If the Walls Could Speak: Mariscal Mine and the West Texas Quicksilver Industry, 1896-1946

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It is rare that a federal employee with the National Park Service has the opportunity to follow-up on a recommendation proposed nearly fourteen years ago. In the summer of 1997, that very opportunity arose when Historic American Engineering Record (HAER)[1] Director Eric DeLony invited me to serve as the project historian for the proposed architectural, photographic, and historical documentation of Mariscal Mine. Protected within the boundaries of Big Bend National Park in west Texas, Mariscal Mine–known variously as the Lindsey Mine, the Ellis Mine, and the Vivianna Mine–is perhaps the best preserved ensemble of structures that best represents the mercury mining industry in the United States.

Second only to California as a leading producer of mercury—and for a brief one-year period (1921) the nation's largest producer—the pock-marked west Texas landscape once teemed with mining activity. Corporate as well as two-man operations riddled the mountainsides near familiar topographic landmarks like Terlingua Creek, Study Butte, Fresno-Contrabando Dome, Maravillas Creek and Mariscal Mountain. In all, more than thirty mines comprised the Terlingua District, a narrow belt extending for approximately fifteen miles east to west. Their combined total accounted for 90 percent of the more than 150,000 flasks (76 pounds per flask) of mercury produced in the district from 1899 to 1970. Although productivity at Mariscal Mine, located forty miles farther southeast, paled in comparison to that of its contemporaries—the Chisos Mining Company of Terlingua and the Big Bend Cinnabar Mining Company at Study Butte—the citadel-like edifice, perched high atop the eastern face of Mariscal Mountain, stands as a final testament to the halcyon days of this once vibrant Texas industry.[2]

Although a known element since the days of the Mesopotamian Empire (ca. 2000 B.C.), mercury enjoyed widespread use throughout Europe and Asia as an amalgam for processing gold and silver beginning about 400 B.C. The advance of the Europeans to the Americas in the fifteenth and sixteenth centuries initiated the quest for new sources of mercury comparable to the ores extracted from Spain's famous Alamaden Mine, which first produced the metal in the twelfth century from crude shaft furnaces. By 1646 more efficient methods of reduction were developed at the Huancavelica Mine in Peru, thus enabling Spain to dominant the mercury production industry well into the 20th century.

Not until 1845, however, when Captain Andrés Castillero, a young Mexican cavalry officer and an experienced metallurgist, located a cave twelve miles south of present San José, California, was the occurrence of mercury on the North American continent confirmed. Castillero's discovery and the subsequent establishment of the New Almaden Mine on the eve of the great California gold rush was nothing short of providential. These two historic events combined to initiate the mercury mining industry in the United States. During the decades 1890 to 1940, America ranked second only to Spain as the world's leading producer of "quicksilver"—the commercial name for mercury.

Among its many uses, the industrial, medical, and military applications of mercury have accounted for 87 percent of U.S. consumption since the birth of the industry. Mercury is unique as the only metal in liquid form at ordinary temperatures. It has seen use in the manufacture of chlorine and caustic soda, in

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electrical components including lighting equipment and batteries, and in precision measurement instruments such as thermometers and barometers. More recent applications include widespread use as a binding agent in the production of wood pulp and paper, as a mildew retardant, and as an amalgam for dental preparations.

It is mercury's well known explosive qualities, however, that have accounted for the coincidental market fluctuations during wartime. The liquid metal, once converted into a crystalline fulminate, becomes the principal chemical ingredient in the manufacture of detonators and other munitions. While there are few satisfactory substitutes for mercury in the production of electrical apparatus and control instruments, sulpha drugs, iodine, and other antiseptics have replaced this unique metal in pharmaceutical use. Similarly, porcelain and plastics have become the preferred material for use in dentistry. Production statistics for Mariscal Mine indicate, however, that it was mercury's strategic uses that provided the broadest market for the ores it produced.[3]

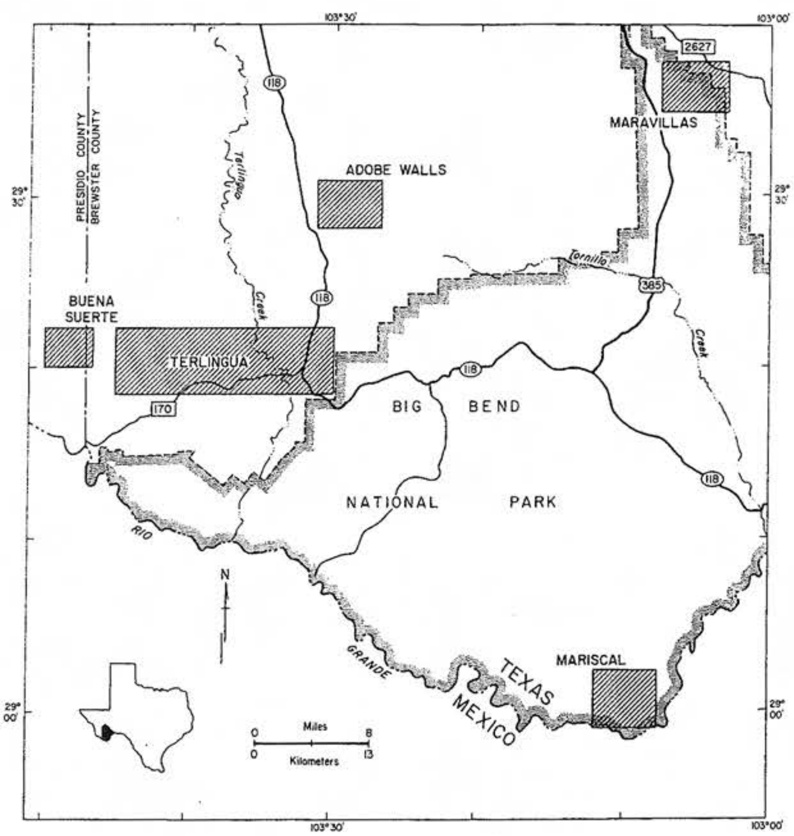

Figure 1. This regional map depicts the principal mercury-producing districts of West Texas. Note that the Mariscal District is shown with the boundaries of present Big Bend National Park. (As illustrated in Rogert D. Sharpe, *Development of the Mercury Mining Industry: Trans-Pecos Texas*, Mineral Resource Circular No. 64, B ureau of Economic Geology. University of Texas, Austin, 1980, p. 2).

The mercury mining industry in west Texas had its origins in Terlingua. While on a mapping expedition through the Trans-Pecos region with the Army Corps of Topographical Engineers in 1840, German geologist Dr. Ferdinand Von Roemer noted numerous sporadic outcroppings of cinnabar, the reddish rock from which mercury is extracted. More than a half century elapsed, however, before west Texans produced the metal in earnest.

Generally speaking, miners in the Trans-Pecos region recovered mercury ore by conventional surface and subsurface methods. Early exploratory methods consisted of sinking shallow shafts or trenches on the surface exposures of cinnabar and then using a diamond-bit, mechanically driven drill to determine the extent of the subsurface deposits. Miners employed typical methods such as drifting, in which workings were driven laterally along mineralized zones to reach deeper ore deposits, and stoping to mine mineralized zones from the bottom upward. Horizontal passageways or crosscuts connected the drifts and stopes, while workers extracted the ore from the mine by a series of inclined or horizontal adits (tunnels). According to one early inspection report by geologist Curt N. Schuette: "The mining methods employed during these early years were indeed primitive with picks, shovels, hand drills, and sledge hammers making up the standard compliment of equipment. As diggings descended to subsurface levels, Mexican laborers surfaced the ore-bearing material in rawhide buckets weighing in excess of eighty pounds attached to their backs."[4]

In 1896 two brothers, Bert and James Normand, owners of the Marfa and Mariposa Mining Com-

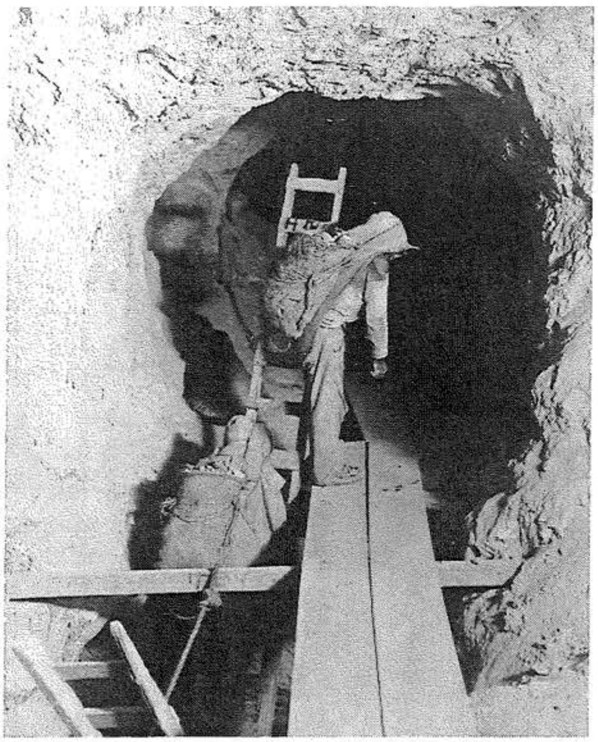

Figure 2. This photo of two Mexican miners with ore -laden burlap sacks dramatically illustrates an early method of cinn a-bar extraction in the Waldron Mine, Terlingua District. (Courtesy, Harry Ransom Humanities Center, W. D. Smit h-ers Collection, University of Texas, Austin).

