# The Ingenious Community: Georgetown, Colorado, and the Evolution of Western American Silver Milling and Metallurgy, 1864-1896

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In 1870, U.S. Mining Commissioner Rossiter W. Raymond boasted that two recent innovations "justify [for] us in America the most valuable contributions that have been made to the metallurgy of silver in the last five years." Usually a conservative chronicler of statistics, the mining commissioner may have exaggerated, but the latter half of the nineteenth century was truly a period of technological innovation in the mining West. The American West was a place, Clark Spence wrote, "where ideas were exchanged, tested against the rugged western environment, sometimes discarded, sometimes adapted or even re-exported in modified form."[1]

The small community of Georgetown, Colorado, was the site of one of Raymond's "contributions" to metallurgy and a site of adaptation. A group of assayers and metallurgists— from Mexico, Germany, Britain, Canada, African-Americans and Anglo-Americans from the U.S. Midwest, and some of the first American college-educated mining engineers—tested and reshaped metallurgical processes to work the district's rich but refractory silver ores.

Located at eighty-five hundred feet in the Rocky Mountains, Georgetown's complex geology, harsh winters, and isolation required innovations to meet regional differences from Old-World mining practice. To provide an environment for innovation, the community required skill, machinery, and capital, as well as that hard-to-define factor that enabled the acceptance of change over tradition. The ingenious community of Georgetown provides a case study for technological innovation.

## Traditional Beginnings

During the 1859 rush to "Pikes Peak," Georgetown arose on the banks of south Clear Creek fork, and was named for Kentuckian George F. Griffith, discoverer of the district. The gold diggings flourished for a season then waned once the easily won placer dust was gone. A chance discovery of high-grade silver ore above the nearly abandoned camp brought a revival. Such news, in the words of a Denver newspaperman, "caused every prospector to wrack his brain to remember where he saw silver out in the hills before." In 1864, several different parties of '59ers staked the most visible mineral outcrops, near timberline at ten thousand feet, and laid out the camps of Peru, Chihuahua, Montezuma, and Argentite—names reflecting their dreams of treasure. The following spring miners found rich ore nearer Georgetown.[2]

The first miners working in the shallow shafts and adits high above Georgetown uncovered high-grade silver ore containing a low percentage of lead. By fall 1865, small ore hearths—a fire-place-sized furnace known to Medieval England—were smelting the galena and argentite, proving that, at least on a limited scale, lead smelting was appropriate for the district. Downhill from the mines and possessing water-power, Georgetown became the location for smelting operations; in the words of one reporter, "the city of smokestacks and sulfur fumes."[3]

Many of the miners who had rushed to the Rocky Mountains came from the Midwest, and it was from that region's lead mining and smelt-


*A bird's-eye view of Georgetown in 1874, with J. Oscar Stewart's mill at lower left and the Pelican Mill (the earlier German mill) at center. (Author's collection.)*

ing industry, established from the 1820s through the 1850s, that Coloradans imported skill and machinery. Scotch hearth furnaces were common in the lead districts of the Mississippi River Valley, where that imported British technology helped the tri-state district of Iowa-Illinois-Wisconsin and the lead regions of Missouri to become productive factors in national mineral markets. Georgetown's first larger plant, a Scotch hearth, arrived from Galena, Illinois—bellows, bricks, and hardware—in the summer of 1866.[4]

Caleb Stowell, an operator at the nearby gold district of Central City, invested in the Georgetown mines and erected this water-wheel-powered smelter along South Clear Creek. In a now-legendary tale, Stowell hired "Professor" Fred Dibbens, who failed to smelt the ore. Lorenzo Bowman, an ex-slave from the lead mines of Missouri, stepped forward asking for an opportunity to try. With twenty years of experience, Bowman was the best metallurgist in the district. He mixed the right amount of flux and ore, blew in the green-flamed high level of heat, and smelted the silver-lead.[5]

During 1866 and 1867, Georgetown witnessed a smelter building craze. Most of these plants would have been familiar to smeltermen in England's Pennine Mountains a century before. Miners formed partnerships or sold their marginally developed prospects to joint stock companies. Lorenzo Bowman—part owner of what would become the rich Equator lode—helped organize the Red, White, & Blue Mining Company, a company organized by the African-American community of Denver and with a range of investors including Frederick Douglas, the famed former fugitive slave. Bowman built a Scotch-hearth smelter a mile and a half above town, which began working Equator ores in 1867.[6]

Miners from Mexico also arrived to work claims. They built a mud and stone cupola fur-

nace to work the galena. The *Rocky Mountain News* reported that, "The furnace is built by Mexicans, under the supervision of one of their number who has had many years experience in the mines of his country." The Mexican community in Georgetown provided early comment on the richness of the district, always getting a hearing when comparing lodes to those of Mexico. A Mexican family had the first child born in the camp and Mexican residents added to the larger community's cosmopolitan feel during the 1860s. Like their U.S. Midwestern, Anglo-American and African-American counterparts, they introduced the traditional practices, though limited in scale, which dominated the first metallurgical works.[7]

However, they all failed because of a diminishing of the rich galena ores, the lack of quality fuel (beyond charcoal), and the lack of the right environment for Mexican-style plants and the Scotch hearth. The Mexicans, Bowman, and the other early smelter operators shut down as the district's miners dug through the galena surface ores. Similarly, an attempt to use German smelting technology failed, as did an early effort by British miners to use a reverberatory furnace. The grandest early plant—the Georgetown Silver Smelting Company, with its 130-foot smokestack on chimney hill in the heart of the camp—blew in the fires of its "immense" reverberatories with much fanfare and praise in 1867. But within a few months it too fell silent. Its stack, with the letters "OK" in brick, stood as the largest monument to the camp's short-lived smelting boom.[8]

Unfortunately, these first efforts—imitations or replications of smelters tried-and-true in England, Germany, Mexico, or the U. S. Midwest—failed because of geology. What Georgetown's operators found was that the galena ores diminished with depth. Geologist Josiah Spurr of the U.S. Geological Survey, writing a half-century later, described the region's difficult ores. Geologically, the surrounding ridges of granite were faulted and filled with once-heated fluids which carried mineral. The fissure deposits were of silver with traces of gold. Glaciation and leaching of these deposits had created rich outcrops. A few hundred feet below, these were replaced by more refractory sulfide ores in combinations with arsenic and zinc. Under shallow deposits of native silver and rich silver-lead galena the ores turned to predominately argentite, polybasite, and tetrahedrite—complex and difficult to work.[9]

Yet the ore was high grade, tempting the smelters to continue to try to make their plants successful. But traditional methods failed them. What was needed was another process or method to win the metals from their ores. A French mining engineer visiting the Georgetown and other districts in the fall of 1867 observed the failed smelting attempts and wrote: "He who finds the means of reducing, *by practical methods*, not those of the laboratory, the ores of Colorado . . . he will have made his fortune. Overnight he would be rich in millions." He added, "To the task, metallurgists! Which of you will become the great man whom the world awaits."[10]

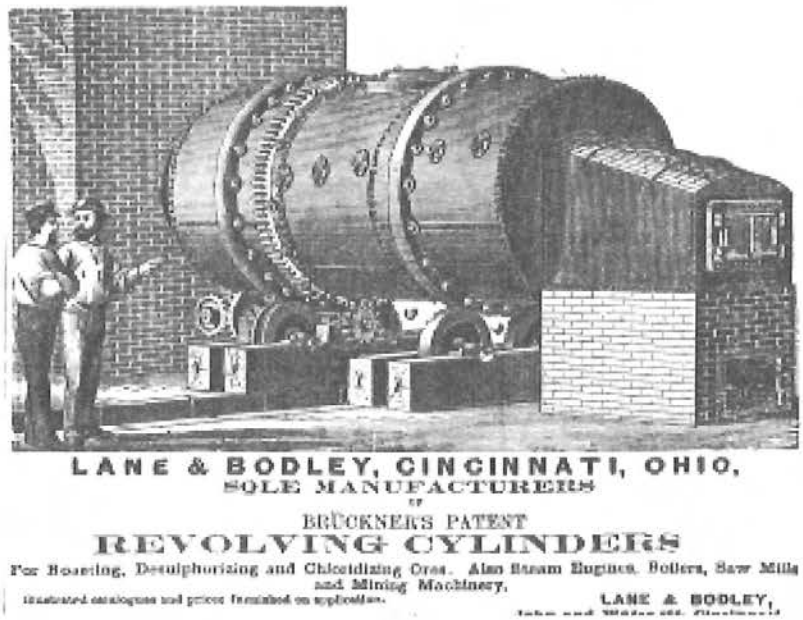
### William Bruckner's Cylinder Furnace

In March 1867, the Central City, Colorado, newspaper editor noted that a "party of scientific Germans" had recently installed new equipment in the old Excelsior mill in nearby Black Hawk. The equipment included a drum-like cylinder roaster, the Bruckner furnace, which promised to roast ores and remove sulfur—a major cost—more cheaply and quickly. Within a month, the editor reported the success of the partners Krause, Reese, and Bruckner in reducing the complex ores of the Central City district at a lower cost and higher return. He added: "We have been very chary of pronouncing any new process or mode of working ores a success, but we see no reason why we should not do so on this occasion." The editor also noted the number of times the Germans tested or assayed

ore as it moved through the process, undoubtedly an uncommon practice for the day and an obvious reference to a more scientific control of the metallurgical works.[11]

William Bruckner—originally Wilhelm H. Bruekner—was born in Saxony, trained in chemistry at Goettingen, and then in mine engineering at Freiberg. He had brought his new invention from California the previous fall. The drum-like, brick-lined, iron furnace revolved, slowly mixing the ore and burning off the sulfur. A fire-box was attached to one end and a flue and chimney to the other. Ores of Central City, once rich in free gold, had become difficult to work because of increased sulfur content with depth. This sulfide caused a loss of gold values in the standard mill of the day. The district was in the doldrums; it needed a roasting furnace that could economically burn off the sulfur. But the standard reverberatory furnace was costly to build in brick, expensive to operate with skilled crews who had to constantly mixed the ore manually, and exacted high costs in fuel. Bruckner had trained in the mills of Freiberg, which used reverberatory furnaces, but eight years' apprenticeship in Peru and Bolivia gave him time to develop a mechanical roaster that cut fuel and labor costs. In 1864, the twenty-eight-year-old Bruckner came to the United States to patent and market his cylinder furnace. After sales in Mexico and Nevada, the owner of the Excelsior mill invited him to Colorado.[12]

In May 1867, Georgetown miners sent a pack-train load of ore for trial in the one-ton capacity Excelsior mill at Black Hawk. The Bruckner furnace worked the complex ores and the crude mill recovered 85 percent of the silver, a profound success. The first plant to profitably work Georgetown's complex silver ores was described by a local editor. The Excelsior worked 150 pounds per operation, eight batches per day. The mill's Dodge crusher and ball mill reduced the ore to sand-sized, then passed it to Bruckner's furnace, of five hundred tons per day capacity. The first-generation Bruckner furnace was five and one-half feet long, and roasted the ore for from five to eight hours. This process burned off the sulfur and, toward the end of the period, common salts were mixed in to convert the silver sulfide into silver chloride. The ore was shoveled onto a cooling floor and then, for three hours, mixed with quicksilver (mercury) in a wooden tub to amalgamate, or capture, the silver.




