style car C - 1915

Graeme Larkin collection
Men using stope lamps in a stope C - 1915

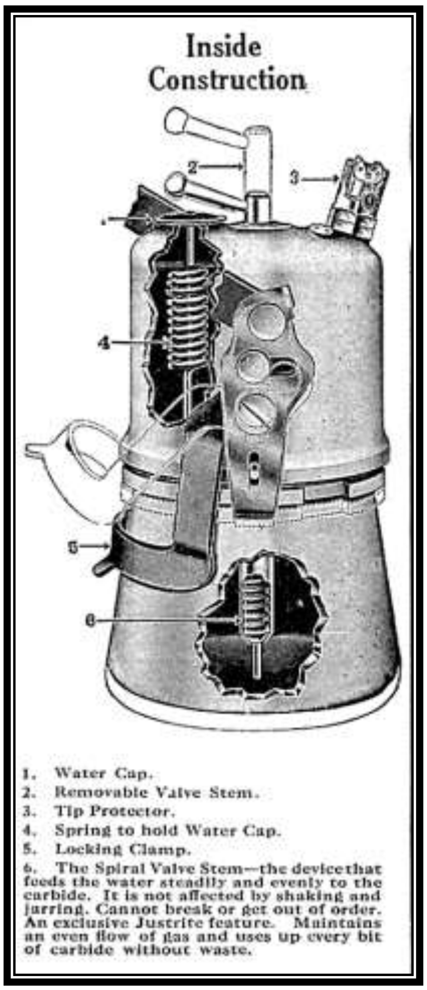
Bisbee Mining & Historical Museum collection
Superintendent style lamps in use in the Czar mine C - 1916

Cap style lamp fitted with a candlestick holder (left) – 1916. This allowed it to be stuck in a timber just as the earlier candlesticks were used.
Graeme Larkin collection

The carbide lamp came in several types, hand held lamps with a bale and a hook, often referred to as “stope lamps’ as a stope miner could hang the lamp by its hook in a convenient place, and the much smaller, cap lamps which attached to a soft cap. Cap lamps afforded "hands free" light and the ability to move about or work in narrow area where hanging the lamp was not practical as a shadow would result from working in front of the light. Superintendent style lamps were, as the name suggest, used by supervisors and engineers. These were fitted with wire handles and lacked both the hook of the stope lamp and the cap bracket of the cap lamp. They were typically a bit smaller than the stope lamps as well.

The lamp its self was made up of two chambers. The lower chamber which screwed off from the upper one contained the small chunks of carbide which were very much like crushed gravel.

The upper chamber was filled with water. A tap protruded into the lower chamber from here. On top of the lid was a small handle for the tap which when turned on allowed a drip flow of water into the lower chamber and on to the carbide. This fusion of water and carbide produced highly flammable acetylene gas which traveled up through the upper chamber and out through a nozzle on the front of the lamp. The front of the lamp consisted of a shiny reflector, the nozzle and a small flint (similar to a cigarette lighter). When the miner wanted light he turned on the water tap and flicked the flint to generate sparks and out shot a burst of flame like a mini blow lamp.



Cutout view of a Justrite Uncle Sam lamp – 1916. This was a common lamp used at Bisbee
Graeme Larkin collection

Left: A stope type carbide lamp in use.
Graeme Larkin collection

Justrite carbide advertisement from 1916
Graeme Larkin collection

Justrite aluminum stope lamp model 110, as made specifically for the Copper Queen Consolidated Mining Company C- 1915.

Graeme Larkin collection

A pair of group photos of miners with their carbide lamps and lunches prior to going on shift. Top – Czar Mine, C – 1928; Bottom - Junction Mine, C – 1935. Interestingly, some of the lunches are in paper sacks, something fairly rare because the mine rats could easily gain access. Perhaps these are new men or surface workers.

Graeme Larkin collection

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The evolution of individual mine lighting
---- electric cap lamps ---

Electric cap lamps were first introduced here in 1938 and then only in the Campbell and Junction divisions. By 1944, all of the mines were using the alkaline wet cell manufactured by the Edison company. These more than doubled the amount of light a miner had to work by. In 1965, these lamps were replaced with sealed, lead acid battery Wheat Mark II lamps which further increased the available light

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Graeme Larkin collection

Miners using early Edison cap lamps, cutting fuses in a stope in the Campbell mine- 1939

Graeme Larkin collection

Engineers with Wheat Mark II lamps waiting for the cage, 2700 level station , Campbell mine - 1974

The Edison alkaline battery proved useful for lighting railway cars and signals, maritime buoys, and miner's lamps. This storage battery eventually became Edison's most profitable product.

While the Edison mine lamp was a true benefit to the miner, it did have its drawbacks. The lamps would leak the alkaline electrolyte if tipped sufficiently. Bending over for any length of time or working in a prone position, common when shoveling gob in a stope, would almost always result in the fluid leaking out and onto the miner. The strong solutions from these batteries burned many a miner's backside.

Advertisement for Edison cap lamps of the same type as used at Bisbee after 1950
Graeme Larkin collection
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Also, the bulb, which had two filaments, was held in place by the pressure of the lens. When the glass was broken, the bulb would pop out, leaving the man in the dark.

Shift boss, Keith Lemon (L) and geologist Richard Graeme, with Wheat Mark II lamps in the Campbell mine – 1974
Graeme Larkin collection

Geologist Richard Graeme, with Wheat Mark II lamp in the Campbell mine – 1972
Graeme Larkin collection

The Wheat lamps were excellent lights with very well sealed batteries. Few burns ever resulted from the use of these exceptional lamps. The two-filament bulbs in these lamps were held in place with a twist. It could be focused from spot to wide by a simple turn of the knob on the lamp head.

Each miner had an assigned lamp. A number was stamped on a metal tag attached to the battery case. One never took some else's lamp, ever. It was the miner's responsibility to always return it to the proper slot on the charging rack and make sure it was charging before left.

Both of types of electric lamps were extremely durable and seldom gave the miner any problem. If there was a problem, the miner would tie a knot in the cord as he placed it in the charging rack at shift's end. The lampman would check the rack at the end of every shift and take any lamps with knotted cords to his work bench and usually have it back on the rack and charged before the man came back on shift the next day.

On periodic Sundays, the electrolyte levels were checked and filled as needed, by a mine electrician.

Lamp charging rack at the Queen Mine Tours was identical to those used in the mines from 1967 to 1975
Graeme Larkin collection

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Selection of mining methods

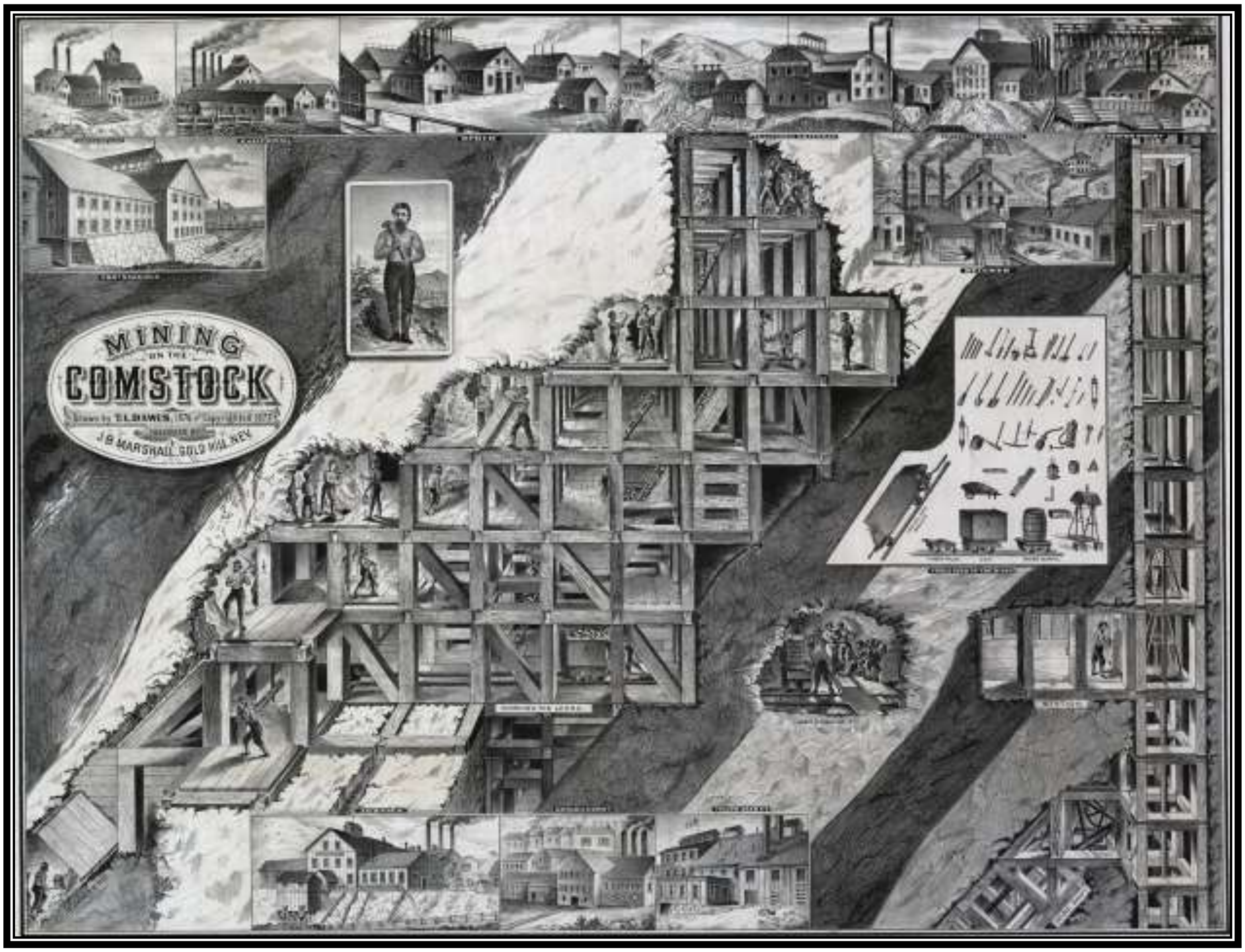
The selection of how to mine an orebody was a very important decision as mining costs varied depending on the amount of timber and labor required to remove the ore. If the mining costs were high, then the grade of ore mined had to be higher to cover the additional costs. Thus, some potential ore could be lost if a high cost technique was selected.
For the most part, the stability of the ore and the hosting rock determined the method to be used and the majority of the oxide ores were soft as was the surrounding rock. This required a good deal of timber to hold the ground in place.
The change from good, competent rock which needed no support to very soft and weak rock that could be difficult to keep open was often very abrupt. The early ores were almost always soft and unstable which forced the choice of mining systems which provided a great deal of support. Squareset timbering coupled with frequent back filling of mined areas was the most common. In fact, until 1912, 100% of all ore mined used this system. Squareset mining was used to mine some ores until the very end in 1975 ~~~~

Graeme Larkin collection
Looking down a crosscut, note the abrupt change in rock from competent to heavy timber support 1910

A mining method was selected based on the factors of the size of the ore body, its value (a function of ore grade and recovery of the metal by processing) and the physical nature of the rock – both ore and hosting waste. Other factors such as blocks of waste in the ore, shape – irregular vs. somewhat symmetrical, were important factors to consider after the other conditions were determined. It was these sets of criteria which combined to determine the use of squareset mining at Bisbee. This choice was a considered decision because so much timber was needed; it was expensive from both the materials and labor perspectives.

Bisbee's ore bodies were very irregular in shape which precluded some other methods because less than complete ore extraction or excessive dilution by waste rock would have occurred. Also, most of the orebodies had internal zones of low-grade or waste that needed to be left in place. This precluded some of the caving methods.

Though expensive, for Bisbee the squareset method was the most practical, just as it had been at the Comstock Lode in Nevada where this ingenious system of timbering had been devise in late 1860.



The classic graphic of the Comstock Lode mining methods – 1876- with squareset stoping in the center and very much as practiced at Bisbee a few years later.
Library of Congress collection

Slide 33

Selection of Mining methods

Before 1912, all of the ores mined at Bisbee were removed using square set methods when changing ore and rock types brought about the introduction of other mining techniques. Extremely soft ores in weak rock began to be mined with top slicing. The massive sulfides which were becoming more common with increasing depth, were mined using the cut and fill method.

These were the three principal methods used over the years. Also, very small tonnages were mined by shrinkage techniques

Off and on for the period, 1925 to 1944, block caving was used, with mixed success, in the East orebody

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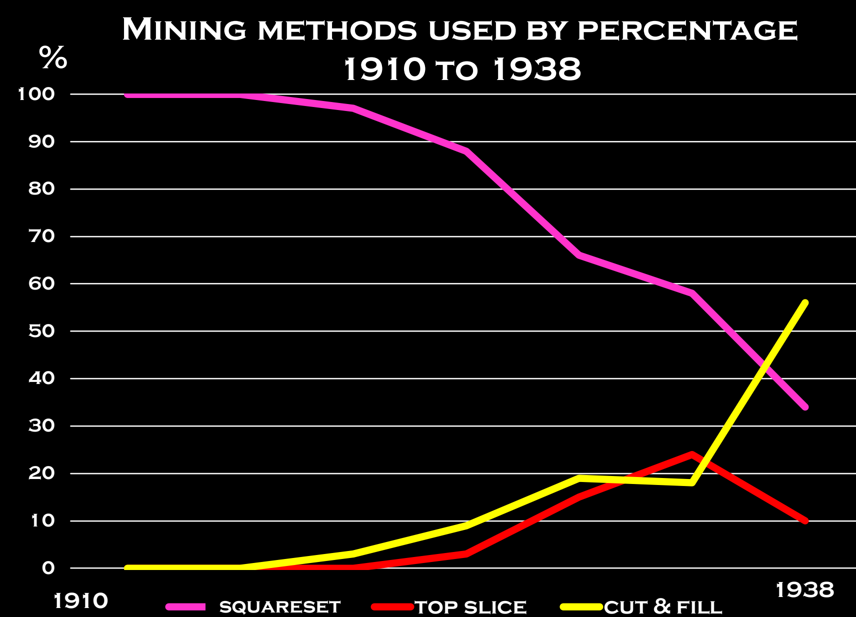

The selection of mining methods employed over time was driven by several factors. To be sure, the deepening of the mines give access to less altered sulfide orebodies which were in more competent rock was an important factor in the increase of cut and fill mining. Equally important was the fact that men of lesser skills could effectively mine in this environment and good, skilled miners became more and more rare over time. Costs were also a driver, as mine timber was becoming much more expensive. Also, cut and fill was less labor intensive, as the rock was moved less often.

Top slice mining was both timber and labor intensive and thus expensive. The increase in this approach was a result of the perfection of this mining technique in mining ores that could not be exploited by other methods. The easily mined ores were gone, now there was little option but to mine the more difficult, albeit at an increased cutoff grade.
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Slide 34

Just how unstable were the ores?

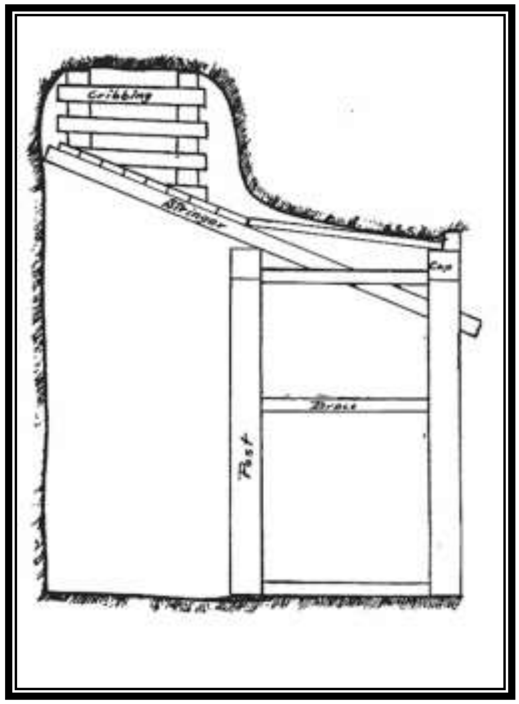
Most of the ore mined in the early days was in a claylike material which had absolutely no strength and was often plastic and would flow under pressure, easily pushing the largest of timbers aside. Workings often had solid walls of 12”X12” timber to keep the area open. The unrelenting force would soon distort the massive timbers and fill in the open space. The best strategy was to get in and mine as quickly as possible, backfill frequently, and get out quickly. Sometimes, “quickly” was several years or more. Often ore was lost because the ground could not be controlled. Note the effects of moving ground where the squeezing has force the post to be cut to allow access to the chute and how low the drift has become. Also, the displaced posts jutting out of the right rib~~~~~

Graeme Larkin collection
Heavily timbered area distorted by pressure– 1915

Graeme Larkin collection
Heavy timbering in a drift – 1910

While the vast majority of mining was in relatively competent rock, some took place under extremely difficult rock conditions. Several types of rock environments required extraordinary efforts to safely and successfully mine. Running ground was a generally used term to describe the material in which it was the most difficult to drive and maintain openings.

The early ores mined at Bisbee were all thoroughly oxidized, ores often surrounded by soft plastic clay-like masses that had no inherit strength and would collapse if not totally supported – always. Later, some of the sulfide ores discovered were surrounded by unconsolidated, granular pyrite. The miners called these "sugar sulfides" as it flowed much like granular sugar. Clearly, this material had no strength and had to be supported. In both cases, not only was support important, but it was also essential to keep the material from oozing or flowing into the open space the miners were creating with their workings, as this would allow voids to develop around the supporting timber. Unsupported voids always represented a place for a collapse to occur and were always tightly timbered. The illustration to the right is an approach for cribbing open spaces at the Copper Queen Branch.



The very arduous task of advancing openings in running or other badly broken ground was referred to as "spiling." This required the physical driving of 4" X 6" boards which had been tapered on one end to aid in their penetration of the unstable ground. The driving of the spiling boards was one of force using 20 pound double-jack, type sledge hammers, swinging a heavy rope supported timber, a pneumatic drill with a wide, flat steel inserted or some other means of pounding.

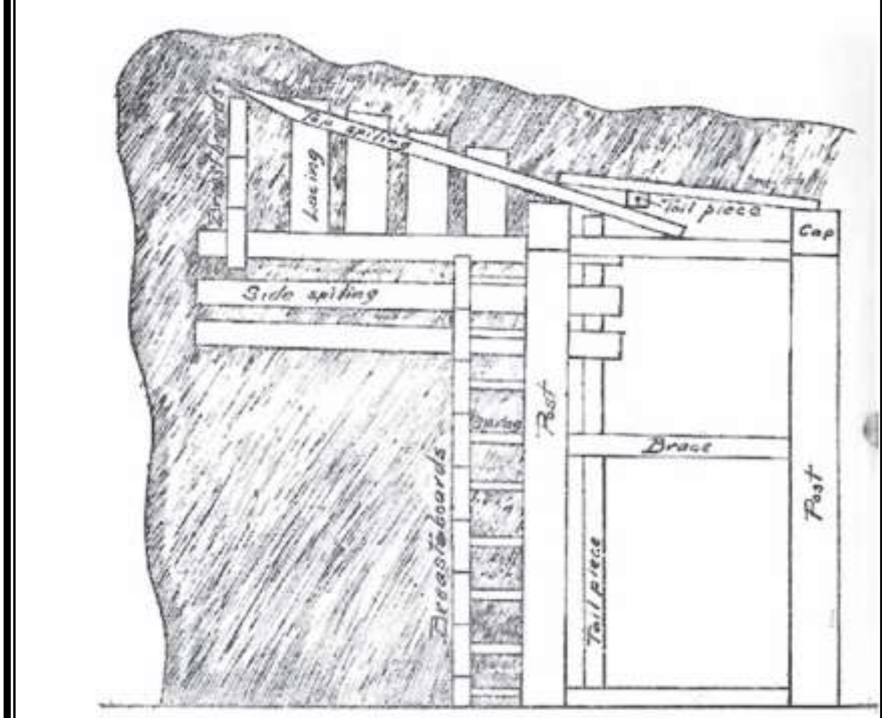
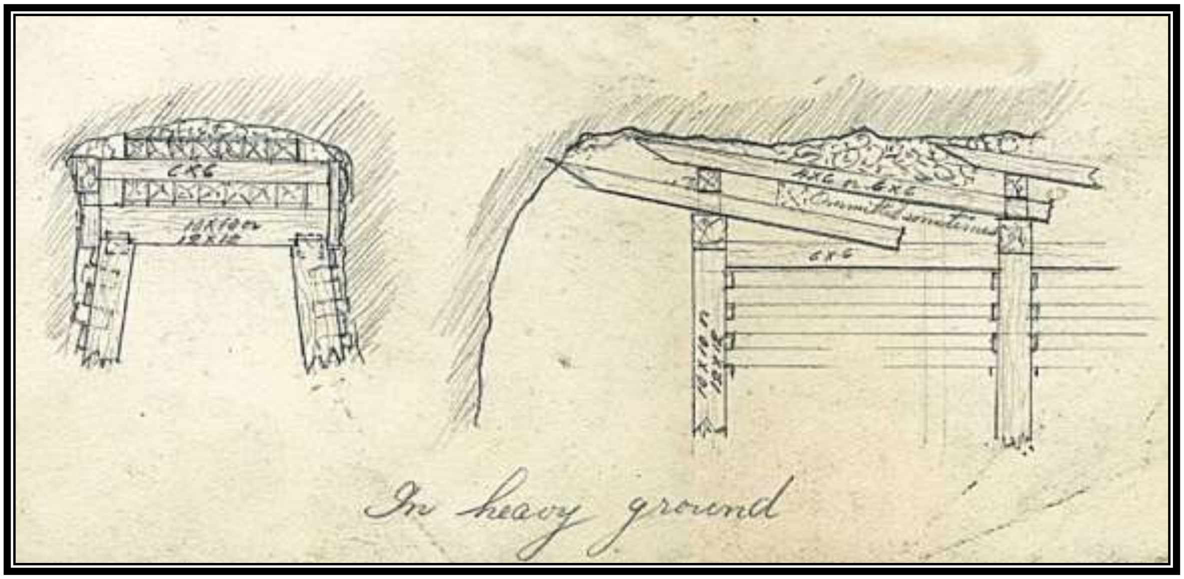


FIG. 2. TOP AND SIDE SPILING AND BREAST-BOARDS. BOOMS NOT SHOWN.

