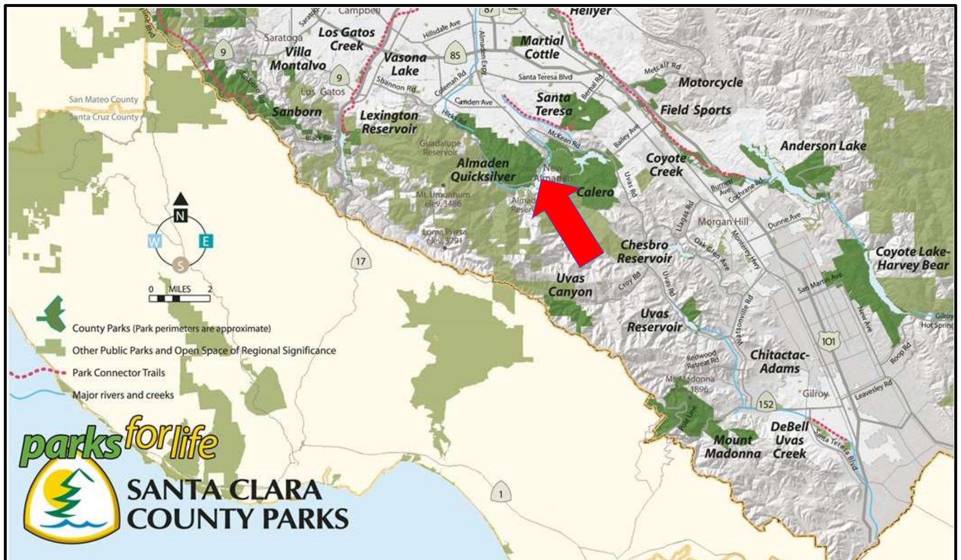
My talk is a hyper-speed introduction to one of the world's great mines and the first non-agricultural large-scale industry of Bay Area. My name is Michael Cox. I am a founding member of the New Almaden Quicksilver County Park Association, formed in 1982 to help the County preserve and promote the rich historical, geological, and biological resources of the 4100-acre Almaden Quicksilver County Park. I have a bachelor's in Geology from Cal State East Bay and an MSc from USD, with a focus on international materials supply management. Ever since I was a kid, I have been interested in mining and materials supply, and took a keen and active interest in the New Almaden mines.

No doubt there are typos in this, especially in the notes. Just let me know if you see any and I will fix them.

Itinerary

- 11:30 am – 12:15 pm BYO lunch/picnic and short presentation
- 12:15 pm – 1:00 pm walk to nearby park entrance to inspect former ore processing cap and closure area
- 1:15 pm – visit New Almaden Mercury Mining Museum. 21350 Almaden Rd, San Jose, CA 95120

Self-explanatory



LOCATION

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This is the location of Quicksilver Park, in green, and the village of New Almaden, at the tip of the arrow. The mine is about 12 miles south of downtown San Jose, CA. On July 4, 1961, New Almaden and the then 3600-acre mining lands were added to the National Register of Historic Places as a Landmark District. From 1972 until 1975, the County of Santa Clara acquired the mining lands in stages and then opened Almaden Quicksilver County Park in 1976. The main mine area, called Mine Hill, was kept off limits until 1999, due to mining hazards that had to be abated.

New Almaden Cinnabar (HgS) Nugget


Photo by Ron Horii, cropped

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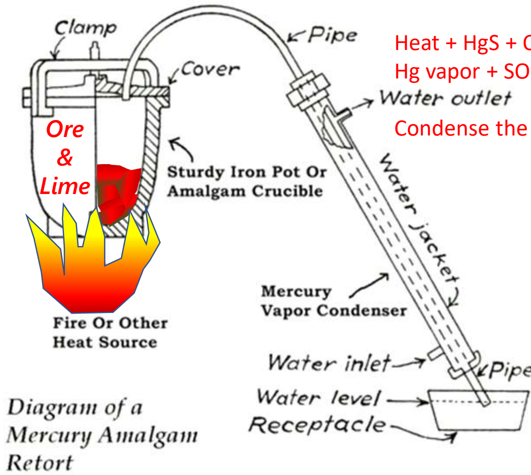
So this is what started it all - this is a placer nugget of cinnabar. The Coastal tribes living in the South Bay found some of these in what we call Deep Gulch creek and traced the source of the nuggets to an outcrop in the mountains. Cinnabar has been found in ancient grave sites throughout the western US and was even introduced to the Spanish conquerors, who used it as a source of vermillion paint. Since ancient times in Europe, cinnabar was used to manufacture vermillion paint. For some reason, early Californians did not realize the red rock was cinnabar. They tried to identify the ore in 1824, and again in 1836, but failed to connect the dots. In 1845, Captain Andres Castillero, a Mexican diplomat in route to Sutter’s Fort, stopped at the Mission Santa Clara and recognized the ore. He immediately claimed the mines and was awarded possession December 30, 1845.

