BONANZAS & BORRASCAS – A COMSTOCK MINING HISTORY
[N]
The Biggest Bonanza:
Assays Unlimited, Digging & Hoisting the Underground

Mining companies conducted frequent assays then for the same reasons that they do today – to determine the course of the vein and the quality of the ore.[1] With respect to the latter point it was important to the companies to know how much gold and silver that a seam or body of ore contained. On an almost daily basis a company had to decide how to proceed underground - where to dig, what to avoid and how to make the best use of labor and equipment. In the 1877 Annual Report of California Mining Company James Fair, as superintendent, informed stockholders that the Assay Department had been established as a part of the Consolidated Virginia Mining Company in 1875, and during 1877 alone 40,484 assays had been conducted on ores from both mines.[2] Company assay records were not concerned with the final assay, a determination made by the United State Mint prior to converting the gold and silver into coins or into bars to be stored.[3] Rather assay records functioned as periodic checks in the absence of detailed underground maps. Assays could also be misused - to hype a mining stock, for example, when a company entered the capital market to raise money for projects not justified by the balance sheets. Proper assays could not be done on the fly. They required the equivalent of laboratories with furnaces that cooked the samples at very high temperatures (today furnaces operate at 1,000 degree). Companies like Consolidated Virginia and California built and staffed their laboratories, some of which were actually constructed underground. Assay records, which are as numerous as any category of documents in the various mining archives, reveal that dozens of samples could be drawn from the extraction areas in a 24-hour period. A sample might be drawn from the face of one wall, and then a sample might be drawn from a car loaded with ore from several parts of the face of the wall, and finally a sample might drawn from dozens of cars with ores from throughout the mine. Each reading could be different, and in some cases the readings could be significantly different.

Scores of assay records survive in the archives of Consolidated Virginia and California Mining Companies. While they represented one of the most extensive set of archival records, they were uneven with respect to content and frequency. Even though Consolidated Virginia and California were separate incorporations, they apparently shared assay facilities. Normally assay-office expenses including wages and supplies appeared in Consolidated Virginia's accounts whereas the cost of assaying ore from California appeared in its own accounts.[4] Assay procedures had been in use for centuries, and while modifications and efficiencies had been introduced over time, the basic format

[1] My appreciation to Mario Desilets of the Nevada Bureau of Mines and Geology, University of Nevada, Reno, for answering my inquiry concerning the frequency of assays.
[2] Annual Report, 1877, California Mining Company, p. 20, NC99/1/5/6, Bx 2, Special Collections, Library, University of Nevada at Reno.
[3] See Hickson, *Mint Mark: "CC"*, 21-31, for discussion of procedures followed at the Carson City Mint from the time of the arrival of the ingots arrived to the minting of the coins.
[4] For how costs were allocated see the Annual Reports for each company in NC99/1/5/1-2 and 1/5/6-7, Bx 2, Special Collections, Library, University of Nevada at Reno.

was well known and understood. A quantity (perhaps no more than an ounce) of ore was weighed and then mixed with lead oxide, and reducing agents and perhaps other chemicals. This mixture was placed in a crucible that was placed in a furnace (up to 1,000 degrees centigrade). The reducing agent changed the lead oxide to lead in the form of thousands of droplets that attached themselves to the gold or silver minerals and sank to the bottom of the crucible. The crucible is removed from the furnace and its contents were poured into a mold and allowed to cool. The slag or residue was discarded, and the result was an alloy of precious minerals and lead. The next step was to place the "lead button" in a cupal that had the capacity to absorb metals like lead that oxidized in furnaces under temperatures of nearly 1,000 degrees centigrade. The result was something called a "dore bead" which contained all the gold and silver minerals and none of the lead. It was weighed and then was immersed in another chemical like nitric acid that dissolved the silver and left the gold. This was called the parting. The gold was weighed and the difference between the weigh of the gold and the dore bead was the weight of the silver. From this process the ratio of gold to silver was computed along with the separate value of the gold and silver according to a predetermined formula. How closely the assayers of Consolidated Virginia or other mining companies followed these procedures remains a matter of speculation in the absence of assay manuals or other such documents. Since assays was taken at all stages, from the interior of the mines through the milling process into the sluices and dumps, the results had high variability. Ore quality was the primary factor, but the wetness or dryness of the ore and the volume of residue contained in the ore could also factors. Ores in the mines tended to have higher assays than the same ore after it had been crushed and prepared for milling. The lowest assays came from the slimes and tailings. Companies like Consolidated Virginia or California where assays were conducted as normal operating procedures surely understood how to interpret the results. The high readings from inside the mine were perhaps misused from time to time in the public arena, but they served as signposts for the miners and managers in determining a course of action.

The two companies shared assay facilities but did not necessarily keep identical assay records. From the surviving assay documentation the records from California are more detailed than those from Consolidated Virginia. The major difference between the two sets of records is that California's assays were keyed to specific areas in the mine or stages in the milling process or other surface locations. Unfortunately the California assay entries were often written in abbreviated forms that cannot always be precisely identified or explained. For the week Monday 3 April through Sunday 9 April (1876), shortly after California made its official debut, scores of assays were taken on the floors or in the galleys of the mine, from cars loaded with ores on the floors and in the mills and at various stages of milling operations. It was common, especially with carloads, to take more than one sample. On the following table are the entries for 8 April, chosen primarily because of the variety of assays.