A schematic diagram of timber placement while spiling at the Copper Queen – 1920.
Graeme Larkin Collection

In running ground, the spiling boards had to be driven side by side, with no space in between. This was done not only in the back, but also along both sides (ribs). Breast boards were in the face to contain the muck until the back and ribs had both been secured, and then removed one at a time and the muck removed. An advance of two to three feet in 24 hours was common under these difficult conditions.

This was incredibly hard work, where miners would swing the heavy hammer to the point of utter exhaustion.   When a spiling board would hit a boulder, this would limit the advance until all the muck was removed, temporary timber set and new spiling boards placed. Then the process would continue again.

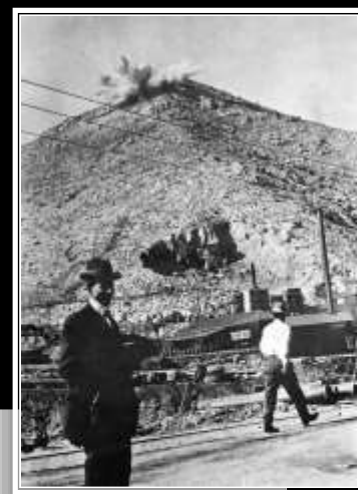


A sketch of a spiling – timber setup from the Shattuck Mine C- 1918
Graeme Larkin collection

Slide 35

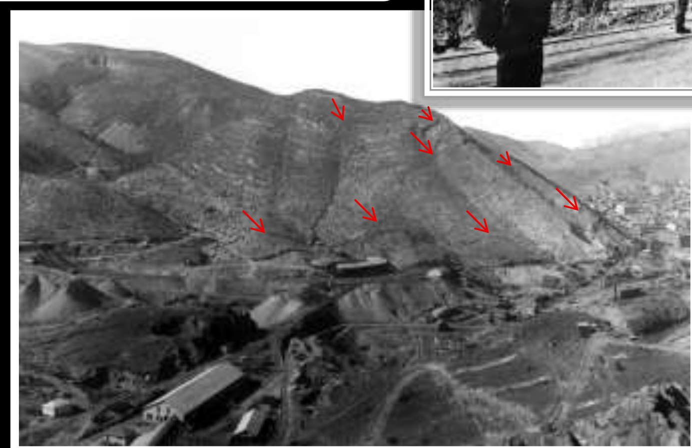
Movement underground soon reached the surface

Queen Hill was in a state of constant movement because of the ore removal and the plastic clays slowly flowing into any open space. Not only was this a huge problem underground in trying to keep open access to the ores, but the moving hill was a concern and boulders occasionally rolled down from the newly formed cracks



Blasting boulders loosened by subsidence on Queen Hill - 1916
Graeme Larkin collection

Graeme Larkin collection
Timbermen repairing area distorted by pressure of moving clays C– 1910



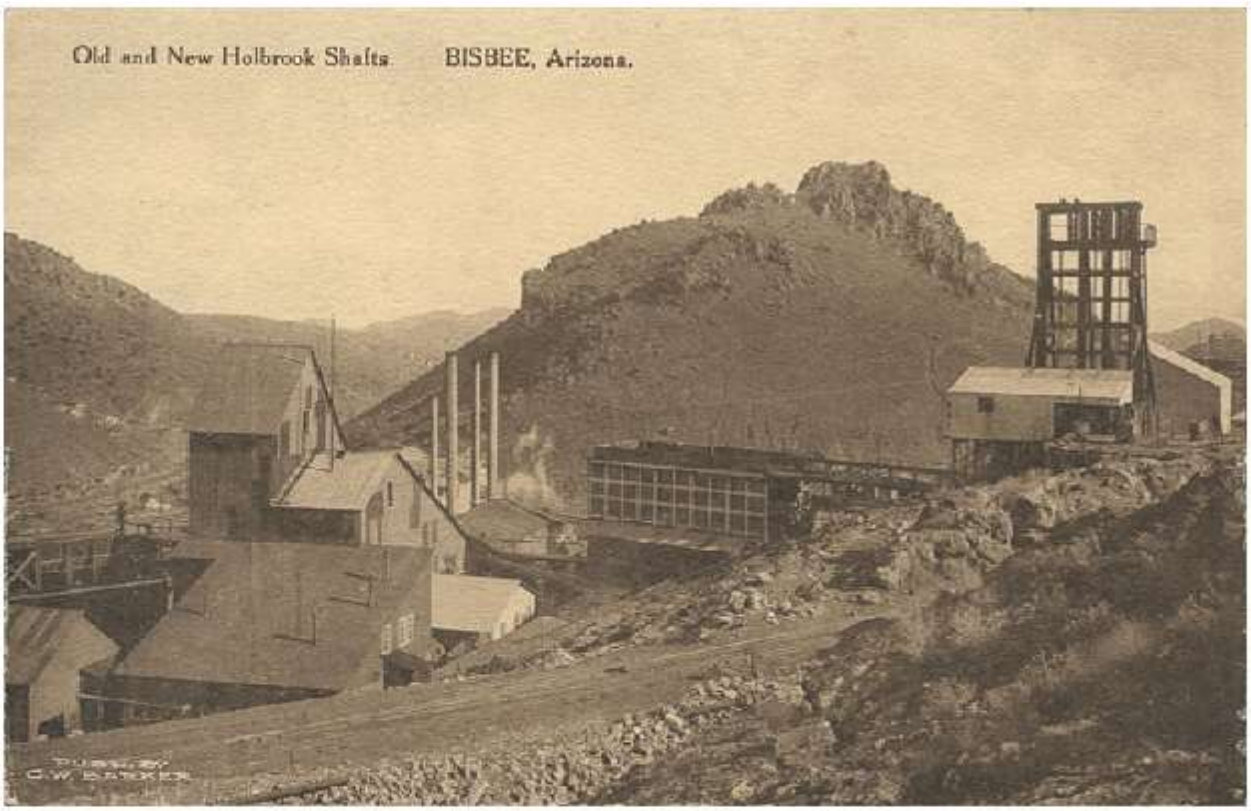
Graeme Larkin collection
Surface cracks caused by the movement of the clays underground C– 1915

The limestone mass which became known as Queen Hill had long been moving, first cracking and adjusting to the development of the oxide ores and the associated clays for tens of thousands of years or, perhaps more. Over geologic time, the cracks caused by this natural subsidence had developed slowly and usually vertically over the orebodies. They were fairly wide zones of ten feet or more but they had filled with calcite thus, they were not obvious before mining began. They were however, zones of weakness and quickly failed again as the support was removed by mining and the subsequent mobilization of the clays.

The slow, but constant movement of Queen Hill toward Bisbee was a great concern to many. The removal of ore and the plastic nature of the oxidation formed clays had the front part of the hill sitting on an unstable mass of jelly-like material. As the cracks on Queen Hill widened and the hill continued to sink, boulders would break loose from the crack faces and a few rolled to the bottom of the hill. The movement of the hill and the cracks were monitored to protect those below, but the hill continued to move. There was nothing that could be done to stop it except suspend mining and that was not reasonable as the whole of the community depended on this continuing.

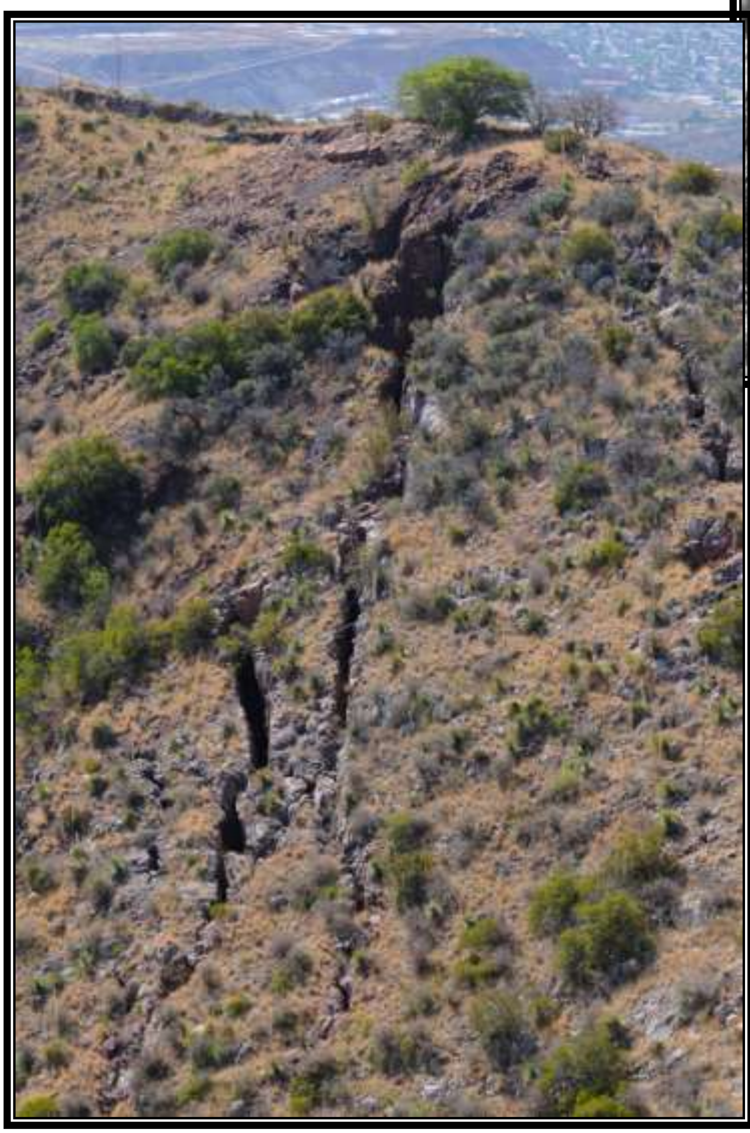
The movement added a twist into the 400 foot deep Czar shaft which caused constant maintenance to be required. The Czar Hoist foundations became unleveled because of this movement and it had to be re-leveled on a regular basis. The first Holbrook shaft was completely lost because of the moving clays and was replaced by a new shaft nearby in 1906.

By the late 1930s, the hill seemed to have settled into its final position. No doubt because little mining was then taking place at is base. Today, there is no evidence of continued movement, but the several series of cracks above the Queen Mine Tours speak of a time when the mountain was unstable.



Postcard view of the old and new Holbrook shafts (Left and right respectively) 1910
Graeme Larkin collection

Surface cracks caused by underground mining under Queen Hill. Right - 1913, below 1975
Graeme Larkin collection



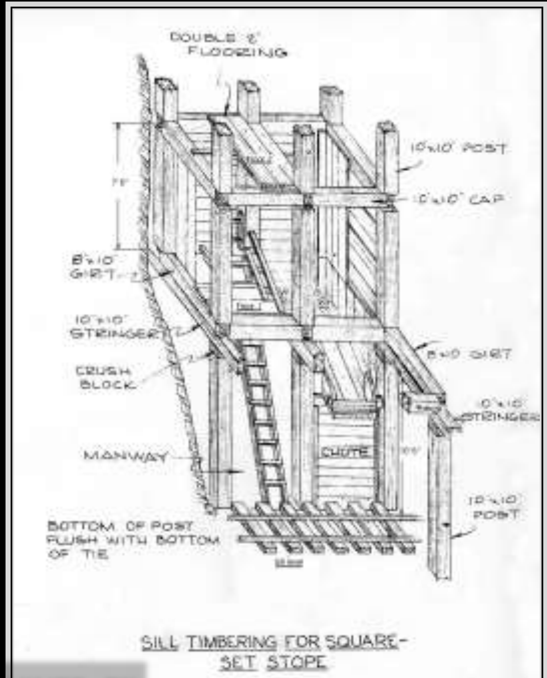
Local lore at Bisbee is that the many cracks on Queen Hill were formed as a result of the massive (7.6 estimated) earthquake that struck Northern Sonora and Arizona on May 3, 1887. This is incorrect as the cracks are all subsidence related and not tectonic in **origin.**

Slide 36

Squareset mining

Each set in a squarest stope was but 5' X 5'X 7' when supported with 10" or 12" timbers, really a small space as shown in the photo below. The slow, steady movement of the ground around these stopes had the timber always making unsettling noises, popping and cracking as it adjusted to the ever shifting weight load, but this is why it worked, it adjusted instead of failing

Graeme Larkin collection
Stope crews in a squareset stope
C– 1900



Graeme Larkin collection
Squareset stope timbering - 1955

30 board feet of timber were used for every ton mined by squareset, thus a typical orebody of 25,000 tons would use enough wood to build more than 30 homes of 2,000 ft^2

~ ~ ~ ~ ~

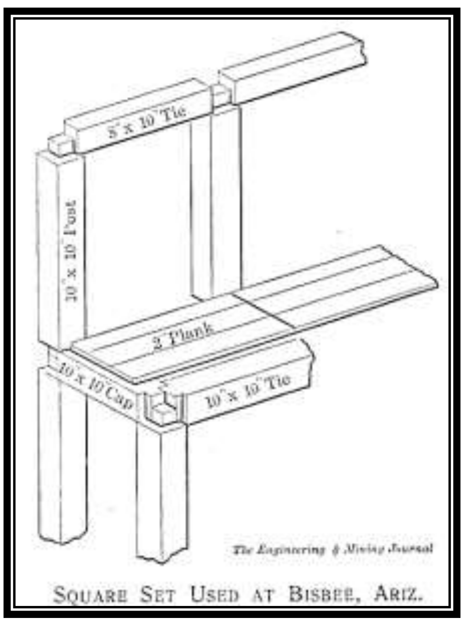
Once an orebody had been found, raises on about 30 foot centers were driven to the top of the ore and if the ore did not extend the 100 feet to the next level, several raises were driven all the way through for access, ventilation, backfilling and supplies. Mining would start on the lowest part of the ore with sections removed usually equal to 20 to 40 sets then backfill (gob) would be poured in from the level above and the open sets filled, tight to the caps. The number of set which could be mined before gobbing depended greatly on the rock quality. Sometimes more than 100 could be mined, but more often between 30 and 40 were the limit. In really bad ground no more than 10 to 12 sets could be left open before gobbing.

Gobbing was a critical part of ground support. Every effort was made to fill all open spaces. This included many hours hand shoveling waste to the very top of the timber in every set. A huge task, often performed lying on one's side, but no space could be left open. The movement of the ground quickly came to rest on the gobbed sections. The gob slowed its overall movement and making the area more stable. It was important to make sure the area above the stope did not start to move as there was always the possibility of more ore above and broken ground is much more difficult to mine. Also, in the early years, the mines were close to the surface and it was important to protect the surface from subsidence to the highest degree possible as the mine facilities were often just above.

Then, the mining would move to the next set above and start the process all over again. This is referred to as "over hand" mining as the work progresses upward.

Orebodies were usually exploited in more than one section at a time as once the ground started to move from mining in one area, it was possible that it might move too quickly and the orebody be lost because of caving.

Very large orebodies typically were mined in as many as four sections at one time while leaving an un-mined pillar between each section. These pillars were large enough to support the mined sides and they would be mined after both sides had been completely mined and gobbed. Sometimes they would be mined from the top down (under hand mining) using top slicing if the ground was particularly bad.



Diagrammatic sketch of how timber is framed and then pieced together in square set timbering – 1912
Graeme Larkin collection

Slide 37

Squareset mining in good ground

When ground conditions permit, squareset mining can proceed by opening up the ground along the upper ore-waste contact and move more or less horizontally several set high and then downward to maximize the amount of ore extracted. Gobbing is still a critical aspect as mining will take place under the gobbed areas. This was an approach with the more competent ore found in some parts of the Southwest mine.

Many of the orebodies found in the areas above the Queen Mine tours were associated with silica breccias and were mined in this manner

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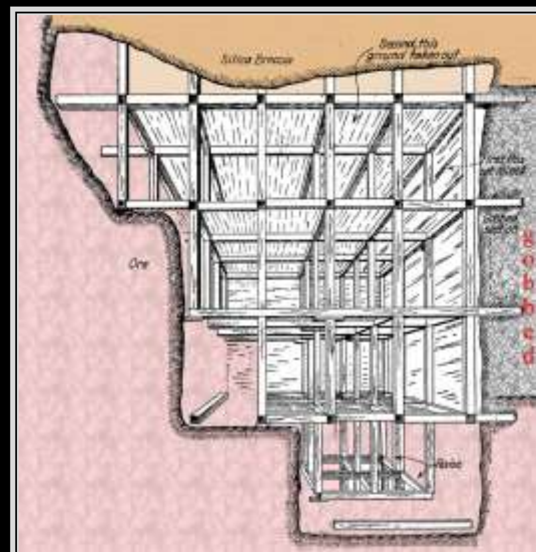
Graeme Larkin collection

Competent oxide ore associated with a silica breccia in the Southwest mine



Graeme Larkin collection

Squareset mining under a competent back C– 1920

Aerial view of Queen hill showing the surface cracks from the collapse of the un-gobbed 105 stope from the 6th to 7th levels Southwest Mine – 1976

Graeme Larkin collection
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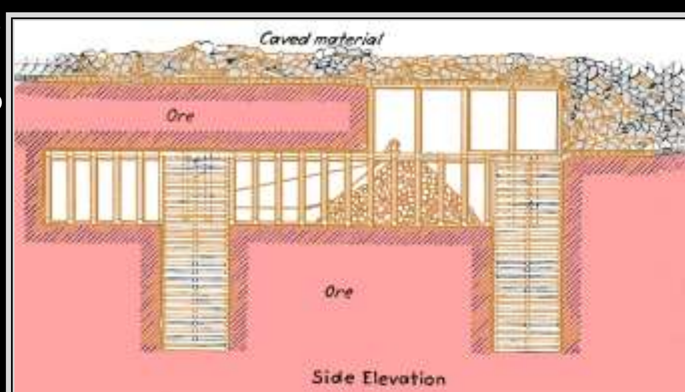
In those rare cases where the ore was weak, but the hosting rock reasonably competent, the approach to squareset mining could be successfully modified as shown above. However, even the hard silica breccias would fail after time unless fully supported.

In the uppermost parts of the Southwest mine where the ore was near the surface, the ore was removed using squaresets, but only partially gobbed if at all because there was no access from above to introduce the gob. Over time, these stopes failed. In the early 1930s one such collapse extended to the surface with the radial cracks very evident today.

Slide 38

Top slicing

The technique called top slicing was used where the ground conditions were the worst, so bad that squareset timbering could not support the ground for long enough to mine all of the ore. It was often used in the sticky, claylike ores that had no strength and would fall or even flow into the squaresets. As the name implies, the mining started at the top, usually with a squareset support. When the first level was mined, the timber was blasted and the rock allowed to cave. The next cut was under this mat of rock and timber. The same process was repeated all the way to the bottom of the ore. The ground above caved for a great distance as there was no backfill or other type of support, thus it was employed only when there was certainty that no ore was above or that the surface would not be impacted. Several minor variations to this method were employed at Bisbee by the C & A and called the Mitchell top slice after a mine foreman ~~~~~



Graeme Larkin collection

Top slice mining as employed by the Copper Queen C– 1920

Only the worst of ground conditions warranted mining in this manner. Top slicing depended on the quick collapse of the overlying waste to become a part of the protective mat of rock and blasted timber. As mining progressed downward, more and more timber was in the mat immediately above the miners, but they seldom ever saw this mat as they had placed a plank (lagging) floor in the cut above to first mine off of and then mine under as it formed a part of the overhead protection.

Because top slicing depended on caving the ground to work, access above such a stope was impossible because the ground was broken, often for a substantial distance above. Thus the need to assure that access above will never, ever be needed.

A large area along the Divide fault, near the intersections of Dubacher canyon and Mule Gulch was mined in this manner. It extended to the 400 level of the Czar mine and for several hundred feet along the strike of the fault. Mining by squareset had been attempted several times, but the ore was too soft and plastic. Soon the sets were squeezed closed. As expected, the subsidence from this mining reached to the surface, directly under Mule Gulch and any water flow entered the mine through the cracks, something that was not desirable. The problem persisted until waste from the Sacramento pit was used to fill the depression and divert the water.

The road between Bisbee and Lowell, the railroad and street car tracks were all affected and had to be relocated into the footwall zone of the Dividend fault.

Slide 39

Cut and fill

Cut and fill stope mining only came about when the competent, massive sulfide ores were mined starting in the early 1910s. The strong back needed only occasional support from umbrella stulls as shown below. When possible, they were inclined as well, to have gravity move most of the muck.

Graeme Larkin collection

Breaking oversized boulders in a cut & fill stope, Campbell mine -1939

Graeme Larkin collection

Inclined cut & fill mining as employed by the C&A – 1930

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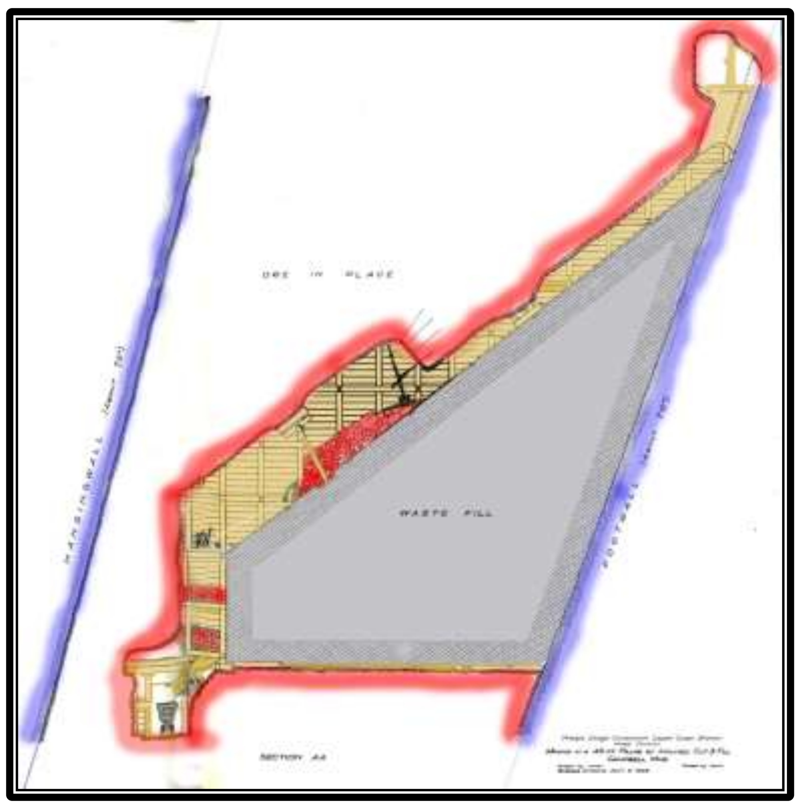
Drilling from the plank floor in an inclined cut & fill stope, similar to what id depicted in the above illustration. Campbell mine – 1939
Graeme Larkin collection

Cut and fill mining was one of the cheapest mining methods every successfully used at Bisbee. While this technique was in common use in many mines for years, it was only after the massive sulfide ores in competent host rock were found at some depth, that it could be employed at Bisbee. This was in 1913. The whole of the success depends largely on the ability of the back to stand unsupported across reasonable mining width.