pany, were the district's first successful commercial producers. Their holdings were in the western sector of the Terlingua District, where they produced upwards of 30,000 flasks of mercury during little more than a decade. By 1905 the mining district had expanded eastward with the establishment of the Texas Almaden Mining Company, known locally as the Dallas Mining Company, and the Big Bend Cinnabar Mining Company near the present village of Study Butte. It was the arrival of Chicagoan Howard Everett Perry to west Texas, however, that transformed the Terlingua District from a regional producer of mercury to one of worldwide stature.[5]

Perry, a wealthy industrialist who had earned his fortune as a shoe manufacturer, inherited a small parcel of land in Brewster County in compensation for an unpaid debt. Not one to let a business opportunity go unheeded, Perry filed a lawsuit that won him uncontested ownership of mining claims near Terlingua. Next, he purchased several adjoining parcels of land and secured a loan for $50,000 to capitalize the Chisos Mining Company, which he incorporated in May 1903. In its first year of production, the mine operated four 700-pound D-type retort furnaces to produce 5,029 flasks of mercury valued at $200,000. This amount represented about half of the total state output for that year.

With the exhaustion of high-grade ores and the more frequent occurrence of ores containing less than 4 percent mercury, Perry, purchased a 20-ton Scott furnace in 1905 from the defunct Colquitt-Tigner Mine, five miles west of Terlingua. This improvement enabled his company to increase its conversion of cinnabar ore to quicksilver at the rate of fifteen tons every twenty-four hours. Nicknamed "El Perrito" by his Mexican employees because of his bulldog-like demeanor, Perry's aggressiveness forced out most of his early competitors. By 1910, for example, Perry's ruthless business tactics caused the Normand brothers to relinquish all claims in the nearby Marfa and Mariposa Mine to the Chisos Mining Company.

By far the largest workings in the Terlingua District, the Chisos Mine consisted of nearly twenty-three miles of subsurface diggings that extended 5,500 feet laterally and 840 feet vertically. During its peak production years (1905 to 1930), the Chisos Mining Company generally exceeded Howard Perry's self-imposed quota of 700 flasks per year. In fact, its level of productivity earned the company an impressive $30,000 per month from 1917 to 1930. In continuous operation from 1903 to 1942, this mine alone produced approximately two-thirds—100,000 flasks—of the total output for all of west Texas.[6]

Meanwhile, less than ten miles east of Terlingua, two additional mining companies rivaled for preeminence within the district. In 1905 W. L. Study incorporated the Big Bend Cinnabar Mining Company, while H. M. Nesmith sank a 150-foot shaft to begin the Texas Almaden Mining Company (Dallas Mining Company). The two Study Butte mines marked the easternmost perimeter of the Terlingua District. During their first full year of production, the two operations combined accounted for 4,273 flasks of mercury. Their most productive years coincided with World War I (1914-18), when the mines accounted for more than $500,000 worth of mercury.

Notably, in 1915, management of the Big Bend Cinnabar Mining Company passed to William D. "Billy" Burcham, who renamed it the Study Butte

Mining Company, and resumed production in January 1916. Burcham wasted no time in designing and installing a "model" 50-ton Scott furnace to increase the productivity of the resuscitated operation. A California-trained engineer with four years practical experience in west Texas, Burcham would, in a few short years, apply his technical "know how" at Mariscal Mine.[7]

As operations in the Terlingua District expanded in number and increased in productivity, other mines, located forty miles to the southeast near Mariscal Mountain, were simultaneously recovering mercury-bearing deposits. While local cattle rancher Martín Solís detected evidence of cinnabar along the northern ridge of the mountain in 1900, no mining appears to have taken place before U.S. Immigration Inspector D. E. "Ed" Lindsey filed numerous claims in what he believed to be Section 34, Block G-3 of Brewster County. A government employee with a flare for investment, Lindsey converted the U. S. Customs headquarters (near present Boquillas Canyon) to a small general mercantile soon after his arrival to the Big Bend region in 1894. Cognizant of the commercial importance of the Solís discovery, Lindsey filed his claims in 1903 and began immediately to mine the high-grade surface ores, which he loaded onto burros for transport to the Study Butte and Terlingua reduction facilities.[8]

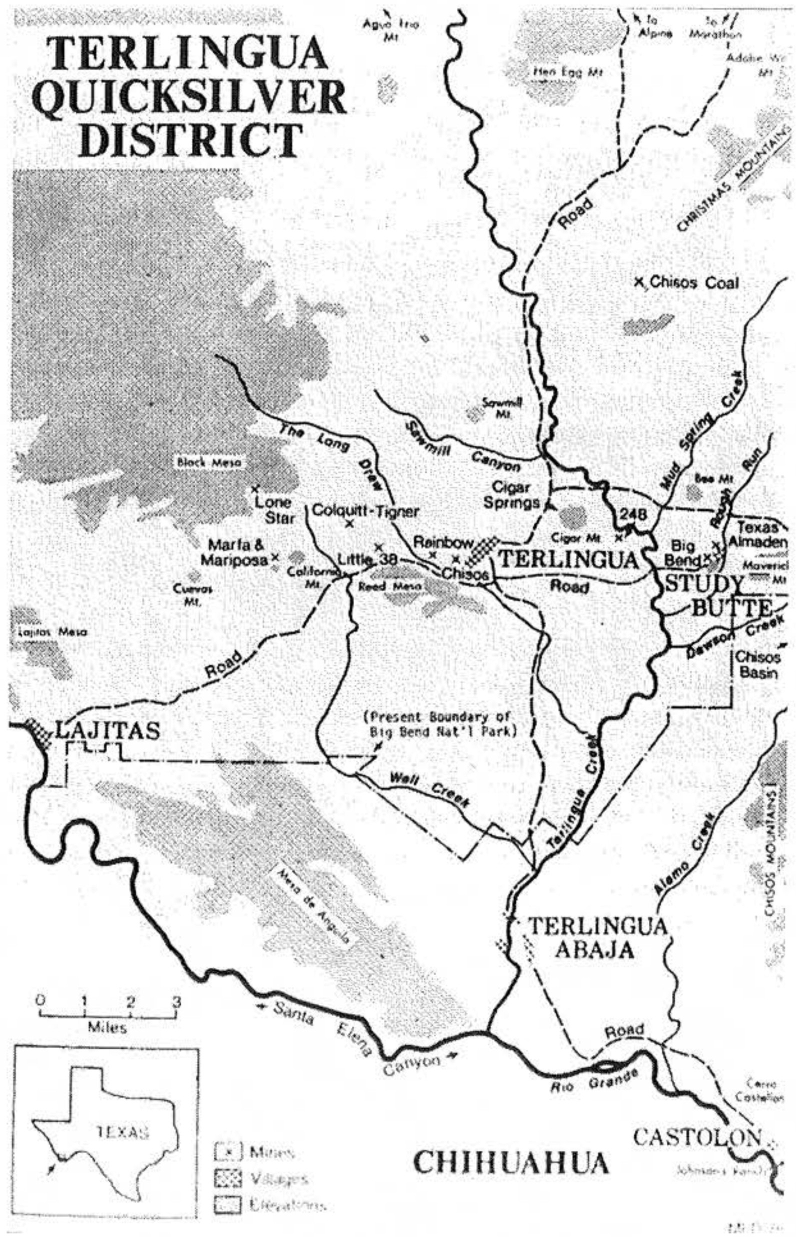

Figure 3. This map shows the numerous quicksilver mining operation sin the Te r-lingua District, located 45 miles northwest of Mariscal Mine. Note the Big Bend Mine in Study Butte, where W. D. Burcham was sup erintendent before relocating on Mariscal Mountain. (Courtesy of Archives of the Big Bend, Chisos Mine Co l-lection, Sul Ross State University, Alpine Texas.)

Not long thereafter, Issac Sanger of Dallas, one of several part owners of the Texas Almaden Mining Company, challenged the so-called Lindsey Mine's claims to Mariscal Mountain in Brewster County court. Sanger and his partners accused Lindsey of developing lands in Section 33, and not Section 34, where Lindsey was said to have filed. The court, therefore, ordered an official survey of the contested area to determine the exact boundary between lands that the Lindsey Mine had filed against those claimed by the Texas company. The survey found in favor of the Dallas-based corporation, and in November 1905 transferred all mineral rights in Section 33 to Sanger's Texas Almaden Mining Company. The following year, Lindsey sold all of his claims to Sanger and returned full-time to his mercantile activities in Boquillas. During his brief occupancy on Mariscal Mountain, the ore Lindsey transported to Terlingua produced a paltry 50 flasks of mercury. Nevertheless, Lindsey reportedly received $35,000 from the sale of his five patented claims.