*A Bruckner Furnace advertisement from the* Engineering and Mining Journal, *16 January 1875*

The amalgam of silver and mercury was separated in the standard way, leaving a silver ingot to be shipped to the mint. The editor observed: "This process contains the advantages of the arrastra and the heap process so much in use in Peru and other South American countries." The editor added that the operators adjusted the amounts of salt or mercury or other additives during the process to meet the varied conditions of the ore batches. Bruckner and his partners closely managed the process to ensure its success.[13]

During the summer of 1867, Bruckner designed a second test mill, this one built in the Georgetown district. Charles A. Martine led the new operation. Another European-trained mining engineer, Martine had taught assaying and chemistry at Columbia University, served in the Civil War, and opened an assay office and consulting business in Central City with his former student George Maynard in 1866. Martine, with the backing of several leaders of the town's German community, organized Garrott, Martine & Co. to buy a defunct gold mill, the What Cheer Mill, at Georgetown. This idle plant included a ball mill to crush the ore and had what were known as Freiberg barrels—wooden kegs rolling in place, used to amalgamate silver with mercury—both familiar German technologies. Martine installed one of the new, larger Bruckner furnaces. The Georgetown newspaper interviewed the Bavarian, who claimed that the process was the same as that used in Austria and Germany for the previous century, except for the addition of the Bruckner furnace. The first run of Nuckolls mine ore recovered 90 percent of the silver in the ore, producing a bar worth $459.65 at .944 fine. When operating, the small, three-ton plant produced twenty-five thousand dollars worth of silver per week.[14]

The process Bruckner introduced was a mechanical improvement on the age-old Freiberg barrel process developed in Freiberg, Saxony, Germany. At the mid-nineteenth century, Freiberg was one of the world's centers for silver production. More importantly, it was home to the world's foremost mining college, the Konigliche Sachsische Bergakamie, just up the valley of the Mulde from Dresden in the Royal Duchy of Saxony. Its graduates heard the call for their expertise from around the world and many came to the United States, especially after the major silver strikes in Nevada and Colorado. They introduced the Freiberg process in the United States, but it failed miserably at the Comstock Lode, Nevada; that district's ores did not require the high-cost preliminary roasting. Bruckner earlier had sold one of his furnaces to the Central mill, one of Virginia City's big mills, but it failed to compete economically for the Comstock's ores. Georgetown's ores, however, required preliminary roasting to remove sulfur. In a not-yet-understood chemical reaction, the revolving cylinder also lessened the miring impact of zinc, a major factor in treating the complex Georgetown ores. Bruckner's process also required less skilled labor, cutting costs. By summer's end, the *Rocky Mountain News* proclaimed the Bruckner furnace "the best invention yet introduced and put in operation in the territory."[15]

## Huepeden, Wolters, & Co. (The German Reduction Works)

In 1868, James D. Hague—compiler of a government report on mines and mining along the fortieth parallel—visited the German Reduction Works. This was the new name of Garrott, Martine & Co.'s plant, after it had been acquired and enlarged by former Central City assayers Luis Huepeden and Albert Wolters, both German-trained. Hague's description of the mill in his government report included a drawing of its Bruckner furnace and noted this successful innovation. Hague tabulated production as nearly $100,000 in less than two years of operation, even with such a limited capacity. The ore came

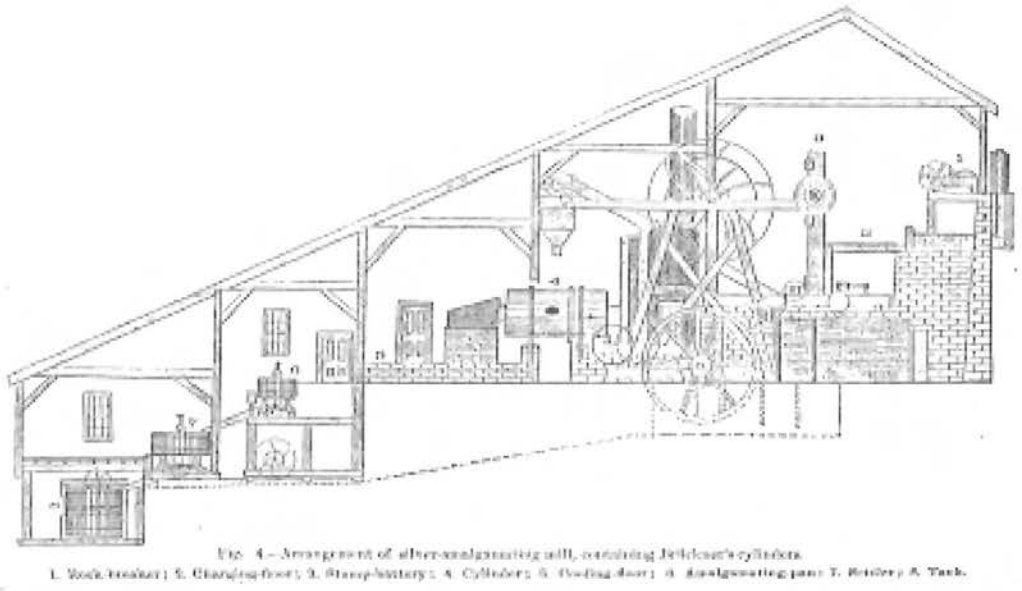
primarily from the Equator, a rich find on Leavenworth Mountain which averaged nearly $150 worth of silver per ton of ore. The German Reduction Works had a Dodge jaw crusher and a ball pulverizer, two second-generation, one-ton capacity Bruckner furnaces for roasting and chloridizing the ore, and Freiberg amalgamation barrels. Huepeden, Wolters, & Co. charged a fee of $60 per ton to work miners' ores, but guaranteed a return to them of 80 percent of assay values on ore processed. During Georgetown's initial bust of 1867 to 1870, when costly smelter after smelter failed, the three-ton capacity German Reduction Works kept producing and maintaining optimism for the prospects of the district's high-grade mines.[16]

Bruckner himself moved to Georgetown and joined its growing German community. Period items in the region's newspapers note German foods and beer, and events related to the Fatherland: the celebration of the one-hundredth birthday of the great German scientist Baron Ludwig von Humboldt and the doings of the German Aid Society, an association formed to raise money during the Franco-Prussian War. Rossiter Raymond, himself a Freiberg-trained engineer and lover of things Saxon, stayed with Luis Huepeden and wrote to his wife that, because of the Germans, "Georgetown, both this year and last, is one of my most delightful stopping places." He added that Huepeden "is a nobleman by birth and refined gentleman. He sits nearby with work clothes and rough hands playing a splendid piano from Dresden." Many writers commented on the German-Alps-like landscape of the Georgetown region. World traveler Bayard Taylor wrote in 1867 that the upper reaches of Clear Creek reminded him "(dimly I must confess) of the Upper Valley of the Rhine, between Splugen and the Via Mela."[17]

What effect this German communal environment had on Bruckner and other innovators is unknown, but, in this atmosphere, he continued to improve his furnace and to experiment. With Frederick L. Schirmer of Wurtenberg, later director of the Denver mint, he operated a simple brick kettle furnace using the *Cazo* process from Peru on the ores of the district. They planned to build an expansive plant on the former Georgetown Silver Smelting Company site. But they stopped work after a year because of the high cost of leasing the building and a failure to find backers, a problem the German faced continually. From his base at Georgetown, Bruckner also began to sell his furnace to outlying districts. He designed one for the adjacent Argentine district, and, in 1868, helped design probably the best German-style amalgamation mill in America—using the Freiberg process and machinery, plus his furnace—for the Baker Silver Mining Company at nearby Bakerville camp.[18]

To the dismay of Bruckner and its owners, the Baker mill burnt down before it could be given a thorough test. This was the last mill built to his German design. Americans had become accustomed to the California stamp mill, developed in the 1850s, with its battery of vertical stems with a heavy metal stamp at each foot for crushing ore. Bruckner's ball mill never took hold in America, nor did the Freiberg barrel for amalgamation. In the early 1860s, the rapid acceptance of what became known as the Washoe process—perfected in Nevada's Washoe District, the Comstock Lode—with its pans and settlers attached to the California stamp mill, replaced the Freiberg barrels for amalgamation. The Nevada or Washoe amalgamation pan has been described as "nothing more than an updated arrastra" attached to a steam engine, which supplied power and steam heat. The chemistry of the Washoe process—adding salt and bluestone (copper sulfate)—was the same as for the Mexican patio process, similar to the *Cazo* process, and to that which was in place in Freiberg's mills of the 1850s.[19]

Where sulfur needed to be removed from the ore and a chloridize roasting performed, one of Bruckner's furnaces could be inserted into a



*An 1870s silver mill with a Bruckner furnace. (From "Bruckner's Cylinders" in Rossiter W. Raymond's* Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains *v. 6 (Washington, D. C.: USGPO, 1874) 496-8.)*

Washoe mill. The earliest, detailed description of such a mill is that of a silver mill in Silver City, New Mexico, a new district where a former Georgetown assayer served as manager and Bruckner served as consultant. Luis Huepeden marketed the Bruckner-Washoe mill at a cost of thirty thousand dollars for a twenty-ton mill. He eventually moved to Salt Lake City and sold similar plants throughout the Great Basin and Montana as well.[20]

An 1880s standard mining reference book described Georgetown's German Reduction Works, but only as a relic of its German design, including a ball pulverizer—Bruckner's *Kugelmuhle*—and Freiberg barrel amalgamation. The author of the reference wrote that the work of the Freiberg barrel "must generally be first learned by the engineer in charge and taught to the men. Since a majority of mill men had experience with or had learned on a Washoe mill, the pan was understood and used rather than the barrel." While the Bruckner furnace was used throughout the West, his mill design failed to receive general acceptance. Bruckner's *Kugelmuhle* design sold well in Germany, however, where he returned for several years.[21]