As the name implies, the ore was cut out then the space filled, in the simplest of terms. The waste gob was then planked over to form a surface onto which the ore could be blasted. The ore would then be mucked into a chute. Inclined cut and fill stopes were the best of all worlds in that the blasted ore largely flowed into the chute by gravity. A slope of about 45 degrees was maintained in the stopes to assure the free flow of blasted ore to the chute while not being too steep to work on safely. Obviously, it also required great care in blasting so that large boulders did not result and block the raise into which the muck was to flow.



Mining of a 45° pillar by inclined cut and fill as employed by Phelps Dodge in the Campbell mine - 1938.
Graeme Larkin collection

The ore bodies were typically mined in sections and it was not uncommon to mine more than one section more or less simultaneously. Mining began at the bottom and worked up and the raise would be extended upward before each fill as mining moved up. Gobbing was relatively simple with waste rock dumped from above and no large amount of special shoveling or slushing required.

Slide 40

Block caving

The orebody which hosted the Sacramento open pit was in two sections the West, mined by the pit and East, most of which was too deep to be mined this way. In early 1920s, portions of the East orebody were prepared to mine by block caving where large areas are undercut and numerous raises driven, then the block was allowed to collapse under its own weight.

The effort met with mixed results as the internal fracturing within the rock mass was not ideal. While substantial tonnages were recovered from some blocks, others failed to cave adequately. The surface impacts were substantial however. In the end, the area was mined by the Lavender pit

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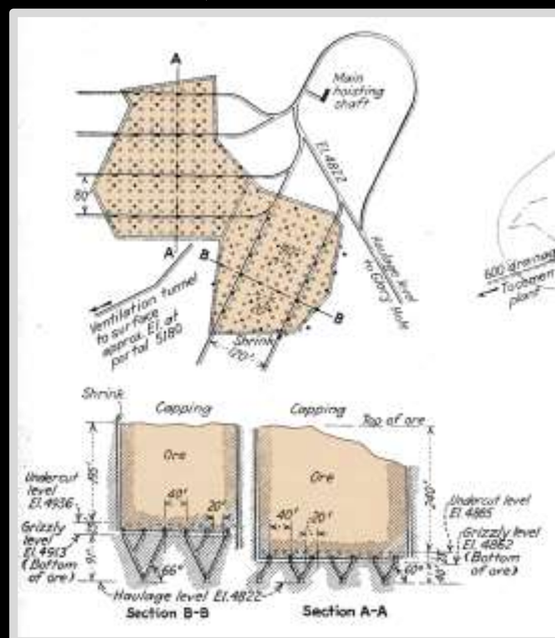

Graeme Larkin collection

Block caving as employed by the Copper Queen

C– 1925

Block caving is a mining method in which ore is allowed to collapse due to its own weight in a controlled fashion into chutes or draw points. Block caving is usually used to mine large orebodies that have a more or less consistent, disseminated grade throughout. The rock mass must contain natural fracturing in sufficient density such that it will naturally cave when undercut. The caved pieces of rock cannot be too large or they will be difficult to extract from the drawpoints.
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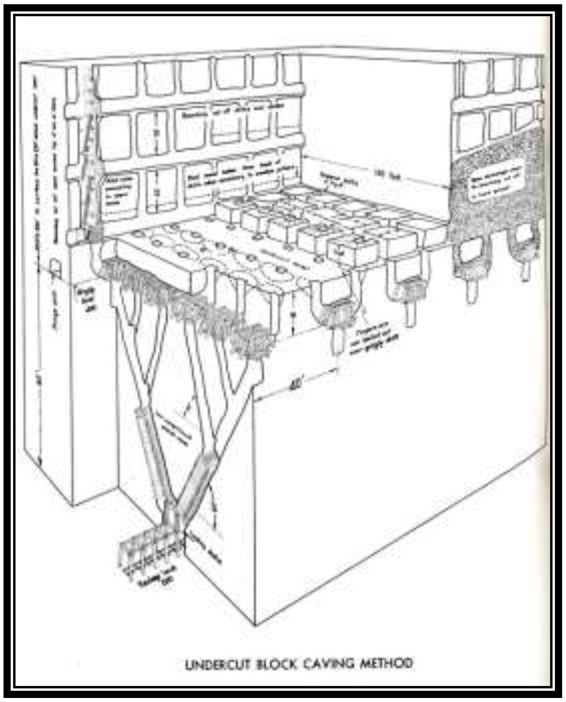

Diagram of the undercut block caving method
as employed at Bisbee – 1938
Graeme Larkin collection

Successful block caving is dependent upon the joint frequency, joint, and joint characteristics of the ore. The most favorable conditions are a rock mass with two sub-vertical joint sets and a flatter joint set having a dip less than about 30 degrees.

Block caving occurs sequentially in segments or blocks 200 to 500 feet on a side in all three directions. A series of haulage tunnels are constructed under the ore to be mined. At approximately 100 foot intervals along each tunnel in a checkerboard pattern, 10’ to 20’ diameter raises connect the haulage tunnels with another series of crosscuts. In the crosscuts, slushers transport the ore back to the main haulage level. The ore falls down finger raises intersecting the cross drifts below. These raises are driven in many directions into the ore above; usually with four or more intersecting at one point in the cross drift. These raises act first as a place to blast the entire underside of the ore block, then later as a funnel to draw the blasted ore. The ore continues to fall under gravity from the bottom of the block as it is pulled from the raises. No further entry can be made in the finger raises once the block begins to cave in.

As broken ore is removed, the capping or non-mineral bearing rock above the ore will gradually descend until broken fragments of it start coming from the draw points, indicating all of the ore has been withdrawn.

There is typically large scale subsidence on surface as a result of block caving. The area of subsidence is usually greater than the caved block but not as deep since it is usually partly filled with collapsed rock from above the cave block.

The area of Upper Lowell was adversely impacted by the block caving efforts of Phelps Dodge during the late 1920s. Ultimately, the Copper Queen Hospital had to be relocated to Bisbee because of subsidence and Lowell school had to be relocated as well for the same reason in 1928. Also, the ice plant was moved to near the Denn Mine while the power plant operated by Arizona Edison was relocated to near Naco (Mill, 1958).

A view of upper Lowell in 1927 with the Copper Queen Hospital in the center and ice plant/power plant to the right with smoke stacks and the Lowell School a bit more to the right.
Graeme Larkin collection

Much the same view of upper Lowell in 1940 with the area that overlay the block caving operations now totally devoid of buildings
Graeme Larkin collection

Slide 41

Timber and timbering

Huge amounts of timber were required to keep the mine workings supported. Many people were involved it getting the timber to the working face in a form which was usable. Timber had to be purchased and delivered to Bisbee, then it was cut to standard lengths and framed so as to minimize the amount of cutting needed underground. Following these steps, it was delivered to the mine yard and ultimately lowered into the mine and trammed to the working area. In all, at least ten men handled every piece of timber from the time it arrive in Bisbee until it was installed underground. The costs associated with this multiple handling were significant

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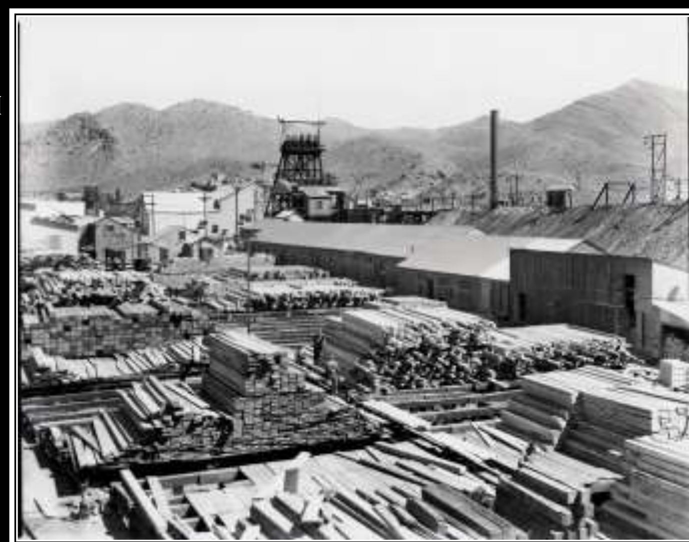
Graeme Larkin collection
Framed timber in the Junction yard ready to be transported to the various mines - 1962



Graeme Larkin collection
The massive timber storage yard at the Junction C - 1932

Timber yard for the Shattuck Mine at the terminus of the aerial tramway, near the Holbrook Shaft -1923
Melvin Elkins collection
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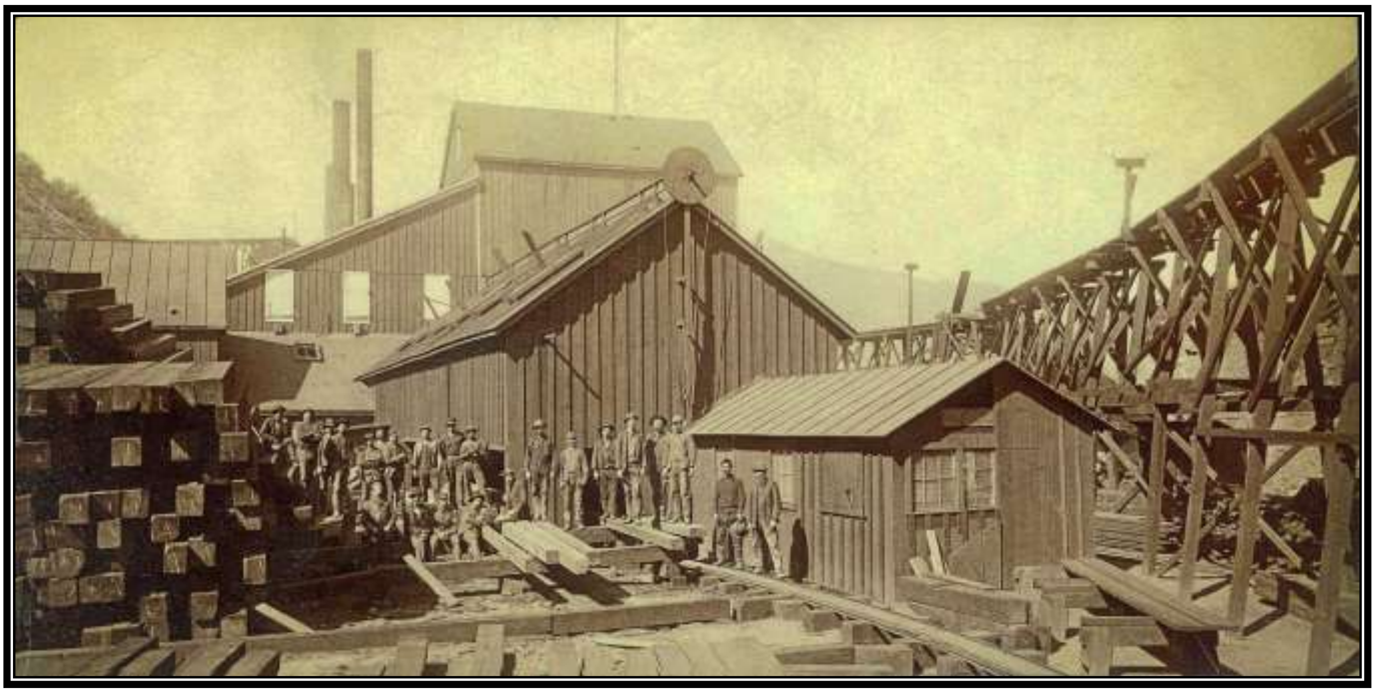
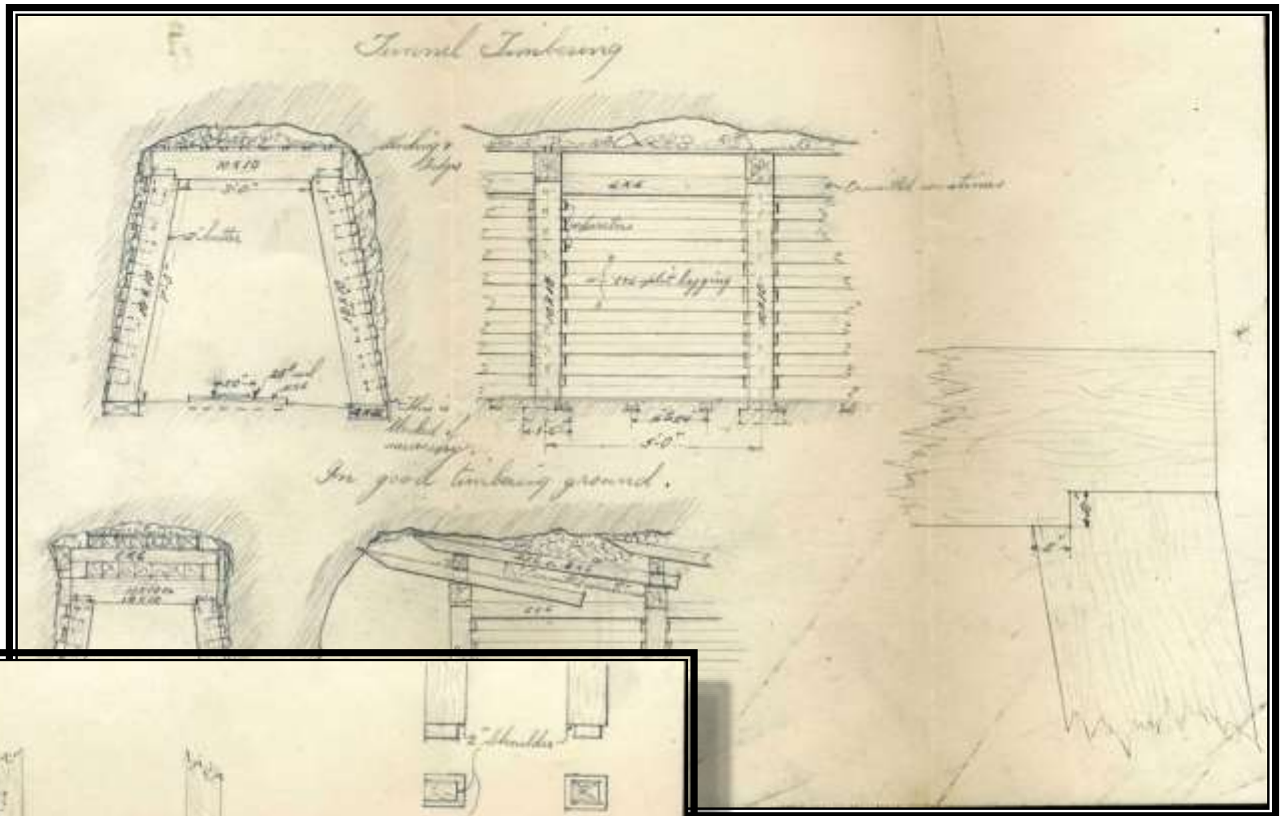
Timber was one of the most needed of all the materials in the mines. Early on, most of the timber used at Bisbee was cut in the Chiricahua Mountains with lesser amounts from the Huachuca Mountains. With the construction of the railroad, it became cheaper to buy timber from the Pacific-Northwest. Obviously, it was always a logistic challenge to buy the timber and have it delivered, especially in the large quantities needed by the mines.

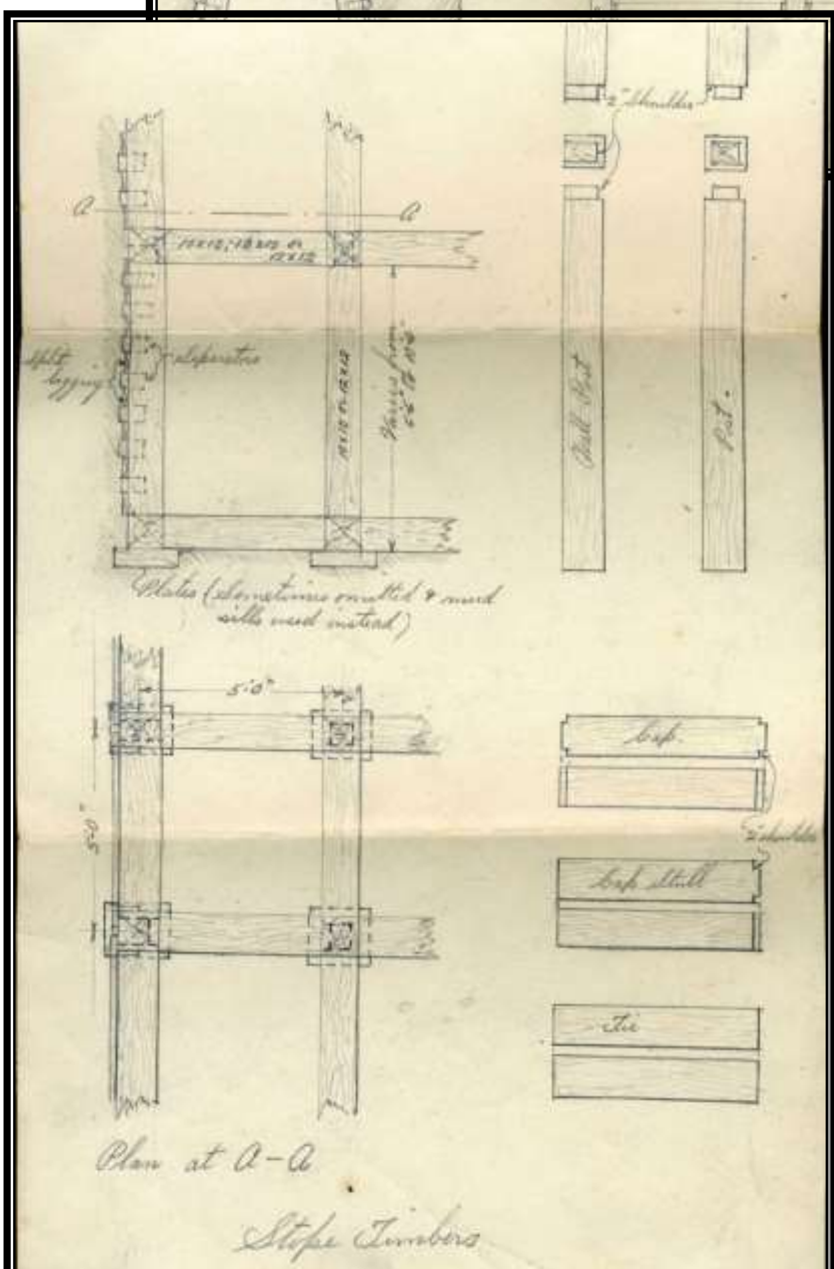
Once it was at Bisbee, it was placed in a storage yard, then set to a sawmill/framing shop where it was cut to the standard lengths and the ends cut or framed in the pattern needed to make it usable underground. Timber was cut and framed for use in raises – both six-post and cribbed; drift sets, squaresets and miscellaneous pieces for stulls of all types. The way the timber was framed allowed it to be pieced together in a way which offered the maximum support.

Early on, each mine had its own timber storage yard, sawmill and framing shop, a necessary duplication of facilities because of a lack of mechanized handling and easy transportation. By 1915 each company had developed centralized facilities.