Sanger's acquisition of Section 34 proved significant. While Section 33, which adjoins it on the west side of Mariscal Mountain, contained most of the valuable mining claims, Section 34 offered a somewhat flatter topography, much better suited to the construction of a reduction facility and all of its appurtenant buildings. Under the direction of H. M. Nesmith, the same superintendent of the Texas Alamaden Mining Company facility in Study Butte, the company carried out extensive exploration on Section 33 and drafted plans to construct a furnace for treating the ores that appeared to be in sufficient quantity to assure commercial success. However, a sudden, dramatic drop in the price of quicksilver forced the Dallas firm to table its plans for the development of Mariscal, opting instead to focus on its Study Butte mine, where a furnace was already operating successfully. Thus the Texas Almaden Mining Company dropped its leases on Mariscal Mountain in 1909, leaving the area virtually unattended until the advent of the First World War.[9]

President Woodrow Wilson's declaration of war on Germany in April 1917, and his subsequent commitment of American troops to France, stimulated an unprecedented demand for quicksilver—especially mercury fulminate--on a global scale. According to writer/historian Kenneth Ragsdale, mercury was "used as a primer to detonate gunpowder in cartridges and shells, [and] became a critical material in war . . . its economic potential multiplied manyfold." Accordingly, mercury production in west Texas alone doubled from an approximate annual output of 4,000 flasks from 1910 to 1915 to an annual average of 8,000 flasks from 1917 to 1919, the highest production level being 10,791 flasks in 1917. Inasmuch as the War Department, as sole purchaser of the strategic metal during those years, paid as high as $125 per flask, the industry flourished as never before, or since.[10]

As the mines of the Terlingua District reaped enormous profits, speculators showed a renewed interest in the idle workings on Mariscal Mountain. In February 1916, W. K. Ellis, a midwestern businessman who first came to Big Bend to establish a wax production plant at Glenn Springs a few miles northeast of Mariscal Mountain, purchased all of the mineral rights previously held by the Texas Almaden Mining Company. In addition to his purchase of Sections 33 and 34 on the northern extreme, Ellis wisely purchased Section 20 near Fresno Creek, a perennial drainage that supplied all of the crucial water consumption needs of the mining operation and its workers. Although Ellis began his endeavor—known variously as the Ellis Mine or the 34 Mine—by simply reworking the high-grade surfaces that Lindsey had previously mined, he eventually sank a shallow shaft along the east face and northernmost end of the mountain. An excerpt from the 1917 *U.S. Mineral Yearbook* noted that by June of that year, the Ellis Mine was working a "50 to 60 foot shaft." This subsurface penetration became the main shaft not only for the Ellis Mine but also for all subsequent mining undertakings.

While it is not certain if Ellis himself designed the processing facilities that accompanied his mining operation, it is known that he underwrote the cost to construct three D-type retorts through which he processed the high-grade cinnabar ore. The same *Mineral Yearbook* entry described the ore-processing machinery as follows:

> Three retorts in which the ore was treated in 1917 are of unusual design, consisting of specially cast tubes 16" in diameter and 12' long set at an angle of 45 degrees. They are charged at the top. The two end ones every 8 hours and the middle one every 6 hours, and discharge at the bottom. About half of the contents are removed before each charging and the total capacity of the 3 retorts is about 4 tons in 24 hours, with a consumption of 1-1/2 cords of wood. A manifold collects the quicksilver vapor and conducts it into small vitrified pipe condensers.[11]

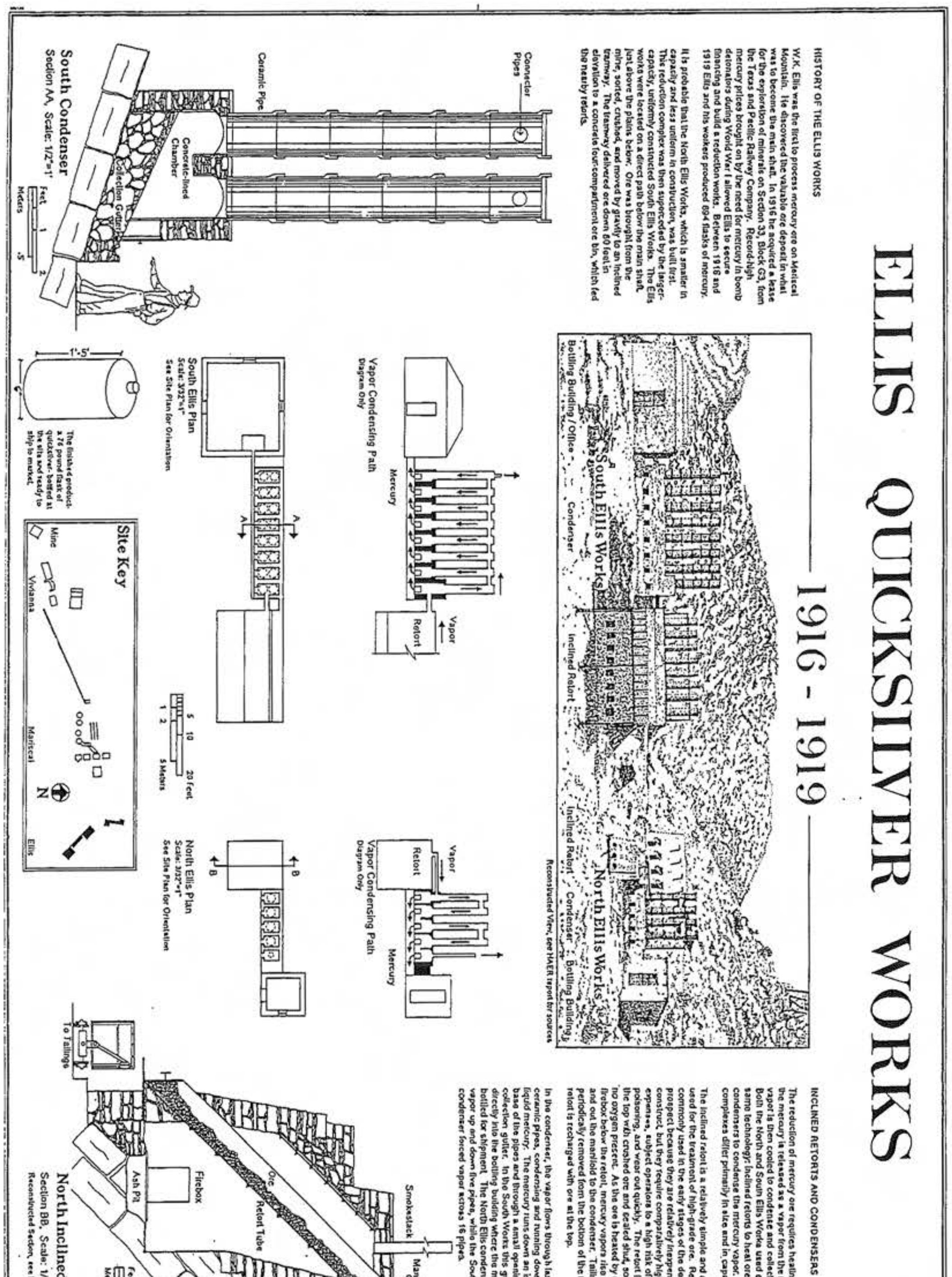

Figure 4. This detailed architectural rendering is a conceptual illustration of how the Ellis Mine retort system appeared while in operation, ca. 1916 to 1919. (Courtesy, Department of the Interior, National Park Ser v-ice, Historic American Engineering Record, Project No. TX -72, Drawing No. 8).

The entry noted further that while these retorts proved to be convenient to charge and discharge and appeared to function satisfactorily, there was an overall loss of quicksilver during processing. Larger retorts, therefore, were planned for installation in 1918 as high-grade ores became exhausted.

Of all the metals, quicksilver is probably the most easily recovered from its ore--cinnabar or mercuric sulfide. It can be easily reduced and, as it can be volatilized at a comparatively low temperature, thus separated without difficulty from nearly all substances that might be present in the ore. The extraction of mercury is based on the simple principle of roasting, which oxidizes the sulfide to produce mercury vapor. According to Curt N. Schuette, coauthor of *The Metallurgy of Quicksilver*, acclaimed as the definitive essay on the mining and processing of mercury, the melting point of cinnabar lies somewhere above 580 degrees centigrade, known as its subliming point. If sublimation alone is to be depended upon to extract the mercuric sulphide content of ore, temperatures somewhat above that melting point are required. When cinnabar is roasted with very little or no air, as when the ore or concentrate is retorted, chemical changes other than those involving oxidation of the sulphide are depended upon to separate the mercury. In the complete absence of oxygen, very little mercury will be released until reaching the subliming point of the cinnabar ore; therefore, during the retort process, furnace workers often added lime to the charge to hasten the release of mercury from its combination with sulphur.[12]

The retort furnace, such as the one employed at the Ellis Mine, was the earliest device used to extract quicksilver from its ore. Generally, the retort furnace served two purposes: it was used in the treatment of selected ore, and to recover quicksilver from the intermediate products of the reduction works—i.e., mercurial soot. Quicksilver retorts are generally made of cast iron, having either a circular or "D-shaped" cross section. They may be mounted singly or linked together in a furnace so arranged that the vaporous gases from the fire box will circulate around all sides of the retort. It is common to encase the retort in fire brick—or as in the case of the Ellis Mine retorts, flagstone—so that the flames from the fire box do not impinge directly upon the cast iron. Designers often used fire-clay throughout the entire length of

Figure 5. This photo demonstrates the resourcefulness of some Mexican mine workers as they adapt to the natural surroundings in order to provide shelter for their families. (Courtesy, Harry Ransom H umanities Research Center, W. D. Smithers Collection, University of Texas, Austin.)

the retort to give added support. Finally, they included two stacks with dampers to closely control the heat of each retort.