FIGURE 1
ASSAY SAMPLES, CALIFORNIA ORE, 8 APRIL 1876

No.	Description of Sample	Value Per Ton			Calculated	%
	1,500 Feet	Gold	Silver	Total	Total	Gold
35	Calif Mill 255 Cars 7th	$116.55	$188.55	$305.10	$305.10	38.20%
36	duplicate	$106.50	$160.90	$267.40	$267.40	39.83%
	Mine					
37	Sill Floor E	$281.35	$450.00	$736.35	$731.35	38.21%
38	Sill Floor NW No 1	$64.30	$133.20	$197.50	$197.50	32.56%
39	Sill Floor W No 1	$48.20	$88.00	$136.20	$136.20	35.39%
40	Sill Floor N No 1	$251.15	$671.20	$922.35	$922.35	27.23%
41	3rd Floor No 1	$112.55	$243.85	$356.40	$356.40	31.58%
42	2nd Floor W No 1	$84.40	$47.75	$132.15	$132.15	63.87%
43	2nd Floor N No 1	$36.15	$98.05	$134.20	$134.20	26.94%
44	2nd Floor NW No 1	$176.85	$346.90	$523.75	$523.75	33.77%
45	Car Sample No 1	$40.20	$88.00	$128.20	$128.20	31.36%
46	Car Sample No 2	$88.40	$108.10	$196.50	$196.50	44.99%
47	Sill Floor S No 5	$8.00	$17.60	$25.60	$25.60	31.25%
48	Sill Floor N No 5	$24.10	$47.75	$71.85	$71.85	33.54%
49	Car Sample No 5	$64.30	$153.35	$217.65	$217.65	29.54%
	Tailings					
50	Calif Mill Pulp 8th	$84.40	$113.10	$197.50	$197.50	42.73%
51	Calif Mill Sulphurates 8th	$8.00	$42.75	$50.75	$50.75	15.76%
52	Calif Mill Night NS 8th	$1.00	$7.50	$8.50	$8.50	11.76%
53	Calif Mill Night SS 8th	$1.35	$10.05	$11.40	$11.40	11.84%
54	Calif Mill Day NS 8th	$1.00	$8.80	$9.80	$9.80	10.20%
55	Calif Mill Day SS 8th	$0.50	$8.80	$9.30	$9.30	5.38%
	Totals	$1,599.25	$3,034.20	$4,638.45	$4,633.45	
	%	34.48%	65.41%	99.89%		

Abbreviations: 7th next to cars is batch number for cars tested; 8th next to California Mill entries is batch number for those types of assays; N, E, S, W & NW designate north, east, south, west & northwest, locations on floors where ore was extracted or piled at time of assays; No 1, No 2 & No 5 refer to tunnels where ore or car samples were taken; NS refers to north sluice and SS to south sluice at California Mill. Entry # 37 has an addition error. See footnote 6.

To begin with at least 20 assays were entered into the assay records beginning with 35 and ending with 55. If other assays were taken, they were not reported. California Mill was the only mill to receive ore from the California Mine during April 1876. At 1,500 feet the main or sill floor had three crosscuts, No 1, 2 and 5, with ore breasts, although the only reference to No 2 is that a carload of ore was designated as originating there. A second and a third floor had been cut below the sill floor in crosscut No 1, and by the end of the summer the number will have reached 10 floors. By far the highest assay was returned from the northern end of No 1 crosscut on the sill floor. A ton of ore from that area was said to be worth $922 with $671 worth of silver and $251 worth of gold. The lowest assays within the mine were noted in the No 5 crosscut south on the sill floor at a total value of $26 per ton. The average value of ores from a floor and not from a car was $324 pr ton. Although the total value of the assays from the second floor of

crosscut No 1 were lower than the previously cited figures, management had to be encouraged because the quantity of gold from a batch of ore in the western wing of crosscut No 1 came in at 64 percent of the total value. On average gold was equal to about a third of the total value. Not unexpectedly by the time the ore had been loaded into cars the values had dropped. The three carloads, one with ore from each crosscut, came in at an average of $181 per ton. At the same time that these tests were made below ground the ore in 255 carloads was assayed above ground. Duplicate assays were done, but the exact procedure was not explained nor described. The first assay yielded $305.10 per ton and the duplicate $267.40 per ton. Nearly 40 percent of the ore was said to be gold. Finally with respect to what was described as tailings, the assays except for pulp fell significantly. It is not clear why pulp was listed on tailings (given the customary meaning of tailings) since the pulp was a mixture of crushed ore and water, flowed into the reduction facilities where it was incorporated with quicksilver and other chemicals to separate the minerals from the ore. It is assumed that the pulp is a reference to the ore undergoing reduction rather than the ore escaping it. The pulp had assays of $197.50 per ton, 42 percent ($84.40) of gold and 58 percent ($113.10) silver. It should be recalled that the yield from California ore in the first month averaged $188 per ton, not far from the yield on the pulp from a single day. Sulphurets (also known as sulphates) were the slimes and tailings that were carried away in the sluices to nearby dumps and pools. The assays in these categories were among the lowest. A range of assays as the ore passed from the interior galleys to the waste dumps was not by any means unexpected.[5] As Grant Smith explained, “The ore as it left the mine was roughly sampled and weighed or estimated, which became the mine’s valuation, with 10 percent or more of moisture included, while the assays made at he mill were of battery samples, dried.” He further noted that the average recovery at Consolidated Virginia was 73.5 percent and at California 74 percent. These ratios were close to the Comstock average of a 30-percent difference between “wet” and “dry” assays”.[6] Indeed, company accounts, especially those kept by The Firm, showed the average monthly “wet” assay (100 percent) and the average monthly “dry” assay (70 percent), but if the 70-percent calculations were higher or lower than 70 percent (70%*wet assay) the difference was described as a surplus or a loss. Consolidated Virginia and California kept the best set of financial records that generally calculated the 100-percent and the 70-percent valuations as well the excesses or losses at each mill for each month. What mattered in the end was how much bullion could be produced from he ores. The ores extracted and processed were so rich that the conventional “wet” and “dry” assay ratios did not apply to Consolidated Virginia and California. In earlier bonanzas this was probably true as well = that the 70-percent benchmark was generally exceeded.