Timber yard for the Czar Mine with the sawmill and framing shop in the center of the photo -1890
Freeport McMoRan archives



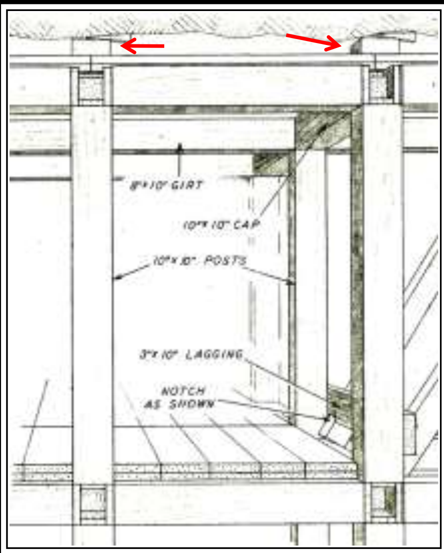


Sketches of timbering, timber sizes and cuts as used in the Shattuck Mine C - 1918
Graeme Larkin collection

Slide 42

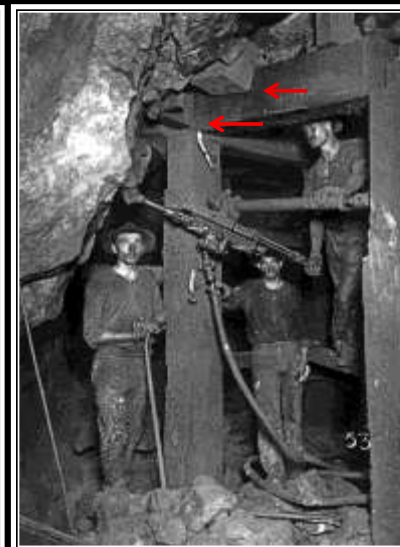
Timber was held in place by pressure, not nails

Wooden wedges and blocks were what held the timber in place. Nails were seldom used and never for support. The wedges, many of them, were driven, tight to apply the needed pressure. This allowed for minor movement without failure as the weight of the rock settled on the supporting timber. The interlocking way the timber was framed became tight with the pressure from the wedges ~~~~~



Graeme Larkin collection
Timber scheme for square set using blocks and wedges - 1955

Graeme Larkin collection
Umbrella stull, note blocks and wedges, Campbell mine - 1974

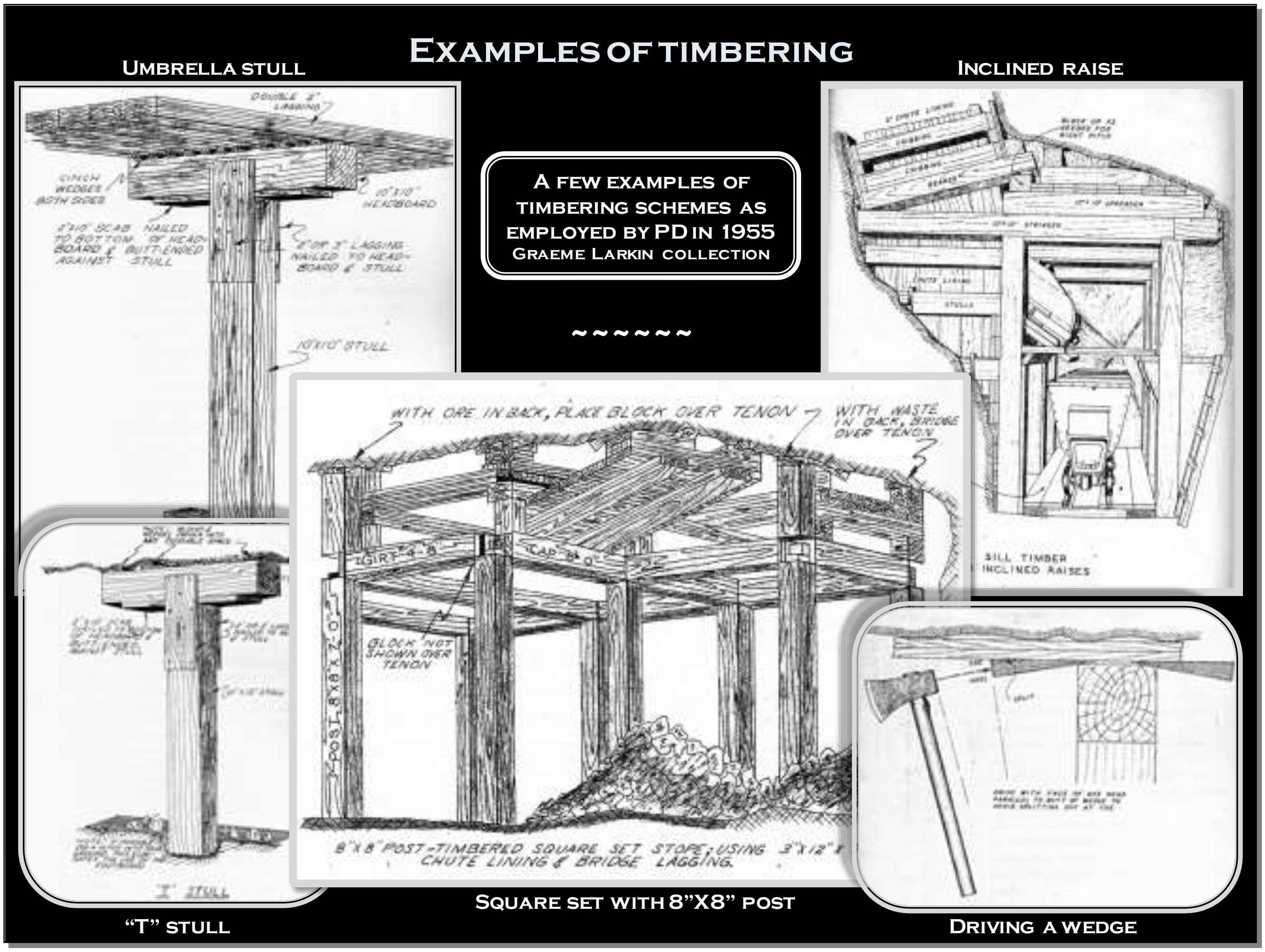


Graeme Larkin collection
Square set showing blocks and wedges - 1908

Wood was always the best support option given the ease of working with it and the tendency of timber to absorb substantial force before breaking. However, timber was always expensive and a substantial part of the overall mining costs. And too, it took skilled workmen to put it in and to maintain it in good condition. However, no better material for supporting the overall support of ground at Bisbee was ever found and not for lack of experimenting.

Over the years structural steel was tried in several locations with less than satisfactory results. Reinforced concrete was also tried and here too the results did not prove satisfactory. It was not until the introduction of rock bolts in the 1950s that a partial solution was found. Still, timber was to be the main support material used at Bisbee until the end.