Recovery of Hg from Ore: Retort

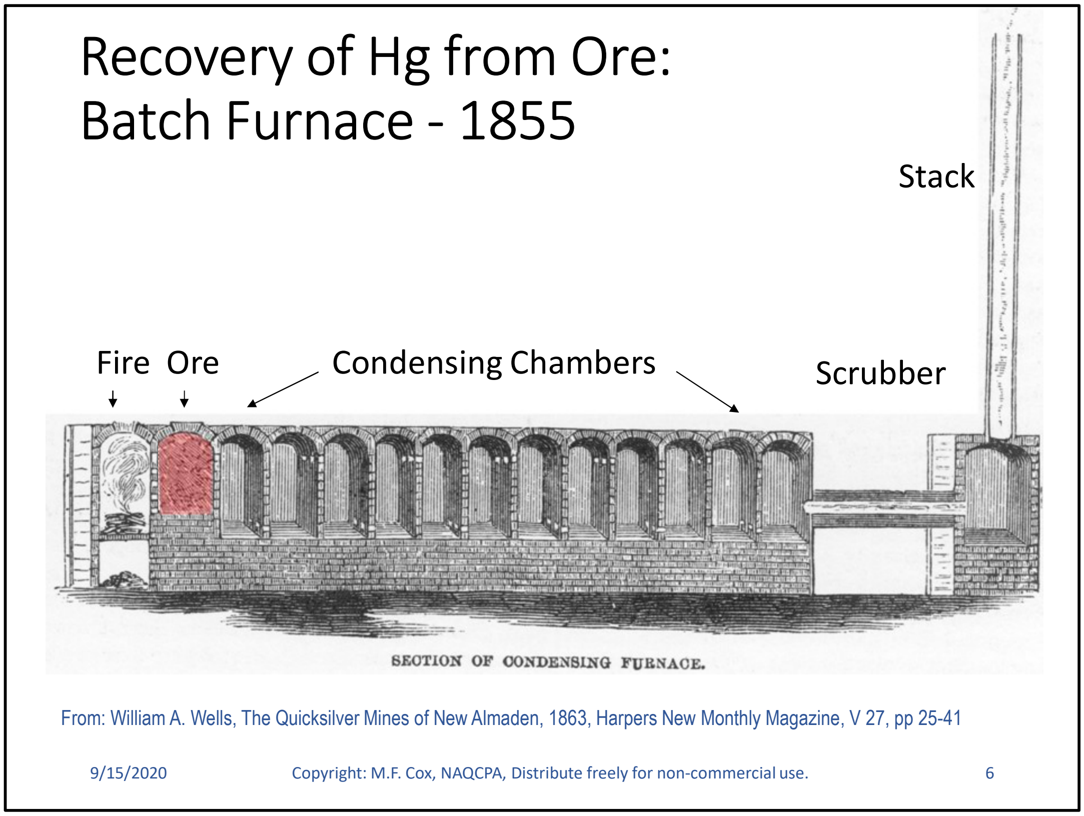


Heat + HgS + O2 =
Hg vapor + SO2 gas

Condense the Hg vapor back to liquid

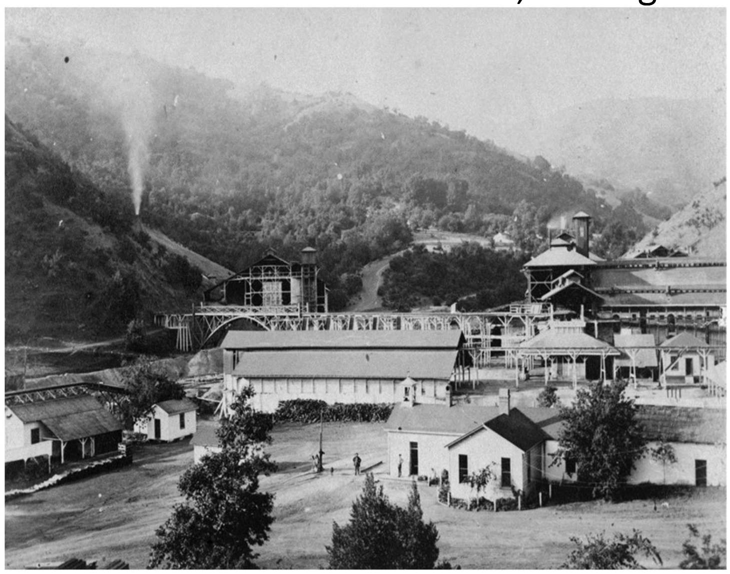
From Nevada Outback Gems, URL: http://nevada-outback-gems.com/Reference_pages/Amalgamation.htm

A retort is typically an iron pipe or vessel that holds a limited quantity of ore that is sealed inside. The container is fired from the outside to heat the ore within. A condenser tube connected to the device lets in oxygen to combine with the sulfur and also functions to condense the mercury vapor back to a liquid. It is always necessary to add calcium oxide to the ore charge, so that enough oxygen is liberated to combine with all of the sulfur in the ore. This type of retort is just an illustration. Miners did not process mercury ore in these devices, as they are too small. This type of iron retort is made to separate gold from mercury. Mercury has long been used as a “solvent” to extract gold from its ore rock.



This is a cut away section of the first type of large-scale furnace used at New Almaden. Furnaces of this type could process tens of tons of rich ore, but did so intermittently. They had to be charged, cooled, cleaned out by hand, and then charged again for the next firing. The process took seven to ten days per charge. Baron and Forbes brought capital, men, and proper mining technology to New Almaden. They constructed large furnaces made of fire brick and attached condensers made of carefully plastered red brick. Mercury condensed in the brick chambers, fell to the floor, and ran out a small hole to a collection trough.

Hacienda Furnace Yard – circa-1880, looking south



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Mining creates waste. This mine released residual mercury in discharge water, ore roasting waste, discharges to air, and the deposition of waste rock to land. This photo shows mist and fume loss to the air. Depending on how well they were built an operated, furnaces could discharge significant amounts of mercury to air. Older brick furnaces and condensers also leak substantial amounts of mercury into the ground.

Mine Closure Process

- Inventory mine openings and assess conditions
- Prioritize and seal with variety of closure techniques
- Smooth dangerous cut faces
- Correct drainage and erosion issues
- Address Environmental, Health & Safety Concerns
  - Complete Solid Waste Remedial Investigations and Actions (RI/FS/RA/RAP/RA) and Obtain Closure
  - Implement Perpetual Water Quality Investigations and Controls, Remedial Actions to Address Water Quality Concerns
  - Address Future Issues
- Implement On-Going Monitoring and Maintenance Programs

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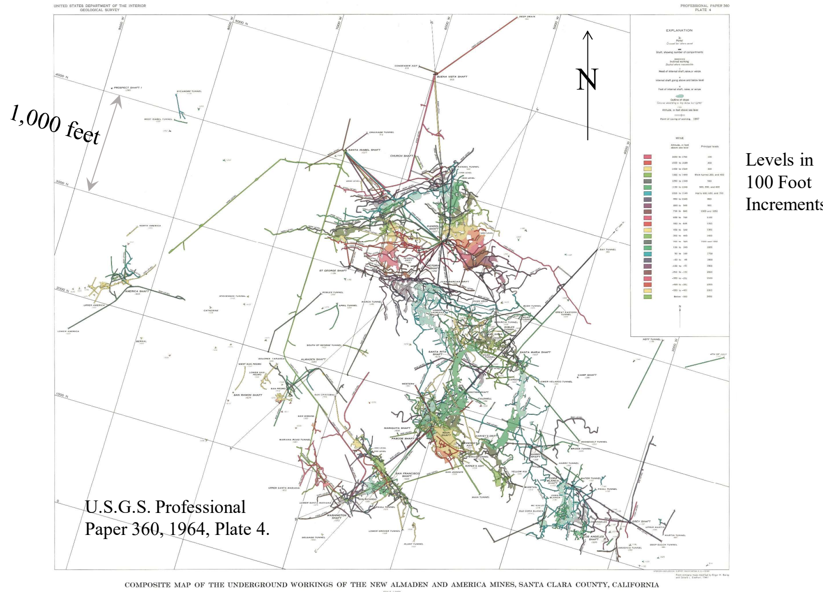
Self-explanatory