As mentioned earlier, each of the three D-type retorts at the Ellis Mine produced 750 to 1,000 pounds per 24-hour period. Typically, workers placed the retort charge in shallow iron pans every 8 to 12 hours. Upon inspection of the early workings in the Terlingua and Mariscal Districts, Schuette commented upon the cost efficiency of the retort reduction method vìs a vìs smaller mining operations: "A small furnace is all that is needed to make a finished product that has a ready cash market."[13]

Although the reduction process itself was simple, it was also labor intensive, thus requiring each mining operation to hire inexpensive labor in substantial numbers. Traditionally, W. K. Ellis previously had employed Mexican laborers at his Glenn Springs wax factory because of their specialized knowledge and experience in reducing the candelilla plant to a wax-like resin. Not unlike his competitors in the Terlingua District, Ellis, too, relied almost exclusively upon poorly paid skilled and unskilled Mexican workers to keep his quicksilver mine functioning. Typically, experienced Mexican miners, many of whom had learned their trade in the Sierra Mojada silver district of southwestern Coahuila, earned $1.25 a day for a ten-hour, six-day work week. By comparison, unskilled miners and common laborers were paid a meager $0.90 a day.

Most of the miners took up residence on the broad plain just below the mine works near Fresno Creek, where they built make-shift hovels of creosote brush or Boquillas flagstone covered with an ocotillo cactus roof into the mountain side. Mexican occupants dug wells along the banks of Fresno Creek, making it the chief water source for the entire mining community. There is evidence on site, however, to suggest that the residents of Mariscal Mountain also dug holding ponds in their effort to capture limited rainfall for community consumption.

Those who did not find employment at the Ellis Mine no doubt made a reasonable living providing related services to the mining community. Among the most critical and immediate needs was firewood. In the absence of abundant fuel sources near the Ellis Mine, Mexican wood haulers used burros to pack huge quantities of mesquite either from the nearby Mexican village of San Vicente or, more likely, from the Chisos Mountains several miles to the northwest. During a 24-hour period, each retort at the Ellis Mine consumed nearly a full cord of wood. For this reason, Mexican wood haulers fared comparatively well inasmuch as good fuel wood typically sold for $5.00 to $7.00 per cord.

While only a short-lived enterprise, the Ellis Mine proved to be the most successful producer of mercury among the three major operations that recovered cinnabar ore on Mariscal Mountain. Historical accounts indicate that the Ellis Mine, active from July 1917 to May 1919, produced and shipped 894 flasks of refined quicksilver, most of which was derived from high grade ore. At its peak, mercury sold for $125 per flask in 1916, dropping to about $117 per flask the following year, $105 in 1918, and eventually to $90 per flask in the final year of Ellis Mine activity. Perhaps intuitively, Ellis quit the mining business and sold out his interest to Billy Burcham, former superintendent of the Study Butte Mine, on the eve of a major quicksilver market recession.[14]

Nevertheless, Burcham set out to develop his newly christened Mariscal Mine with all of the enthusiasm of an undaunted prospector in search of the mother lode. A graduate in 1910 from Stanford University's highly touted mining engineering program, Burcham supervised silver mining operations in Silver Peak, Nevada, and Shafter, Texas, before accepting the superintendency at Study Butte in 1915. On April 24, 1919, Burcham acquired the holdings of W. K. Ellis, including the latter's home at Glenn Springs, where Burcham and his wife, the former Rubye Richardson of Alpine, established headquarters for the recently incorporated Mariscal Mining Company. In partnership with Charles Bondies, August A. Wesserschied, and Baldwin F. Schirmer, three mining speculators from New York, Burcham capitalized his new company at $40,000 and promptly designated himself general manager. It was Burcham's intent to use most of the new capital to modernize Mariscal Mine.

To begin, Burcham extended the shaft that Ellis sank in 1917 to the 250-foot level in hope of penetrating the Buda Limestone formation, where mercury-bearing cinnabar commonly occurs in huge deposits. Notably, during the four years (1919-23) that Mariscal Mine operated, drifting did not extend to

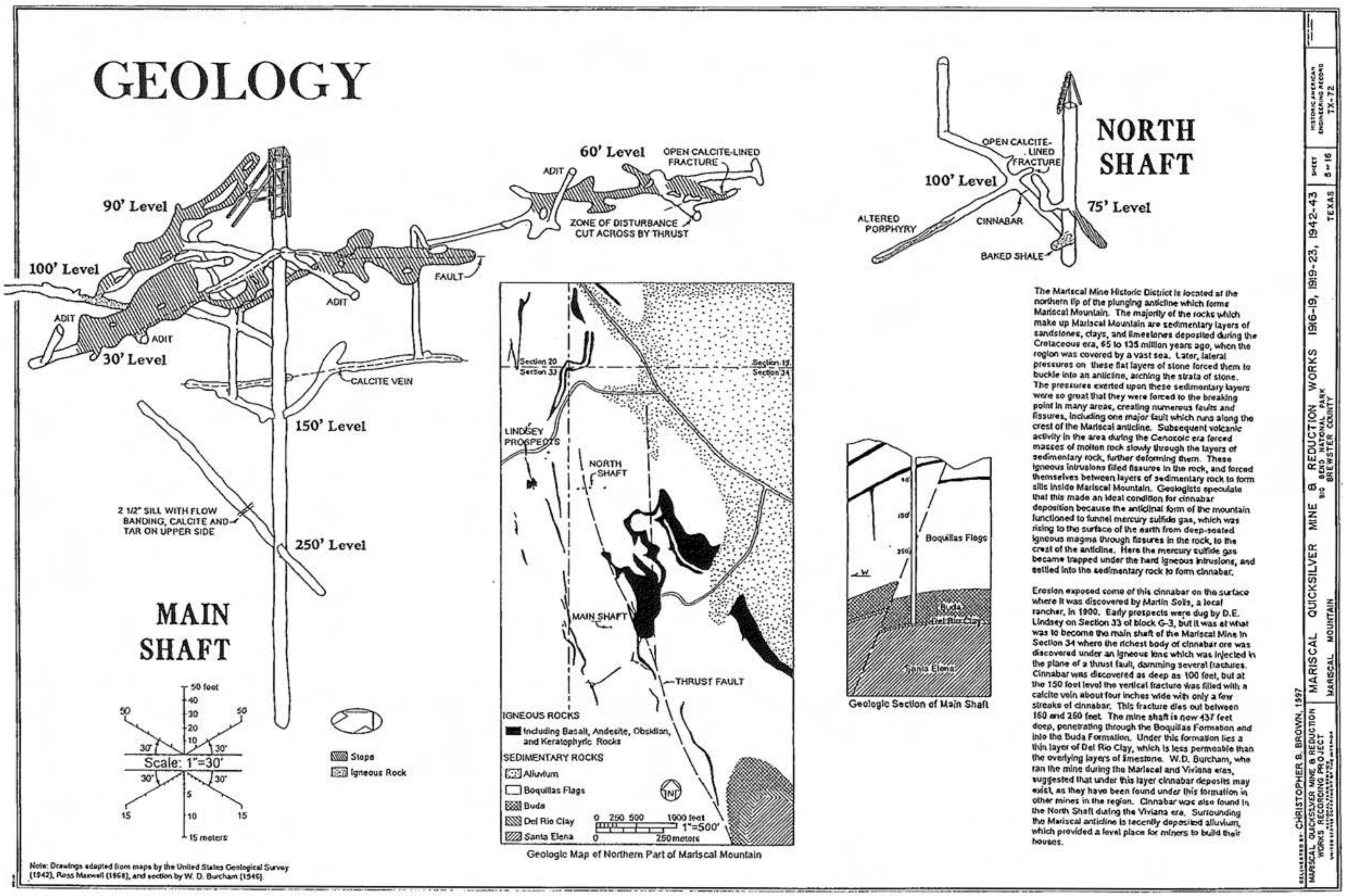

Figure 6. This is an architect's composite drawing of the geology of Mariscal Mine as cited in W. D. Burcham's 1946 report. (Courtesy, Department of the Interior, National Park Service, Historic American Engineering Record, Project No. TX-72, Drawing No. 5.)