Slide 43


EXAMPLES OF TIMBERING
UMBRELLA STULL
INCLINED RAISE
A FEW EXAMPLES OF
TIMBERING SCHEMES AS
EMPLOYED BY PD IN 1955
GRAEME LARKIN COLLECTION
~~~~~~
DOUBLE 2" LAGGING
CINCH WEDGES BOTH SIDES
10"x10" HEADBOARD
2"x10" SCAB NAILED TO BOTTOM OF HEAD-BOARD & BUTT-ENDED AGAINST STULL
2" OR 3" LAGGING NAILED TO HEAD-BOARD & STULL
10"x10" STULL
WITH ORE IN BACK, PLACE BLOCK OVER TENON
WITH WASTE IN BACK, BRIDGE OVER TENON
GIRT 4'-8"
CAP 8'-0"
POST 8"x8"x7'-0"
BLOCK NOT SHOWN OVER TENON
8"x8" POST-TIMBERED SQUARE SET STOPE; USING 3"x12"
CHUTE LINING & BRIDGE LAGGING.
SILL TIMBER
INCLINED RAISES
"T" STULL
SQUARE SET WITH 8"X8" POST
DRIVING A WEDGE


32 Stope
Cole Shaft.
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Previous page; left – segmented sets in the Cole Adit – 1962; Right – experimental timbering scheme for top slice mining in the Cole Mine – 1920.
Below – squarest timbering in a stope, with miners inserted for scale C – 1904.
Graeme Larkin collection

Slide 44

Rock Bolts are used for back support

During the early 1950s, expansion shell rock bolts with a flat plate washer were introduced into some of the cut and fill stopes where the ore was narrow and could be mined in one pass. They were also used in cross cuts successfully replacing timber.

Army surplus, steel landing mats were often pined with several rock bolts to hold a wider area and chain link fencing could be pined to cover an even wider area with small, loose rocks to prevent raveling

Graeme Larkin collection

A thin bedded cut & fill stope, ideal for rock bolt use, - Campbell mine

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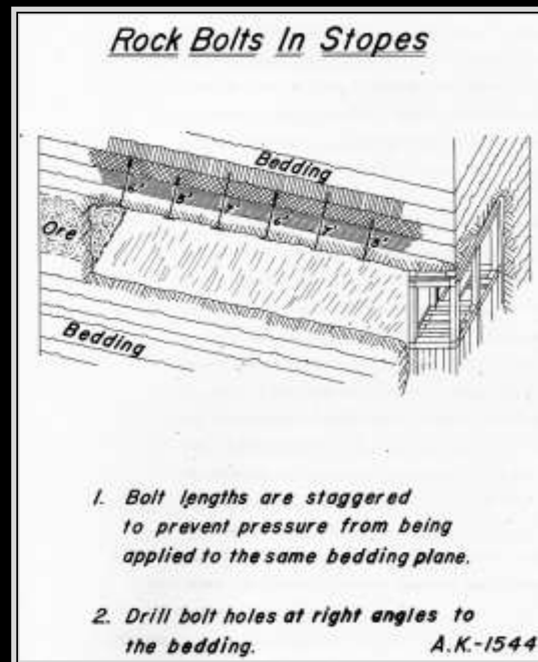
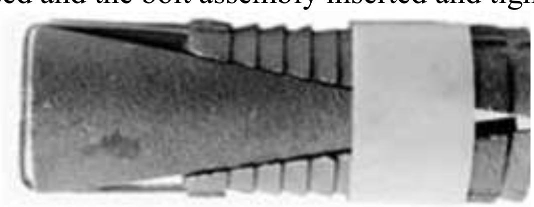


Graeme Larkin collection

Safety illustration for the use of rock bolts-1955

To emplace a rock bolt, a 1 ¼ inch diameter hole was drilled slightly longer than the bolt to be used and the bolt assembly inserted and tightened by a special wrench made for this use.



Expansion shell for a rock bolt

The rock bole assembly came complete and all connected. It consisted of a 5/8 inch diameter threaded rod with a square head at the opposite end. A two piece expansion shell was attached to the threaded end and a 6” X 6” square, flat steel washer was on the rod. As tightening took place, the shell expanded in the hole and the flat plate washer was pulled up very tight against the rock. It was this compressive pressure which held the rock in place.
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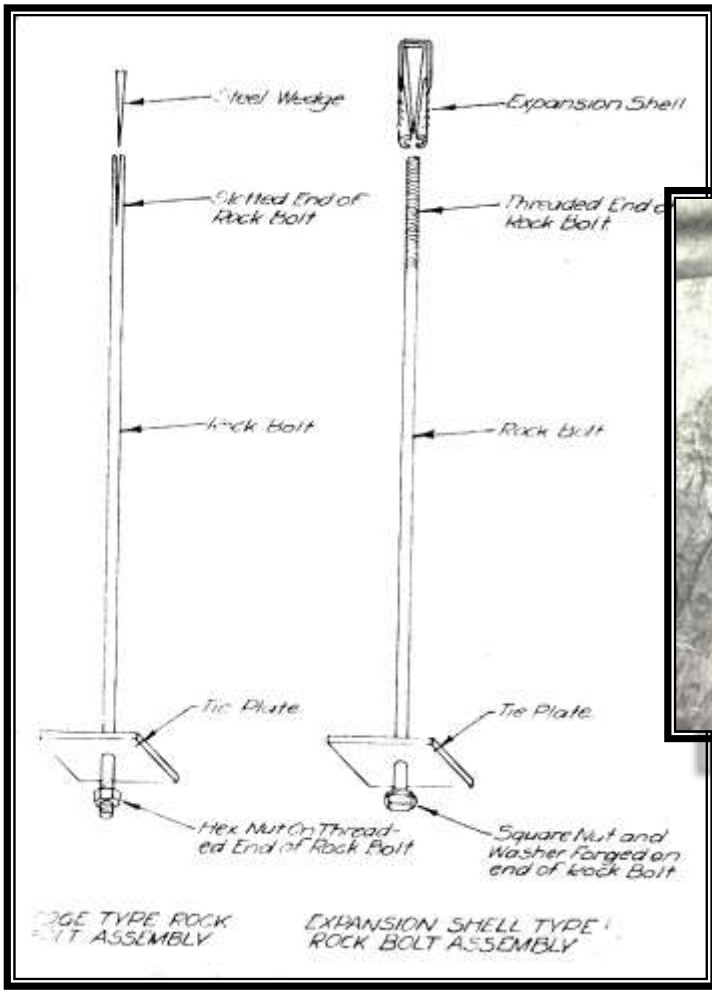

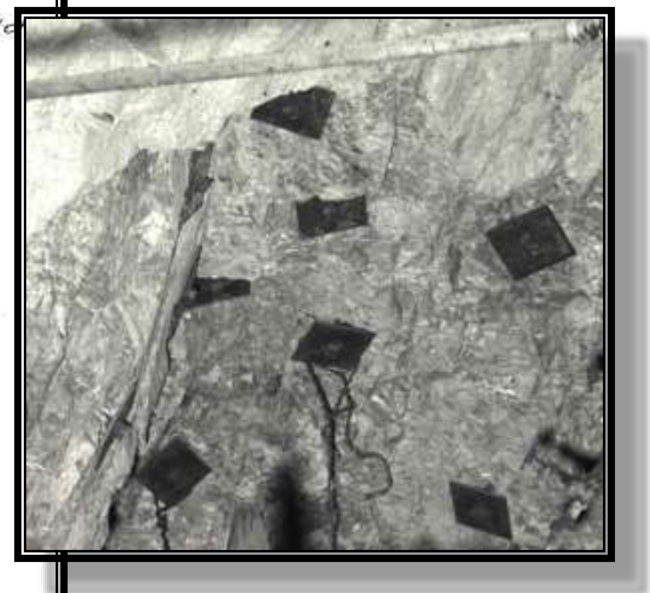

Expansion shell, rock bolts in place
3100 level Denn mine
Graeme Larkin collection

ROCK BOLT TYPES USED AT BISBEE – 1955
GRAEME LARKIN COLLECTION

As shown above, a wedge type bolt was also used here. However, these were less dependable than the expansion shell type and thus saw less use.

At the end of World War II, there were an incredible number of surplus landing mats used to make landing strips in the Pacific theater. They were 6 foot long, relatively thin with stiffening ridges and holes spaced about every foot and they were cheap, very cheap. Some genius thought of pinning them to raveling rock walls with rock bolts to hold larger areas. The rock bolts had flat, six inch square washers which covered only a small area. It worked and soon there were few landing mats around as they we all being used in mines and construction projects.

SLIDE 45

MECHANICAL MUCKING MADE WORK MORE PRODUCTIVE

THE INTRODUCTION OF MECHANICAL MUCKING AND LOADING EQUIPMENT IN THE 1930S WAS A MAJOR CHANGE.

COMPRESSED AIR SLUSHER MOVING BROKEN ROCK IN A STOPE 1938 (R)
BISBEE MINING & HISTORICAL MUSEUM COLLECTION

USING AN OVERSHOT MUCKING MACHINE ON THE 2833 LEVEL CAMPBELL MINE 1973 (R)
GRAEME LARKIN COLLECTION

EIMCO OVERSHOT LOADER WORKING IN A CROSSCUT IN THE CAMPBELL MINE - 1939 (R)
GRAEME LARKIN COLLECTION

INDIVIDUAL PRODUCTIVITY INCREASED SUBSTANTIALLY, COSTS SOON DROPPED, AND LOWER GRADE ORE COULD NOW BE MINED, VERY LITTLE ROCK WAS NOW MOVED BY HAND.

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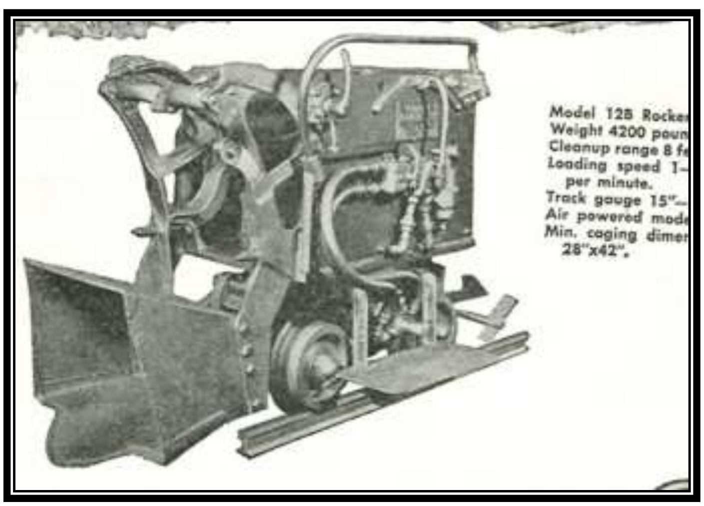

Ad for the Eimco 12B overshot loader - 1939
Graeme Larkin collection
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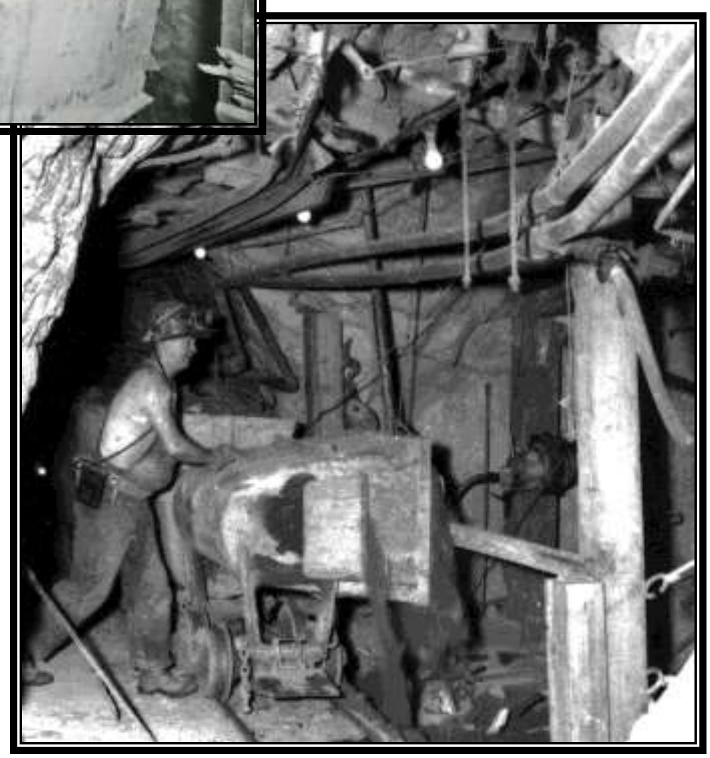
One thing stayed constant – muck raked into the raises still had to be loaded into mine cars on the level below for haulage to the appropriate pocket for dumping and subsequent loading into skips for hoisting to the surface. Surprisingly few improvements had evolved over the years.

Sticky muck still had to be forced to flow by the motor swamper using eight foot long blow pipes with compressed air and steel bars to prod the hard sulfide boulders that jammed a chute door. I personally have spent hundreds of hard hours doing both; much as had predecessors for fro decades. For some task, there was no substitute for a strong back.

Left: Preparing to start loading "H" cars from what appears to be a new "Verde" style chute in the Campbell Mine C-1955.
Graeme Larkin collection

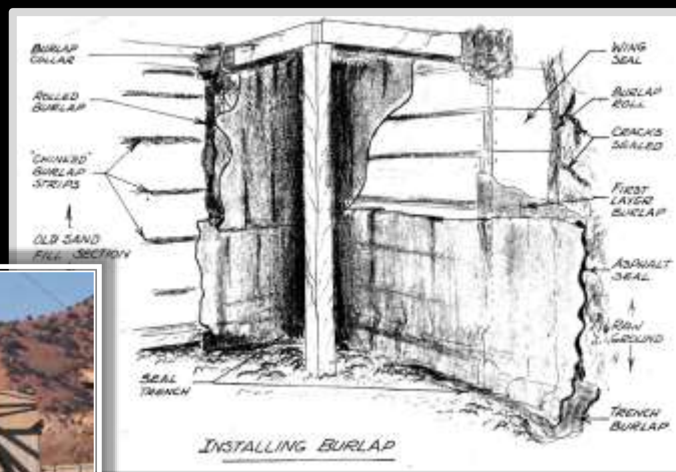


Right: Dumping an "H" car into the ore pocket on the 2833 level of the Campbell Mine – 1974.
Photo by Pete Kresan

Slide 46

Gobbing changes

Finding sufficient waste for gob had always been a problem. This was solved by using treated tailings from the concentrator beginning in the early 1960s. A "sand plant" was built at the Campbell Mine as it was near the main tailings line. The sand plant removed the slime part and most of the pyrite, thus making a more course product which was then mixed with minor amounts of cement and piped and to the area in need of gob. It was deposited as a slurry, filling the opening completely and allowed to drain, leaving a compact mass, safe to mine under in just a few days



Graeme Larkin collection

Diagram of how to install the burlap lined, retaining structure for sand fill gobbing - 1967

Graeme Larkin collection

The sand plant at the Campbell - 1964

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Pyrite was removed from the tailings to mitigate against sulfide mine fires as pyrite was usually the principal material which burned. The sand plant at the Campbell was large enough to provide sand for all three operating mines. Old haul trucks from the Lavender pit were converted to transport sand to the Cole and Dallas when needed. A small plant and holding tanks were constructed above the Cole mine area to provide the sand to these two mines as their proximity and multiple interconnections allowed the Cole plant to connect to the active areas in the Dallas via underground.

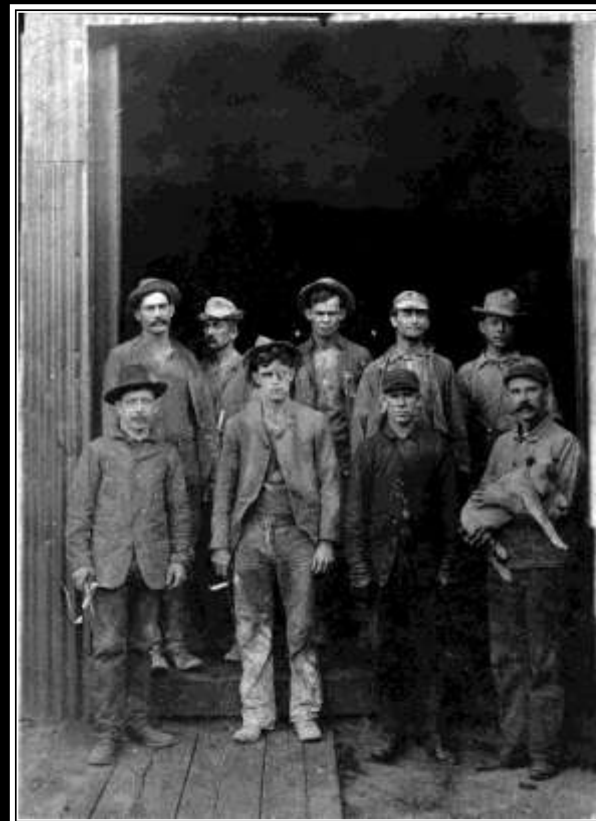
The introduction of sand fill in 1964 and 1965 brought with it a good deal more water which needed to be removed from the working areas. The grades on new crosscuts were increased to 6" per 100' and water ditches kept cleaner. While it was a great deal of work to prepare a stope for sand fill, it was a much cheaper and safer way to backfill. The hydraulic filling allowed for complete filling and there was surprisingly little compaction of the tailings as they drained.

Slide 47

The jobs related to underground mining

There were many other roles to fill at any mine, all of which aided in the process. A few are:

- Hoist engineer and oiler
- Cager
- Motorman and swamper
- Powder Monkey
- Ventilation engineer
- Pumpman and oilers
- Safety man
- Tool nipper
- Sanitary nipper
- Pipe and track man
- Slusher repair crew
- Diamond driller, helpers
- Surface shops
- Engineers
- Geologists



Graeme Larkin collection

A group of surface and underground workers at the Gardner mine hoist house C - 1905

Slide 48

The Hoist engineer

This was a most responsible job. Every person who went into the mine literally placed his life in the hands of these men. The manual hoist in use here were finely tuned pieces of equipment. To precisely put a loaded cage at the station, a dial indicator showed it was near, but the marking on the drum was absolutely right on.

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Graeme Larkin collection

Campbell hoist with engineer (top) ;dial indicator and drum with level markings (above) -1939

Cage arriving at a level in the Campbell mine with cager opening the gates 1950 Graeme Larkin collection

Hoisting engineers were the highest paid of all of the hourly workers, appropriately so, when the responsibility of the job is considered. These men were, carefully selected, underwent annual medical examinations to assure their fitness and spent years as a "Hoist Oiler." As oilers, they were responsible for the lubrication as well as continually checking the mechanical condition of this complex equipment. They were also responsible for the cleaning of the host and hoist house, both of which were maintained in absolute spotless condition. After several years of working as an oiler, they were allowed to relieve the hoist engineer during his lunch break and other periods. This apprenticeship, of sorts, made the oiler keenly aware of the need for complete cleanness and mechanical perfection as a part of forming the responsible character of these exceptional men. It often took ten or more years for an oiler to advance to hoisting engineer, in part because of the low turnover in this group and in part due to the necessary training.

The method of communication between hoist engineer and the cager was a series of bell signals which were codified by the State of Arizona. Each of the signals came in a mind bending blur of sound yet must be absolutely understood before moving. An example is if men were to be lowered to the 2200 level, the cager would ring 2-1-2-3-2 with 2-1-2, the signal for the 2200
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level and 3-2 to indicate that men were being lowered. A rope speed of 800 feet per minute was the maximum for moving men, while 1,000 feet per minute was allowed for rock and materials.

Each of the two sides would operate simultaneously with individual task being performed such as loading or unloading supplies, some of which could be heavy enough to stretch the thick cable and he must be ready to compensate for this change. The bell sound for the individual drums was different, allowing the hoist engineer to distinguish between the sides. A light would flash as well with each pull of the bell rope by the cager. Hoist engineers were forbidden to talk to anyone while the hoist was in motion because of the absolute concentration necessary to operate the machinery.

When hoisting muck, the drums were synchronized to have one skip being loaded from a pocket in the shaft while the other skip was dumping.

Skips passing at the same point in the Campbell shaft – one going down and the other going up - showing that they were perfectly synchronized for hoisting rock -1939
Graeme Larkin collection

Skip dumping into the ore bin at the Campbell Shaft -1939
Graeme Larkin collection

Loading railcars from the ore bin at the Campbell Shaft -1939
Graeme Larkin collection

Slide 49

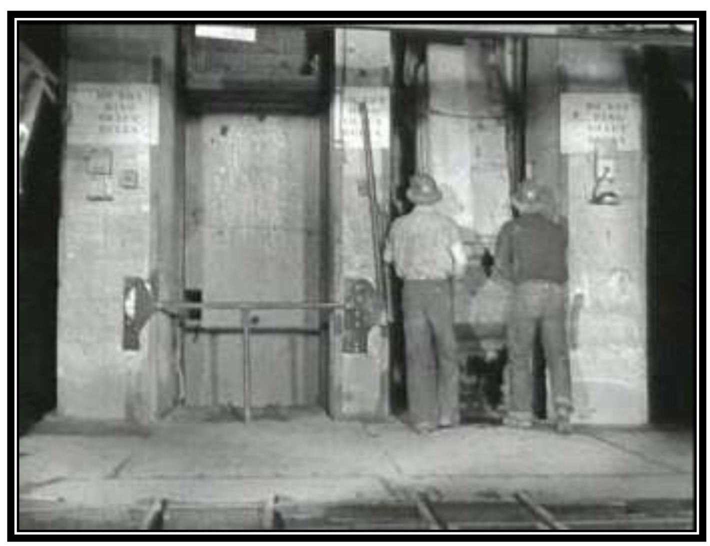
Everything needed came down the shaft

It took a great deal of supplies and materials to keep a large mine operating and everything had to be lowered down the shaft Cagers worked in pairs, one on top and one below. In part, the job was to load the needed supplies on the cage and then the man below would unload them on the station of the appropriate level . The motor crew or others would then take the supplies to the area where they were needed or to be stored for later use. This was hard work as little used here was light in weight ~~~~~

Graeme Larkin collection
Cagers with a "Scott" truck load of timber, Campbell mine - 1939

Graeme Larkin collection
2966 level Campbell station with supplies and material lowered in part of one shift - 1962

Cager at surface (L), Campbell mine -1974
Pete Kresan photo



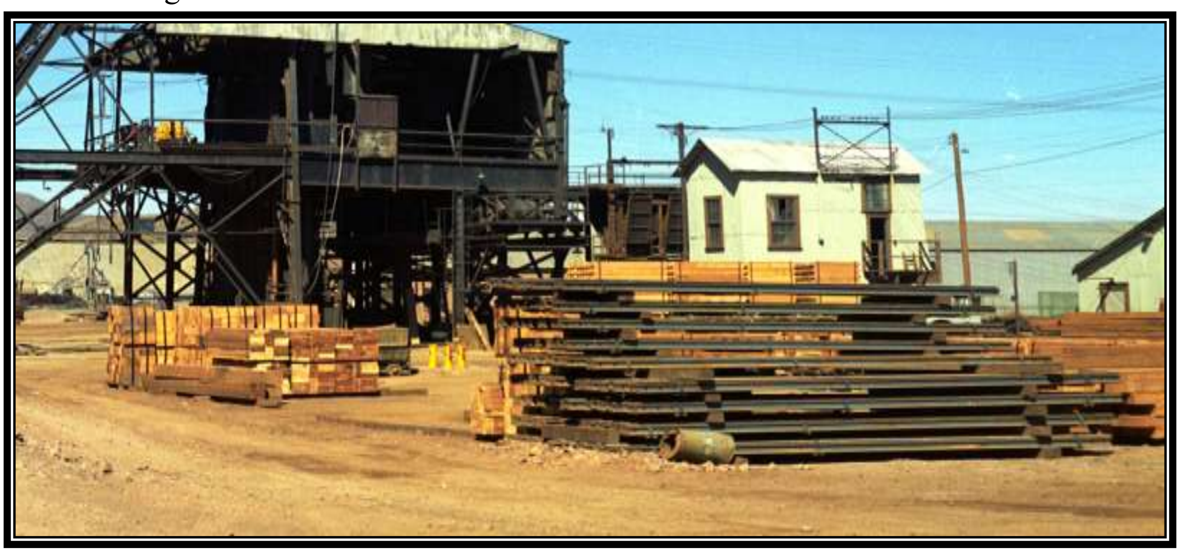
Cager & helper unloading timber on a Scott truck Campbell mine - 1939
Graeme Larkin collection

The handling of materials at the shaft was always a problem as so much had to be lowered, and quickly as, at most shafts, no ore could be hoisted until all the supplies were down. Until about 1930, every item that could not be placed in a car of some type was handled individually. This meant that anything longer than three feet was a problem and most timber was longer than three feet.

Scott trucks were a reasonably successful effort to reduce the handling of individual pieces of timber in several steps of the process. The timber was loaded and secured with chains onto the Scott trucks at the sawmill/framing shop after it had been cut to the standard length. The trucks were then made into small trains and pulled to the Campbell mine on a narrow gauge (18") rail line built in 1932. Alternatively, the Scott trucks were loaded onto highway trucks for transport to the Cole or Dallas.

At the mine, the whole truck with timber was loaded onto the cage by standing it vertically and lowered. Special, small wheels on one end allowed for the relatively easy removal from the cage. A motor crew would then pull the truck to the point of need and it was unloaded, then returned to the sawmill for use again. These were used from 1932 until 1953 when steel bands replaced them.

The timber was banded into bundles which were sent by highway truck to the mine. Forklifts would take the bundles to the shaft where a small electric chain hoist on the cage would pull the bundle into a rocking base which tilted the bundle backward when loaded and would tilt forward to aid in unloading the bundle on the shaft station.



Supplies in steel-banded bundles at the Junction mine yard ready to be lowered into the mine – 1962
Graeme Larkin collection

Handling timber bundled and banded with 1¼” steel bands and using small electric hoist on the cage to load and unload at the Junction Mine - 1952.

The top photo shows the loading into the cage on the surface, while the bottom illustrates the unloading onto a timber truck underground.

Source *Mining Engineering*, March 1953.

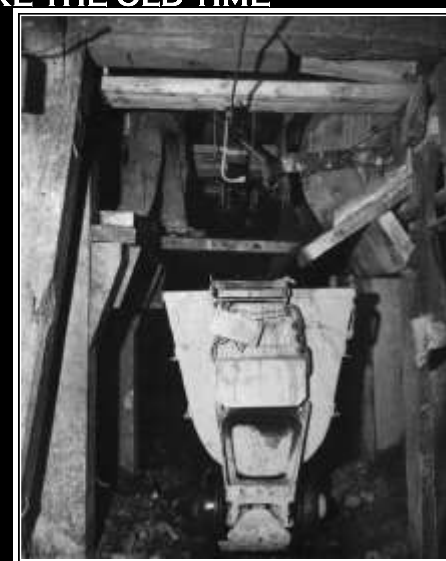
Graeme Larkin collection

Slide 50

The motor remains much the same

Motors changed little over the ensuing decades and the work of the motor crew remained much the same. The task of loading the cars from stope chutes was still that of the motor swamper. All ore and waste haulage as well as the deliver of supplies to the work areas was their job. The cars did change to several sizes of rocker dump types, which were easier to empty when dumped. Haulage remained a critical aspect and like the old time trammers, these crews were one of the few that worked all three shifts as it was always a real challenge to keep the ore and wasted moved. Often more than one motor worked on a level at a time to meet the need ~~~~~

Pete Kresan photo
Motor crew hauling "H" style cars, 2833 level Campbell mine – 1973



Pete Kresan Photo
Loading an "E" type card from a stope chute 2833 level Campbell mine – 1973

As the mines grew, it often became necessary to have several motor crews operating on the same level. The obvious risk of collisions and congestion brought about the use of a block type system to control motor traffic. The level was divided into zones or blocks with manually controlled, electric signal lights at all of the entrances and the exits of a block.

The signal light controls were in areas of good visibility for safety reasons. At the entrance were a pair of pull ropes which changed the lights. The first rope entering a block would turn on all of the red lights at the entrances to the block, while the first rope on leaving (the second rope on entering) would turn off the red lights and turn on green lights at all of the block's entrances. Thus, as a motor entered the block, the first rope was pulled and it turned the lights red, indicating a motor was active in the block. Upon leaving the block, the first rope was pulled which turned the light green, indicating to other motors that it was safe to enter the block.

Block light indicating that there is rail traffic with in the block and that other motors should not enter and that foot traffic should be aware.
Graeme Larkin collection

Slide 51

The Powder Monkey and the powder magazine

Explosives are a tool in mining with good care and safe storage a vital function. The man who cared for them was the Powder monkey. He kept the magazines well stocked and accounted for the explosives used by work area.