49 miles of workings in main mine



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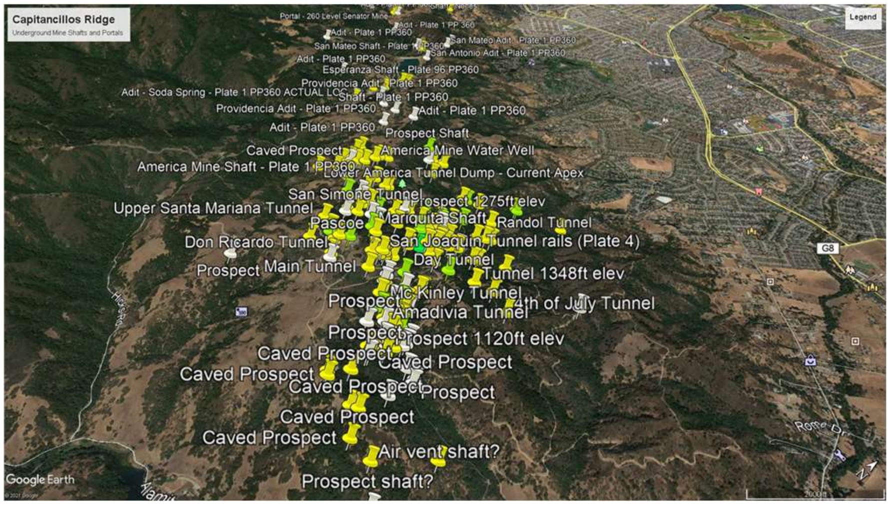
This is a planimetric view of the mine, looking down on the underground workings. Each color represents a 100-foot vertical interval. The grids are 1000 sq ft.

Oblique View of Main Mine and Openings



The underground closure process inventoried and inspected 358 mine openings in the park. About 90 of those required closure work.

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This view of mine opening placemarks added to my Google Earth™ application is a glimpse of some of the roughly 360 underground mine openings inventoried in the park.

Underground Opening Closures

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Section title

The mine requires ventilation to reduce the potential for cave-ins and carbon dioxide gas accumulation. Unfortunately a trade off is the release of picogram to milligram concentrations of mercury vapor per cubic meter of ventilated mine air. The underground workings have elevated trace concentrations of mercury in air, both due to natural outgassing, but also because the miners used black powder for blasting and the heat of the powder cooked some of the ore and released elemental mercury. A larger hazard if trespassers might get into the mine workings is that of carbon dioxide. The host rock for the ore is predominantly quartz and carbonate minerals. Oxidation of the rock releases CO_2, which is heavier then air and settles in the lowest points of the workings, presenting an immediate suffocation hazard if someone were to inadvertently walk into a CO_2 pool. Unconsciousness comes within seconds of doing so, and death by suffocation soon follows.

Mine Opening M-66 - final

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The closures had to be designed to keep out the curious vandals. Initially many attempted to break back into the mines, so the closures were designed to discourage such attempts. Today the interest in doing so seems to have abated.

Paul Stope Collapse

Some of the openings were very large and problematic. For example, this collapsed roof of a large room known as the Paull stope. The room slopes away from the viewer and could easily contain thousands of dump truck loads of rock and soil. Note the old automobiles at the bottom of the hole, relicts from prior closure attempts – yes, the miners shoved wreck cars into the collapse, hoping they might bridge the 15-foot diameter hole.

Paul Stope Closure - Formwork

M.F. Cox photo, 1984-1985

The solution was to bridge the opening with a concrete slab measuring 20 ft x 20 ft x 3 ft thick.

Paul Stope Closure – Completed Pour

M.F. Cox photo, 1984-1985

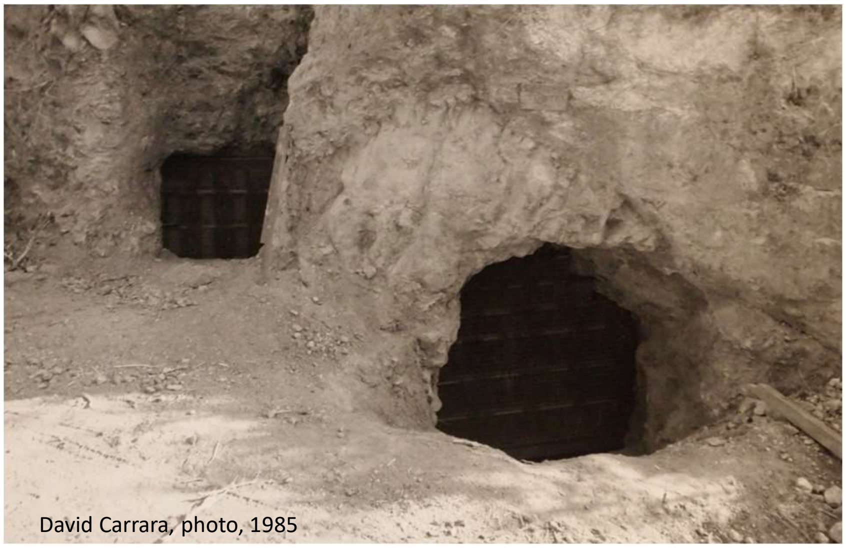
This is the slab after filling with 4,000 psi concrete and while curing. The outer forms were striped off and then a French drain system installed to keep groundwater away from the slab. The side and bottom form work could not be recovered and was left in place.

Yellow Kid Stope Closures

M.F. Cox photo, 1985

This is an opening to a stope that is about 50 feet wide and goes down dip for over 100 feet. If fill were placed into the opening, it would simply creep down hill, especially if it got wet. The solution was to key in I-beams to retain rip-rap fill that will bury the closure and seal off access. These stopes were non-ventilating. Their connections to the main mine had failed and/or were filled with mud from surface drainage that was not diverted away from the openings.