the 150-foot level. A more important renovation, however, was Burcham's decision to upgrade the mine's ore reduction system. In consort with Curt N. Schuette, a 1917 graduate of the College of Mining, University of California at Berkeley, and foreman at the mine since its inception, Burcham designed and built a four-tile, four-shaft, 50-ton capacity Scott furnace on the north slope of Mariscal Mountain directly overlooking the old retort furnace system employed by the Ellis Mine. The new furnace—built at the cost of more than $10,000—contained 160,000 locally manufactured bricks for its exterior. In addition, more than 20,000 fire bricks were transshipped by rail from St. Louis to Marathon, Texas, then by freight wagon to the mine site in order to line the interior of the three-story structure. A description of the furnace, which appeared in a 1929 San Francisco publication, noted one characteristic of the Scott furnace at Mariscal Mine that distinguished it from those common to the Terlingua District:

> This furnace differed from the usual type in only one particular. The customary timber buckstays were replaced with structured steel, the uprights being six-inch channels and the belts being eight-inch I-beam with 1-1/8-inch truss rods. These held together at the corners with 1-1/8-inch bolts under the nuts and heads of which were 50-ton car springs. The object of this arrangement was to keep the tension constant. It was apparently satisfactory as no cracks of any magnitude developed in the brick work.[15]

Even though the company exhausted one-quarter of its capital to build the furnace, Burcham no doubt justified the expenditure as necessary to enable Mariscal Mine to become competitive with other local and regional producers.

The ubiquitous Hüttner-Scott furnace (generally known as the Scott furnace) was the uncontested hallmark of the U.S. mercury mining industry for almost a half century. First developed in 1875 at New Almaden, California, by Robert Scott, a furnace mason, and mechanical engineer H. J. Hüttner, the furnace revolutionized the reduction of mercury from its solid to liquid state, making the process both simple and economical. In the Scott furnace one or more pairs of narrow shafts containing shelves of fire-clay tile set at an angle of 45 degrees and placed alternately against the walls of the shafts to form a zigzag pattern replace the open ore shaft. These form a series of inclined hearths down which the ore travels by gravity. The ore is heated by the hot gases emanating from the fire box below, which pass through the flues formed by the inclined tiles. A single shaft usually contains about 26 tiers of tiles, making the vertical dimension of the shaft itself about 30 feet. The length of the furnace is determined by the number of tiles used in each tier, usually from two to five; and the width is determined by the number of shafts (the furnace at Mariscal Mine being a four-tile, four-shaft variety).

The walls that separate the fire box and dust chambers from the ore shafts are called the "pigeon walls" that are perforated by ports or "pigeon holes," which correspond to the flues under the various tiers of tile. The fire box rests directly under the flues in the lower third of the furnace. Hot gases, after traversing through these flues, rise in and pass through the chamber at the rear of the furnace to the next set of flues until they enter the chamber directly above the firebox. Here the gas stream again takes an upward path, and after traversing the flues in the top third of the furnace, passes through the upper dust chamber to the exit pipes. The gas stream thus follows an S-shaped path, and in traversing the ore shaft three times, approximates concurrent flow. Each pair of shafts is charged through a narrow throat that extends the length of these shafts. Meanwhile, the roasted ores are extracted from the furnace at the bottom through an opening known as the "draw." The Scott furnace is usually built on a massive foundation of either masonry or concrete. The furnace is equipped with a mechanical discharger (i.e., ore cart tramway at Mariscal Mine) that delivers the roasted waste into cars in a central tunnel below the structure.

Built of ordinary red brick, most Scott furnaces have external bracing in which the buckstays and horizontal members are generally constructed of timber. Because of the potential for an external fire that could virtually devastate the entire superstructure, some Scott furnaces, such as the one at Mariscal Mine, were braced with structural steel. The designers placed peepholes, made from either rectangular or

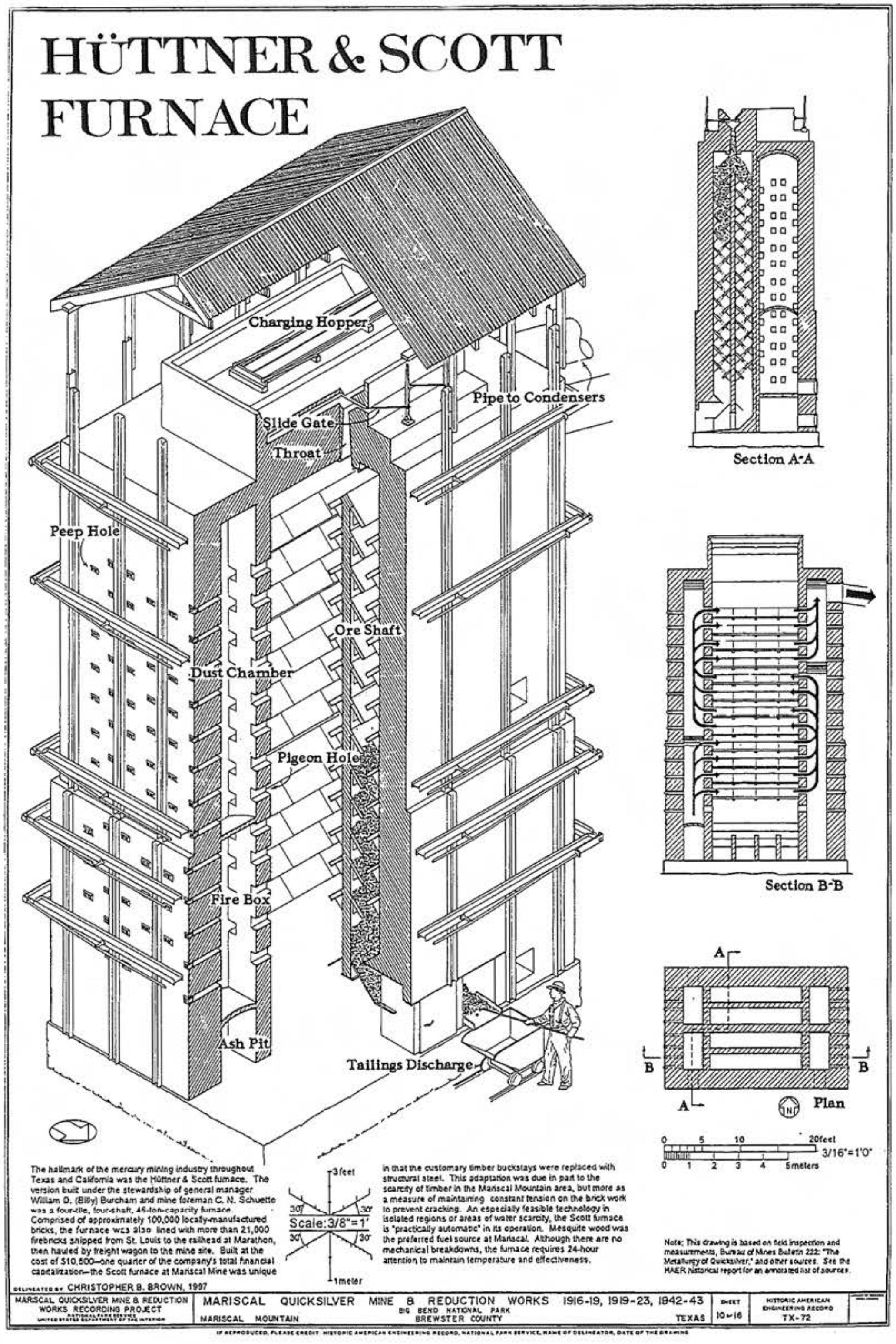

Figure 7. This axonometric drawing is an architect's rendering of the Hüttner & Scott Furnace as it would have appeared during the apex of mining activity at Mariscal Mine, 1919 to 1923. (Courtesy, Department of the Interior, National Park Service, Histor ic American Engineering Record, Project No. TX-72, Drawing No. 10.)