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[5] See Report of Assays, 3 April-10 April & 1-6 August 1876, California Mining Company, NC99/1/2/1, Bx 5, Special Collections, Library, University of Nevada at Reno. Any of the Bullion Records between 1876 and 1881, California Mining Company, can be consulted for examples of 100/70 percent figures. NC99/1/3/7, After Bx 1, Special Collections, Library, University of Nevada at Reno.

[6] Smith, *The Comstock Lode*, 255. Smith provided no source, but his ratios are close, although somewhat lower, compared to the ratios that I calculated from the monthly mill accounts. Seldom did losses show up, i. e., less than 70 percent, even in the declining years. I discussed the mill accounts in the previous section.

FIGURE 2
ASSAY SAMPLES, WEIGHTS AND VALUES, CONSOLIDATED VIRGINIA ORE, 1 APRIL 1877

Sample #	Weight (ozs)			Value ($)				Gold
	Gold	Silver	Total (calculated)	Gold ($40+/oz)	Silver ($2.50/oz)	Total	Total (calculated)	($/oz) (calculated)
1	0.100	3	3.100	$4.00	$7.55	$11.55	$11.55	$40.00
2	0.100	3	3.100	$4.00	$7.55	$11.55	$11.55	$40.00
3	0.150	8	8.150	$6.00	$20.10	$26.10	$26.10	$40.00
4	0.050	2	2.050	$2.00	$5.00	$7.00	$7.00	$40.00
5	0.075	4	4.075	$3.00	$10.05	$13.05	$13.05	$40.00
6	0.025	1	1.025	$1.00	$2.50	$3.50	$3.50	$40.00
7	0.750	17	17.750	$30.15	$42.65	$72.80	$72.80	$40.20
8	1.600	20	21.600	$64.30	$50.20	$114.50	$114.50	$40.19
9	0.025	1	1.025	$1.00	$2.50	$3.50	$3.50	$40.00
10	0.025	1	1.025	$1.00	$2.50	$3.50	$3.50	$40.00
11	0.025	1	1.025	$1.00	$2.50	$3.50	$3.50	$40.00
12	0.025	1	1.025	$1.00	$2.50	$3.50	$3.50	$40.00
13	0.050	2	2.050	$2.00	$5.00	$7.00	$7.00	$40.00
14	1.000	22	23.000	$40.20	$55.20	$95.40	$95.40	$40.20
15	1.950	64	65.950	$74.35	$160.65	$235.00	$235.00	$38.13
16	1.300	27	28.300	$52.25	$67.75	$120.00	$120.00	$40.19
17	1.625	31	32.625	$65.30	$77.80	$143.10	$143.10	$40.18
18	1.400	42	43.400	$56.25	$105.40	$161.65	$161.65	$40.18
19	1.200	14	15.200	$48.20	$35.15	$83.35	$83.35	$40.17
20	1.200	23	24.200	$48.20	$57.75	$105.95	$105.95	$40.17
21	4.400	113	117.400	$176.85	$283.65	$460.50	$460.50	$40.19
22	0.800	22	22.800	$32.15	$55.20	$87.35	$87.35	$40.19
23	0.500	25	25.500	$20.10	$62.75	$82.85	$82.85	$40.20
24	1.000	29	30.000	$40.20	$72.80	$113.00	$113.00	$40.20
Totals	19.375	476.000	495.375	$774.50	$1,194.70	$1,969.20	$1,969.20	
Averages				$32.27	$49.78	$82.05	$82.05	$40.02

See footnote 7.

Even though California's assay records gave more details about locations, Consolidated Virginia's assays offered more details about the contents of the ores. A short ton of ore, of course, weighed 2,000 pounds, but from that ton only a few ounces of gold and silver might be drawn. The more metal the richer the ton of ore. In many instances a ton of ore could be streaked with gold and silver and yield virtually nothing. The assay records of Consolidated Virginia included not just the value in dollars and cents of the gold and silver but also their weight in ounces per ton. On 1 April 1877 24 samples from unspecified locations were assayed. This was not a random choice by me but rather was dictated by the manageable size of the assay data. On most days scores of tests were made on ores from Consolidated Virginia, and on some days nearly a hundred tests would be made. The number of assays was directly related to the number of tons of ore delivered to and prepared at the mill(s). The first question to ask, therefore, is whether

the less voluminous ore yields in dollars and cents for this one day fit what has been computed as an average for the month. The April average per ton yield was $90 per ton, down from $94 per ton in March. The 1 April average was $82 per ton, somewhat below the two monthly averages but not sharply divergent from them. It would appear that the per-ton yield on 1 April generally reflected the state of the mine in the spring of 1877. The second observation is that these 24 tons of ore from which samples were drawn yielded nearly 20 ounces of gold (4 percent) and 476 ounces of silver (95 percent) for a total of 495 ounces. Since gold was 16 times more valuable than silver by the standard formula gold accounted for $32 (39 percent) of the $82 per-ton yield and silver for $50 (61 percent). The more gold, of course, the richer was the per-ton yield. Finally some tons had little or no value and some had extraordinarily high values. Samples 1-6 and 9-13 were hardly sufficient to make for a profitable operation. But the remaining tons from $73 per ton (#7) to $461 (#21) more fully explained the enormous richness of Consolidated Virginia's ores. On average among the 24 tons a ton yielded less than an ounce of gold but with batch number 7 it was almost 4.5 ounces of gold. The yield of silver was even greater. The average silver yield was 20 ounces, but this batch yielded 117.5 ounces. By any measure the richness of the ton from which sample number 7 was taken was noteworthy, being almost six times greater than the average. Recall that March 1877 was approximately four years after the company made its first official declaration. Although a bit long in the tooth as a productive mine Consolidated Virginia could still yield up extraordinarily rich ores.[7]