Yellow Kid Stope Closures



David Carrara, photo, 1985

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This is a view of two stope closures prior to burial.

Yellow Kid Stope Closures

M.F. Cox photo, 1985

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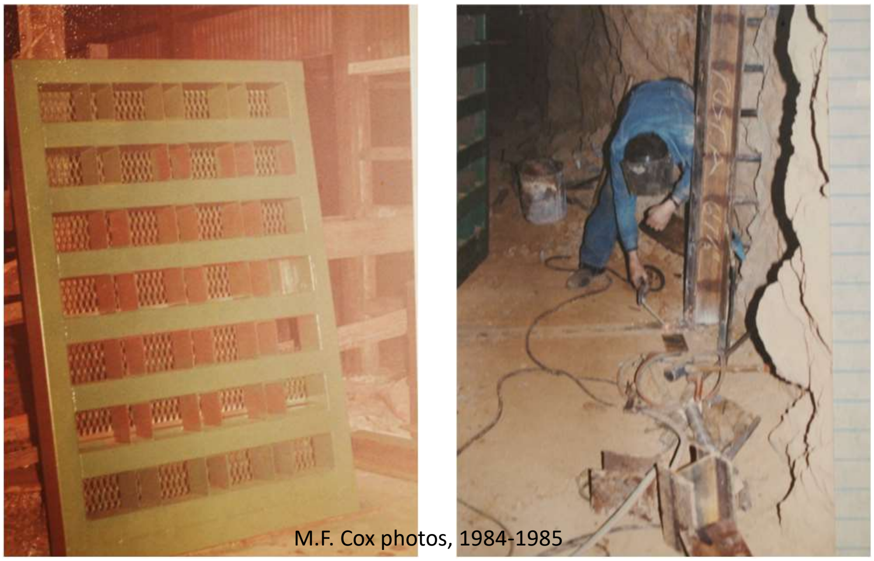
This is the process of “rocking” the closures prior to burying them. We created a graduated “barrier” of rock, starting with large boulders next to the closures in order to discourage vandals. This rip-rap then graded to smaller cobbles and gravel, so as to retard or prevent piping of wet soil through the closure during periods of heavy rain. The “rocked” closures were then buried under local borrow. The Chief Engineer, the late Andrew Niven of County Parks, did the calculations for sizing the steel pins, I-beams, and expanded metal grating so as not to have excessive deflection after burial was completed.

San Cristobal Tunnel Portal



M.F. Cox photos, 1984-1985

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A very significant closure was that for the portal of the San Cristobal tunnel. This tunnel on the 300-foot level of the mine (300 feet below the summit of Mine Hill) provided ventilation and access for a large portion of mine workings above the 800-level, below which the workings are flooded. A substantial gate had to be installed to ensure curious vandals with power saws would be discouraged from trying to cut through the closure. A bat passage was later added by making a 6-inch high opening toward the top of the gate.

San Cristobal Tunnel Portal

M.F. Cox photo, Jan., 2019

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This is the San Cristobal portal in 2019.

Opencut Remediation

Section title.

San Francisco Opencut - 1960

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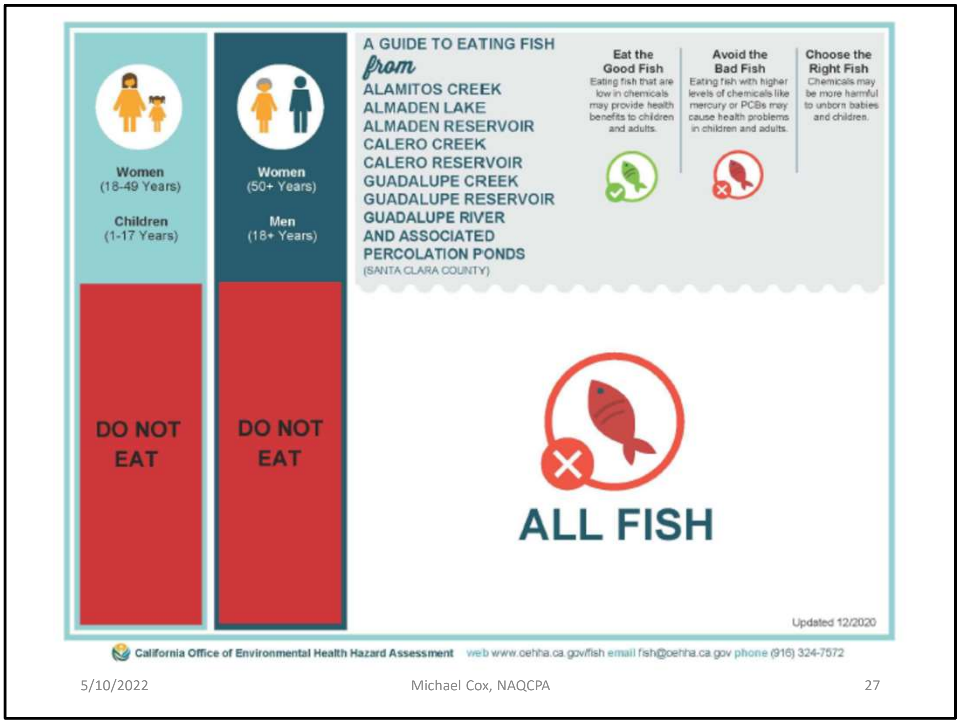
1960 – NW and uphill from Mine Hill rotary furnace. Cropped to right is Geraldine Mary Camilleri, daughter of Reno “Andy” Camilleri and Geraldine Steed. Andy, owner of Andy’s pet shop in San Jose, CA, bankrolled mining enterprises on the Hill from 1956 to 1963. No Mine Safety and Health inspector would have ever allowed the steep sided circuit excavated with pan scrapers. The circuit was excavated to allow the scrapers to drive in a loop and pick up ore being bulldozed down from a rusty-brown zone of ore. Above this is grey sandstone and then colluvial soils. The San Francisco shaft dating the 19th Century is sticking up from the pit floor and has electric wires running to it. It was being used for ventilation and utility access for workings that are merely tens of feet below the pit bottom. The earlier Paul stope collapse slide is an example of a place where the ceiling collapsed due to the encroachment of the cut work.