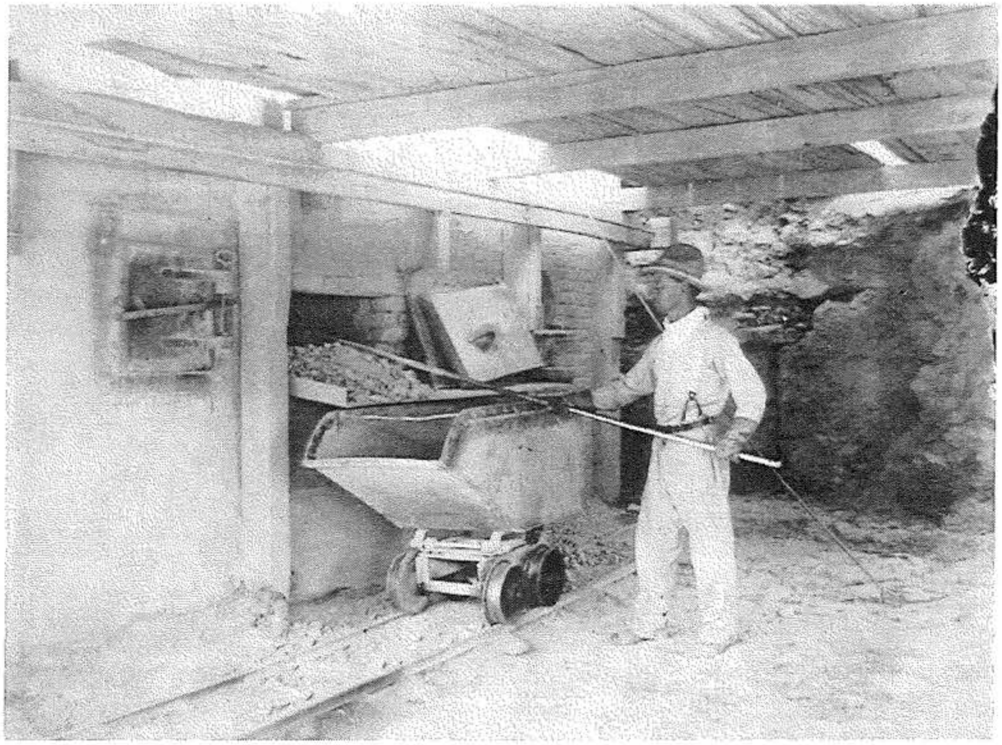

Figure 8. Mexican nationals such as the man pictured here virtually dominated the labor force in the West Texas quicksilver indu stry. This mine worker is shown extracting roasted ore from the Scott furnace. (Courtesy, Marfa Historical Society, Frank Dunca n Collection, Marfa, Texas.)

circular metal plates, on the outer walls of the furnace to correspond with the pigeon holes on the interior walls. In the event of a "hang-up," workers introduced an iron rod through the peephole to loosen the ore. Typically, a four-shaft, four-tile furnace processed 40 to 50 tons of ore in a 24-hour period. Toward the end of its usefulness to the industry, proponents of the Scott furnace heralded the out moded technology as antiquated but nonetheless practical. "It is true that the well-seasoned, saturated Scott furnace functions beautifully," wrote Charles G. Maier in a scientific paper he presented to fellow mining engineers at their October 1929 gathering in San Francisco. "It [Scott furnace] is practically automatic in its operation," he noted, "requiring little attention to keep it in proper working order." "The percentage of [mercury] recovery is among the highest."[16]

From all indications, however, the Scott furnace that Burcham and Schuette installed at Mariscal Mine was plagued with flaws from the outset. According to Lloyd Wade, a former employee of Burcham's who was interviewed several years later, the furnace was inefficient and consequently not as productive as the general manager had envisioned. The mine apparently suffered from other inadequacies that seem to have been manifested in the condenser system. Sometime in 1919, when Burcham and Schuette built the Scott furnace, they also constructed a series of three concrete condenser chambers that were connected to the furnace by large ceramic tubes. These condenser units, only one of which appears to have seen regular use, were connected in turn by four smaller ceramic tubes to a large limestone chimney located about 100 yards uphill. Hoping to reduce the amount of stack loss of refined ore, Burcham erected two large redwood tanks on the east side of the condensers through which all fumes were diverted en route to the chimney.

Despite some detectable inefficiencies, the condenser system at Mariscal Mine functioned in a fashion that was standard to the industry. The heated gases from the furnace ordinarily were reduced in temperature by bringing them into contact with the cooler surfaces of the condenser, in which temperatures were lowered by either air cooling, water,—or as in the case of the Mariscal system—both. Next, the condensed liquid mercury collected in gutter-like drains running along the lower side and bottom of the condensers from which workers collected it into the cast iron flasks for shipment. Oftentimes the resultant residue, or mercurial soot, also required collection and reprocessing to extract all remaining traces of quicksilver. Although the two processes of cooling and collecting were considered separately, in actual operation they functioned simultaneously.[17]

Mariscal mine owners expanded their operation in other ways as well. About one hundred yards downhill from the Scott furnace, directly below the original ore bins and retorts employed in the Ellis operation, the company erected a stone building that served as both a small commissary and the company's main office. Although Burcham paid his laborers in U.S. currency, the company recaptured most of the wages through the miner's purchase of household commodities, clothing and groceries from store manager Rocindo Rodríguez. Above the commissary, the company installed a blacksmith shop, where Filberto Marufo, reportedly a deserter from the Mexican Army, attended to virtually all of the mine's mechanical needs. Opposite his shop, a large concrete platform housed the engine and hoist equipment required to operate the headframe from which large trapezoidal-shaped buckets were lowered into the main shaft. Of the twenty to forty men employed at Mariscal Mine, all were Mexican nationals except Burcham, mine superintendent W. R. Wyatt, foreman Schuette and an unknown brick-kiln specialist. While the company paid its workers little in wages, mine owners did erect twenty or more two-room dry masonry stone and adobe structures as housing. In contrast to these modest dwellings, however, Superintendent Wyatt's residence was a six-room, adobe brick and wood framed house with pitched roof and an unattached garage.

More damaging to the company than its constant mechanical difficulties, were the numerous financial setbacks that plagued Mariscal Mine throughout its active years. Worse still, these monetary crises coincided with a declining commercial demand for proc-

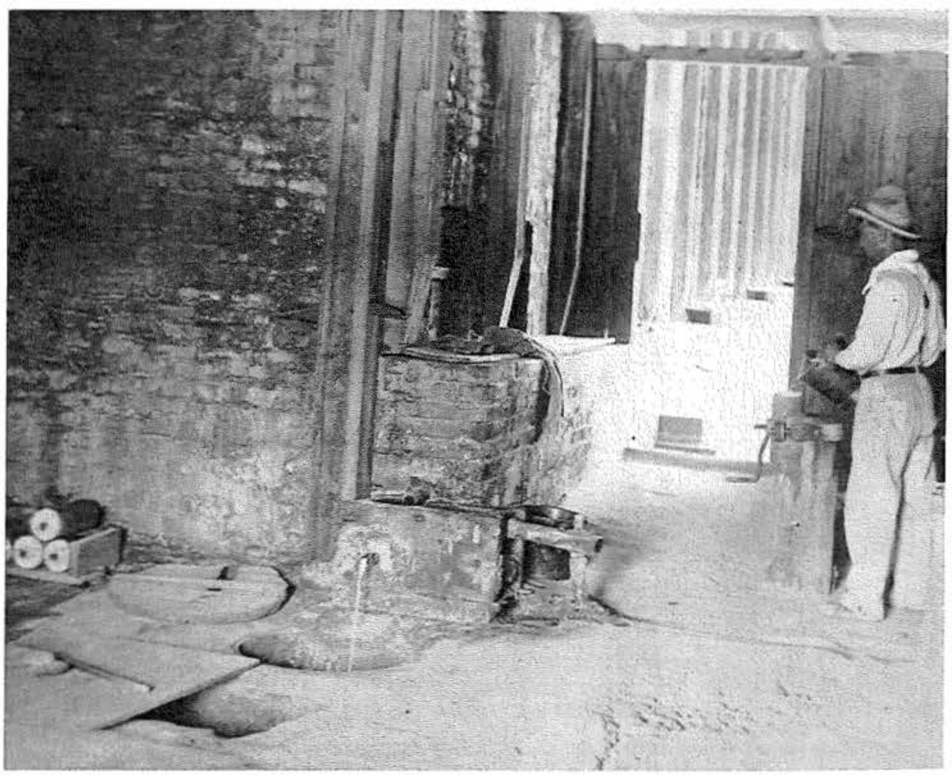

Figure 9. The final step in processing quicksilver is to bottle the resulting liquid (visible at the lower left of this photo) into cast iron flasks that weigh approximately 76 pounds when full. (Courtesy, Harry Ransom Humanities Research Center, W. D. Smithers Collection, University of Texas, Austin.)

Figure 10. Mexican wood haulers such as the man pictured here provided an inval u-able service to the mercury mining industry. These workers earned anywhere from $5.00 to $7.00 per cord of wood. (Courtesy, Arc hives of the Big Bend, Clifford Casey Collection, Sul Ross State University, Alpine, Texas.)

essed mercury. During the four years of operation (1919-23), Burcham found it necessary to refinance the Mariscal Mining Company no fewer than three times. On August 26, 1921, the corporation created a Board of Trustees, which promptly authorized the issuance of 200,000 shares of stock at 10 cents per share to help revive the struggling enterprise. Meanwhile, the San Francisco price for mercury plummeted to $47 per flask, forcing the company to borrow an additional $20,000 against its deed of trust, which included all of its mining properties. For the remainder of its corporate history, Mariscal Mine borrowed money in hope that the market, which did rise modestly to $65 per flask during 1922-23, might eventually rebound.