Whether other companies were as disciplined as The Firm in conducting assays or whether other companies could afford to be that disciplined cannot be determined on the basis of current archival records. Nor can it be shown how the companies used the assay data. Given the volume of assays conducted daily The Firm must have had extensive first-hand information about its underground operations. The weekly reports seldom contained specific assay references, although they often reverted to descriptive adjectives such as "good", "fine", "favorable" and even "excellent" to describe the ore seams. From an historical perspective, however, assay data are valuable because they demonstrate so clearly the variation in the mineral content. It is easy to assume from much that has been written that every batch or carload of ore was rich in gold and silver, and yet the assays revealed how unrealistic and mistaken such assumptions were. Experienced miners surely understood this phenomenon, and as the high assays within the range began to disappear and low assays began to predominate (as was the case for both Consolidated Virginia and California in 1877 and 1878), they had to adjust their strategies and their forecasts. One interesting observation from California's assay records is that during 1876 the assays from the floors between 1,600 and 1,700 feet never reached the values of the assays from the floors between 1,500 and 1,600 feet. To be sure, assays from the lower floors yielded values that were well above Comstock averages but more often below $100 per ton than

[7] Ore Assay, Assay Office of the Consolidated Virginia Mining Company, 1 April 1877, NC99/1/2/2, Bx 5, Special Collections, Library, University of Nevada at Reno. Twelve additional samples were taken. Ten of them were identified as located at Mariposa Mill (primarily for tailings) or at surface facilities such as slimes or wastes. Two of the samples were identified as paid for by John Mackay. Except for Mackay's samples at $127 and $143 per ton the per-ton values ranged between $3 and $50. Why Mackay was credited with two of the 12 samples was not explained.

above it. To cite one example, on 1 August 9 samples taken from the sill or main floors plus floors 8 through 10 of No 1 crosscut at 1,500 came in at $202 per ton and 14 samples taken from the sill floor plus 2 through 8 of No 5 crosscut at $69 per ton. The difference between the two crosscuts is indeed significant because both were higher than the assays of $39 per ton from the main crosscut at 1,600 feet and several of its floors. Of course the numbers could change as work progressed, and in some cases they did change[8]. Over time, however, they did not improve. As the mines expanded and the assays fell, the companies must have know sooner than they cared to acknowledge that the future of one of the richest ore body ever discovered in the United States was finite. For Consolidated Virginia and California as well as other companies ever-deepening probes at 2,000 feet, 3,000 feet or even 4,000 feet could not be sustained. Assays could not predict where the next bonanza might occur but they could document when one was finished. And for the historian they can also document the unpredictability that accompanied even the most triumphant of the mining bonanzas.

In its most basic form mining was an earth-moving business. By the time of the 1880 Census, which compiled information on the length of tunnels, drifts, crosscuts, shafts, inclines and winzes, the Comstock underground network was estimated to be nearly one million feet or 185 miles in length. Imagine a tunnel 10 feet by feet 1 million feet long. The volume of soil, rock, clay and ore that had to be removed to create this tunnel would be 100 million cubic feet.[9] But the underground network of approximately 1 million feet in length was far more complex than represented by the image of a single tunnel. The 1880 Census also reported on the average size of the network's components:[10]

Drifts 6' x 7'
Single Winzes 6' x 7'
Double Winzes 12' x 7'
Shafts 5.5' x 15'

Specific Shafts:
Foreman 8.5' x 28'
Combination 8.5' x 28'
Yellow Jacket 9.5' x 23'
Orbiston 8.5 x 23'
Old Shafts 8' x 20'

This list surely did not exhaust all the possibilities of how spaces were created underground, but it underscored the diversity of spatial arrangements within mining complexes. All the shafts listed in the 1880 Census totaled 56,000 feet in length and

[8] Report of Assays, 1 August-6 August 1876, California Mining Company, NC99/1/2/1, Bx 5, Special Collections, Library, University of Nevada at Reno.
[9] 1880 Census available On-Line at www.census.gov/prod/www/abs/decennial/1880.html, United States Census Bureau. *Statistics and Technology of the Precious Metals*, vol. 13, 124-125, Table XVI.
[10] 1880 Census available On-Line at www.census.gov/prod/www/abs/decennial/1880.html, United States Census Bureau. *Statistics and Technology of the Precious Metals*, vol. 13, 125.

averaged about 9 feet by 23 feet. The total cubic feet would be in excess of 12,000,000. The weight of so much debris would depend on the components – stone was heavier than dirt – but it too was measured in millions of pounds. Between 1860 and 1885 from 7 to 8 million tons of ore - about 300,000 per year – was crushed and processed in Comstock mills. The tons of debris removed to extract and lift the ore were surely several times greater than the ore itself.