In the early 1980s, the presenter helped the County seal up the old mines and regrade open cut scars to reduce erosion. In the 1990s and 2000s, the presenter helped to investigate mercury pollution in the park.

This is a photo of the San Francisco opencut in 1986, after the closures and regrading were completed. The grading mainly being done to keep surface water away from the mine closures and underground workings. When finished, the old ratty open pit looked pretty good. Subsequently, the County decided to use the open pit for the encapsulation of mining wastes excavated from different locations in the park where encapsulation in place was not practical. Most of the cut is now filled with mining waste under a cover of three feet of clayey soil.

Mercury Pollution Cleanup

Section title



The mercury pollution problem is a fish problem. Microbial organisms and small plants uptake mercury from polluted sediments and water. Luckily sediments is the main issue, because normally cinnabar (HgS, the main ore of mercury) and mercury do not dissolve appreciable in water. None the less, these tiny part-per-billion levels in the critters and plants get into little fish and critters feeding along the bottom of the water bodies. Bigger critters east little critters, and the mercury concentrations increase as one moves up the food chain to the top-level predatory fish. The biomagnification can be by a factor of one-million times or so. Piscivorous birds and wildlife might be harmed, as well as people that eat the fish. It is a real problem, but the sources and chemistry are as complex as the biosphere.

1928-1929 Recovery of Leaked Mercury

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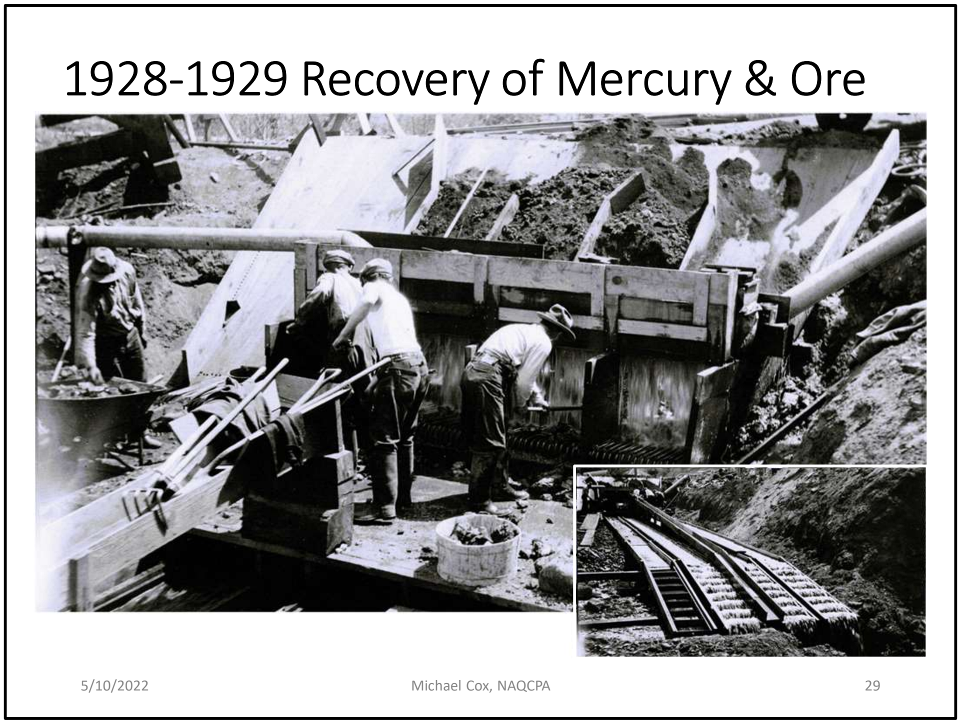
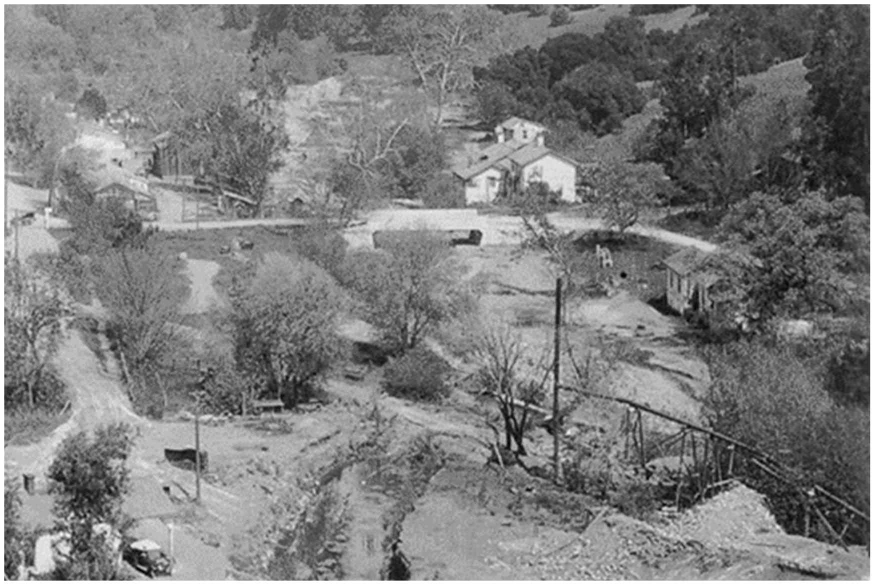
This photo is witness to an event that had a profound impact on Bay mercury- the excavation and hydraulic processing of soil and waste under the Hacienda furnace yard at New Almaden, principally in 1928 and 1929, 1937 through 1939, and on a much smaller scale in the 1950s and 1960s during periods of peak mercury prices. This will be the first time anyone has seen this story. I spoke to many “old timers” in the way back, when they were still alive, and many described the excavation of the former furnace yard at New Almaden and neighboring mercury mines, in order to recover spilled mercury and partially-roasted mercury ore. Apparently, the early furnaces, especially the old batch or intermittent furnaces, did not always fully roast all of ore fed into the furnace. It’s relevant because Chris Kim of Stanford University worked with Jim Rytuba of the U.S.G.S. and others to characterize the forms of mercury in burnt ore. It turns out the residual mercury is not just cinnabar, it is other chemical forms too, many of which are more soluble, toxic, and prone to bioaccumulation.