### J. Oscar Stewart's Mill

In 1867, while Bruckner and the Germans succeeded with their first test mill, twenty-nine-year-old J. Oscar Stewart gave up his failed smelting attempt in the Georgetown district. Besides, one of his partners had been nearly lynched and had fled after being caught robbing sluice boxes. Undaunted, Stewart returned to St. Louis and Cincinnati for backing (he raised $350), in order to try again. In St. Louis, Augustus Steitz, a respected German mining engineer who had earlier mentored Stewart, advised that he build an amalgamation mill with reverbratory furnace—basically a Freiberg process operation. That fall, he pulled together parts from the abundant idle mills of Georgetown—stamps and amalgamation pans—and built a small reverberatory furnace. Stewart, a mechanic with enough metallurgical

knowledge to run the mill, surprisingly made a success with the two-ton test plant. His career was about to turn around.[22]

In 1869, he organized the Stewart Silver Milling Company, with stock sold to Midwestern investors, to replace his small plant with the largest silver amalgamation mill in the Rocky Mountains. Since Midwest foundries of that time lacked the ability to build machinery to his design, Stewart turned to San Francisco manufacturers' equipment, easily transported over the just-completed transcontinental railroad, and built what reporters called Colorado's first "Nevada" style mill. But Stewart re-machined the Washoe pans and settlers, and claimed them as his own patent.[23]

He also replaced the reverberatories with a shaft furnace, leading to a patent infringement suit from Carl Stetefeldt. Stewart countered, correctly, that, around 1860, mining engineer Moritz Gerstenhofer had invented the shaft furnace in Germany. The basic method involved roasting and converting sulphide into oxide ore while dropping it down through heat. Albert Wolters, Freiberg graduate and later a partner in Heupeden, Wolters & Co. at the German Reduction Works, had brought the Gerstenhofer shaft furnace to Colorado and built one at the Lyon's works at Black Hawk in 1866. The Lyon's works were well known to Coloradans like Stewart. John P. Arey of the plant joined Stewart and introduced an improved Gerstenhofer furnace called the Arey shaft furnace at the Stewart mill.[24]

At the same time, in Austin, Nevada, Stetefeldt improved the Gerstenhofer furnace design by removing the terraces, or shelves, and making it a straight shaft furnace. Ore and salt dropped at the top fell through rising flame and heat, which converted the ore into workable silver chloride. When the Manhattan Mining Company—the largest operator in the Reese River District, Austin, Nevada—added the Stetefeldt furnace to its mill in 1869–70, it cut roasting costs in half. The Stetefeldt furnace was declared a success. To Stetefeldt, the Arey furnace seemed an obvious infringement on his patented design.[25]

Stetefeldt, like Bruckner, was German, but had graduated from the School of Mines at Clausthal in the Hartz Mountains. In 1866, he came to the United States as an employee of Rossiter Raymond, who sent him to operate a branch office in Austin, Nevada, center for the Reese River mines. The miners there had built Washoe pan amalgamation mills but found them capturing only a small percentage of the metal. Reese River ores were similar to the complex silver sulfides of Georgetown. Freiberg graduate John Veatch introduced the German roasting process into the district at his Oregon mill. He built reverberatory furnaces in the Washoe pan mill, as Stewart had done. But Stetefeldt increased and improved silver recovery by replacing reverberatories with his shaft furnace.[26]


*A receipt from the Stewart mill.*
*(Courtesy of the Jesse Randall Collection, Denver Public Library.)*

Rossiter Raymond, Stetefeldt's friend and mentor, used the editorial pages of the *Engineering and Mining Journal* to tout Stetefeldt's furnace. Raymond may also have been instrumental in bringing the Arey Furnace Company and Stetefeldt to a patent dispute settlement by 1872. Unfortunately, because of its limited ability to process the complex Georgetown silver sulphides, Stewart abandoned the shaft furnace. The Arey furnace would be used elsewhere in Colorado and Arizona, but the Stetefeldt furnace dominated the mining camps to the West, as much a result of the successful foundries' and machinery firms' market dominance as of the Stetefeldt furnace's qualities.[27]

We lack any comment by Bruckner on the failure of the shaft furnace in Georgetown, though one would expect unexpressed glee. Stetefeldt blamed the failure on Stewart's workmen, while Stewart simply replaced the shaft furnace with old-style reverberatories; for some reason he would not introduce the Bruckner furnace into his mill, though everyone around him used the cylinder. The Reese River district lacked the zinc blend that complicated the ore matrix of Georgetown's mines. These ores, unfortunately for Stetefeldt, required slower roasting and chloridizing than occurred in the quick drop down the Stetefeldt shaft furnace.

Bruckner and Stetefeldt used national mining magazines and meetings as forums to continue the debate on which furnace was best. The dean of U. S. mining engineers, Rossiter Raymond, called the contest a draw—the Bruckner revolving cylinder being ideal for smaller mills, with the Stetefeldt furnace being better for large plants. But for Georgetown, with its high zinc content, the Stetefeldt furnace failed to meet expectations and was abandoned. Later analysts wrote that Stetefeldt's furnace could only work less complex sulfide ores, a function for which the Bruckner furnace excelled.[28]

Bruckner's furnace patent faced similar infringements from imitations, most notably the Howell-White furnace. John White had developed his unsuccessful imitation of the cylinder furnace shortly after Bruckner won prizes for his at the San Francisco mechanics' fair. John Howell, a neighbor of Stetefeldt's and a successful mill man in the Reese River district of Nevada, improved the White furnace around 1870, elongating it and putting fires at both ends. San Francisco machinery manufacturers sold the Howell-White furnace to West Coast and Nevada camps, dominating the market over Bruckner's Cincinnati-manufactured furnace.[29]

During the early 1870s, Stewart continued to improve his Georgetown mill while becoming a leader in the community, at the time Colorado's major silver mining camp. Stewart was part of the transition of Georgetown's population to Midwestern and Yankee, replacing the previous, more cosmopolitan community. He became president of the local bank, a member of the city council, built a showcase house, and taught Sunday school at the Baptist church. He also designed, with Arey, mills for operations from Alturas, Idaho to Arivaca, Arizona.[30]

Stewart's mill ensured that Georgetown leapt "to the eminence of the best district in Colorado." When President U. S. Grant visited the territory and Georgetown, the mills provided a walkway paved of silver bars, symbolic of Colorado's prosperity. For 1874, the Stewart Silver Reducing Company milled 2,647 tons ore, with an average value of $180 per ton, producing $436,181.43 in silver bullion. It was the biggest silver mill in the Rocky Mountains. Then the mill burnt down, again, on 19 December 1875, which explains, in part, J. Oscar Stewart's 1878 decision to go to work for the Golden State & Miners' Iron Works in San Francisco. It could be said of Stewart that there was not a piece of patented machinery that he could not replicate, modify, and call his own.[31]

Also in 1874, the Pelican mill—the old German Reduction Works—with its jerry-rigged setup, aging Bruckner furnaces, and Freiberg bar-

rels, produced a good portion of the $650,000 output of the Pelican mine bonanza. U.S. Mining Commissioner Rossiter Raymond reported a production of $2,203,947 worth of metal for the county, nearly half of Colorado's total metal production.[32]

### David Brunton and Leaching

Stewart never seemed pleased with his mill, forever seeking ways to reduce costs and improve the percentage of silver separated from its ores. Stewart needed a process to work the enormous tonnage of rock that assayed at under forty dollars per ton—unworkable at the then high cost of milling and freighting. The inventive mechanic began tests on the leaching of silver ores.

Stewart's first leaching attempt, based on a German precedent, failed. He then turned to a process recently patented by two Canadian chemists. T. Sterry Hunt and James Douglas had perfected a process whereby solvents could leach copper from its ores, and Hunt had also shown—at least in the laboratory—how to leach silver from ores carrying both metals. Stewart brought James Douglas to the works to test the process, which the Canadians assured him would work. After building a test plant they succeeded, and, on 9 June 1874, James Oscar Stewart secured a new patent for the Hunt, Douglas, and Stewart process of silver leaching. A large leaching plant was added to the Stewart mill complex in Georgetown.[33]

However, Stewart needed a skilled chemist to ensure the accuracy of the chemical process. He hired a twenty-six-year-old Canadian, David Brunton. Trained in chemistry and assaying at the University of Michigan's early but short-lived mining engineering school, Brunton was hired by Stewart especially to control the use of costly hyposulphite of soda, which had to be imported from Germany. Brunton decided not to worry about consumption of hypo, but rather to determine how to find or make it locally. He solved the problem by making hyposulphite of calcium using waste sulfur dioxide from the roasting furnaces. This created a supply of hypo solvent so abundant and cheap that its slop and waste were no longer of concern. Brunton credited his success to very good advice from countrymen Hunt and Douglas, the true inventors of the process.[34]

Unfortunately for Brunton, the winter 1875 fire at Stewart's mill left him without a job, but only briefly. With the success of leaching, a group of Chicago investors hired him to design a similar mill. The Clear Creek Reduction Works, designed by Brunton and opened in 1876–77, was a combination concentration, amalgamation, and leaching mill, and one of the most complete of its kind. He used Bruckner furnaces to roast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*A drawing of the Clear Creek Works of David Brunton*
*(Courtesy of the David Brunton Collection, Colorado Historical Society.)*

and chloridize the ore, while the Hunt, Douglas, and Stewart leaching process and mercury amalgamation separated out the silver. Brunton found that Bruckner's chloridizing roasting furnace, besides forming silver chloride, formed zinc chloride, which acted as an excellent displacer of the dissolved or leached silver. Brunton used the zinc in the ore, once a liability, to make the cheap extraction of silver possible.[35]

The process was simple. The concentrator middlings were sent to the roasters, which, at a low heat and with salt added, formed zinc chloride and silver chloride. The chlorides passed to an agitator, where the silver immediately went into the hypo solution. When the agitator was stopped, the sludge settled, and the solution was drawn off to where it flowed over copper plates. This produced, Brunton wrote, "a beautiful crystalline precipitate of silver, the dissolved copper being recovered on scrap-iron."[36]