The longest underground network belonged to Chollar Potosi (approximately 65,000 feet) and next two were Overman/Caledonia and Yellow Jacket in Gold Hill (between 58,000 and 59,000 feet). Overman and Caledonia mines had never ranked among the major producers, and Yellow Jacket had fallen from the ranking producers in the early 1870s. Consolidated Virginia and California (along with C&C Shaft) combined for about 66,000 feet, 13 miles or 7 percent of the total. While the ore had to be hoisted and some of the non-ore components were also hoisted, a large portion may have been stored underground in abandoned tunnels or stations or galleries. Weekly reports acknowledged the problem of debris piling up in passageways used to ventilate the interiors or to transport the ores. Some of the debris came from crumbling walls and collapsing ceilings of the tunnels themselves, but some of it was debris that had to be removed and stored in order to reach or pursue the ore veins. Even if stored underground the residue had to be transported to storage areas and would have to be transported again if the storage areas became impediments. In short, little direct evidence on how much debris was removed, where it was stored or how often it was relocated can be pulled from the companies' records. The references concerning debris removal were general in nature even though it must have occupied more time and effort than ore removal.

By the late nineteenth century mechanization played an increasingly larger role in underground mining, and that included earth-moving activities. In Spanish American mines the workers were the transporters, and some could perform near incredible feats of hauling in sacks strapped to their backs a hundred or more pounds of ore up rope ladders several hundred feet to the surface.[11] On the Comstock few workers if any hauled ores to the surface or around the interior on their backs. Rather machines and conveyances performed the tasks of moving and hoisting. In his 1873 Report the State Mineralogist offered a description of how ors were removed from the interior of the mine:

> The ore, as it is worked out or broken down by the miners in the stope, is thrown down to the track station below, either falling upon the floor of the drift or into a receiver or bin, whence it is loaded into the drift car and carried to the shaft. There the car, containing its load, either of ore or waste rock, is placed upon the cage or platform in the shaft and raised to the surface, where it is run from the cage on to another track, and so conveyed to the appropriate ore bin or waste dump, according to its character, and thus delivered of its load without any intermediate handling. The car in general use in the Comstock Mines is made of wood, and has a

[11] Peter Bakewell, "Mining in Colonial Spanish America," in Leslie Bethell, ed., *The Cambridge History of Latin America, The Colonial Period*, 2 vols. (Cambridge: Cambridge University Press, 1984), 130-131.

> capacity of one thousand six hundred or one thousand eight hundred pounds.[12]

Spared the arduous task of hauling the ore late-nineteenth-century workers still performed equally arduous tasks of digging out the ores and loading up the cars that were lifted to the surface or transferred within the mine. Scores of picks, sledges, shovels, handles and drills (hand rather than mechanical) appeared in property inventories appended to company annual financial statements.[13] Some of the drilling had been mechanized by the mid-1870s with the introduction of diamond bits and air compressors, but much of the work of constructing a tunnel or mining a stope or loading a car was accomplished with picks, sledges and shovels.

Consolidated Virginia kept daily hoist records that were specially described as conveyance of "pay ore". Even though rock and waste hoists were also included, pay ore was the main product in the hoist records. These records usually had two sets of figures: ore that was hoisted from the mine and ore that was delivered to the mill. Hoisted ore was also referred to as extracted ore. The terms were used interchangeably. The records showed in tons and pounds the volume hoisted from the level to the surface each day of the month. For the month of June 1874, for example, about 8,300 tons of ore were hoisted along with 750 tons of rock. A year later 16,068 tons of ore were hoisted but only 108 tons of rock. Considerably more ore was hoisted than rock or other components, and for some days no rock was hoisted at all or not recorded as being hoisted.[14] The origination of the rock was not noted. Was it associated with the ore being hoisted or was it from another operation within the mine? The rock hoists were almost incidental to the ore hoists. Any attempt to determine a ratio between ore and rock hoists from the few dual entries found in the hoist records would be of little value. Far more non-ore hoists would have to be recorded to account for all the debris that had to be removed to reach the ore bodies.

Consolidated Virginia was the mine of choice to visit because it was assumed (correctly) to be the most mechanized and best managed of the Comstock operations. Dan De Quille, the *Territorial Enterprise's* relentless and renowned scrivener, justified his choice to inspect Consolidated Virginia for precisely these reasons: "all the latest and most approved machinery and…all operations are conducted in systematic and scientific manner."[15] Although specific are missing, De Quille presumably visited the hoisting works at Consolidated Virginia's main shaft (not to be confused with the C & C Shaft and Hoisting Works under construction). That hoisting works was badly damaged if not destroyed in the fire of October 1875, and although a new hoisting works was ready

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[12] "Biennial Report of the State Mineralogist...1873 and 1874" in *Appendix to Journals of Senate and Assembly*, 7th Legislative Session, 1875, 125.

[13] See for example the Annual Report for the Year 1875 (issued 1876), Consolidated Virginia Mining Company, NC99/1/5/1 and Annual Report, 1876 (1877), California Mining Company, NC99/1/5/6, Special Collections, Library, University of Nevada at Reno. Listed under Inventory of Property in both cases.

[14] Ore Book, June 1874, Consolidated Virginia Mining Company, NC99/1/3/3, After Bx 1, Special Collections, Library, University of Nevada at Reno. Several accounts refer to the ore as "pay ore" since the term ore can have several meanings. Some ore could have streaks of gold and silver and yet be of such little value that it was discarded.