Powder monkey in a magazine
C – 1920

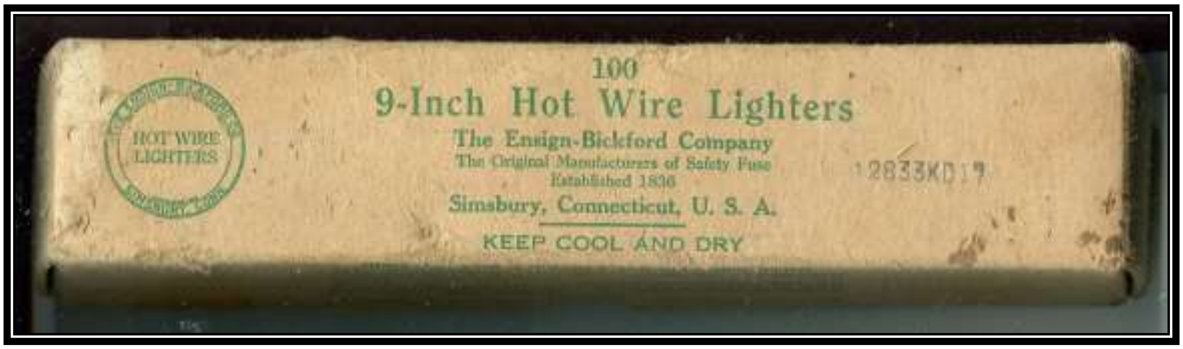
Powder magazines were near the working areas on every level . They were placed in dry, dead end crosscuts and kept well ventilated. Fuses and caps were stored in the same area, but well removed from the explosives ~~~~~~~

Powder magazine 116 XC 2833 level Campbell mine 1973 (above)

50 # boxes of dynamite in a magazine C – 1925 (left)
Both - Graeme Larkin collection

The Powder Monkey was always an older and experienced miner. One who could not or chose not to continue in the physically demanding job of mining. My maternal grandfather spent the last 15 years as one until he retired at the age of 75. These were responsible men with attention to detail necessary. The magazine could never run out of dynamite, fuse and primers, loading sticks, spitters, spitter boards or skewers, all of which were stocked in each and every magazine. These men were practitioners of the “first in, first out” principals of warehouse management long before it became a common trend. Dynamite had a shelf life of just a few months until it became less dependable, thus it was important to keep the stock rotating with the older powder dispensed first.

He would order powder and supplies on a regular basis. The dynamite for each level would arrive at the surface from the central magazine on the surface. The boxes of dynamite were placed in special wooden car designed just for this use. The red painted powder car would be lowered to the waiting powder monkey on the appropriate level only when no one was in the shaft. The powder monkey would immediately hand tram the car to the appropriate magazine. Explosives were never allow to stay on a shaft station, as a safety precaution, and no motor haulage was permitted because of the very real danger of accidental explosion from the sparks which were constantly made by the contact of the trolley pole with the trolley wire. Fuses were handled separately in special cans which were made in the tin shop.



Above – spitter box - 1970
Graeme Larkin collection

In the magazine area, the skewers, spitter boards and loading sticks were stored just outside as can be seen in the 1973 photo above where the spitter boards and skewers are in cardboard fuse boxes at the left. Powder sacks were stored here as well as kept by the miners for convenience. These were made in the Rope shop and of heavy treated canvas with no metal parts except for a few aluminum rivets to secure the shoulder strap.

Inside the magazine were fuse racks with lengths of fuse pre-cut to standard lengths and with the caps attached, a function performed in a shop with the finished product shipped to the mines, then to the magazines in the round cans such as the one by the fuse boxes in the above photo. The miners would take the take number of fuses of the needed length, roll them into a coil and put them in a powder sack. No dynamite would be placed in this bag as mixing the two until they were to be placed in the hole was absolutely forbidden. Blasting caps were the most sensitive of all of the explosives used underground and could be set off by impact, such a dropping the sack. This was an uncommon occurrence, but always a possibility. If a cap exploded by its self, a minor injury can result, but if it is mixed with dynamite, the resulting injuries would be horrible to fatal.

Boxes of dynamite were at the end of the magazine on shelves from which the miner would take the needed number of sticks of the appropriate type and place them in a separate powder sack from the fuses. A skewer and the needed spitter boards and spitters could be put in the sack with the dynamite. The miner would then fill in a form recording the work place and quantity of explosive materials taken. It was largely an honor system as the powder monkey worked only day shift and

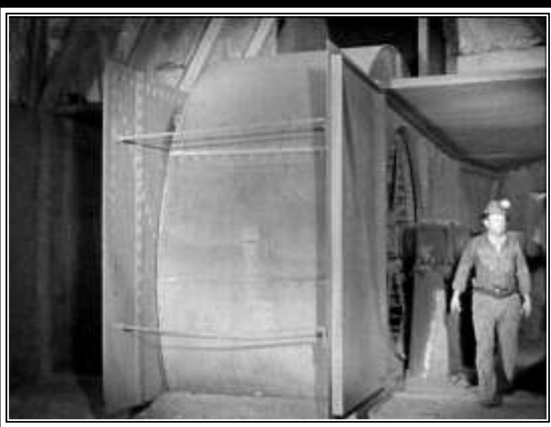
Left – Fuse can of the type used to transport fire fuse already cut to length with the blasting caps attached from the fuse house at the Junction Mine to the various powder magazines
Queen Mine Tours collection

usually had more than one magazine to care for, thus he was seldom present when the materials were removed. However, he was responsible to reconcile the inventory with the slips filled in by the miners. In truth, errors were few and there were very few known abuses of this trust based system.

Slide 52

Mine ventilation

As the mines deepened the need to use forced air ventilation became more and more pressing. In 1912 , the CQ began at the Gardner. Over time more and larger fans were added. This is a complex endeavor, because it was important to get good air where it was needed. The drawing at the side gives a sense of the complexity. Mine fires made this effort ever more important



Graeme Larkin collection
65,000 cubic foot/ minute fan, 2200 level
Campbell mine -1939

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Graeme Larkin collection
Ventilation scheme for the Gardner mine
1925

Air doors were strategically placed in pairs - separated by a distance a bit longer than a typical motor and cars - forming an air lock, as only one door was to be open at a time. These wooden doors controlled the flow of air, forcing it to the areas in need of ventilation.

Air door in a crosscut Campbell mine 1939
Graeme Larkin collection
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Motor passing through an open air door in the Campbell mine - 1939
Graeme Larkin collection

"Having donned regulation mine costumes early one morning, we started for the underground cavern. After descending the Czar shaft 200 feet to the 'second level,' we walked southwestward toward a point almost directly beneath the summit of Queen Hill. A quarter of a mile or more—it seemed at least a mile—from the big shaft we came to the foot of a 'raise,' up which we were drawn 400 feet by an electric hoist. The journey from the shaft along the level through solid limestone had been cool and comfortable, but as we went up the raise both the moisture and temperature of the air increased, because we had entered the 'leached ground,' where the oxidation of the original ores produced heat, just as does burning coal. A few yards from the raise we reached the top of a 'man hole' cut through the heating ore. Now it was necessary to climb forty feet down vertical ladders to the heavy plank door that guarded the cave.

Excerpt from the January 15, 1912 New York Times, describing a trip into a cave on the 5th level of the Southwest mine
Graeme Larkin collection

The article above tells of a time when the Southwest mine was hot, uncomfortably hot.

Most of the mine workings at Bisbee were hot and humid, even in the oxide areas such as found in the Queen Mine. This was an artifact of the continuing oxidation of the ores. The mines became cool after multiple, interconnecting workings had been established and natural ventilation had been function for some time.

As the mines deepened, sulfide ores became more and more common making the already uncomfortable mines unbearable. In the oxide areas the temperatures were seldom above 90 degrees, but the humidity was also at 90%. This made for a difficult, inefficient working environment. The sulfide environments were hotter as the natural oxidation of sulfide minerals is an exothermic process and the amount of heat liberated can be high, very high. This was particularly true in the transition zone, just above the oxides, where the sulfides are oxidizing at a relatively high rate.

Natural ventilation had long been depend upon to ventilate the mines and for a while it was enough, if effort was made to have more than one entry into a work place such as several raises from level to level passing through a stope. Soon, however, the productivity of the men became lower and lower because of the difficulty in breathing the poor quality air.

Also with the sulfides came mine fires and the highly toxic gasses they liberated. These had to be controlled to allow mining to continue in the other parts of the mine. A strong, steady and pressurized flow of air would keep the gasses in the fire zones and not allow them into the main air stream. However, this was not available until forced ventilation came into use.

With the advent of pneumatic drills in 1905 came some very important relief as the exhaust from the drills was fresh, cool air. For a while, this was enough. Also, it became common to just open a compressed air line into a dead end working which helped even more, but this was a noisy, inefficient practice.

Large fans were placed in the Gardner mine and doors to control air flow were installed to force the air to the desired areas. The Gardner shaft had air entering, thus it was termed “downcast” while the Irish Mag and the Hoatson were exhausting air and were termed “upcast”.

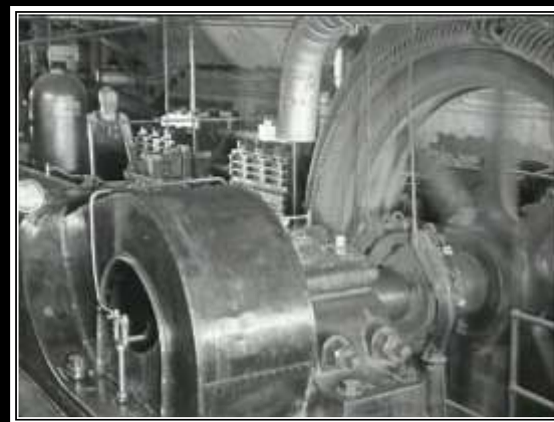
In the last years of operation the Junction, Campbell, Cole and Congdon shafts were down cast while the Denn, Dallas, Saginaw and Gardner were upcast. Because of the very high humidity of the mine air, the upcast shafts were always wet, often miserably so. Working in the shaft at the Dallas, while warm was unpleasant because of the wetness. Conversely, the down cast shafts were dry, but very often uncomfortably cold, even in the summer, because of the great volume of air moving through the small space of the shaft. Coming off of shift in a down cast shaft, one always wore a jacket on the cage, year around, because you were wet from work and the short ride to the top was bone chilling.

Ventilation engineers were specialist and always an important part of the engineering team as every change in the mine, no matter how simple, had to consider ventilation. Very much to their credit, no one ever was ever killed at Bisbee from fire gasses because of the caution taken by these capable engineers over the years.

Slide 53

Pumping the mines

The mines at Bisbee were always wet. On average, more than 5,000 gallons per minute were pumped with peaks double that. The Junction became the main pumping shaft by 1918 with most waters routed to it until 1940 when pumps were added at the Campbell



Graeme Larkin collection

Graeme Larkin collection

View of a wet crosscut, 2700 level Campbell mine - 1974

Views of the huge # 3 positive displacement pump on the 2200 level Junction mine 1939

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Graeme Larkin collection

The pump station on the 2200 level of the Junction mine was something to behold. First built in 1924, it continued to operate until 1981 when pumping was suspended. It consisted of five positive displacement and one centrifugal pump with a capacity of between 1000 gpm and 2250 gpm against a head of 2,500 feet to the storage tanks. The plungers of the positive displacement pumps delivered such a force, that it was essential to consistently bleed super compressed air into the pump column to keep the hammer of the pumps from destroying the one inch thick walls on the 16 inch diameter pump column. The air would act as a shock absorber becoming more compressed with the pulse of the plungers as they forced the water out of the chambers into the pipe line.

The noise generated by these machines and their huge electric motors defies description. It was impossible to talk to anyone, even by shouting face to face.
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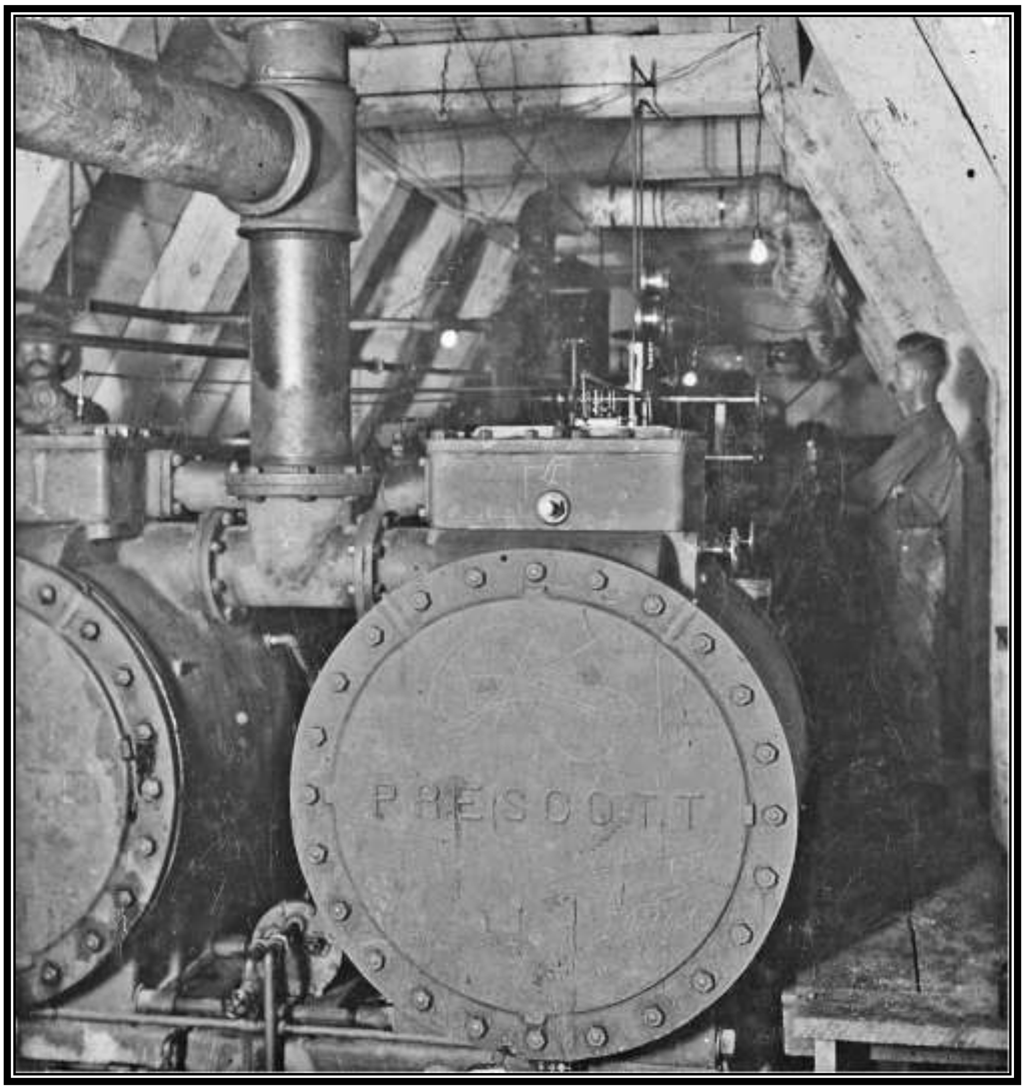
Notes on the 2200 level pump station from a 1930 booklet
Graeme Larkin **COLLECTION**

The Bisbee mines have always been wet and at the present time are making water from the 200 level of the old mine to the present 2,700 level, a vertical distance of over 2,700 feet. The amount of water has steadily increased as the mines have become deeper. At present all water is routed to the 2,200 level at the Junction Shaft where the main pump station is located. Water from the 2,700 station is pumped to the 2,200 level where it goes to the surface. Equipment in the pump stations is as follows:

2200 LEVEL PUMP STATION

No. of Pumps	Type	Head	Motor Rating	Capacity G.P.M.
2	4—7¾" Plungers 24" Stroke .	2200	750 H.P.	1000 each
1	4—7¾" " 36" " .	2200	1050 H.P.	1500
1	4—6⅛" " 24" "	2200	960 H.P.	1200
1	7 Stage Centrifugal	2200	1750 H.P.	2250
1.	6—7¾" Plungers 36" Storke .	2200	1500 H.P.	2250



Steam driven, piston pumps, with 1,000 GPM capacity on the 910 level of the Briggs Mine – 1905.
Graeme Larkin collection

Slide 54

The 2700 level pumps

The deepening of the Junction in the 1930s hit substantial water which required that a large pump station be built. As the Campbell was developed, it became necessary to add pumps on the 2700 level to first pump to the Junction pump station on this same level which was then pumped to the 2200 level and to the surface. With exploration east of the Campbell fault came more water and pumps were installed to lift it directly to the top. ~~~~~

Graeme Larkin collection

The 2,000 gpm pumps on the, 2700 level
Campbell mine -1962

Graeme Larkin collection

Pump station on the 2700 Junction station
1972

Slide 55

Deepening the Denn and Campbell required more pumps

The Denn had a long history of hitting heavy water flows as it was sank deeper and deeper. Dropping to the 3100 was no exception, the exploration to the east found even more. Pumps were installed to lift this water to the 2966 level where it was added to the Campbell water hit below the 2700 at the pump station there and relayed to the 2700 then, on to the surface were it was used in the concentrator as it was clean ~~~~~

Graeme Larkin collection
One of the pumps on the 3100 level Denn mine -1962

Graeme Larkin collection
Pump man at the pump station on the 2966 level Campbell mine -1962

Drill water

While mine water had to be pumped out of the mine, water for drilling and dust control was brought in. This water was typically the cleaner of the mine waters pumped to the surface storage tanks. In returning it to the mine, pressure control was an important consideration as too much would burst the pipes and too little would not lift it to the higher parts of the stopes . Each level had a small , open surge tank on the station which was filled from the main feed line in the shaft. This tank fed the level below , thus the total head was no more than 100 to 133 feet, On the level, the pipe lines were advanced along with the development by the crosscut or raise crew, as part of their normal work. Future changes and repairs on the level were the responsibility of the pipe and track repairman. Repairs or changes to the main feed line were carried out in the shaft by the underground “bull gang.”

Drilling water to all working areas was a high priority as the control of drill generated dust was an absolute requirement. Care was taken to assure the necessary volume of water at the right pressure was always available.

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Slide 57

Compressed air

The need for compressed air in the underground came with the introduction of pneumatic drills, but once it was there, a number of other pieces of pneumatic equipment were introduced. Air powered slushers for stope mucking were among the more common as were mucking machines.

At the beginning, each mine had its own compressors which supplied its respective need. When the large steam power plant was constructed near the Sac shaft, high volume compressors were installed at this central location to supply all of the CQ's mines. The C&A had a similar plant near the Oliver. Later the whole of the district was provided air from the Junction power plant.

Getting the air where it was needed, at the required pressure was a challenge. In busy working areas with a number of stopes where there was a substantial demand, both volume and pressure were a concern. It was common to place air receivers , (pressure rated tanks to store air) to accommodate the surging demand. ~~~~~

Slide 58

Safety was real, it was preached and practiced

Mining was hazardous work and good safety practices made a big difference. Every effort was made to make the workplace safer and to train the men in all aspects of the job. The safety department came into being in 1913 and the difference was real and immediate. The mines at Bisbee were among the safest anywhere ~~~~~

Graeme Larkin collection
Safety photo showing the wrong way to hoist drill steel into a stope C - 1915

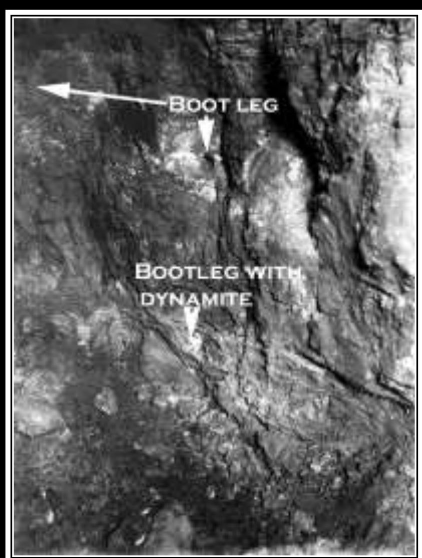
Graeme Larkin collection
Safety photo showing the correct way to hoist drill steel into a stope C - 1915