The old mining companies knew the brick furnaces and condensers leaked, after all, brick is a rather porous medium. In the 1870s, the companies began to excavate under the old furnaces to recover the leakage, usually by washing the excavated material to free the much more dense mercury from the rock and soil. These activities were relatively small scale until a mining campaign in 1928-1929 that sought to excavate and process the soils under the old furnace sites. In these two years, tons of material was excavated. Miners found not only the leaked mercury in saturated soils down to bedrock, they also discovered calcine dumps rich with what they called half-burned rock, as well as deposits of natural cinnabar cobbles and gravel. It was all run though a hydraulic plant to recover the mercury. Louis Artnous, a miner living in the Hacienda at the time, noted that more mercury went down the creek than was captured in the washing plant and long sluice boxes. He was correct, as we will see.

Hacienda Furnace Yard – 1936, detail looking north



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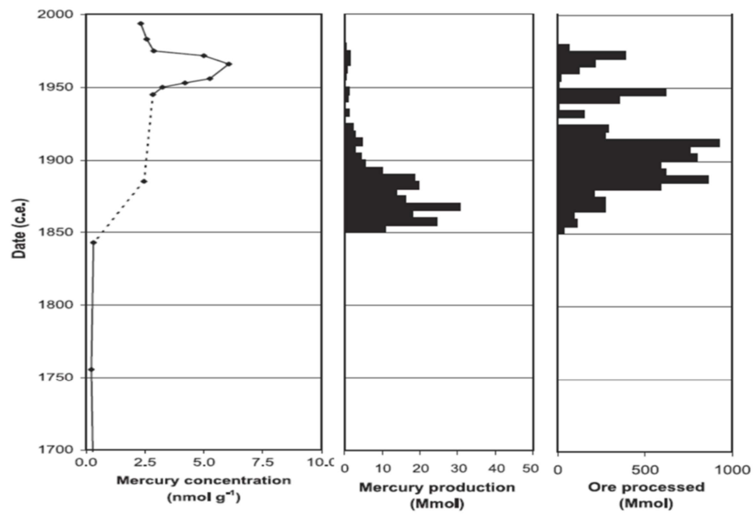
This view of the furnace yard and the village of New Almaden, looking north, shows, seven years later, the destruction of the 192801929 washing operation. Here we can make the argument that deliberate cleanup of leaked mercury resulted in an environmental catastrophe. The proof might just be in the soil cores collected from the South Bay and tested for total mercury, but first, notice the character of Alamitos Creek. It is clogged with sediment from the washing of the excavated soils, an excavation clearly visible to the lower left of the photograph. BTW- these photos are in the archives of the County of Santa Clara New Almaden Mercury Mining Museum (Interpretive Center).



Total mercury with depth (age) in SF Bay mud core

Temporal total mercury profile in a piston core of tidal flat mud. From Conaway et al., 2004, Mercury deposition in a tidal marsh of south San Francisco Bay downstream of the historic New Almaden mining district, California, “Marine Chemistry,” Vol. 90, pp. 175-184 (mercury mole = 0.2006 Kg)

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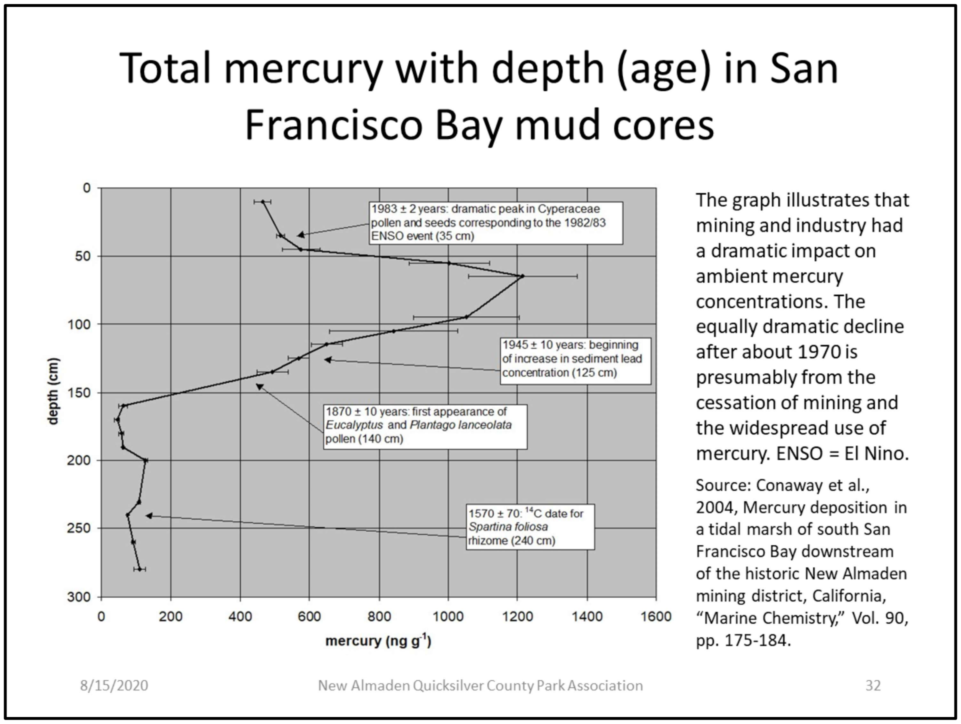
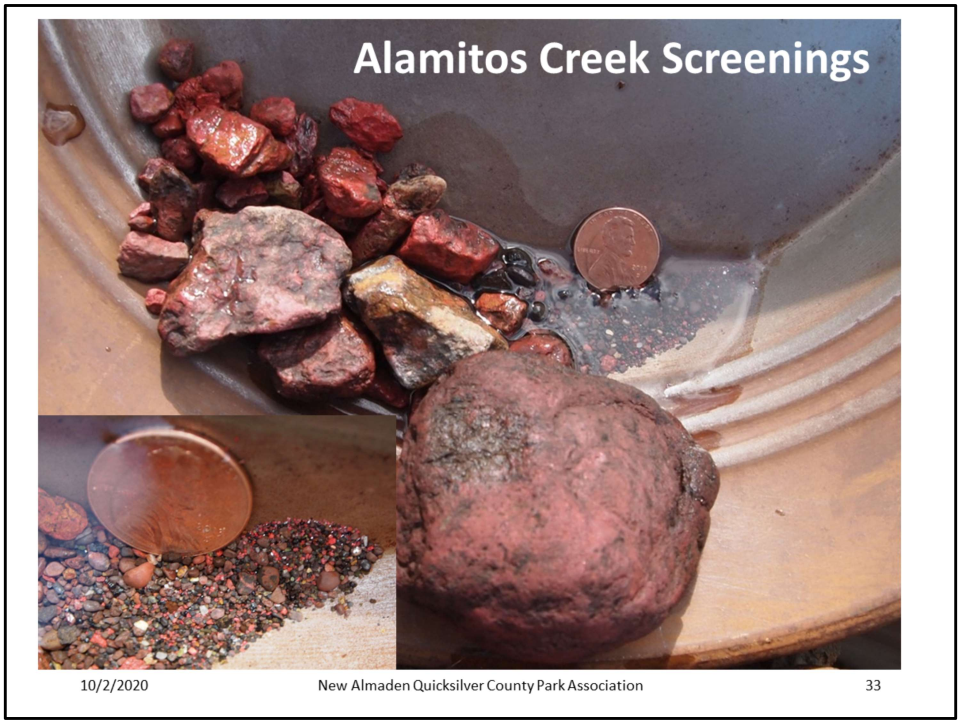
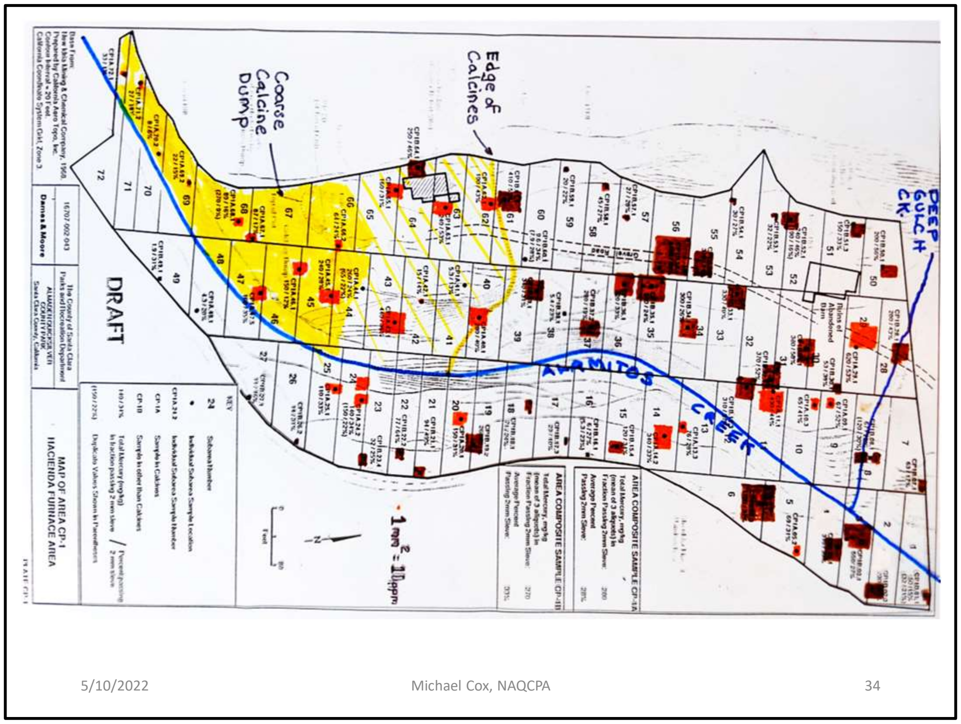
This is a fascinating chart modified from Conaway et al. Based on resource estimation from the U.S.G.S., it illuminates that the best ore, the highest yields from the least ore rock processed, came early in the mining history. Almost immediately in the mining history, more and more material had to be processed to get less and less yield, dramatically so after the invention of a new type of furnace in 1872. Understanding sediment mercury requires understanding the many contributing factors. Total mercury analyses of Bay mud cores reflect that there has been a background mercury concentration of around one hundred billionths of a gram of mercury for every gram of sediment. Put another way, the mud contains about 0.00001% mercury by weight before mercury pollution associated with human activities. The peak percentage associated with human pollution is about twelve times greater, and coincides with the global peak in mercury use in the 1960s. If the mine is the only significant source of mercury to the bay mud that was sampled, the peak in the 1960s and 1970s is questionable. Why are there not similar peaks for the other two major intervals of ore processing.? The next slide from the authors changes the picture.



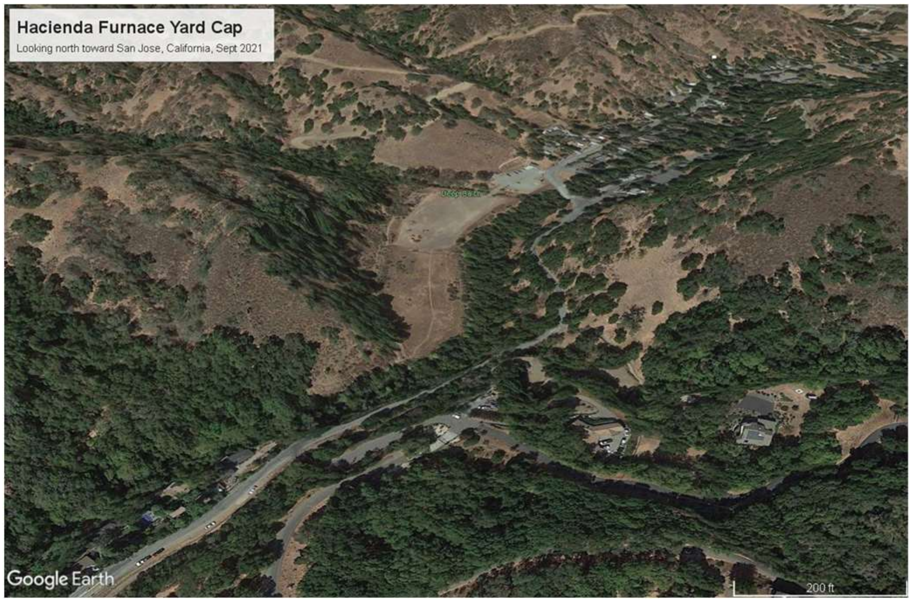
In this chart the author’s have more sample analysis on a single core of Bay mud to elucidate additional detail regarding the mining impact. The delay of the peak impact from the peak of mercury production at New Almaden is not well understood. The authors argue that a similar delay seen in the impact of gold mining mercury-process tailings to North Bay sediments indicates that a substantial lag is normal, and they recognize that episodic substantial storms and peak flows can dramatically increase trace mercury concentrations at the Bay. This author believes that a substantial lag is not normal. Additional work is needed to understand the combination of the principle factors of peak flow, land use, mercury use in households and manufacturing, hydrology, sedimentation versus erosion, and significant “mercury-releasing” events at the mercury mines. This presenter believes a “great mercury blowout” occurred at New Almaden, and to a lesser degree at the Guadalupe, and Senator mine furnace yards, when the furnacing facilities were demolished and the ruins mined for mercury that escaped from the furnacing, as well as for natural alluvial cinnabar. Evidence of the “great mercury blowout” persists.



In Alamitos Creek in New Almaden, the presenter is able to readily pan out elemental mercury and so called “half burned” ore. In fact, the presenter has panned elemental mercury easily to Lake Almaden, some 6 miles by road from the Hacienda. This material, in the shallow sediment of the creek bed, in combination with the findings of the Bay mud core analyses, suggest that reworking of the furnace yard may have had as great an impact or even more of an impact than dumping about one million tons of burnt mercury ore into Alamitos Creek from roughly 1854 through 1916. Proof will require far more sampling, but it is plausible that the sluicing of the furnace yard caused more damage to the Bay than the much slower discharge of burnt ore. This is old material, released long ago but still rolling along. It is heavy. It does not dissolve. So it does not move very far or disappear. Nonetheless, the trace amounts of mercury that do escape through water, air, and biota, are great enough to potential harm wildlife. This is why it is best to remove these legacy materials. The impact is not obvious, but the impact will continue until this material is removed from the system.



Additional evidence of the “great mercury blowout” can be seen in total mercury analysis results from the Hacienda furnace yard. The presenter worked on the Phase-III characterization of the property. The furnace yard was capped with two to three feet of clean clay soil in the 1990s, after the sampling work was completed from 1986-1991. This is a hand-drawn map of the sample results using squares to represent relative total mercury concentration in soil passing a 2 mm sieve and collected at the surface. The yellow area to the left is a pile of burnt ore, called calcines. The hatched area in the middle is a mixture of calcines and spoils from the excavation and washing of site soils under the former furnaces. To the right are spoils from the reworking of the site after 1916. The calcines have the lowest average mercury values and the soil tailings have the highest concentrations. The mixture of the two is mid-level in average concentration. Again, more work is needed to study this, but it appears that the discharge from mining the wrecked furnace yard was and remains a significant source of mercury to the Bay. The creek bed waste is needs to be taken out of the watershed..



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This is the capped furnace yard in an oblique aerial view looking north. Alamitos Creek has a revetment along its west side. Because of this, the creek migrated east and caused a small portion of Alamitos Road to collapse. This issue has since been corrected, but it is an important lesson. Revetments cause runoff to “shotgun” and the stream will bend at some point or points to dimmish the additional energy.

September 27, 2021

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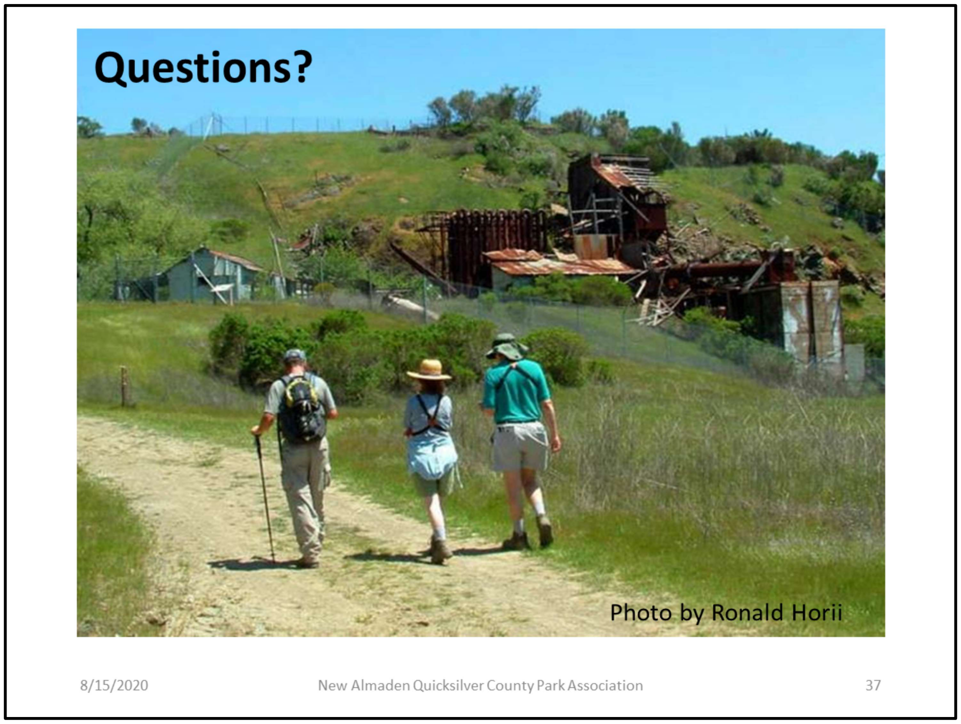
Capping was used to encapsulate all of the major piles of furnace mercury ore tailings (calcines) in the park. Some was excavated and encapsulated in the former San Francisco opencut (center background) because encapsulation in place was not feasible.



Today the 10,000 acres of mining lands formerly owned by the Quicksilver Mining Company of New York are both private and public. About 6,000 acres of the former mining lands are open space. Some of the former mining buildings, in ruin, are still there, as is the village of New Almaden. Shown here is the rotary furnace plant on Mine Hill This plant was the first large-scale mercury processing on Mine Hill, adjacent to the mine. It was built in 1940, operated until the end of 1945, rebuilt in 1956, and operated until the mines finally closed in late-1975. How we the people address the problems of our past for the benefit of people’s in the future will determine our history.