[15] De Quille, *The Big Bonanza*, 221.

within months it seems unlikely that De Quille was describing the new building since his book *The Big Bonanza* was published in 1876.[16] In any event the pre-fire hoisting works of Consolidated Virginia was reputed to be the best equipped and the most efficient, and from De Quille's description it was indeed a building to behold. The main building was of "great size" to which was attached "several large wings". In this complex of buildings were a boiler room (with its recognizable "tall, black smoke-stacks"), a blacksmith's shop, a carpenter's shop, a machine shop and of course the principal chamber with the hoists. "Almost the first object that attracts our attention upon entering the place [main room] is the mouth of the main shaft." The reason – "great volumes of steam" curling and hissing out of the mouth. Upon closer inspection one observes an opening of about 5 feet wide by 20 feet long, which was divided into 4 compartments: 3 cages for carrying workers and ores and a fourth known as the pump compartment. The machines that ran the cages ands the pumps were located around the room wit attendant engineers. For visitors, apparently, watching workers descend or ascend through the steam was a cause of '"palpitations of the heart'" – "Nothing can induce some persons to venture into the steaming shaft after they have taken one good look at it…."[17] The business at hand, of course, was to move workers back and forth from the surface of the mine and to hoist as much ore as was efficiently possible.

The focus of the hoist documents is on the ores. I have created a profile of ore-hoist data for each June from 1874 through 1879. To tally and analyze all the hoist figures would be an enormous undertaking (even with a computer), and while it might yield some interesting daily or monthly trends it probably would not add much more than can be observed from a more limited dataset. During six Junes from 1874 to 1879 approximately 58,000 tons of ore were hoisted. (Figures more or less agree with crushed ore totals at the mills.) A second set of figures – ore delivered or shipped to the mill – could differ from the hoisted figures by as little as a few tons or as much as several hundred tons. The June pattern of ore hoists followed the overall trend of ore production at Consolidated Virginia. June tonnage rose in 1875 over 1874, fell back in 1876, rose again in 1877 and declined sharply in 1878 and 1879. The June with the most tons hoisted – 16,000 or 28 percent- was 1875 and with the least tons – 3,500 or 6 percent - 1879. Consolidated Virginia had access to three different shafts – Consolidated (Virginia), C&C and Gould & Curry. The records indicated that a few hundred tons were lifted through Gould & Curry, but the rest was lifted through Consolidated and C&C. Although the records noted how much was lifted through Gould & Curry they did not distinguish between the two principal shafts. The Consolidated Virginia Shaft was a workhorse, no doubt, but being older and located in less stable ground it was in constant need of repair. Periodically it went out of service, and in May 1878 it was closed for the rest of that year to be retimbered. The C&C Shaft was deeper and faster but like Gould & Curry had long connecting drifts from the shaft to the stations. Stations for loading ores

[16] *The Big Bonanza* did contain a final chapter (73, pp. 426-436) on the "great fire" in which De Quille noted that the Consolidated Virginia hoisting works was destroyed but made no mention of the new hoisting works. Mackay and Fair began construction immediately, and new hoisting works was in operation by the Spring of 1876. De Quille's book was published in 1876, and it seems unlikely that there was enough time to tour a finished building and include that tour in the book. Whatever building he was describing it was still impressive.

[17] DeQuille, *The Big Bonanza*, 222-223.

into hoisting cages were located at every 100 feet between 1,200 and 1,500 feet and (beginning at 1,550) between 1,550 and 1,950. At 1,550 the mine was connected to a drift from Gould & Curry and to C&C. All the stations from 1,550 and lower had access to C&C. During the six Junes about 1 percent of the hoisted ore was loaded at stations 1,200 (feet) and 1,850 and only a tenth of a percent came from the station at 1,950 feet. Between 5 and 7 percent was loaded at 1,400 and 1,750 respectively. Two-thirds of the ores were loaded at station 1,500, 1,550 and 1,650. The station at 1,500 had had 26 percent followed by 1,650 with 23 percent and 1,550 with 19 percent. The ranking of the stations changed from year to year. In June 1874 ore was hoisted only from 1,300 and 1,400 in almost equal proportion, and a year later ore was lifted from 1,400, 1,500 and 1,550 with more than three-fifths from 1,500, one third from 1,400 and the remainder from 1,550. In 1876 while 1,400 and 1,500 contributed 16 and 22 percent respectively, the action had clearly shifted to 1,550 with 62 percent of the total. The station at 1,650 came into its own in 1877 with two-thirds of the hoists, but 1,550 continued strong with the remaining one third. Before 1877 most of the ore above 1,550 was probably hoisted through the main shaft of Consolidated Virginia because it was closer to the ore body. After 1877, however, as new drifts were opened between the ore body and the shaft, C&C was the preferred hoisting shaft. And of course in 1878 the main shaft was closed for most of the year. Gould & Curry was marginal at best because it was a long trip of about 1,500 feet from the mine to the shaft. In 1878 ore was hoisted from four stations. Extractions resumed at 1,200 with 7 percent and had reached 1,850 with 8 percent. Two other deep stations – 1,650 and 1,750 – accounted for 58 percent and 35 percent respectively, although total hoists had fallen to 8,200. In the final June (1879) total hoists came in at the lowest figure (3,800) since 1874 with 98 percent from 1,500 and the remaining 2 percent at 1,950. No new ore bodies were found at 2,000 and below, and the existing ore body, as enormous as it was, had reached its edge.[18]

During the six Junes profiled above nearly 58,000 tons of ore were hoisted from all stations between 1,200 and 1,950 feet. By a simple calculation the average daily hoist amounted to 320 tons (58,000 tons/180 days). Some daily hoists in the most active June, 1875, came in between 700 and 800 tons. Hoist figures from Eliot Lord by way of the *Territorial Enterprise* covered to three different dates: 461 tons on 19 March 1875 (which Lord called a "notable exhibit"), 908 tons on 16 March 1876 and (a whopping) 1,034 tons on 26 November 1877[19] Although the assignment of the specific shaft was somewhat vague, the first two figures appeared to be hoists through the main shaft of Consolidated Virginia. The final figure of 1,034 could not be related explicitly to any shaft. Of these three daily hoists the first figure, reported by DeQuille, was certainly the least controversial when compared to the aforementioned daily hoist records. The second and third figures were more than double the first and surpassed figures compiled from the hoist records. From the various June hoist records 1875 was the highest of the six: the

[18] Ore Books, June, 1874-79, Consolidated Virginia Mining Company, NC99/1/3/3, After Bx 1, Special Collections, Library, University of Nevada at Reno.