Graeme Larkin collection
Safety cartoon about making the workplace safe 1955

Slide 59

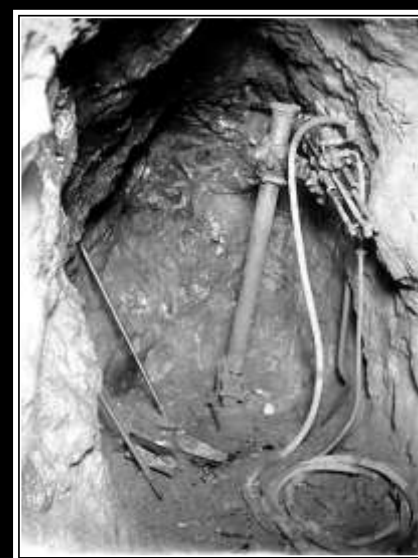
Safety ~ the drill hole bootleg

A bootleg is the remnant of a drill hole from the previous round. These were common, but potentially dangerous, features in many machine drilled faces. It was not rare for a small amount of the explosive to remain in the bootleg The first stick of powder had the sensitive blasting cap which could explode. Thus it was easy for the pressure of the operating drill to cause a blast ~~~~~



Graeme Larkin collection
Bootlegs in a working face, one of which contains residual dynamite C - 1915

Graeme Larkin collection
Safety cartoon concerning drilling a bootleg
1955



Graeme Larkin collection
Safety photo showing site where a miner was killed by drilling a bootleg C - 1915

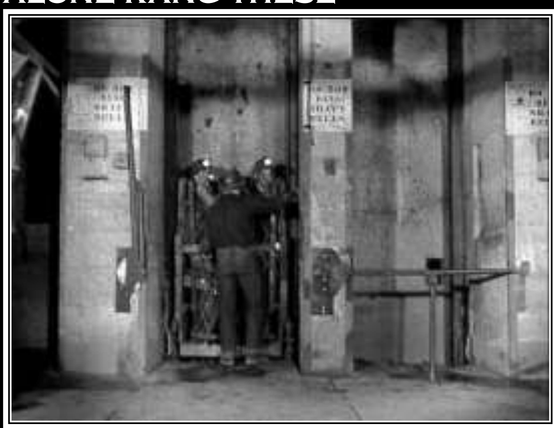
The small remnant of a previous blast hole was referred to as a "bootleg." It was absolutely forbidden to drill in or very close to a bootleg, even if the end of the hole can be seen and the miner certain it was empty. Collaring (starting) the hole was always the most difficult part of drilling as the bit would dance around on the rock face, so bootlegs were tempting, but the risk was just too great. Anyone who was caught using a bootleg was fired on the spot.

These bootlegs sometimes contained residual dynamite and with the dynamite there was often a blasting cap which, for some reason, did not explode with the pervious blast. Blasting caps are much more sensitive to rough handling and were almost certain to explode under the pressure of drilling. More than one miner and/or his crew were either killed or badly hurt when this was done.

Slide 60

Safety in hoisting – the station and shaft bells

Accident involving the hoisting of men were usually severe, often fatally. Thus, many precautions were employed. Only qualified and trained employees were ever allowed to use the bell system to move the gage. The signal code was posted on every shaft station, it was intended to be used to notify the cager to come to the level via the "call bell" hung nearby . This bell did not signal the cage to move. It was the shaft bells that were used for this and the cager alone rang these



Graeme Larkin collection
Cager about to pull the shaft bell to signal the hoist engineer to stop the cage, Campbell mine - 1939

Graeme Larkin collection
Bell signal chart on station 400 level Powell mine 1962

Graeme Larkin collection
Call bell on station 2700 level Junction mine 1972

Two, independent bell systems were employed. Shaft bells for signaling to move the cage and call bells. The call bells were signal bells used to notify the underground cager that a cage was needed at the level from which the call emanated. This bell would ring on every level in the mine as well as the surface at the shaft collar and in the hoist house. By law, the state code of bells was posted on each level. As a backup and to be sure the person calling the cage was aware where he was, every station also had a sign with the level and the call bell code.

Call bells were set back away from the shaft to preclude the accidental use of the shaft bell. As can be seen in the above photo, a call of 2-2-4 would indicate to the cager of a need for a pick up on the 2700 level. The cager responded as he could, however a 20 to 30 minute wait was common except at the end of the shift or at the lunch time run. If an accident occurred, seven bells were rung followed by the station signal which would bring almost instantaneous response by the cager. The mine foremen (not shift bosses, engineers or anyone else) would ring the level call twice in secession and, needless to say, when the big boss called, service was soon to arrive, but woe to the insolent pretender who tried this call. He was soon standing in front of the mine foreman explaining why he should not be fired for disrupting the work of the cagers who had to get all of the supplies down to working levels and that were a huge task.

The shaft bells were, as the name implies, actually in the shaft. These were the sole domain of the cager as any signal told the hoist engineer to move the cage in the compartment from which the signal came. As the hoist engineer could not see anything, he would do as the bells instructed. If a cager was doing something in the same compartment and the cage move suddenly because of the unauthorized use of the shaft bell, he would most certainly be badly hurt. As can be seen in the above left photo, there was ample signage to help avoid this dangerous possibility.

Shaft bell in the number 3 compartment 1400 level Cole Mine – 1964.

Graeme Larkin collection

Slide 61

Safety – The cage and the hoist rope

A broken hoist cable was a fear. If it happened, safety dogs would stop the cage by digging into the guides. Every effort was taken to make sure this never happened by comprehensive rope maintenance and frequent inspections

Graeme Larkin collection
Safety dogs
Sunrise shaft cage
1960

Hand inspecting the hoist cable on the Cole hoist by slowly running every foot through lightly gloved hands
1966 (upper R)
Graeme Larkin collection

Coiling hoist cable on the 1400 level Cole station preparatory to cutting the drum end of the cable
1966 (R)
Graeme Larkin collection

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A hoist cable breaking was the worst nightmare of every mine manager. The potential death and destruction from such an event were the worst of all possible events. Bisbee never suffered any loss of life or damage from such an event. There is only one recorded event of a cable breaking and it was in the muck compartment at the Sacrament shaft in the late 1930s and was the result of a kink in the rope caused by slack rope not being taken up in the proper fashion.

This lack of such accidents was not because of luck, it was because of good care and a set of operational and maintenance practices that took luck out of the equation. To be sure, there were backup safety dogs on all cages, just in case. These were cam type cast iron masses mounted on a shaft on the cage and there were four in total, two for each side. When the cable was tight, it held large coil springs in tension. These springs were connected to the shafts with the dogs. If the cable went slack, as it would do if it broke, the springs would cause the shaft with the dogs to rotate, forcing the teeth into the guides and bring the cage to a safe stop. The dogs were tested weekly by the boiler shop based, cage repair crew. A beam would be place across the shaft to support the cage and the rope allowed to go slack. This would kick the dogs in as well as activate the radio "slack rope" signal.

Hoist cable maintenance was a complex and time consuming task involving a number of procedures. Every month, every hoist cable was inspected by running it through either bare hands or hands with very light gloves (see above photo). The idea was to find broken wires or to detect any distortion such as a kink would cause. At the same time, regular intervals were cleaned of the heavy lubricating grease and oil then wire wear observed and the rope measured with a micrometer to determine wear. Tonnage lifted was an important factor in cable wear and two points would suffer the highest wear – where it passed over the sheave when at the collar and where the cable would start a new lap on the drum.

To change the lap point, one full drum diameter length of the cable would be cut from the drum end. This required supporting the cage in the shaft at the lowest level of the mine, then carefully coiling the cable on top of lagging (to keep it free of rocks) on the station of the level as shown in the photo above. The cable was then re-secured to the inside of the drum with the bolts and steel plate type clamps and the slack carefully pulled up as it was uncoiled by hand to prevent any kinking. The other wear point had to be corrected by cutting the cage end by an amount equal to 1/3 of the distance to the sheave. This was a much more complex task as the cable was connected to the cable by a zinc filled socket.

The cage would be supported in the shaft, at the surface, the king pin and safety chains removed then the cable pulled to a nearby spot, the point to be cut selected and tightly wrapped with soft iron wire then cut with a large hydraulic cable cutter. A large, cone shaped, cast steel socket threaded onto the rope and a second spot wrapped with wire. The first wire wrapping then cut and removed which allowed the cable to open up as it naturally does when unrestrained. The cut end was flared by separating the individual wires from the lays and bending them back. The whole mass was then absolutely cleaned of all grease with solvent and paint brushes, a very time consuming process. The hemp core would be removed at this time as well. The clean, flared mass of wires was then dipped into hydrochloric acid for a few moments to prepare wire surfaces to accept the zinc metal. The wires were they washed and thoroughly dried and the socket pulled into place, over the wires and the distribution of the wires in the socket made even. The socket end is plugged on the outside with moist fire clay and molten zinc poured into the socket until full, making sure that no voids are in the metal by constant vibration during the slow pouring of the zinc. The socket is then reattached to the cage and the safety chains re-installed.

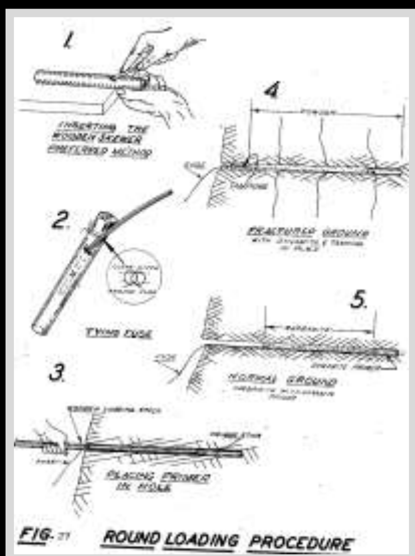
Either of these procedures forced the relocation of the level markers on the dial indicator in the front of the hoist engineer as well as the remarking of the drum to locate the cage exactly at the levels. The ropeman would take the cage to each level and signal the hoist engineer when it was spot on for marking. Each and every level in the mine had to be marked thusly.

These tasks were always performed on down days, typically Sundays as it was a long process. A process which would have had an unacceptable adverse impact on production during operating days.

Slide 62

Safety in blasting

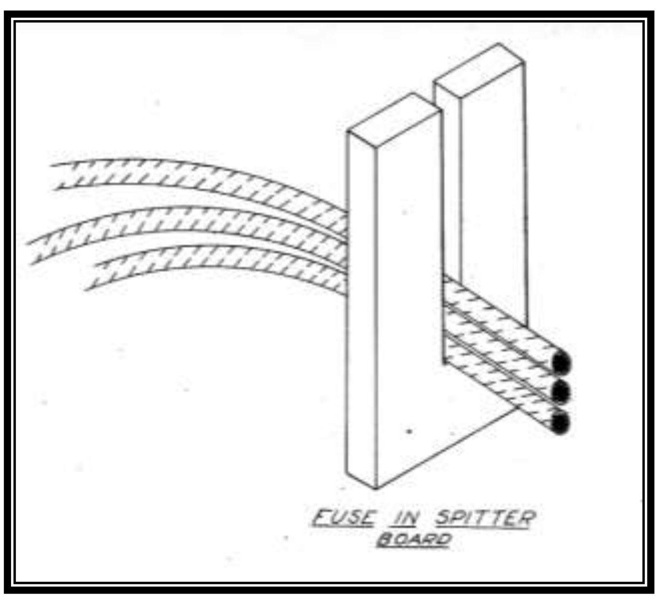
Blasting had the potential to cause very bad accidents, thus a good deal of training and care was give to this step of the process. Two men were always present and non-sparking materials used in contact with the powder and caps



Graeme Larkin collection
Safety procedure for loading blast holes-1967

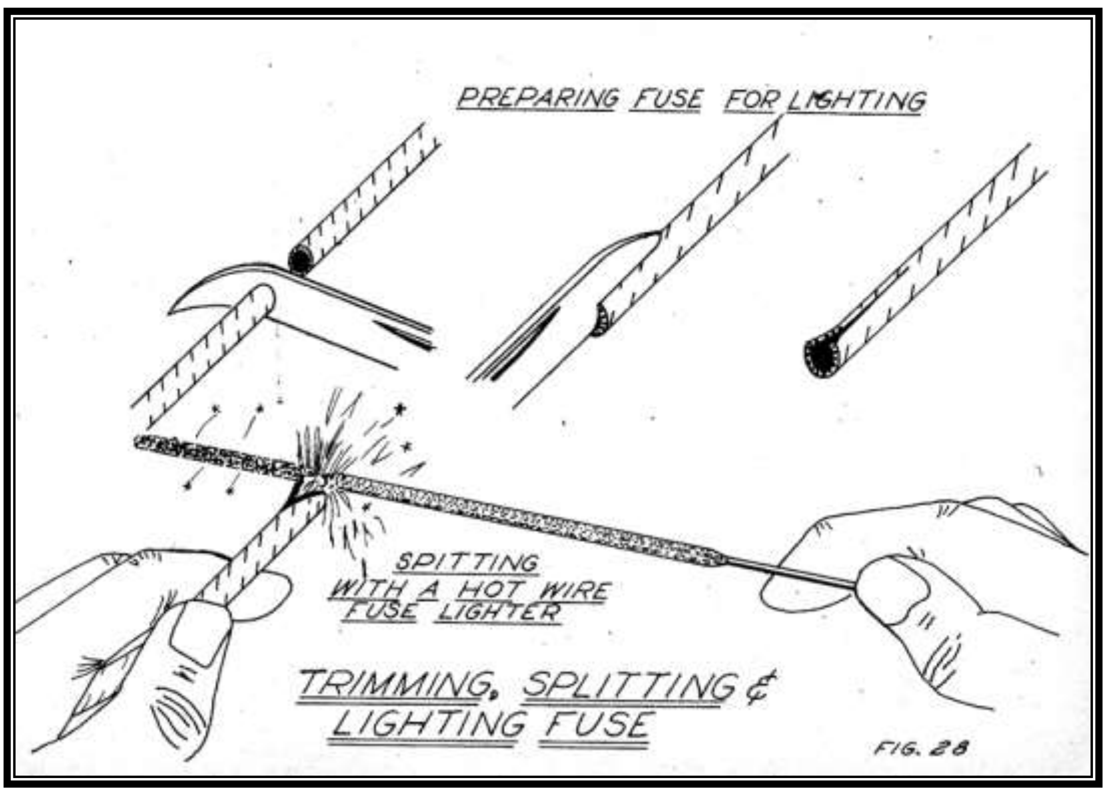
Loading a crosscut round using a wooden loading stick Campbell mine 1939 (upper R)
Graeme Larkin collection

Spitting a crosscut round Campbell mine 1939 (R)
Graeme Larkin collection



Safety drawing of fuses in a spitter board – 1955
Graeme Larkin collection

Placing fuses in a spitter board – 1939. Note: the spitter boards are made from Apache Powder boxes.
Graeme Larkin collection



Safety drawing of trimming and spitting fuse – 1955
Graeme Larkin collection

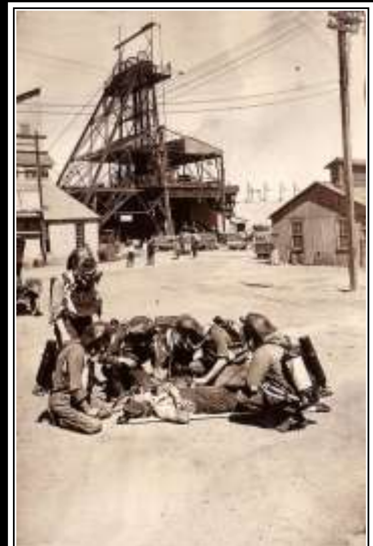
Slide 63

Safety - mine fire prevention and response

Mine fires were an ever present threat and potentially deadly. Bisbee suffered many such fires, but no one was ever killed. In part because of the preparedness of the companies. From 1908 until 1975, the mines here were plagued by fires. The great majority were sulfide fires caused by spontaneous combustion. The danger was the same from all – carbon monoxide a silent killer if inhaled even in very small amounts. The key – keep it contained

Graeme Larkin collection
Automatic steel fire doors- in concrete frames C -1915

Graeme Larkin collection
Multiple mine fire procedure signs 400 level, Czar mine -1962

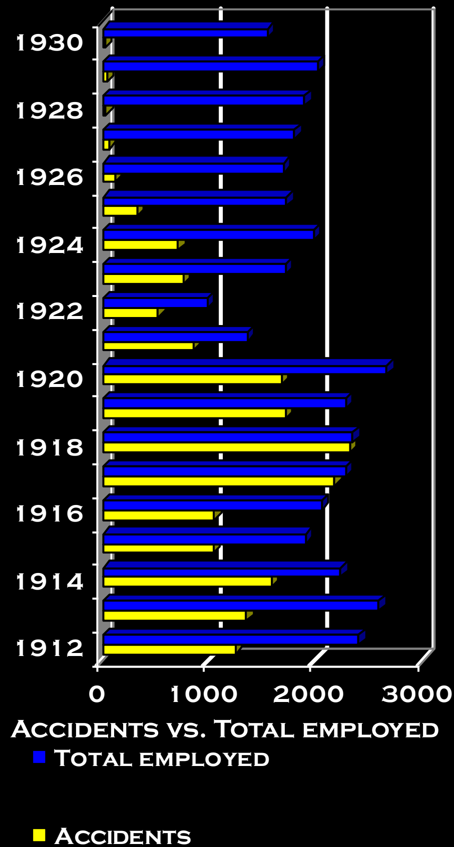


Graeme Larkin collection
Fire rescue drill in the Junction mine yard -1920

A part of the Copper Queen "Helmet crew" used in firefighting and control of ventilation during a fire C – 1917
Graeme Larkin collection

Slide 64

The safety dividend



Every job performed in the mines had been thoroughly evaluated by experienced, safety conscious miners. Together with the safety department, manuals were developed which covered every aspect of the task and the safe approach to complete it. These manuals were called "Code of Safe Practice" and every employee was given the particular one which corresponded to his assignment.

Slide 65

Drinking water

The physically demanding work in often hot environments brought the need to have a dependable supply of clean, cold, drinking water. While miners often carried canteens, it was still essential to have water in the working areas. This was accomplished by using wooden kegs with a capacity of about ten gallons with a drinking fountain type fixture attached to a short piece of ¾ inch hose. The kegs were filled at the station or surface each shift and taken to points near the active stopes on the levels by the motor crew. The wood allowed the keg to sweat which served to cool the contents. At the Junction, an ice plant was built in the 1920s, to chill the water because of the very hot conditions underground.

By the early 1950s, all working levels had high volume water coolers installed and these were also in several of the working areas. ~~~~~

Graeme Larkin collection

1300 level Cole station, note the water cooler and air receiver -1962

Drill water was everywhere, but it was not potable --- ever ---- and all were instructed to never consume even the smallest amount. After all, this was mine water and the drainage ditches throughout the mines were convenient places to dispose of last night's beer and everyone used them in this manner. In fact, the drainage ditches, or water ditches, as they were officially known, were called "piss ditches" by the typically less than refined miners, because that is what they used them for.

Every effort was made to keep the kegs and their contents clean. The metal lids were made so that they could not be used to drink from. The drinking fountain like fixture was constructed so that contact with the lips was impossible. Each and every month, all of the kegs were taken to the surface on a Sunday and the inside steam cleaned to inhibit algae growth. Now, while the insides were clean, the exterior of the kegs was often the opposite. The handling and re-handling by the motor crews coupled with the general dusty or muddy environment made the outside of the cleanest of kegs, an unappealing source of water.

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Sanitation

Underground mines by nature are closed environments. Thus the need to dispose of excrement in a hygienic manner is self evident. Until 1915, empty dynamite boxes were used as toilets and a nearby can contained lime to be used to cover the latest contribution. Lime was both antiseptic and reduced the odor. A full box would be disposed of in the gob of a nearby stope. In all, this worked, but was never the best. Steel toilet cars were designed by the Copper Queen and a huge improvement made in waste handling. The cars were filled to about six inches from the top with a water/creosote mix . The oily creosote formed a layer on top of the water and while adding its own strong odor, it stopped the water from smelling too badly. The cars were place near the working areas and were changed out on a monthly basis . ~~~~~~

Graeme Larkin collection

Toilet car at the cleaning station in the yard of the Campbell mine -1962

Illustration of the Copper Queen toilet car – 1916
Graeme Larkin collection

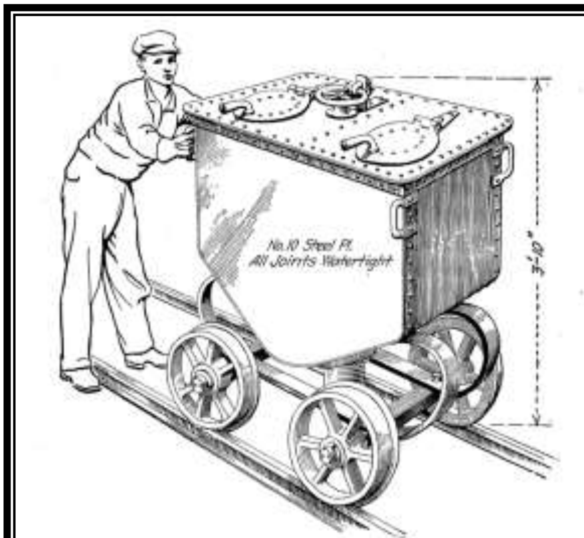

FIG. 3. MINE LATRINE CAR

The aroma of an underground toilet car is both unforgettable and indescribable. The strong smell of creosote permeated the air, and to be sure was the dominate odor, but other, less agreeable smells floated in the air as well. Few lingered while about natures business as these were unpleasant at best.

Toilet car on the 2966 level of the Campbell Mine 1970. The setting is typical - a little used, dry crosscut near the working stopes.
Graeme Larkin Collection

Local lore has a number of “Honey car” stories, all humorous, and perhaps even a few true. Greasing the black rubber seat was a common prank. Stories are told of miners changing carbide in their lamp while using the car, and then dumping the mostly spent contents into the adjacent hole and thus, into water. This would quickly form highly flammable, acetylene gas. Then the stories go on to say the miner disposed of his burning cigarette into the same hole, igniting the acetylene and either badly burning a most private and sensitive part of the body or literally blowing him off of the car as the right mix of air and acetylene is explosive.

The cars were handled by the “Sanitary Nipper” a man often teased, but never maligned. You wanted to be sure he did not “overlook” the car in your work area when it was time to change it out. Equally important was making sure he was not mad enough at you to park the car at the blower intake for your work place, or worse, spill a small amount of the contents at your ventilation blower. He had a number of ways to get your attention if you did not respect his humble, but necessary job.

When changed out, the cars were trammed by hand to the shaft station and taken to the surface. Hand Tramming these from, oft times, distant locations was not easy work and the downhill gradient of the track to the shaft station both helped and hindered as the full cars were heavy and unwieldy on the sloping track. More than one honey car got way from the nipper on the way out and derailed on a curve. The cleanup of these incidents was, needless to say, an unpleasant task and despite washing and frequent dustings with lime a lingering odor reminded all who passed of what had occurred at that particular spot.

Once the cars were on the surface, the contents emptied into a sewer line. This was done by opening the valve at the bottom of the car by turning the wheel on top. They were thoroughly washed and refilled with the creosote - water mix and sent back underground.

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The mine shops

A large number of different trade skills were necessary to keep a big mine running. Everything the miners used had to be maintained and repaired, often. Much of the equipment needed in the mines was actually made in the shops such as mine cars, drill steels, ventilation pipe, specialty tools, cable slings, and all types of bags and boxes for use underground.

This required a sizable, skilled workforce and complex in which to perform their task. Early on, each mine had their own set of shops. By 1910 each company had centralized these functions. The C&A used the Junction and the CQ used the Gardner /Lowell

1. Warehouse (supply)
2. Machine shop
3. Electric shop
4. Boiler shop
5. Pipe & rigging shop
6. Blacksmith shop
7. Rope shop
8. Carpenter shop
9. Framing mill
10. Underground pipe

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Graeme Larkin collection

View of the Junction mine complex and shops - 1950

The many shops necessary to support the mines and their principle functions included:

Warehouse – Purchase and maintain a reasonable stock of supplies and materials for the mines and mine shops
Boiler shop – mine car repair, make chute door kits, build mine cars, repair slushier blocks, build and repair cages
Rope shop – maintain hoist cables, sew flay rope (manufacture) make slings, powder bags, nail bags, repair lamp belts
Tin shop – make vent pipe, vent pipe fittings, tool boxes, fuse cans
Machine shop – Manufacture replacement parts for most anything, maintain hoist and pumps
Blacksmith shop – sharpens drill steel, bits, picks, axes, make specialty tools, timber dogs
Electric shop – maintain underground power for lights, pumping, slushers, trolley,
Pipe shop maintain water lines (drill water, compressed air, pump,
Carpenter shop – put new handles in sledge hammers and picks, make air doors, cut spitter boards
Saw mill/framing mill cut and frame timber, make wedges and blocks
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Slide 68

Many craftsmen supported the mines with their work

The many multi-skilled craftsmen in the shops at Bisbee were as good as anywhere and they kept the mines running

Sewing flat hoisting cable in the C&A rope shop C– 1918
Graeme Larkin collection

Graeme Larkin collection
Sharpening detachable drill bits in blacksmith shop – 1939

Pick /steel sharpening arrangement in the CQ blacksmith shop C– 1912
Graeme Larkin collection

Graeme Larkin collection
Sharpening drill steel in the CQ blacksmith shop C– 1916

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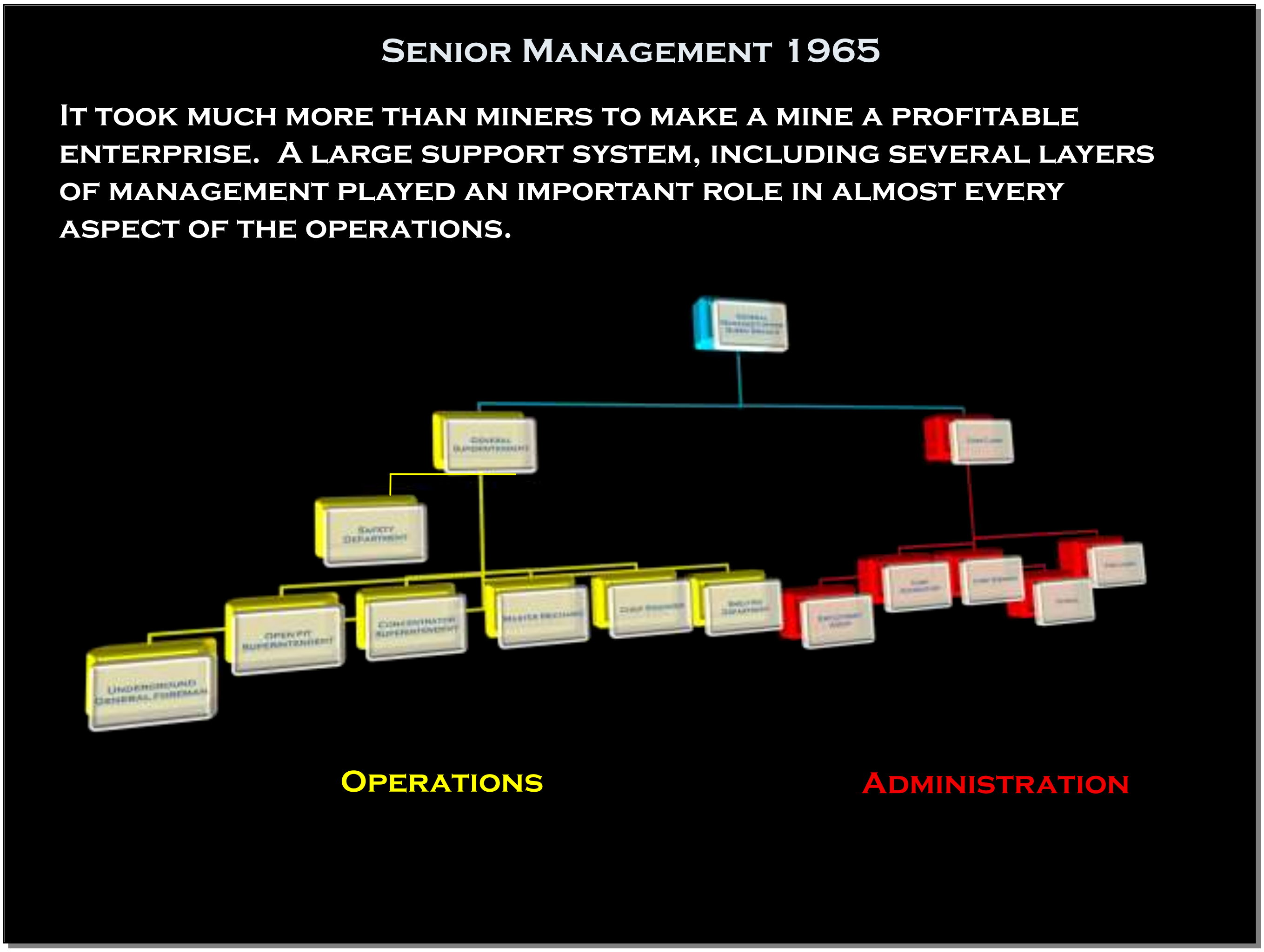
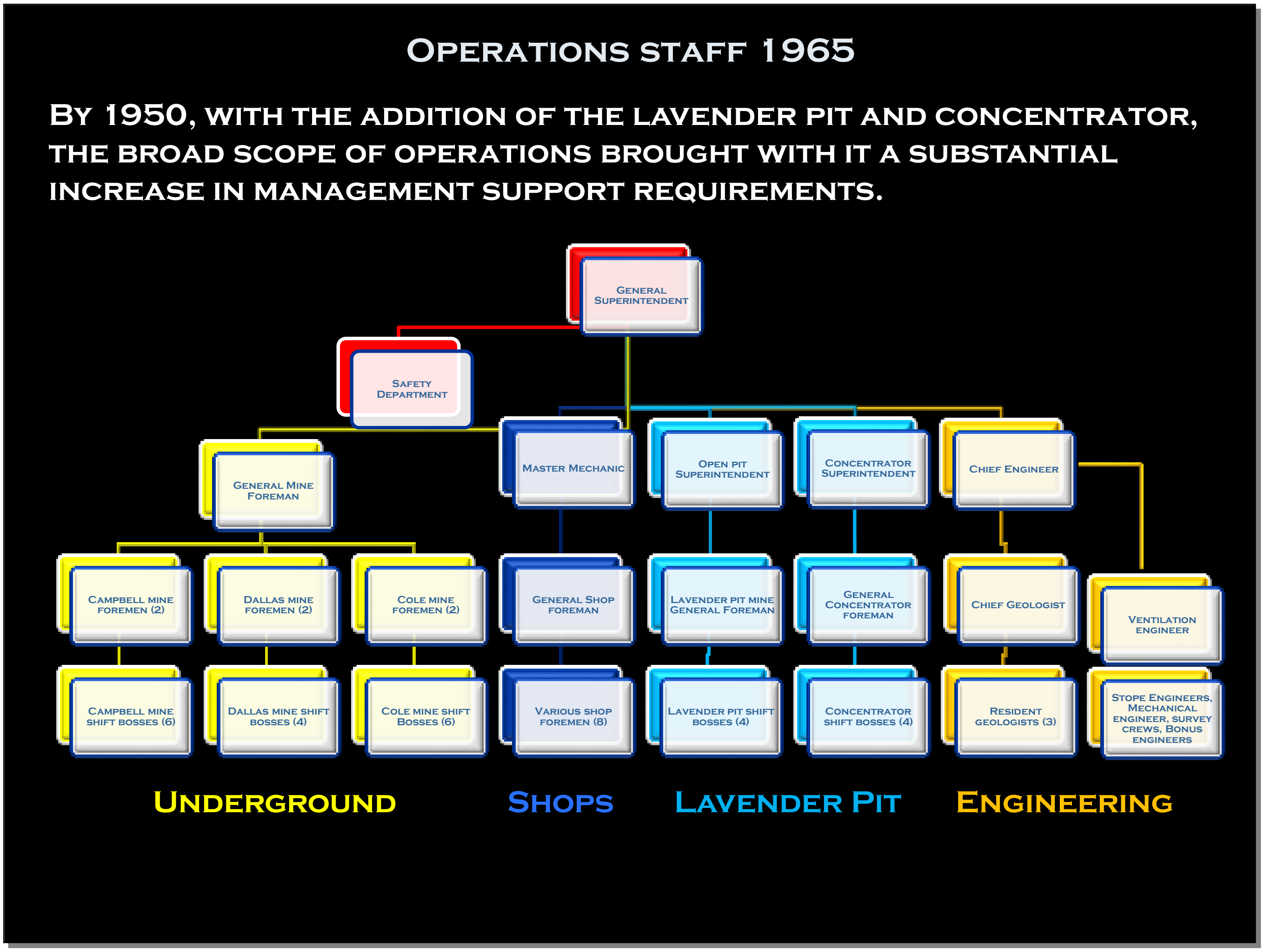
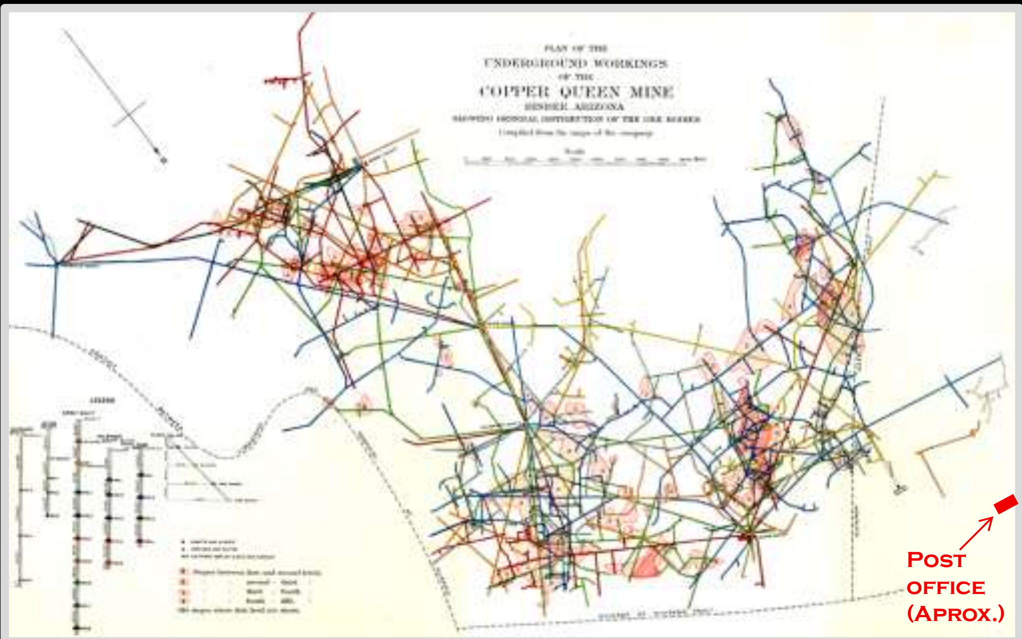

Senior Management 1965
It took much more than miners to make a mine a profitable enterprise. A large support system, including several layers of management played an important role in almost every aspect of the operations.
General Superintendent
Safety Department
Underground General Foreman
Open Pit Superintendent
Concentrator Superintendent
Master Mechanic
Operations
Administration

Slide 70


Operations staff 1965
By 1950, with the addition of the Lavender Pit and Concentrator, the broad scope of operations brought with it a substantial increase in management support requirements.
General Superintendent
Safety Department
General Mine Foreman
Master Mechanic
Open Pit Superintendent
Concentrator Superintendent
Chief Engineer
Campbell mine foremen (2)
Dallas mine foremen (2)
Cole mine foremen (2)
General Shop Foreman
Lavender pit mine General Foreman
General Concentrator Foreman
Chief Geologist
Ventilation Engineer
Campbell mine shift bosses (6)
Dallas mine shift bosses (4)
Cole mine shift Bosses (6)
Various shop foremen (8)
Lavender pit shift bosses (4)
Concentrator shift bosses (4)
Resident geologists (3)
Stope Engineers, Mechanical engineer, survey crews, Bonus engineers
Underground
Shops
Lavender Pit
Engineering

Slide 71

The mines at Bisbee are very complex



Graeme Larkin collection

Map of the Copper queen mine -1902

High quality surveying and engineering were essential to interconnect the many shafts on all of the levels. It was also very important to be able to connect from level to level with raises for the efficient mining of ores with ventilation and back filling. This too required very precise engineering.

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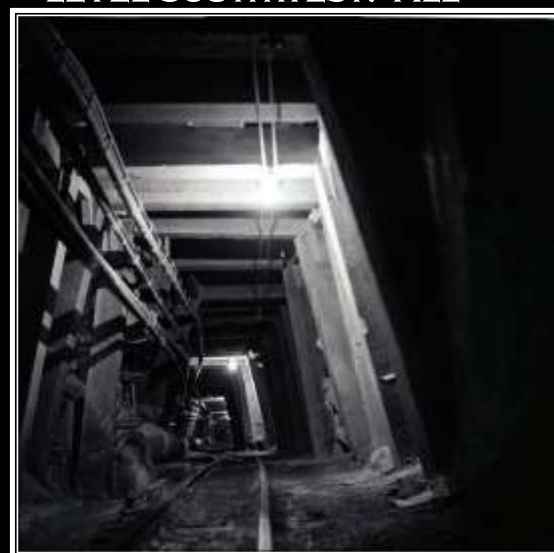
Slide 72

Engineering was good at Bisbee

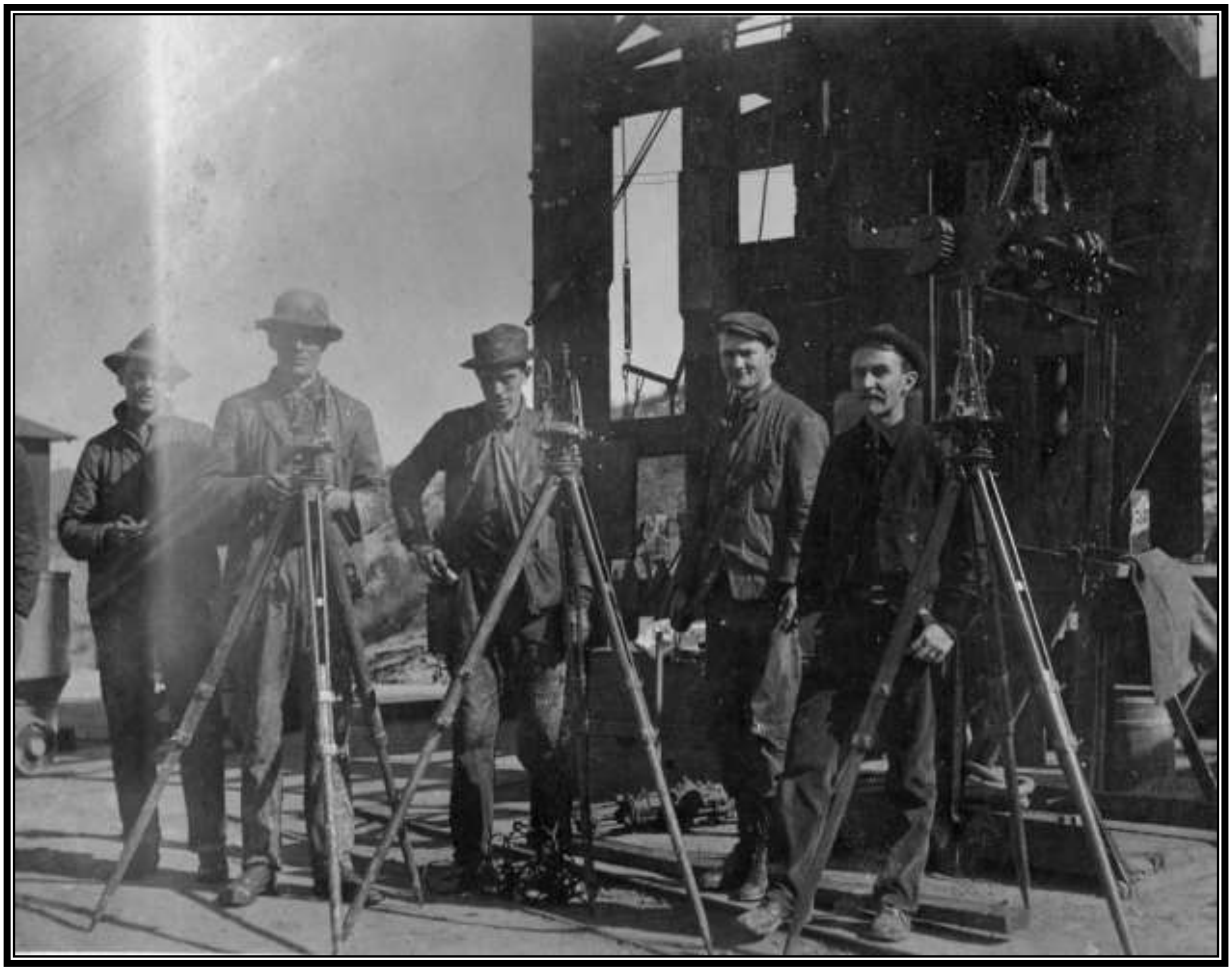
Very good engineering skills were an important part of successful mine operations. It was a common practices to connect two headings driven from two or more points to expedite the work. The Campbell shaft was both sunk from the surface and raised to from the 1300' level. The connection was made at 700' below the surface and was essentially perfect with no variance. It was a similar story with the Sunrise shaft which was worked with raises from the Queen tunnel level and the 7th level Southwest. All connected within inches which is essential for the operation of a shaft. Crosscuts were often driven from very distant points and the connections were always good but not perfect. The great distances made this difficult and too, it was not essential. This shows the connection on the 2966 level of headings driven from the Campbell and Denn shafts. The modest double curve it the rail shows the variation in the two crosscuts. The change in grade is evident as well with the slope toward the Denn shaft~~~~~



Graeme Larkin collection

Looking toward the Denn on the 2966 level Campbell mine -1962

The water from the 3100 level Denn was pumped to the 2966 level and carried by pipe to the point where the Campbell/Denn connection was made and then allowed to flow in a water ditch to the 2966 Campbell pump station. The point shown in the photo above is where the two headings joined. The slope of the heading drive from the Denn is toward the Denn shaft at a grade of 0.33% or 4" per 100 feet. The slope on the Campbell side was slightly greater in order to make the connection at the same elevation as the distance from the Denn to the connection point was greater than the distance to the connection from the Campbell shaft.



Underground survey crews at the Lowell Shaft - 1904
Graeme Larkin collection

There were a number of two-man survey crews in the mines. Every crosscut had to be given lines daily to stay on course; all new advance in the crosscuts had to be surveyed as to direction, distance and grade (inclination to give elevation), all of which was then recorded for plotting on the mine maps in the office; most raises needed to surveyed daily to assure they were headed to the desired point (this is far more complex than it would seem as a slight variation would bring the raise many feet from the intended target); shafts needed to be plumbed and kept absolutely in line and vertical.

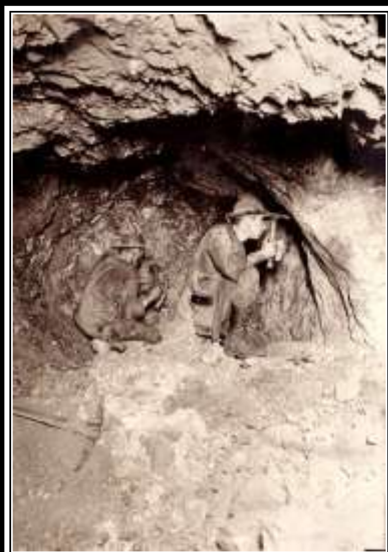
These were all important and exacting task, but which had to be performed rapidly so the miners could quickly return to work. As the miners were paid for advance, then were in a hurry to be rid of the survey crew and made little secret of their desire to start mucking again.

Slide 73

Geologist kept on searching for new ore

To the geologist fell the task of finding new ore. To do this, thousands of feet of diamond drilling were done each year as well as geologic mapping of every crosscut, raise and stope to understand the controls which governed ore placement. Even with all of this, new ore was very difficult to find as the clues were so subtle. Inches away from an orebody, the rock looked unaltered with no hint of the riches nearby. But success did come and sufficient ore was always found to replace what had been mined each year. ~~~~~

Graeme Larkin collection
Diamond drilling Campbell mine 1950



Graeme Larkin collection
Geologist and assistant sampling working face C - 1915

Graeme Larkin collection
Diamond drilling core being removed from core barrel Campbell mine -1950

The geologist only became a part of mining at Bisbee in 1905 with the C&A bringing in the first. The Copper Queen was slower as the senior management placed little faith in the ability of science to replace the mysterious senses of an experienced miner at finding ore. By 1913, geologists were employed in all of the mines.

Good, detailed geologic mapping of all working areas helped to develop a better, but not perfect, understanding of the natural features which controlled ore deposition. As geology is an imperfect science, this better understanding aided in the search for new ore, but did not guarantee success as it was not uncommon at all to find all of the right conditions for ore deposition, but no ore. Many of the massive sulfide replacement bodies were either low grade or barren of copper and these masses were far more abundant than the ore bodies.

The wide-spread use of diamond drilling was a great savings as previously all prospecting had been done by driving of crosscuts and raises. It was much cheaper to drill a small hole for the hundreds or even thousands of feet than to drive a development heading to the same point.

Once ore type mineralization was found with the drill, a number of holes would be drilled in fan patterns to determine the probable extent of the mass. The drill core from all holes was reviewed and recorded (logged) underground at the drill location by the geologist on a daily basis with sulfide bearing pieces sent to the assay lab for analysis. The information from the drill core was transferred to the individual maps corresponding to the elevation of the hole at a given distance from the point it was started (the hole collar). This information helped give a more in depth understanding of the areas the holes passed through.

Rock quality was also noted as so much of the rock masses were cut by numerous faults. The ground was frequently so broken that it was necessary to pump cement into the hole to keep it from collapsing. The photo above of the drill core shows a very white section which is cement that had to be placed to keep the cooling water on the bit. The cemented part of the hole was then re-drilled when set.

Malachite/goethite ore in place – Southwest mine, view 5 feet.
Graeme Larkin collection

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Engineers and Geologist work together

The work products of the engineers and geologist were combined to make maps of every working every 8 feet vertically. Some 12 horizontal slices of the mine were mapped per 100 vertical feet. Note the survey plumb line in the photo below

Graeme Larkin collection

Burton & tape survey in a cut & fill stope, 2833 level Campbell mine -1973

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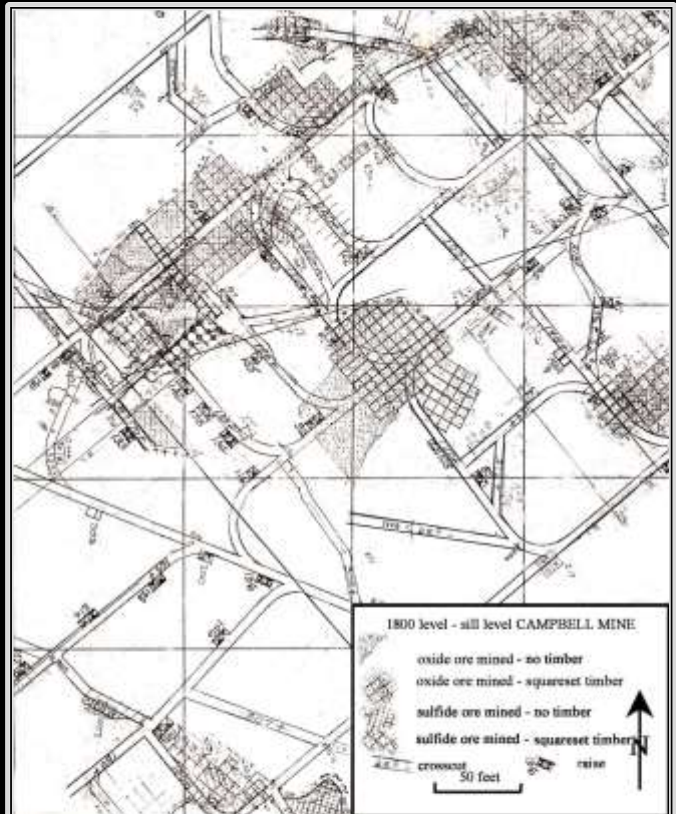

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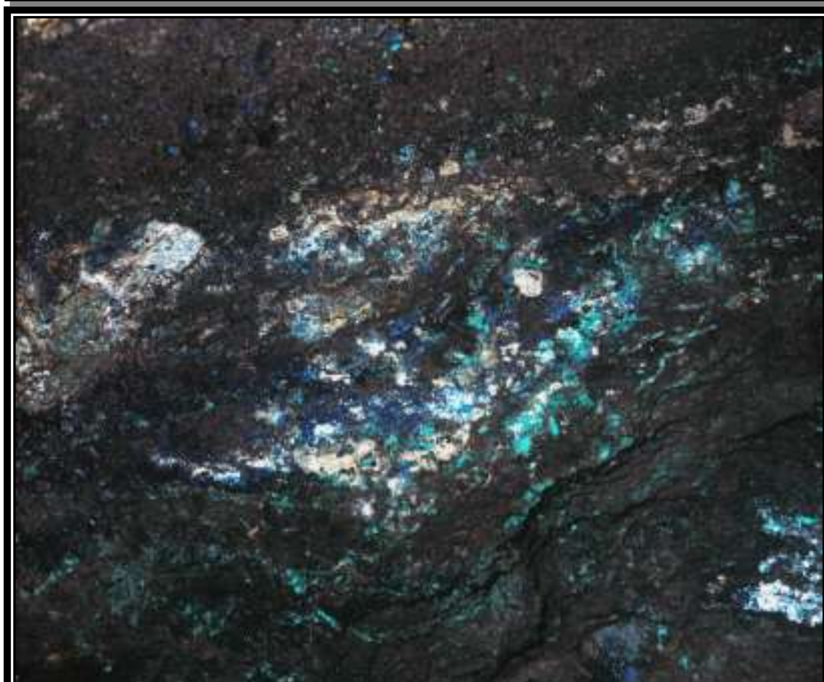
Sill level map, 1800 Campbell mine -1950



Azurite and malachite in manganese oxide in place – 770 level Junction Mine
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Slide 75

Sampling and Assaying

The whole of the mine depended on the copper that was in the rock, but how could one discern between ore and waste, low-grade and high grade. They often looked very similar. Every new working face, every fresh muck pile was sampled every shift . Motor crews sampled every ore train and an automatic sampler took a split of the ore being dumped into the ore bins at the surface. All of these samples were collected at shifts end, prepared in the sample mill overnight then sent to the assay office for determinations. The results were in the right hands by the end of dayshift . A 24 hour turnaround on samples, not bad service at all.

These results were used to direct exploration, plan mining and predict copper production.

Hundreds of assays were made each and every day for copper gold, silver as well as other elements, when required. Without this rapid and accurate information, the mine would have been far less efficient ~~~~~

Graeme Larkin collection

A wet determination for copper content in the assay office at Bisbee - 1950

The samples were delivered to the various shaft stations by motor crews who collected them from the work areas. After the men had been hoisted, cagers collected the samples from the stations and took them to the surface for pickup by a truck which delivered them to the sample mill. At the sample mill, the sample sacks were emptied into pans along with the paper tag which the person who collected the sample placed in the bag. These trays were dried in large ovens, and then the samples crushed and ground to a very fine particle size for easy chemical digestion. A 200 gram split of the whole sample was then packaged in a paper bag, labeled and sent to the assay lab.

Base metal determinations were typically made using wet chemistry while gold and silver content were determined by fire assay, a much more intense process. Hundreds of determinations were made every day by the assay office and these in turn were used to direct much of the activity in the mines.

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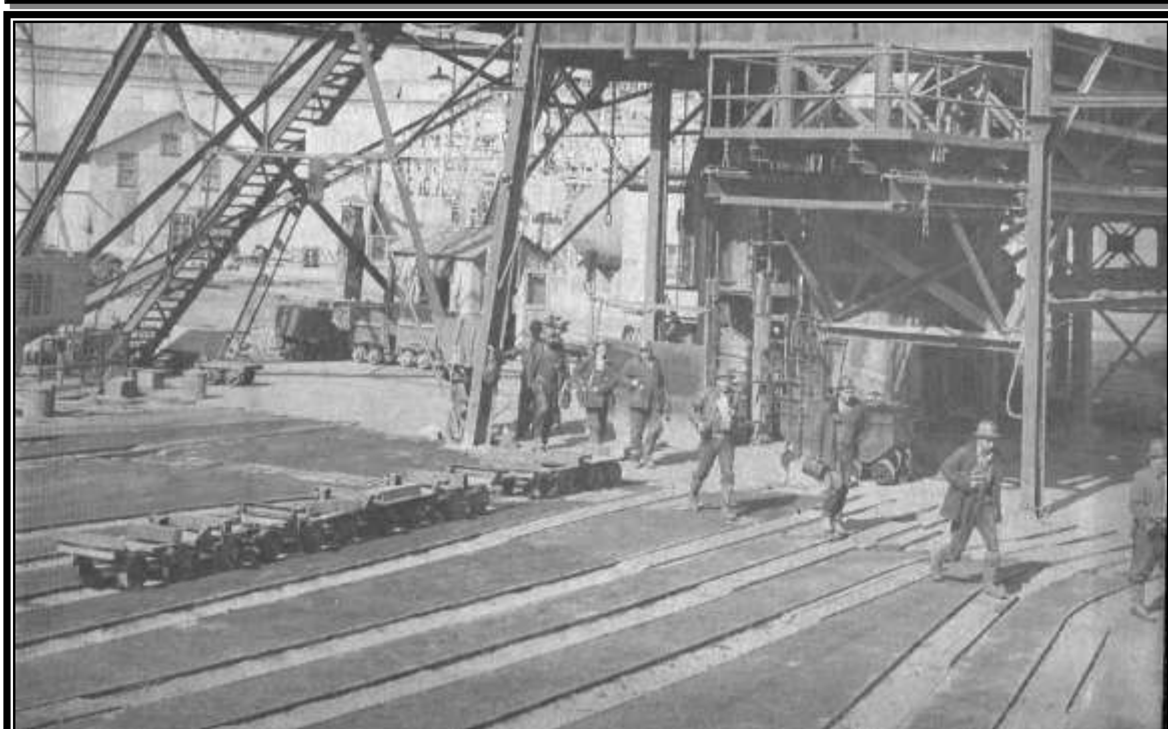
The end of the shift

To be sure, the labor of a miner became easier with mechanization. While, it was never easy work, it was good, honest work. Work which was done by good men, skilled men, who left an indelible print on Bisbee on Arizona, on America

End of Shift, Bisbee
Oil on panel, about 14 x 20 inches (1924).
University of Arizona Mineral Museum

Taking the drill out of the saddle on a bar & column setup
Campbell mine -1939
Graeme Larkin collection

Breaking boulders on the grizzlies in a cut and fill stope
2833 level
Campbell mine - 1973
Graeme Larkin collection



Miners removing their lamps to place them on the charger on the way to the change room at the end of shift, Junction Mine - 1956
Graeme Larkin collection

There was a ritual of sorts about coming off shift. Almost always there were thoughts about the day, the things accomplish and the things left undone. Miners were largely paid for what they accomplished during a two week period. That is why they had work on their mind, planning for the next shift, ready to ask the shift boss for supplies, if needed and leave word for the opposite shift that will be in your workplace for the next eight hours about any important issues.

The cage ride to the surface was always cool, if not downright cold. Wet with sweat, the rushing air on the way up the shaft would chill, even in summer. Thus, everyone wore a coat on the cage, but never underground in the work areas. You turned your light off before boarding the cage, so as not to shine the light in others eyes. Between leaving the cage and the change room, the lamp was off the lamp belt and placed in its spot on the charging rack. Then off to the shower and on to home, or where ever there was good beer.

A trail of men on their way to the change room at the end of shift, lunch pails in hand. Junction Mine C - 1920
Graeme Larkin collection