Apparently, Billy Burcham's hope was never realized. In light of all of these problems, the Mariscal Mining Company produced a mere 394 flasks of mercury before it officially ceased production in 1923. Most of the activity during this period was devoted to exploration and improvement of the mine's facilities at the expense of actual processing. This probably accounts for the meager output Mariscal Mine achieved during its tenure. Following the mine's shutdown, there was no activity at Mariscal for more than a decade. In 1934, H. R. Gard of Alpine attempted to secure financial backing to reopen the mine but failed. Two years later, A. C. Spalding, one of many investors who had loaned money to Burcham, filed a suit against the defunct company in Brewster County District Court. The judge ruled that Spalding had a valid claim. He not only awarded Spalding the sum of $19,687.40 but also ruled that all of the properties of the former Mariscal Mining Company be sold at public auction. Spalding assumed title to all of the mine's properties for a token bid of $100. Notably, the judgement did not carry with it the rights to mineral claims or mineral leases in Section 33, which reverted to their original owner, the Texas and Pacific Railway Company.[18]

Burcham's hope for a resurgence in the commercial market for mercury did not materialize until the advent of the Second World War. As in the first global conflict, the demand as well as the price for mercury soared. In response, Burcham reorganized financially and reopened his mine in 1942 under the new rubric Vivianna Mining Company. Just as he had before, Burcham expanded exploration to create two standard 4 x 5-foot compartments; the main shaft reaching the 438-foot level, and a north shaft extending to about 100 feet. In all, the Vivianna Mine comprised more than 2,000 feet of under-

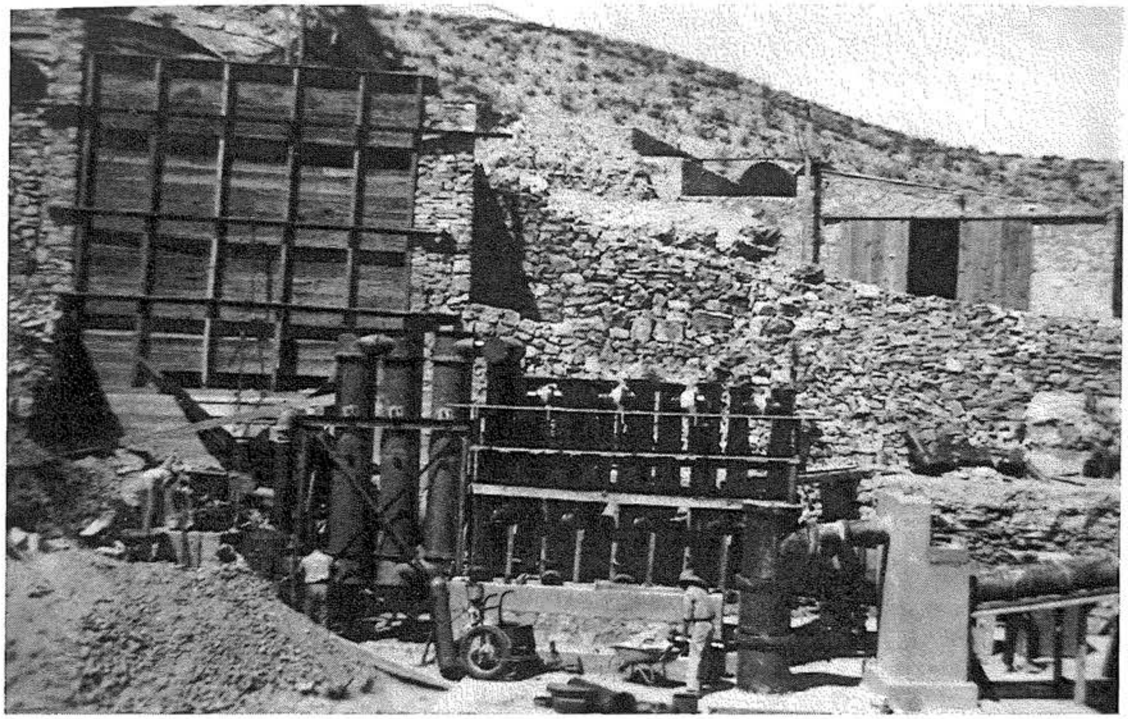

Figure 11. Above is one of only three photos in existence that depict the Vivianna Mining Company while it was still active (ca. 1942). This photo clearly shows the rotary-kiln furnace operation. (Courtesy, Archives of the Big Bend, W.D. Burcham Collectio n, Sul Ross State University, Alpine, Texas.)

ground workings at intervals descending to 250 feet below the surface. Mine owners used a D-13,000 Caterpillar engine to hoist the 9-cubic-foot buckets into and out of the shaft.

Burcham's most notable modification to the previous operation was his installation of a 30-ton Gould-type rotary furnace, which replaced the inefficient Scott furnace that had presented problems since 1919. Not surprisingly, the Chisos Mining Company introduced the first rotary furnace to west Texas. Typically, furnace shells, averaging 50 to 60 feet in length and set at an incline of one foot for every eight feet of pipe extending outward from a firebox, positioned at one end of the kiln over a small pit into which the roasted ore is discharged. Most furnaces rotated at one-third to two-thirds revolution a minute, processing about 30 to 50 tons of ore in 24-hours.

On the whole, rotary kilns were far more productive as well as more efficient than the old Scott furnace. In the latter, for example, the ore is heated very gradually, frequently taking a full day or more to complete the process. With the rotary kiln, such as the model installed at the Vivianna Mine, reduction time never exceeded more than an hour. Because of the short roasting period, however, the grade of ore fed to the rotary furnace had to be fairly standard. A second obvious advantage of the rotary furnace was its mobility. Unlike the Scott furnace, the rotary kiln could be easily disassembled and moved whenever necessary. Impressed with this latest technology, it may have been Burcham who ordered the Scott furnace partly dismantled in an effort to reprocess the mercury-soaked brick.[19]

It appears that Burcham harbored great expectations for the Vivianna Mine because the company built ten additional three-room concrete houses for its workers, which apparently were never occupied. In the end, even modern technology and Burcham's implacable optimism could not make the Vivianna Mine a commercial success. In fact, during its two years of production, Burcham's latest venture accounted for a sum total of 97 flasks of mercury before the company once again succumbed to financial distress. The 83rd Judicial District Court in Alpine declared the Vivianna Mining Company insolvent in late 1944. Accordingly, the judge declared the debt-ridden company dissolved and ordered it into receivership. Not one to surrender easily, Burcham made one last futile attempt to salvage the operation in a proposal submitted on December 21, 1946. The plan, it seems, was never executed.

What remained of the Vivianna Mining Company, a disparate array of structures and mining equipment that had accumulated since the Ellis Mine undertaking in 1916, was sold to the highest bidder for $7,250. In 1948, Robert N. Pulliam, owner of Bob's Mining Company, disassembled most of the functional equipment, transporting it to the Terlingua District, where mines such as the Maggie May remained operational. Portions of the Gould rotary furnace were reported to have been sent to Arizona in the mid-1950s to be put to use in the reduction of uranium. As for Burcham, he remained in the Big Bend region reportedly lending his expertise to the Puerto Rico Mining Company of Coahuila, Mexico. On May 31, 1972, at the age of 87, the indefatigable William David Burcham died in Brewster Memorial Hospital, Alpine, Texas. With his demise, the forty-year odyssey of mercury mining on Mariscal Mountain came to an end.[20]

For all intents and purposes, the mercury industry in Texas ceased to exist with America's entry into the Cold War, as strategic interests shifted away from mercury fulminate to fissionable materials such as uranium. While some small-scale exploration and sporadic production of mercury continued at the Study Butte Mine (Diamond Shamrock Corporation) into the mid-1960s, domestic demand for quicksilver was marginal. In recent years, the development of mercury substitutes coupled with a growing awareness of the environmental effects of the metal, accelerated a downward tendency in its commercial value. Moreover, United States producers can no longer effectively compete with their European competitors because of the latter's labor cost advantage. During the past two decades, mercury imported from Canada, Spain, Algeria, Yugoslavia, and Mex-

Figure 12. This photo shows the now abandoned mineworks on Mariscal Mountain as they appear today within the confines of Big Bend National Park. (Courtesy, Department of the Interior, National Park Ser v-ice, Big Bend National Park, TX.)

ico have supplied America's domestic needs.[21]

Today, embraced within the boundaries of Big Bend National Park, the long abandoned mineworks of Mariscal Mine enjoy the protection of the federal government. Literally only a shell of the mining operation stands in evidence of nearly a half century of social and economic activity. On the westernmost end of the site are the remains of the mining community that once housed an estimated 40 to 50 Mexican nationals in addition to the non-Hispanic mine superintendent and foreman. Scattered across the plain are numerous unroofed remains of rudimentary shelters as well as more traditional housing in various stages of deterioration. As one ascends the steep incline toward the mineworks, the hollow remains of the Ellis retort operation become more defined. Fragments of ceramic tile that once formed the condenser system are dispersed all around, but the stone-lined casings of the south retort system remain intact. Those on the north side, while discernible, are partially covered by tailings produced during subsequent operations.

Immediately overlooking the Ellis mineworks are the structures that best represent Mariscal Mine at the apex of its activity. Most striking is the nearly collapsed Scott furnace partially inset into the side of the mountain, unmistakable because of the thousands of mercury-soaked red bricks riddled all around the once massive structure. More imposing, however, are the three sentinel-like condensers, whose sunbaked masonry and concrete walls are visible for miles as one approaches the site via Old River Road. These sturdy structures, too, are mostly skeletal representations of their former appearance. Occasional fragments of decayed timbers and twisted metal suggest the labyrinth of wooden trusses and steel rails that once comprised the main ore delivery system. Near the pinnacle of the mountain stands the abandoned wreckage of the Vivianna Mine and the now metal-grated shaft from which marketable ore was once removed. At this level, one encounters the few existing indications of the mechanical equipment that represented the heart of the mining activity. Most impressive is the rust-covered fire box that once fueled the rotary kiln. Detectable, too, are the metal anchor bolts upon which the main hoist was fixed in order to raise and lower the now heavily oxidized ore buckets, which now lie dilapidated from years of disuse.

For nearly a century, mercury production reigned supreme in west Texas. Today, eclipsed by the overpowering oil and gas production that has become the economic mainstay of the Permian Basin, the contributions of the once-thriving quicksilver industry have all but faded. More telling, is the gradual disappearance of its technology, which enabled the industry to sustain itself. For this reason, Mariscal Mine, despite obvious signs of decay and abandonment, assumes increasing importance in the social and economic history of the Big Bend region with the passage of each successive year. Embraced within the boundaries of the national park, Mariscal Mine, perhaps more than any other mining complex to survive the astringent environs of the Trans-Pecos region, best illustrates the Texas mercury mining industry from its boisterous beginnings to its silent demise.

NOTES

1. The Historic American Engineering Record is a Washington-based federal program that the U.S. Congress established in 1969 for the purpose of documenting outstanding works of engineering and industry that are to be preserved in the Library of Congress. The major portion of this essay is an extract from the project completed for the National Park Service in the summer of 1997.
2. Roger D. Sharpe, *Development of the Mercury Mining Industry: Trans-Pecos Texas*, Mineral Resource Circular No. 64 (Austin: Bureau of Economic Geology, 1980), 13; J. Harlan Johnson, "A History of Mercury Mining in the Terlingua District of Texas," Part I, *The Mines Magazine* (September 1946), 190-91; Clifford B. Casey, *Soldiers, Ranchers and Miners in the Big Bend* (Santa Fe: Department of the Interior, National Park Service, Southwest Regional Office, 1969), 211-13.
3. Lindell, *The Handbook of Non-Ferrous Metalurgy (1926)*, 1, 227; Carey McWilliams, *North from Mexico: The Spanish-Speaking People of the United States*, (1949; reprint, New York: Greenwood Press, 1968), 139-40; Sharpe, *Mercury Mining Industry*, 11; Casey, *Soldiers, Ranchers and Miners*, 209-11; "Mercury Potential of the United States," Bureau of Mines Information Circular 8252 (Washington, D.C.: Department of the Interior, Bureau of Mines, 1965), 338.

4. Casey, *Soldiers, Ranchers and Miners*, 215-19; Sharpe, *Mercury Mining Industry*, 9-13; Arthur R. Gómez, *A Most Singular Country: A History of Occupation in the Big Bend* (Provo: Brigham Young University, Charles Redd Center for Western Studies, 1994, 2d printing), especially 113-29; C. N. Schuette, *Quicksilver, Bureau of Mines Bulletin Number 335*, 3-7.
5. Johnson, "Mercury Mining in the Terlingua District," Part I, 392-94; Kenneth Baxter Ragsdale, *Quicksilver: Terlingua & the Chisos Mining Company* (College Station: Texas A & M University Press, 1995, 3d printing), 16-18.
6. Ragsdale, *Quicksilver*, 22-79; Gómez, *A Most Singular Country*, 122-23. Statistics on Chisos Mine as cited in Sharpe, *Mercury Mining Industry*, 13.
7. Johnson, "Mercury Mining in the Terlingua District," Part I, 392-94; Sharpe, *Mercury Mining Industry*, 20, *Alpine Avalanche*, June 8, 1972.
8. Clyde P. Ross, "Quicksilver in the Terlingua Region, Texas," *Economic Geology*, 36 (n.d.), 119; Gómez, *A Most Singular Country*, 116, 126; Brewster County Mining Records, vol. 1, 527-38; Brewster County Deed Records, vol. 9, 119.
9. Brewster County Deed Records, Vol. 35, 546; Casey, *Soldiers, Ranchers & Miners* 224-26; Ross Maxwell, "The Mariscal Mine," in Paul H. Pausé and R. Gay Spears, eds, *Geology of the Big Bend Area and Solitario Dome, Texas* (Austin: West Texas Geological Society, 1986), 274.
10. Quote as cited in Ragsdale, *Quicksilver*, 14; Production statistics as cited in J. Harlan Johnson, " A History of Mercury Mining in the Terlingua District of Texas," Part II, *The Mines Magazine* (October 1946), 447.
11. Gómez, *A Most Singular Country*, 126-27; Casey, 226-28; Excerpts from *Minerals Yearbook, 1917* as cited in William D. Burcham, "Geological Report: On the Vivianna Mine, Sections 33 and 34, Block G-5, Brewster County, Texas, 1946" Exhibit B, 4 in W. D. Burcham Collection, Archives of the Big Bend, Special Collections Library, Sul Ross State University, Alpine, Texas, Box 2; Reference to "The 34 Mine" in Walter Harvey Weed, ed, *The Mines Handbook: A Manual of the Mining Industry of the World*, vol. 14 (New York: W.H. Weed, 1920), 1338.
12. The author derived most of the technical and processing information included in this essay directly from L. H. Duschak and C. N. Schuette, *Metallurgy of Quicksilver*, Bulletin 222 (Department of the Interior, United States Bureau of Mines, 1925), 4, 7-11.
13. Ibid., 142-45; for other detailed information on retort furnaces see, Lewis E. Aubury, *Quicksilver Resources of California*, Bulletin 27, (Sacramento: California State Mining Bureau, 1908), 200-08; Walter W. Bradley, *Quicksilver Resources of California*, Bulletin 71 (Sacramento: California State Mining Bureau, 1918), 210-17; Burcham, "Geological Report on the Vivianna Mine," Exhibit B, 4; Schuette quote as cited in, *Quicksilver, Bureau of Mines Bulletin Number 335*, 3.
14. For additional information on the Ellis wax production plant at Glenn Springs, which W. D. Burcham purchased from Ellis in 1919 along with the mining operation at Mariscal Mountain see, Curtis Tunnell, *Wax, Men, and Money: A Historical and Archeological Study of Candelilla Wax Camps along the Rio Grande Border of Texas*, Report 32, (Austin: Texas Historical Commission, Office of the State Archeologist, 1981), 6-10; Casey, *Soldiers, Ranchers and Miners*, 228, 244-49; Production statistics for these years as cited in Johnson, "Mercury Mining in the Terlingua District," Part I, 393-94, Part II, 447.
15. J. A. Udden, "Report on Quicksilver Mine on Section 33, G-3, D. & W. Ry. Co. in Brewster County, Texas, and Adjoining Claims in Section 34 of the Same Block," Exhibit B, 4, in Burcham, "Geological Report on Vivianna Mine"; information on Schuette's college training in, *Metallurgy of Quicksilver*, 8, fn. 16; detailed description of Scott furnace at Mariscal Mine as cited in Charles G. Maier, "The Present Status of Our Quicksilver Industry," in *Quicksilver Industry in 1929*, Technical Publication 64 (New York: The American Institute of Mining and Metallurgical Engineers, 1929), 22-23; Casey, 228-43.
16. Duschak and Schuette, *The Metallurgy of Quicksilver*, 47-51; quote on efficiency of Scott furnace cited in, Maier, "The Present Status of Our Quicksilver Industry," 21-22.
17. Casey, *Soldiers, Ranchers and Miners*, 234-37; Lloyd Wade interview with Clifford Casey, February 27, 1968, Oral History Collection, Big Bend National Park; J. Harlan Johnson, "A History of Mercury Mining in the Terlingua District of Texas," Part III, *Mines Magazine* (March 1947), 30.
18. Casey, *Soldiers, Ranchers and Miners*, 228-32, 244-49; references to W. R. Wyatt as Mariscal Mine superintendent cited in, Weed, *The Mines Handbook*, 1922, 1475; production statistics for Mariscal, Ibid., 1926, 1453 Maxwell, "The Mariscal Mine," 276.
19. Burcham, "Geological Report on the Vivianna Mine," 1-3; Robert G. Yates and George A. Thompson, *The Viviana [sic] Quicksilver Mine, Mariscal Mining District, Brewster County, Texas*, Press Release #27684, October 12, 1943 (U.S. Department of the Interior, Geological Survey, Washington), 1-3; for detailed discussion of rotary furnace see, Duschak and Schuette, *Metallurgy of Quicksilver*, 94-97; on advantages of the rotary kiln see, Maier, "Present Status of Quicksilver Industry," 21-25.
20. Burcham, "Geological Report on the Vivianna Mine," 4-8; Casey, *Soldiers, Ranchers and Miners*, 242-44; *Alpine Avalanche*, June 8, 1972.
21. Sharpe, *Mercury Mining Industry*, 27.