[19] Ore Book, June, 1875, Consolidated Virginia Mining Company, NC99/1/3/3, After Bx 1, Special Collections, Library, University of Nevada at Reno; Lord, *Comstock Mining and Miners*, 312 with citations from Dan DeQuille, *The Big Bonanza…*, 324, and two issues of *Territorial Enterprise*, 16 March 1876 and 28 November 1877.

company hoisted between 600 and 700 tons during seven days, between 500 and 600 toms over 16 days and under 500 tons for seven days. (Note: the company hoisted every day of the month.) No other June in the profile matched this hoisting schedule. One should pause to consider what was involved here with ore being hoisted (perhaps in combination with rock) from several different levels and perhaps in several different shafts. The average for June 1875 was 536 tons per day. How many trips would be required to lift that volume of ore over 24 hours in a single shaft? About 22 tons had to be lifted each hour average distance of about 1,500 feet. Since according to Consolidated Virginia's own records each car carried from 1,600 to 1,800 pounds, about 26 cars would have to be lifted every hour from the interior to the surface. If only a single car were lifted with each hoist, then 2.5 minutes would be allowed to place the car in the cage, hoist the cage to the surface, remove the car from the cage and drop the cage. That was hardly possible. The key was the number of cages, each with a single car, which could be lifted at once. A double or triple compartment shaft, each with its own cage or a deck of two or three cages in each compartment would compress time needed to load, lift and unload several dozen cars in one hour. (In the shafts with double- or triple-decker cages and more than one compartment, it was possible for one compartment to ascend while the other compartment was descending, and they could load and unload simultaneously.) In these multi-compartment shafts with multi-deck cages 700 to 800 cars and perhaps even 900 to 1,000 could be lifted in a days so long as equipment breakdowns and traffic snarls did not delay the operations. More than likely an average lift of 500 cars per day over an extended period would be considered highly efficient and successful, although both the anecdotal and archival record indicated that an average day could be trumped.

There is no question that C&C Shaft was a large, powerful and efficient system that could have shattered previous hoist records. Lord, ever fascinated by the application of technology to mining, compiled C&C Shaft data, some of which may have been drawn from the 1880 Census. The main hoisting engine in the newly constructed C&C Shaft was described as a "double cylinder, horizontal, direct-acting, with brake fly-wheels" 2,000 horsepower engine. The 1880 Census described it as a "double cylinder, 26-inch diameter by 6-foot stroke, direct acting" of 2,200 horsepower.[20] (In an 1881 report the C&C Shaft hoisting engine was said to have 2,680 horses while the Yellow Jacket engine was slightly larger at 2,941 horses.) It could whisk a three-decker, iron cage (4,000 pounds) with three cars (1,200 pounds each) loaded with 4,800 pounds (1,600 pounds each) of ore or waste for a total of 12,400 pounds with "perfect ease" while lowering a companion cage at the same time. (It also had a third compartment for auxiliary operations.) If the raising and lowering of the triple-decker cages could be accomplished in minutes, one could redo the calculations in the preceding paragraph: in a dual compartment shaft with triple-decker cages one would project 6 hoists with 18 cars per hour and a 9 and 10 minutes turn-around. That was certainly doable. One has to assume that not only did the machinery work efficiently and continuously under very tight

[20] 1880 Census On-Line at www.census.gov/prod/www/abs/decennial/1880.html, United States Census Bureau. *Statistics and Technology of the Precious Metals*, vol. 13, 130, Table 18. Both Lord and the 1880 Census specify triple-decker cage, although in an earlier description of the shaft operations Fair used the term double-decker cage. It is possible that a third deck was added or that somehow three cars could be loaded in an essentially double-decker cage.

scheduling, but (as Eliot himself suggested) the work force also performed with efficiency and diligence.[21] The average daily tonnage of 320 hoisted during the six Junes from 1874 through 1879 works out to a more manageable number of four hoists per hour (in a triple-decker cage).