The Clear Creek Reduction Works became the major custom mill in the Georgetown district, with its leaching process replacing amalgamation as the primary medium of extraction. In the words of one contemporary, "what Hill's works are to Gilpin County, the Clear Creek works are to Georgetown." High praise. More importantly to the owners, it was "managed on business principles and making money for its owners." In the next year, Brunton designed duplicate mills at Caribou, Colorado, and Silver Peak, Nevada. He also became a partner of Frank Taylor, Clear Creek Reduction Works' manager, and the son of its owner. Over the next quarter century, the Taylor and Brunton firm would become known throughout the West.[37]

During Brunton's time, Georgetown had become home to a large number of the new fraternity of college-educated American mining men looking for their first jobs. Brunton was an integral part of the changing American tone of the camp. During the 1870s, these college-educated mining engineers started their own mining journal, Colorado's first; began a technical school and then served as adjunct faculty for the not-so-nearby, just-established Colorado School of Mines; organized a scientific society; and truly created Georgetown as Colorado's "Silver Queen." According to one 1870s Georgetown resident and Columbia School of Mines graduate, "those were great days." With the silver rush to Leadville in 1878–80, most of this mining fraternity packed over the mountains early enough to reap some of that bonanza camp's rich rewards.[38]

Brunton was among them. He later wrote: "When I came West, mining engineers were scarce, and, worse than that, American mining engineers were not considered to be in the same class as the German." His generation would bring about a change. Brunton would be one of the most innovative mining engineers of his generation, best known for his "Brunton compass," and for his advances in ore-sampling machinery. But these would come after his auspicious start in Georgetown.[39]

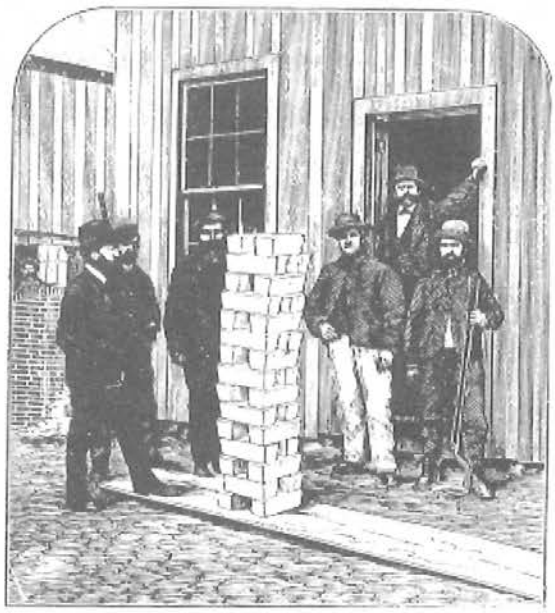
## Richard Pearce, John Collom, and the Cornishmen

In the fall of 1871, thirty-four-year-old Richard Pearce arrived to inspect mines in Clear Creek County for British investors. On his return to London, he recommended closing the company's mines, but advised the Swansea Smelting and Mining Company's directors to build a smelter to treat the ores of the region. Pearce had been reared in the mining country of Cornwall, gone to work in the mines as a boy, and had attended the Royal School of Mines in London, which helped earn him a place as manager of a smelter in the great smelting center of Swansea, Wales. For six years, Pearce had worked with high-grade copper-silver ores shipped from Chile, which needed an additional step to separate the silver—the Ziervogel process as improved by Pearce, the most advanced method

of its day. Pearce described the similarities of ores in Colorado to those he had worked in Swansea; he proposed to work the quartzose silver ores of Georgetown in a mix with the auriferous copper pyrites—gold-copper ores—of Colorado to produce gold, silver, copper, and other metals. He with a positive response. In March 1872, the stocky Cornishman returned with his wife and children to the banks of South Clear Creek[40]

During 1872, Pearce brought a crew of Welsh and Cornish workers to build a Swansea-style plant at a failed smelter the company bought at Swansea, Colorado, four miles downstream from Georgetown. By summer, they were roasting coarse ore in kilns and reverberatory calcining furnaces, which burnt off the sulfur. From there, the product was reduced in a common Swansea smelting furnace. The copper matte poured from the furnace contained high values in precious metals, gold and silver. The matte was freighted by wagon to a railhead, then transshipped by rail and ship to England for refining. Georgetown miners overwhelmed the small plant with silver ores, and the first season's production equaled a successful thirty-five thousand dollars from the eight-ton capacity smelter. Unfortunately, Pearce couldn't buy enough of the gold-copper ores, thought these were abundant at Empire, a camp near the plant. Instead, he had to lease a mine in Central City and pay the expense of hauling ore over the divide to the smelter. Additional complications included the cost of freighting to Swansea, Wales, refineries, and disputes with the Welshmen over the price of the matte. Pearce's backers agreed to fund expansion, with the addition of a plant to refine matte on site, but the financial panic of 1873 interceded.[41]

During the summer of 1873, the four diminutive smelters treating the ores of the region were close to financial failure because of a drop in mineral prices. Pearce's Swansea smelter competed for ores with the nearby Whale smelter, a smelter at Golden, and Nathanial P. Hill's Boston & Colorado smelter at Black Hawk, adjacent Central City fifteen miles away. Hill, a former chemistry professor at Brown University, wisely sought technological advantage and hired Pearce away from the Swansea plant, though that smelter's directors worked out an arrangement to have Hill's works, under Pearce, refine its output. Pearce introduced the Ziervogel process at Black Hawk, and improved the works to nearly replicate the Swansea, Wales, smelter he had managed, with frontier adaptations. Most notable of these was the necessity to burn local pine instead of fine Welsh coal.



*Richard Pearce, at left, and crew at the Black Hawk smelter inspect a stack of silver ingots, ca 1875. These were most likely made from ore from Georgetown. (Author's collection.)*

The key to the Ziervogel process was creating a water-soluble copper-gold-silver sulfate, where hot water and salt carried off the silver in solution. This left a "gold bottom"—high-gold-content copper granules later melted into a matte—and a solution pregnant with silver that was precipitated out by running across copper plates. Dilute sulfuric acid was used for the final parting of the silver, which was cast into ingots. This sophisticated process required more

skilled staff than any previous Colorado plant. Pearce brought members of the Swansea, Colorado, plant crew to Black Hawk, as well as new additions from Europe.[42]

In 1873 too, a railroad reached Black Hawk, a marketing advantage for Hill's works over the other smelters, each of which closed within a year or two. The completion of the Pearce-designed plant to work silver at the Black Hawk smelter was heralded by the mining community and, more importantly, caused immediately increased production at the silver mines of Georgetown. During the mid-1870s, while Hill's works under Pearce, located in the gold district of Gilpin County, became the major silver producer in the territory, Georgetown and Clear Creek County continued as the "banner mining County of Colorado."[43]

Fundamental to the continued prosperity of the mining region was the development of the railroad system. The arrival of the Colorado Central Railroad in Georgetown in August 1877, after a decade of waiting, and its extension to the mines at Silver Plume ended the district's isolation and, more importantly, its high freight costs. Where twenty-dollar-per-ton rock was considered waste pre-railroad, it now became ore worth shipping. The railroad acted as a funnel for ore out of the district, causing Georgetown silver mill owners to add to or convert their plants to concentrators. They produced concentrates to ship to distant smelters rather than bullion to ship to the Denver mint. By 1880, the peak year for silver production, the ore buying and shipping business took over the district's product. These shippers built new plants called "samplers" and sent ore to large-scale, centrally-located smelters, near coal fields, at Denver—where Hill moved his works—Pueblo, and elsewhere.[44]

This shift had begun in 1868, as railroads approached the Rocky Mountains and when Charles A. Martine set up his ore-buying agency in Georgetown. The dapper Bavarian with his hard accent was still buying ore in the 1870s, but by then as part of the operation of George Washington Hall, a Yankee lumberman. Other businessmen built ore-buying operations, or what became known as samplers, with a competent assayer as an assistant to buy and ship ores. The Public Ore Market, the Miners' Sampling Works, and a half-dozen other samplers operated in the district from the 1870s to the 1890s, buying and shipping ore to smelters on the flatlands. Mining district samplers have been described as being like farm communities' rail-side grain elevators. Each bought small lots from individual producers and combined them into large-tonnage shipments, increasing the power, in a sampler's case, to negotiate more favorable rates from railroads and distant smelters.[45]

Taylor and Brunton converted their Clear Creek Reduction Works into an ore-buying agency and initiated a string of samplers in other western mining camps. In 1884, in his typically innovative manner, Brunton invented a totally automatic sampling machine and introduced it into the first completely mechanical sampling mill in the country—the Rocky Mountain Reduction Company's sampler in Clear Creek County.[46]

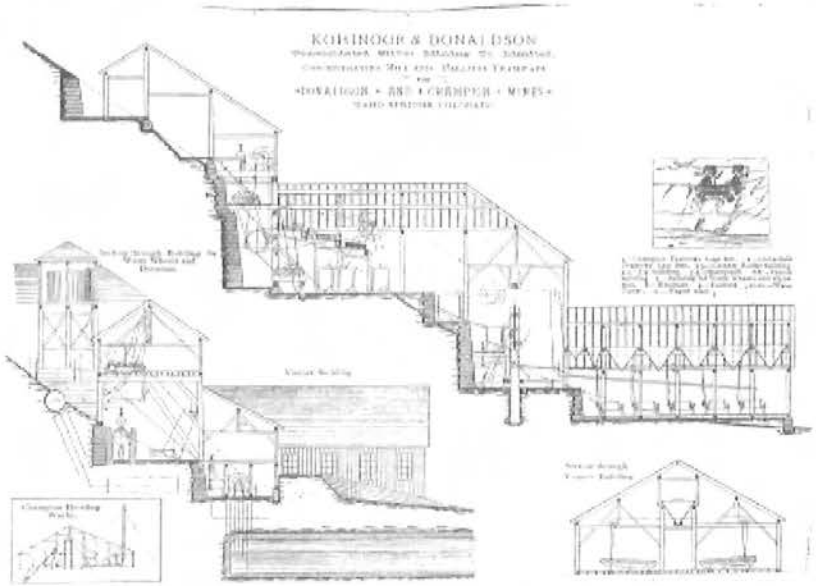
Concentrators—plants that increased the percentage of metal in ore by using gravity to separate out waste rock—had operated in the district since the initial smelter construction boom. The concentrate they produced was always shipped out of the district. Their technology came directly from Europe: Cornish rolls for crushing and the Hartz jig or Cornish buddel for concentrating. At the Terrible Mine an early concentrator used English technology, its owners being the London-based Terrible Mining Company, Ltd. During the years from 1872 to 1875, Cornish Mine Captain George Teal started with hand jigs, then added a Cornish rolls crusher, sizing screens, mechanical jigs, and circular buddles. This imported British technology, watched by an assayer, became the district's first successful concentrator. Imitations of this concentrator were built down the valley of South

Clear Creek. The workforce of the Terrible Mine created a Cornish and British enclave at Silver Plume, Georgetown's nearest mining-camp neighbor.[47]

British concentrating technology dominated the district, with many failed attempts at improvement. The best example of a failed innovator is that of Devonshireman John Collom. He came to Colorado in 1865 via Lake Superior, Michigan, and was early to the silver strikes. He invented an improved concentrating machine at Lake Superior, the Collom jig, which was nearly universally accepted in that copper-mining country. While continuing to improve his jig and an ore-washing machine, he designed a series of milling and smelting plants near Georgetown: at Empire from 1865 to 1866, Montezuma in 1867 and 1868, Swansea from 1869 to 1871 (the plant that Pearce's backers bought), and in Golden in the mid 1870s. Each became a financial failure. In 1880, he was still in the county, trying without success to invent the perfect concentrating machine for the district's ores. One wonders about the Boston investors who continued to back his many failed enterprises.[48]

Other concentrating mills were built for specific mines, served their purpose of upgrading material from an ore dump for shipment, and were then removed. The rare, still-standing Lebanon mill has been studied and is typical of the era. Designed by Berlin native and New York assayer Julius Pohle for the Lebanon Mining Company, this simple plant included a Blake jaw crusher to reduce the size of the raw ore, and a jig that used water and gravity to separate waste rock from ore. The mill operated above Georgetown from 1871 to 1878, served its purpose under manager Pohle, and then shut down.[49]

But Georgetown's technologists, although using the latest European technology, with adaptations or improvements from the Great Lakes region, still failed to perfect a concentrator that would capture more of the mineral. They also failed to separate out such problematic minerals as zinc. State of the art plants, such as the one built for a British firm, the Kohinoor and Donaldson Consolidated Silver Mining Company, Ltd., contained Cornish rolls and jigs, and vanners instead of buddles by the 1880s. Cornishman Thomas A. Rickard, a graduate of the London Royal School of Mines, started his career as an assayer with the firm, working for




*Kohinoor & Donaldson's state-of-the-art concentrator in the 1880s. (Courtesy of the Jesse Randall Collection, Denver Public Library.)*

an uncle at the plant. But like many of his contemporaries, he had become less than accepting of innovation. They relied on European tradition, which meant accepting mineral loss and paying a penalty to smelters for shipping ore tainted with zinc.[50]

One of the mill men of Georgetown, L. F. Olmsted, shared this sentiment in an 1880 district history. After chronicling the innovations of Bruckner, Stewart, Brunton, and others, he opined that no new processes would be discovered or were needed. Indeed, in his opinion: "We may fitly close by stating that the man [or woman] with a new process generally meets with a cool reception in Clear Creek County."[51]

### Carrie Everson and Flotation

By the 1880s, Georgetown had developed a tourist industry, catering to Midwesterners seeking cool retreats in the mountains. Travelers, from politicians to Gilded Age business leaders, rode the rails to Georgetown and toured its heights, especially Mount Grey; or they rode over the famous Georgetown Loop, where the railroad looped over itself to gain altitude in the gorge between Georgetown and Silver Plume. By the mid-1880s the mining industry left the air relatively clean, since ore roasting and its sulfurous fumes had by then been removed from the district to smelters on the plains near Denver.[52]

Among the summer visitors to the district in 1885 were Chicago doctor William Knight Everson and his wife Carrie. The Eversons had invested in the Golden Age Mining Company of Marcus Mill "Gold Brick" Pomeroy, a philosopher-turned-promoter of mines and a railroad tunnel under the Continental Divide near Georgetown. This charlatan had claimed that poor returns at the Golden Age were due to the technology of the period, bringing Everson and other investors to grief. But Carrie Everson developed a process she thought might save their investment.[53]

Born Carrie Jane Billings in Massachusetts on 27 June 1842, she moved to Springfield, Illinois, with her parents in 1844. Her family was in the shoemaking business, one of the early industries that used simple chemical treatments—in this case tannic acid to process leather. She may have learned the basics of chemistry there, but after she married in 1864, Carrie Everson became her husband's medical assistant and grew still more familiar with chemicals. One biography noted that she studied "various branches of science and [became] proficient in chemistry."[54]

During the early 1880s, Carrie tested a revolutionary process to separate metal from crushed fine rock in her husband's Chicago lab. On 4 August 1886 she received a patent. In it she stated that "the discovery that forms that basis of my invention is that metals and metallic substances in a commuted state will unite with compounds of fats or oils and acids, and that such compounds will not unite with comminuted quartz or other rocky gangue." Plainly, metal particles from the crushed ore, when mixed in a solution of fats or oils, would be carried off, leaving behind the gangue, or waste rock.

At the time of her patent, the Eversons were in Georgetown vacationing and promoting their discovery. They displayed a small model and explained how the process worked. On 5 August 1886, the editor of the *Georgetown Courier* described—unclearly—Everson's process:

> The material consists of a cheap chemical compound of a plastic character, that is six parts water. Into this the dry pulverized ore is mixed to saturation. It is then introduced into a tempered and chemicalized water bath, where it is agitated thoroughly for a few minutes, when, to the astonishment of all, the sand or rocky portion all drop[s] to the bottom of the vessel, which is so arranged to carry it away instantly, while

> all the mineral of every kind adheres to the material and floats in the water above until discharged from the bottom. The mineral is then precipitated from the mass, which can be used over and over again.

Carrie Everson's discovery, which the editor crudely described, is the basic scheme for today's "flotation" process of mineral concentration. This revolutionary process would transform the mineral industry at the beginning of the twentieth century, but in 1886 "flotation" was far from being perfected. That summer, the Eversons offered *Courier* readers the chance to invest in a fifty-ton test plant.

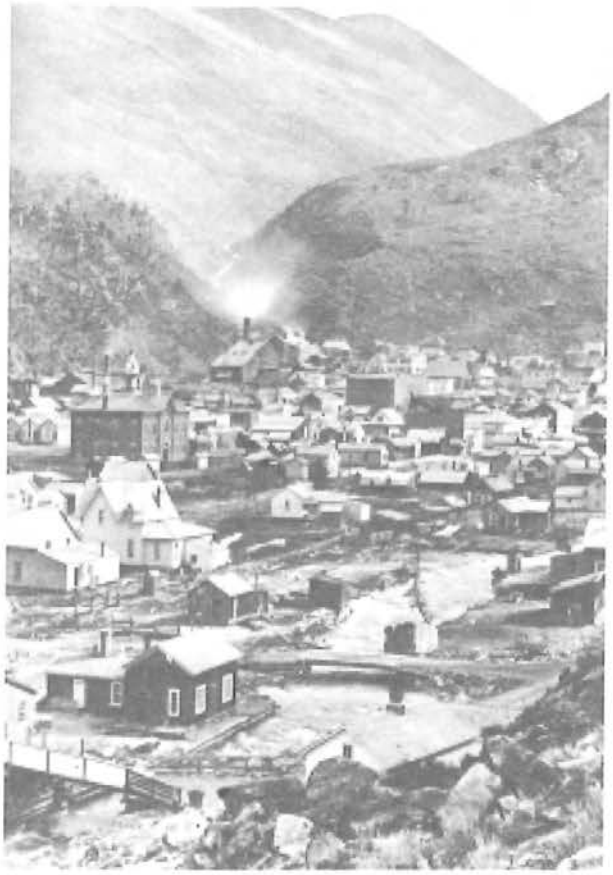
Two weeks after the above announcement, however, Dr. Everson hurried from Georgetown to Abilene, Kansas. Carrie had also invented a food supplement to quickly fatten cattle, and he had found investors in that prairie cow town. His health failing, Dr. Everson's announced plans to form a corporation to promote Carrie Everson's process were not completed before his death on 20 January 1889. Carrie moved to Denver, becoming a nurse and missionary.[55]

Nearly, thirty years later, after the flotation process had proven itself and authorities on the process sought Carrie Everson, Thomas Rickard, the Cornishman mentioned above, now editor of the *Engineering and Mining Journal*, became one of the major critics of the "tale" of her discovery. To him, Everson's "flotation process" was a farce. According to the legend he retold in his standard history of mining, she had discovered the process while "washing oil-stained ore-sacks in her brother's assay-office when she noted the floating pyrite on the water contaminated by the oil." Nothing could be further from the truth. Rickard, scion of a family of respected British mining engineers, defended the Commonwealth patent holders' claim to the process and discounted the Everson story out of hand. But twentieth-century infringers on those patents upheld Carrie Everson's discovery of the basic concept of the process.[56]

There may have been a bias against Everson because she was a female in a male-dominated business—witness Rickard's tone. Women were in the mining business, however, and many succeeded. Mrs. Mary Krom operated an assay office in Denver at the time, while the owners of the Pelican-Dives Mine in Georgetown had enough confidence in Miss Helen Nelson, telegrapher, to appoint her manager of their mine in 1887. But most men shared the views of an editorialist in the *Georgetown Courier*, who wrote about "the formation of a Ladies' Bullion Club," that it "is pleasant, in this era of women's rights, to see the dear creatures coming to the front from all directions; but would it not be well for the gentler as well as the rougher sex to know something of a business before they invest money in it?"[57]

What Carrie Everson also lacked was the financial support necessary for an extended period of experimentation. A recent study of the development of the flotation process in England and Australia reveals a decade-long effort to perfect the complex machinery and chemical solutions needed to make the process work. Flotation was perfected at Broken Hill, Australia, and was introduced into the United States in the 1910s, whereupon interest in Everson's early experiments brought about a search for her. The Colorado Scientific Society gathered information in 1915, but found that she had died the year before. They found no evidence she ever found a strong financial backer, though a small test plant was built in an abandoned mill in Silver Cliff, Colorado, in 1891. Another limited attempt, with a new partner in Baker, Oregon, failed as well, and the depression of 1893 ended these efforts.[58]

The crash of 1893 and the demonitization of silver brought an end to Georgetown's prosperous years. The designs and hopes of Carrie Everson—wife of a doctor who lost money in-



*Georgetown, 1877, with the Clear Creek Company works at center. (Courtesy of the David Brunton Collection, Colorado Historical Society.)*

vesting in Colorado mines—were never given a real chance in the Georgetown district, site of the embryonic flotation process's first display. The community lacked financial resources, with the decline in silver prices, and had settled into a long period of decline. Or, maybe, the innovative community of the 1860s and 1870s, had become stuck in tradition, unwilling to support Carrie Everson or any other innovator. The district revived briefly, oddly enough, thanks to the introduction of flotation mills in the 1910s.[59]

## Conclusion

Like so many mining camps, Georgetown's decline followed the collapse of the silver market in 1893. It remained prosperous a few more years—its last million dollar year was 1896—because of some lucky, rich finds, low operating costs, and the tenacity of its mining fraternity. During the latter half of the nineteenth century, the Georgetown district of Colorado was one of twenty major silver-producing regions of the western United States. From roughly 1859 to the 1890s—from the time of the mining stampede to Colorado until the silver crash at the end of the century—silver production in the United States rapidly increased and eclipsed that of older mining countries. Mines in the states of Nevada, Colorado, Montana, Idaho, Arizona, and Utah poured forth nearly half of the world's silver output. Importantly, the technological innovations developed to work Georgetown ores were disseminated to other isolated, but high-grade silver camps, from Montana to Arizona and into Mexico. The special report on precious metals prepared for the 1880 census reveals in its list of mills and their equipment, the widespread use of the Bruckner furnace, Stewart leaching works, and other innovations.[60]

There were many experimenters and innovators. There were many experiences similar to Georgetown's. Georgetown was marked by a special mingling of experimenting, inventing, and contriving. The voices were in many tongues, but bonded by the common effort to separate silver from rock. Bruckner, supported by his German colleagues and the community, contributed his mechanical innovations and process. Stewart, a member of the Anglo community that dominated the social and political world of Colorado, was an able imitator and persistent mechanic who added as well to the improvements needed to work the various ores of the isolated district. Brunton represented the American-educated mining engineer's influence. Important too, were the trials of the numerous Devonshiremen, Cornishmen, and others from the United Kingdom.

What factors and environments nourish innovation? A community of support is important—as it was to Lorenzo Bowman and his

African-American partners and to the Mexican miners. But let's not see Georgetown through rose tinted glasses. Any view that it was egalitarian and integrated is refuted by such local newspaper items as follows: "A negro was shot by a man named Joe Bush in an Alpine [Street] saloon, 'just to see him kick.'" Lorenzo Bowman lost his mine to a claim jumper. Mexicans, always a small portion of the population, moved away from mining to lower-paid wood cutting and packing.[61]

Community support was important to Bruckner and the short-lived German high society of Georgetown. As Robert Bruce points out, "Germany, as the leading producer of both European science and political refugees, was the main source of those refugee scientists who came to stay." They even brought their Dresden pianos. This welcome became less enthusiastic with the increase of American-trained talent and, oddly, the rise of the German Empire, to which many of the German emigres returned. Obviously, community support, broadly defined, was essential to Americans like Stewart, who took over the district. The British seemed to remain the longest, and to remain the most determined of failures—witness John Collom—but this was because of the high rate of investment coming from the United Kingdom.[62]

Education, especially knowledge of chemistry, was critical, as was scientific method. David Brunton relished experimentation and his chemical trials show shear joy in discovering answers to real problems. The methodical approach of Freiberg-trained William Brunckner was noted by contemporaries, indicative of the rarity of scientific method among early Colorado mill men. J. Oscar Stewart advertised his education at the Cincinnati technical academy—a high school, but better than most educational offerings in the 1850s—while Carrie Everson was a self-taught chemist aided by her husband's medical lab. Richard Pearce combined Cornish and Welsh experience, a year of schooling at the Royal School of Mines and advanced study of German processes at Freiberg and Mansfield, plus experience working the silver-copper ores of Latin America, to successfully adapt existing technologies to the isolated, local conditions of Colorado. Pearce would continue to innovate, and became, according to Rodman Paul, "a dominant figure in Colorado sciences related to mining." Pearce himself wrote: "Cornishmen as a rule do not make great pretensions to high scientific attainments." But even he would admit that western mining benefitted greatly from the chemical revolution of a century before, and from its more willing acceptance by Coloradans than by the rule-of-thumb, tradition-bound workers of Swansea, Wales.[63]

By 1880, mining boom and innovation moved west over the Continental Divide to the Leadville district and its era of successful innovations in silver-lead smelting. These technologists and innovators were a mobile lot; none stayed in Georgetown for their entire careers. They either followed rushes to new fields or settled in regional centers like Denver, San Francisco or Salt Lake City. Their fortunes varied. Pearce prospered, while Bruckner died an impoverished hermit at the age of fifty-two, still tinkering with methods for assaying and reducing silver ore. As the editor of the *Engineering and Mining Journal* wrote, Bruckner "was deficient in business sagacity, and it is said, was not successful in making money by his inventions."[64]

With the arrival of the railroad in the district and the shift of smelting from local mills to large-scale facilities at Denver, the era of metallurgical innovation at Georgetown closed. The amalgamating and leaching processes used in its mills were used in other isolated mining camps throughout the American West until replaced by the cyanide process and flotation in the twentieth century. Flotation, its basics discovered by Carrie Everson and first discussed in Georgetown, failed to

develop there because of a lack of finances, gender bias, and because of the protracted experimentation ultimately necessary to perfect the process. Another factor may have been a shift in attitude away from innovation, as millman Olmsted observed.

After nearly three decades of prosperity, the Georgetown district, like so many others, declined until postwar interest in preserving the town saved its diminishing historic fabric. Georgetown, Colorado, today is a tourist town fifty miles west of Denver. Its Victorian downtown adds to the nostalgia of exploring mining's past, especially as presented by the Colorado Historical Society's railroad ride and mine tour. Nearby are the ruins of the Clear Creek Reduction Works; fire scars still reveal the site. A water siphon now marks the site of the German Reduction Works, Georgetown's first successful silver mill, and the Stewart plant's site can be faintly traced among the new condominiums and homes.

These ruins are little noticed by tourists, though they are the physical reminders of early labors by Mexicans, African-Americans, Germans, Britons, Canadians, and Americans. After interviewing David Brunton in 1915, mining-engineer-turned-historian Thomas Arthur Rickard summed up their metallurgical accomplishments, writing:

> Forty years is no great lapse of time, as measured by the historian, but to the eager exploiters of the Great West it is as a geologic period. In those Eocene mornings of 1875, Mr. Brunton found Central City and Georgetown in the throes of metallurgical revolution. The free-milling precious-metal ores of the oxidized zone had been succeeded, at a shallow depth, by heavily pyrite and complex ores. Roasting before pan amalgamation and hyposulphite leaching had brought the Bruckner, Kustel, and Stetefeldt furnaces into prominence. The Collom jig had just been invented; but concentration was crude. N. P. Hill had established his smelter at Black Hawk, and had just been joined by Richard Pearce, now living near Liverpool, England, after a long career of useful accomplishment. The Stewart mentioned by Mr. Brunton was J. O. Stewart, who had an important custom mill at Georgetown. He had built an annex for the application of the Hunt & Douglas process, a method lending itself to graphic representation by the chemical formulae that used to bother many of us in our student days. The process is now obsolete, but the names of its two inventors live in the annals of mining.[65]

As should the names of all of the participants in this diverse and ingenious community.

## Notes:

1. *Engineering and Mining Journal,* 13 Dec. 1870. The innovations were the Stetefeldt and Bruckner furnaces described below. Clark C. Spence, *Mining Engineers and the American West, the Lace-Boot Brigade, 1849-1933* (New Haven: Yale University Press, 1970), 370.
2. Quote from the *Daily Mining Journal* (Black Hawk), 11 July 1865. Liston E. Leyendecker, *The Griffith Family and the Founding of Georgetown* (Niwot, Colorado: University Press of Colorado, 2001), *passim.* Liston E. Leyendecker, *Georgetown, Colorado's Silver Queen 1859-1876* (Ft. Collins: Centennial Publications, 1977), 7-17. This essay benefited from exchanges with the late Liston Leyendecker, lost too early to the mining history fraternity.
3. James E. Fell, Jr., *Ores to Metals, The Rocky Mountain Smelting Industry* (Lincoln: University of Nebraska Press, 1979) 58-61, *passim*, provides a broader context as well. Quote from the *Mining Reporter* (Central City), 2 Oct. 1866.

4. One writer described the Mississippi River lead regions and concluded: "The smelting furnaces throughout the West [meaning the Mississippi Valley] are all on the same plan, the Scotch hearth being in universal use. The blast is usually supplied by a large bellows, worked by a small over-shot, water-wheel, the whole arrangement being of the most simple description. The slag is worked over in a round blast furnace." The Scotch hearth had been developed in Britain in the seventeenth century and with the opening of the American lead regions in the nineteenth, accompanied furnace hands and miners across the Atlantic. They worked well for the high-grade, narrow, but rich veins of Missouri, Illinois, Iowa and Wisconsin. Josiah Dwight Whitney, *Metallic Wealth of the United States* (Philadelphia: Lippincott, Grambo & Co., 1857), 419-20. See also: Roger Burt, *The British Lead Mining Industry* (Redruth, Cornwall, U. K.: Dyllansow Truran, 1984) 213-6; Hazel M. Martell and M. C. Gill, "Ore Hearth Smelting," *British Mining, No. 41, Memoirs* (Northern Mines Research Society, 1990), 21-36.
5. Leyendecker, *Georgetown*, 18-19. *Rocky Mountain News* (Denver), 14 May, 2 Aug. 1867. *Colorado Miner* (Georgetown), 27 June, 25 Oct. 1867, 29 Dec. 1870. *Mining Review* (Georgetown), Sep. 1872. David S. Digerness, *The Mineral Belt: An Illustrated History, Featuring the Denver, South Park & Pacific Railroad, and the Gold-and-Silver Mining Industry of the Fabulous Mineral Belt of Colorado*, v. III (Denver: Sundance Books, 1982), 162-3.
6. *Rocky Mountain News*, 14 May, 2 Aug. 1867. *Colorado Miner*, 27 June, 25 Oct., 29 Dec. 1867. *Mining Review*, Sep. 1872. Ovando J. Hollister, *The Mines of Colorado* (Springfield, Mass.: Samuel Bowles & Co, 1867), 249-62, describes the plants.
7. *Colorado Miner*, 8 Aug. 1867. The smelter is described in the *Rocky Mountain News* (2 Aug. 1867): The Mexican furnace is "built of adobes, soil and boulder, and is no doubt a facsimile of like concerns used in the separation of silver galena ores in Mexico. It consists of a square cupola or hollow tower of mud and adobes, into which the ores and fuel is [sic] fed from the top and is [sic] smelted by a blast at the rear of the bottom of the cupola, assisting in the operation. The melted metal is drawn from a tap hole in front, being a little below the point of elevation where the blast enters the furnace. The metal is then transferred to a large hollow hearth or basin, where it is scorified." Notebooks, J. S. Randall Collection, Colorado Historical Society.
8. Fell, *Ores to Metals*, 59-61. Duane A. Smith, "Decade of Frustration: Colorado and California Silver Mining in the 1860s," *Southern California Quarterly* (Summer 1974): 135-58. *Mining Review*, 6 and 26 Nov. 1866, 21 May, 4 June 1867. *Colorado Miner*, 24 Oct. 1867, 14 May 1868. *Rocky Mountain News*, 14 May 1867, 6 Nov. 1868. L. F. Olmsted, "Mills and Milling," *History of Clear Creek and Boulder Valleys, Colorado* (Chicago: O. L. Baskin & Co., 1880), 342.
9. Josiah E. Spurr and George H. Garrey, *Economic Geology of the Georgetown Quadrangle*, USGS Professional Paper 63 (Washington, D. C.: U.S. Government Printing Office, 1908), *passim.*
10. Louis L. Simonin, *The Rocky Mountain West* translated from original French edition of *Le grand-ouest des Etats-Unis*, Paris, 1869, by Wilson O. Clough (Lincoln: University of Nebraska Press, 1966), 54. Italics his.
11. Quotes from the *Mining Reporter* (Central City), 5 Mar., 16 Apr. 1867. *American Journal of Mining* (later, *Engineering and Mining Journal*), 4 May 1867.
12. *Engineering and Mining Journal*, 11 Aug. 1866. *Mining Reporter*, 7 and 14 May 1867. *American Journal of Mining*, 4 May 1867. Obituary in *Engineering and Mining Journal*, 19 Feb. 1887. DeWitt Clinton Travis biography in *Portrait and Biographical Record of Colorado* (Chicago: Chapman, 1899), 792.
13. *American Journal of Mining*, 4 May 1867, quoting the Central City *Times*.
14. *Mining Review*, 30 Oct., 11 Dec. 1866. *Colorado Miner*, 25 July, 8 Aug. 1867. *Rocky Mountain News*, 10 Aug. 1867. C. K. Wolfe (manager), "Story of the Chamberlain Mill," Apr. 1901, Colorado Historical Society.
15. William Crooke and Ernst Rohrig (*Practical Treatise on Metallurgy Adapted from the Last German Edition of Professor Kerl's Metallurgy* (London: Longmans, Green, and Co., 1868), 320-62) describe the Freiberg process. "Bruckner Cylinder" section of Rossiter W. Raymond's, *Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains; Being the Sixth Annual Report of the U. S. Commissioner of Mining Statistics* (Washington: U.S.G.P.O., 1874), 496-8. *Engineering and Mining Journal*, 12 Oct. 1867. Quote from *Rocky Mountain News*, 10 Aug. 1867.
16. James D. Hague, *Mining Industry* (Washington, D. C.: USGPO, 1870), 610-13. The *Colorado Miner* chronicled weekly the operation during these years. Some ore did not require roasting, which accounts for the discrepancy between furnace and mill capacities.
17. *Colorado Miner*, 23 Sep. 1869. Rossiter W. Raymond to his wife, Georgetown, 7 Oct. 1870, Rossiter Worthington Raymond Collection, Colorado Historical Society. Bayard Taylor, *Colorado, a Summer Trip* (New York: Putnam, 1867), 74. See also: Isabella Bird, *A Lady's Life in the Rocky Mountains* (1874. Reprint. Sausilito: Comstock Editions, 1972), 178-9; Helen

Hunt Jackson, in "Georgetown and the Terrible Mine," *New York Independent*, 10 Sep. 1874, [reprinted in her *Bits of Travel and Home* (Boston: Roberts, 1878)] wrote: "Georgetown is the American cousin of Bad-Gastein."

18. *Rocky Mountain News*, 6 Nov. 1868, describes the Schirmer and Bruckner works. For Baker, see: Hague, *Mining Industry*, 112; *Colorado Miner*, 9 Sep. 1869.
19. Otis E. Young, *Western Mining* (Norman: University of Oklahoma Press, 1970), 199, 248-50. Quote from Guido Kustel, *Nevada and California Processes of Silver and Gold Extraction* (San Francisco: Frank D. Carlton, 1863), 63.
20. J. M. Locke, in "The Bruckner Revolving Furnace," *Transactions of the American Institute of Mining Engineers* 2 (May 1873–Feb. 1874): 295-9, describes the Tennessee mill, Silver City, New Mexico. For Bruckner in New Mexico see: *Colorado Miner*, 31 Sep. 1869; *The Borderer* (Las Cruces), 20 Mar. 1872; *Mining Life* (Silver City), 8 Nov. 1873; *Arizona Star* (Tucson), 6 Dec. 1878; and 1870 census enumeration sheets, Aztec mill, Elizabethtown. Huepeden advertisement appears in *Colorado Miner*, 25 Feb. 1868 to 17 Mar. 1870, intermittent; *Utah Mining Gazette* 3 June 1872; and Raymond, *Mining Statistics for 1872*, 329.
21. Thomas Egleston, *The Metallurgy of Silver, Gold, and Mercury in the United States* (New York: John Wiley & Sons, 1887), 344. *Engineering and Mining Journal*, 19 Feb. 1887.
22. Louis C. Harrison, *Empire and the Berthoud Pass* (Denver: Big Mountain Press, 1964), 186. Digerness, *Mineral Belt*, III: 163-4. Olmsted, "Mills," 341. Baskin, *History of Clear Creek County*, 80. Hague, *Mining Industry*, 609-10. *Rocky Mountain News*, 26 Mar. 1867, 13 June 1868, 6 July 1890. *Colorado Miner*, 26 Mar. 1868, 6 May 1869. The tale of William Clifton's near lynching appears in *Georgetown Courier*, 21 Feb. 1884.
23. *Colorado Miner*, 6 May, 23 Sep., 14 Oct., 1869. *Engineering and Mining Journal*, 5 Oct. 1869. Raymond, *Mining Statistics* 3 (1872), 344-5.
24. *Rocky Mountain News*, 18 Oct., 8 Nov. 1869. *Engineering and Mining Journal*, 15 Feb., 31 May, 1 Nov. 1870. *Colorado Miner*, 9 June 1870. *Mining Review*, Sep. 1872, describes the new mill with its Arey furnace after the original Stewart mill burnt down on 14 January 1872; gives production statistics. Fell, *Ores to Metals*, 19-24, 27. A description of the Gerstenhofer furnace at work in Freiberg is in: John A. Church, *Notes of a Metallurgical Journey in Europe* (New York: D. Van Nostrand, 1873), 57-8.
25. *American Mining Journal*, 4 Jan. 1868. *Engineering and Mining Journal*, 15 Feb. 1870. Donald R. Abbe, *Austin and the Reese River Mining District* (Reno: University of Nevada Press, 1985), 28-9. Austinites questioned the patent; see Spence, *Mining Engineers*, 239.
26. Spence, *Mining Engineers*, 239. R. W. Raymond, "Biographical Notice of Charles A. Stetefeldt," *Transactions American Institute of Mining Engineers* 26 (Feb. 1896–Oct. 1896): 537-544.
27. *Engineering and Mining Journal*, 31 May, 1 Nov. 1870, 10 Sep. 1872, 1 Aug. 1874. The American Metalurgical Company of New York, with Raymond as consultant, held the patents for the Gertenhofer and Stetefeldt furnaces; *American Mining Journal*, 4 Jan. 1868. During this period Raymond also edited the *Engineering and Mining Journal*, which advertised a patenting service. Raymond mentions mentoring in "Anton Eilers," *Engineering and Mining Journal*, 28 Apr. 1917.
28. *Engineering and Mining Journal*, 17 Jan. 1871, 14 Mar. 1874, 16 Jan. 1875. Raymond, *Mining Statistics for 1872*, 268; and *for 1875*, 369. C. A. Stetefeldt, "On the Progress which has been made in the Construction of Dry-Crushing Silver Mills, and in the Treatment of So-called Dry and Base Silver Ores, in the West of the United States," *Annual Report of the Director of the Mint* (Washington, D. C.: USGPO., 1883), 738-46.
29. Ernest Oberbillig, "Development of Washoe and Reese River Silver Processes," *Nevada Historical Society Quarterly* X (1967): 5-43. Sam P. Davis, *The History of Nevada* ((Reprint. Las Vegas: Nevada Publications, n.d.), 336. Raymond, *Mining Statistics for 1872*, 167-9, 268.
30. *Rocky Mountain News*, 15 Apr. 1871, 16 June 1872. *Colorado Miner* 8 and 10 Apr. 1873. Samuel Cushman, *The Mines of Clear Creek County* (1876), 9-10, 94. Arey moved to Arizona and was early to Tombstone; *Arizona Star*, 10 Jan. 1878.
31. Quote in *Engineering and Mining Journal*, 3 Sep. 1872. *Mining Review*, Feb. 1875. Raymond, *Mining Statistics for 1874*, 368-9. "Silver Mills" file, Colorado Historical Society. Stewart in 1880 census enumeration sheets for Alameda, California, on San Francisco Bay. J. O. Stewart to F. M. Wetherill, 15 Nov. 1879, Golden State & Miners Iron Works, San Francisco, F. M. Wetherill Collection, Colorado Historical Society.
32. *Mining Review*, Feb. 1875. Raymond, *Mining Statistics for 1874*, 368-9. Leyendecker, "The Pelican-Dives Feud, A Study in Frustration and Terror," *Colorado Historical Society Essays and Monographs*, no. 1 (Denver, 1985), 11. The only other contemporary silver district of note was Caribou, Boulder County; see Duane Smith, *Silver Saga, the Story of Caribou, Colorado* (Boulder: Pruett, 1974). Technology and people came to Caribou from Georgetown.
33. Raymond, *Mining Statistics for 1875*, 410. *Mining Review*,

27 Dec. 1875.

34. D. W. Brunton, "Technical Reminiscences," *Mining and Scientific Press*, 27 Nov. 1915.
35. Brunton, "Technical Reminiscences." T. A. Rickard, "David W. Brunton," in *Interviews with Mining Engineers* (San Francisco: Mining and Scientific Press, 1922), 69-96.
36. Rickard, "David W. Brunton," 69-96.
37. Rickard, "David W. Brunton," 69-96. Olmsted, "Mills," 342. Quote from *Rocky Mountain News*, 4 Apr. 1877.
38. Brunton lists the men who worked with him and then moved on in an undated sheet, David W. Brunton Collection, Colorado Historical Society. Quote from Theodore F. Van Wagen, "Reminiscences," manuscript, Denver Public Library. *Colorado Miner*, 3 Aug. 1878.
39. Rickard, "David W. Brunton," quote from p. 88.
40. T. A. Rickard, "Richard Pearce, the Biographic Sketch of a Pioneer Metallurgist," *Engineering and Mining Journal*, 10 Mar. 1928, 404-409. Harrison, *Empire*, 247. "Richard Pearce," *Dictionary of American Biography* 14, 353-4. Pearce introduced the silver separation process discovered by Huttenmeister Ziervogel of the Mansfield Mining & Smelting Company, Germany.
41. *Engineering and Mining Journal*, 10 Sep. 1872. *Mining Review*, Oct. 1872, Jan. and Apr. 1873. Besides the gold mine at Central City, Pearce worked the Wood Lode in Lawrence Gulch for its uranium ore, sorted and hand jigged it at the Swansea works, then shipped it to England, where it sold for two dollars a pound. This was probably the first uranium mined in the West. *Mining Review*, Feb. 1873.
42. Rickard, "Pearce," 407. Fell (*Ores to Metals*, *passim.*), details Hill's works and Pearce's role. *Mining Review*, Feb. 1875. *Engineering and Mining Journal*, 19 June 1875.
43. *Engineering and Mining Journal*, 19 June 1875. Prior to the successful adaptations by Pearce, half of the silver product of the county—the ore averaging $260 per ton and more of silver—was shipped to distant smelters as far away as Mansfeld, Germany.
44. Frank Fossett, *Colorado, its Gold and Silver Mines, Farms and Stock Ranges, and Health and Pleasure Resorts* (New York: C. G. Crawford, 1880), 42-3, 355-66. Digerness, *The Mineral Belt*, III:273-5. Van Wagen, "Reminiscences," Denver Public Library.
45. John Willard Horner, *Silver Town* (Caldwell, Idaho: Caxton Printers, 1950), 279. Mary Virginia Kennedy, "The Silver Queen: A Study of Silver Mining in Georgetown, Colorado, 1885–1896," M. A. Thesis, University of Denver, 1969, 50-56, table 4. Albert Williams, Jr., "Public Ore Sampling Works," *The Engineering Magazine* (April 1892): 34-43.
46. Rickard, "David W. Brunton," 77-8. David W. Brunton, "A New System of Ore-Sampling," *Transactions American Institute of Mining Engineers* 13 (1884-1885): 639-645.
47. *Mining Review*, Mar. 1874, Apr., Aug., and 1 Nov. 1875. *Engineering and Mining Journal*, 28 Oct. 1876. Clark Spence, "Colorado's Terrible Mine: A Study in British Investment," *Colorado Magazine* (January 1957), 48-61. S. R. Krom improved Cornish rolls in the 1860s and marketed them as Krom rolls and concentration, which were used in some plants, such as Olmsted's Washington mill and the Clear Creek Company mill. S. R. Krom, "Improvements in Ore Crushing Machinery," *Transactions American Institute of Mining Engineers* (1885-1886): 497-508.
48. *Mines Register* (Central City), 24 Apr. 1866. *Colorado Miner*, 8 Aug. 1867, 13 Jan. and 29 Dec. 1870. Harrison, *Empire*, 161. Fell, *Ores to Metals*, 56-8. Raymond, *Mining Statistics for 1875*, 286-9. See: Dianne Newell, *Technology on the Frontier, Mining in Old Ontario* (Vancouver: University of British Columbia Press, 1986), 28-160, for information on John Collom. Angus Murdoch, wrote in *Boom Copper, the Story of the First U. S. Mining Boom* (Calumet, Michigan, 1943), 124: "John Collom . . . invented his jig on the range. In principle, it is still in use."
49. Liston Leyendecker, "The Lebanon Mill and Mine Complex," *The Colorado Magazine* (spring/summer 1978): 161-180. The mill is preserved as part of the Colorado Historical Society's Georgetown Loop Railroad and Mining Historical Park.
50. T. A. Rickard, "Early Days in Colorado," *Mining and Scientific Press*, 27 Nov. 1915. T. A. Rickard, "T. A. Rickard," *Interviews with Mining Engineers* (San Francisco: Mining and Scientific Press, 1922), 520-552. The successful innovations in concentration in nearby Gilpin County were used on Georgetown ore, as were Frue vanners; see H. William Axford, *Gilpin County Gold, Peter McFarlane, 1848-1929, Mining Entrepreneur in Central City* (Chicago: Swallow Press, 1976). The most significant innovation in concentration, the Wilfley table, was developed fifty miles west of Georgetown in the 1890s, at Kokomo; see Jay E. Niebur with James E. Fell, Jr., *Arthur Redman Wilfley, Miner, Inventor, and Entrepreneur* (Denver: Colorado Historical Society, n.d.). On vanners, a Canadian innovation, see Newell, *Technology*, 80-82.
51. Olmsted, "Mills," 345.
52. *Among the Silver Seams* (Georgetown: Courier,1886). P. R. "Bob" Griswold, Richard H. Kindig, and Cynthia Trombly, *Georgetown and the Loop* (Denver: Rocky Mountain Railroad Club, 1988), *passim.*

53. H. C. Parmelee, "Carrie Jane Everson and the Flotation Process," *Metallurgical and Chemical Engineering*, 15 January 1916, 67-69. Dawn Bunyak, "To Float or Sink: A Brief History of Flotation Milling," *Mining History Journal* 7 (2000): 35-44. I have benefited from exchanges with Jeremy Mouat and Dawn Bunyak, who is working on a biography of Everson.
54. Bunyak, "To Float or Sink," 35-44.
55. Bunyak, "To Float or Sink," 35-44. *Georgetown Courier*, 3 Sep. 1886.
56. T. A. Rickard, *A History of American Mining* (New York: McGraw Hill, 1932), 397. T. A. Rickard, "The Everson Myth," *Mining & Scientific Press*, 15 Jan. 1916.
57. *Georgetown Courier* 12 May 1887; quote appears in 5 June 1880 issue. *Colorado Business Directory* (Denver, 1882), 1038. Sally Zanjani, *A Mine of Her Own, Women Prospectors in the American West, 1850-1950* (Lincoln: University of Nebraska Press, 1997), 181.
58. Jeremy Mouat, "The Development of the Flotation Process: Technological Change and the Genesis of Modern Mining, 1898-1911," *Australian Economic History Review* (March 1996), 3-31. Henry E. Wood also claimed to have discovered the process: Wood, "Reminiscences of an Old Assayer in Colorado," Huntington Library, p. 3; *Engineering and Mining Journal*, 13 Oct. 1928. This parallels the development of the cyanide process; see Robert L. Spude, "Cyanide and the Flood of Gold: Some Colorado Beginnings of the Cyanide Process of Gold Extraction," *Essays and Monographs in Colorado History*, no. 12 (1991), 1-35.
59. Charles W. Henderson, *Mining in Colorado, a History of Discovery, Development and Production*, U.S. Geological Survey, Professional Paper 138 (Washington, D. C.: USGPO, 1926), 16, 32. *Mines, Mining, Milling, Clear Creek, Colorado* (Idaho Springs, Colorado: Clear Creek Metal Mining Association, 1932), 31. The last standing mill in Georgetown is a flotation mill of the 1920s.
60. Henry Dudley Teetor, "Some of the Mines and Miners of Georgetown, Colorado," *Magazine of Western History* (3 Sep. 1890): 490-505. Representative biographies are: Clark C. Spence, "Robert Orchard Old and the British and Colorado Mining Bureau," M.A. thesis, University of Colorado, 1951; Christine Bradley, *William A. Hamill, the Gentleman from Clear Creek* (Fort Collins: Colorado State University, 1977); "Benjamin Bowden Lawrence," *Mining and Metallurgy* (June 1921), 25-6. Rodman Wilson Paul, *Mining Frontiers of the Far West, 1848-1890* (New York: Holt, Rinehart and Winston, 1963), *passim*. Walter R. Crane, *Gold and Silver* (New York: John Wiley & Sons, 1908), 578-635. Henderson (*Mining in Colorado*, 109) gives Clear Creek County production as $87 million by 1923, $52 million worth of silver and $8 million of lead. The peak year for silver values produced was 1880 ($2.2 million), while the peak for silver metal produced was 1894 (2.2 million fine ounces).
61. Horner, *Silver Town*, 76. M. B. Shelton, *Rocky Mountain Adventures* (Boston: Christopher Publishing House, 1920), 52.
62. Robert V. Bruce, *The Launching of Modern American Science, 1846-1876* (Ithaca: Cornell University Press, 1987), 27. Spence, "Terrible Mine," 48-61. Clark C. Spence, "The British and Colorado Mining Bureau," *The Colorado Magazine* (April 1956): 81-92. Clark C. Spence, *British Investment and the American Mining Frontier, 1860-1901* (1958. Reprint. Moscow: University of Idaho Press, 1995), *passim*.
63. On schools, see Clark C. Spence, "'We Are the Trustees for Posterity': The Western Movement for a National Mining School, 1850-1900," *Nevada Historical Society Quarterly* (Fall 1986): 155-174. Cyril Stanley Smith, "The Interaction of Science and Practice in the History of Metallurgy," *Technology and Culture* (Fall 1961): 357-367. Paul, *Mining Frontiers*, 124. *Engineering and Mining Journal*, 13 Feb. 1875. Rickard, "Pearce," 406. Rodman Wilson Paul, in "Colorado as a Pioneer of Science in the Mining West," *Mississippi Valley Historical Review* (June 1960): 34-50, notes the importance of the silver boom of the late 1860s–1870s, but overlooks the early innovations and adaptations at Georgetown.
64. *Engineering and Mining Journal*, 19 Feb. 1887. C. A. Martine may be the exception on mobility; after he died in Georgetown, the first ingot poured from the German Reduction Works was found in his estate and was donated to the Colorado Historical Society.
65. Rickard, "Early Days in Colorado," offprint from *Mining and Scientific Press*, 27 Nov. 1915, 22. Guido Kustel—a Frieberg-trained Austrian who had a significant career, primarily in Nevada, California, Arizona, and Mexico—may have been the only person mentioned by Rickard to not have visited Georgetown. In the early 1870s, he did design a smelter in Chicago that processed some of Georgetown's high-grade output. Obituary in *Mining and Scientific Press*, 19 Aug. 1882.