It is inconceivable that deep underground mining necessary to exploit the riches of the Comstock could ever have achieved even modest success without the new technologies in the form of bigger motors, stronger materials and better mechanics. Moving workers, supplies and ores a third of a mile in a matter of minutes could not have happened without the technological benefits that grew out of the so-called industrial revolution. Under such heavy and constant use, however, the components of the systems were subject to considerable "worn and tear." At an operation as large as Consolidated Virginia hundreds of cars were needed to move ore (or waste) to the surface. Over the course of a year dozens if not scores of cars were damaged or destroyed. Cars were fabricated on site because the technology that was fairly straightforward and simple. Consolidated Virginia bought wheels and axles of certain specifications from iron and steel fabricators. The carriages were made from timbers purchased locally, the same timbers used to frame the interior of the mine. Apparently management paid close attention to how well suppliers handled their orders. In one order for 12 sets of wheels and axles Fair reminded the supplier, Prescott Scott & Company: "Please have them made correctly this time!" as an earlier batch did not meet specifications.[22] Perhaps more important to the hoisting operation was the cable that pulled the cage to the surface or dropped it to the interior. Not only did the cable have to be strong enough to handle five to six tons, but it also had to be laced properly to pass smoothly through the pulleys and coil on or uncoil from the drums easily. Wire cables or "wire ropes", as they were called, predominated in Nevada mining as well as in Story County mines. The flat variety was more common than the round or the combination of flat and round varieties. They came in various sizes and dimensions, all of which were duly recorded in the 1880 Census.[23] Cables could be purchased from domestic and foreign suppliers. In one purchase from Hazard Manufacturing, San Francisco, Fair acknowledged the arrival of the wire rope in good time and good condition. He complained, however, that the cost at 29 cents a pound plus the freight made the purchase more expensive than he had anticipated. He urged Hazard to find a more economical way to deliver such a heavy item in order to lower the total cost. Three months later Mackay complained in a letter to Hazard that the rope did not work properly because it was incorrectly laced. The wire, he wrote, was "much inferior to any I ever saw [with] cracks and breaks." He declared their product unsatisfactory. By the end of 1876 Fair was negotiating with an English company, Henry W. Hammond, to supply wire rope. He specified that it was to be 5 inches by ½ and

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[21] Ore Book, June, 1875, Consolidated Virginia Mining Company, NC99/1/3/3, After Bx 1, Special Collections, Library, University of Nevada at Reno; Lord, *Comstock Mining and Miners*, 347-348 plus footnote 1, p. 347. 1880 Census On-Line at www.census.gov/prod/www/abs/decennial/1880.html, United States Census Bureau. *Statistics and Technology of the Precious Metals*, vol. 13, 136.

[22] Copy of Letter from James Fair to Prescott Scott & Co, 11/13/75, Letterpress Book, Consolidated Virginia Mining Company, 1 September 1875-27 January 1876, NC99/2/5, Bx 6, Special Collections, Library, University of Nevada at Reno.

[23] 1880 Census On-Line at www.census.gov/prod/www/abs/decennial/1880.html, United States Census Bureau. *Statistics and Technology of the Precious Metals*, vol. 13, 135-137, Table 22.

2,200 feet long. He wrote that "The quality and manufacture is [sic] the most important item", and then he added that the company must find an economical way to ship the product from England to the western United States.[24] Fair did not disclose the price under consideration, and whether the purchase was ever consummated cannot be documented. Surely the freight alone would have made the cable per pound more costly than a domestic brand, although the higher cost might well have been offset by better performance and longer life. Despite frequent complaints about suppliers' high prices Mackay and Fair were known to be willing to sacrifice price for quality. In the case of wire rope a defective product imperiled the lives of the workers who rode the cages daily and jeopardized the efficiency of the operation.

While the above referred to cable 5 inches by ½, a common size for Comstock shafts, the cable in the dual-compartment, triple-decker-cage C&C Shaft used a heavier flat steel cable – 7 inches by 5/8th although the third or pump compartment had a standard 5 inches by ½ cable. Another Mackay and Fair property, Union Shaft, also used the 7 inch cable for its three-decker cage. The largest cable belonged to the "new" Yellow Jacket Shaft. It was 8 by 5/8th and lifted a double-decker cage, each of which carried two cars side by side for a total of about 16,000 pounds. While the hoisting system required an expensive plant, in particular a reinforced foundation to hold the engine, pulleys, gears and the hoisting frame, the size and the strength of the cable became a metaphor for applications that could speed up the operations. In the case of the Comstock steel cables had replace hemp ropes found in the earliest shafts, and the size of the cable quadrupled in a decade. Hoisting hundreds of tons of ore or rock as well as hundreds of workers could not have taken place without stronger cages, bigger engines and of course larger cables. The average life of a standard cable was said to be about two years. In the C&C Shaft, according to the census agents, it had a lifetime of 18 months. Was the shorter lifetime of the hoisting cable at C&C a direct result of the heavy daily hoisting schedule discussed above? The tears and splits in the cable wire often occurred in the "sheaves" or pulleys built at each station so the cage could be securely latched for loading and unloading. In C&C the sheaves were reported to be 45 feet high and 11 feet in diameter. Cables could be mended, but the task required the replacing of large sections – 75 to 100 feet – of the cable. If Mackay and Fair were paying about 30 cent per foot for the five-inch cable, and, say, twice that for a seven inch cable then replacement could run between $50,000 and $100,000 for cable from 2,000 to 3,000 feet in length. Given the output of their mines the outlay for new cable was probably not viewed as a major expense. It may have been a different story at Yellow Jacket's new shaft because the attempt to recover that mine never achieved profitability.[25]

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[24] Copy of Letter from James Fair to Hazard Manufacturing Co., 12/03/75 and from John Mackay to Hazard Manufacturing Company, 03/26/76, Letterpress Book, Consolidated Virginia Mining Company, 1 September 1875-27 January 1876, NC99/2/5, Bx 6, Special Collections, Library, University of Nevada at Reno; Copy of Letter from James Fair to Henry W. Hammond, 12/23/76, Letterpress Book, Consolidated Virginia Mining Company, 1 November1876-31 August 1878, NC99/2/8, Bx 6, Special Collections, Library, University of Nevada at Reno.

[25] The 1880 Census contained information on hoisting cables for all the major mines and shafts on the Comstock. 1880 Census On-Line at www.census.gov/prod/www/abs/decennial/1880.html, United States Census Bureau. *Statistics and Technology of the Precious Metals*, vol. 13, 136-138.

Links: