NPS Form 10-900-b
(Revised March 1992)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

This form is used for documenting multiple property groups relating to one or several historic contexts. See instructions in *How to Complete the Multiple Property Documentation Form* (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer, to complete all items.

XX New Submission ____ Amended Submission

A. Name of Multiple Property Listing

The Mining Industry in Colorado

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

Precious and Base Metal Mining Industry in Colorado: 1858–2005
Industrial Metals Industry in Colorado: 1870–2005
Coal Mining Industry in Colorado: 1858–2005
Mining Technology, Methods, and Equipment in Colorado: 1858-2005

C. Form Prepared by

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organization Private contractor / Mountain States Historical date June 30, 2006 (revised July 27, 2008)

street & number 687 W. Linden St. telephone ____

city or town Louisville state CO zip code 80027

D. Certification

As the designated authority under the National Historic Preservation Act of 1966, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation.
(See continuation sheet for additional comments [ ].)

State Historic Preservation Officer
Signature and title of certifying official Date

State Historic Preservation Office, Colorado Historical Society
State or Federal agency and bureau

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

Signature of the Keeper Date of Action

The Mining Industry in Colorado
Name of Multiple Property Listing

Colorado
State

Table of Contents for Written Narrative

Provide the following information on continuation sheets. Cite the letter and the title before each section of the narrative. Assign page numbers according to the instructions for continuation sheet in *How to Complete the Multiple Property Documentation Form* (National Register Bulletin 16B). Fill in page numbers for each section in the space below.

Primary location of additional data:

☒ State Historic Preservation Office
☐ Other State Agency
☐ Federal Agency
☐ Local Government
☐ University
☐ Other

Name of repository:
Office of Archaeology and Historic Preservation
Colorado Historical Society

Statement of Historic Contexts

Introduction

Mining was far and away the most significant industry in nineteenth- and early twentieth-century Colorado and has remained important since that time. The Pike's Peak Gold Rush brought unprecedented numbers of people into the region and that in turn led to powerful social, economic, and political changes that brought about the creation of Colorado Territory in 1861, culminating in the admittance of Colorado to the Union in 1876. Mining in all its phases remained the great engine of the Colorado economy until the early twentieth century. The industry also contributed to significant technological advances and that, combined with the professional studies of all aspects of the industry, had powerful ramifications in the industry's global expansion in both the nineteenth and twentieth centuries. Though sometimes derided as a "mom and pop" industry and one of quaint ruins, mineral development in the Centennial State both reflected and contributed to the dramatic industrial and technological advances of the late nineteenth and twentieth centuries. Moreover, the powerful advance of industrial metal mining, coupled with immense coal production, contributed immeasurably to state, national, and international development.

The topic of mining is much too large for a comprehensive in-depth treatment here. Rather, this document seeks to provide a basic historical overview of mining activities and related technology in order to assist cultural resource professionals, landowners and managers, and the general public in identifying and evaluating mining and mining-related properties in relation to the eligibility criteria established by the National Register of Historic Places. The document focuses on the three closely related mining industries–precious and base metals, coal, and industrial metals. The geographic area includes the entire State of Colorado, although mining activities, particularly of metal ores, occurred primarily in the mountainous western half of the state. As the document's title infers, the historic contexts relate to the business and technology of the major mining functions of extraction, beneficiation and refining. The development of railroad transportation is also discussed, as railroads and mining grew, prospered, and declined in a symbiotic relationship.

Several related topics are treated only superficially. Mining supply operations involved the development, manufacturer and delivery of the many pieces of specialized equipment necessary for successful ore mining and processing. While much of this equipment is discussed in the mining technology context, the actual business practices of mining supply and equipment are left for other venues.

Similarly, the commercial, residential, social and ethnic history of mining camps and towns is only broadly sketched here. Future historic context development in each of these areas will greatly aid in an understanding of the human aspects of mining history. Labor history is also limited to a general outline of some of the more prominent events and movements.

Excluded entirely for reasons of topic manageability are the oil and oil shale industries and the gravel and stone quarry industries. Each of these important resource industries deserves its own in-depth treatment.

Part I – The History

1. The Precious and Base Metal Mining Industry in Colorado: 1858–2005

1.1 Introduction: Before Pike's Peak Gold Rush

Nobody knows who made the first discovery of gold and silver in Colorado. The earliest record dates to the 1760s, probably 1765, when the Spanish explorer Juan Maria de Rivera led a party into the San Juan Mountains ostensibly searching for a non-desert route from Santa Fe to California. While in the region, he and others in his party apparently discovered gold or silver (or both) in what is believed to be Baker's Park, the site of present-day Silverton. What mining took place there in the years that followed remains conjectural. Some surreptitious extraction may have evolved in the late eighteenth or early nineteenth century–and the word *la plata* (Spanish for silver) as an element of various placenames suggests that there was–but if so, these first miners kept their work secret to avoid paying taxes to the Spanish crown. In the 1860s and 1870s, American miners may have found evidence of Spanish efforts, but that evidence was lost in new development. If the Spanish miners did indeed recover gold, silver, or other metals from ore, production must have been small and inconsequential. It produced no rush or permanent settlement, but probably initiated or contributed to the rumors of gold in the Rocky Mountain region.

Fur trappers in search of beaver began pushing into the Rocky Mountains toward the end of the eighteenth century, and their work in the cold remote waters led to gold discoveries. Perhaps the earliest evolved from the work of James Purcell, a trapper out of St. Louis. Around 1800, he found gold in what is today South Park, in central Colorado, but fled the Rockies to escape hostile Indians. News of his discovery, reported to the explorer Zebulon Pike at Santa Fe in 1807, remained buried in Pike's journals, lost until the mid-twentieth century, and so Purcell's discovery and probably that of others, had little, if any, direct impact on the rise of gold and silver mining. Nonetheless, the rumors and unconfirmed reports spread by trappers and traders about gold in the mountains formed part of the basis that eventually led to mining development decades later.

These early discoveries were also caught up in the political intrigues and territorial transfers that eventually made the region part of the United States. In 1800, Spain transferred Louisiana to France, which in turn, in 1803, sold it to the United States in the famous Louisiana Purchase. Although both the transaction and the boundaries were disputed, the southwestern boundary of Louisiana became the Arkansas River via the Adams-Onis Treaty with Spain in 1819, and later the international boundary with Mexico following its independence from Spain in 1821. Beginning in 1836, the new Republic of Texas made illegitimate claims to some of this area. Finally, in 1848, via the Treaty of Guadalupe Hidalgo, the United States acquired vast new lands south and west of the Arkansas, some of which eventually made up the remainder of the territory that would one day comprise the State of Colorado. Aside from rumors and unconfirmed reports, however, there was little inkling of the vast treasure in gold, silver, and other metals in the region and no perception of the sudden transformation their development was soon to bring.

What altered everything were events in California. In January 1848, James Marshall, a carpenter from New Jersey, discovered gold at John Sutter's sawmill on the American River in north-central California. Although he and Sutter tried to keep the discovery secret, that effort failed, and the sensational news of the "royal metal" touched off the California Gold Rush. It drew thousands of people from all over the world, stimulated underground mining, and set in motion the search for gold throughout the entire American West.

As the California Rush mounted in the very late 1840s and early 1850s, thousands of argonauts hurried west on the various trail systems from the Missouri-Mississippi Valley area. Among the most important was the

Santa Fe Trail. Would-be miners followed it west to around present-day Pueblo, then turned north to follow Fountain Creek to the future site of Colorado Springs. From there they continued north over Monument Divide to pick up Cherry Creek, which they traced northwesterly to its junction with the South Platte River at the site of what is now Denver. From that point, they continued their northern journey to pick up the Overland Trail to California in what is now southern Wyoming. There were variants on this passage because of the different trails in the High Plains Region, but the key was that the journey brought many people into the environs of what became Denver.

The consequences were significant. Throughout the 1850s, argonauts bound for California made an uncounted number of gold discoveries along Cherry Creek, at its junction with the South Platte River, and other locations in the general vicinity. Among the first was that of a Lewis Ralston and possibly a John Beck who found the royal metal on what is today Ralston Creek in Arvada, a few miles northwest of Denver. Findings like this added to the unconfirmed accounts the fur trappers had left behind, and so the rumors of gold at “Pike’s Peak” continued to grow. The mountain actually lay some 60 miles south of these discoveries, but it was the only major landform identified by name on most maps of the region. Finally, in the winter of 1857/58, William Green Russell, a Georgia miner who had found gold on this very route while traveling to California some years before, put together a prospecting party to make a systematic search for the metal. This group, augmented by a group of Cherokees led by John Beck from the Indian Territory (present-day Oklahoma), arrived on Cherry Creek in the late spring of 1858. They found inconsequential signs of gold here and there, but eventually, as they traced the stream north and west, they found a substantial deposit of placer gold at the stream’s junction with the South Platte River. It was this discovery that touched off the Pike’s Peak Gold Rush, generally associated with the year 1859, although it actually began in 1858 and continued on until an indefinite time in the early 1860s.

1.2 Pike’s Peak Gold Rush and Placer Mining: 1858 to the early 1860s

Russell’s famous discovery on Cherry Creek was an outgrowth of many years of work.[1] He traveled there by heading north along the Front Range of the Rockies, and somewhere along Cherry Creek, probably near its junction with the South Platte River, Russell became one of many to find gold, but he hurried on to California with his companions. At some point, he struck up a friendship with Beck, a Cherokee originally from Georgia, but like others, forced out and thrust into the Indian Territory by Jackson’s controversial Indian removal policies. How Beck and Russell met remains conjectural, but in the winter of 1857/58, they resolved to make a systematic search for placer gold they both had found along the Front Range of the Rockies.

They took the familiar route west. They journeyed along the Santa Fe Trail to where Fort Pueblo had once stood (in downtown Pueblo today), then headed north along Fountain Creek, crossed the divide to pick up Cherry Creek, and then followed it north to its confluence with the South Platte River (Fig. E.I.1). As they went, they probably began finding traces of gold, or gold colors, on Dry Creek (near present-day Dry Creek Road), but not enough to hold them. They finally reached the junction of Cherry Creek and the South Platte, and there they found a substantial deposit of placer gold and set to work in June of 1858. Russell and his 50 associates were ecstatic about the prospect of sudden wealth, but their dreams quickly dissipated. The placer held too little gold to make them wealthy, so little in fact that Russell and others actually left for Montana for a time. As chance would have it, however, an itinerant trader named John Cantrell happened upon the prospectors’ camp. He traded goods for gold, then headed east. The farther east he got, the more that Russell’s minor discovery seemed in his mind like the second coming of the California Gold Rush. He related his account to merchants and newspaper editors, and they passed the word. With the Midwestern economy still in the throes of recession caused by the nationwide

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[1] An experienced miner from Auraria, Georgia, one of America’s few gold regions prior to the California Rush, Russell had taken one, if not two, trips to the “Golden State” in the early-to-mid-1850s.

economic Panic of 1857, these people proclaimed what was in reality an insignificant discovery as the second coming of the California Gold Rush. Pike's Peak Gold Rush was on!

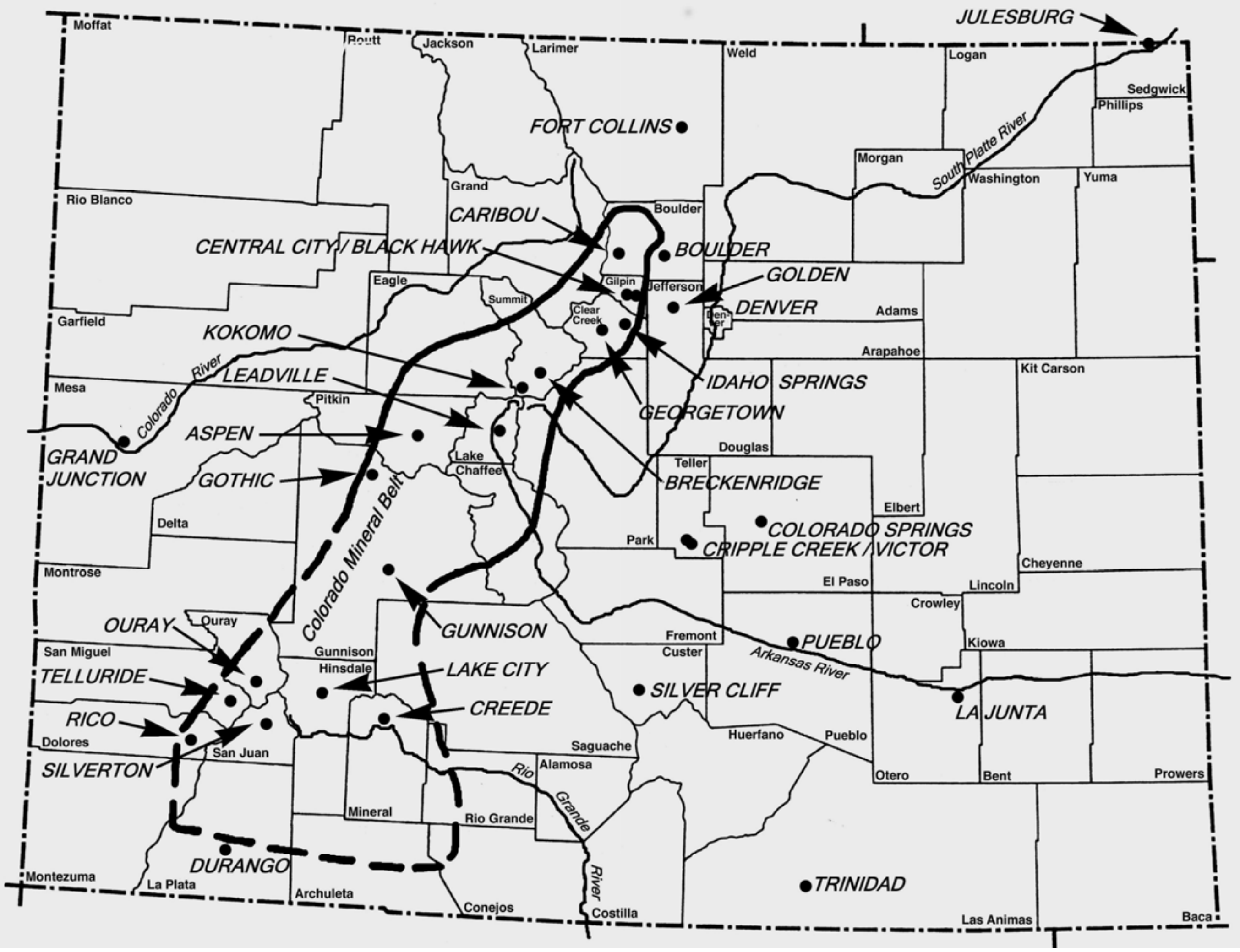

Fig. E.I.1 The Colorado Mineral Belt showing precious and base metals.

The new Rush began to take shape in the fall of 1858. The first "boomers"–eventually known as "'58ers"–had begun to stream in, often in ones and twos, and sometimes in small groups. They spread out across the High Plains searching for gold and creating the region's first mining camps, towns, and townsites: among them Montana City, St. Charles, and Auraria City along the banks of Cherry Creek, Arapahoe (no longer in existence) off toward the future "Golden City" (now Golden), and "Boulder City" (now Boulder), at the site of large red boulders where Boulder Creek enters the Plains from the mountains. There were others, too, for the most part log towns and tent cities. All of these first developments, however, rested more on hope than anything else. The reality was that the '58ers had found very little gold. And that in turn meant that a fiasco loomed all along the High Plains as thousands of argonauts began heading west to "Pike's Peak."

What saved the Rush were the events of that fall and winter. Among the ‘58ers moving into the region were John Gregory and George A. Jackson. Both had similar backgrounds; Gregory had mined gold in Georgia and California, and Jackson in California. In the fall of 1858, Gregory found himself at Fort Laramie on his way to the West Coast once again, but with winter settling in, he realized that it was too late to continue his trip. As the news of the discoveries at Pike’s Peak filtered north, Gregory decided to make his way to Cherry Creek. He quickly realized that the discoveries there and at Arapahoe held little gold, but as the year ended, he decided to venture into the mountains. Heading up what is now Golden Gate Canyon north of Golden, he made his way to a branch of the Vasquez Fork of the South Platte River, a stream now known as North Clear Creek. From here, he worked his way south until he found a rich placer deposit in the gulch that now bears his name–Gregory Gulch–located between the sites of what were to become the towns of Central City and Black Hawk. It was now winter. He retreated from the mountains and fell in with some ‘58ers waiting out the season at Arapahoe. This was known as the Indiana Party, consisting of a small group of prospectors from South Bend, Indiana.

At the same time, Jackson was making his way west with a larger party. In the late fall of 1858, while this group made camp probably in the general area of present-day Loveland, Jackson left, ostensibly on a hunting expedition, although his actions suggest that he was really searching for placer gold. He visited Denver, concluded that there was little gold there, then headed west, to ascend what is now known as Mt. Vernon Canyon. Eventually, he made his way to Chicago Creek, just south of today’s Idaho Springs. Here in January 1859, he found a rich deposit of placer gold. With winter growing more intense, he concealed the site to make it look like a hunter’s camp, then retreated to the High Plains to rejoin his companions. Like Gregory, he apparently did not tell them of his discovery.

Fig. E.I.2 Panning and sluicing in the Pike’s Peak Gold Rush, 1859. Collection of James E. Fell.

In the late winter and early spring of 1859, the "'59ers" began arriving in "Denver City" (now Denver) and other incipient towns only to confront the reality–there was little gold at the site of the Russell and other "diggings." Many would-be miners, discouraged by the truth and low on supplies, turned around and went home–the "go-backers," as they were termed. Just at that time, however, Gregory revealed his discovery to the Indiana Party and Jackson his findings to his companions. The Indiana Group persuaded Gregory to take them to the site where they now began developing the rich placer in what soon became known as Gregory Gulch. Jackson took his group back to his site on Chicago Creek. Placering at both locations now commenced in earnest.

As the news of these discoveries burst over the High Plains, many of the '59ers surged into the mountains–some bound for the site of the Gregory Diggings and others for the site of the Jackson Diggings. What this meant was that during spring and summer, a group of new mining towns emerged at the site of these placer deposits: Black Hawk, Central City, and Nevadaville in the hills near the Gregory Diggings (all of them located in what would become Gilpin County). A series of towns spread all along South Clear Creek: Idaho Springs, Empire City, Elizabeth's Town and George's Town (the latter two eventually consolidated into Georgetown), Spanish Bar, and Silver Plume, with camps extending all the way west to the base of what became known as Loveland Pass–all of them spurred by Jackson's work. These primitive communities would later be located within Clear Creek County. Like the communities created by the '58ers, settlements in both these counties were mostly log towns and tent cities populated overwhelmingly by young men–very few women participated in the Gold Rush.

The excitement continued in 1859, as prospectors pressed farther into the mountains. From the new Boulder City, where the Aiken Party had found gold in 1858, some pushed west to find substantial deposits at a place they named Gold Hill. Other groups pressed west across Loveland Pass to the headwaters of the Snake River. Still more headed southwesterly into South Park, the site of the still-unknown discovery of Purcell, to found camps such as Fairplay and Buckskin Joe toward the northwestern rim of this high mountain valley.

As placer mining pushed its way toward the central Rockies, there was significant change on the High Plains. The original mining camps of Auraria City and Denver City–small towns really–grew dramatically, but not as mining communities per se. As the placer deposits around them dwindled to nothing, these towns emerged as the transportation and distribution centers for the mines on the forks of Clear Creek and beyond. The same was true to a lesser degree of Boulder City and the new Golden City.

As summer gave way to fall, and fall to early winter in 1859, everyone in the bustling gold regions had to make an important decision. There were few amenities in the mountains, and living in rude log cabins and windy tents presented problems for the oncoming winter months. There was also the question of food–or more accurately, the lack of adequate supplies of food. Snow and ice also made placering a seasonal profession, one almost impossible to practice in winter. As a result, most '59ers decided to retreat from the mountains. Some chose to stay the winter at Denver, Auraria, or other "cities." Others chose to leave the area, some for good, but others to raise capital, buy more supplies, and return the following year for more systematic work in the new gold country. This was a tradition that lasted several years during the Rush.

The year 1860 saw the Rush expand. As veterans from 1858 and 1859 returned for yet another season in the "High Country," they were joined by first-time gold-seekers. Together, they revitalized the camps of 1859 and contributed toward the development of more permanent communities. They also pushed the Gold Rush farther west and south and began evolving the important concept of the Colorado Mineral Belt.

Among the key groups in 1860 were the Slater Party and the Tabor family. Horace and Augusta Tabor were '59ers. Originally from northern New England, they had homesteaded in Kansas in the 1850s, and so were just a few hundred miles from the gold region when news traveled across the plains in 1858 and early 1859. Packing up their son, they headed west to the High Plains. Horace prospected with little or no success in the valleys above Clear Creek. Augusta had better luck cooking and washing clothes at Golden. In the winter of 1859/60, the Tabors stayed at various places on the High Plains rather than return to Kansas. Then, responding to rumors of gold farther west, they and others crossed South Park to reach the Arkansas River in the general area of present-day Buena Vista. From here they turned north to reach the infant community of Cache Creek (now Granite) farther upriver, but they were, like so many others, disappointed to find too many miners and too little gold.

Reasoning that the gold found at Cache Creek had washed down river, the Tabors decided to ascend the Arkansas toward its source. They were not alone in this effort. They eventually reached what is now known as Malta, where the river breaks into its East Fork and West Fork. They chose to follow the East Fork. About a day's travel ahead was a group known as the Slater Party. It had not only headed up the East Fork, but had also broken off from that stream to follow a gulch heading easterly into the mountains that formed the barrier between the Arkansas Valley and South Park. As the Slater group penetrated an open area a mile or so northeast of the river, one of its members, an Abe Lee, dug through the snows to the flowing waters below. There he panned some of the gravels, found gold colors, and allegedly shouted to his companions, "I've got California here in this pan," an offhand remark that gave the region its name: California Gulch. It was the first known discovery of metal in what eventually became Colorado's most important mineral producing area, though not for another two decades.

News of Lee's discovery quickly passed downriver. The Tabor Party came up quickly; so did others, and as the news spread, hundreds, maybe thousands, rushed there in the summer of 1860. Prospecting ensued all along the gulch from the Arkansas River to the high hills and mountains beyond. Some say that as many as 10,000 people surged to the North Arkansas that summer, a figure that seems exaggerated, like most statistics on the Rush. A more likely figure would be a thousand people. Others say that Augusta Tabor was the only woman in camp, another inaccurate statement, although men certainly overwhelmed women in terms of numbers. But the production of gold was not exaggerated. California Gulch was probably the richest deposit of placer gold yet found in the region.

The central Rockies saw other efforts as well that year. Prospectors swarmed into McNulty Gulch and the Ten Mile region north of California Gulch. Other gold-seekers pushed on into what became Breckinridge on the headwaters of Blue River–a name later changed in spelling to Breckenridge. There were other discoveries as well.

The San Juan Mountains in southwestern Colorado also drew attention in 1860. Charles Baker, a veteran '59er, led a party that found placer gold in the area near the future town of Eureka, and the whole area became known as Baker's Park, the site of the future town of Silverton. More parties came in 1861 the next year, and that led to the founding of Animas City. There was exploration elsewhere in the San Juans, but unlike along the Front Range, no permanent settlements emerged. The San Juans were remote and rugged, supply lines long, tenuous, and expensive, and the Ute Indians hostile to miners. By the end of 1861 or early 1862, gold-seekers had apparently abandoned the region. It would have to wait another day.

Nonetheless, as the news of Baker's work spread, it contributed to the formation of the concept of the Colorado Mineral Belt. This was an elongated oval that ran roughly from Boulder in the northeast down through California Gulch, and on to the San Juan Mountains in the southwest. For the next century and a half of mining, it would form the heart of metal production–first gold, then a whole series of other metals as they were discovered, mined, and extracted in sequence here and there.

Like the California Gold Rush a decade before, the Pike's Peak Gold Rush focused on what was called placer mining (See Section E.II.1.3). This was sometimes called "poor man's mining" because anyone could get into it with minimal cost. The techniques were simple. There was panning–in which a pan, analogous to an oversized frying pan without the handle, could be used in searching for or recovering gold. Miners shoveled dirt and gravel into the pan–the reason why so many mining areas took the name "diggings" or "diggins"–then, by sloshing the dirt and gravels around with water the very heavy gold sank to the bottom of the pan, while the dirt and gravels were washed out and discarded in what were known as tailings. Panning was inefficient, however. It was used largely in searching for gold or gold colors in gravels, and quickly gave way to other techniques, notably the rocker and especially the sluice or sluice box–long boxes open at the top, but with slats or riffles placed crosswise at the bottom to catch the gold as water washed through the device. All of these techniques depended on the same principle–the very heavy weight of the gold caused it to sink and be washed from sands, dirt, and gravels carried off by the water.

Miners sometimes improved the recovery of gold by using mercury, which was also known as quicksilver. While gold is largely inert, it does form a loose chemical combination with mercury, and so placer men sometimes dropped mercury into the bottom of rockers or set it behind the slats in the bottom of sluices to enhance the recovery of gold. The resulting product, known as an amalgam, was then put into the bottom of a retort and heated to break down the amalgam. The mercury would be volatilized, recovered, and reused while the gold was left behind in the retort. Using mercury increased the yield of gold, but also created a serious environmental problem. Handling the mercury and breathing its vapors led to body absorption–first manifested by a condition known as "the shakes," an irreversible assault on the central nervous system that often led to death. This was, however, little understood and of no concern in the Gold Rush. Some mercury also escaped into stream beds, enhancing the concentration of heavy metals and creating a long-term environmental problem to go with the tailings.

1.2.1 Hardrock Mining: 1859–67

As the 1860s began, there was a significant shift in the industry. Early mining consisted largely of placering, but almost from the outset, hardrock mining began to evolve, where surface ore could readily be found (See Section E.II.2). John H. Gregory again led the way. In May 1859, some five months after his discovery of placer gold, his continuing search for metal led him to the first gold found in hard rock. Other miners in the Black Hawk-Central City area and then elsewhere in the larger gold region added their discoveries. Hardrock mining gradually evolved from this work even though most individuals in the Gold Rush focused their efforts on placering.

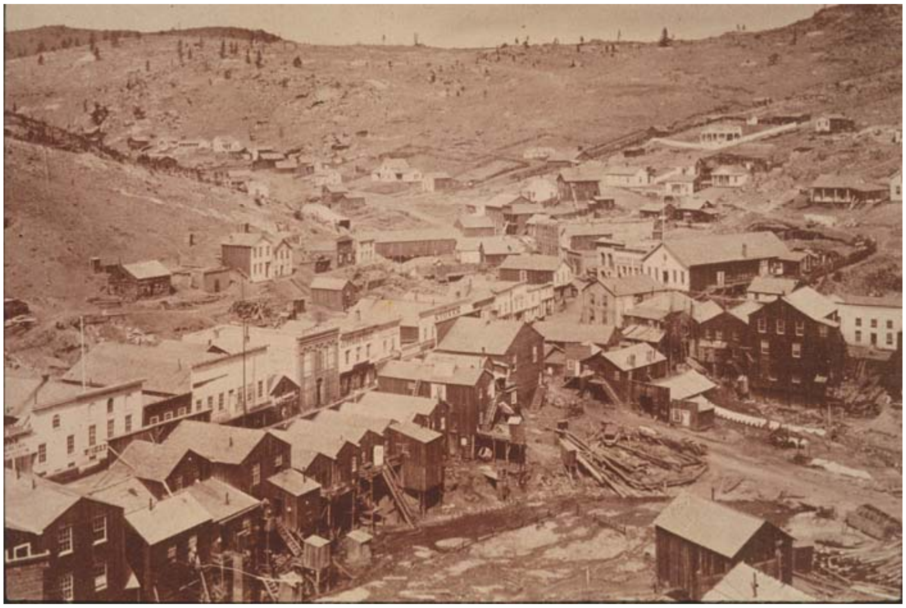

Fig. E.I.3 The mining town of Central City, Colorado, about 1864. Collection of James E. Fell.

There were two problems associated with hardrock mining: the first was removing the ore from the ground; the second was recovering the gold and other metals from the ore. Both required capital investment, a steady labor force, skillful management, and new technology, all beyond the reach of most placer miners.

Hardrock mining evolved simultaneously with placer mining. The first efforts probably seemed similar to quarrying, but as the search for gold ensued, miners resorted to more effective methods used elsewhere–that is to say, they sank shafts vertically into hard rock or they drove adits (often called tunnels) laterally into hillsides. Hardrock mining began on the forks of Clear Creek, notably at Central City and Black Hawk, and then spread elsewhere.

When did the Pike's Peak Gold Rush come to an end? This is a difficult question. If we know that the Gold Rush began in 1858 and is most associated with the year 1859, we have a problem as to when it ended. A convenient date is 1861, the year in which Congress created Colorado Territory. A better definition would be the point at which the production from hardrock mining surpassed production from placering, for at this point, the day of the ordinary person-as-miner passed into oblivion. There is no clear-cut date, however, at which this happened. The Rush was sequential: the High Plains in 1858, the Front Range of the Rockies and beyond in 1859, and the central Rockies in 1860. A date of 1861 or 1862 seems appropriate.

As hardrock mining evolved, the first quarry-like openings gave way to shafts or adits, and with them surface plants evolved. They consisted of buildings to house offices and machinery, tracks and structures to move ore, and buildings to provide power. Their most characteristic element was the vertical head frame. They were sometimes open at the top, but more often enclosed in a shaft house. More than anything else, shaft houses and headframes became symbolic of mining areas. Built largely of wood in this era, they provided the structure and apparatus to lower men and supplies below ground and to lift ore and waste rock to the surface. These structures began to evolve in the very late 1850s, but did not become common until the early 1860s. A second important related structure was the trestle designed to move ore cars that carried ore to a structure to await shipment or processing, or that carried waste rock to the mine dump, which sometimes resembled a giant apron, and was thus sometimes called a "mine apron."

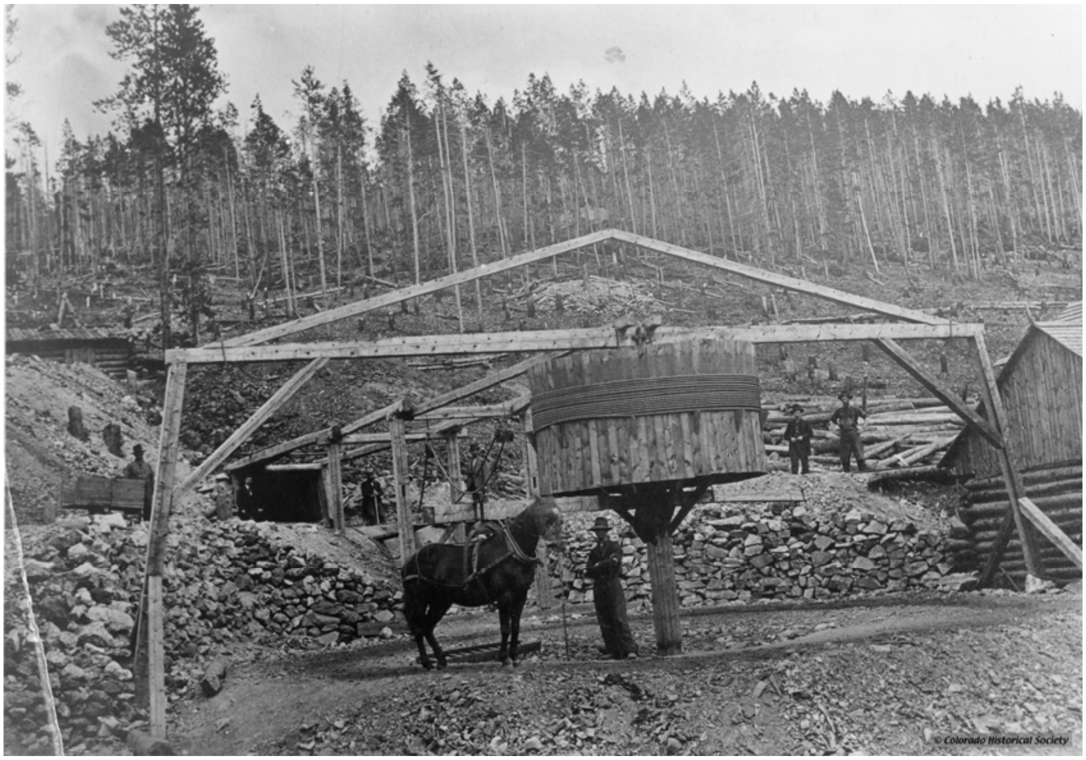

Fig. E.I.4 A single-horse powered whim provided hoisting power for an 1860's hardrock mine. Location unknown. Collection of the Stephen Hart Library, Colorado Historical Society.

Once mined and brought to the surface, the next step was to extract the gold (and later other metals) from the ore. This was again a difficult problem. As placer mining gave way to hardrock mining, the technology of recovery changed. Yet there was a similarity–the use of mercury to recover the gold. As miners brought up the first ores from underground, the first device used to recover gold was the "arrastra"–a very old device whose named derived from the Spanish verb meaning "to drag." (See Section E.II.4.4.) The arrastra was a circular device with a stone floor, stone sides, and a central pivot. From the pivot, a long arm extended from which were suspended heavy rocks known as mullers. Draft animals walking a perpetual circle dragged the rocks over the ore, crushing it so as to free the gold that would be recovered through amalgamation with mercury on the stone floor. It was a device long used in Mexico, its likely place of origin. Sometimes in the Rockies, however, streams powered arrastras. They appeared on the forks of Clear Creek very early, perhaps by 1859, but their day was brief. Arrastras were slow and clumsy and did not free enough gold. They soon gave way to stamp mills (See Section E.II.4.3).

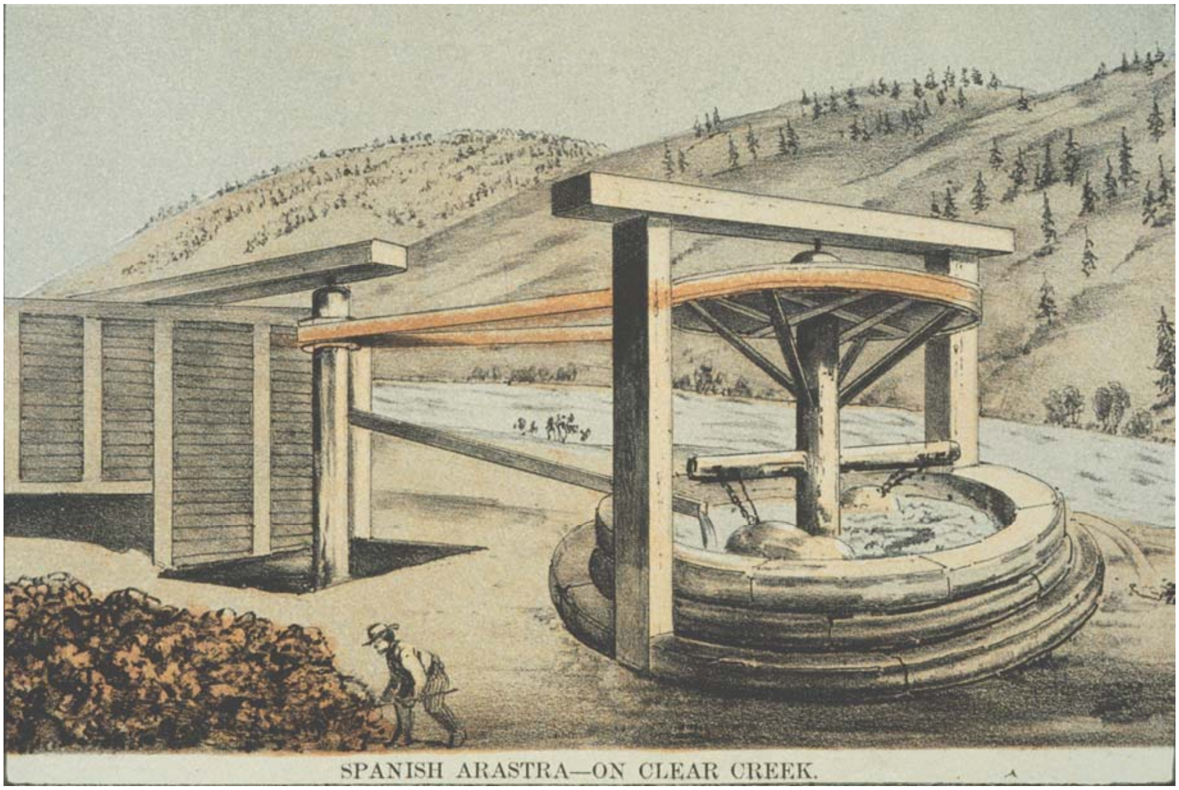

Fig. E.I.5 A water-powered arrastra used in the early 1860s for crushing gold ore. Collection of James E. Fell.

Stamp mills were a far more sophisticated technology, although the device itself was actually centuries old. Stamps were heavy iron blocks or cylinders controlled by a cam device. As a stream of water washed the ore under the stamps, the heavy blocks crushed the ore to a sandy-like consistency to free the gold. The water then washed the sand into a trough or over copper plates generally embedded with mercury via capillary action. The mercury caught and held the gold in an amalgam. Workers then scraped off the amalgam, sent it to a retort, and there recovered the gold and the mercury. The waste product of the process was called tailing or tailings, deposited in what was called a tailings pond or pile nearby and left to dry. Miners in California had used these stamp mills extensively, and as a result, they were sometimes called “California” stamp mills, although that name was something of a misnomer.

In theory, stamp milling recovered all the gold and reused all the mercury, but this was hardly the case in practice. Yields were sometimes high early on, but never approached 100%, meaning that it would prove profitable to rework the tailings. Mercury also escaped into the environment.

The first stamp mills appeared in 1859 as hardrock mining emerged, but their consistent use dated more from 1860 as industrialized mining made headway throughout the gold region. Stamp mill machinery was powered in two ways, using either water, taken from nearby streams, or steam. Steam-powered stamp mills used boilers to make steam to drive the machinery. Water-powered mills had the advantage of requiring smaller capital investment as the water was “free,” but suffered from the disadvantages of being located in an arid region with comparatively few streams, and in a climate in which these streams froze in winter. Far more flexible were steam-powered mills. Although requiring greater capital investment for the boilers to generate power, they could work year-round and did not depend on the seasonal vagaries of stream flow. Eventually, steam-powered mills predominated.

Finally, there was another development of the Gold Rush–the discovery of silver. As the Rush expanded up South Clear Creek and across Loveland and Argentine Passes in 1859, then on into California Gulch in 1860, the gold miners began to find what they called “black cement,” “black sand,” or “the damned blue stuff.” All they understood at first was that the mysterious substance clogged sluices and frustrated placer mining, but as time passed, as early as 1859, some people began to realize that this was a silver-bearing lead ore. That was of interest, but during the Gold Rush, the miners did not have the technology to extract the silver and lead, and so they largely ignored these deposits and pushed on. Small amounts of silver, however, were recovered in the stamp milling process.

By the early 1860s, the Gold Rush had largely come to an end. The placer deposits opened in the late 1850s had largely been worked out, given the small claims and the development of the “black sands.” So as the placer era ended, so, too, did the Rush per se–a phenomenon based largely on placering. By the early 1860s, Colorado’s mining industry was in the transition to the hardrock era. The result was the abandonment of many of the original placers that had produced and sustained the Rush along with many of the associated camps and towns. Mining now became industrial, and for the next few years it focused largely, though not entirely, on two areas: Gilpin County and Clear Creek County, both created by the first Territorial Legislature in 1861.

As the 1860s evolved, most people in the region directed their attention towards hardrock mining. In Gilpin County, the focus was on gold, and south across the high ridge in Clear Creek County, miners concentrated on both silver and gold. In the early 1860s, mining in these areas boomed based on the older, though dwindling placers, and the development of hardrock gold mining. Individual owners or partnerships often formed corporations to raise capital and limit liability. Some mining companies built stamp mills, and other entities built custom mills–that is to say, they bought ore from mining companies or simply charged a fee for processing. Yields from the stamp mills sometimes approached 80%, but generally it was less, even though tailings could be reprocessed. The fever of gold extraction using placer mining that characterized the Rush of 1858/59 gradually, even imperceptivity, evolved into a boom based on hardrock mining. One simply crushed the ore and recovered the gold through amalgamation with mercury.

As the industry went forward, subtle changes occurred. As miners blasted shafts ever deeper, the nature of the ores changed. The iron and copper oxides present in the upper ores gave way to iron sulfides and copper sulfides below. Few really understood the nature of what eventually became known as secondary enrichment. Over the course of millions of years, the action of water and oxygen had converted the upper copper and iron sulfides into oxides and washed away much of the rock and gravel, concentrating the amount of gold in the ore mined. The recovery of gold from the upper ores was both easier physically as well as more technologically feasible.

When the miners sank shafts past 50 or 75 or 100 feet in depth however, the nature of the ore changed. Sulfides appeared and the gold content in the ore decreased. Although the problem had been noticed as early as 1861, most miners dismissed the matter in those early days. Nevertheless, by 1863 and 1864, the problem had become general throughout Gilpin County. Yields from stamp mills plunged as low as between 10 and 20% , and sometimes there was no yield at all from what miners termed “rebellious” ores. As gold production declined, desperation ensued, and in that environment any number of charlatans appeared to take advantage of the fearful and gullible. This led to a phenomenon known as the “process mania” of the mid-1860s, when various “professors” and “scientists” came up with inventions to solve the problem. Many remedies looked convincing because they ultimately purported to recover the gold by the well-known process of amalgamation with mercury. But without exception, they failed miserably and made the growing technological impasse even worse.

Compounding the problem was the Civil War. As yields of gold plunged, the surging inflation of the conflict made many people clamor for gold or shares in gold-mining companies. The sale of stock in Colorado mining companies in 1863 produced a boom in what many investors thought were gilt-edged securities, hardly realizing that many companies had little in proven reserves or had found themselves frustrated by the failure of the mills. There was a spectacular securities boom in 1864, but when the bust came, investment capital virtually dried up. This was followed by the Indian War that broke out on the plains in the summer of 1864. As it spread across the region in the winter of 1864 and 1865, it disrupted communication and transportation to the East.

All of these matters led to disaster. The failure of the stamp mills, the process mania, the stock speculation and collapse, and the Indian Wars all had their combined impact. Production of gold and other metals peaked to about $4.5 million in both 1864 and 1865, then plunged for three years. Mines and mills closed, miners lost their jobs, towns dried up, and people left both the mining region and Colorado itself. So the boom launched by Russell’s discoveries at Cherry Creek in 1858 peaked out some six to seven years later in 1864 and 1865, then production plunged until 1867 and 1868 when output finally plateaued near the 1861 level. Colorado’s first mineral boom had gone bust in roughly ten years.

1.2.2 Gradual Recovery: 1868–78

The developments that eventually revitalized the mining industry originated about the time the industry collapsed. The end of the Civil War in 1865 freed up both capital and labor, some of which would be redeployed into mining in Colorado and the West. The end of the Indian Wars in eastern Colorado, culminating in the forced removals of the Cheyenne and Arapaho peoples, meant the reopening of the wagon routes across the plains. And the completion of the transcontinental railroad through Nebraska and Wyoming in 1869 provided a regional economic stimulus. Although the line bypassed Colorado in part because of the engineering problems in crossing the Rockies, entrepreneurs in the territory launched their own railroad companies to connect the High Plains communities with the Union Pacific track at Cheyenne. These efforts bore fruit in 1870 when the Denver Pacific Railroad linked Denver to Cheyenne. Later, the Colorado Central Railroad put down rails from Golden to Cheyenne. Finally, the Kansas Pacific Railroad extended its track through Kansas to Denver. This new infrastructure provided a powerful stimulus to the minerals industry and the economic recovery of the territory as a whole.

Another key to revitalization was finding a way to recover gold from deep ores. That was coming too. As early as 1864, at Black Hawk, James E. Lyon and other investors tried the smelting process to effect the recovery of gold from the refractory ores resistant to stamp milling. That effort and several by other entrepreneurs failed, but in essence, these individuals began the introduction of an important new technology, smelting, soon to have a profound impact on the minerals industry. (See Section E.II.4.1.) Smelting is a high-heat process in which wood or coal, charcoal or coke, is burned to make the ore molten or liquid; chemical and physical changes then take place in the furnace, and the result is the production of a valuable intermediate product known as matte or bullion along with the waste product known as slag. Matte is formed if the base metal in the ore is either copper or iron or both. Bullion is formed if the base metal in the ore is lead. The base metals are used to collect and hold the more valuable gold or silver, and then the intermediate product is refined to extract the various metals. The waste product is a black, glassy-like substance deposited near the smelter on the slag dump.

As the mining industry approached its early zenith in 1864 and 1865, the growing problems with deep ores in Gilpin County and with silver-lead ores in Clear Creek County led to new technological ventures that helped resolve the growing problem. In Gilpin County, the earliest systematic effort stemmed from the work of James E. Lyon. An investor in mining properties (along with George Pullman, later the inventor of the Pullman Palace Car), Lyon built a small smelter that used what was called a reverberatory furnace for smelting. His efforts in 1864 and 1865 showed the way, but did not achieve the success that Lyon and his associates envisioned. More important was the work of Nathaniel P. Hill. A college professor at Brown University in Providence, Rhode Island, Hill moved to Colorado to invest in and manage mines in 1865, just as the boom peaked. Frustrated by the failure of the stamp mills, Hill for a time consulted on Lyon's project, then embarked on a study of smelting at Swansea, Wales, the leading copper-smelting center in the world at that time. Convinced that the Welsh Process or Swansea Process would work in Colorado, in 1867, Hill persuaded Boston investors to finance the Boston and Colorado Smelting Company. In 1868, he built the company's first plant at Black Hawk during the nadir of the collapsing economy.

Fig. E.I.6 The Boston and Colorado Smelter at Black Hawk in the 1870s. Collection of James E. Fell.

Hill's plant proved successful from the outset, and its success helped spur a turnaround in the economy. As the company began operations, Hill bought ore and tailings known to contain gold. In the process, the ore was piled up, set on fire, and allowed to burn in the air for a month or more to burn off sulfur. Tailings were sent to a calcining furnace for the same purpose. The roasted products were then sent on to the smelting furnace. This was a low-slung device known as a reverberatory furnace because the firebox was separate from the ore charge, and the heat generated was said to reverberate down on the ore and so made it molten. Once molten, various chemical and physical changes took place, the upshot being that the iron and copper in the molten ore collected and held the gold and silver in what was known as a copper matte or simply matte. This product was then collected, allowed to cool, and shipped to Europe where the refining extracted the individual metals. The waste product from the smelting, known as slag, was dumped wherever convenient near the smelter and allowed to cool. In theory, the slag held no metals, but in actuality it did, and so reworking slag in later years became an important facet of the industry.

The success of Hill's company provided a local market for ore and mill tailings. The mines at Central City gradually came back to life–also aided by new capital investment, more miners, and better transportation. Hill's company gradually expanded, added its own refinery to extract metals in the 1870s, and by the mid-1870s was producing as much as half of Colorado's output of precious metals (as measured by value). Others sought to imitate his success, and so other smelters using the Welsh Process emerged in Denver, Golden, and Empire. But none enjoyed the success that he did. One after another, they fell by the wayside.

Meanwhile, on South Clear Creek and across the central Rockies, miners discovered silver-bearing lead ores as early as 1859, but for the most part, there was no effective way to recover the silver and lead. As a result, the bulk of the ores mined had been discarded and the deposits ignored or abandoned despite repeated efforts at recovering the silver and lead. In the late 1860s, however, silver-lead smelting emerged almost simultaneously with Hill's introduction of the Swansea Process. The first efforts evolved largely along South Clear Creek when entrepreneurs built both Scotch hearths and reverberatories in order to smelt the silver-lead ore into bullion, an intermediate product in which the lead in the ore was used to collect and hold the silver. (Matte might also be produced as well depending on the composition of the ore.)

These first efforts, however, had very little success. Both the Scotch hearth and the reverberatory, while effective in working lead ores in Missouri and elsewhere, could not recover enough of the silver to be effective in the Rockies. The ore had far less lead than in lead districts elsewhere, and the silver was the more valuable product. In these early plants, a substantial amount of both lead and silver disappeared into the slag. But entrepreneurs tried these technologies for the best part of a decade until the mid-1870s. They returned a profit only when ores were exceptionally rich and could stand the loss of significant amounts of metal, but they failed when working the bulk of the silver-lead ores in the region.

During the early-to-mid-1870s, however, other entrepreneurs turned to another technology in an effort to solve the problem of working silver-bearing lead ores. This was the blast furnace. Like Hill's Swansea Process, it was a European technique–one developed in Central Europe earlier in the century. Unlike the flat, low-slung reverberatory, the blast furnace was vertical (either columnar or rectangular) and for fuel it used either charcoal or coke, which also participated in the ongoing chemical and physical changes used to recover the valuable metals.

Although it evolved in Europe, the blast furnace appeared in the U.S. in the late 1860s and early 1870s, generally introduced by individuals who had trained at mining schools and smelting plants in what is today Germany. The key places in the U.S. where blast furnaces were built were Eureka, Nevada, Salt Lake Valley in Utah, Omaha, Nebraska, and St. Louis, Missouri. Colorado participated in this early development as well, notably the plants of the Boston Silver Mining Association at Saints John and the Mt. Lincoln Smelting Works at Dudley. Unlike their counterparts elsewhere, however, these enterprises had only limited success.

As mining recovered slowly in the 1870s, Colorado witnessed the continued development of supporting infrastructure. Prospecting throughout the Mineral Belt and elsewhere led to the discovery of new mineral deposits, notably those that held silver-lead ore, and railroads began threading their way through the plains and into the mountains. The most important of the new lines was William Jackson Palmer's Denver & Rio Grande Railway, which built down the Front Range of the Rockies. To create business for the enterprise, Palmer and his associated investors founded Colorado Springs, launched what became the Colorado Coal & Iron Company to produce steel at Pueblo, and helped open the Southern Coalfield running from Walsenburg to Raton, New Mexico. Another line was the Denver South Park & Pacific Railway, which built from Denver southwesterly up Waterton Canyon to South Park and the mining camps there. A third crucial enterprise was the Colorado Central Railroad, which built from Golden up Clear Creek Canyon to tap the ores of Black Hawk, Central City, and Nevadaville on North Clear Creek, and then to Idaho Springs, Empire, Georgetown, Silver Plume, and other camps on South Clear Creek. Not surprisingly, mining revitalized in Gilpin and Clear Creek Counties, and a subsequent boom emerged farther west in Park County, notably on the slopes of Mount Lincoln and Mount Bross, above the branch smelter developed at Alma by Hill's Boston and Colorado Smelting Company.

There was also a silver boom during the 1870s at the new town of Caribou in western Boulder County–the state's first major silver producer, although its heyday was brief. The rise of Caribou led to efforts to build silver mills there and elsewhere, but the various types of technology used in the mills to recover the silver proved only marginally successful, if successful at all.

The 1870s witnessed problems in the price of silver. As mining developed in Colorado, the price of gold held steady, fixed by law, at $20.67 per ounce. The price of silver fluctuated owing largely to supply and demand, but was also impacted by government coinage policies in the United States and abroad. In the1860s, silver prices generally remained high at about $1.25 an ounce or more. This benefitted early silver mining, but because the price was above the coinage value, in 1873, the federal government demonetized silver. As production of the "white metal" rose sharply, thanks largely to the Comstock Lode in Nevada, the price declined slowly but steadily. That in turn spurred protests from miners and farmers throughout the 1870s as silver prices slid below the old coinage value of $1.25 an ounce and launched a movement for the free and unlimited coinage of silver at a ratio of 16:1 with gold. This effort bore partial fruit in 1878, with the passage of the Bland-Allison Act, which provided for the government resuming coinage, but not at the rate the miners wanted. The price of silver continued to fall, albeit slowly throughout the 1880s and into the early 1890s.

Despite the emphasis on hardrock mining that evolved in the early 1860s, placer mining did not end entirely. The almost universal type of placering–done by individuals and small groups that characterized the Gold Rush–remained quite limited in terms of aggregate production, and many small claims were essentially "abandoned." But in the 1870s, if not before, a number of shrewd miners, realizing that profit lay in economies of scale, began consolidating claims. Once they acquired large tracts of ground, they worked the old placers through two techniques: booming and hydraulic mining. Booming consisted of impounding water behind a small dam, then blowing it up to release a torrent of water that washed away entire areas to free the gold that was later recovered in sluice boxes. Hydraulic mining was far more sophisticated and significant. In this technique, developed in California in the 1850s, water was impounded, then drawn down through a system of pipes. The water built up such powerful pressure that when miners trained the nozzles on a hillside, the force of the water washed away everything. The gold continued to be recovered in sluices, as before. Placering thus remained an important element in the minerals industry, but had also gone down the road of industrial mining.

This second period of mining in Colorado lasted roughly ten years, from 1868 to 1878. Like the Gold Rush era, it was in many ways a formative time. It was an era of slow revitalization spurred by a renewed focus on hardrock mining, railroad construction, and smelter development, coupled with a waning interest in placering. By the early 1870s, aggregate production returned to the levels seen a decade before in the mid-1860s, but the growing production of silver, notably from Caribou, meant that the value of silver and gold produced were about equal.

The amount of silver, however, which was worth far less than the royal metal, greatly exceeded the amount of gold produced. The mines, mills, and smelters also recovered small amounts of lead, copper, and iron. The focus of production remained in Gilpin and Clear Creek Counties although there was a growing interest farther west in Summit and Park Counties. There was also a renewed interest in the distant San Juans, particularly after the Ute removal in the mid-1870s, but the area was so remote that little mining occurred there until late in the decade.

1.3 Early Mining Law

Colorado's first miners took up mineral lands in accordance with the traditions and laws of that era, all of which were in evolution. Like their counterparts in California and Nevada, Colorado's first miners simply moved West, took the lands they wanted to mine, and legitimized their activities through what were called mining districts.

These practices began in California during the Gold Rush there. The creation of mining districts reflected traditions drawn from Mexico and the Spanish Empire, the lead-mining regions of Wisconsin, as well as Cornish and German mining codes. Miners in a particular area simply met and organized what they called a mining district. They drafted a code of "laws" for the district, elected a presiding officer and a recorder to keep track of claims. The main principle was that a claim belonged to the individual who discovered it, so long as he kept at work on it–what became known as the "Law of Use." Local codes also specified the size of claims–generally keeping them small so as to give more miners a chance to find gold. The codes also provided a means for resolving the inevitable disputes that would arise. While the purpose of mining districts was primarily to provide enough civil law to legitimize mining, they also provided criminal justice, one in which the entire district gathered to try and sentence those accused of malfeasance. Not surprisingly, a hodgepodge of rules, regulations, and practices developed as mining grew first in California in the late 1840s and then in Nevada and Colorado in the late 1850s.

Given this situation, mining districts eventually gave way to federal law. In 1866, through the efforts of Senator William M. Stewart of the State of Nevada, Congress passed a law that in essence recognized and legitimized the development of lode claims. For one, it sanctioned the past, present, and future efforts of miners to extract minerals from the public domain. For another, it created a procedure to obtain title to mining claims. And third, it recognized the legality of existing ad hoc developments–in other words, it recognized local customs of the mining districts. In 1870, Congress extended the principles of this law to placer claims. Finally, Congress modified and enhanced the previous two statutes in what became known as the Mining Law of 1872, which became the central mining law for the nation. In this statute, which built on previous legislation, Congress added greater specificity to the marking, recording, size, and forfeiture of mining claims, and also in this legislation, it created the so-called "Law of the Apex," which gave claimants the right to mine beyond the sidelines of their claim. This provision led to both violence and immense litigation in years to come.

1.4 A Focus on Silver, The Leadville Boom and After: 1878–93

For the first two decades of Colorado's development, mining focused on the Eastern Slope particularly in Gilpin and Clear Creek Counties, and to a lesser degree in Park and Summit Counties, but that was all about to change dramatically in the late 1870s. In the middle years of the decade, Alvinus B. Wood and William H. Stevens, two miners from the Alma area in South Park, decided to rework the old placers in California Gulch. They were experienced men–having operated placer mines around Alma and having developed hardrock mines there as well. They had also become disgruntled with their other partners–Nathaniel P. Hill and his associates with the Boston and Colorado Smelting Company–over what eventually became known in the industry as "Custom Smelter Syndrome," the view that smelter operators were using their control of the reduction process to siphon off profits from the mines. As Wood and Stevens began work in the Upper Arkansas Valley, they acquired the old Starr Placer in California Gulch–located roughly at the point where the stream running down through the gulch entered the open area to the west as it flowed down toward the Arkansas. Wood and Stevens engaged in hydraulic mining to recover gold, but as they did so, they noticed the dark, iron-stained rock that had frustrated placer miners there in the early 1860s. Curious about the substance, they found its source high on Iron Hill, just north of California Gulch. They took samples over the range to Alma, where they had it assayed by Herman Beeger, the metallurgist for the Boston and Colorado Smelting Company. Beeger determined that the mineral was a rich silver-lead ore with substantial amounts of iron. That was of considerable interest, but the reverberatory furnace of the Alma Smelter could not reduce this type of ore.

Armed with this knowledge, however, Wood and Stevens quietly went to work. First, they began to acquire claims high on Iron Hill–notably the Lime, Rock, and Dome–and they searched for a place to sell the ore they might produce. That search brought them into contact with August R. Meyer, an ore buyer for the St. Louis Smelting and Refining Company. Organized in 1871, this enterprise built a plant in St. Louis, using blast furnaces to reduce silver-lead ores to silver-lead bullion, after which the silver and lead were extracted by so-called "wet" methods. The firm originally intended to work lead ores from Missouri along with silver-lead ores floated down the Missouri River from Montana, but by the mid-1870s, in the search for additional material, it had hired Meyer to scour the slowly developing silver-lead districts in the West. That search brought Meyer and the St. Louis Company into contact with Wood and Stevens–and Colorado– to the eve of a dramatic new mineral boom.

In 1876, Wood and Stevens induced Meyer to visit California Gulch. Meyer was so impressed by the content of ore quarried from the Lime, Rock, and Dome, that he went to New Mexico to obtain wagon teams to carry the product over the mountains to railheads from which it was shipped to St. Louis. The mineral apparently returned a profit for all concerned, but everyone recognized that transportation was very expensive. In search of lower costs, in 1877 Meyer and the Smelting Company's president Edwin Harrison visited the northern Arkansas Valley. There they decided to erect a branch smelter on the old Starr Placer just north of California Gulch. Built in 1877 this plant, known as the Harrison Works, though managed by Meyer, provided a local ore market. As Wood and Stevens made shipments from the Lime, Rock, and Dome, and as the Harrison Works smelted the ores to bullion bound for St. Louis, the news spread. By mid-1877, hundreds and then thousands of miners headed to California Gulch. They overwhelmed the existing community of Oro City located in the steep-walled gulch; a new community arose around the Harrison Works. By early 1878, it had become known as Leadville.

Leadville's growth in the late 1870s was breathtaking. Prospectors located innumerable claims on Carbonate Hill, Iron Hill, and Breece Hill, which formed the northern flank of California Gulch. They pushed farther north into Stray Horse Gulch and then on to Fryer Hill and other locales. Into production came a host of mines. So, too, did new smelters, some located north and east of town, others located in the lower part of California Gulch south and west of town. And then there was Leadville itself. Originally, in the late 1870s, its main thoroughfare was Chestnut Street, which ran east-west near California Gulch, but as the city developed, businesses switched over to Harrison Avenue, named after the President of the Smelting Company, which ran north-south along the foot of Fryer Hill south to California Gulch. From Leadville radiated satellite communities nearer the mines. One was the extant settlement of Oro City, but new ones were established such as Finn Town, Swede Town, and others. They reflected the diverse ethnic makeup of Leadville, which by the 1880s became dominated by Irish miners living largely on the east side of the community. Almost overnight, Leadville had emerged as the second or third largest city in Colorado. Its ore production dwarfed everything that Colorado had produced in the previous two decades combined. So spectacular was its output that there was even an effort to move both the state capital in Denver and the new state university in Boulder to Leadville, located two miles above sea level deep within the Central Rockies. By 1880, this town, also known as “Carbonate Camp” or “Magic City” had emerged as the greatest mining and ore-processing center not only in Colorado but also in the entire American West.

Fig. E.I.7 Chestnut Street in Leadville, Colorado, about 1880. Collection of James E. Fell.

The first ores from Leadville were relatively easy to reduce. As the mines came into production, they shipped mostly a rich silver-bearing lead ore in the form of a carbonate–hence Leadville’s nickname–the “Carbonate Camp.” Some properties like the Iron Silver Mine, which evolved from Wood and Stevens’ claims, produced some iron, a few others produced some gold, zinc, and other metals all destined to have a huge impact on Leadville, but not in the early years. The mining companies shipped the carbonate ores to the first smelters that used blast furnaces to reduce them to silver-lead bullion. This bullion was in turn shipped largely to refineries in Omaha, Chicago, points farther east, and even to Europe. A few smelters in Leadville did build refineries, but the dominant trend was to ship the bullion, the key intermediate product, east for further work. Unlike the reverberatory furnace used so successfully by Hill’s Boston and Colorado Smelting Company, Leadville’s blast furnaces were tall, square or rectangular units in which the fuel–first charcoal made from local forests and eventually coke made largely from coals from the Southern Coalfield near Trinidad–provided the heat and participated in the reduction process. Leadville’s early smelters tended to look like oversized barns with pipes going everywhere. About 15 in number by 1880, they made Leadville not only the largest silver-lead smelting center in the world, but also the most technologically advanced.

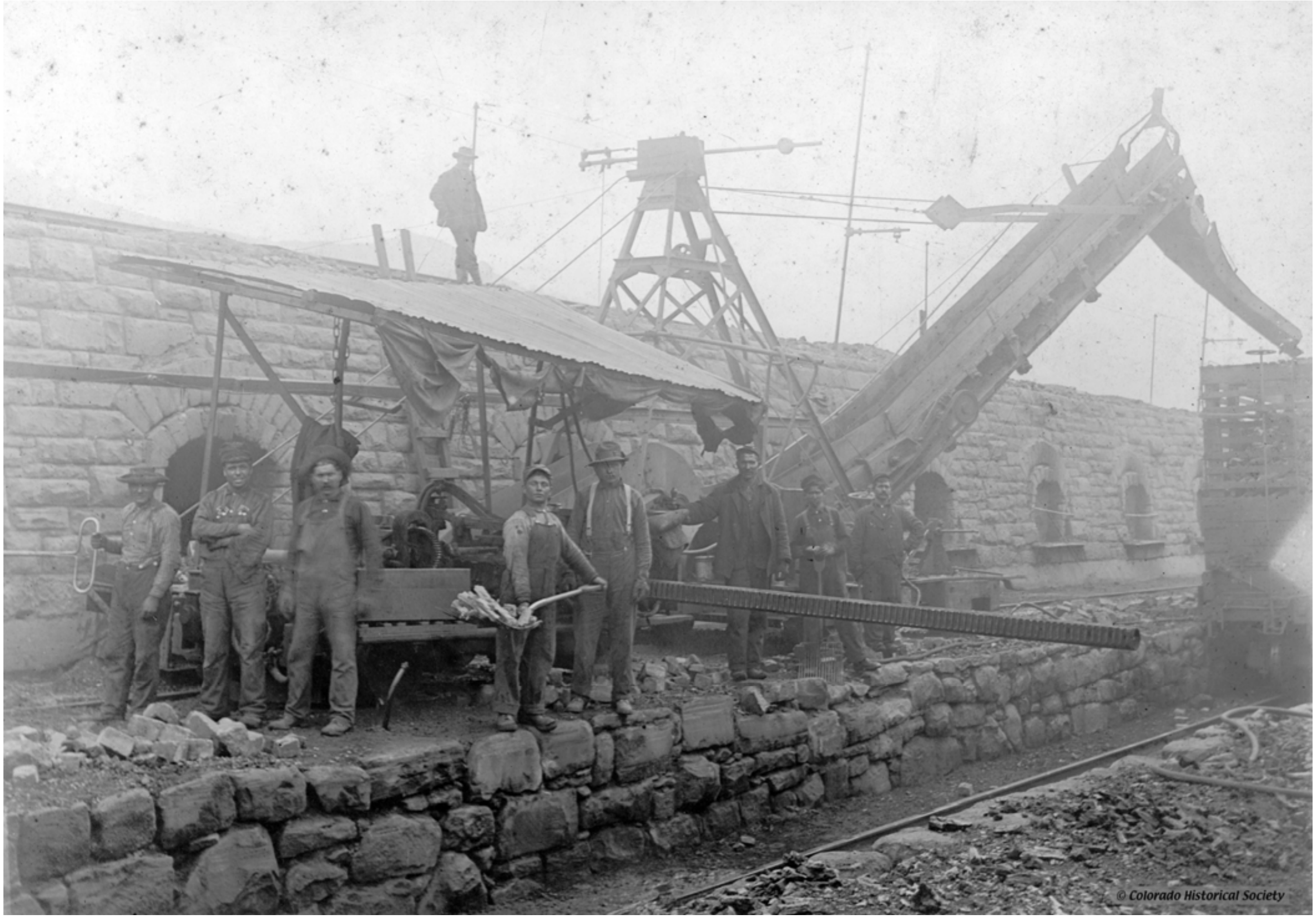

Fig. E.I.8 Coke ovens in operation at Segundo, Colorado, about 1910. Collection of the Stephen Hart Library, Colorado Historical Society.

The sensational rise of Leadville had a powerful impact on mining in Colorado, in the West, and globally. In terms of production, the district's combined output in 1878 and 1879 exceeded Colorado's entire production for the previous two decades. Leadville's emergence shifted the focus of mining away from the Eastern Slope to central Colorado, and its output prompted a powerful statewide economic boom that lasted 15 years until 1893. The city's dramatic emergence in the late 1870s coincided with the final decline and de facto collapse of the famous Comstock Lode in Nevada. By the early 1880s Leadville was the foremost silver-producing center in the United States and for a time the largest lead producer as well. Coupled with the soaring production of Butte, Montana, as a copper center–a boom spurred by Hill's construction of a matte smelter there–by the mid-1880s, both Leadville and Butte had emerged as the two foremost mining centers in the American West.

Even so, the nature of mining at Leadville changed in the course of the 1880s and early 1890s. As miners gradually exhausted the carbonates that had sparked the Rush, and as they blasted ever deeper into lower grade ores, they began to build concentrating mills to remove some of the waste rock and cut costs. This meant that miners began shipping both ore and what were known as "concentrates" to the smelters. The production of concentrates led in turn to the proliferation of tailings, the generally gray or yellowish, sandy-like waste product of the milling process. They accumulated around mine and mill sites, often held in check by ever-growing cribwork made of massive logs. But given that the tailings piles from concentrates held valuable metals, mining and milling companies removed, reworked, and redeposited them over the years. Also, as the lower ores appeared, they were sulfides, not carbonates; that is to say, the lead carbonate comprising the base metal segment of the ore gave way to galena, or lead sulfide, which was both lower in metal grade and harder to process. So as the concentrating mills appeared, so, too, did roasters at the smelters, as an entirely new step in the reduction process evolved.

Finally, in the 1880s Leadville witnessed the strong production of another two metals: zinc and gold. Some miners had noticed both in Leadville ores in the late 1870s, but these metals did not become important until later. Mines in California Gulch, notably the A.Y. and Minnie (owned by Meyer Guggenheim and a silent partner), were central to the development of zinc extraction in the mid-to-late 1880s. Gold extracted from the Little Johnie Mine on Breece Hill was crucial to what became known as the Leadville Gold Belt, as this mine

Fig. E.I.9 Ibex Mine, Leadville, about 1900. Collection of the Stephen Hart Library, Colorado Historical Society. .

passed into the control of a group of investors who turned this, and a large group of other properties, into the Ibex Mine, one of Leadville's most important later producers. Throughout the 1880s and into the 1890s, thanks to the development of new mines and the continued production of older ones, Leadville generally led Colorado's mineral production. Its technology was the best available, and it dramatically enhanced the development of both mining in the central Rockies as well as the transportation, distribution, and smelting centers on the plains.

Silver-lead mining throughout the central Rockies was heavily impacted by the "Carbonate Camp." North of Leadville, the boom drew prospectors into the so-called Ten Mile region, where there had been placering for a time in the 1860s. There was a winter rush in 1878/79 and from that emerged the towns of Carbonateville, Robinson, Kokomo, and Recen, all of which depended on Leadville to a greater or less degree for miners, equipment, capital, and ore reduction. Leadville spurred further development in the older mining town of Breckenridge, founded early in the Pike's Peak Gold Rush. To the south in Chaffee County, prospectors found mineralization at what became St. Elmo and other nearby towns, and Leadville induced further interest in the Gunnison Country and San Juan Mountains. West across the Collegiate Peaks, Leadville spurred the search for minerals in the Roaring Fork Valley. This led to a gold discovery at a place soon named Independence (and the pass from the Arkansas Valley to the community became known as Independence Pass.) More importantly, the boom prompted the discovery of silver-lead ores from Ajax and Smuggler Mountains. As a result, a new town, known as Ute City, evolved at the base of Ajax Mountain, but because of the spectacular yellow foliage in the fall, this community soon changed its name to Aspen. Its mines eventually proved so rich that for a time in the early 1890s, Aspen superseded Leadville as Colorado's foremost silver producer.

Leadville also drew Colorado's railroad systems ever farther into the mountains. This was vital to mineral development due to the symbiotic relationship between the two industries. The most important of the railroads was the Denver & Rio Grande. As the great boom unfolded on the North Arkansas, Palmer's road built south from Pueblo into the Southern Coalfield, bound for Raton Pass and New Mexico. At this juncture, the Palmer group witnessed another line approaching Pueblo as well. This was the Atchison, Topeka, and Santa Fe Railroad, coming across Kansas. The Santa Fe set its sights on booming Leadville and graded a line through the narrow Royal Gorge and up the Arkansas Valley. Just at this time, Palmer and the Rio Grande decided that they wanted to tap the Leadville trade as well. This decision touched off the so-called "Royal Gorge War" a largely bloodless conflict in which both sides built fortifications and hired armed thugs to prevent the other from building through the Gorge. The imbroglio was eventually settled via the so-called "Treaty of Boston." The Rio Grande gave up its trackage rights over Raton Pass to the Santa Fe, which eventually built into New Mexico and on to Los Angeles, California. In return, the Rio Grande received the rights to the Royal Gorge route up the Arkansas and thus transformed itself into a regional carrier that would have a powerful impact on the minerals industry. The first sign of this came in 1880 when the Rio Grande completed its track up the Arkansas Valley to reach Leadville. The line's arrival enhanced the boom there and fostered further mining development throughout the central Rockies.

The Rio Grande was by no means the only line to penetrate the central Rockies as a result of the Leadville Boom. The Denver South Park & Pacific Railway extended its rails toward Buena Vista in the Arkansas Valley, where it joined the Rio Grande to provide service to Leadville via a joint trackage agreement. Eventually in the mid-1880s, the South Park constructed a line from Como in South Park over Boreas Pass into Breckenridge and then north around the mountains via the Ten Mile Valley and over Fremont Pass to Leadville. In another burst of construction, the South Park built south and west from Buena Vista to the Chalk Cliffs, up to the small camp of St. Elmo, and then via the high and long Alpine Tunnel into Gunnison Country, providing a powerful stimulus to mining there at camps like Gothic and Crested Butte.

The impact of the railroads was immediate. They lowered the costs of everything, brought new mines and mining towns into being, and sparked booms in Denver and Pueblo, which became ever more important transportation and distribution centers for the mines and mining towns in the central Rockies. The railroads also sparked a smelting boom at Denver and Pueblo, for it was easier and cheaper to allow the ores to run downhill to those communities and bring in coal and coke from the coal mines of southern Colorado. Denver and Pueblo emerged as major smelting centers in the late 1870s–Denver when Hill consolidated his smelting operations at the new company town of Argo just northwest of town, and Pueblo when the Palmer group built its steel plant there. Pueblo, however, began tapping the Leadville ore trade in the late 1870s. By the late 1880s, with Leadville, they formed the three major smelting centers in Colorado.

Mining at Leadville and throughout the central Rockies spurred further railroad construction and additional mining in the late 1880s and early 1890s. One reflection of this was the Colorado Midland Railway, which began building west from Colorado Springs in the mid-1880s and put the first broad-gauge line into the mountains. Naturally, the Midland headed to Leadville, which it reached in the mid-1880s. From there, it built on to Aspen. The narrow-gauge Rio Grande built north through the Ten Mile Valley and then north to Wheeler Junction and around the mountains to Aspen–both Midland and Rio Grande reaching Aspen in 1887 and sending the community into a spectacular boom that lasted for some six years until 1893.

1.5 Gold and Silver Mining, The San Juan Mountains: the 1860s to the 1890s

1.5.1 The San Juans in the 1870s

Meanwhile, what of the San Juan Mountains of southwestern Colorado, the site of Juan Maria de Rivera's discoveries of about 1765? Whatever the discoveries associated with Rivera and others in the 1760s and perhaps later, mining in the San Juans effectively began with the Pike's Peak Gold Rush and the work of Charles Baker. In the spring and summer of 1860, as miners resumed work in the Front Range of the Rockies, and as others pushed into South Park and to California Gulch, Baker led a party of seven individuals into the southern San Juans. Eventually, they made their way to the future site of Silverton, located in a large bowl-like area in what would later become known as Baker's Park. Baker's party had indifferent success that first year, but in 1861, he returned with a dramatically larger group searching for gold, but what they found was mostly silver–which proved hard to recover. A number of Baker party members apparently explored much of the San Juans, but they found little gold. Other prospectors had a similar experience–little gold, and the silver would have to wait. So with these ventures, mining or efforts to mine the San Juans came largely to an end for roughly a decade. Nonetheless, the efforts of Baker and others helped to establish the concept of the Colorado Mineral Belt as running from Boulder County in the northeast to the San Juan Mountains in the southwest.

Interest in the San Juans revived in the early 1870s. Again, Baker's Park served as the prime focus. Prospectors returned there in early 1871, notably one Miles T. Johnson, who may have opened the Little Giant Mine and built a mill to work the gold ore. Johnson's work touched off a small boom the next year, but more importantly, the rush put pressure on the federal government to remove the Utes in order to pave the way for mining. Negotiations ensued, and in the Brunot Treaty of 1873/74, the Utes agreed to give up their lands in the latter year. It is not a coincidence that serious mining development in the San Juans began in 1874.

It was also at this juncture that the federal government decided to conduct formal surveys of the region. The responsibility fell to the War Department and the Interior Department, and to complete the work, they secured the moneys for what became known as the Wheeler and Hayden Surveys–both of which proved fateful for mining development.

First came the Wheeler Expedition in 1874 and 1875, and then the Hayden Survey. The members of these expeditions studied the flora and fauna of the region, investigated routes through the mountains, and found signs of mineralization deep in the mountains. One thing was very clear in both of these reports. The investigators had mining in mind. Among the most important members of the Hayden Group were Franklin Rhoda, who reported on routes and mineralization, and William Marshall, who reported on mineralization and early town building in what became known as Ironton Park on the northern flank of the San Juans. Marshall also commented on the extremely difficult transportation problems that miners would have to overcome in the rugged mountains.

By the time these surveys went forward, however, miners had already set their sights on the region. Anticipating the Ute removals, they founded Silverton and Howardsville in 1873/74, followed by Eureka and Animas. On the northern end of the mountains, pioneers founded the town of Ouray in August 1875.

As mining evolved in the San Juans in the mid-1870s, so, too, did the transportation systems essential for mineral development–the two had a symbiotic relationship here as elsewhere. The great transportation pioneer of

Fig. E.I.10 Lake City, Colorado, in the 1880s. Collection of the Stephen Hart Library, Colorado Historical Society.

the San Juans was Otto Mears. A Russian immigrant, Mears had engaged in mining in California, served in the Civil War, and finally made his way to Colorado. In the late 1860s, he began building toll roads in the Arkansas Valley, then cast his eyes on the Gunnison and San Juan regions as sites for additional toll roads just at the time the federal government extinguished the Indian title, in part through Mears' help in the Brunot negotiations. In February 1871, Mears organized the Saguache & San Juan Toll Road Company to build a route west over Cochetopa Pass, south to Lake San Cristobal, and then southwesterly to Baker's Park. Mears' builder, Enos T. Hotchkiss, got to Lake San Cristobal by the end of the year, but while at work, he discovered the outcrop of what became known as the Hotchkiss Lode; this touched off a gold rush to the new town of Lake City on the eastern flank of the San Juans. As the rush to this town began in 1872, the line pushed southwest. It crossed the rugged Engineer Pass to reach the Animas River, which it then followed into Baker's Park, reaching the new town of Silverton in 1877. This wagon line had a powerful influence in opening the area to mining development.

Meanwhile, in 1876, when the federal government moved the Los Pinos Indian Agency to a point about 11 miles south of present-day Montrose, Mears built a new branch of his wagon line. From Gateway, he built west over Blue Mesa, down the Cimarron River, and on to the Uncompahgre River near Montrose, and from there south to the new Ute agency, and on to Ouray, on the northern periphery of the San Juans.


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Fig. E.I.11 Silverton, Colorado, in the 1880s. Collection of the Stephen Hart Library, Colorado Historical Society.

But it was the arrival of the Rio Grande Railroad that really opened up mining in the San Juans in the mid-to-late 1870s. William Jackson Palmer’s railroad had built west from Cañon City through the Royal Gorge to Salida, then built additional trackage west to the Gunnison Country and south to Antonito, Colorado. From there, it extended its line west along the Colorado-New Mexico border and then north toward the newly established Animas City in the San Juans. When the town refused to grant the Rio Grande the concessions that Palmer wanted, he and his associates founded the community of Durango, which quickly emerged as the transportation and distribution center for mines in the region. When the Rio Grande finally built north to Silverton, it spurred mining development, prompted the Greene Smelter at Silverton to relocate to Durango (with investments from the Palmer group), and led Otto Mears to built additional short line railroads in the San Juans itself. The coming of the “Iron Horse” began a new era of mineral development throughout the region.

1.5.2 The Red Mountain District

As mining developed in the San Juans in the mid-1870s, prospectors investigated what had become known as Red Mountain Pass, so-called because of the color of several high peaks that dominated the area. The pass connected Silverton to Ouray. These individuals gradually located various claims, and in 1881, they

Fig. E.I.12 Yankee Girl Mine at Red Mountain Town, Colorado, in the 1880s. Collection of the Stephen Hart Library, Colorado Historical Society.

created the Red Mountain District. Its boundaries were not precisely defined, but included the general area near the summit of Red Mountain Pass and the surrounding mountains. It was in this district in July 1881 that several prospectors located what they named the Congress Mine, destined to be one of the district's important producers, while another group located the Guston Mine some distance away. Initially, neither provided much ore. The arrival of the Denver & Rio Grande Railroad, first at Durango, and then at Silverton in 1882 gradually lowered mining costs, provided access to smelters to reduce the ore, and thus stimulated development. The Congress was apparently the first mine at Red Mountain to prove successful.

The success of the Congress, coupled with rail access at Silverton, spurred further work. Production from the Congress rose. Then John Robinson, while ostensibly out hunting, spied an interesting mineral outcrop that he claimed for himself and his Guston Mine partners. They called the new prospect the Yankee Girl and began sinking a shallow prospect shaft that broke into one of the latter mine's four chimneys of rich silver ore. Concerned about rivals, the Robinson group located several claims nearby, two of which eventually proved to have rich ore chimneys as well, notably the Robinson and the Orphan Boy. But the locators lacked the capital for systematic development. So, a short time later, after they had shipped some rich silver-lead ores from the Yankee Girl, they sold the mine for a reported $125,000 in order to use the proceeds to develop the Robinson and the Orphan Boy.

Fig. E.I.13 Red Mountain Town, Colorado, about 1880. Collection of the Stephen Hart Library, Colorado Historical Society.

The first production, the ballyhoo headlines, and the sale of the Yankee Girl prompted a boom at Red Mountain. Hundreds of miners, other workers, and people of every sort rushed into the district and created a sensation throughout the San Juans. Production rose sharply at the Guston, Robinson, Congress, Orphan Boy, and Yankee Girl, and preliminary work began on a new property soon to prove another sensation–this was the National Belle. But mining tended to focus on the Yankee Girl. The purchasers of the original mine included O. P. Posey and George Crawford, Eastern investors who would soon play important roles in the San Juans. They eventually acquired the Orphan Boy, and in 1883, they incorporated these and probably other properties into the Yankee Girl Mining Company. As work on these mines continued, however, the water began to flow in and drown the workings, so that the enterprise had to install pumping equipment or drive drainage tunnels. More mines came to be sold to Eastern investors, and still more came on stream, notably the Genessee and the Vanderbilt.

Town building surged apace with ore production. When mining began, the only communities in the Red Mountain Pass area were Sweetville (which evolved into Chattanooga) and Poughkeepsie. Then Rodgersville appeared, but only briefly before it evolved into Red Mountain Town. Then there emerged Red Mountain City and Congress. Eventually, down valley to the north developed the small town of Ironton in Ironton Park. These settlements were first tent "cities," later log towns, and still later, if they survived, small communities with one- and two-story structures, false fronts on the business buildings, wooden sidewalks, and sometimes wooden corduroy roads. Red Mountain Town gradually emerged as the most important of these communities as its rivals declined and faded away. Well down valley and to the north the growing town of Ouray became an important transportation, distribution center, and sometime reduction center serving the Red Mountain District and others in the San Juans. As it prospered and it looked like it would become permanent, the settlers erected brick buildings, an architectural stage most mining camps rarely, if ever, achieved.

With the mines opening in the early 1880s, Red Mountain appeared destined to become one of the great mining centers in Colorado irrespective of the high production costs stemming from the isolation, high transportation fees, difficult weather (notably in winter), and the growing menace of water in the workings. Mining continued, as did transactions and consolidations, notably when the Posey-Crawford group, which owned the bellwether Yankee Girl, bought the National Belle Mine late in 1884. This group now possessed the most important properties in the district. Sales and consolidation continued; the Genessee-Vanderbilt Mines came under the control of one syndicate, while the Guston was sold to an English company. Eventually, one T. E. Schwartz became the manager of many of the mines. Production grew, however, and for a time in the mid-1880s, Red Mountain out produced all other mining districts in the state, save the great Leadville. But falling grades of ore, along with lower prices for silver and lead, forced many mines to curtail production or eventually close. Even though perhaps as many as 2,000 people worked in mining at Red Mountain, by the mid-1880s the district was in trouble.

A core problem for mining at Red Mountain was transportation, or more accurately, inadequate transportation. The Rio Grande never extended its rails north of Silverton, and ore from Red Mountain either went by mule train or ore wagon south to Silverton or north to Ouray for shipment to the smelters. In the mid-to-late 1880s, however, Otto Mears and others, notably Messrs. Posey and Crawford, built the Silverton Northern Railroad to Red Mountain and from there down to Corkscrew Gulch at Ironton Park in 1888. The descent further north to Ouray proved too steep for a conventional railroad. Nonetheless, Red Mountain now had service and that reinvigorated mining in the region. There was another boom similar to that of the early 1880s as this line meant that much lower grades of ore could be shipped. Red Mountain surged again, so much so that ore production overwhelmed the Silverton Northern's hauling capacity to move it. The Yankee Girl and the Guston, with common management provided the bulk of production, and during this second boom, the Yankee Girl passed into the hands of an English company. So, too, did the National Belle, Silver Bell, and other mines, purchased by National Belle Mines of London.

The new boom, however, was short-lived. Even though English capital now dominated the district, it could do nothing to stem the impending decline. As silver continued to slide in price and as the ore in the mines proved ever less and discontinuous, production fell. This was compounded by the water problem and by the huge amounts of sulfuric acid that ate away pipes, tools, and machinery, making Red Mountain one of the first places in Colorado where this problem became acute. By the early 1890s, the mines began to close one by one again. Fires in town and on mining properties complicated the issue, and a devastating blaze consumed most of Red Mountain Town itself in August 1892.

1.5.3 Marshall Basin

While Red Mountain and other districts became established in the central and southern San Juans, there was also activity on the west side of the mountains. In the early-to-mid-1870s, placer miners pressed into the San Miguel River Valley where they worked seasonally into the 1880s and beyond. As elsewhere, these efforts ranged from those of individuals and small groups using pans, toms, and sluices to large companies using hydraulic mining techniques to work more substantial acreage. A prominent enterprise was the San Miguel Gold Placers Company, headed by Benjamin F. Butler, the controversial Civil War general; this firm claimed to have 900 acres of land on the river.

Fig. E.I.14 Marshall Basin, above Telluride, Colorado, about 1890. Collection of the Stephen Hart Library, Colorado Historical Society.

As placer mining led to hardrock mining, Telluride emerged at the point where the waters of several streams coalesced from the majestic mountains beyond. In the search for gold, beginning in the 1870s, placer miners ascended the streams into the steep basins above their camp. There they found the outcrops of several deposits of what would eventually evolve into a series of famous mines. One key player in this was J. H. Ernest Waters, an Englishman working for either the Chinese government and/or English bankers in Hong Kong. The record is unclear, but Ernest Waters' presence presaged important British investment in the region.

The earliest lode mines developed were the Sheridan, Mendota, Smuggler, and Union, high above timberline in Marshall Basin. All located on the same vein, they were staked and claimed in 1875 and 1876, and the four mines evolved at altitudes ranging from 11,500 to 12,500 feet: the Mendota was the highest, followed by the Sheridan, Smuggler, and the Union. The original ore lay near the surface, which made mining easier than otherwise, but the harsh weather and high altitude enhanced problems, let alone the avalanche danger and high costs of transportation. Shipping the ore proved a problem, some being carried down by mule trails to Pandora just east of Telluride, and some was hauled up over the Mendota Ridge and down to Ouray.

Fig. E.I.15 Pandora Mill at Telluride, Colorado, about 1890. Collection of the Stephen Hart Library, Colorado Historical Society.

Given these circumstances, the discoverers and early owners sold out whenever they could. They lacked the capital for real development. The mines changed hands from time to time, but eventually, through the energies of Ernest Waters, consolidation began. In 1887, he organized the Sheridan Consolidated Mining Company, then acquired the Oriental and the Pandora Mines farther down the mountain, and perhaps most importantly, ended up with a stamp mill at Pandora, destined to become the milling center of the area. Eventually, Ernest Waters' company purchased the Mendota. Meanwhile, John Porter, an important investor in San Juan projects, put together an investment group that acquired and merged the Smuggler and the Union, and then for a reported $400,000, his enterprise bought the Sheridan-Mendota and merged it with the Smuggler-Union under the latter name. "The Pandora Mill," also acquired in these complex transactions, now emerged as the most important in the district, although over the next century, there were actually several different mills working ores with different technologies at Pandora.

With the merger complete, the Smuggler-Union became one of the most famous gold mines in Colorado. The enterprise added bunkhouses for the crew and erected a powerhouse, offices, and storage buildings. But the key problem was getting the ore from the mines to Pandora Mill. To solve both this problem and to eliminate the cost of lifting ore up shafts, Ernest Waters drove an incline from 11,700 feet in Royer Gulch to the Smuggler-Union vein. Then from the portal where the company built ore bins and bunkhouses, he installed a suspension bridge across Royer Gulch (said to have been the highest suspension bridge in the world at the time); from there he constructed a massive incline for a double-tracked funicular railway known as the Sheridan Incline. Some 6,900 feet long, it carried the ore down 2,200 feet directly to Pandora Mill or to the Rio Grande Southern Railroad. Although it was a spectacular engineering achievement, the funicular railroad proved cumbersome, and eventually the company replaced it with a complex tramway system that remained in use for the rest of the mine's development. Finally, after all this effort, in 1899, the Porter group sold the company to the New England Exploration Company, headed by Colonel Thomas Livermore of Boston, Massachusetts.

1.6 The Silver Crash and After: 1893 to circa 1900

Since the recovery spawned by the Boston and Colorado Company in the late 1860s, silver had been of ever increasing importance in Colorado's metal production, and it surged to prominence with the rise of Leadville and the central Colorado boom. Gold clearly took a back seat in the heady 1880s dominated by the surging output of the white metal–but that was the problem–there was too much production.

The decline in silver prices in the United States was long and slow. Prior to the boom at the Comstock Lode in Nevada in the late 1850s, the nation had little silver, and the price was generally higher than $1.25 per ounce. The federal government fixed the price of gold at $20.67 per ounce, and thus the ratio in the prices was about 16:1. As the Comstock came on stream, followed by silver districts in Colorado and elsewhere, the price began falling, owing to supply and demand. With the price of silver above $1.25 an ounce, shrewd entrepreneurs began melting down coins because the silver bullion could be sold for more than the face value of the coins it came from. That prompted Congress to pass the Coinage Act of 1873, which ended the production of silver coins. Just about that time, however, the growing output of silver forced the price below about $1.25 an ounce, and so began the agitation for what was called "resumption"–the resumption in coining silver, particularly the free and unlimited coinage of silver at a ratio of 16:1 with gold. Had such a measure become law, it would have boosted silver prices back to at least $1.25 an ounce, but such a law was not to be. Congress remonetized silver through passage of the Bland-Allison Act of 1878, but there was not enough silver minted into coins to keep prices from falling. The rise of Leadville and other silver mining centers only served to depress the price. It generally fell by about one or two cents a year, and by early 1893, it stood at about 80 cents an ounce.

Then on June 26, 1893, came disaster. On that day, the British Parliament accepted the report of the Herschell Committee, which recommended that Her Majesty's Mints in India cease the coinage of silver rupees. Overnight, the price of silver plunged from 80 cents to 64 cents an ounce, a 20% collapse, then continued sinking to 60 cents an ounce, a 25% loss. Almost instantly, the American silver industry began shutting down. Mines closed, mills closed, and smelters closed. Railroads curtailed service, banks failed, and real estate investors sold their holdings at heavy losses. Thousands of people lost their jobs. In mining, unemployment soared in all the silver regions, reaching 40% to 50% in the larger communities, and nearly 100% in places supported by only one or two mines. By the Fourth of July, virtually the entire silver industry had come to a halt. The Silver Crash of 1893 was a catastrophe in the West, and especially in Colorado, where silver production formed the backbone of the minerals industry and the state economy. Later in the year, the repeal of the Sherman Silver Purchase Act of 1890 put even greater pressure on the industry. Some historians believe that in Colorado the ravages of the Crash created an economic crisis equal to or worse than the ravages of the Great Depression of the 1930s. The psychological impact of the collapse was also so great that innumerable historians have written–incorrectly–that it destroyed the silver industry in Colorado and the West.

As 1894 began, the price of silver finally stabilized at about 60 cents per ounce, and the silver industry gradually came back to life. The mines, mills, and smelters reopened; so, too, did many ancillary businesses. But there were significant changes that were quickly evident. The most obvious change was in wages. The price of silver was now about 25% less than it had been six months before, and as the industry rehired workers, the wages offered workers were about 25% less as well. So, in effect, hardrock miners, mill workers, and smelter men bore the brunt of the silver collapse. That, of course, had important consequences. The 1890s witnessed a dramatic increase in unionization and the beginning of a virulent labor-management war that would last for at least a quarter century.

The most powerful union that began organizing the metal miners was the Western Federation of Mines (WFM). An outgrowth of the Butte Miners Union in Montana, it quickly superseded the long-faltering Knights of Labor in ore-producing areas and by the mid-1890s had become a powerful force throughout the West and especially in Colorado. As workers sought to boost wages back to what they had been before the Silver Crash, recruiters for the WFM enjoyed huge successes among miners, mill workers, and smelter men. When owners, often hard-pressed themselves, in general refused to bargain and negotiate, the WFM evolved down the road to strikes. The first major confrontation with management was the Leadville Strike of 1896–97, which shut down the entire district. Ultimately, as violence between the two sides loomed, owners persuaded the governor to call out the National Guard to keep order; at Leadville and in other confrontations to come, this had the effect of breaking the strike. By the mid-to-late 1890s, Colorado had become a battleground between labor and management.

There were many other changes fostered by the Silver Crash. One was consolidation. Mergers in the industry were nothing new, but the crash enhanced this movement in order to reduce operating costs and take advantage of economies of scale. That also meant that employers needed fewer workers, which also put downward pressure on wages and exacerbated the labor situation. To reduce operating costs in other ways, mining companies used capital to acquire more machinery, which also reduced the need for workers. Many of the more marginal mines never reopened, although some of the larger, better capitalized enterprises acquired at least some of the marginal producers. The low price of silver also shifted the emphasis in prospecting to the search for gold.

As the industry struggled, there were other efforts to reduce costs as well. One was the greater interest in driving deep tunnels under older workings. Deep tunnels promised three things–miners hoped to dewater workings, explore for minerals at greater depth, and reduce mining costs by allowing ore cars to roll downhill out of mines, eliminating the cost of lifting minerals up shafts. The beginnings of this work preceded the Silver Crash, but again, the plunge in the value of the white metal accentuated the effort. The most famous of these was the Yak Tunnel at Leadville, which eventually ran from the base of Carbonate Hill to Iron Hill and Breece Hill and eventually to the Resurrection Mine. It was a great success. Others, such as the Joker Tunnel at Red Mountain and the Argo Tunnel at Idaho Springs, were less successful. Deep tunnels, however, formed a key element in industry thinking from the 1890s forward.

There was also a greater interest in milling technology, and with that came the increasing use of shaking tables. The most famous was the so-called Wilfley table, developed by a miner-turned-engineer Arthur Redman Wilfley, at Kokomo, just north of Leadville in the 1890s. The Wilfley and other shaking tables allowed for a more effective separation of various minerals, particularly those with similar but slightly different specific gravities. By the late 1890s, shaking tables had come into use throughout Colorado.

1.7 The New Focus on Gold: the 1890s to circa 1900

1.7.1 Cripple Creek

As silver mining lurched into intensifying trouble in the 1880s and early 1890s, Colorado moved almost simultaneously to the eve of its greatest gold boom. It was a phenomenon long in development. As Colorado Springs came into being in the 1870s, its residents needed beef. On the flanks of Pike's Peak, which loomed high over the city, grazing of animals for the local market began. Slopes, hills, and valleys stretching away from the west side of the mountain in particular saw the development of grazing, and there in the late 1870s and early 1880s, various individuals discovered placer gold. A flurry of production gave way to stock speculation, which in turn went bust, damaging the district's reputation among prospectors, miners, and speculators. With Leadville's output soaring, the focus of miners in Colorado turned to silver and lead in the central Rockies.

By the early-to-mid-1880s, most people had turned their attention away from gold on the west side of Pike's Peak, but grazing on the high slopes continued. In the mid-1880s, however, Bob Womack, a cowboy working for cattle interests in Denver, began looking for gold in the Cripple Creek area. After a steer became crippled by a fall into an unnamed creek, the waterway became known as Cripple Creek. Not content with just tending cattle, Womack devoted at least some of his time to placering and washed out small amounts of gold that he spent on his time off in Colorado Springs. Eventually, in 1890, he discovered what became the El Paso Lode. The news of gold at Cripple Creek resurrected interest and out to the area came various individuals bent on finding more. Among them was Winfield Scott Stratton, a carpenter from the city. Just a few miles away from Womack's claim, Stratton also made a major gold discovery at Battle Mountain. Given that he allegedly made his discovery on the Fourth of July, he named his claim the Independence. As he developed the mine, the news spread, more discoveries followed, and the boom at Cripple Creek was on. Stratton emerged as the district's first millionaire once his and other claims began production through the Portland Gold Mining Company, destined to be one of the district's great producers.

As silver prices declined and finally crashed by 1893, Cripple Creek surged as a great new mining center for gold. The developments in infrastructure of the previous two decades served it well. It was only a short passage to extant railroads, and the Midland Terminal Railway along with the Florence & Cripple Creek Railroad were soon built into the area. New mines arose at the towns of Cripple Creek, Victor, Goldfield, and other communities, and the fame of Stratton's Independence, along with the Portland, Ajax, and other mines spread far and wide. Output surged, the State Legislature created a new county in Teller County, and production from the Cripple Creek District made it one of the foremost gold-producing areas in the world. By 1900, what had been little more than a grazing area had emerged as an industrial center with a large population, many mills, and a diverse labor force.

A crucial element in Cripple Creek's development was improving technology. Early on, mining companies had used stamp mills to recover their gold or had shipped ore to the smelters at Denver and Pueblo, but just as Cripple Creek emerged as a world-class gold center, so, too, did the revolutionary new cyanide process. In the early nineteenth century, scientists experimenting with prussic acid (made from dissolving sodium or potassium cyanide in an acid medium), discovered that the acid did something remarkable–it could dissolve and precipitate gold–which, of course, is virtually inert. After decades of experimentation, in the 1880s, European and South African metallurgists evolved a commercial process that could be used on a massive scale in the minerals industry. Among the first Americans to take an interest was the Leadville pioneer and millionaire Horace Tabor, who acquired the U.S. rights through his Gold and Silver Extraction Company. He did little with the process while on his road from riches to ruin, but others did. In the mid-1880s, near Crestone, Colorado, a small mining enterprise used the process successfully for the first time in the Centennial State. Success in other states and countries in the late 1880s and early 1890s advertised the process, and by the mid-1890s, it came into general use at Cripple Creek, Victor, and other towns in the new mining district. Here, it was used on a vast scale for the first time in American history, and elsewhere in Colorado, cyanide mills came into use in some districts.

Cyaniding was far more efficient than stamp milling and far less expensive than smelting. In essence, various devices crushed the ore into a very fine consistency, then water carried the sands into cyanide vats. There, the gold dissolved into solution, which was then run off, and then precipitated out through the use of zinc shavings. By the early twentieth century, the process had come into generally accepted use throughout the mining industry, although it could not be applied to all types of gold ores.

1.7.2 The San Juans

Elsewhere in the 1890s, there was both progress and retreat. In the San Juans, when the price of silver stabilized early in 1894, some of the mines in the Red Mountain District reopened, but it was only a temporary reprieve. Lower grades of ore, water, sulfuric acid, and other problems meant that only a few mines like the Yankee Girl and National Belle could operate, and even then with mostly skeletal crews. The glory days–the booms of the early and late 1880s–seemed increasingly to be a thing of the past. The mines appeared to have largely exhausted the chimneys of ore they had worked, and with at least one now as deep as 1,300 feet, costs were rising simply because of depth. By the end of the 1890s, the Red Mountain District had dwindled dramatically. Most of the mines lay shuttered and closed, and the population had declined in concert. Only the Congress, Silver Bell, and Silver Ledge continued their desultory operations on small pockets of rich ore.

Given the problems inherent in the district on the one hand and the slumping price of silver on the other, miners at Red Mountain and elsewhere in the San Juans turned their attention to gold, whose price held steady. News of the great discoveries at Cripple Creek spurred their efforts. One operation was of particular note. In 1896, across from the Yankee Girl, a group of entrepreneurs launched the Treasury Tunnel in hope of striking gold ore believed to be located deep in the mountains between Ouray and Telluride. The mine operated for a decade during which time it produced much hope, but far less ore. Yet in future years it would be a key in the massive consolidation of mines between Red Mountain and Telluride.

In the same year, 1896, another group of entrepreneurs launched their plan for what became known as the Meldrum or Hammond Tunnel. A central player in this was Andrew S. Meldrum, an elderly carpenter at the Sheridan Mine in Marshall Basin who had been central in locating and developing the Guston and the Yankee Girl at Red Mountain. He developed the idea of running a tunnel from the Red Mountain District large enough for a narrow-gauge locomotive to steam through the mountains to Telluride. It would find ore at depth and attract tourist traffic as well. But by 1900, only 2.2 of the 6 miles had been completed, and with their funds exhausted, and little of the projected rich ores found, the project came to a sudden halt, and the once well-to-do Meldrum eventually died a pauper.

Other projects also faltered, but one that had some promise was the Barstow. It began working around 1900 following the "grey copper" that resembled the Telluride ore located to the west across the divide. The company did develop an aerial tramway, built a 40-stamp mill, and shipped perhaps $700,000 mostly in gold before closing in 1917.

Another plan was to consolidate and reopen the older, nonworking, but still famous mines in the district. The key player in this effort was George Crawford, a former director of the Silverton Railroad and a part owner of the Yankee Girl. In 1902, Crawford spearheaded the organization of the Red Mountain Railroad, Mining and Smelting Company, whose goal was to drive what became known as the Joker Tunnel from a point near the Silver Bell beneath the old workings of the Yankee Girl, Guston, Genesee-Vanderbilt, and other mines. The goal was to explore at depth, mine, and dewater all at the same time. Construction commenced in 1904, and by 1907, the Joker extended some 4,800 feet to reach the mines either directly or through laterals. The Joker succeeded in opening up workings closed for years by too much water. Crawford gained control through purchase or lease of about 2,000 acres of mining property, but the tunnel never got farther than the Genessee and so never reached the National Belle or the Congress. The Joker closed in 1913, which effectively shut down the most of the district again. The Silverton Railroad closed a few years after World War I.

1.7.2.1 Savage Basin

While the bulk of the early work in the high basins above the San Miguel River focused on what became the Smuggler-Union Complex, gold mining also emerged in nearby Savage Basin. The name dates to about 1876 when one Charles Savage began prospecting the steep terrain. Later, in 1886, Otis C. Thomas, known as "Tomboy," located what he or others named the Tomboy Mine. Development proceeded at a desultory pace, but in 1894, with the collapse in the price of silver, greater attention was paid to gold. In that year, a group of businessmen in Telluride purchased both the Tomboy and the nearby Belmont Mine for a reported $100,000 and began working. Production rose to a reported $1.8 million in 1897, when the Telluride investors sold the mine to an English syndicate said to be headed by the Rothschilds, the great English banking family, which then established the Tomboy Gold Mining Company, Ltd. The various Tomboy managements built many buildings and structures, notably an aerial tramway that took the ore down some 1,800 feet to a company mill, located near the Argentine vein, also located by Savage in 1876, but little worked until bought by the Tomboy group. In 1902, the company opened a new stamp mill, and in 1916 a flotation mill nearby. The Tomboy stood as a large and famous gold producer until it finally closed in 1927.

Like central Colorado, the San Juans endured its share of labor-management problems. The most notable occurred in September 1903, when mine and mill workers went on strike throughout the Telluride District, a work stoppage that eventually turned violent, particularly at the famous Smuggler-Union Complex.

1.7.2.2 Ouray

The most important mine near the town of Ouray, deep in the San Juans, was the Camp Bird. The claims that eventually evolved into the famous mine were located in the late summer and fall of 1877 when one William Weston, an English promoter for the Kansas Pacific Railroad, fell victim to the lure of silver and hurried west to the new Mount Sneffels Mining District. With George Barber, another Englishman experienced in mining, they staked a number of claims in Imogene Basin, named for Imogene Richardson, the wife of prospector Andy Richardson. The most important claims were the Gertrude and the Una (named for Weston's relatives), both at a height of over 11,000 feet. These claims held gold, but not enough to make them profitable to work.

Fig. E.I.16 Camp Bird Aerial Tramway, near Ouray, Colorado, about 1910. Collection of the Stephen Hart Library, Colorado Historical Society.

Nearly 20 years passed, and by the mid-1890s, the mines and claims in Imogene Basin were largely closed and many abandoned. By this time, a new mine developer entered the San Juans. He was Thomas Walsh, whose smelter near Silverton needed ore. One of his new friends was Andy Richardson, a now elderly prospector who had named the basin and the pass after his wife Imogene. Richardson brought the area to Walsh's attention. In 1896, Walsh journeyed over the mountains and liked what he saw. He concluded that by acquiring large numbers of claims, he could reduce the cost of production through economies of scale and thus begin working the abandoned mines. Most people had sought silver in the basin, but Walsh was looking for gold, and given his experience at Cripple Creek and elsewhere, he found gold-bearing ore that everyone else had discarded in the search for silver. Quietly, Walsh bought up all the claims he could. In the winter of 1896/97, he and Richardson organized the Camp Bird Mining Company. They shipped their first ore to the U.S. Depository Mill a mile away, then as they developed the mine in 1897, they built their own amalgamating-concentrating mill two miles away, connected by the usual aerial tramway. It produced both gold and silver along with a gold-silver-copper-lead concentrate. Richardson was the initial mine manager until he was eventually pushed aside. He ended up

Fig. E.I.17 Camp Bird Mill Complex, near Ouray, Colorado, early in the 20th century. Collection of the Stephen Hart Library, Colorado Historical Society.

reasonably well-off by the standards of the day, but Walsh made a profit of about $2.4 million, then sold the mine to a new British enterprise, the Camp Bird, Ltd. in 1902, for at least $3.1 million and a share of the future profits.

The new British owners and especially Walsh did very well. The mine produced another $15 million in profit from 1902 to 1916 before it closed owing to the onset of World War I, the growing cost of mining and pumping, and the declining values of the reserves. In 1916, the enterprise suspended operations and drove a new, lower tunnel. The company also mothballed the boarding house and other buildings on the 3-Level, and dismantled the tramway. The new tunnel at the 14-Level required 19 months for driving, but finally reached the Camp Bird vein some 11,000 feet from the portal. This was the way it was operated–on various levels. But the tunnel achieved little, and the mine closed in 1920. There would be some work in future years, in fact, nearly all the way to the end of the twentieth century, but the heyday of the mine was past.

1.8 The Long Decline: circa 1900–2005

1.8.1 Decline and Revival: circa 1900–1939

The value of the metals produced in the "traditional" mining industry built on gold, silver, lead, and zinc peaked in 1900 in terms of value, and the mining industry went into a long period of slow, secular decline in terms of the value of the production. Prospecting languished, ore values in general declined, and the ores became more expensive to mine owing to the greater depth of the workings and the increasing problem of flooding. Considerable efforts were made to increase efficiency: there were further consolidations throughout the industry, smelters continued closing, and milling (cheaper than smelting) was enhanced. There was also continued interest in driving deep tunnels under older workings in the hope that they would find ore at depth, dewater the mines, and allow ore cars to roll downhill, a more economical proposition than lifting ore up shafts. The Yak Tunnel in Leadville was the most famous and probably the most successful of these deep tunnels. But in the first years of the twentieth century none of this work could stem a gradual decline that suggested that this traditional industry might peter out as soon as the early 1920s.

The slow contraction was evident everywhere. Consolidations and newer technology meant fewer jobs. Mines closed, and mining towns began fading slowly away. Enterprises sold off machinery where they could, leaving various structures in place. Given that silver and gold in the ores continued to decline, the industry became more dependent on mines that had ores with one or both of those precious metals, along with lead, zinc, copper, and sometimes iron. The base metal content of these ores became ever more important, but that in turn meant that mines were increasingly prone to downturns in economic cycles, notably the declines experienced in 1907 and again in 1913 to 1914. Zinc production in particular grew, particularly at Leadville, where it would eventually supersede lead as the primary base metal recovered.

The decline could also be seen in the smelting end of the industry. In 1899, partly in response to cost and profit pressures from within the industry, nearly all the major silver-lead smelting companies sold out to the newly-incorporated American Smelting and Refining Company, one of the great industrial consolidations of the era and part of a national wave of mergers around the turn of the century.

The declines were also mirrored in growing labor-management struggles. The impact of declining production constricted the number of jobs, and depressed wages and salaries. The result was that the very late nineteenth century and the first years of the twentieth century witnessed virulent disputes, most notably the strikes at Cripple Creek, Telluride, and Leadville. Colorado governors, notably the controversial James F. Peabody, sometimes called out the National Guard: to maintain law and order, said some; to break unions and strikes, said others. Whatever the truth, Colorado became nationally known as a battleground between capital and labor in both its metal mines and coal mines, and in its mills and smelters as well.

What temporarily altered this slow, but steady, decline was World War I. It broke out in Europe in August 1914, and as the conflict evolved into history's most titanic war up to that time, the belligerents began to place orders for everything they needed in the United States. That stimulated the economy, and ended the growing downturn of 1913 to 1914, which in turn had a profound impact on the Colorado mining industry. Given wartime demands for lead and zinc, prices rose, which increased production from many mines, notably in Leadville, given its extensive zinc deposits, but from other places as well. While this expanded production did not return output to the levels seen about 1900, they were in general the highest in roughly 15 years.

The war also stimulated demand for rare "exotic" metals now needed to harden and toughen steels–notably vanadium, tungsten, and molybdenum. For the first time in history, their output became important, and Colorado evolved as the world's leading producer of both tungsten and molybdenum. In the process of vanadium mining, the state produced substantial amounts of what was considered a "useless" byproduct just thrown on mine dumps–the metal uranium. Uranium would be in great demand from World War II onwards. (See Section E.I.3.)

The war years were good for the mining industry, although this was punctuated by casualties once the U.S. entered the conflict directly in 1917, and later by the notorious influenza epidemic of 1918 to1919, which claimed many lives in the mining areas.

This period also saw the advent of even more sophisticated milling technology–ore flotation. The genesis of ore flotation remains a matter of controversy. In the 1880s and 1890s, Carrie Everson, a nurse in Denver, began seeking a means to recover gold and other minerals from low-grade ores found in mines her husband had purchased. Experimenting at both Georgetown and Denver, she discovered what became known as the flotation process. When ground very finely to free the minerals present and then agitated with saponifying agents–i.e., soap–the sulfides and other minerals adhered to the soap bubbles and rose to the water surface generally as dark gray bubbles. From here, the bubbles could be run off, the water evaporated, and the minerals recovered for further processing. Although Everson recorded the first patents on the process, she and various business partners were never able to make this radical, counter-intuitive technique a commercial success. Some twenty years passed, and others outside the U.S. finally made ore flotation viable in the market. Beginning around 1910, new entrepreneurs imported the process into the U.S. and to Colorado, and then ensued another decade or more of litigation over the patent rights of this remarkable technology. Both sides had a vested interest in discrediting Everson's work and did so successfully. But from an industrial perspective, the process came into use in Colorado during World War I at Leadville, the San Juans, and other areas. It dramatically enhanced milling. Differential flotation eventually evolved, and like cyaniding and the use of shaking tables, flotation became central in twentieth-century ore processing.

For the Colorado mining industry, however, the advent of peace in 1919 only brought hard times. As war demand for everything halted, the economy went into a recession, and the result in the mountains was a near collapse of the mining industry in all its forms. Demand for the new metals like tungsten, molybdenum, and vanadium also evaporated, shutting down those mines and milling plants (Section E.I.3), and output from the traditional mining industry retreated so dramatically that production totals for the late 1910s and early 1920s continued the secular decline of the first years of the twentieth century. Coupled with that, the famous Cripple Creek District now declined as well after some 30 years of world-class production. For Colorado mining as a whole, the 1920s saw diminished returns nearly everywhere. The industry that had brought the territory and state into being in the late 1850s, some 60 years before, was but a shadow of its old self. Some towns and camps disappeared, others saw their population fall off dramatically, and innumerable people left.

As the mines struggled with diminishing production or closed altogether, the mills and smelters shut down in conjunction, and as ore and mining traffic dried up, the mining railroads dwindled as well. With the permission of federal regulators, the now-famous railroads that helped open and sustain the industry pulled up the rails and abandoned many routes, a process that continued all through the twentieth and into the twenty-first centuries.

If the 1920s brought hard times to mining, conditions grew worse in the 1930s. The advent of the Great Depression in 1929 shocked the entire economy. As millions lost their jobs, capital spending imploded, prices for lead and zinc fell sharply, and the impact on an already reeling industry proved devastating. By 1932 to 1933, economic conditions throughout the United States had become so bad that demand for metals largely ceased. In the early 1930s, nearly every metal mine in Colorado closed as the industry came to a virtual standstill. Famous old mining towns like Aspen and Breckenridge and many others stood largely abandoned. The industry spawned by the Gold Rush in 1858 essentially ended production. Many mines never reopened.

During the Great Depression, the Roosevelt administration did what it could to revitalize the minerals industry. In 1935, Congress passed the Gold Standard Act, which lifted the official price of gold from $20 per ounce to $35 per ounce. The purpose of the new price–a 75% increase over the old–was to stimulate gold mining, but it had little such impact in Colorado. And to some degree, the Act offset its own goals when it decreed that individuals could no longer own gold, or gold coin, and only limited amounts of gold jewelry, in an effort to shore up government reserves of the royal metal with the mythology that the currency was backed by gold. Innumerable Americans turned in gold. The administration also managed to boost silver prices, but again, this effort brought little perceptible impact on silver mining.

By the late 1930s, however, the industry began to show a glimmer of hope for at least some renewed production. New mills using more advanced technology came into being in Leadville and some other towns to rework old mine dumps and mill tailings in order to recover metals lost in earlier, less efficient processing. The Hamm Mill in Leadville was one of these new mills. Ore flotation, notably differential ore flotation, was important in these new processing efforts. Smelting, though still significant elsewhere, never staged a comeback in Colorado, as it was generally too expensive to work the limited production here. Concentrates from old and new mills now went out of state rather than to the very few remaining Colorado smelters, notably the Arkansas Valley Plant in Leadville.

The late 1930s also saw further consolidations in the industry and continued interest in driving deep tunnels to advance production. New enterprises with an eye to future economic recovery entered the state. In Leadville, various geologists and engineers familiar with the area became convinced that if and when metals prices ever recovered the old mines might be profitably reopened by further consolidation and the use of more modern technology to compensate for the low-grade ores from greater depths. To that end geologists, mining engineers, and others began to explore older workings, particularly through the Yak Tunnel. From this effort emerged the Resurrection Mining Company. The American Smelting and Refining Company also began consolidating claims and mines in the district.

1.8.2 World War II

By the time World War II began in Europe in 1939, most of the traditional Colorado mining industry was a shadow of its former self. There were custom mills here and there. The Arkansas Valley Smelter, for example, continued to reduce ore and concentrates shipped from throughout the state and elsewhere, but there was little production in general. Even the boost to gold and silver prices in the mid-1930s had failed to revive production.

World War II did, however, bring about a slight spur to the traditional mining industry. As the developing conflict grew more intense in East Asia in the late 1930s, and as Europe plunged into war in

Fig. E.I.18 Resurrection Mill Complex, near Leadville, Colorado, in the 1940s. Collection of the Stephen Hart Library, Colorado Historical Society.

September 1939, the United States began to rearm. That effort boosted prices for lead and zinc; it spurred interest in exploration and potential production, particularly from large mining companies that might acquire larger tracts of land and mine with the advantage of economies of scale. There was growing interest and some growing production from 1939 through 1941.

All that changed with the Japanese attack on Pearl Harbor in Hawaii on the morning of December 7, 1941; this brought the United States into the War. Demand for metals of every sort now surged, and the federal government played a central, perhaps unprecedented, role in wartime production. The Roosevelt administration soon deemed gold an unnecessary metal in the war effort, and forbade mining for it–at least directly. This, however, was a two-edged sword because aside from the Cripple Creek District and placer gold, Colorado's gold came largely in conjunction with the mining and processing of other metals. The administration also earmarked various other metals (primarily lead and zinc) as strategic, and to spur production, it provided prospecting and exploration services through the U.S. Geological Survey and the U.S. Bureau of Mines. It also provided investment capital through the Reconstruction Finance Corporation and the newly formed Defense Metals Exploration Company and the Metals Reserve Company. Massive mobilization of the armed forces limited the availability of experienced miners. As a result, the federal government sometimes gave draft deferments to miners. The army also released former miners from duty so that they could engage in mining, and on occasion, used soldiers in mining activities, although that was quite limited. Many women took mining jobs traditionally held by men, although women rarely worked underground in any capacity.

The War also prompted strong efforts to recycle and rework. People scoured old mining areas to scavenge for all sorts of abandoned, rusting machinery, and perhaps some that was neither rusting nor abandoned. It also meant that new operators carried away old mine dumps and tailings piles to rework them in Colorado or elsewhere. With so many railroads gone, but with new highways built, the truck came into general use in the industry. All this changed the mining landscape, but neither the high prices for metals nor government investment (or indeed any other factors) returned the industry to what it had been in the late nineteenth and early twentieth centuries.

1.8.3 Post World War II

The Cold War that unfolded in the wake of World War II tended to keep the price of base metals relatively high. There was demand for lead and zinc, and for a time, that sustained some older mining districts. At Red Cliff, the New Jersey Zinc Company produced massive amounts of zinc from a once minor area known as Gilman in Eagle County. For a time there was expanded production in Leadville at the old Colonel Sellers Mine (established in the late nineteenth century). And another key development was the remarkable Resurrection Mine in Leadville through the work of Newmont Mining Company and others, and the working of the "down-dropped block" in Iowa Gulch by the American Smelting and Refining Company. But their efforts were severely impacted by the serious recession of 1957. Eventually, these properties were worked jointly for a time in what was known as the Res-ASARCO Joint Venture.

Even if most mining areas continued to fade away in the wake of World War II, the postwar years saw the spectacular development of the Idarado Mine (centered around the Treasury Tunnel), producing lead, copper, zinc, gold, and silver. It emerged out of work initiated in the Red Mountain and Telluride areas in the 1870s. Entrepreneurs had developed many mines there in the central and western San Juans, and in the early twentieth century, a new generation of entrepreneurs had driven adits from the Red Mountain area west toward the Telluride side, but none of their projects had enjoyed much success as the traditional minerals industry died away at Red Mountain. Now times changed, however. Between 1921 and 1924, the Million Dollar Highway was upgraded and moved west across the valley closer to the Treasury Tunnel, but the mine itself had little life until it passed into the hands of the San Juan Metals Company in the 1930s in the midst of the Great Depression. This enterprise built a new boarding house, mill, and offices in 1937, but had little success with the nation still locked in the throes of the Great Depression.

In 1939, several new parties formed the Idarado Mining Company to acquire the Treasury Tunnel, Barstow, Black Bear, Imogene, and other mines. In return for the Barstow claims, Oscar H. Johnson of the Mine and Smelter Supply Company in Denver became president. The investors included the Newmont Mining Company, Sunshine Mining Company, Barstow Mining Company, Black Bear Mining Company, and the Callahan Zinc-Lead Company. The Idarado Mining Company reportedly leased its properties to the Metals Reserve Co., a subsidiary of the Reconstruction Finance Corporation, and beginning in 1943, the Sunshine Mining Company operated the tunnel and drove a 7,000 foot extension of the Treasury Tunnel. But in 1944, Newmont bought out Sunshine and reportedly repaid the moneys invested by the Metals Reserve Company.

In 1945, the Red Mountain Mill was rehabilitated and reopened. The Idarado Mine deposited its tailings in Treasury Lake near the mill, but this eventually proved inadequate. Later, the Idarado Mining Company reportedly purchased the old Ironton townsite for a new tailings pond. Red Mountain Creek was rechanneled in 1950 and a new tailings pond constructed in 1951. Treasury Lake was finally filled in with tailings and other waste rock and became a parking lot for trucks at the mill.

In 1949, the newly formed Idarado and Telluride Mines, Inc. (or TMI) began negotiating to seek ways of mining based on access to mills rather than property boundaries. This led to a five-part agreement between TMI, the Idarado Company, Tomboy Gold Mines, the Atlas Mining Company, and the Newmont Mining Company to establish areas of mining. But in 1952 and1953, market conditions forced TMI to close–the upshot being the Idarado Mining Company's buyout of TMI in May 1953.

A major event in this process was the consolidation of milling operations. In 1954, the Red Mountain District became connected with Telluride via the Treasury Tunnel and TMI's Mill Level Tunnel. Then in 1956, the Idarado Mining Company closed the Red Mountain Mill, built in 1937, and consolidated all milling operations to "the" Pandora Mill, which was completely rebuilt in 1955. From this point onwards, production at the mine generally grew to more than 400,000 tons of ore per year, and output peaked in 1966. After that, production declined, and the mine gradually became unprofitable, leading to its closure in 1978. This shutdown became permanent in 1984. Ultimately, the Idarado Mining Company began to reclaim the site on both sides of the divide by recontouring the land, revegetating the tailings areas, and building concrete channels to take water around tailings impoundments.

The 1980s and 1990s saw the traditional mining industry continue to wane. The Colorado School of Mines worked its Edgar Mine, but only for teaching purposes, not ore extraction. A few other mines, such as the Phoenix near Idaho Springs and the Old Hundred near Silverton, converted operations largely to tourism. In Boulder County, very small operators like Tom Hendricks continued exploring and mining a little gold ore near Caribou. Production in Leadville finally came to an end when ASARCO closed the Black Cloud Mine in 1999. About the only key development in traditional gold and silver mining was the new open-pit gold mine at Cripple Creek, which began operations in the 1990s and continued into the early twenty-first century with a state-of-the-art facility for recovering gold.

Fig. E.I.19 Loading in open pit mine near Cripple Creek, Colorado, in 2004. Collection of James E. Fell.

Fig. E.I.20 Leach field at open pit mine near Cripple Creek, Colorado, in 2004. Collection of James E. Fell.

Fig. E.I.21 Open pit gold mine near Cripple Creek, Colorado, in 2004. Collection of James E. Fell.

1.8.4 Environmental Cleanup: the 1960s to 2005

As the traditional mining industry waned in the years after World War II, there was growing public interest in the environmental consequences of mining and in the environmental cleanup of mining areas. Some mid-century studies had suggested that mining and its waste products yielded deleterious consequences, but they influenced few until the 1960s when Rachel Carson's book, *Silent Spring*, galvanized the environmental movement all over the United States. Although Carson's sensational and highly controversial work focused on the harmful effects of pesticides, its impact carried into many quarters. Mining was one. In the years that followed, there were many studies of mining's impact, and that led to the passage of various laws governing the cleanup of dumps, tailings, slag piles, and mine sites. Powerful litigation also followed–so much so that some commentators claimed that by the late twentieth century, the main product of the minerals industry was litigation.

As the litigation resolved itself in the late 1980s and after, the few surviving mining companies and other entities began the process of reclamation. In Leadville and elsewhere, mining dumps and tailings piles were moved, covered over with earth, and revegetated. Trees and shrubs were planted. Land and waterways were recontoured. Concrete culverts were built to divert water around tailings piles and other dumps so that the water would not pick up heavy metals. New water treatment plants were also built. At the same time, various state agencies began the process of closing the thousands of open shafts, adits, and tunnels. This reclamation process continues today even as this Context is written, but the long-term consequences of the cleanup effort remain uncertain.

Fig. E.I.22 Concrete culvert used in environmental Remediation in 2005. Collection of James E. Fell.

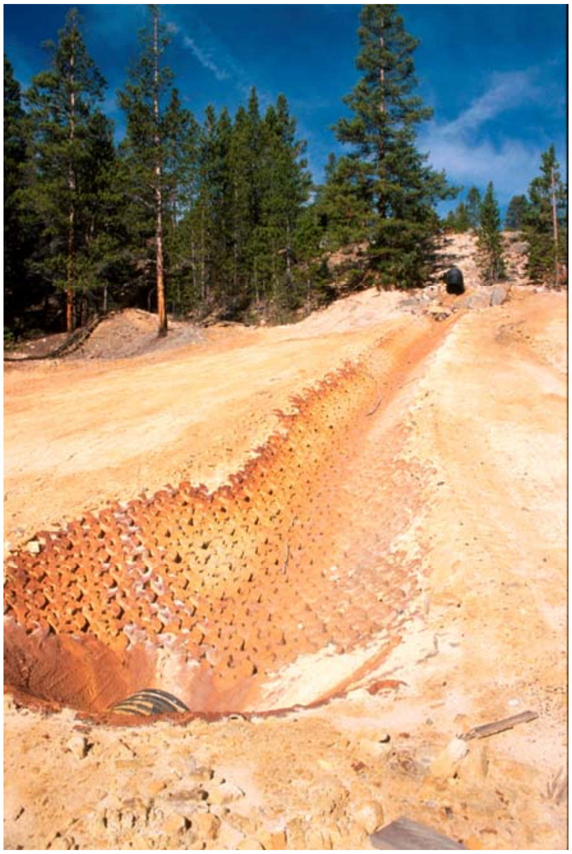

Fig. E.I.23 Lined ditch used in environmental remediation in 2005. Collection of James E. Fell.

Fig. E.I.24 Cribbing at the ruins of the A.Y. and Minnie mines, Leadville, 2005. Collection of James E. Fell.

Fig. E.I.25 The Apache Tailings remediation, Leadville, 2005. Collection of James E. Fell.

2. The Coal Mining Industry: 1858–2005

2.1 Expansion: 1858 to circa 1900

As with the case of metal mining, no one knows who made the first discovery of coal in Colorado. The Indian Peoples who inhabited the region probably knew about coal, but apparently it played no role in their cultures. The oldest known reports of coal stem from the work of trappers, traders, and military personnel in the early-to-mid-nineteenth century. From that work emerged a small body of literature even before the Pike's Peak Gold Rush of 1859. One of the first discussions of coal along the Front Range appeared in the report of the Gunnison-Beckwith Expedition of the 1850s, but it produced little interest and certainly no rush to develop the coal deposits. The Rocky Mountains were remote. During the early stages of the Pike's Peak Gold Rush, however, reports of coal prompted a few prospecting parties to search the region. That quest led in turn to the discovery of several deposits northeast of the new "Denver City" (Fig. E.I.2).

As subsequent work revealed, the coal deposits lay in an arc running northeast to northwest some 15 to 25 miles away from the heart of town. This locale eventually became known as the Northern Coalfield. The development of the Northern Coalfield was slow. Most people surging into the High Plains in the late 1850s and early 1860s were placer miners who focused their energies on the search for instant wealth from gold. Nonetheless, some entrepreneurs mined a little coal from a few mines several miles from Denver and shipped it profitably into the burgeoning gold camps. Coal was heavy and hard to transport without railroads, however. "The mines" saw little development, and so, this first "industry" grew very slowly, but it was a beginning.

What initially spurred the development of the coal mines was the rise of hardrock mining in the mountains, the evolution of new towns there, and the advent of communities on the High Plains. As supplies of wood dwindled, the need for fuel created a growing demand for coal. That in turn spurred the development of what were called "wagon mines," a name that stemmed from how the coal was shipped. The most important of the first wagon mines were at Marshall, located on South Boulder Creek about 20 miles northwest of Denver. Here in 1863, James Marshall opened a deposit to supply coal to Denver and other markets, a business in which he enjoyed some success. The next year, Marshall also launched the Colorado iron industry when he built a crude blast furnace to produce that metal, but he was not successful in that enterprise. The coal in the Northern Coalfield was a sub-bituminous coal or lignite, which was too low in grade in quality for reducing ores to metals. Eventually, Marshall shifted his blast furnace fuel from coal to charcoal and kept producing iron for a time. This change was significant. It meant that he and others understood that the coals mined in the Northern Coalfield were unsuited for either metallurgy or steam making. Instead, the product would go to households and businesses essentially for heating.

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If Marshall and others had opened key deposits in the Northern Coalfield during the early stages of the Gold Rush, then it was left to others to find and develop more important deposits elsewhere. In 1860, several prospectors discovered good grades of bituminous coal just east of Canon City. This would eventually prove to be a good-quality steam coal, but there was very little production early on. The cost of transportation and the distance from the primary markets of Denver and the burgeoning mining towns on the forks of Clear Creek proved prohibitive. The overarching Colorado economy also proved a problem. Given that metal mining, notably gold production, drove the Colorado economy, it was no surprise that the collapse of the gold industry in the mid-to-late 1860s seriously hampered efforts to advance coal mining. Despite its early promise, the production of coal was minimal during the decade, mostly a sign of things to come.

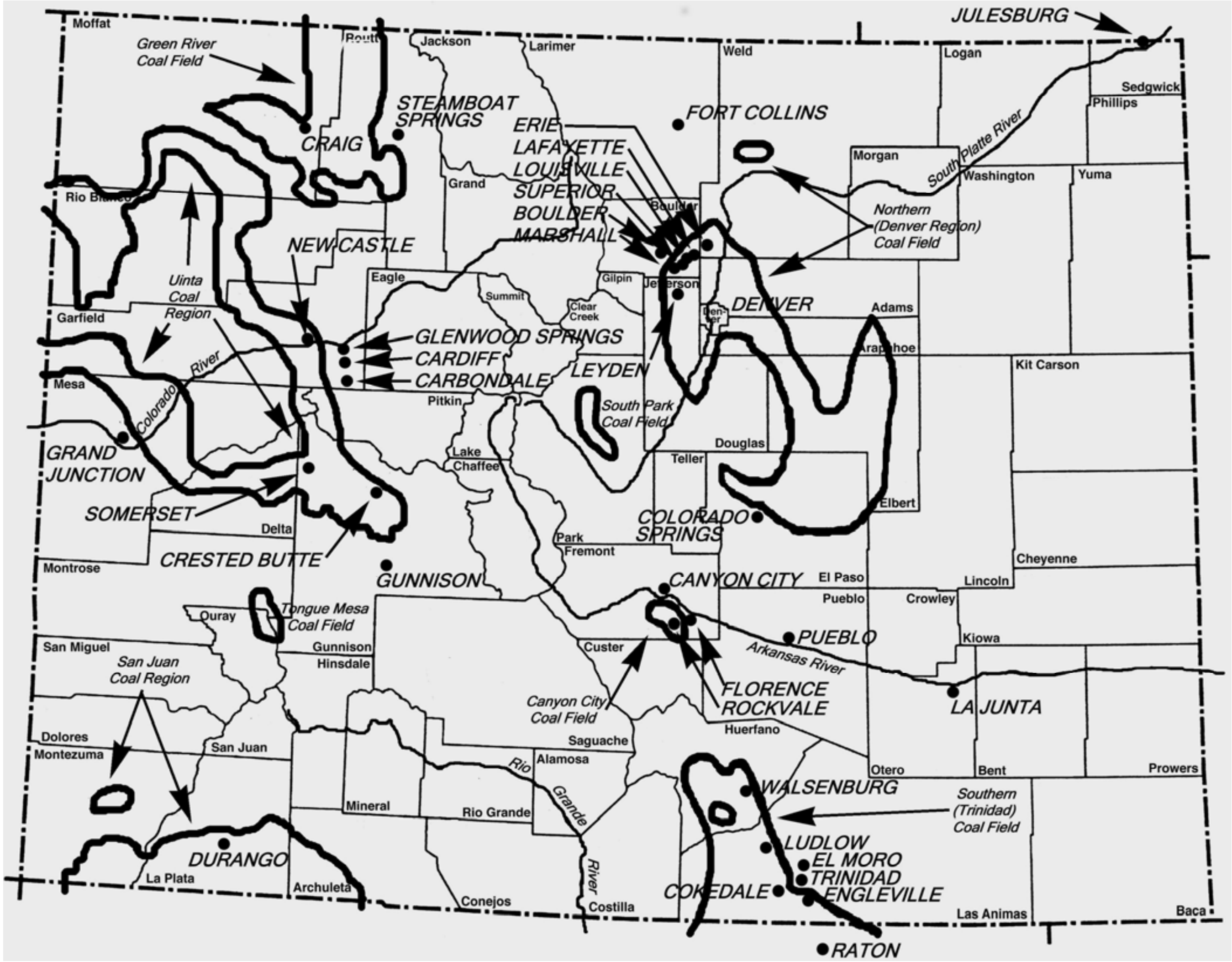

Fig. E.I.26 Map illustrating the coalfields in Colorado.

What spurred the advance of coal mining was the revitalization of metal mining in the late 1860s, coupled with the first railroad construction in Colorado. As metal mining recovered with the building of the Black Hawk and other smelters, the railroads finally arrived in Colorado. The Denver Pacific connected Denver to the Union Pacific main line at Cheyenne in 1870, and the Kansas Pacific came to Denver a couple of months later. Then the construction of other lines radiating from Denver and other communities increased service. The railroads created not only a demand for steam coal but also a means to carry it cheaply to distant markets.

The impact of the railroads came first in the Northern Coalfield. In 1871, the Boulder Valley Railroad, building off the Denver Pacific line, laid track to the new town of Erie, some 20 miles north of Denver; it stimulated renewed development of the Northern Coalfield. The key enterprise was the Boulder Valley Coal Company, which was closely connected to the Kansas Pacific Railroad, then approaching Denver. That relationship reflected a necessary component of future coal-mine development–the association with (even the ownership of) coal mines by railroad companies. Production of the Boulder Valley Mine surged as it became Colorado's largest producer for a time, and overall the statewide coal industry now grew strongly, based primarily on the renewed output from this field. Erie became the most important coal town in Colorado. Because the low-grade coal from the Northern Coalfield could be used only for domestic purposes, production evolved into a seasonal actively during fall, winter, and spring. In the summer, most of the mines closed, which turned miners into agricultural workers on the nearby farms and ranches. This would be characteristic of the Northern Coalfield until production petered out in the late 1940s and 1950s.

So, despite rising production from the Northern Coalfield since the early 1870s, it would not be ascendant for long. The as-yet untapped resources of the Southern Coalfield would soon overtake and overwhelm it. Here, as with metal mining, William Jackson Palmer and entrepreneurs involved in the Denver & Rio Grande Railway played a central role.

As it came into being over 1870 and 1871, Palmer and his associates envisioned building a railroad that would connect Denver with Mexico City. To that end, in 1871, Palmer began laying rails south along the Front Range of the Rockies. The Palmer group quickly founded Colorado Springs as a tourist resort–"Newport in the Rockies," some said–but as they built farther south, Palmer and his associates turned their attention more to heavy industry. Once they reached Pueblo, they built track some 36 miles west up the Arkansas Valley to tap the coal region near Canon City and the company town of Labran. Clearly, Palmer hoped to free the railroad from the inferior lignite mined at Erie. There at Canon City, they purchased about 1,100 acres of coal lands, including the Musser Mine, which had opened in the early 1860s. Through a series of complex transactions, Palmer's group put the coal lands into their development vehicle, the Central Colorado Improvement Company, created in 1871. Through other subsidiaries this enterprise built the last few miles of track to the coal mines, then, through still yet more subsidiaries, it opened the coal mines themselves. The semi-company town of Coal Creek came into being as well. The Canon City area was to be an important region of coal mining.

The U.S. financial Panic of 1873 hurt coal mining in Colorado for a time, but with the railroads and the metal mines expanding, the downturn was short. In southern Colorado, the Palmer group was bent on dramatic new expansion as the Rio Grande built south. Responding to discoveries of coal farther south toward Raton Pass, the gateway to New Mexico, the Palmer group organized the Southern Colorado Coal and Town Company. This enterprise set about acquiring coal properties near the railroad's projected line, notably the Trinidad Field, which studies had indicated could produce high-quality coking coal. As the line built south, the Town Company built Cucharas, Walsenburg, El Moro, and other coal towns. Unlike the case in metal mining, company towns would feature large in coal-mine development.

Meanwhile, new railroads entered Colorado and spurred production further. The Atchison, Topeka, and Santa Fe followed the Arkansas Valley to Pueblo. The Chicago Burlington and Quincy built across the plains to Denver, and the Denver and New Orleans began building from the capital city toward Texas. All of these lines needed coal, and so their advent, coupled with the end of the Panic of 1873, enhanced mining development, as did a new venture fashioned by the Palmer group. In the Northern Coalfield, the town of Louisville joined Erie and Marshall to comprise the three major producers in that field.

In southern Colorado, the immense debts incurred by the Rio Grande's construction temporarily cost Palmer control of the line, but the return of good times, along with investments by the Union Pacific, freed the railroad from the Santa Fe and restored Palmer to a position of control. These new internal arrangements, however, meant that the control of the railroad and the various coal companies began to separate. The Santa Fe railroad also organized an enterprise itself, the Cañon City Coal Company. To compete, in 1879, the Palmer interests merged their enterprises into the Colorado Coal and Iron Company (CC&I), which would use the coal and coke produced in the Southern Coalfield, notably at Trinidad, El Moro, and Walsenburg, to provide fuel for a new iron and steel plant to be built at Pueblo. As production grew, the Palmer interests also developed the first fully-planned company town–Engleville near El Moro– laid out in a grid pattern and including a company store. This was the coal industry's first real company town in Colorado.

By the early 1880s, Palmer had set his empire in motion. The CC&I opened its steel plant–the Bessemer Works–in south Pueblo, and integrated its operations with the coal mines and coking plants in the Southern Coalfield. The nominally independent Rio Grande Railway tied everything together. As these operations went forward, Palmer and his associates began laying track and building towns in central Colorado to tap the booming silver-lead business spawned so dramatically by the rise of Leadville. Production of coal soared in the Southern Coalfield, at Cañon City, and eventually at Crested Butte deep in the mountains. But once again, Palmer overextended himself. His dramatic expansion in Colorado, combined with the construction of his new Rio Grande Western Railway, building east to the Rockies from Salt Lake City, proved too much. In 1883, he lost control of the original Rio Grande again. This time, the break completely severed the connection between the railroad and the CC&I and it led to key changes in the enterprise.

By this time it had become apparent that CCI suffered from a problem that would plague the enterprise throughout its history. Coal mining from the Southern Coalfield was a profitable venture, but the steel plant at Pueblo could not compete with Eastern companies in manufacturing and selling rails, its principal product. When Palmer controlled both the Rio Grande and CC&I, this had meant little in the larger picture, but when he lost control of the railroad, the Rio Grande's new management jacked up shipping rates. The higher costs that resulted imperiled the Coal and Iron Company. Finally, in 1884, with CC&I floundering, the board of directors blamed Palmer for the company's problems and removed him from control. To address the problem, the new management cut the wages paid the workers–and thus set the stage of the bitter labor/management wars to come in the coal industry.

Meanwhile, as Palmer struggled ahead with his multiple enterprises in southern Colorado, the Santa Fe Railroad also continued to stimulate the coal business further in the Southern Coalfield. Arriving in Trinidad in 1878, just as Engleville came into being, the Santa Fe prompted several local entrepreneurs to enter the coal business. Then in 1879, the railroad incorporated the Trinidad Coal and Mining Company. Two years later, in 1881, the line reorganized this enterprise as the Trinidad Coal and Coking Company and put it under the leadership of William B. Strong, president of the Santa Fe itself. This gave the railroad two bases for its coal operations, Trinidad and Canon City.

By the early 1880s, Colorado's coal industry was well established. Production from the Southern Coalfield running from Walsenburg to Trinidad led the way, followed by the Cañon City mines, and then by the lignite mines in the Northern Coalfield. CC&I and the Santa Fe railroad dominated output. Miners tended to live either in company towns or quasi-company towns, a situation dramatically different from what prevailed in metal mining, where the company town was virtually unknown.

Further consolidation was coming in coal, again as a result of railroad expansion and railroad wars. During the 1870s, Jay Gould, president of the Union Pacific line (U.P.), hoped to create a rail monopoly in much of the West. To that end, he secured control of a number of railroads operating in Colorado, but his objective also meant seeking control of the coal mines that provided fuel for the steam engines and a product to carry to market. That led Gould and the Union Pacific to acquire coal mines served by lines the U.P. controlled. Having acquired the Denver Pacific and Colorado Central lines, which served the Northern Coalfield, Gould in turn acquired coal mines there beginning in 1879. He operated them first through the railroads, but then folded them into the Union Pacific Coal Company, which now controlled coal lands in Louisville and Erie to consolidate these with the coal mines at Como and Baldwin on the line of the Denver South Park & Pacific.

Sluggish economic conditions in the mid-1880s brought change, however. As rail traffic declined, the railroads cut back on their coal purchases. Some mines closed. As operators then cut wages at the properties that remained open, employees responded by organizing unions, and strikes developed. The Knights of Labor was the most prominent union involved as these strikes developed toward the end of 1884. But strong corporate opposition, lack of labor solidarity, hard times, and the controversial use of Afro-American strikebreakers meant that the strikes were largely unsuccessful. The coal companies introduced labor-saving devices to improve efficiency. Better times returned in 1885, but the workers did not share in the returning prosperity. Some strikes continued in that year even after the Union Pacific sold its mines to David H. Moffat, Jr. of the Marshall Coal Company, but violence ensued, and many of the mines closed there. By the end of the year, the coal miners' organizations were dead.

As mining returned to prosperity in the mid-to-late 1880s, two companies dominated the industry: CC&I and the Santa Fe's group of coal companies. They controlled about 70% of the market. In the late 1880s, Henry Sprague of CC&I acquired coal lands in the Yampa River Valley and south of Glenwood Springs, and financed the Aspen and Western Railway to carry the product to the famous new silver camp at Aspen, but this overextended the company, and Sprague apparently elected to leave before he was ousted. He was replaced by Edward J. Berwind, who arrived from the East.

After taking potshots at both of his predecessors, Palmer and Sprague, Berwind sought to adopt what he called "better business practices." He opened new mines in the Southern Coalfield, rehabilitated older properties. He also carefully studied the matter of company housing, which led him to the conclusion that this would be a good vehicle to help control the labor force and make a profit at the same time. Berwind, however, remained saddled with the problem of an unprofitable steel company. After four years of struggle, in 1892, he gave way to C. H. Meek, a railroad manager with no experience in the business. Meek's role, however, would be important in the company's destiny.

Meanwhile, another individual destined to play a large role had joined the industry. He was John C. Osgood, who had operated coal companies in Iowa and Illinois for the Chicago, Burlington, and Quincy Railroad. Successful in the Midwest, the railroad sent him to Colorado to develop coal properties as the line extended service into the Centennial State. In 1883, with colleagues from Iowa, Osgood organized the Colorado Fuel Company. He leased an anthracite mine near Crested Butte and bought bituminous coal from CC&I for the purpose of reselling on the larger market. As the mini-recession of 1884 passed, he purchased many coal properties on the Western Slope with Burlington railroad investors, notably in the Crystal River Valley, and added toll roads to provide the infrastructure to move the coal. He also organized the Denver Fuel Company, which bought coal lands near Sopris in the Roaring Fork Valley, and he had the Colorado Fuel Company purchase a mine in the Northern Coalfield at Erie. More reorganizations followed so that by 1890, the Colorado Fuel Company owned mines in the Northern Coalfield north of Denver, the Southern Coalfield from Walsenburg to Trinidad, and the Western Slope in Garfield and Pitkin Counties and in the Yampa River Valley. He also acquired another larger producer, the Grand River Coal and Coke Company, which had been organized to mine

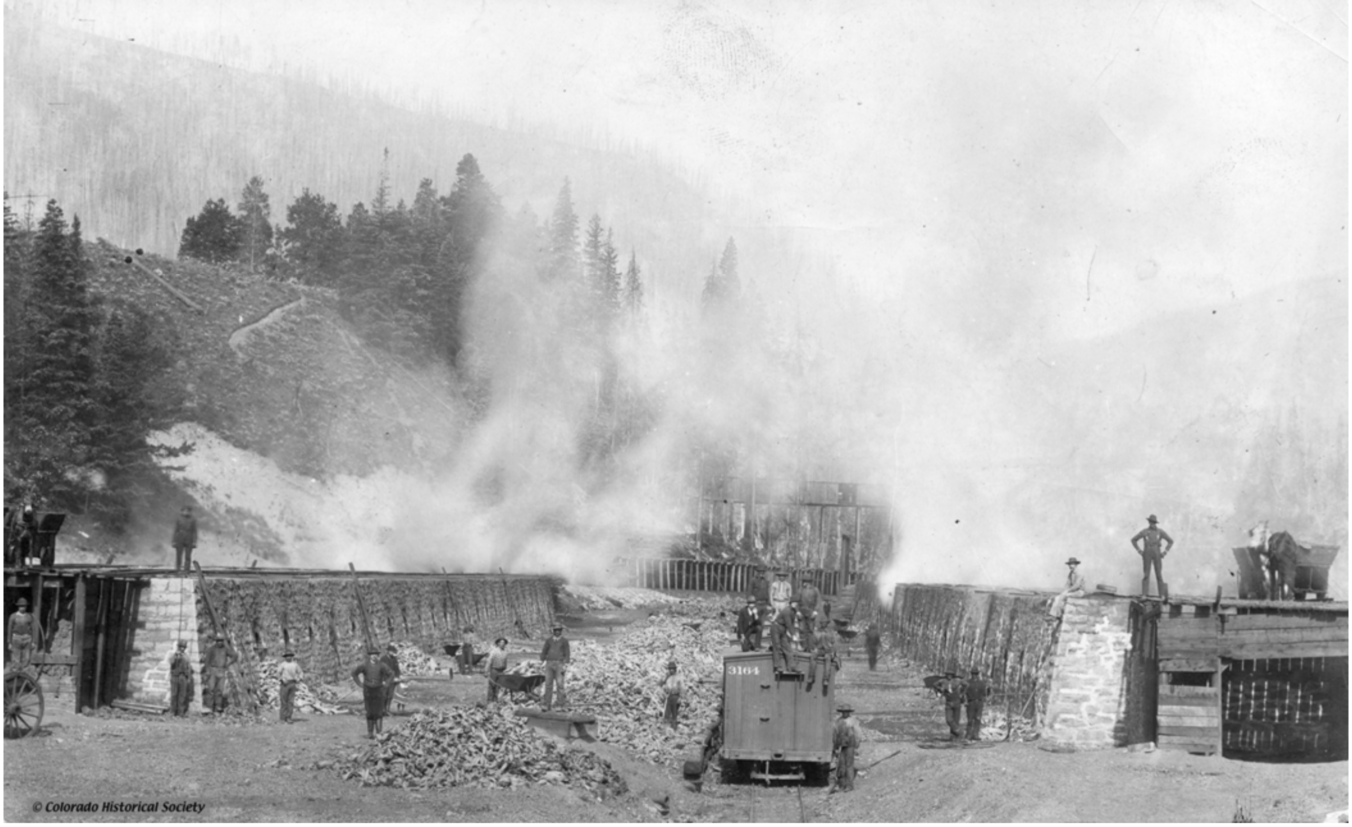

Fig. E.I.27 Coke ovens in Crested Butte about 1920. Collection of the Stephen Hart Library, Colorado Historical Society.

coal in western Colorado, notably at Cardiff near Glenwood Springs. By the early 1890s, output from his enterprise began to challenge that of the CC&I for leadership in the state.

Much more than his earlier rivals, Osgood developed company towns, particularly at Rouse near Trinidad and Sopris in the Roaring Fork Valley. He wanted to control his work force and thwart labor problems by providing workers with a higher standard of living than they enjoyed elsewhere in the industry.

Rather than compete indefinitely with his rival Meek and CC&I, in 1892, Osgood and Meek agreed to merge their interests to form a new entity: the Colorado Fuel and Iron Company (CF&I). The new enterprise dominated production in the Southern Coalfield and on the Western Slope, and it enjoyed an important position in the Northern Coalfield through its properties at Erie. At the outset, annual production amounted to 1.8 million tons per year, more than half of Colorado's total output. Osgood's chief rival remained the Canon City Coal Company, controlled by the Santa Fe Railroad, which also expanded near Canon City and Trinidad, notably at Rockvale and Starkville.

Osgood flourished because his enterprises focused solely on coal in a growing economy, whereas the CC&I had been held back by the unprofitable steel operations at Pueblo. The future looked bright for Osgood and his new firm, but neither he nor anyone in his organization could have foreseen the widespread ravages of the Silver Crash and the Panic of 1893.

Meanwhile, despite the growth in output in many parts of Colorado, production from lignite in the Northern Coalfield remained extensive. By 1890, there were 25 mines in operation, but intense competition eroded profits from the home-fuel heating business. Various informal operating agreements failed to stem the competition. As early as 1886, John H. Simpson of Louisville came to believe that a formal consolidation was the only answer for the industry. Finally, in 1891, after years of effort, he formed the United Coal Company, which consolidated a few of the mines. Although his company also purchased properties near Canon City, in the Southern Coalfield, his acquisitions in the Northern Coalfield gave his enterprise control of two-thirds of its production and made it the third largest producer in the state by 1892, once Osgood had merged his several enterprises into the Colorado Fuel and Iron Company (CF&I). By 1893, Colorado's coal production was dominated by these three companies: CF&I, the United Coal Company (United Coal), and the Santa Fe interests.

As in silver-lead mining, the Silver Crash and the Panic of 1893 shook the coal industry. As the metal mines closed and the economy plunged into the worst economic downturn in state and national history up to that point, the coal industry spiraled downward in tandem. Osgood's new Colorado Fuel and Iron Company witnessed a 42% plunge in production. The Union Pacific Railroad failed, which in part forced the Union Pacific Coal Company into failure as well, although production fell only 9%, probably because much of its coal was lignite used in homes; people had to have heat no matter what. The Santa Fe's three coal companies–Trinidad Coal and Coke, Canon City Coal, and the Vulcan Coal Company on the Western Slope–saw their production decline about 18%. In 1896, the Santa Fe Railroad leased its coal mines to Osgood's Company. And Simpson's United Coal Company there in the Northern Coalfield saw its market share collapse from 63 to 36%, which forced the company into receivership. After trying to weather a labor upheaval in 1898, it passed into the control of the new Northern Coal and Coke Company in the same year.

The seminal figure in the Northern Coal and Coke Company was James Cannon. He believed that acquisitions, mergers, and consolidations would reduce competition in the Northern Coalfield and spur higher prices that would benefit the new firm. He began work by leasing mines on the one hand and buying bonds from the United Coal Company on the other. By acquiring even more mines and limiting production, he gradually came to control about two-thirds of the Northern Coalfield's output, and by the early twentieth century, his Northern Coal and Coke enterprise emerged as the third largest producer in Colorado, behind only CC&I and the even newer Victor Company.

Just as important as the growing consolidation in the industry were changes in labor relations. As was the case in metal mining, the coal companies slashed jobs and wages to continue in business as best they could in hard times. Here again, workers bore the brunt of the crisis, although companies did extend credit at their stores and delay payment of rent. The CF&I cut the hours worked in half. But some companies missed paydays. In lieu of cash, some began to pay in scrip, which now became a basic currency in the industry, redeemable only at the company store. Sporadic strikes developed here and there in the coalfields, but they had little success. Tensions and lack of communication between ethnic and racial groups, belligerent mine guards, and successful company efforts to thwart organizers had a telling effect, but did not end the growing interest in labor organization. In April 1894, the United Mine Workers of America (UMWA), meeting in the East, called for a nationwide walkout to help coal miners everywhere. This had a powerful impact in Colorado. In May, about 4,000 Colorado coal miners, about 75% of the workforce, left their jobs. But the end of the walkout in the East undercut Colorado miners and effectively ended the strike in the Centennial State. By August, the walkout was over.

The strike of 1894 had ended, but labor strife continued as both sides prepared for confrontations to come. CF&I deposited moneys into a strike fund. A strike flared up in the Northern Coalfield in 1896, and as good times began returning, this strike achieved some wage increases for the miners. By the end of 1896, workers in the Northern Coalfield made more than their counterparts elsewhere. Nevertheless, the largest enterprise in the field, United Coal, refused to pay the wages it had agreed to elsewhere.

The Panic of 1893 finally ended during the years 1896 and 1897, and the coal industry surged back to unprecedented levels of production. The Colorado Fuel and Iron Company and the Union Pacific Coal Company remained the first and second in the state in terms of production levels, with CF&I producing a little more than one-third of the state's total. Expansion was also probably the greatest at CF&I. In 1901, Osgood sold about 400,000 new shares of stock for a reported $40 million–much of it acquired by Eastern investors such as John Gates, Edward H. Harriman, and John D. Rockefeller. With the capital raised, Osgood opened new company towns and mines in the Southern Coalfield–Primero, Tercio, Quattro, and Hezron–and expanded production near Redstone deep in the mountains. CF&I doubled production.

As the industry recovered in the late 1890s, other new players entered coal production. Delos A. Chappell of Trinidad, a small entrepreneur in the industry, organized the Victor Fuel Company in 1890 and acquired mining property at Hastings, a few miles north of Trinidad. It soon opened four mines and erected coke ovens, and though hard hit by the Panic of 1893, the company eventually rebounded and increased production in the late 1890s. Continuing to expand in the Southern Coalfield and at Canon City, it eventually surpassed the Union Pacific enterprise as the second largest producer in the state.

Meanwhile, things were changing at CF&I. As Gates, Harriman, and Rockefeller bought the firm's securities, Gates pushed for further expansion at the steel plant. An internal struggle between the major investors then evolved, and Gates sold out at the end of 1902. The chief buyer was Rockefeller, who now acquired more than 40% of both the stock and bonds. Osgood and the earlier investors remained in control of management, but Rockefeller had emerged as the central force in the company's future. The company's expansion did not bring in enough revenue to pay interest and dividends, however. Osgood borrowed even more money to meet his bills, and like his predecessors, overextended himself. With CF&I on the brink of receivership, he agreed to turn management over to Rockefeller and Gould in return for their efforts to keep the company solvent. But a year later, Osgood himself was out–but not out of the coal business.

While in control of CF&I, Osgood had developed several enterprises that did not become part of CF&I. One of these firms was the American Fuel Company, which he organized in 1900 to mine coal at Raton, New Mexico, at the southern tip of the Southern Coalfield, and farther west in northwestern New Mexico at Gallup. Osgood also controlled the Redstone Improvement Company. Formed late, as the dramatic expansion at CF&I began, he apparently could not sell either company to CF&I as he had others in the past. He also acquired an interest in Chappell's Victor Coal Company, now the state's second largest producer. His work there began in 1899, when he quietly began buying stock. By 1903 Osgood held the controlling interest. That year, though forced out of CF&I, or perhaps having designed a clever exit strategy, he merged the Victor and American companies into the Victor-American Coal Company.

At the same time, a new enterprise was coming along as well. This was the Rocky Mountain Fuel Company, which began to acquire mining properties in the Northern Coalfield and elsewhere. It grew rapidly, and by 1903, its production rivaled the Northern Coal Company. Although it had interests in the Northern Coalfield, it concentrated its efforts on the Canon City and southern Colorado areas.

But even as these matters played out, another new coal area was being opened up in Colorado–and once again by the railroads. In the late nineteenth century, David H. Moffat, Jr., president of the First National Bank of Denver, the most important financial institution in the state, and an investor in both coal and metal mines, incorporated a new railroad. This was the Denver Northwestern & Pacific Railway. Its goal was to build a standard-gauge railroad from Denver across the Rockies and on to California. To that end, it began building from Denver north toward Boulder, tapping coal mines at Leyden in the northern part of Jefferson County. The road climbed up the foothills of the Rockies, then turned west up South Boulder Canyon to reach Rollinsville, and a few miles west of there, it began climbing up the High Line to cross the Rockies well above timberline, then down into Middle Park. From Middle Park, the line turned north to reach Kremmling, largely a cattle town, and from there through Gore Canyon toward North Park. As the line reached North Park in northern Colorado, it in effect opened the immense coal reserves of that area, and new production now came on stream in Routt County to compete with the Northern Coalfield, the Southern Coalfield, Canon City, and central Colorado.

Labor-management relations in the industry continued to remain cool, and that situation helped finish off Northern Coal. In 1911, it went out of business after it sold its mines to the Rocky Mountain Fuel Company, which now emerged as the third-largest producer in Colorado after CF&I and Victor-American. That same year, it was challenged by another enterprise in the Northern Coalfield, the American Fuel Company, which hoped to attract workers with a favorable labor policy and by negotiating with the UMWA. But Rocky Mountain Fuel responded by slashing prices, which drove the new enterprise out of business a year later, in part to dominate the coal market, and some say, to thwart favorable union policies.

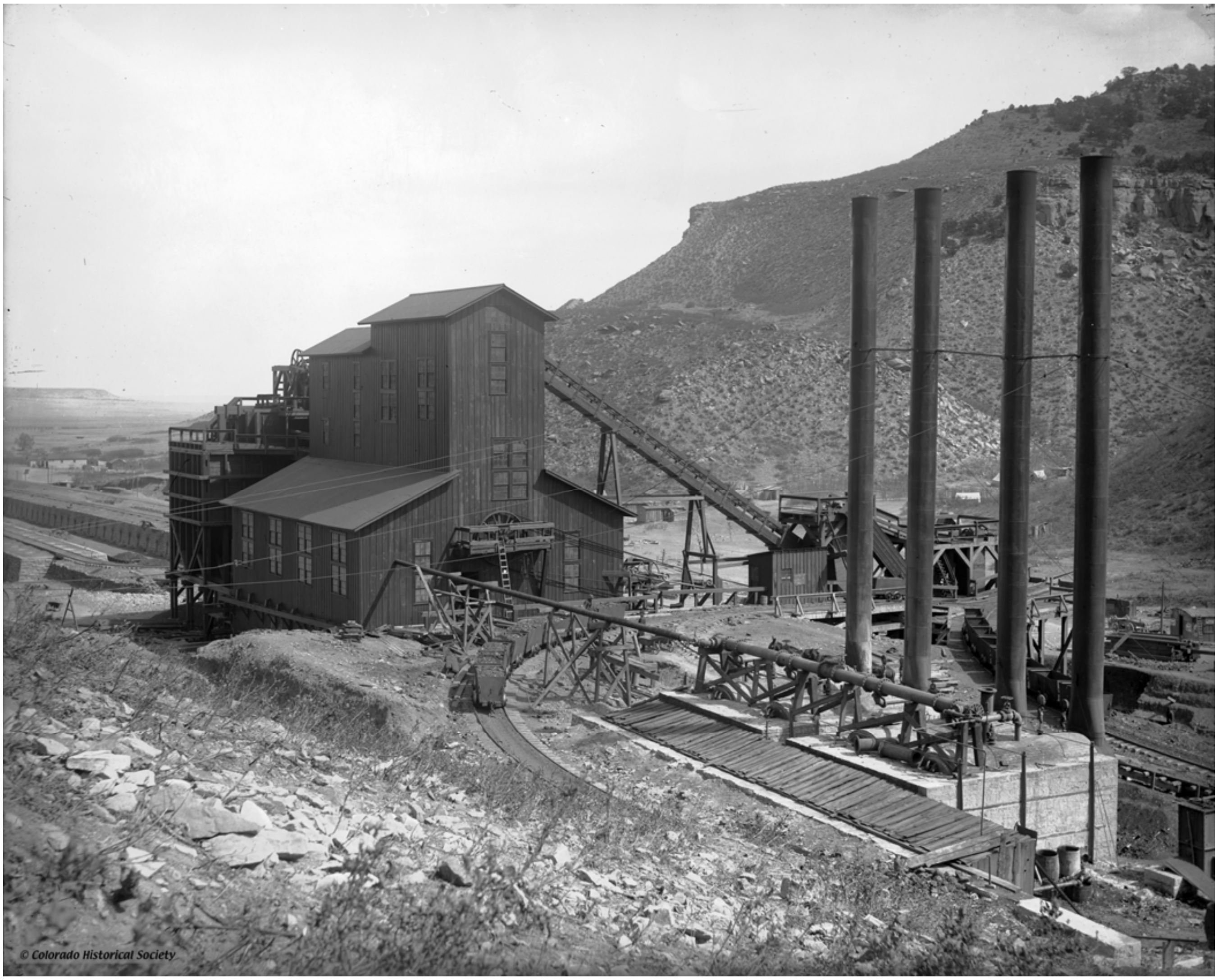

Fig. E.I.28 Unidentified coal mine in Las Animas County about 1910. Collection of the Stephen Hart Library, Colorado Historical Society.

2.2 The Long Decline: circa 1900–2005

As was the case in metal mining, World War I temporarily induced a false prosperity and masked significant changes impacting the coal industry nationally. The most important was the development of other fuels, notably petroleum and natural gas. In 1890, coal had supplied about 90% of the nation's fuel needs, but that figure began to decline substantially by the turn of the century. By 1910, it had fallen to 77% and by 1920 to 73%. The trend accelerated in the 1920s to the point where coal accounted for only 58% of usage by 1930.

The national decline in coal consumption profoundly impacted Colorado's output, but there were unique statewide factors that also contributed to the growing problems in Colorado. The most important was the dramatic but long-term decline of traditional metal mining, from the turn of the twentieth century onwards. As the mines that produced gold, silver, lead, zinc, copper, and other metals declined in output and closed their doors, they needed far less coal (or none at all) to produce the power needed. There was in turn far less need for coal to power the mills and smelters as well as far less need for the coking coals used to reduce the ores and concentrates to bullion and matte. As metal mining retreated in all its aspects, towns declined and disappeared and railroads cut service, all of which combined to lessen coal usage as well. So both national and statewide trends impacted the industry as it evolved in the years after World War I.

In 1920, Colorado had 231 coal mines in operation employing some 13,665 men producing 12.5 million tons of coal. In 1930, there were 275 mines, but they employed only 10,015 men producing 8.2 million tons of coal. Although the number of mines had increased, many were very small (if not tiny), wagon or truck mines developed by miners to supply either themselves or local markets. The Big Three producers that had evolved in the late nineteenth and early twentieth centuries bore the brunt of the decline. CF&I reduced its operating mines from 22 to 11; Victor-American from 9 to 4; and Rocky Mountain Fuel from 16 to 6. The fall in output was dramatic: roughly one third. The decline at CF&I, however, was more than 50%.

The surge in the use of fuel oil was a major reason. The railroads began turning away from coal to petroleum. Homes began to switch from lignite to natural gas, particularly that piped in from Texas. Even CF&I began switching some of its operations from coal to natural gas–it was cheaper and more efficient than the company's own product. These shifts had a devastating impact on the Northern and Southern Coalfields, as well as the Canon City area in Fremont County. In order to reduce production costs so as to compete, operators substituted capital for labor by introducing new equipment: notably improved drills and cutters, more efficient loaders and self-propelled cars to move coal to the surface. This reduced the number of jobs available, but it did little or nothing to stem the falling demand. It did, however, undercut the influence of the UMWA, hurt badly in the strike of 1913/14 (notorious for the infamous Ludlow Massacre of April 20, 1914) and now more concerned about saving jobs in an obviously declining industry. Frustrated by the UMWA's inability to enhance wages and benefits, some workers turned to the Industrial Workers of the World (or IWW), a union better known as the "Wobblies." Unlike the UMWA, it hoped to overthrow the capitalist system and replace it with a socialist or Marxist utopia. The IWW staged a strike in the Northern Coalfield from 1927 to 1928, but the union had picked an inopportune time. The decade was generally hostile to organized labor. When violence flared, notably at the Columbine Mine, the largest unit in the Rocky Mountain Fuel Company system, combined with state and local authorities (notably the Colorado Rangers), broke the strike and probably destroyed the IWW in the coal regions in the process.

The strike did, however, facilitate a new ethos at the Rocky Mountain Fuel Company. Its militantly anti-union president John J. Roche had died on the eve of the strike in 1927, and in the course of 1928, his daughter Josephine Roche became the principal stockholder in the enterprise. A prominent reformer in the Progressive Movement of early twentieth-century Denver, she was shocked at the violence, and sympathetic to labor. As a result, she installed new management that broke ranks with other producers when her company recognized the UMWA as the bargaining agent for the workers. The two sides signed a labor-management contract, the only one in the Colorado industry at the time. Despite this amelioration of the normally strident labor conditions, the company's mines and union signs to "Buy from Josephine," it did nothing to stem the industry's decline. Problems for the company and the industry only got worse with the onset of the Great Depression in 1929.

The 1930s were disastrous for Colorado coal, as for much of the economy. In October 1929, the stock crash on Wall Street heralded the arrival of the economic catastrophe known as the Great Depression. Millions lost their jobs, consumer spending dried up, capital spending evaporated, and by the early 1930s, about 25 to 33% of all working Americans had lost their jobs. Hard times stalked the land for 12 years until 1941.

The Colorado coal industry, in decline throughout the 1920s, retreated further in the crisis. Production fell, and the number of jobs, plus the number of days worked, declined still further as mines closed or curtailed operations. The new administration of President Franklin Delano Roosevelt sought to promote relief, recovery, and reform throughout American society, and this extended to the coal industry, in part through the National Recovery Act of 1933 and especially the Guffey-Snyder Act (or National Coal Act) of 1935 and the Guffey-Vinson Act (or Coal Conservation Act) of 1937. These laws attempted to harmonize the often bitter labor-management relations in the industry in the hope that greater harmony would help promote economic recovery. To that end, the government set up commissions and boards that sought to establish output quotas, set prices, boost wages, and create collective bargaining, but the laws and the commissions were assailed by adverse rulings from the U.S. Supreme Court. Not until the late 1930s and early 1940s did these initiatives finally receive favorable treatment in the courts.

The Colorado coal industry hit bottom in 1934. Then began a slow recovery, reflecting modest improvements in the economy, only to plunge again in the recession of 1938, recovering slightly by the late 1930s. By 1940, the production of the Big Three enterprises came to an aggregate of only 2.2 million tons, one-third their output in 1930. The number of mines in operation had dwindled still more. In part, this reflected the ravages of the Depression, but it also reflected the relentless economic shift from coal to fuel oils and natural gas, along with the collapse of the traditional minerals industry.

All this changed, at least temporarily, in 1941. As the U.S. mobilized for World War II and began aiding the Allied cause with goods of every kind, massive government spending dramatically spurred economic recovery, fueled still more at the end of the year when the U.S. entered the conflict itself. Colorado's coal output surged in 1941. A measure of prosperity returned to the mines, the UMWA signed favorable contracts spurred by high demand, high profits, and strong patriotism. Yet wartime production never exceeded 8.2 million tons, which was substantially less than output earlier in the century, and production even fell in the later stages of the war. Aggregate employment and the number of mines operating also declined. There were fewer jobs, as machines took over more and more of the work that workers had done in the past.

For coal producers in Colorado, the War proved to be only an aberration from long-term decline. The downward trend that had developed back in the 1920s resumed with the coming of peace in 1945.The major companies led the shutdowns. CF&I continued with more mine closure immediately war ended. The Rocky Mountain Fuel Company shuttered its last two mines (the Industrial at Superior in 1945 and the Columbine at Erie in 1946), and in effect went out of business. Victor-American closed more mines in the late 1940s as well. This pattern continued into the 1950s. CF&I closed more mines in southern Colorado, Canon City, and Crested Butte. By 1951 Victor-American had closed the last of its mines, in Routt County and in the Southern Coalfield.

Districts that produced coking coal felt the pinch as well in the 1930s. When the silver-lead smelter at Durango closed in 1930, so, too, did the mines and coke ovens near town. Also closing were the coal mines in the Somerset-Carbondale-Crested Butte District; they were too far from Pueblo to be competitive once the silver-lead smelters disappeared. The only coke-making area that held its own through the Depression was the Trinidad Field, which was closer to the CF&I plant at Pueblo, but the decline in the use of bituminous coal for other purposes still led to the contraction of that district.

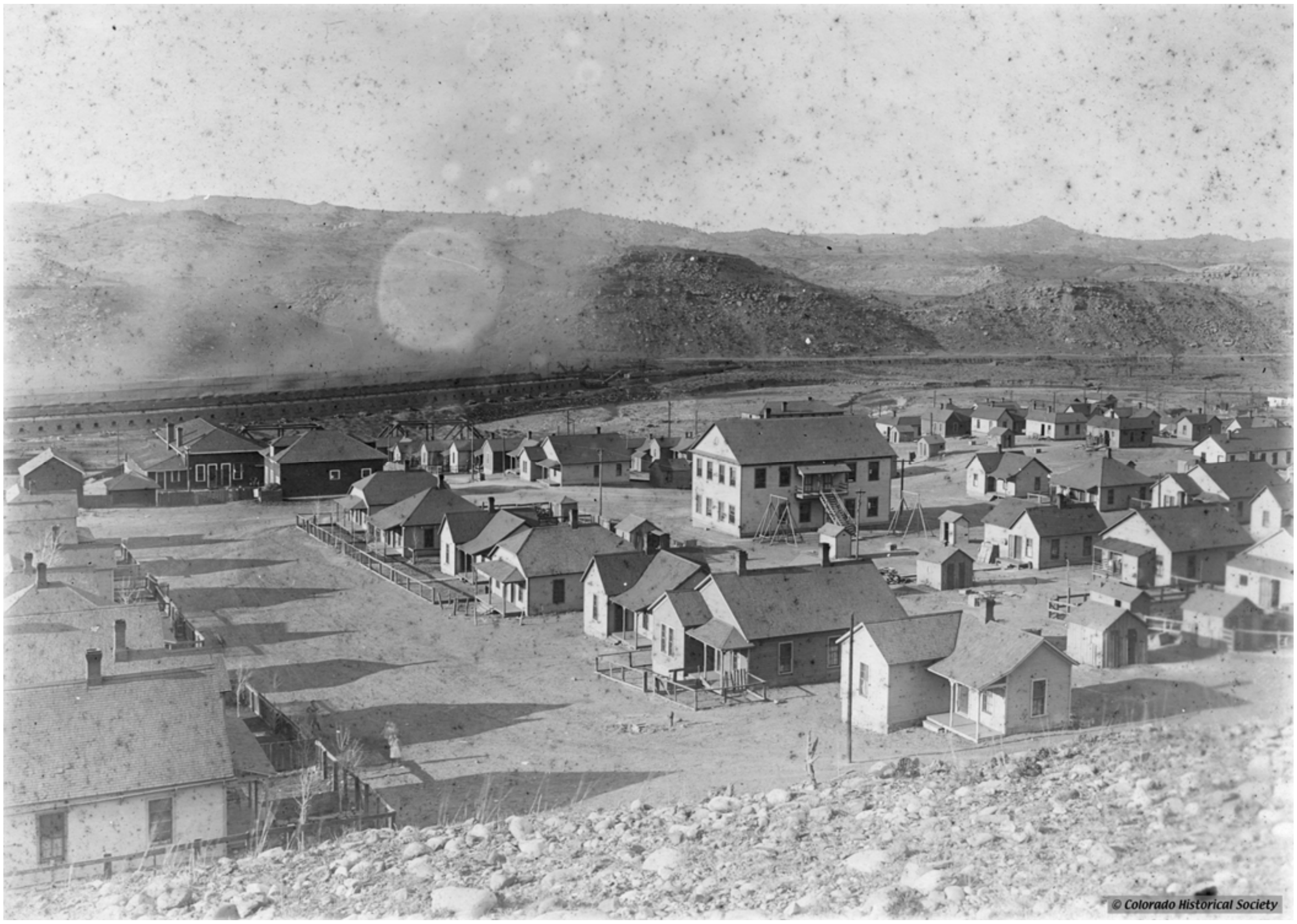

Fig. E.I.29 Company town of Segundo, Colorado, about 1910. Collection of the Stephen Hart Library, Colorado Historical Society.

As with coal, the onset of World War II temporarily changed the picture for coking coals. Military and other construction demands for steel allowed the blast furnaces at Pueblo to work at full capacity for nearly the entire war. That meant that there was a steady demand for coking coal and coke. Through the Defense Plant Corporation, the federal government built even more coke ovens, known as Battery E, to help CF&I boost its production of steel. The company acquired Battery E at war's end in 1945. Another spur to the production of coking coal came when the industrialist Henry J. Kaiser built a steel plant east of Los Angeles, California. He relied partly on Colorado coking coal, so much so that he bought supplies from CF&I and later acquired his own mines in Colorado.

The war also led to another important development. One Charles Allen organized a steel syndicate that purchased CF&I from the Rockefellers. That ended the family's sometimes controversial involvement that had lasted for nearly half a century.

As coal mines closed everywhere in Colorado after the war, the steadiest production came from the mines producing the coking coal needed by CF&I and sometimes by iron and steelmakers elsewhere. Coking coal production, which had boomed during World War II, remained a steady business for some 30 years after the war until the mid-1970s, particularly during the Korean and Vietnam Wars. Given that circumstance, CF&I ceased production of all other types of coal. While this meant that CF&I phased out all its mining outside the Southern Coalfield. In the early 1950s, it also meant the opening of an entirely new property–the Allen Mine–at Weston, a few miles west of Trinidad, where the company had discovered a deposit with an estimated 80 million tons of coking coal. Not surprisingly, given its new orientation, the enterprise renamed itself the CF&I Steel Corporation in 1966.

Other large enterprises also moved into Colorado in search of coking coal. The most important was the U.S. Steel Corporation, the nation's largest steelmaker, which owned smelting plants in Utah. In 1955, it purchased the Somerset Mine in Gunnison County and took over operations six years later in 1961. It also bought the entire production from the mines at Coal Basin, near Redstone, owned by the Mid-Continent Coal Company.

Environmental legislation also began to have an impact on the coal industry as was the case in metal mining. In 1971, CF&I built new coke ovens and modified others to meet federal air standards, then closed its other outmoded facilities.

Even so, dramatic new changes were coming in smelting technology–changes that would impact both coal mining and steel production. In the early 1970s CF&I installed its first electric furnace, which reduced its need for coke and thus coking coal. To provide the power, the Public Service Company of Colorado built an entirely new power generating station known as the Comanche Plant or Comanche Unit. It was fired with coal, although that coal came on unit trains from mines in Wyoming. (A unit train is a freight train carrying one commodity only, bound for a single destination.)

The postwar years also saw the final collapse of coal as a home-heating fuel. In 1950, it still provided heat for about one-third of American homes, but oil and natural gas use continued to advance, and by 1970, coal's role in heating dropped to less than 3% of the nation's houses. Mines closed, employees departed, and the industry died away. And when the population of company towns dwindled down to nothing, notably in the Southern Coalfield, CF&I razed entire communities. The few coal towns that survived were mostly in the Northern Coalfield, where the company town had never been strong–places like Louisville, Lafayette, and Erie. They remained but shadows of their old selves, however, as property values plummeted and people moved away, at least until the mid-1970s, when the expansion of metropolitan Denver turned them into high-priced bedroom communities. By then, however, few traces of the coal industry remained visible on the landscape.

By the 1960s and early 1970s, Colorado's traditional coal industry had entered the final stages of its development. The Northern and Southern Coalfields had moved inexorably to the verge of their final collapse and shutdown, and many thought that coal production in Colorado would soon cease altogether. But the fact was that coal mining in Colorado was soon to undergo a renaissance of sorts as a wholly different industry emerged. The key to that revival was growing demand for electricity, coupled with new mining technologies. In 1957, the Public Service Company had presaged this revival when it opened the Cameo Mine in Mesa County, the first modern mine-mouth plant in the state–that is to say, a facility in which the coal moved directly on conveyors from the mine to the electric plant in order to be burned to generate electricity.

More important than that was the development of the open-pit or strip mine. As in metal mining, this was hardly a new technology per se–it dated back to the mid-nineteenth century, if not before–evolving from the quarries of that era. Perhaps based on precedents set in metal mining, notably at Bingham Canyon, Utah, the idea behind the new technology was to strip away what was called the overburden, or in other words, the non-coal covering of the coal seam, and then use even more gigantic equipment to mine the coal and load it immediately on trains or trucks for shipment. Strip mining for coal had grown slowly but steadily in the U.S. from about 1920 forward, but it comprised less than a quarter of aggregate output by 1950. In the 1950s, however, that production surged until by 1970, about two-thirds of national production came from such strip mines located mostly in the

West, where most of the nation's deposits of low-sulfur coal lay. While Wyoming and Montana became the key producers from strip mines, northern Colorado witnessed such developments near Craig and other communities. Draglines became key devices in the industry.

Strip mining in Colorado developed quite slowly, as it did elsewhere. Some operators produced small amounts of coal from open pits in Jackson County as early as 1911, and some production came from Elbert County in the 1920s, 1930s, and 1940s. By the early 1950s, two mines in Routt County comprised most of the state's open-pit production, but that was only about 9% of total output, a figure magnified by the collapse of underground mining.

That figure was about to rise dramatically, however. Strip mining in Colorado began to focus on North Park, a region originally opened to production just after 1900 by David H. Moffat, Jr.'s Denver Northwestern and Pacific Railway. This late twentieth-century development, however, also came in a new age of environmentalism spawned in the 1960s by Rachel Carson's book *Silent Spring*. This new phase of coal mining would therefore develop with different concerns from other types of underground mining.

Routt County in the North Park area became the focus of strip mining in Colorado. Coal companies moved in, and by 1973, the ten mines in operation produced nearly half the state's coal output, although they used only about one-quarter of the aggregate work force in the industry. As early as 1945, the Edna Mine near Oak Creek, about 25 miles south of Steamboat Springs began surface mining operations. Others followed, and at least one strip mine opened near Montrose on the Western Slope. Strip mines required massive capital investment to get them going, and so it was not surprising that many operators either were or became subsidiaries of much larger corporations headquartered elsewhere, such as the Gulf Oil Company and the General Electric Company. Much of this coal went on unit trains to public utilities, notably the plants of the Public Service Company and the new Colorado-Ute Electric Association, which distributed electricity to cooperatives spawned by the Rural Electrification Administration. Operating from Montrose, it built its first plant at Nucla, Colorado, in 1959, and the second at Hayden in the 1960s. The ultimate result of this powerful shift in the industry was fewer mines and fewer workers, but substantially higher production. And in underground mining, the heavy capital investment needed for machinery to reduce unit costs squeezed out the small producers as well. Unit trains became a key factor in the early 1950s, particularly as the coal slurry pipelines began to pose a competitive threat, although that was probably not really the case in the arid West, where there was too little water to make the slurry feasible.

In 1990, new amendments to the Clean Air Act further stimulated coal mining. These new pieces of legislation were designed to reduce sulfur dioxide in the air, and thus reduce acid rain and acid snow. That in turn increased the demand for low-sulfur coal, plentiful in Colorado. While this stimulated strip mining, it also produced a resurgence in underground mining and the use of the longwall system (i.e., where a mineral is extracted along a vein or seam in one operation along a working face or "wall" 80 meters or more in length). This old mining technique was now upgraded with the introduction of mechanization. By the mid-1990s, underground mining comprised 70% of Colorado's output.

But if most of this growth was inspired by electrical utilities in Colorado and elsewhere, the use of metallurgical coal continued to decline. The closure of smelters in Colorado and elsewhere in the 1980s reduced demand, CF&I shifted its steel production entirely to electric furnaces, and finally in 1995, the Allen Mine west of Trinidad, now assailed by high costs resulting from geological faults and a poor roofing, ceased production. With its closure ended over 125 years of the production of metallurgical coal from the entire Southern Coalfield.

By the early twenty-first century, Colorado coal mining focused almost exclusively on the production for coal for utilities. The production of metallurgical coal had ended, and the use of coal for domestic consumption consisted of only 1% of output. Yet there is a vitality in the industry, one not seen in most phases of metal mining. The future of coal in Colorado seems to be a bright one.

3. The Industrial Metals Industry in Colorado: 1870–2005

Colorado came into being because of gold, and in the years that followed the Pike's Peak Gold Rush, the development of silver, coupled with the associated base metals like lead, zinc, and copper (and coal as well), sustained the state's minerals industry and its overall economy until well into the twentieth century. But as events proved, Colorado was a storehouse of other metals little known, little understood, and rarely produced in the heyday of gold and silver mining. The very late nineteenth and twentieth centuries brought significant change. Scientific and technological advances revealed uses for these "exotic" metals (some of which existed in relative abundance in Colorado), which helped spark an entirely new phase of metal mining in Colorado.

These technological developments were two-fold. One was the ability to harden and toughen steels through alloys with molybdenum in particular. The second was to find material to meet the needs of the new Atomic Era that emerged in the 1930s and 1940s. Colorado would be central in these developments.

3.1 Molybdenum

The demands for harder and tougher steels focused attention on one of these metals as the twentieth century began. That was molybdenum, a word hard to pronounce, and hence sometimes called "moly" by some and "moly-be-damned" by others. As is the case for gold, silver, and other metals, no one knows for sure who made the original discovery of this metal in Colorado. It is believed that in the mid-1870s a prospector, miner, and freighter named Charles J. Senter ventured into the Ten Mile District (the "Ten Mile") north of Fremont Pass probably in search of gold. Then in the late 1870s, he joined the nearby Leadville rush. Frustrated there, however, he joined the midwinter rush that carried hundreds north across Fremont Pass to the Ten Mile in the winter of 1878 and 1879. As the heavy snows melted, Senter focused his prospecting on the slopes of Bartlett Mountain, which rose above a once-rich placer deposit in McNulty Gulch just north of the summit of Fremont Pass–it seemed to be the likely source of the gold in McNulty Gulch. There on the slopes of Bartlett Mountain in the summer of 1879, Senter staked three claims that he called the Gold Reef. Perhaps they held a little gold, but what Senter really found were broken rocks that held dark, graphite-like streaks sometimes covered with a canary-yellow mineral that looked like yellow rust. Although he had found little or no gold, he had found what would prove to be the world's largest deposit of molybdenum, a rare scientific curiosity of little or no use at that time (Fig. E.I.3).

About the same time, the geologist Samuel Franklin Emmons arrived in Leadville to begin what was to become the great pioneering study of the district. As Emmons assembled his staff, he hired the French chemist Anthony Guyard to conduct the metallurgical analyses. While analyzing gneiss from one of the Leadville smelters, Guyard discovered the metal molybdenum. Where it came from, no one could ascertain, but it seems likely that it came from the Ten Mile in ore shipments to one of Leadville's smelters. Guyard's discovery apparently never became public at that time. The knowledge lay buried for a century in Emmons' scientific papers in the National Archives of the United States.

As the years passed, many individuals working in the Ten Mile found the same type of rock that Senter had. Many mistook the dark streaks for graphite or galena, and so many individuals found abject disappointment instead of instant wealth from their work on Bartlett Mountain. Senter built a cabin there and a small community named Senterville emerged, but no one got rich searching for gold. All they continued to find was the black-streaked rock. Finally, in the mid-1890s, Rudolph George, a faculty member at the Colorado School of Mines, identified the ore as molybdenite–the key substance being molybdenum disulfide–and the canary-colored substance molybdenum oxide. That was of interest, but of no commercial value as there was no market. Later in the 1890s, one Hugh Leal drove an adit into the depths of Bartlett Mountain, hoping to find gold-bearing ore at depth, but all he found was the worthless molybdenite, which he dumped wherever he could.

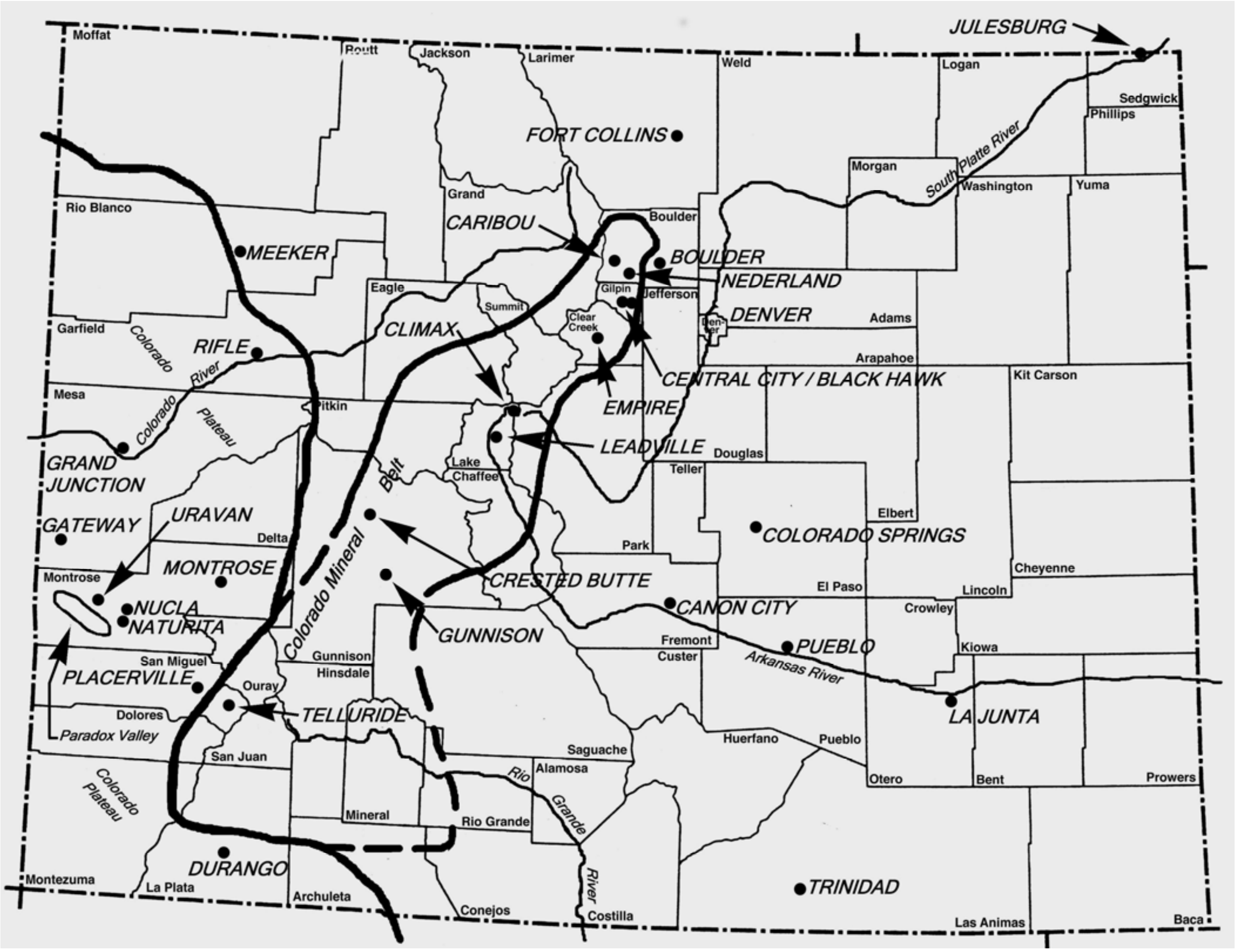

Fig E.I.30 Map of the industrial metals industry in Colorado from 1870–2005.

What was probably unknown to most of these individuals in the late nineteenth century was the developing knowledge that molybdenum could be used to harden and toughen steel. One of the first who did was an E. G. Heckendorf of Denver, who owned a claim on Bartlett Mountain, but he failed to interest anyone in developing molybdenum properties. Another who became interested was an Otis Archie King, who was milling ore from the Wilson Mine in Ten Mile with the newly developed flotation process. In 1913, King sold some concentrates to Blackwell & Company of Liverpool, England. The price paid was $1.75 per pound or about $3,500 per ton of concentrates. That was a remarkable return, but as King remembered later, that single ton comprised world demand for one year. King's recollections were inaccurate, but demand scarcely reached more than ten tons. While scientists and engineers in the steel industry now understood that molybdenum was an effective alloy in making harder and tougher steels, the metal had apparently sparked little interest in the steel industry because molybdenum was so rare.

World War I changed everything almost overnight. The tank and other armored vehicles made their first appearance in warfare; to withstand battlefield conditions, they had to be manufactured from hard, tough steels, and this spurred molybdenum demand from Britain and Russia. In 1915, King mined molybdenum ore from one of Senter's claims, recovered the product using the flotation process in a plant owned by the new Pingrey Company, and made the first commercial shipment from Ten Mile. King's work sparked a rush for claims on Bartlett Mountain. Heckendorf took the lead, acquiring property from various parties, but he lacked the capital to develop a mine. Finally, in October 1916, as the War raged in Europe, he secured the backing of Max Schott of Denver, the local representative of the American Metal Company (sometimes called Amco), the American part of a tripartite international mining consortium. Others in this consortium were Henry R. Merton & Company based in London and Metallgesellschaft from Frankfurt, Germany. Schott convinced Amco to take options on Heckendorf's claims, and the next month, this new syndicate took over the properties and began building a tramway, flotation mill, and housing for its employees. Then in 1918, it transferred these properties to the newly organized Climax Molybdenum Company, named after Climax, South Park's railroad station on the summit of Fremont Pass. The U.S. had now formally entered World War I, and no sooner had the company come into being than the U.S. government seized everything through the office of the Alien Property Custodian. Later, when the government sold off the German interest, it destroyed the old Amco-Merton-Metallgesellschaft alliance.

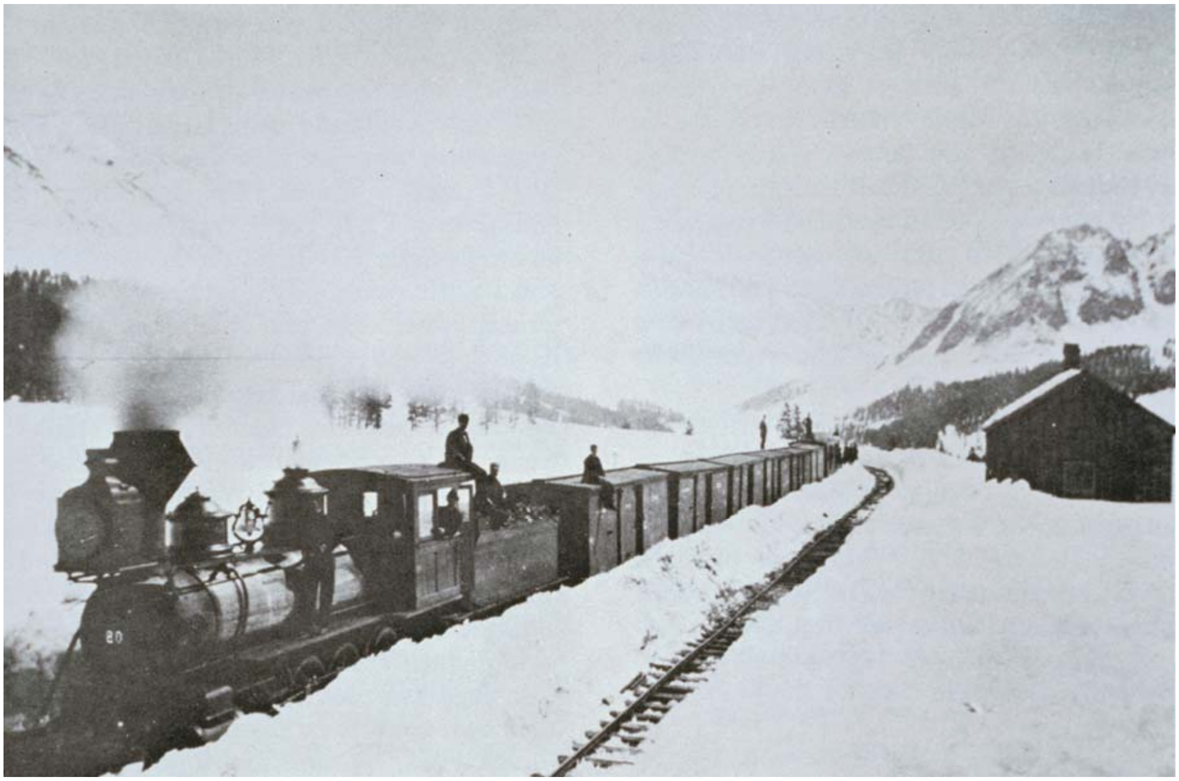

Fig. E.I.31 Train at Climax Station in the 1880s. Collection of the Stephen Hart Library, Colorado Historical Society.

Molybdenum was a boom industry as the War continued in Europe, but once the fighting ended near the close of 1918, the demand for armor plate collapsed, the molybdenum market evaporated, and all the mines on Bartlett Mountain closed. The boom and bust had lasted less than four years, and its collapse in the postwar years was consonant with the sharp declines going on in silver, lead, and zinc mining at that very time. The bust hurt the small producers the most; many went bankrupt. After much legal wrangling, by the mid-1920s, the Climax Molybdenum Company had consolidated virtually all of Bartlett Mountain.

As Ten Mile faded away as a silver producer in the 1920s, like so many other old districts, there was growing interest in the molybdenum deposits even though all the mines had shut down by 1920. The Climax Company appointed a dynamic engineer, Brainerd Phillipson, to try to develop new markets for the metal. During the 1920s, with the advent of mass automobile production, Phillipson persuaded the principal manufacturers to use molybdenum in steel frames. With that, and the advent of new markets, demand for molybdenum soared. Phillipson became the president of Climax, and under his leadership, output surged from nothing in 1923 to 3.5 million pounds in 1929. This was 90% of American production and 80% of world production. Geologists also determined that Bartlett Mountain was the largest known deposit of molybdenum in the world–and remains so to this day.

Unlike coal and other metals in Colorado, the Great Depression did not have a major impact on Colorado's molybdenum production. There was a small downturn in output in the early 1930s, but aside from that, production rose sharply–ten-fold–during the decade and stood at nearly 27 million pounds per year by 1940.

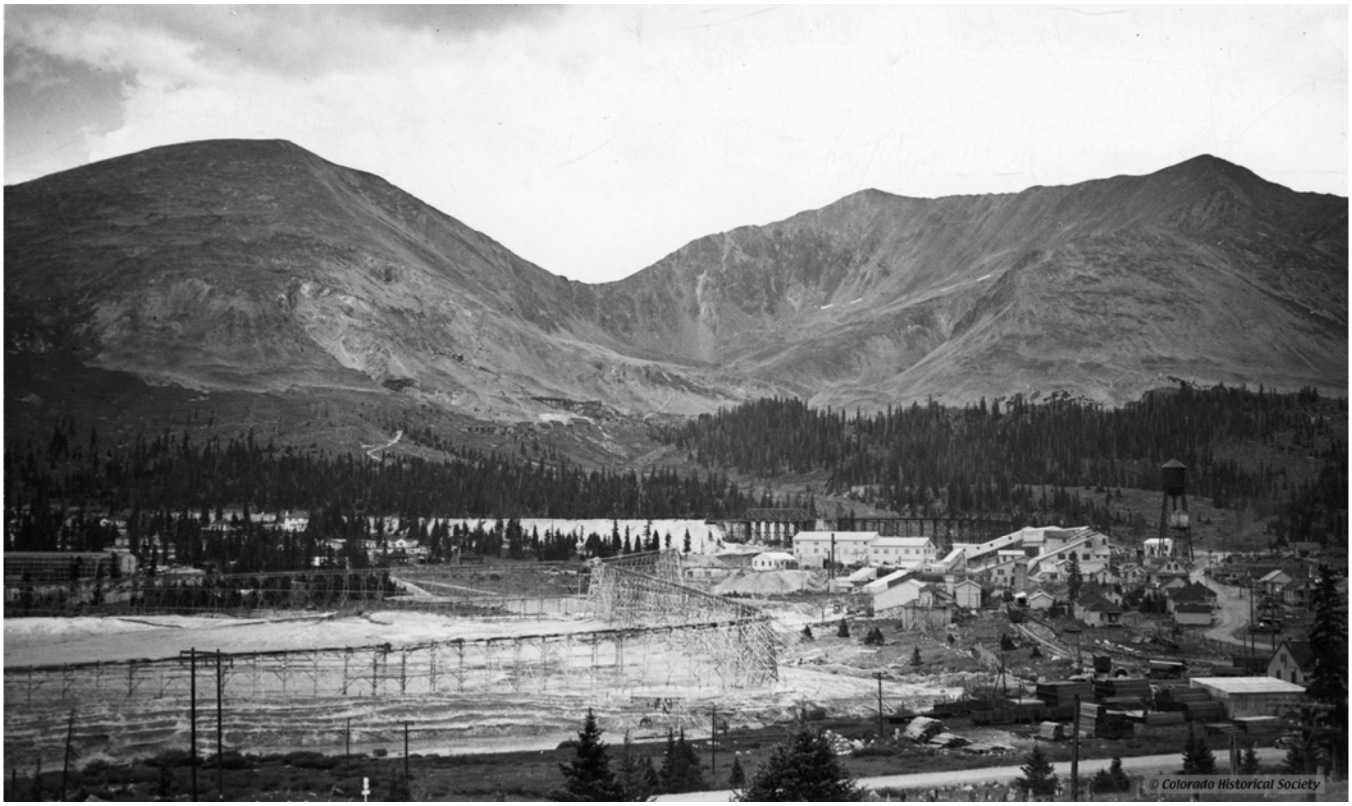

Fig. E.I.31 Climax Molybdenum Mine in the 1930s. Collection of the Stephen Hart Library, Colorado Historical Society.

As production soared, Phillipson and his successor Max Schott built a company town at Climax, something rare in metal mining. Other employees chose to live in Leadville, Kokomo, or other now dilapidated mining towns within driving distance of the mine.

The advent of World War II created an unprecedented demand for molybdenum. Armor plate came into wider use, and the tank became the key vehicle in land warfare. Production at Climax surged despite labor and materials shortages. When the War ended in 1945, many expected that military cutbacks would curtail production substantially, but the great coalition that had won the war fell apart in the hour of victory, and in its stead emerged the phenomenon known as the Cold War. Beginning in the mid-to-late 1940s, for the first time in American history, the United States developed a massive standing peacetime army, and that led to continued demand for molybdenum. By 1961, output at Climax reached more than 49 million tons per year.

Significant corporate changes evolved as well. The Climax Company had long maintained a close association with the American Metal Company, which had been one of its original founders in 1917. This enterprise had grown itself, and finally in 1957 the two enterprises merged to form American Metal Climax, Inc., one of the world's largest mining companies, and certainly the world's largest producer of molybdenum from the mine at Fremont Pass. From its inception, most people referred to the company as "Amax." In recognition of this, the enterprise eventually changed its name to Amax, Inc.[1]

With demand and prices for molybdenum and prices high, Amax formulated plans to develop an open-pit mine to go with its underground operations. Given that such massive production would lead to immense amounts of tailings, the enterprise purchased virtually the entire Ten Mile Valley, the site of older, now largely abandoned mining towns of Carbonateville, Robinson, Kokomo, and Recen. So as it advanced its plans, Amax bought up townsites, large and small private holdings, mining claims, and other property, and exchanged private lands for Forest Service property. After several years of planning and work, Amax finally acquired the valley. Then as it expanded its underground operations and developed the open pit, it began mining the ore, processing it via flotation to recover the molybdenum disulfide, which was sold to steel companies, and deposited the tailings in the Ten Mile Valley. By now, the Climax Mine was the single largest and most important mine in Colorado history.

As the 1970s and 1980s evolved, Amax expanded operations elsewhere in Colorado. The work of new geologists revealed an immense deposit of molybdenum near the foot of Berthoud Pass in Clear Creek County. During the 1970s, Amax used many of the profits from the Climax Mine to open this deposit, probably the world's second largest deposit of molybdenum, in what became known as the Henderson Mine. This massive operation, running from Berthoud Pass west through the mountains and under the Continental Divide to a point near Silverthorne, included the operation of underground trains when it finally came on stream at the end of the 1970s. Also during the late 1970s, Amax made plans to extract a third deposit of molybdenum, this one located in the depths of Mt. Emmons, named for the famous geologist, near the coal-mining town of Crested Butte.

As these massive projects evolved, however, dramatic events altered the industry's development and the company's fortunes. During the 1970s and early 1980s, smaller competitors continued to produce molybdenum, copper mining companies began recovering molybdenum found in trace amounts in tailings, the downsizing of cars in the wake of the energy crisis of the mid-1970s, and the recycling of steel from cars and tanks, all combined to change the supply/demand equation in the industry. In the early 1980s, just as the Henderson Mine opened, increasing capacity, the price of molybdenum sagged. This compelled Amax to close the Climax Mine, still the world's largest producer, in favor of the more efficient Henderson. It also fought off a hostile takeover from Standard Oil of Ohio at a time when many large oil companies were moving into metal mining (generally with

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[1] In terms of pronunciation, company personnel generally used the short "a" sound, while the larger public generally used the long "a" sound.

disastrous results). Still, Amax made plans to open the Mt. Emmons deposit. But here the combination of low molybdenum prices and virulent opposition from the local tourist industry, combined with environmentalists and historic preservationists, combined to thwart that project as well.

As the 1980s and 1990s continued, the once very profitable Amax struggled. It came under fire from environmentalists owing to the massive tailings pond in the Ten Mile Valley, although the company did have one of the best, if not the best, environmental records among Colorado mining companies. Finally, it merged with an out-of-state coal company to form Cyprus-Amax, but after a time, the enterprise sold itself to Phelps Dodge, Inc., the great Arizona copper producer whose operations stretched back to the 1870s. Phelps Dodge continued operations at Henderson, but replaced the underground trains with the world's longest conveyor belt to move concentrate out of the mines for shipment. The Climax Mine remained closed, and that at Mt. Emmons sat still. In the early twenty-first century, Phelps Dodge began reclaiming the Climax tailings pond, and in 2005, unconfirmed reports suggested that it was about to reopen the mine, closed for 25 years.

3.2 Tungsten

If molybdenum was a rare metal that came into production because of the industrial and military uses of the twentieth century, so, too, did another exotic metal – tungsten. Like molybdenum, it was identified for the first time in the 1780s by Europeans. The German chemist Scheele made the first discovery. Like molybdenum, it was a scientific curiosity, of interest only to a few academics of that time, and of little or no industrial use until the very end of the nineteenth century.

In the 1870s, Nederland, Colorado, had emerged largely as a supply and distribution center for the silver mines at Caribou, a few miles to the west. The heyday of Caribou was brief, however. For several years during the 1870s, its production created a sensation on the one hand and promotional scandals on the other. Dutch investors, who probably lost most of their investment, left the name of their country in the name of Nederland itself. For the bulk of the 1880s, 1890s, and early 1900s, mining in the area proved sporadic and production modest, although the town of Ward became a considerable producer in the 1890s and after. For the most part, Boulder County, once an important mining center, had drifted into the background as a center of mineral production as the early twentieth century began.

Tungsten had long figured, unknowingly, in mining development in the Nederland/Caribou area in the western part of Boulder County. In 1870, Samuel P. Conger, a veteran prospector, discovered what became the Caribou Mine and helped launch the town of Caribou. As the spectacular mining there surged forward, prospectors and miners gradually became acquainted with what they called "heavy iron," "hematite," "black iron," or "barren silver." It was a heavy dark mineral, which suggested that it contained gold, iron or lead, which in turn implied silver and possibly gold. Prospectors did many assays on the substance, but they were to no avail in determining what made the rock so heavy. Years later, around 1900, Conger's partner, one J. H. Wanamaker, returned to Colorado from the Dragoon Mountains in Arizona. There, he had see the same ore, and told Conger that it contained tungsten. In fact, it was an ore known by the name of ferberite.

Tungsten now joined the list of metals produced in Colorado. Keeping their knowledge a secret, Conger and Wanamaker leased property north of Nederland from ranchers by the name of Lake and Barnsdell and began to develop the ore body. By year-end, his miners had taken out 40 tons of ore. For the next few years, he and others mined small amounts and established Boulder County as a source of tungsten. The days of Conger and Wanamaker in the burgeoning industry proved brief, however. When the lease expired in 1903, Lake and Barnsdell took over what had become known as the Conger Mine. They turned it into the largest tungsten mine in the world. Iron and steel companies in the East quickly entered the market–developing both mines and mills via subsidiary enterprises, notably the Wolf Tongue Mining Company, the Colorado Tungsten Company, and the

Primos Chemical Company, to name several. Even one German-controlled company entered the business. The nationwide financial Panic of 1907 hurt the mines severely, although the scientific study of the deposit began at that time.

Fig. E.I.32 Wolfe Tougue Mine near Nederland in the 1910s. Collection of the Stephen Hart Library, Colorado Historical Society.

Mining itself had also gone through different phases. Given that Conger and Wanamaker commenced operations with minimal capital, they used numerous open pits and trenches, and there was what was also known as "gopher mining" for float. Gradually, these crude methods gave way to standard practices. To process the ore, the first operators converted older gold and silver mills in the area into the state's first tungsten mills. By the 1910s, five plants had gone into business near Nederland, but all of these mills had technological problems in concentrating the ores using Wilfley tables and other devices.

Even as tungsten mining developed, there was an air of mystery about the work. It was public knowledge that General Electric and other companies used it in manufacturing incandescent lights, but rumors also surfaced that some manufacturers were secretly using it to produce armor plate.

By 1905, the burgeoning industry had become largely consolidated by the subsidiaries of larger enterprises, notably those in the steel industry. The price was little changed, and the deepest mine only 200 feet in depth, but increasing use in steel manufacture caused the price to rise until the Panic of 1907, when the falling economy caused prices to plunge. Although many producers closed and others struggled along, there was more concentration, notably when the Primos Mining & Milling Company, a subsidiary of Primos Chemical Company, took over a group of claims and transformed itself into the largest tungsten mining company in the world. The Conger Mine was its principal property. In 1909, the enterprise built the Primos Mill at a place known as Lakewood (a site in the mountains between Nederland and Ward). Output in the district remained sporadic, however, and even the Primos enterprise closed its mine and mill for a time. Even the onset of World War I did nothing for the industry, at least at the outset.

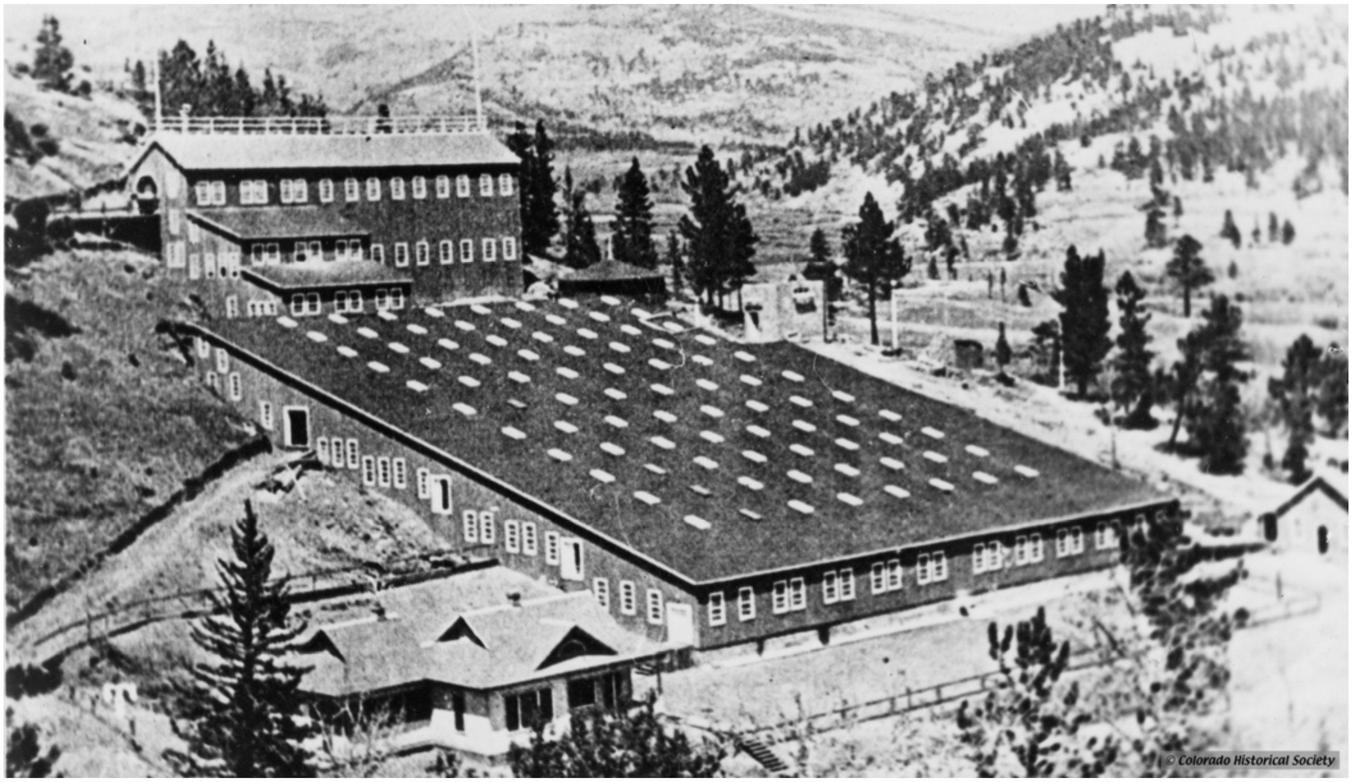

Fig. E.I.33 Primos Tungsten Mill in Lakewood, north of Nederland, Colorado, about 1920. Collection of the Stephen Hart Library, Colorado Historical Society.

That was all about to change. The demand for high-speed steels induced by war caused the price to surge in 1915 and produced a powerful three-year boom. The extant companies acquired older mines, prospectors swarmed over the area, the price of tungsten surged nearly ten-fold, and nearly doubled again in 1916 to bring it to a high of nearly 20 times the prewar price. New mines opened and new mills were built. The Primos Company and the Wolf Tongue Company remained the largest in the district. The population of Nederland surged, and new communities like Lakewood, Ferberite, and Stevens Camp (later called Tungsten Post Office) sprang to life, along with various tent cities here and there in the district. Prices fell sharply in the latter part of 1916 due to competition from new mines in China, but production continued to be strong. Output from the Wolf Tongue Company surged past the Primos. Eventually, however, the continuing fall in prices in 1918 curtailed production. In 1919, when prices plunged to prewar levels, the boom was over. Most mines closed, and production slumped to levels not seen since 1901.

The interwar years were hard on the Boulder County tungsten industry. The Wolf Tongue and Vasco mining companies, subsidiaries of enterprises making high-speed steels, continued operations in a small way–they were in fact the only tungsten producers in the U.S. in 1920. The Primos Company and its Conger Mine, the single most important producer that had closed in 1919, remained shuttered, and there was no American production at all in the early 1920s. Cheaper Chinese ore flooded the American market until Congress imposed a tariff on imports. The late 1920s did see a little production, but the onset of the Great Depression finally shut down even these small producers again by the early 1930s.

Production and prices, however, began to rise in the mid-to-late 1930s despite the ravages of the Great Depression. One important development came when the Vanadium Corporation of America purchased the old Primos Company and with it acquired the Conger Mine. In the late 1930s, as the industry sprang back to life, the Vanadium Corporation and other producers enjoyed better times, fueled, of course, by rearmament for World War II.

War, of course, changed everything, as it had two decades before in World War I. The surging price of tungsten led to enhanced production and the construction of new mills in the district. A vital development was the advent of the Metals Reserve Company, a federal agency, which began buying ore at premium prices, although tungsten rates were only about one third of the highest prices reached in World War I. The Bureau of Mines and U.S. Geological Survey both financed and conducted exploratory drilling. Other government agencies made loans. The Metals Reserve Company began to stockpile ores for future shipment rather than milling it right away, but when prices fell in 1944, the Metals Reserve Company announced it would pay less. By the end of the year, all the mines had closed again except the Conger and the Forest Home. They closed as the war ended in 1945. There appears to have been some mining and milling in the postwar years, but production was minimal. The day of tungsten mining in Colorado had ended.

3.3 Radium, Vanadium, and Uranium

Even as the minerals industry in Colorado unfolded based largely on the search for gold and silver, lead and zinc, other discoveries gradually laid the foundation for new branches of mining and processing to come. In 1898, the French scientists Pierre and Marie Curie finally succeeded in isolating the metal radium, which proved luminous in the dark and soon revealed that it had properties important in treating cancer. This touched off a global search for this exceedingly rare and very expensive metal.

Colorado became central in this search, again based on work that stretched back into the late nineteenth century. In 1881, a prospector named Tom Talbert had sent samples of a yellowish ore from a place known as Rock Creek, in Montrose County, to Leadville, to be assayed. Talbert hoped that the rock would prove to be high in gold or silver, but he was disappointed in the findings that it held little in the way of precious metals. In 1898, however, the Western Slope area attracted greater attention when a Gordon Kimball of Ouray sent ore samples to the French chemist Charles Poulot, then working in Denver while doing some assaying for a small copper mine in the Paradox Valley. Knowing of the work of the Curies, Poulot determined that the ore held uranium. That revelation not only enabled Kimball to sell some ore and stimulated the search for more, but also persuaded Poulot to ship additional specimens to the scientific community in France. There it was determined that the ore consisted of vanadium and uranium in what was known as carnotite, an ore named in honor of the French engineer Adolphe Carnot. This carnotite ore from western Colorado, however, was special–it held minute amounts of radium. Gradually, an industry emerged in the early twentieth century–but it was quite small. The ores were low in grade, the area remote, and living conditions were difficult. The new Radium Company of America and other enterprises made shipments, and eventually, it led prospectors to unearth a substantial deposit of vanadium south of Paradox Valley in San Miguel County. Though small, it was enough to supply the national need for vanadium. Thus, several new branches of the Colorado minerals industry came into being in a roundabout fashion.

Radium was one. Poulot and others built a mill near Slick Rock in 1900, and other mills came into being at Paradox and Cedar. The initial market remained small because it was confined to illumination, but when medical research proved that radium was effective in treating cancer, demand surged. Supply was so tight that prices ranged from $120,000 to $180,000 per gram, and grew even more restricted when political problems ended radium shipments from Austria to Western Europe. This meant that western Colorado would become the world's leading supplier of radium.

As demand soared and supply from Austria became restricted, a radium industry emerged on the Western Slope. Into the region came a number of companies that built mills at Uravan, Denver, and other places to work the carnotite ores. These developments were influenced by other issues, however: the growing conservation movement of Theodore Roosevelt, designed to protect the nation's resources for long-term use, and the onset of World War I. In 1913, the U.S. Bureau of Mines became concerned that most American carnotite (the only domestic source of which was western Colorado), was being shipped abroad. This seemed detrimental to the national interest, so in 1913 it led to the creation of the National Radium Institute, whose goals included countering the recent European near monopoly on radium extraction, and enhancing American production and supply, thereby lowering costs for medical usage.

The work of the Institute brought quick results. It developed a concentrator at Log Park, near Naturita, Colorado, and built a plant at Denver to produce radium, a facility the Institute continued to operate until the plant was sold to the Standard Chemical Company in 1917. Other enterprises built facilities as well, all of which combined to make Denver the "radium capital of the world" from ores mined on the Western Slope. Standard Chemical produced about two-thirds of output. Meanwhile, Secretary of the Interior Franklin Lane sought to withdraw carnotite lands from entry, but his proposal ran into opposition from Colorado's Congressional representation and the industry itself. As a result, radium production remained at the discretion of market and industry forces, but the concept of a national, government-directed industry had at least entered the national debate.

The onset of World War I vastly increased the importance of the domestic radium industry. When the Austro-Hungarian Empire joined forces with Germany, the European source of radium–from pitchblende in Austria–was now completely cut off. Simultaneously, the demand for radium grew, for, when mixed with zinc sulfide, it dramatically increased luminosity, which was now significant in airplane and other instrumentation at night. As the War unfolded, about 95% of radium went to military use. By now the 350 claims on the Western Slope owned by Standard Chemical were the most numerous controlled by any one entity.

Priorities shifted once the U.S. formally entered the War in April 1917. Vanadium, long considered a waste product in radium work, became a valuable substance itself as an alloy in steel. This meant that radium mining and milling shifted to producing vanadium as well. Standard Chemical and a newer enterprise, the Radium Company of Colorado, came to be the two major entities. As production went forward, the concept of a "Uravan Mineral Belt," running from Gateway down Paradox Valley to Slick Rock, and then over the border into southeastern Utah became important.

Colorado's position of leadership in radium production was to be a brief, however. Demobilization reduced the need for metals, prices dropped, and the Western Slope industry began to close. Even worse for American radium, in the early 1920s, the development of rich pitchblende deposits in the Belgian Congo led to the production of more inexpensive ores and metal than the domestic industry could produce. This largely destroyed the industry on the Western Slope. It had produced about 67,000 tons of ore from which were extracted about 202 grams of radium and more than 500 tons of vanadium. Another product was uranium, but it had no use at the time, and was just left on mine and mill dumps.

The Western Slope industrial metals industry languished throughout much of the 1920s, but work finally resumed in the course of the Great Depression centered largely on vanadium. In the late 1920s, the United States Vanadium Corporation (a subsidiary of the Union Carbide and Carbon Corporation), acquired the properties of Standard Chemical, including the Joe Junior Mill at Uravan. Then, in the early 1930s the Vanadium Corporation of America acquired the assets of the Colorado Radium Company and the U.S. Radium Corporation. These enterprises established new towns, notably Uravan and Vancorum, and they refurbished expanded older mills and built new ones. They came to dominate vanadium production in the region, although output was very small. The Great Depression of the 1930s made it possible for these enterprises to expand and build very cheaply, but at the depths of the Depression in 1933, there was virtually no vanadium production per se..

Fig. E.I.34 U.S. Vanadium Mill in Uravan during the 1940s. Collection of the Stephen Hart Library, Colorado Historical Society.

As in the case of World War I, the onset of World War II in Europe in 1939 dramatically altered the destiny of Colorado’s mines with radium, vanadium, and uranium. Rearmament, first in Britain and France in the late 1930s and then in the United States in the early 1940s, dramatically increased the demand for vanadium. In fact, the projected needs increased beyond the capacity of the known ore reserves. Given this circumstance and the growing involvement of the U.S. in the Allied cause, the federal government limited exports of vanadium in July 1940 and, once the U.S. entered the War in December 1941, put vanadium under an allocation system. Faced with the need for many metals strategic to the war effort, the federal government also created the Metals Reserve Company in 1942, to spur investment in mining projects to produce what was needed. This reinvigorated the Western Slope industry. Vanadium production surged–once again spearheaded by the work of the two dominant players: U.S. Vanadium and the Vanadium Corporation of America, which expanded facilities at Uravan and Rifle, and built new ones at Durango and Grand Junction.

Fig. E.I.35 Uranium processing plant in Rifle during the 1940s. Collection of the Stephen Hart Library, Colorado Historical Society.

It was a heady day for the vanadium industry. New enterprises entered the market, many new mines opened, and production even surged beyond war-spawned demand. The U.S. Bureau of Mines conducted an extensive drilling program on the lands of some producers. The Public Roads Administration built roads. By 1944, so much vanadium had come to market that the Metals Reserve Company canceled its buying program and the mines began to close again. By war's end in 1945, the Uravan Mineral Belt had produced some 650,000 tons of carnotite ore from which the processing plants extracted some 24 million pounds of what was called "redcake," the concentrate bearing vanadium.

If vanadium had been central to the war effort, so, too, was the once-useless byproduct of the industry: uranium. In 1939, German scientists suggested that by bombarding uranium with low-energy neutrons, a chain reaction called fission could split the nucleus of the atom in such a way that it would release massive amounts of energy: i.e., an atomic bomb. As the War raged in Europe, in 1941, a group of scientists led by the famous physicist Albert Einstein spearheaded an effort to develop an American bomb. Also in 1941, President Franklin D. Roosevelt created the Advisory Committee on Uranium, and by the end of the year, the federal government had launched a uranium development program. The Army Corps of Engineers was assigned the responsibility of developing the bomb itself in what became known as the Manhattan Project.

One challenging problem was to find enough uranium to build one or more bombs. At the time, the only uranium-producing area in the United States was the Colorado Plateau where, for decades, uranium wastes had been discarded on mine dumps and tailings. The mines were small, and the processing facilities nonexistent because up to this point, uranium had been considered a largely worthless byproduct of other mining. But U.S. Vanadium and the Vanadium Company of America became vital to production by reworking old tailings and mining new carnotite ore.

In March 1943, the Manhattan Project leased land just south of Grand Junction to build a mill to rework old tailings. This mill received sludge and tailings from other vanadium/uranium mills largely in Colorado and Utah, and for three years before its closure in 1946, it produced substantial quantities of uranium destined for bomb manufacture in New Mexico.

In the postwar years, the onset of the Cold War witnessed something unprecedented in American history–a mining rush created by the federal government in the quest for more uranium. In August 1946, the creation of the Atomic Energy Commission (or AEC), put all control of uranium under the purview of this agency and its civilian leadership, superseding the Manhattan Project. Spurred by the lack of known uranium resources in the United States, the AEC signed contracts with various producers, but the prices offered were too low to spark the required search and production, although new mills did come into being at Naturita, Grand Junction, Rifle, and Uravan to work extant resources. The benefactors were largely existing companies. Small operators put pressure on the AEC, as did Colorado's U.S. Senators Edwin C. Johnson and Eugene Millikin, members of the Joint Committee on Atomic Energy, and that, coupled with the onset of the Korean War in 1950, prompted the AEC to dramatically increase the price paid for uranium oxide. With the price set remaining unchanged until 1962, it became the foundation of a new phase of the industry.

Meanwhile, in 1952, Sheldon Wimpfen arrived in Grand Junction to take charge of the AEC Grand Junction Operations Office with the goal of quadrupling uranium production. He sent geologists into the field, provided advice and information, established field camps to support exploration, built airstrips to facilitate the search, improved roads, and by the mid-1950s, his work had gotten some 800 mines into production on the Colorado Plateau. Colorado again emerged as the nation's leading uranium producer. With all of this government support, the industry shifted through the mid-decade from one comprised of many small producers to a few immense producers: many of the major mining companies in the States. They had capital and the best technology, and soon dominated production. Uranium stock prices surged as speculation boomed.

The boom, however, was a short one. By the mid-1950s, this stock speculation crashed, production exceeded expectations, and newer producers in New Mexico and Wyoming overtook Colorado enterprises as the leading uranium producers in the nation. In October 1958, the AEC curtailed its unlimited buying program with the decision to honor only existing contracts. Exploration in Colorado plunged; smaller producers now only had the big companies as sources for sales. The industry appeared to be in collapse. But if "uranium for bombs" came to an end, initiatives for nuclear power plants became a reality when in 1957 the Eisenhower administration shifted its emphasis away from bomb building to a peaceful use for this atom. This gave Colorado's uranium industry a new lease on life in the late 1950s. Even better news came a few years later in 1962 when the AEC, concerned that domestic industry would not be able to produce enough uranium, announced a "stretch-out" guaranteeing government uranium purchases lasting until 1970. What also spurred output was that in 1964 Congress made it possible for private companies to again control uranium for power generation. Exploration and production on the Colorado Plateau surged again.

Colorado's output of these metals was significant. Mines in the Centennial State accounted for about 13% of aggregate U.S. production during these years. Vanadium continued to be produced as well, with Colorado accounting for some 74% of total U.S. production.

This second uranium boom, however, was also coming to an end. Growing environmental concerns, public protest, and the Three-Mile Island Disaster in Pennsylvania in 1979 turned many Americans against the use of uranium in power plants. Declining demand led to a collapse in prices that forced out both large and small operators. The Uravan Mill closed in 1984 and the last mining company, Rajah Ventures, shut down production in 1990.

But if mining and milling were over, the cleanup stage had only just begun. The Uranium Mill Tailings Radiation Control Act of 1978 forced the cleanup of tailings and mill sites, and the Department of Energy initiated its Uranium Mill Tailings Remedial Action Project. The town of Uravan virtually disappeared. The cost of the cleanup probably approached the value of the uranium produced.

Uranium mining activity along the Front Range had also been developed from the 1940s onwards, notably in Gilpin and Jefferson Counties. The most famous mine is this area became known as the Schwartzwalder Mine, named after one Fred Schwartzwalder, a German-born janitor working at Golden High School. In the late 1940s, as the uranium boom swept over the land, he spent his weekends prospecting the hills west of Golden. There in the late 1940s, probably 1949, on a copper-stained crack on Ralston Creek, eight miles north of Golden, he found uranium with his Geiger counter near an old prospect hole left over the from gold mining era. He developed the property with hand steel and other primitive techniques despite a heart condition. Eventually, he struck a seam of pitchblende. With government help, he developed his mine, but later at government urging, he sold out to the Denver-Golden Oil and Uranium Corporation, which developed the property. Later it was operated by both the Cotter Corporation and Commonwealth Edison (a Chicago-based utility company), before competitive pressures forced it to close.

* * *

Mining remained the dynamo of the Colorado economy until the early twentieth century. The industry also contributed to significant technological advances, and combined with the professional studies of all aspects of the industry, had powerful ramifications in the industry's global expansion in both the nineteenth and twentieth centuries. Mineral development in the Centennial State both reflected and contributed to the dramatic industrial and technological advances.

Writing about the American mining industry in 1885, observer Clarence King noted the "intelligence and versatility of our skilled mine operatives." By this time, both United States engineers and practices were being exported world-wide instead of being imported, reversing a previous trend. Mining engineers combined the theoretical knowledge of the university with the practical experience of field operations and seat-of-the-pants innovations to meet the challenges of the diverse geology and the demands of impatient financial investors. It was the mining engineers who most shaped the Colorado mining landscape in their efforts to extract maximum yield for minimum investment. The next section provides a detailed examination of the changing mining technology used in Colorado and its remaining physical legacy.

Fig. E.I.36 Preserved mine headframe at Cripple Creek in 2004. Collection of James E. Fell.

Part II – The Technology

Mining Technology, Methods, and Equipment in Colorado: 1858-2005

Introduction

The State of Colorado features an unusually diverse array of metals and minerals that manifest in many forms. The rugged Rocky Mountains offer silver and industrial metals such as hardrock ore, gold as both placer deposits and ore, and industrial minerals such as fluorspar in veins. In addition, the sedimentary formations in and around the mountains present anthracite and bituminous coal, uranium, and alloy metals such as vanadium. Over the last 150 years or so, no one single method has proved effective for finding and extracting such a wide array of metals and minerals. Instead, engineers and mining companies have adapted extant technologies to categories of mineral formations, and where known methods failed, they pioneered new solutions.

Below is a discussion of the general methods and technologies used to find and extract minerals from Colorado's principal categories of mineral formations. In many cases, the methods and technologies are specific to individual types of formations, although some of the machinery was ubiquitously applied. The categories include placer deposits, hardrock ore bodies, and minerals such as coal found in sedimentary rock.

1 Placer Mining

1. 1 The Nature of Placer Deposits

For thousands of years, people have prized gold for its rarity, appearance, malleability, and chemical stability. Gold oxidizes and forms compounds only under the most unusual physical circumstances, and otherwise remains in its native state. As a relatively soft metal with a low melting temperature, superheated fluids and gases associated with geothermal and magmatic activity have tended to deposit gold in the form of veins, replacement bodies, and disseminated deposits in existing rock formations. Typically, mountain-building events, such as those that uplifted the Rockies, both created the fluids, gases, and the geological conditions for the formation of gold ore, which often occurs with other metals.

Over millions of years, erosion attacked these mountainous areas and dismantled the ore veins that cropped out on ground surface. Most of the minerals and metals were washed into waterways where they suffered reduction and dissolution, both physically and chemically, and decomposed into sediments. Stream action concentrated the sediments on the floors of drainages, and high runoff mobilized the sediments and washed them downstream.

Because gold is soft and inert, however, it neither dissolves nor forms chemical compounds and only slowly disintegrates through physical reduction. Hence, as erosion freed gold from its parent veins, the particles migrated into nearby drainages and slowly sifted downward into the gravel floors due to their high weight. As each high-runoff event mobilized and shifted the stream gravel, gold particles worked their way down toward the bedrock floor where they became concentrated and remained for thousands of years. Over time, water carried the gold from small, steep gulches near the parent veins into streams, then into rivers.

Because erosion is an unending process, fresh gold is constantly freed from its parent veins and introduced in small volumes into drainages, while older material continues to accumulate on the bedrock floors.

Hence, fine gold disseminated throughout the upper strata of a stream's gravel often represents a richer deposit at depth. Overall, miners termed gold-bearing gravel *placer deposits* and referred to broad areas of such gravel as *placer fields*.

Mining companies and geologists identified five general types of placer deposits, exemplified by those found in the Upper Blue River drainage in Summit County and near Central City in Gilpin County. The first consisted of what were known as gulch placers or gulch washings, and these consisted of rich, gold-bearing gravel lining the floors of minor drainages that were often steep. Because gulch placers lay near a parent vein, offered few places for fine material to settle out, and were subject to high-energy, intermittent stream flows, the gravel tended to be coarse, the gold particles large and rough, and the gravel beds thin. Easily discovered and worked with relatively little effort, the gulch placers were the first to be found and yielded handsomely through hand mining.

The second type of placer deposit was outwash gravel created when streams re-deposited sediments left by glaciers or early waterways. The streams mobilized and distributed gold-bearing gravel over broad areas of low-lying topography, such as around Fairplay in Park County. The third type was limited to relatively arid areas that featured gold veins at ground surface, such as around Central City. Erosion and weathering attacked the veins and freed the gold. Runoff was not sufficient enough to immediately shunt the metal into waterways, but it did leave a veneer of gold-bearing soil easily processed by hand.

The mining industry recognized the fourth type of deposit as bench gravel or terrace gravel, and prospectors found these formations high on the sides of principal river valleys. Bench gravel initially formed as side- and bottom-moraines left by glaciers, such as along the Blue River, or as thick stream gravel left high and dry by a stream incising downward into the valley floor, such as along Clear Creek.

Deep placers, also known as valley gravel, constituted the fifth deposit. These filled the floors of major drainages and were created in the same way as bench gravels, except that the moraines and thick gravel beds remained on the valley floors, where stream action spread the gravel out.

1. 2 Prospecting for Placer Gold

While some of the placer deposits lent themselves to specific types of extraction processes, all could initially be discovered by basic prospecting. All a prospector needed to do was to excavate pits preferably in stream gravel then reduce the material in a gold pan. The presence of a few flakes of gold from the upper gravel would have suggested the potential for more at depth, spurring the prospector to dig deeper pits. By the late 1850s, experienced prospectors understood that the worth of a deposit could only be accurately assessed by testing gravel from near bedrock, which required considerable labor to access. If the prospector confirmed the presence of placer gold in economically viable quantities, he was ready to begin mining.

1.3 Placer Mining Methods

One of placer mining's main attractions was that it was within practical and economic reach of individual miners as well as organized companies. Gulch and outwash placers, as well as gold-bearing soil, saw mining by individual miners who worked by hand, and by companies with complex systems that depended on infrastructures. Bench and valley placers, however, tended to be the domain of capitalized companies because the gold was too fine and disseminated to be profitably won by hand.

When working by hand, individual miners often employed pans, cradles, and small sluices to separate gold from gravel. Miners merely excavated pits and trenches into stream gravel, and when they approached bedrock, the miners shoveled the gold-bearing material into a cradle or sluice. A cradle was a portable wooden box with a rounded bottom, a slanted board featuring riffles, and a lever. The miner rocked the cradle back and forth while introducing water, which washed off the gravel and left the heavy gold trapped behind the riffles. A sluice was a small, portable wooden flume with riffles nailed to the floor. The miner placed it in a stream and shoveled gravel into the interior, and the flow of water washed the light gravel away. When miners exhausted the gold-bearing gravel in their pits and trenches, they shifted laterally, began new excavations, and filled the old pits with tailings. Over time, this created hummocky assemblages of tailings piles, pits, trenches, and buried excavations on valley floors.

Organized mining companies had the same goals as individual miners, except that they relied on infrastructures to process gravel in high volumes from groups of claims. Companies often erected systems of sluices, work stations, water-diversion structures to move streams out their beds to expose gravel, and ditches and flumes to deliver water to otherwise dry areas. The sluices tended to be lengthy, more than 1,000 feet in some cases, and featured either several branches feeding into a trunk line or several parallel sluices. Common sluices ranged from 2 feet wide and as deep, to 4 feet wide and 4 feet deep. They featured a relatively gentle gradient so fine gold was not washed off and stood on timber piers supported by timber or stacked rock footers. Workers usually installed the sluices in trenches and shoveled the surrounding gravel into the current flowing through the device. After prolonged excavation, workers reduced the height of the surrounding gravel until the sluice bed manifested as a raised berm.

When the sluice floor became choked with fine sediment, a worker closed the head gate and shut off the water flow so the gold caught behind the riffles could be recovered. Workers stepped down into the sluice and, under watch of a guard or superintendent, began removing large gold particles and scraping out gold-laden sand. The particles were collected and weighed while the sand was treated with mercury, which amalgamated with gold dust that was too fine to be easily picked out. After cleanup operations, the sluice was ready for more gravel and a worker opened the head gate, admitting water again.

While hand methods were highly effective for gulch and outwash placers, the costs of labor were too high and the rate of processing too limited for most bench and valley placers. By nature, these deposits tended to feature fine gold disseminated through broad, deep gravel beds that had to be mobilized and processed using economies of scale for profitability. Such conditions required the investment of considerable capital to build the infrastructures necessary to achieve production in economies of scale, and mining companies arranged their infrastructures to carry out several distinct methods.

One of the most popular and earliest was known as *booming*, and it involved the sudden release of a torrent of water into placer workings from a nearby reservoir (Fig. E.II.1). The rush of water mobilized and carried gravel en masse through sluices, where riffles (often retaining mercury) collected the gold. Companies rarely employed booming alone but used this method to supplement the hand mining described above.

To facilitate both the consumption of high volumes of water and the processing of large tonnages of gravel, companies formally engineered their infrastructures. Networks of supply ditches pirated water from area streams and directed it to the placer mine and reservoir, distribution ditches shunted the liquid into the sluices, and boom ditches carried water from the reservoir into the workings. All featured head gates, and the sluice systems were as noted above.

Fig E.II.1 A stream placer near Hoosier Pass, Summit County, around 1880. Organized placer companies employed engineering and capital to work stream placers. Ditches provided water for booming, which relied on a torrent to carry gravel through systems of sluices. Some operations also used derricks to hoist large boulders, exemplified by the structure between the sluices. When workers cleaned gold from the sluices, they shoveled the excess sediment out. In this photo, workers piled it between the sluices. Denver Public Library, Western History Collection, X-60097.

Hydraulic mining, developed in California, was another method for processing thick gravel beds using economies of scale (Fig. E.II.2, Fig. E.II.3). A monitor (also known as a giant), was the key instrument in hydraulic mining. A monitor was a large nozzle that emitted a jet of water under pressure so high that miners were unable to pass sledgehammers through it. A worker played the jet against gravel banks, which crumbled and liquefied, and with the help of booming, were washed into sluices. The infrastructure for hydraulic mining was similar to that for booming with additional components for the monitors. To create the necessary pressure, ditches delivered water to a reservoir located far upslope from the mine, and a flume or pipe directed water into a structure known as a penstock or pressure box. A penstock was basically a rectangular tank made of planks retained by stout framing at least 6 feet wide, 6 feet high, and 8 feet long. A pipe, often at least 24 inches in diameter, exited the structure’s bottom and descended to the mine, decreasing in diameter incrementally to increase the water current’s velocity and pressure. The pipe entered the placer workings and connected to a monitor located on a strategically placed station, which commanded a full view of the gravel banks.

Fig.E.II.2 Hydraulic placer mining at French Gulch, Summit County, 1897. Heavily capitalized companies dominated placer mining by the late 1870s and employed advanced engineering to work bench deposits that offered disseminated gold. Denver Public Library, Western History Collection, Williamson-Haffner, X-60193.

Fig.E.II.3 Hydraulic placer mining at Gold Run Mine, Breckenridge, Summit County, between 1880 and 1890. A high-pressure jet of water, emitted by a monitor against gravel banks, washes the gravel through a system of sluices. Hydraulic mining required capital, advanced hydraulic engineering, and extensive claim holdings. Denver Public Library, Western History Collection, X-60113.

Valley gravel deposits, found primarily along the Blue River and around Fairplay, proved to be the most troublesome to mine. Between the 1860s and 1890s, prospectors and mining companies proved that the gravel offered disbursed, fine gold, fueling speculation that the underlying bedrock floor was probably lined with a wealth of metal. The problem that discouraged mining lay with the very nature of the gravel beds, which were as thick as 70 feet in the Blue River. Technology was inadequate to manage an excavation large enough to render the disbursed gold profitable, let alone expose bedrock at such depths.

During the late 1890s, two movements began that overcame the problems presented by the deep gravel. The first was deep-pit mining, practiced primarily on the Blue River around Breckenridge (Fig. E.II.4). There, a number of companies flumed the Blue out of its bed and employed a combination of derricks to hoist boulders, conveyors to shuttle gravel out of their pits, and hydraulic elevators to simultaneously siphon water and gravel off the floors. Hydraulic elevators consisted of an hourglass-shaped chamber with an internal pipe that ended in a nozzle. A jet of water squirted through the chamber’s narrow portion, creating a vacuum behind the nozzle. The area under vacuum featured a port through which gravel could be drawn in and sent upward by the jet. The slurry generated by the elevators went through a system of sluices, which recovered gold. While large pits proved to be engineering successes, most were economic failures.

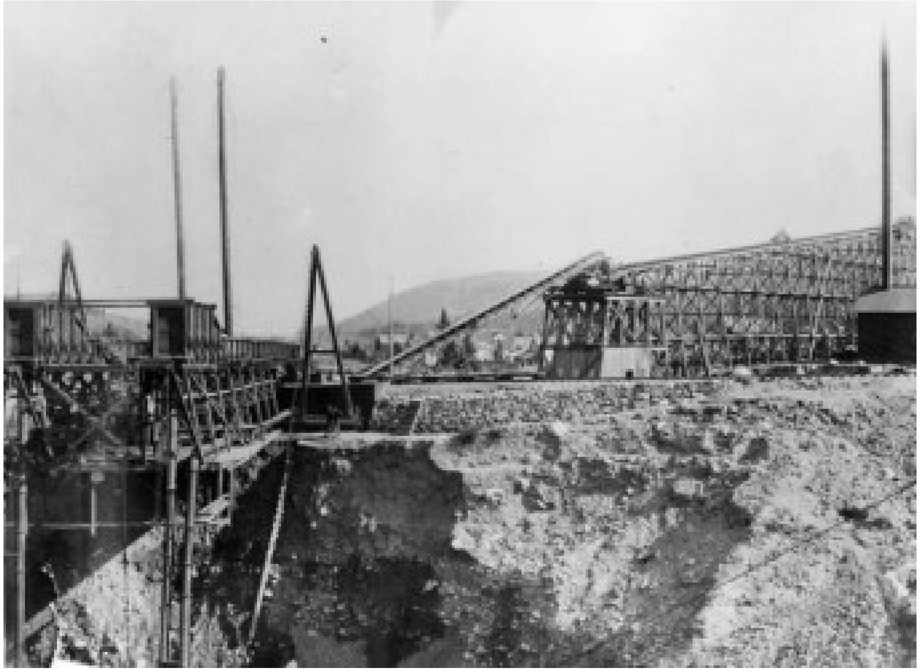

Fig. E.II.4 Deep-pit mining at Gold Pan Pit, near Breckenridge, Summit County, between 1900 and 1913. Engineers and investors long suspected that rich placer gold lay along the bedrock floors of the Blue River near Breckenridge. By around 1900, several companies employed advanced engineering to remove the gravel in deep pits, as shown here. Conveyors carried overburden gravel to tailings dumps and hydraulic suction elevators, supported by timber structures, siphoned gold-bearing material and dumped it into sluices. Operating costs exceeded profits at most pits. Denver Public Library, Western History Collection, X-62420.

The second and only truly profitable means of mining valley gravel was dredging, where floating gravel-processing factories recovered fine gold from sediments at all levels and scraped bedrock where possible (Fig. E.II.5, Fig. E.II.6). All the dredges used in Colorado featured a wooden hull similar to a barge, fitted with gantries at both ends and a superstructure at center. The gantry on the bow supported a bucket-line that excavated gravel and delivered it to processing machinery in the superstructure. The bucket-line dumped raw gravel into a hopper on the hull, and a conveyor lifted it to a set of screens and a washing facility. Oversized cobbles and boulders were screened out and dropped onto a conveyor known as a tailings stacker that extended out from the stern. Mud and fine sediment washed off the gravel went directly into sluices that either floated on pontoons alongside the dredge or were mounted in the superstructure. A steam engine supplied by a locomotive boiler powered dredges until the late 1900s, when some were electrified.

To operate a dredge, the mining company had to float the hull in a pond located on the valley floor, which often required the acquisition of sufficient water rights. Mooring cables stayed the dredge and held it fast against forces created when the bucket-line began devouring river gravel. To maneuver the dredge and direct the bucket-line into fresh material with broad, gradual, sweeping motions, a worker adjusted the mooring cables with winches. To access the deep layers of gravel, another worker controlled the pitch of the bucket-line and attempted to lightly scrape bedrock, where the highest concentrations of gold lay.

Fig. E.II.5 The stern of the Reliance dredge, at the mouth of French Gulch during winter in 1905. The tailings stacker, braced by the tall gantry, extends right and features a canvas shroud to prevent freezing. Water from processing pours out of the flume at center. Denver Public Library, Western History Collection, X: 60156.

Fig. E.II.6 The Reliance dredge's bow, possibly in 1906. This features the bucket-line for excavating gravel. The gantry and cables controlled the heavy bucket-line's elevation. The bucket-line delivered gravel to processing machinery in the superstructure. Denver Public Library, Western History Collection, X: 60161.

2. Hardrock and Coal Mining

2. 1 The Nature of Hardrock Ore Deposits and Coal Beds

While placer gold claimed importance to Colorado because it initially drew prospectors and miners, it was hardrock ore that kept them in the region. In general, potentially economically viable minerals and metals found in the hard, metamorphic and igneous rock formations of the Rockies constituted hardrock ores. In Colorado, the principal economic metals included semi-precious silver and precious gold, as well as lead, zinc, and copper (known as base metals), as well as tungsten, vanadium, and molybdenum (known as industrial metals).

The common traits shared by most hardrock ores, which influenced how companies mined them, were the nature of the ore formations and their geographic locations. The ore formations were functions of the events that built both the existing and the ancestral Rocky Mountains. During these periods, superheated, plastic magmatic bodies slowly intruded the basement rocks deep under the surface and exerted great pressure. As these bodies made their way upward, pockets of liquid rock and superheated fluids and gases attempted to escape through paths of least resistance. Faults and fissures provided these paths, and they ranged from microscopic to several feet in width and tended to be oriented vertically. As the gases and fluids lost pressure and heat during ascent, insoluble minerals first precipitated out on the fault walls, followed by soluble minerals and metals with low melting points. The result was irregular and mineralized bands or seams impregnated with metals in the surrounding rock, which the mining industry recognized as *veins*. Most veins were barren of metals while some offered disbursed ore. A few featured rich pockets or stringers, and nearly all terminated less than 1,000 feet deep. While this is a great oversimplification of Colorado's mountainous economic geology, some understanding is necessary to appreciate how mining companies extracted ore.

In terms of geographic location, most of the faulting and magmatic activity occurred in a belt extending southwest from today's Rocky Mountain National Park to the San Juan Mountains. Given this, the veins manifested among the most rugged and inaccessible terrain, which presented a raft of problems for profitable mining. The crucial issues included bringing the payrock (i.e., rock that yields a profit to the miner) to the surface, providing support for activities underground, and shipping the ore to market, which are discussed below.

Coal beds differed from hardrock ore bodies in many ways. First, they consisted of carboniferous material instead of metals and hard minerals. Second, the encasing rock was sedimentary in origin and much softer than the metamorphic and igneous formations comprising the main portions of the Rocky Mountains. Third, the beds tended to lie at relatively low angles, and last, except for at Crested Butte, most coal beds flanked the spine of the Rocky Mountain Range.

The coal began as vegetation communities and highly organic matter in shallow seas and lakes surrounding the Ancestral Rockies, before the existing range was uplifted. Over millennia, thick beds of organic matter accumulated and were buried by sediments eroding off the Ancestral Rockies in a sequence of individual episodes. Pressure and heat associated with both burial under hundreds of feet of sediments and tectonic activity compressed and altered the organic matter into coal and oil. The sediments likewise were compressed, altered, and solidified into sandstones, conglomerates, and shales.

When the current Rocky Mountains began to rise, the thick sedimentary layers arched upward, fractured, eroded open, and continued to rise. At the same time, erosion attacked exposed areas and exhumed the basement rocks of the Ancestral Rockies, as well as igneous and metamorphic formations created during the uplift. This left disjointed but extensive coal beds between layers of sedimentary rock on the east and west sides of the existing Rockies, and blocks of similar formations scattered in basins within the mountain range. The sedimentary and coal beds represent the lower portions of the original arch and so slope away from the mountain range.

2. 2 Prospecting for Hardrock Ore

Finding the ore formations was the first step in hardrock mining, and this was the task of prospectors. Popular history suggests that individual or pairs of prospectors simply excavated pits with "pick and shovel" in hopes of striking ore, or wandered the countryside until they found rich vein outcrops. In actuality, successful prospecting usually involved a basic knowledge of mineralogy and geology and hard work, as well as the use of strategy and planning. Prospectors also rarely worked alone because parties ensured safety and security, increased the likelihood of finding ore through group efforts, and hastened the examination and sampling of mineral bodies.

The process of prospecting often began with a cursory survey of an area of interest where prospectors sought geological and topographical features suggestive of ore bodies. They often examined visible portions of bedrock for seams, joints, outcrops of quartz veins, dykes, unusual mineral formations, and minerals rich with iron. In regions where vegetation, sod, and soil concealed bedrock, prospectors also scanned the landscape for anomalous features such as water seeps, abrupt changes in vegetation and topography, and changes in soil character.[2]

If an area offered some of these characteristics, the party of prospectors may have shifted to more intensive examination methods. One of the oldest and simplest sampling strategies, employed for locating gold

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[2] Bramble, *The ABC of Mining*, 1980, 11-13; Peele, *Mining Engineer's Handbook*, 381-85; Young, *Elements of Mining*, 1946, 19-26.

veins, began by testing steam gravel for gold eroded off a parent vein. By periodically panning samples, a party could track the gold upstream, and when members encountered the precious metal no more, they knew they were near the point of entry. The party then turned toward one of the stream banks and began excavating test pits and panning the soil immediately overlying bedrock in hopes of finding a continuation of the gold. They tested soil samples horizontally back and forth across the hill slope in attempts to define the lateral boundaries of the gold flecks, then moved a short distance upslope and repeated the process. Theoretically, each successive row of pits should have been shorter than the previous one, since erosion tended to distribute gold and other minerals in a fan from their point sources. By excavating several rows of pits, the prospectors were able to project the fan's upslope apex where, they hoped, the vein lay. Employing such a sampling strategy occasionally paid off, but the party of prospectors had to undertake considerable work in the form of digging prospect pits with pick and shovel, hauling soil samples to a body of water over rough terrain, and panning in cold streams.[3]

One of the greatest drawbacks to systematic panning was that it detected only gold, while the Rocky Mountains abounded with other metals such as silver. In addition to searching for gold particles, prospectors also scanned the stream gravel and other areas of exposed soil for what they termed *float*, which consisted of isolated fragments of ore-bearing rock. As with free gold, natural weathering fractured ore bodies and erosion transported the pieces down slope, often in a fan. If the prospectors encountered ore specimens, they walked transects to define the boundaries of the scatter, narrowing the search to the most likely area. Applying the same methods used to locate gold veins, prospectors excavated groups or rows of pits and traced ore samples until they could project where the vein supposedly lay. With high hopes, the prospectors sank several prospect pits down to bedrock and chipped away at the material to expose fresh minerals.[4]

If the exposed bedrock suggested the presence of an ore body, the party of prospectors may have elected to drive either a small shaft or adit with the intent of sampling the mineral deposit at depth to confirm its continuation. After clearing away as much fractured, loose bedrock as possible with pick and shovel, a pair of prospectors would then bore blast-holes with a hammer and drill steels. They often bored between 12 and 18 holes, 18 to 24 inches deep, in a special pattern designed to maximize the force of the explosive charges they loaded. Prior to the 1880s, prospecting parties usually used blasting powder, but by the 1890s most had converted to stronger but more expensive dynamite. Until economically viable ore was proven, the operation was classified as a *prospect adit* or *prospect shaft*.

2. 3 Deep Exploration and the Development of Ore Bodies

The general methods by which engineers and miners searched for and extracted ore and equipped their mines to do so were universal throughout the West. The mines and prospects in Colorado were no exception, and they fell into several common patterns. A *prospect* differed greatly from a *mine*. A prospect was an operation in which prospectors sought ore. The associated workings ranged from shallow pits to adits or shafts with hundreds of feet of horizontal and vertical workings. A mine, by contrast, consisted of at least hundreds of feet of workings and a proven ore body. All mines began as prospect operations, and when prospectors determined the existence of ore, the activity at the mineral claim often shifted at first to quantifying how much ore existed, then to profitable extraction.

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[3] See note 2 above.
[4] See note 2 above.

In efforts to address the two production issues above, mining companies hired crews of miners who proceeded to enlarge the small adit or shaft and systematically block out the mineral body. Generally miners and engineers classified ore bodies into one of two forms; either as a *vein*, or massive and globular. Typically, gold and tungsten tended to be deposited in veins, while industrial metals such as copper and iron were deposited in massive form. Silver and other industrial metals such as lead and zinc occurred in several forms including veins, massive bodies, as well as what were known as chimneys. At the point where a tunnel or shaft penetrated the mineral body, miners *developed* the body with internal workings consisting of *drifts* driven along the vein, *crosscuts* extending 90 degrees across the vein, internal shafts known as *winzes* which dropped down from the tunnel floor, and internal shafts known as *raises* which went up. Drifts and crosscuts explored the length and width of the ore, and raises and winzes explored its height and depth.

Miners and prospectors consciously sank a shaft or drove an adit in response to fundamental criteria. A shaft was easiest and less costly to keep open against fractured and weak ground, and it permitted miners to stay in close contact with an ore body as they pursued it to depth. A shaft also lent itself well to driving a latticework of drifts, crosscuts, raises, and winzes to explore and block out an ore body.

Mining engineers distinguished between vertical and inclined shafts. One contingent of engineers preferred inclined shafts because, as they pointed out, mineral bodies, especially veins and coal seams, were rarely vertical and instead descended at an angle. In addition, inclined shafts needed smaller, less expensive hoists than those used for vertical shafts. The other camp of engineers, however, claimed that vertical shafts were best because maintenance and upkeep on them cost less. Vertical shafts had to be timbered merely to resist swelling of the walls, while timbering in inclines had to also support the ceiling, which was more expensive, especially when the passage penetrated weak ground. These engineers also argued that inclined shafts consumed money, as they required a weight-bearing track for the hoist vehicle, as well as needing maintenance (such as replacing rotten timbers and corroded rails.)

An adit or tunnel, by contrast, was easier and faster to drive and required significantly less capital than a shaft. Some mining engineers determined that the cost of drilling and blasting a shaft was as much as three times more than driving an adit or tunnel. Prospectors and mining engineers alike understood that adits and tunnels were self-draining, they required no hoisting equipment, and transporting rock out and materials into the mine was easier. However, adits and tunnels were not well suited for developing deep ore bodies because interior hoisting and ore-transfer stations had to be blasted out, which proved costly and created traffic congestion. One other problem, significant where the rock was weak, lay in the enormous cost of timbering the passages against cave-in. While the exact differentiation between a tunnel and an adit is somewhat nebulous, mining engineers and self-made mining men have referred to narrow and low tunnels with limited space and length as *adits*. Passages wide enough to permit incoming miners to pass outgoing ore cars, high enough to accommodate air and water plumbing suspended from the ceiling, and extending into substantial workings have been loosely referred to as *tunnels*.[5]

Despite the hypothetical advantages of shafts and adits, in some cases factors beyond the control of miners or engineers governed the actual choice. Geology proved to be a deciding criterion; steep hillsides, deep canyons, and gently pitching ore bodies lent themselves well to exploration and extraction through adits. In many cases prospectors who had located an outcrop of ore high on a hillside elected to drive an adit from a point considerably down slope to intersect the formation at depth, and if the ore body proved economical, then the mining company carried out extraction through the adit.[6]

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[5] Twitty, *Reading the Ruins,* 30.

[6] Colliery Engineer Co., *Coal & Metal Miners' Pocketbook*, 1893, 257; Int. Textbook Co., *Preliminary Operations,* A40: 8.

One additional, significant factor influenced the decision to sink a shaft instead of driving an adit. Historians of the West aptly characterized intense mineral rushes as frenzies of prospectors who blanketed the surrounding territory with claims. In most districts the recognized hardrock claim was 1,500 feet long and 500 to 600 feet wide, which left limited work space both above and below ground. A shaft was the only means to pursue a deep ore body within the confines of such a claim.[7]

3. The Mine Surface Plant

Driving underground workings in mines and deep prospect operations required support from on-site facilities. Known among miners and engineers as the *surface plant*, these facilities were equipped to meet the needs of the work underground. Large, productive mines boasted sizable surface plants while small prospect operations tended to have simple facilities. Regardless of whether the operation was small or large, the surface plant had to meet five fundamental needs. First, the plant had to provide a stable and unobstructed entry into the underground workings. Second, it had to include a facility for tool and equipment maintenance and fabrication. Third, the plant had to allow for the transportation of materials into and waste rock out of the underground workings. Fourth, the workings had to be ventilated, and fifth, the plant had to facilitate the storage of up to hundreds of thousands of tons of waste rock generated during underground development, often within the boundaries of the mineral claim. Generally, productive mines, as well as complex and deep prospects, had needs in addition to the above basic five requirements, and their surface plants included the necessary associated components.[8]

Open-pit mines had similar needs to underground operations, but because miners worked on the surface, the surface plants lacked some facilities such as ventilation. Transportation systems had to facilitate the movement of materials into and rock out of the surface workings, and the entry into the workings had to be unobstructed.

The basic form of a surface plant, whether haphazardly constructed by a party of inexperienced prospectors or designed by experienced mining engineers, consisted of a set of *components*. In terms of underground operations, the entry usually consisted of either a stabilized shaft collar or an adit portal. Most surface plants featured transportation arteries permitting the free movement of men and materials into and out of the underground entry. Miners moved materials at adit operations in ore cars on baby-gauge mine rail lines, while shafts required an additional hoisting system to lift vehicles out of the workings. Materials and rock at shaft mines were usually transferred into an ore car for transportation on the surface. The surface plants for all types of mines included a blacksmith shop where tools and equipment were maintained and fabricated, and large mines often had additional machining and carpentry facilities. Most of these plant components were clustered around the adit or shaft and built on cut-and-fill earthen platforms made when mine workers excavated material from the hill slope and used the fill to extend the level surface. Once enough waste rock had been extracted from the underground workings and dumped around the mouth of the mine, the facilities may have been moved onto the resultant level area. The physical size, degree of mechanization, and capital expenditure of a surface plant was relative to the constitution of the workings below ground.

In addition to differentiating between surface plants that served tunnels from those associated with shafts, mining engineers further subdivided mine facilities into two more classes. Engineers considered surface plants geared for shaft sinking, driving adits, and underground exploration to be different from those designed to facilitate ore production. Engineers referred to exploration facilities as *temporary-class plants*, and as *sinking-class plants* when associated with shafts. Such facilities were by nature small, labor-intensive, energy inefficient,

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[7] *Morrison's Mining Rights*, 1899, 17, 20; Peele, *Mining Engineer's Handbook*, 1474.
[8] Twitty, *Reading the Ruins*, 27.

and most important, they required little capital. *Production-class plants* on the other hand usually represented long-term investment and were intended to maximize production while minimizing operating costs such as labor, maintenance, and energy consumption. Such facilities emphasized capital-intensive mechanization, engineering, planning, and scientific calculation.

Mines underwent an evolutionary process in which the discovery of ore, the driving of a prospect shaft or adit, installation of a temporary plant, upgrade to a production plant, and eventual abandonment of the property all were points along a spectrum. Depending on whether prospectors or a mining company found ore and how much, a mine could have been abandoned at any stage of evolution. Engineers and mining companies usually took a cautionary, pragmatic approach when upgrading a sinking plant to a production plant. Until significant ore reserves had been proven, most mining companies minimized their outlay of capital by installing inexpensive machines adequate only for meeting immediate needs.

Mining engineers understood that temporary plants consisted of light-duty, inexpensive, and impermanent components and classified them by their size, energy efficiency, performance, and purchase price. Machine foundations also fell under this classification. Because of low cost, ease of erection, and a brief serviceable life, timber and hewn-log machine foundations were strictly temporary, while production-class foundations consisted of concrete or masonry. The structure of wooden foundations usually consisted of cribbing, a framed cube, or a frame fastened to a pallet, all of which were assembled with bolts and iron pins, and buried in waste rock for stability and immobility. The construction and classification of machine foundations is of particular importance because they often constitute principal evidence capable of conveying the composition of the surface plant.[9]

3.1 Surface Plants for Adits

The surface plants for adits and shafts shared many of the same components. Yet, because of the fundamental differences between the two types of mines, the layout patterns and characteristic for each were different. Following is a list and description of the principal components found at most adit operations, and since adit operations and open-pit mines had similar needs, the descriptions apply to open-pit mines.

3.1.1 The Adit Portal

The adit portal was a primary component of both simple prospects as well as complex, profitable mines. Professionally trained mining engineers recognized a difference between prospect adits and production-class tunnels. Height and width were the primary defining criteria. A production-class tunnel was wide enough to permit an outgoing ore car to pass an in-going miner, and headroom had to be ample enough to house compressed-air lines and ventilation tubing. During the latter portion of the Gilded Age (defined here as from the 1870s until the 1910s), some mining engineers defined production-class tunnels as being at least 3½ to 4 feet wide and 6 to 6½ feet high. Anything smaller, they claimed, was merely a prospect adit.[10]

Mining engineers paid due attention to the adit portal because it guarded against cave-ins of loose rock and soil. Engineers recognized *cap-and-post timber sets* to be best suited for supporting both the portal and areas of fractured rock further in the adit. This ubiquitous means of support consisted of two upright posts and a cross-member, which mine workers fitted together with precision using measuring rules and carpentry tools. They cut square notches into the cap member, nailed it onto the tops of the posts, and raised the set into place. Afterward, the miners hammered wooden wedges between the cap and the adit ceiling, and between the posts and adit walls

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[9] Ibid., 30-32.
[10] Peele, *Mining Engineer's Handbook*, 459; Young, *Elements of Mining*, 1923, 463.

to make the set weight bearing. Because the adit usually penetrated tons of loose soil and fractured rock, a series of cap-and-post sets were required to resist the heavy forces, and they had to be lined with *lagging* to fend off loose rock and earth. In areas penetrating swelling ground, the bottoms of the posts had to be secured to a floor-level crosstimber or log footer to prevent them from being pushed inward.

Wood used for the purposes of supporting wet ground decayed quickly and had to be replaced as often as several times a year and as infrequently as every few decades in dry mines. Professionally trained mining engineers claimed that dimension (milled) lumber was best for timber sets because it decayed slowly and was easy to frame, but high costs discouraged its use where hewn logs were available.[11]

3.1.2 Mine Transportation

Miners working underground generated tons of waste rock that had to be hauled out, while tools, timbers, and explosives had to be brought in. As a result, both prospect operations and large, paying mines had to rely on some form of a transportation system. The conveyances used by prospectors had to be inexpensive, adaptable to tight workings, and capable of being carried into the backcountry. To meet these needs, prospect outfits often used wheelbarrows on plank runways. A wheelbarrow cost as little as $12, it was easy to pack on a mule, and it fit into tight workings. Mining engineers recognized the functionality of wheelbarrows, but classified them as strictly serving the needs of subsurface prospecting because of their limited load capacity, awkwardness of handling, and propensity for being crushed.[12]

Outfits driving substantial underground workings required a vehicle with a greater capacity. The vehicle most mining outfits chose was the ore car, which consisted of a plate-iron body mounted on a turntable that was riveted to a rail truck. Cars were approximately 2 feet high, 4 feet long, and 2½ feet wide, they held at least a ton of rock, and they had a swing gate at the front to facilitate dumping. Further, the body pivoted on the turntable to permit the operator to deposit a load of rock on either side of or at the end of the rail line.

Ore cars ran on rails sold in a variety of standard sizes by mine-supply houses. The units of measure were based on the rail's weight-per-yard. Light-duty rail ranged from 6 to 12 pounds-per-yard, medium-duty weight rails included 12, 16, 18, and 20 pounds-per-yard, heavy mine rail weighed from 24 to 50 pounds-per-yard, and anything heavier was used for railroad lines. Prospecting outfits installing temporary plants usually purchased light-duty rail because of its transportability and low cost. Mining engineers erecting production-class transportation systems had miners lay track using at least medium-duty rail because it lasted longer.[13]

The specific type of rail system installed by a mining operation reflected the experience and judgment of the engineer or superintendent, as well as the financial status of the company, the extent of the underground workings, and whether the mine produced ore. The basic rail system used in nearly all Colorado mines was fairly simple and straightforward. The track consisted of a main rail line that extended from the areas of work underground, though the surface plants, and out to the waste-rock dump. Miners in the underground workings drilled and blasted, shoveled the resultant shot rock into an ore car, and a miner then pushed the loaded car out of the adit and onto the edge of the waste-rock dump where he discharged the car's contents. As the drilling and blasting crew advanced the adit, they laid rails in the new space to facilitate bringing the car close for loading. Productive mines and deep prospect operations usually had rail spurs extending off the main line underground to other headings in feeder drifts and crosscuts where drilling and blasting teams were at work. Spurs also branched off into stopes and ore-bin stations. Substantial mines with extensive surface plants also featured spurs off the main line on ground surface that extended to different parts of the waste-rock dump, to a storage area, and to the

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[11] Int. Textbook Co., *Preliminary Operations at Metal Mines*, A40: 42.
[12] Twitty, *Reading the Ruins*, 42.
[13] Int. Textbook Co., *Preliminary Operations*, A40: 53; Young, *Elements of Mining*, 1923, 192.

mine shop. Many large mines built special stake-side, flatbed, and latrine cars for the coordinated movement of specific materials and wastes.

Mining engineers understood that hiring miners to hand-tram single-ore cars was the most cost-effective means of transportation at small and medium-sized operations. But at large mines, where high volumes of materials had to be handled efficiently over great distances, they strongly recommended the use of ore trains pulled by a motive source greater than one or two struggling miners. Mining companies in Colorado, especially in the coal industry, often turned to the use of draft animals. As mining matured through the nineteenth century, miners learned that mules were the best animals suited for work underground because they were reliable, strong, of even temperament, and intelligent.

The electric locomotive, termed an *electric mule* by some miners, arrived in the West during the 1890s. Mining engineers working for coal mines in the East and in the Appalachians introduced the first electric locomotives in 1887 or 1888 to move the immense volumes of this fossil fuel. The early machines consisted of a trolley-car motor custom-mounted onto a steel chassis, and they took their power from overhead *trolley lines* strung along the mine's ceiling.

The spread of electric mules to Colorado proved slow. Locomotives required special mechanical and electrical engineering, which was in a nascent state during the 1890s and 1900s. In addition, electric mules were too big for the tortuous drifts typical of most metal mines, and they required considerable capital to purchase, install, and operate. During the first decade of the twentieth century, the electrical system necessary to power a locomotive included a steam engine, a generator, electrical circuitry, plumbing for the engine, installation, and an enclosing building. The system alone cost around $3,100, and a small locomotive cost an additional $1,500. Further, an electric locomotive cost approximately $7.50 per day to operate. A mule, on the other hand, cost only $150 to $300 to purchase and house, and between $.60 and $1.25 to feed and care for per day.[14]

Upgrades to the rail line necessary to accommodate a heavy locomotive presented the engineer with additional costs. Mules were able to draw between three and five ore cars that weighed approximately 2,500 pounds each, and for this 16 pound rails spiked at an 18-inch gauge proved adequate. But electric locomotives and their associated ore trains usually weighed dozens of tons, and as a result they required broad tracks consisting of heavier rail. Mining engineers recommended that at least 20 pound rail spiked 24 inches apart on ties spaced every two feet be laid for small to medium-sized locomotives. Heavy locomotives required rail up to 40 pounds per yard spiked at 36-inch gauge. The reason for the heavy rails and closely spaced ties was that the heavy machines pressed down on the rail line and perpetually worked uphill against the downward-flexed rails. This wasted much of the locomotive's power and energy, and engineers sought to minimize the sag with stiff rails on a sound foundation of closely spaced ties.[15]

Some academic mining engineers criticized the fact that electric locomotives were tied to the fixed route defined by the trolley wires. To remedy this problem, electric machinery makers introduced the storage battery locomotive around 1900, which had free reign of the mine's rail lines. Despite its independence, very few Colorado mining companies employed battery-powered locomotives because they were costly and required a recharging facility. In general, electric locomotives required wide tunnels, and because they had long wheel-bases and ran on broad-gauge track, they were unable to negotiate the tight corners typical of Western hardrock mines. While the mighty machines were able to pull significant numbers of loaded cars and increase a mining company's economy of scale, the physical limitations presented by locomotives required engineers to virtually preplan

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[14] General Electric Co., *Electric Mine Locomotives*, 23; Peele, *Mining Engineer's Handbook*, 862, 871.

[15] Colliery Engineer Co., *Coal Miners' Pocketbook*, 767; Int. Textbook Co., *Hoisting, Haulage, Mine Drainage*, A55:6; Int. Textbook Co., *Rock Boring, Rock Drilling*, A48: 2; Int. Textbook Co., *Mine Haulage*, 1; Young, *Elements of Mining*, 1923, 192.

expansive underground workings with broad curves, side tracks, and areas to turn the locomotive around. While such efforts were conducive for, even typical of, coal mining, they were not appropriate for the piecemeal work endemic to Western hardrock mining.

A few prominent academic mining engineers espoused the compressed-air locomotive, which saw limited use in Colorado beginning in the 1890s. This interesting contraption consisted of a compressed-air tank fastened to a miniature steam locomotive chassis. The locomotives were able to negotiate tight passageways, had plenty of motive power, spread fresh air wherever they went, and did not require complex electrical circuitry. Some of the machines were even able to operate on the ubiquitous 18-inch rail gauge. However, compressed-air locomotives were not inexpensive, costing as much as their electric cousins, and required a costly compressor capable of delivering air at pressures of 700 to 1000 pounds per square inch.

During the Great Depression, greater numbers of well-financed mining companies relied on mechanical locomotives in hopes of producing ore in the high volumes necessary to make a profit at that time, while many outfits working medium-sized mines continued the tradition of employing mules. For mining companies with capital, electric trolley locomotives remained popular while compressed-air and battery-powered locomotives saw increased use. For Colorado's small mines, locomotives and the necessary improvements to the rail lines were well beyond their financial means. These companies continued the age-old method of hand labor to move cars. During the capital-scarce times of the Depression, these outfits constructed rail lines out of whatever rails and ties they were able to salvage. They straightened bent rails, used large nails instead of proper rail spikes, and fashioned ties from a variety of pieces of lumber. To save materials, impoverished mining outfits spaced the ties far apart, spliced rails of varying lengths and weights into a single line, and broke connector plates that usually featured four bolt holes in two to make them join twice as many rails.

3.1.3 The Mine Shop

Every prospect operation and paying mine required the services of a blacksmith who maintained and fabricated equipment, tools, and hardware. The common rate for driving an adit with hand-drills and dynamite in hard rock was approximately one to three feet per 10-hour shift. Over the course of such a day, miners drilled numerous blast-holes and blunted drill steels in substantial quantities. For this reason, the blacksmith's primary duty was to sharpen the steels.[16]

To permit the blacksmith to work in foul weather, mining companies erected buildings to shelter the shop (Fig. E.II.7). The shop structure tended to be small, simple, and rough, and operations lacking capital often relied on local building materials such as hewn logs or dry-laid rock masonry. Prospecting and mining outfits almost invariably located the blacksmith shop adjacent to the adit portal to minimize handling heavy batches of dull drill steels.

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[16] Hoover, *Principles of Mining*, 150; Int. Textbook Co., *Rock Boring, Rock Drilling*, A48: 13; Peele, *Mining Engineer's Handbook*, 184; Young, *Elements of Mining*, 1946, 87.

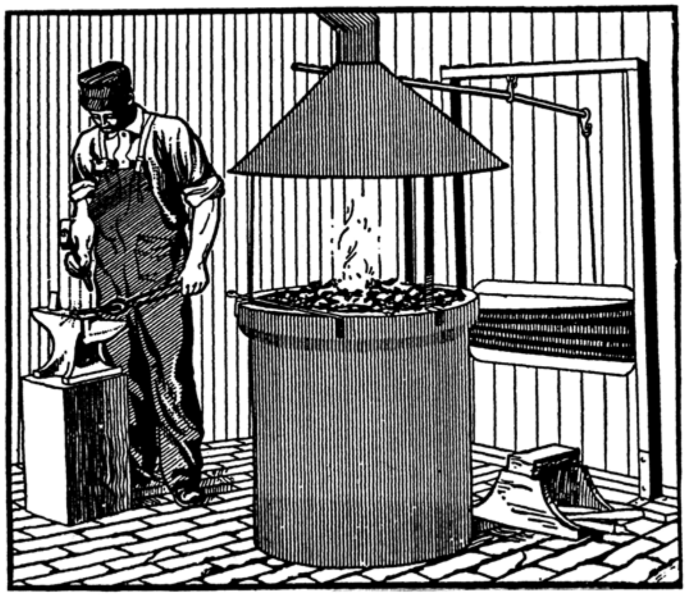

Fig. E.II.7 A typical blacksmith shop built by prospect operations. The shop was austere, features simple appliances, and could only accommodate basic work. Prospect outfits, however, tended to use free-standing pan forges, or those illustrated below. Small, poorly capitalized mining outfits also erected such shops. Drew, *Farm Blacksmithing*, 1.

Blacksmiths at small operations required few tools and much skill for their work. A typical basic field shop associated with prospect operations consisted of a forge, bellows or blower, anvil, anvil block, quenching tank, several hammers, tongs, a swage, a cutter, a chisel, a hacksaw, snips, a small drill, a workbench, iron stock, hardware, and basic woodworking tools. Prior to the 1910s, some mining outfits working deep in the backcountry far from commercial centers dispensed with factory-made forges, both to save money and because they were cumbersome to pack, and used local building materials to make a vernacular forge. The most popular type of custom-made forge consisted of a gravel-filled dry-laid rock enclosure usually 3 by 3 feet in area and 2 feet high (Fig.E.II.8).

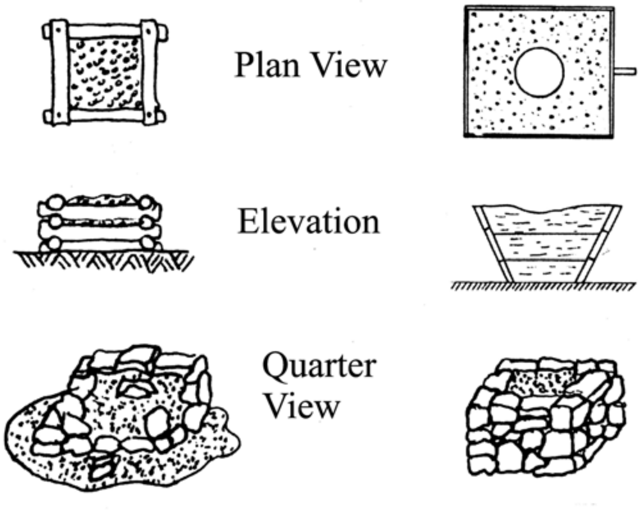

Fig. E.II.8 Forges typical of those used in mine and prospect shops. Upper left is a gravel-filled log forge, upper right is a gravel-filled wooden box forge, and lower right is a gravel-filled rock forge. Over time, rock forges decayed and collapsed, manifesting as the structure at lower left. Twitty, *Riches to Rust*, 42.

Miners working in forested regions substituted small hewn log walls for rock. A tuyere, often made of a two-foot length of pipe with a hole punched through the side, was carefully embedded in the gravel, and its function was to direct the air blast from the blower or bellows upward into the fire in the forge.[17]

The shops that served prospect operations were inadequate to handle the materials of larger, productive mines. The size of a shop and its appliances were functions of capital, levels of ore production, and the era during which it was built. The shops at small mines typically featured a forge and blower in one corner of the structure, an anvil and quenching tank next to the forge, a workbench with a vice located along one of the walls, and a lathe and drill-press. Rarely did shops at small mines include power appliances; instead, most of these shops were equipped with manually operated machinery.

A greater availability and affordability of steam engines, air compressors, and electricity during the 1890s brought power appliances within reach of modestly funded mining operations. Typical shops at medium-sized hardrock mines featured traditional labor-intensive facilities occasionally augmented with between one and several power appliances. Such shops were equipped with at least one forge, an accompanying blower, an anvil, a quenching tank, two stout workbenches, a lathe, a drill-press, and an array of machine and carpentry tools. Because medium-sized mines had materials handling needs exceeding those at small mines, associated forges were typically either a 4 by 4 foot free-standing iron pan model, a gravel-filled iron tank 4 feet in diameter and 2 feet high, or a 3 by 3 foot gravel-filled wooden box. Blacksmiths often lined their pan forges with firebricks and poured a thin cap of grout over their tank and box forges, which provided a sound bed for the fuel, focused the flow of oxygen toward the fire, and facilitated removal of residue and clinker. The lathes and drill-presses may have been power driven at mines in developed mining districts, and manually powered at remote mines. In

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[17] Twitty, *Reading the Ruins*, 45.

addition to the above appliances, many shops at large mines were also equipped with a mechanical saw, a grinder, and a pipe threader, which may have been power driven.[18]

The physical composure of a shop building reflected the financial state of a mining company. Outfits with limited financing used local building materials, while well-capitalized mining companies with access to commercial centers often erected frame buildings. One trait shared by most shops was the use of windows to afford natural light to permit the blacksmith to see what he was doing through the smoke and soot. Due to the risk of fire started by loose embers, the floors of most blacksmith shops were earthen. The blacksmith arranged the shop interior to suit the cramped space, usually scattering his tools on the workbench and forge, arranging iron stock and hardware inside and outside the shop building, and his coal either in a sack or wooden box near the forge.

At large, substantial mines, the primary function of shop laborers continued to be drill-steel sharpening (Fig. E.II.9).

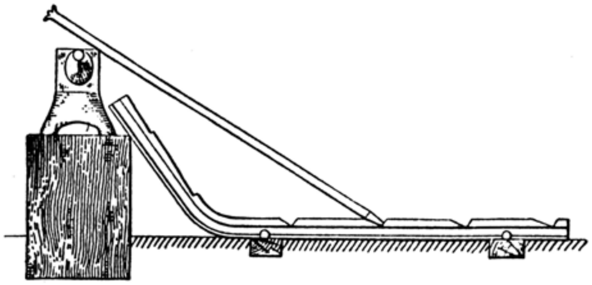

Fig E.II.9 A backing block. This was used to brace hot drill steels during sharpening. The item at left is an anvil on a timber block. Backing blocks were embedded in the shop floor adjacent to the forge, and were used in conjunction with steels for rockdrills. *E & M J, Details of Practical Mining,* 1916, 14.

But the mechanization of mining during the 1890s required the sooty blacksmiths to change their sharpening methods, as well as their materials handling processes. The most significant changes came about as a result of the widespread embrace of compressed-air powered rockdrills to bore blast-holes underground. While the machines proved to be a mixed blessing for their operators, generating silicosis-causing rock dust and being difficult to handle, they were a boon for shop workers. The noisy and greasy machines produced high volumes of dulled steels and broken fittings. Contrary to today's popular misconceptions, rockdrills replaced hand-drilling wholesale in Western mines by the late 1910s, and not earlier, as supposed. The conversion evolved over the course of 30 years, progressing more rapidly among well-financed mining companies than at small operations. During the conversion period, blacksmiths became proficient in sharpening both hand steels and machine drill steels, each of which had specific requirements.[19]

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[18] Ibid., 65.
[19] Int. Textbook Co., *Mine Haulage*, A24: 1.

The large volume of dull rockdrill steels, machine repair work, and the manufacture of fittings constituted a heavy workload for shop workers. In an effort to facilitate the completion of projects in a timely manner, mining companies usually hired a blacksmith and a helper for metalwork, and a carpenter and another assistant for woodwork. In terms of metalworking, the blacksmith's helper proved to be particularly important. Blacksmiths traditionally sharpened hand steels alone because the implements were relatively short, light, and easily managed. This was not the case with machine drill steels, which were heavy and up to eight feet long.[20]

In the first decade of the twentieth century, the largest of Colorado's companies attempted to mechanize the sharpening process with compressed-air-powered drill-steel sharpening machines, which had just been released onto the market. The early drill-steel sharpeners, similar in appearance to large horizontal lathes, consisted of a cradle approximately eight feet long and a tall sharpening mechanism that stood on several legs bolted to a substantial foundation. Leading rockdrill makers introduced competing units during the early 1910s that had abandoned the lathe-like form and stood on a cast-iron pedestal bolted to a timber foundation. The net result was a reduction in the amount of floor space they occupied, from at least 10 by 2 feet in area to between 5 by 2 feet and 2.5 by 2.5 feet.

The reduction of size and price of the new drill-steel sharpeners, and their ease of use, made them attractive to a broad spectrum of medium-sized and large mines. Both moderate and well-financed mining companies with an expectation of longevity installed the improved drill-steel sharpeners with increased frequency through the 1910s. Most small mining companies with limited funds, on the other hand, did not purchase drill-steel sharpeners because such outfits lacked available capital, their miners were unlikely to generate enough dull steels to justify the expense, and they did not possess adequate air compressors. Instead, they relied on traditional forge sharpening methods.

Particularly large and highly profitable mining companies, usually backed by significant capital, were able to afford the costs associated with building highly mechanized and heavily equipped shops. Progressive mining engineers and shop superintendents suggested that shop facilities be arranged according to the stages drill steels underwent during sharpening. The bulk of the appliances, according to the engineers, should have been in order of: a forge, drill-steel sharpener, another forge for tempering, quenching tank, grinder, and finally, a finished drill-steel rack. Such an arrangement of shop appliances required a spacious building, at least 50 by 30 feet in area, and particularly large shops included multiple sharpening circuits. These shops were also equipped for heavy machine work, and in accordance they featured power appliances, a mine rail line running through the interior, and one to several small boom derricks for moving heavy items.[21]

Mining engineers and shop superintendents at large mining operations also installed power hammers to permit a single blacksmith to do some types of fabrication work that usually required a team of two. Shop superintendents overseeing the best mines installed factory-made steam or compressed-air-powered models, which consisted of a heavy plate iron table fixed to the top of a cast-iron pedestal, and a piston hammer that pounded items with tremendous force. These hammers were expensive to purchase and transport, occupied the same area as a drill-steel sharpener, and weighed several tons. Many engineers were unwilling to spend the considerable quantities of capital required, even though they recognized the usefulness of such a power appliance. The alternative they employed consisted of affixing a heavily worn but operational rockdrill onto a stout vertical timber. The old drill stood over a plate iron table fastened onto the top of a truncated timber post often 1 to 2 feet high, and when a shop worker threw the air valve open, the drill's chuck rapidly tapped the iron table.[22]

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[20] Twitty, *Reading the Ruins*, 66.
[21] Ibid., 76.
[22] Ibid., 77.

3.1.4 Mine Ventilation

The use of explosives for blasting, open-flame lights, the respiration of laboring miners, and natural gases in coal mines turned the atmosphere in underground workings into an intolerably stifling and even poisonous environment. Ventilating mine workings was not an easy proposition, but it was necessary. Many mining outfits completely ignored the problem until the workings attained significant length, and even then efforts were feeble at best. Mining engineers approached the ventilation problem by relying on one or a combination of two basic systems. The first, *passive ventilation*, relied on natural air currents to remove foul air, but it proved marginal to ineffective in dead-end workings. *Mechanically assisted systems,* the second, were expensive and intended for production-class plants. As a result they were rarely used at prospect adits.

Some prospecting outfits employed several variations of ventilation systems that cleverly combined passive and mechanical means. One of the simplest semi-mechanical ventilation systems consisted of a canvas windsock fastened to a wooden pole. The windsock collected air wafted by breezes and directed it through either canvas tubing or stovepipes into the underground workings. The obvious drawback to the system was poor performance on calm days. Prospecting outfits employed another semi-mechanical system in which they linked the air intake on a stove or furnace to tubing ducted into the workings. A surface worker stoked a fire in the stove, which drew foul air out of the underground through the ducting.[23]

A few prospecting operations attempted to employ primitive mechanical systems for ventilation. These outfits installed large forge bellows and small hand-turned blowers at the mouths of adits and shafts, and used stovepipes or canvas tubing to duct the air into the workings. Bellows effectively ventilated shallow workings, but they lacked the pressure to clear gases out of relatively deep adits and shafts. Hand-turned blowers cost more money and took greater effort to pack to a prospect operation, but they forced foul air much more surely from workings.

The simple windsocks and hand-turned mechanical blowers that worked for prospect operations were not effective for the workings comprising medium-sized and large mines. Mining engineers applied several better methods for providing the miners with fresh air. One of the most popular systems involved an *incast* air current balanced by an *outcast* current laden with the bad air. Multiple mine openings proved to be the most effective means of achieving a flushing current, and temperature and pressure differentials acted as the driving forces that moved the air.[24]

Mechanical ventilation proved to be more effective, but also much more expensive. One of the most popular and effective approaches for ventilating deep workings lay with power-driven fans and blowers (Fig E.II.10).

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[23] Ibid., 51.

[24] Int. Textbook Co., *A Textbook on Metal Mining*, A41: 133; Int. Textbook Co., *Coal and Metal Miners' Pocket Book*, 381; Lewis, *Elements of Mining*, 1946, 454; Peele, *Mining Engineer's Handbook*, 1038; Young, *Elements of Mining*, 1923, 255.

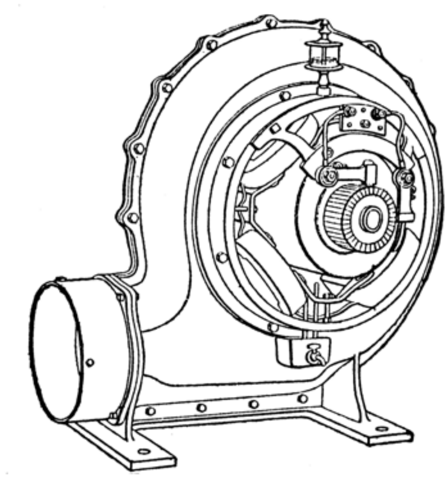

Fig. E.II.10 A common type of ventilation blower used to force fresh air underground. Ducting was fastened to the nozzle at left. The machines were usually driven by a belt. Int. Textbook Co., *Steam and Steam-Boilers*, A41: 46.

Mining machinery manufacturers offered engineers three basic varieties of blowers in a multitude of sizes. Engineers termed the first design, which dates back to the 1870s, the *centrifugal fan*, and miners knew it as the *squirrel cage fan* This machine consisted of a ring of vanes fixed to a central axle, much like a steamboat paddle wheel, enclosed in a shroud. The fan, turning at a high speed, drew air in through an opening around the axle and blew it through a port extending out of the shroud. Manufacturers produced centrifugal fans in sizes ranging from one to over ten feet in diameter. The small units were employed for both mining and a variety of other purposes such as ventilating industrial structures, and the largest units saw extensive application in coal mines.

A variety of foundation types can be found (Fig.E.II.11, Fig E.II.12.)

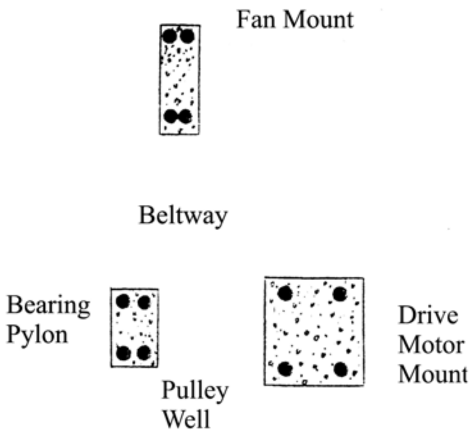

Fig. E.II.11 Foundations commonly left from ventilation blowers and their drive motors. The blower in Fig.E.II.10 was probably anchored to such a foundation. Twitty, *Riches to Rust*, 80.

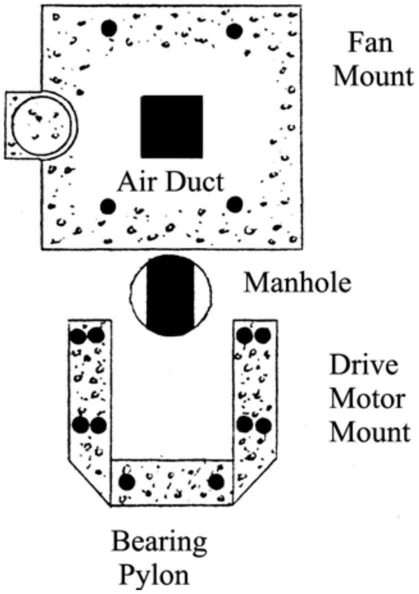

Fig. E.II.12 A foundation for a belt-driven ventilation blower. The fan forced fresh air into the port in the foundation at top, which led to ducting for the mine. Twitty, *Riches to Rust,* 272.

The second type of fan also acted on centrifugal principles, but it consisted of a narrow ring of long vanes encased within a curvaceous cast-iron housing. The *propeller fan,* the third type of blower, was similar to the modern household fan, and it too was enclosed in a shroud.

3.2 Surface Plants for Shafts

The surface plants that supported work in shafts incorporated many of the same components as those associated with adit mines. However, due to the vertical nature of shafts, the surface plant also necessarily included a hoisting system, which engendered specific engineering needs. Typical hoisting systems installed by operations in Colorado consisted of a hoist, a headframe, a power source, and a hoisting vehicle. The components of a hoisting system shared fundamental relationships with each other, and they interfaced with the other facilities comprising the surface plant. For example, the type of hoist an engineer selected influenced the type of headframe, the power source, and the transportation system he subsequently installed. Yet, the greatest factors that overshadowed the types of plant facilities an engineer installed included the financial state of the mining company, the operation's physical accessibility, and the quantity of proven ore (Fig. E.II.13, Fig. E.II.14, Fig. E.II.15). The following section discusses the variety of the hoisting systems employed during the nineteenth century until around 1960.

Fig. E.II.13 The C.O.D. Mine, Cripple Creek, during the mid-1890s. This is an example of a typical shaft house for a small, productive mine. The headframe stood underneath the building's high point and the smokestack denotes the location of the hoist. Note the mine rail line exiting the broad doorway. The shaft house also probably enclosed a blacksmith shop and an area where miners dressed timbers. A stack of cordwood in the background served as boiler fuel, and an office and storehouse stands at right. Colorado Historical Society, F-44120.

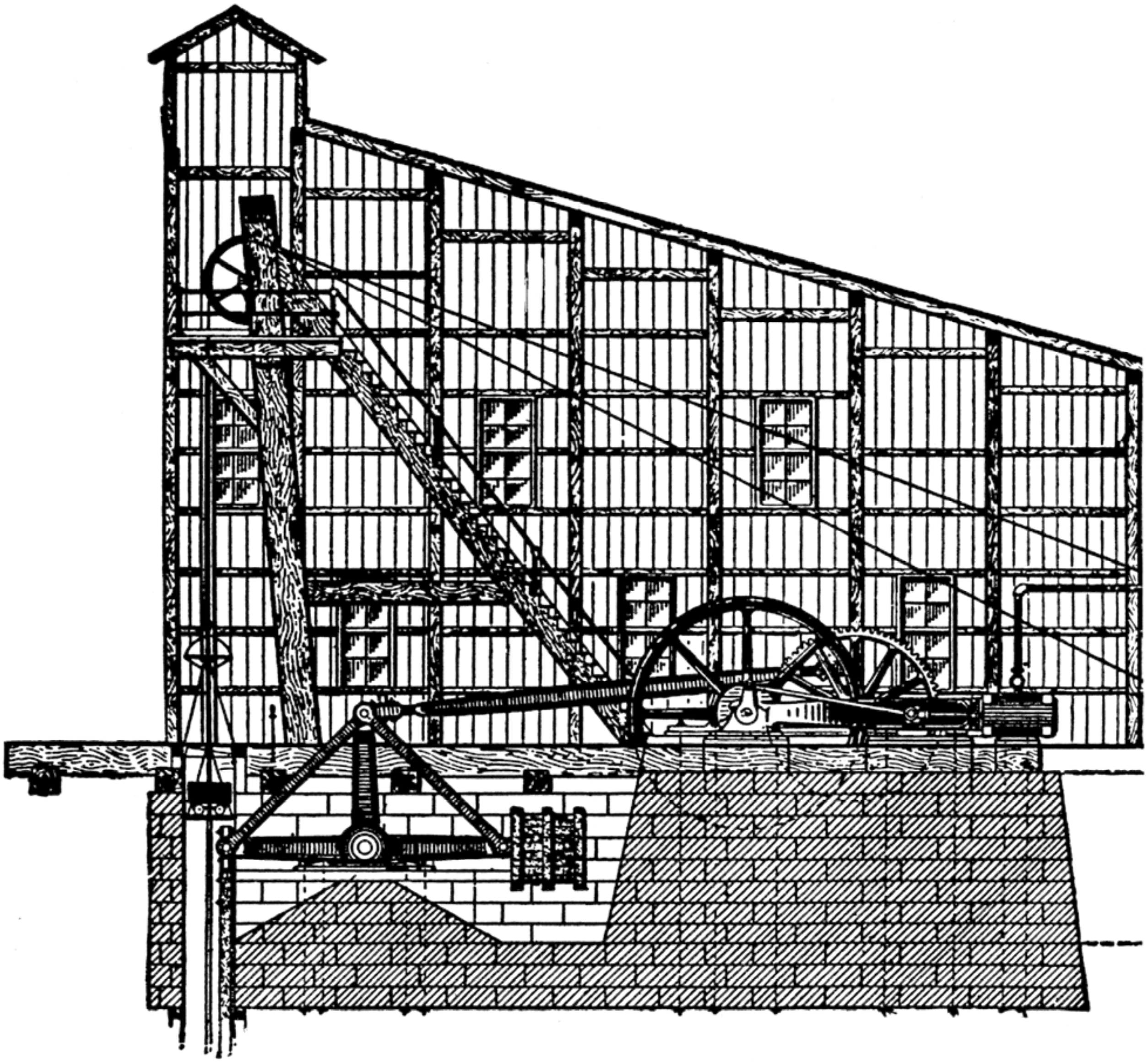

Fig. E.II.14 Cross section of a lofty shaft house for an advanced, heavily equipped mine characteristic of the 1870s and 1880s. A massive double-drum hoist anchored to a masonry foundation is at right, and a headframe stands over the shaft at left. Cages hang from cables in the shaft, and the mechanism adjacent is a Cornish pump, which saw limited application in Colorado. The pump consists of a beam that pivoted at center and an assemblage of solid shafts extending down the shaft to plungers. A counterweight at right balanced the weight of the shaft assemblage. Int. Textbook Co., *Steam and Steam-Boilers*, A42:3.

Fig. E.II.15 Surface plant components at the Joe Dandy Mine, Cripple Creek. The surface plant components of large mines were often housed in individual buildings. This practice had extended to most smaller shaft mines by the 1910s when the U.S. Bureau of Mines outlawed shaft houses. The headframe (a four-post derrick), stands in the open and denotes the shaft. A hoist house enclosed the hoist and a workshop. It stands at lower right. A blacksmith and machine shop is visible slightly above the hoist house, and an ore-sorting house is left of the headframe. Note the trestle linking the ore-sorting house and second landing in the headframe. Eric Twitty, taken 1998.

3.2.1 Shaft Form and Hoisting Vehicles

Experienced prospectors and mining engineers recognized that crude prospect shafts were inadequate for anything other than a cursory examination of the geology underground. In instances where a prospecting outfit strongly suspected or had confirmed the existence of ore, they sank a better, more formal shaft that was conducive to deep exploration and even, the outfit hoped, ore production. Between the 1880s and 1920s, mining engineers were critical toward distinguishing between temporary-class shafts and production-class shafts.

Engineers understood that the size of a shaft directly influenced a mine's level of production. Small shafts limited the quantity of ore that could have been hauled out per vehicle trip, and large shafts facilitated economies of scale. Temporary-class shafts, used for prospecting, often featured one large compartment 3½ by 7 feet in-the-clear or less.

During the 1880s, engineers established a standard for the composition of production-class shafts. The convention dictated the division of production-class shafts into a *hoisting compartment* and *manway*, also known as a *utility compartment*, and feature timbering to support guide rails for the hoisting vehicle. Further, mining engineers defined production-class shafts as needing to have a hoisting compartment at a minimum 4 by 4 feet in-the-clear. By the late nineteenth century the definition expanded as a result of the introduction of larger hoisting vehicles. Mining engineers felt that a 4 by 5 foot hoisting compartment was better suited for ore production, and 5 by 7 feet was best because it facilitated large loads.[25]

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[25] Eaton, *Practical Mine Development*, 13; Int. Textbook Co., *Coal and Metal Miners' Pocket Book*, 261; Peele, *Mining Engineer's Handbook*, 251; Young, *Elements of Mining*, 1923, 171, 461.

Mining engineers also came to recognize the utility of balanced hoisting. The use of one hoisting vehicle to raise ore became known as *unbalanced hoisting*, and while this system was very inefficient in terms of production capacity and energy consumption, it was the least costly to install. *Balanced hoisting* relied on the use of two shaft vehicles counterweighing each other, so that as one vehicle rose the other descended. The use of two hoisting vehicles required a shaft featuring two hoisting compartments and a double-drum hoist, which constituted a considerable expense. But the hoist only had to do the work of lifting the ore, and as a result this system was energy efficient and provided long-term savings. Wealthy companies, anticipating production over an extended period of time, spared the expense and installed balanced systems.

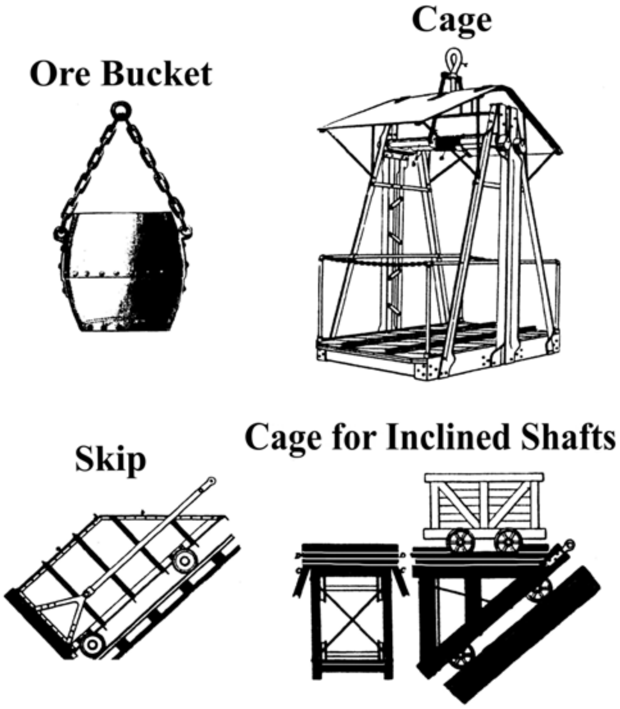

Fig. E.II.16 Types of hoisting vehicles in shafts. The sinking ore bucket at upper left required no guides and was common among small operations. The cage at upper right ran on guide rails and carried workers or an ore car. The skip at lower left was used in vertical and inclined shafts, ran on guide rails, and required guides in the headframe to empty. On the lower right is a cage for inclined shafts. Modified from Ingersoll Rock Drill Co., *Rock Drills*, 64; Int. Textbook Co., *Hoisting, Haulage, Mine Drainage*, A53: 9; Int. Textbook Co., *Steam and Steam-Boilers*, A23: 79, 87.

Mining companies in Colorado used four types of hoisting vehicles. The first was the *ore bucket*, the second was the *cage*, the third was the *skip* (Fig E.II.16). The last was the ore bucket (skip or cage) and crosshead.

The ore bucket, or sinking bucket, found great favor with prospect operations because its shape and features were well suited for the primitive conditions typical of mines under development. Ore buckets consisted of a body with convex sides that prevented the rim from catching on obstructions such as timbers, and permitted the vessel to be able to glance off the shaft walls while being raised. Manufacturers forged a loop into the bail to hold the hoist cable on center, and the bottom of the bucket featured a ring so the vessel could be upended once it had reached the surface.

A mining industry institution for over 100 years, the cage consisted of a steel frame fitted with flooring for crews of miners and rails to accommodate an ore car. Nearly all cages used in Colorado featured a stout cable attachment at top, a bonnet to fend off falling debris, and steel guides that ran on special fine-grained 4x4 inch hardwood rails. After a number of grizzly accidents in which hoist cables parted, mining machinery makers installed special safety-dogs on cages designed to stop an undesired descent. Usually the dogs consisted of toothed cams that were controlled by springs kept taught by the weight of the suspended cage. If the cable broke, the springs retracted, closing the cams onto the wood rails.

Cages proved to be highly economical because mining companies did not have to spend time transferring ore and waste rock between various vehicles. A miner or trammer underground merely had to push on an ore car and another worker retrieved it at the surface. But cages presented mining companies with several drawbacks. One of the biggest problems lay in drilling and blasting a shaft that not only possessed enough space in-the-clear to make way for the cage, but one that was large enough to accommodate the timbering that anchored the guide rails.

Cornish mining engineers originally developed the skip for haulage in the inclined shafts of Michigan copper mines during the 1840s and 1850s, and they became popular in Colorado’s coal mines. The typical skip consisted of a large iron or wood box on wheels that ran on a mine rail line. Skips had little dead-weight, they held much ore, coal, or waste rock, and because they ran on rails, they could have been raised quickly.

During the 1890s, mining engineers began to recognize the skip as being superior to the cage for ore production in vertical shafts. Skips were lighter than cages because they did not have the combined dead-weight of the vehicle and an ore car, and the reduced weight resulted in energy savings. Skips also offered the benefit of being quickly filled and emptied, resulting in a rapid turnover of rock. Shortly after the turn –of –the century, large Western mining companies began replacing cages with skips for use in vertical shafts. The change proceeded slowly through the 1900s, and accelerated rapidly during the 1910s, so that by the 1930s, most large and many medium-sized mines were using skips.

Mining companies engaged in deep shaft sinking took great risks when they used ore buckets. To prevent the bucket from swinging and catching on the shaft walls, emptying its contents onto the miners below, some mining companies installed a hybrid hoist vehicle that consisted of an ore bucket suspended from a frame that ran on guide rails bolted the length of the shaft. The frame, known as a *crosshead*, held the ore bucket steady and provided miners with a platform to stand on, albeit dubious, during their ascents and descents in the shaft. The advantage of using a crosshead was that miners working underground were able to switch empty buckets with full ones, and the system was easily adaptable to a cage or skip at a later point. Many small, poorly financed, and marginally productive mining companies in remote locations favored this type of hoisting vehicle. (In any form, mining engineers considered ore buckets as temporary-class hoisting vehicles.)

3.2.2 Hoists

When prospectors and mining companies decided to sink a shaft to explore a mineral body at depth, they were forced to install a hoisting system to permit vertical work. Like other surface plant components, hoists came in a wide range of sizes, types, and duties suited for prospecting and ore extraction. Hoists designed for prospecting adhered to *sinking-class* characteristics, and hoists intended for ore production adhered to *production-class* characteristics (Table E.II.1).

Table E.II.1: General Hoist Specifications: *Type, Duty, Foundation*

Hoist Type	Hoist Class	Foundation Size	Foundation Footprint	Foundation Profile	Foundation Material
Hand Windlass	Shallow Sinking		Rectangular	Wood frame over shaft	Timber
Hand Winch	Shallow Sinking	3x3 ft.	Square or Rectangular	Flat	Timber
Horse Whim: Malacate	Shallow Sinking	7 to 10 ft. Diameter	Ovoid Depression	Cable Reel Axle Located in Pit	Timber
Horse Whim: Horizontal Reel	Sinking	4x4 ft.	Rectangular	Timber Footers in Depression	Timber
Horse Whim: Geared	Sinking	4x4 ft.	Rectangular	Timber Footers in Depression	Timber
Steam Donkey	Sinking	Portable	Rectangular	None	None
Gasoline Donkey	Sinking	Portable	Rectangular	None	None
Single-Drum Gasoline	Sinking	2.5x8 ft. to 4x14.5 ft.	Rectangular	Flat	Timber or Concrete
Single-Drum Gasoline	Sinking	2.5x8 ft. to 4x14.5 ft.	T-Shaped	Flat	Timber or Concrete
Single-Drum Geared to Gasoline Engine	Sinking	3x8 ft. to 8x14.5 ft.	L-Shaped	Flat	Timber or Concrete
Single-Drum Steam	Sinking	6x6 ft. and Smaller	Rectangular	Flat	Timber or Concrete
Single-Drum Steam	Light Production	6x6 ft. to 7.5x10 ft.	Square or Rectangular	Flat	Concrete or Masonry
Single-Drum Steam	Moderate Production	7.5x10 ft. and Larger	Rectangular	Irregular	Concrete or Masonry
Double-Drum Steam	Moderate Production	4x7 ft. to 7x12 ft.	Rectangular	Irregular	Concrete or Masonry
Double-Drum Steam	Heavy Production	7x12 ft. and Larger.	Rectangular	Irregular	Concrete and Masonry
Single-Drum Geared Electric	Sinking	5x6 ft. and Smaller	Square or Rectangular	Flat	Concrete
Single-Drum Geared Electric	Production	6x6 ft. and Larger	Square or Rectangular	Flat	Concrete
Single-Drum Direct-Drive Electric	Production	5x6 ft. and Larger	Square or Rectangular	Flat	Concrete
Double-Drum Geared Electric	Heavy Production	6x12 ft.	Rectangular	Irregular	Concrete
Double-Drum Direct-Drive Electric	Heavy Production	6x12 ft.	Rectangular	Irregular	Concrete

(Twitty, *Reading the Ruins*, 291).

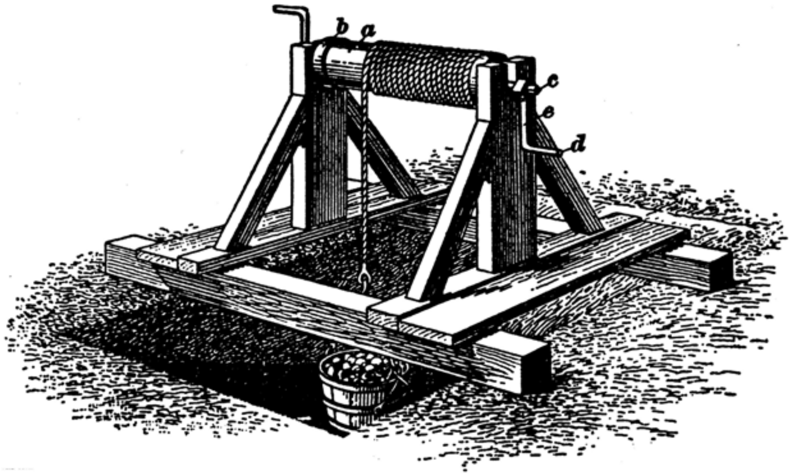

Fig. E.II.17 A hand windlass. Prospectors usually used hand windlasses over shafts less than 100 feet deep. Most shallow shafts featured hand windlasses. Int. Textbook Co., *Hoisting, Haulage, Mine Drainage,* A50: 2.

The *hand windlass* was the simplest form of sinking-class hoist, and prospectors used it for shallow work (Fig. E.II.17). The windlass was an ages-old manually powered winch consisting of a spool made from a lathed log fitted with crank handles, and its working depth was limited to approximately 100 feet. Prospectors sinking inclined shafts had the option of using what mining engineers termed a *geared windlass* or *crab winch*, which offered a greater pulling power and depth capacity. Geared windlasses cost much less than other types of mechanical hoists, and they were small and light enough to be packed into the backcountry. The winch was not easily used at vertical shafts, however, because the rope spool and hand crank fitted onto a frame that had to be anchored onto a well-built timber structure.[26]

Prospect operations often worked at depths greater than the limitations presented by windlasses, forcing them to install more advanced hoisting systems. The *horse whim* proved to be a favorite in Colorado because it was relatively inexpensive to purchase and operate, was portable, and was simple to install Through the 1860s, the mining industry accepted the horse whim as a state-of-the-art hoisting technology for both prospecting and ore production. But by the 1870s, practical steam hoists came of age and the status accorded to horse whims began a downward trend. By around 1880, the mining industry had fully embraced steam hoists. On the whole, mining engineers felt that horse whims were well suited for backcountry prospecting, but they were too slow and limited in lifting power for ore production.[27]

Mining companies and prospect outfits could select from several varieties of horse whims. The simplest and oldest version, christened by Hispanic miners as the "*malacate*" (mal-a-ca-tay), consisted of a horizontal wooden drum or reel directly turned by a draft animal. Early malacates featured the drum, a stout iron axle, and bearings fastened onto both an overhead beam and a timber foundation. Prospectors usually positioned the drum

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[26] Twitty, *Reading the Ruins*, 177-78.
[27] Ibid., 196.

so that it rotated in a shallow pit that they lined with either rockwork or wood planking. The cable extended from the drum through a shallow trench toward the shaft, passed through a pulley bolted to the foot of the headframe, then up and over the sheave at the headframe's top. The draft animal walked around the whim on a prepared track, and the party of prospectors usually laid a plank over the cable trench for the animal to walk across. The controls for the malacate consisted of brake and clutch levers mounted to the shaft collar, connected to the apparatus by wood or iron linkages that passed through the trench.[28]

Mining machinery makers offered factory-made horse whims that were sturdier and performed better than the older handmade units. The *horizontal reel horse whim* consisted of a spoked iron cable reel mounted on a timber foundation that miners embedded in the ground, and it performed like the malacate (Fig. E.II.18).

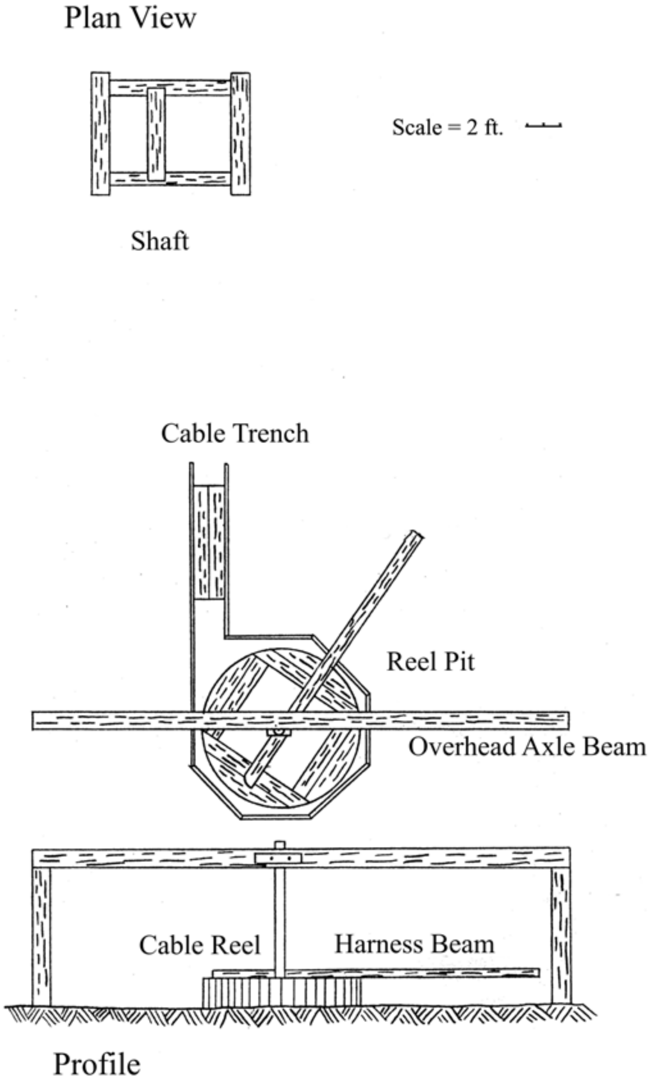

Fig. E.II.18 Plan view and elevation of a horizontal reel horse whim. This was the most popular form of whim prior to the 1880s, when the mining industry embraced the geared model. Usually, only the reel pit and trench remain at prospect sites today. Twitty, *Riches to Rust*, 158.

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[28] Ibid., 197.

These whims remained popular among poorly funded prospect operations into the 1900s. The *geared horse whim* appeared in Colorado during the 1880s and was commonly used in prospect operations into the 1910s (Fig. E.II.19).

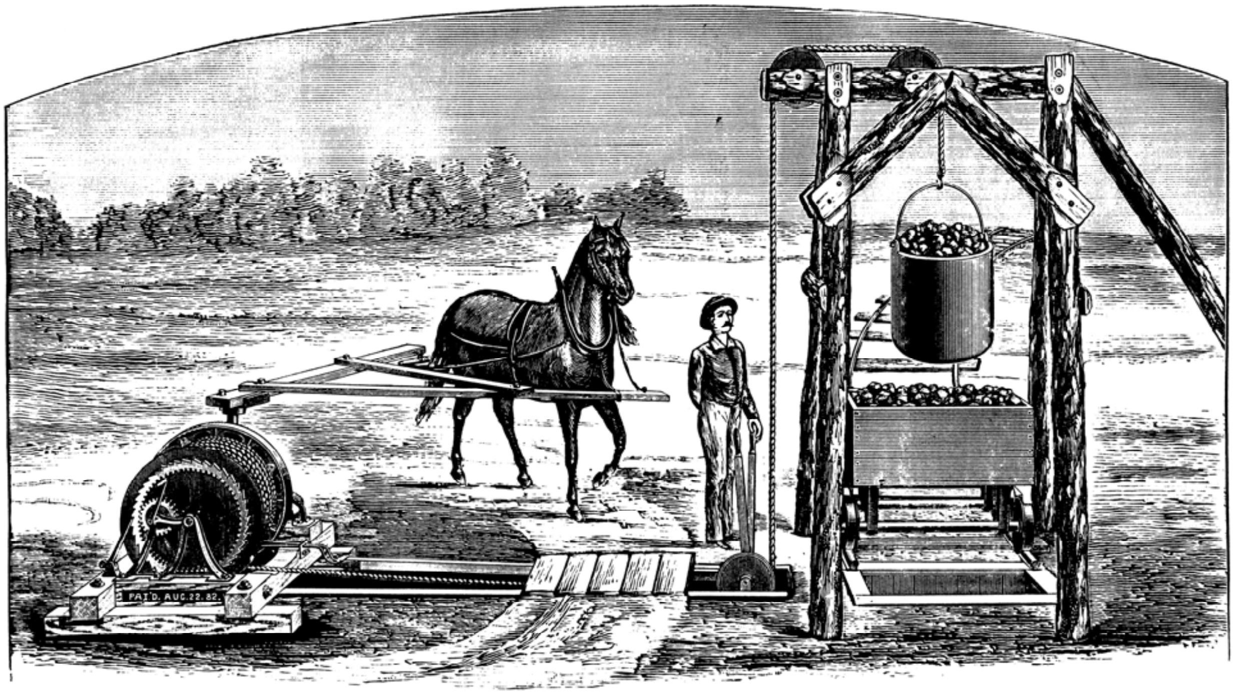

Fig. E.II.19 A geared horse whim. These were the most primitive form of mechanical hoist, but because of their simplicity and portability, they were a favorite among prospectors. Ingersoll Rock Drill Co., *Rock Drills,* 60.

The machine consisted of a cable drum mounted vertically on a timber frame, with a beveled gear that transferred the motion from the draft animal's harness beam. Geared horse whims were supposedly both faster and could lift more than horizontal reel models. They featured controls and cable arrangements similar to the other types of whims.[29]

A horse whim required a headframe over the shaft, and in keeping with the temporary-class structures built by prospect operations, the structures were small and simple. Prospectors favored using either a tripod, tetrapod, or a small four-post derrick that was just wide enough to straddle the shaft.

Prospect operations working in deep shafts began to use steam hoists in large numbers by around 1880. These systems required a relatively substantive infrastructure that had to be planned and engineered, and hence were beyond the financial means of simple, poorly financed partnerships. Steam hoisting systems included a heavy hoist and boiler, cable, pipes, a headframe, and foundations. The mining company also had to provide a reliable source of soft water and a source of fuel for the boiler. After around 1880, the *geared single-drum duplex steam hoist*, known simply as a single-drum steam hoist, was the most popular type (Fig. E.II.20).

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[29] Ibid., 198.

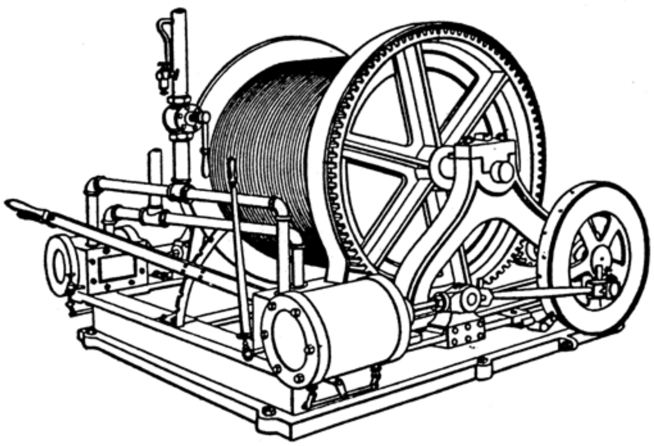

Fig. E.II.20 A single-drum geared steam hoist. These were the most common form of power hoist employed prior to the 1910s, when electric and gasoline models became popular. Note the two steam cylinders flanking the cable drum, the geared drive-shaft opposite, and the drive rods linking the two. Int. Textbook Co., *Hoisting, Haulage, Mine Drainage,* A50: 8.

These hoists became the ubiquitous workhorse for shaft mining and featured a cable drum, two steam cylinders flanking the drum, reduction gears, a clutch, a brake mechanism, and a throttle.

Mining engineers selected the specific model and size of hoist primarily according to the budget granted by the company, and secondary on the speed and depth he anticipated working. Nearly all of the sinking-class hoists that engineers selected for deep prospecting had bedplates smaller than 6 by 6 feet in area and were driven either by gearing or by a friction-drive mechanism. A “friction drive” consisted of rubber rollers that pressed against the hoist’s drum flanges, and while these systems cost less than geared hoists, they were slow and apt to slip under load. Both types of hoists had limited strength, which was often less than 40 horsepower, a slow speed of 350 feet per minute, and a payload (i.e. the revenue-producing part of a cargo) of only a few tons. Professionally educated engineers defined such hoists as sinking-class in duty and not for ore production, which applied well into the twentieth century.[30]

A significant number of deep prospect operations in Colorado fell into an awkward niche where horse whims were inadequate, but the outfit could not, or would not, come up with the capital necessary to install a stationary steam hoist and boiler. During the late 1870s, machinery manufacturers introduced a revolutionary type of hoisting system that met the needs of these small operations. The *steam-donkey hoist*, so named for its broad utility, consisted of either a small single cylinder or duplex steam hoist and an upright boiler mounted onto a common wood or steel frame. While donkey hoists were not manufactured exclusively for mining, being used for logging and in freight yards, they endeared themselves to prospect operations. The durable machines withstood mistreatment, were relatively inexpensive, did not require much site preparation, and could literally be dragged

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[30] Ibid., 201.

around the landscape. In addition, donkey hoists did not require a deep understanding of engineering; almost anyone could have operated one.

Prospect operations seeking riches deep in the backcountry reluctantly spent the capital required to install steam equipment. The problems they faced were twofold. Not only did these operations have to ship and erect the hoisting system, but they also had to continuously feed it fuel and water, which proved costly. In the early 1890s, the Witte Iron Works Company and the Weber Gas & Gasoline Engine Company both began experimenting with a new hoisting technology that alleviated many of the fuel and water issues faced by remote prospect operations. Witte and Weber both introduced the first practical petroleum engine hoists. These innovative machines were smaller than many steam models, they required no boilers, and their concentrated liquid fuel was by far easier to transport than wood or coal.

Despite the potential advantages, mining companies in Colorado did not immediately embrace petroleum hoists. Steam technology, the workhorse of the Industrial Revolution, held sway in the mining industry into the 1900s for several reasons. First, many mining companies and practicing mining engineers were by nature conservative, and out of familiarity they stayed the course with steam into the 1910s. Second, during this time, petroleum engine technology was relatively new and had not seen widespread application, especially for hoisting. The few operations to employ petroleum hoists during the 1890s found the engines to be cantankerous and their performance limited. Further, petroleum hoists were slow (possessing speeds of 300 to 400 feet per minute), could not raise much more than 4,500 pounds, and their working depth was limited to less than 1,000 feet. For these reasons professionally educated mining engineers felt they were barely adequate for sinking duty, and total acceptance took approximately 15 years.[31]

The petroleum hoists used by Colorado prospect operations were similar in form to the old-fashioned steam-donkey hoists. A large single cylinder engine was fixed to the rear of a heavy cast-iron frame and its piston rod connected to a heavy crankshaft located in the frame's center. Manufacturers located the cable drum, turned by reduction gearing, at front, and the hoistman stood to one side and operated the controls. Because the early petroleum engines were incapable of starting and stopping under load or of being reversed, they had to run continuously, requiring the hoistman to delicately work the clutch when hoisting, and disengage the drum and lower the ore bucket via the brake.

For production-class hoisting systems, steam technology maintained supremacy until the 1920s, when gasoline and electric power finally superseded it. Prior to the 1920s, machinery manufacturers offered steam hoists in a wide array of sizes for ore production. Manufacturers also offered hoists equipped with either *first-motion* or *second-motion* drive trains. First-motion drive, also known among mining engineers as *direct drive*, meant that the steam engine drive rods were coupled directly onto the cable drum shaft, much like the way the drive rods were directly pinned onto a steam locomotive's wheels. Second-motion drive, also commonly known as a *geared drive*, consisted of reduction gearing like the sinking-class hoists discussed above.

The difference in the driving mechanisms was significant in both performance and cost, and each served a distinct function. Gearing offered great mechanical advantage, which permitted the use of relatively small steam cylinders. The arrangement of the gear shafting and cylinders on a common bedplate permitted the hoist's footprint to be compact. First-motion hoists, on the other hand, required that the cable drum be mounted at the ends of large dual steam cylinders so that the drive rods could gain leverage. Where the footprint of geared hoists was almost square, the footprint of first-motion hoists was that of an elongated rectangle with the long axis oriented toward the shaft. First-motion hoists were intended by manufacturers to serve as high-quality production-class machines designed to save money only over protracted and constant use, while geared hoists were intended to be inexpensive and meet the short-term needs of small, modestly capitalized mines. First-motion hoists were

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[31] Ibid., 211.

stronger, faster, and more fuel efficient than geared models. The large size, combined with the necessity of using high-quality steel to withstand tremendous mechanical forces, and the fine engines made the purchase price of first-motion hoists three to four times that of geared hoists (the latter costing from approximately $1,000 to $3,000 for light to heavy production-class models.) First-motion hoists had a speed of 1,500 to 3,000 feet per minute, compared with 500 to 700 feet per minute for geared hoists. These hoisting speeds reflect the ability of first-motion hoists to work in shafts with depths well into the thousands of feet. Geared hoists usually relied on old fashioned but durable slide valves to admit steam into and release exhaust from the cylinders, while first-motion hoists were usually equipped with Corliss valves for the engine, which were initially more expensive but consumed half the fuel.[32]

Not only were the costs of purchasing first-motion hoists high, the expenses associated with their installation were exorbitant. Because geared hoists were self-contained on a common bedplate, the surface crew at a mine merely had to build a small foundation with anchor bolts projecting out of a flat surface, and drop the hoist into place. First-motion hoists, on the other hand, required raised masonry pylons for the steam cylinders, pylons for the cable drum bearings, a well for the drum, and anchor bolts in masonry between the pylons for the brake posts. The hoist pieces then had to be brought over, maneuvered into place, and simultaneously assembled.

Mining engineers chose specific hoists based on the power delivered by the engine, which had a proportional relationship with the hoist's overall size. Geared hoists smaller than 6 by 6 feet were usually made for deep exploration and delivered less than 50 horsepower. Hoists between 7 by 7 feet and 9 by 9 feet were for minor ore production and offered 75 to 100 horsepower. Hoists 10 by 10 feet to 11 by 11 feet were for moderate to heavy production and generated up to 150 horsepower, and larger units were exclusively for heavy production. Mining engineers rarely installed geared hoists larger than 12 by 12 feet, because for a little more money they could have obtained an efficient first-motion hoist.[33]

Regardless of the nature of the drive mechanism, single-drum geared and direct-drive hoists were restricted to serving a shaft with a single hoisting compartment, which had inherent inefficiencies. Double-drum hoists, on the other hand, offered greater economical performance because they increased the tonnages of rock produced while saving energy costs. They achieved this through a balanced hoisting system, which required two hoisting vehicles. As the hoist raised one vehicle, the other descended down the shaft in a balanced fashion. Not only did the hoist only have to do the work of raising the ore and not the dead-weight of the hoisting vehicle, thus saving energy, but also two vehicles raised more rock than one. However, double-drum hoists possessed several drawbacks that restricted their appeal to only particularly well-financed mining companies. The hoists were considerably more expensive than single-drum models to purchase and install, and sinking and timbering a shaft with two hoisting compartments and the obligatory utility compartment constituted a great cost.

Like single-drum hoists, double-drum units came with geared or first-motion drives, which were either self-contained on a bedplate or consisted of components that had to be anchored to masonry foundation piers. Double-drum geared hoists, ranging in size from between 7 by 12 feet to 12 by 17 feet, were slower, less powerful, and noisier than their direct-drive brethren, and they cost much less to purchase, transport, and install. Like single-drum geared hoists, double-drum geared models had weight, speed, and depth limitations mining engineers with high expectations would not tolerate. The ultimate answer for raising the maximum quantity of ore in minimal time was the installation of a double-drum first-motion hoist. This type of hoist ranged in size from approximately 18 by 25 feet to over 30 by 40 feet in area, and its visual impact mirrored its performance. The extreme difficulty and exorbitant costs of transporting and installing these massive machines relegated them to only the most heavily capitalized mining companies with highly productive operations in well-developed mining

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[32] Ibid., 242.
[33] Ibid., 244.

districts. Not only did these types of double-drum hoists permit mining companies to maximize profits, but also they served as a statement to the mining world of a company's financial status, levels of productivity, and quality of engineering. By the Great Depression, the mining industry embraced the electric hoist for most types of shaft work. Machinery makers overcame the problems and limitations experienced by the mining industry during the 1900s and 1910s, and by the 1930s they were producing a variety of single- and double-drum models for shaft sinking and heavy ore production. Like the steam hoists of old, electric models came in four basic varieties: geared single- and double-drum units, and direct-drive single- and double-drum units (Fig. E.II.21).

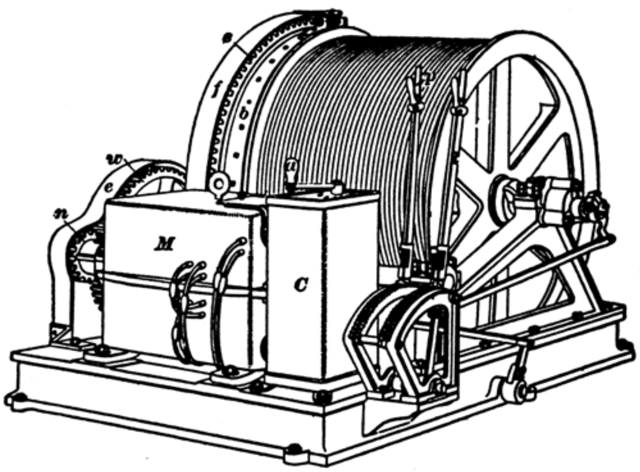

Fig. E.II.21 A typical geared single-drum electric hoist. The motor is at the rear (left) and turned the cable drum through reduction gears behind. These hoists became common and replaced steam models in areas wired for electricity by the 1910s. Int. Textbook Co., *Hoisting, Haulage, Mine Drainage,* A50: 39.

The geared electric hoists were built much like their steam ancestors in that the motor turned a set of reduction gears connected to the cable drum, and the components came from the manufacturer assembled onto a heavy bedplate. The gearing permitted hoist manufacturers to install small and inexpensive motors ranging from 30 to 300 horsepower. Direct-drive electric hoists, on the other hand, had huge motors rated up to 2,000 horsepower attached to the same shaft that the cable drums had been mounted on. These hoists, considerable in size, had to be assembled as components onto special foundations, as did the old direct-drive steam hoists.[34]

Like the antiquated steam hoists, mining engineers classified single-drum electric hoists smaller than 6 by 6 feet in area as meeting the qualifications for sinking duty. Most of the production-class hoists installed by engineers during this time featured motors rated to at least 60 horsepower for single-drum units and 100 horsepower for double-drum units. Even with large motors, these geared hoists had slow hoisting speeds of less than 600 feet per minute, their payload capacity was limited, and they were not able to work in the deepest shafts. Out of economic necessity during the capital-scarce Great Depression, many mining companies had to settle for

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[34] Eaton, *Practical Mine Development*, 86, 295; Lewis, *Elements of Mining*, 1946, 187; Staley, *Mine Plant Design*, 137; Young, *Elements of Mining*, 1946, 203; Zurn, *Coal Miners' Pocketbook*, 1928, 760.

small, slow, sinking-class hoists. It was not uncommon for these companies to use hoists with motors rated at only 15 horsepower, which in better times might have been used instead for work over winzes underground.[35]

During the Great Depression, some outfits reconditioning abandoned mines on narrow budgets cobbled together hoists from machinery that had been cast off during earlier decades. Miners exercised creativity in making obsolete machinery work, and their solutions fell into several basic patterns. One common method involved obtaining an old geared steam hoist, stripping it of the steam equipment, and adapting an electric motor to turn the hoist's gearing. To adapt the motor to the hoist, miners had to build a small foundation with anchor bolts adjacent to the hoist, and they had a machine shop custom-make a pinion gear for the motor with teeth capable of meshing with the hoist's bull gear. After ensuring that the original clutch and brake worked and that the hoisting cable was sound, the miners were ready to go to work.[36]

Mining outfits with limited funding practiced another clever means of bringing new life to antiquated steam hoists. Unlike the method described above, the miners left the steam equipment on the hoist intact and ensured that the pistons and valves were in good condition. They reconnected pipes to the hoist's cylinders and, instead of routing the line to a boiler, used compressed air to power the hoist, which acted like steam. The only drawback to such an innovation was that a costly multistage compressor had to supply the air. In some cases, impoverished mining operations were able to contract with neighboring companies that possessed the necessary compressors for the air.

The third practice that impoverished mining companies followed involved assembling hoists from odd and unlikely pieces of machinery. A system favored by outfits lacking resources and an understanding of fine engineering consisted of coupling a small hoist stripped of everything but the brake and clutch to the power train of a salvaged automobile. Slow, noisy, and of questionable reliability, these contraptions worked well enough to allow mining operations to turn a small profit. Lacking the money and possibly the knowledge of how to construct a proper foundation, miners simply bolted the hoist and salvaged automobile to a flimsy timber frame that had not necessarily been anchored in the ground.[37]

Small and medium-sized mining outfits that had access to capital were able to afford factory-made gasoline hoists (Fig. E.II.22).

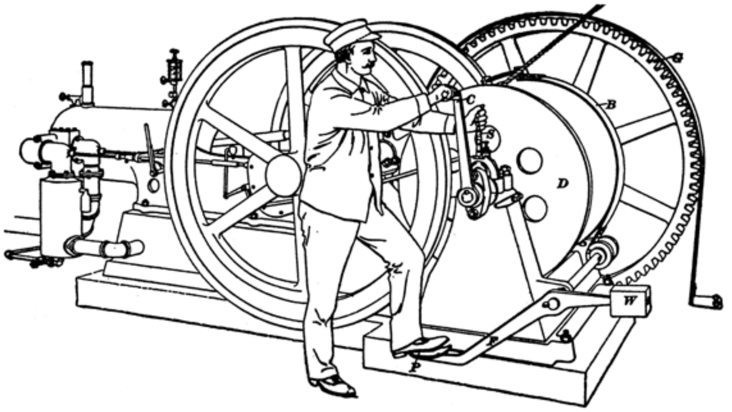

Fig. E.II.22 A gasoline hoist. Machinery manufactures introduced the gasoline hoist during the 1890s and they became fairly popular by the 1900s. Despite their large size, gasoline hoists were generally accepted for deep prospecting, but not ore production (although poorly capitalized companies did used them for this.) A single-cylinder engine is at left, duel flywheels are at center, and the cable drum is at right. Int. Textbook Co., *Hoisting, Haulage, Mine Drainage,* A50: 31.

Mining companies continued to use the old single-cylinder gasoline hoists, and they also purchased

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[35] Twitty, *Reading the Ruins*, 341.
[36] Ibid.
[37] Twitty, *Reading the Ruins*, 343.

factory-made donkey hoists offered by machinery suppliers such as Fairbanks-Morse and the Mine & Smelter Supply Company. The donkey hoist manufactured during the 1930s consisted of a small automobile engine that turned a cable drum through reduction gearing. The makers designed the little machines to be portable and affixed all of the components onto a steel frame. The affordability, portability, and independence suited these machines for backcountry use, especially during the capital-poor times of the Great Depression.

Few historic shaft mines retain their hoists but instead only now feature foundations. By examining the footprint of a foundation, it is often possible to determine the exact type of hoist that a mine featured. Foundations for production-class *single-drum steam hoists* and *single-drum electric hoists* tend to be slightly rectangular and flat, feature at least six anchor bolts around the outside, and usually consist of concrete or masonry (Fig. E.II.23, and Fig. E.II.24). Some foundations greater than 8 by 8 feet in area may feature a depressed center that accommodated a large cable drum.

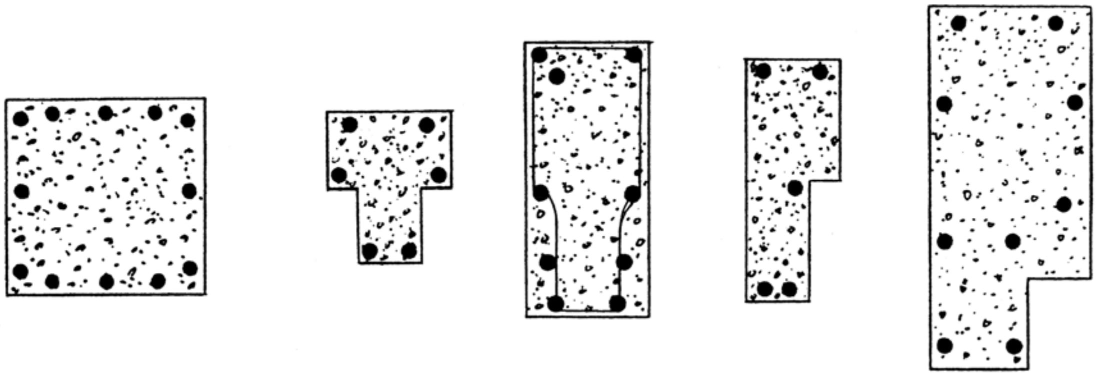


Fig. E.II.23 Types of hoist foundations (plan views). Single-drum steam hoists were usually bolted to foundations like the one at left, and the other foundations represent various types of gasoline hoists. Twitty, *Riches to Rust,* 178, 241.

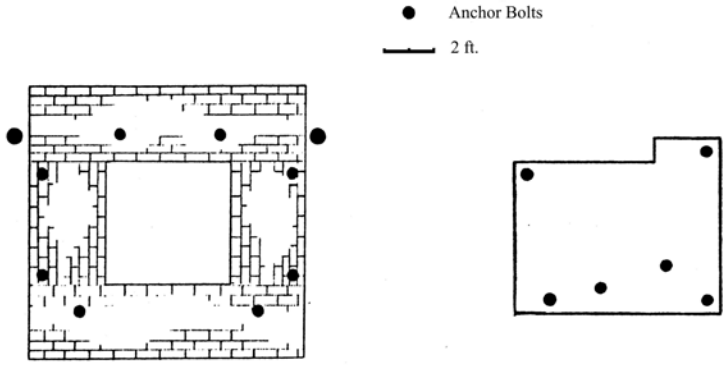


Fig. E.II.24 Typical foundations for single-drum steam hoists (plan views). The foundation at left features a well for the cable drum. Single-drum electric hoists were usually anchored to foundations like the one at left. Twitty, *Riches to Rust,* 166, 241.

Direct-drive single-drum hoists were usually bolted to complex foundations that anchored the machines' individual components (Fig. E.II.25).

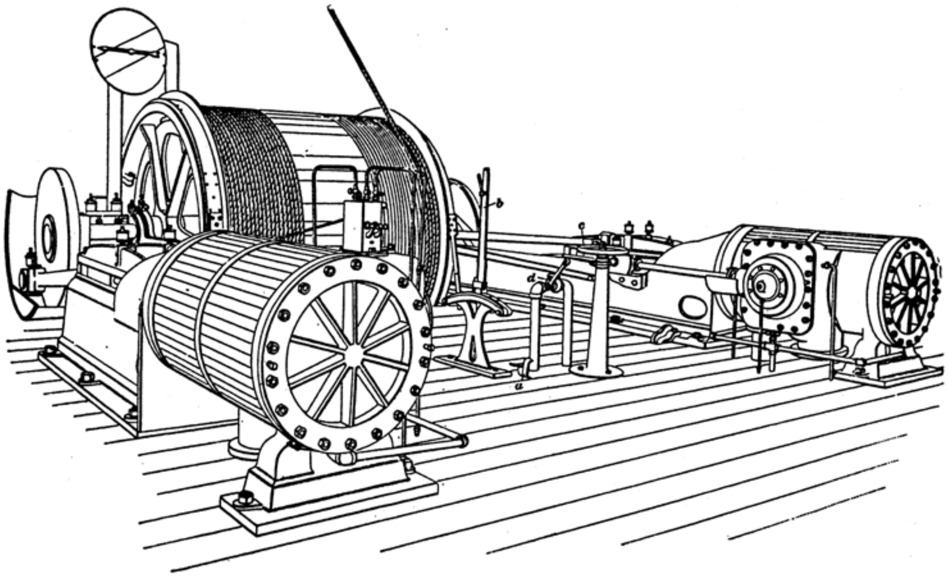
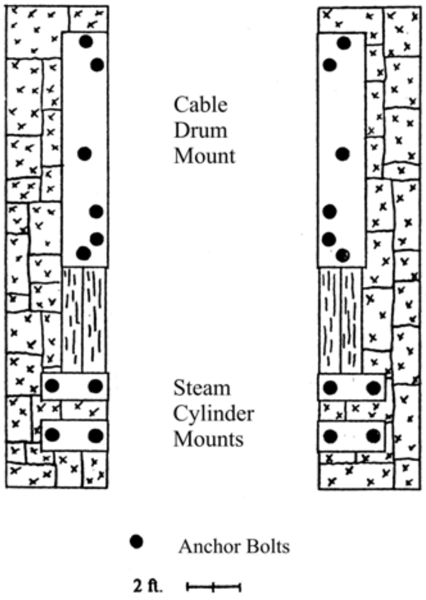


Fig. E.II.25 A rear quarter view of a direct-drive single-drum steam hoist. Compare to the geared steam hoist (Fig. E.II.20). Powerful steam cylinders flank the hoist's controls, and the drive rods are directly coupled to the cable drum. Int. Textbook Co., *Hoisting, Haulage, Mine Drainage,* A50: 16.

The foundation for a direct-drive single-drum steam hoist usually consists of two parallel masonry footers capped with dressed sandstone or granite blocks (Fig. E.II.26).

Fig. E.II.26 A typical foundation for a direct-drive single-drum steam hoist. Foundations such as this usually stand on rock footers and are less than 14 by 17 feet in area. Twitty, *Riches to Rust,* 241.



The blocks toward the rear supported the steam cylinders and feature clusters of heavy anchor bolts. The blocks toward the front supported the cable drum's bearings and feature additional heavy anchor bolts. Foundations are rarely larger than 14 by 19 feet in area.[38]

Foundations for *double-drum geared steam hoists* tend to possess an elongated rectangular footprint oriented 90 degrees to the shaft (Fig. E.II.27, and Fig. E.II.28).

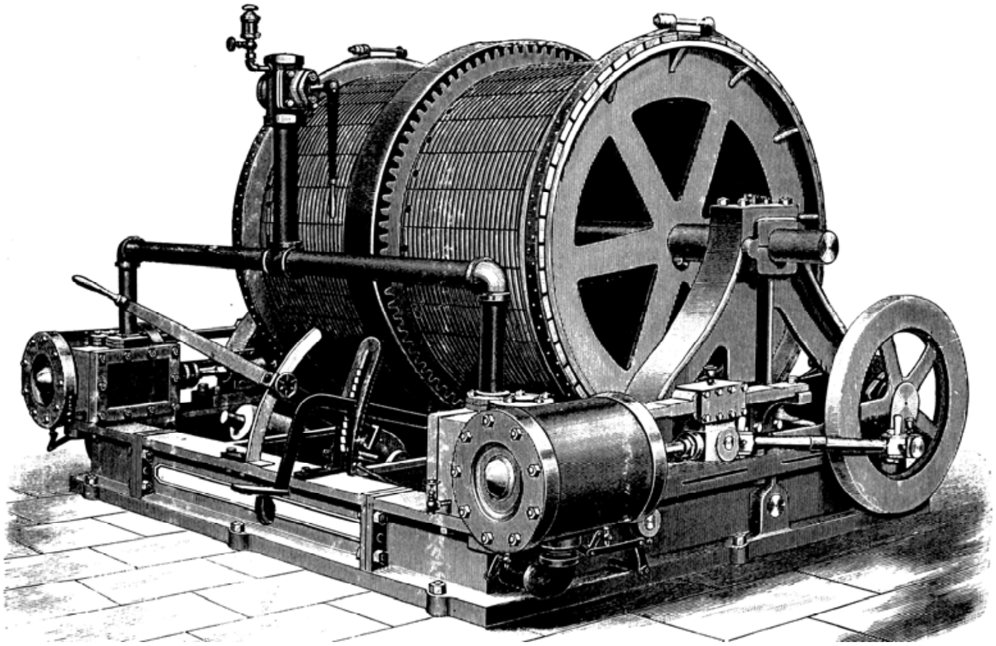


Fig. E.II.27 A rear quarter view of a geared double-drum steam hoist. Compare to the geared steam hoist (Fig. E.II.20). Double-drum hoists were used to achieve balanced hoisting in three-compartment shafts. Ingersoll Rock Drill Co., *Rock Drills,* 58.

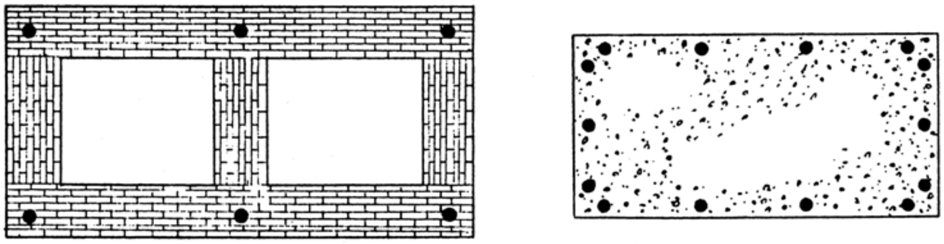


Fig. E.II.28 Typical foundations for a geared double-drum steam hoist. The foundation at left features wells for the cable drum. The foundation at right anchors a relatively small hoist. Twitty, *Riches to Rust,* 242.

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[38] Twitty, *Riches to Rust*, 240.

They usually consist of concrete or masonry, feature a perimeter of anchor bolts, and wells for the cable drums. Small anchor bolts on the edges of the drum wells often braced brake shoes.

Double-drum geared electric hoists were bolted to foundations similar to those for their steam-driven counterparts (Fig E.II.29, and Fig. E.II.30). The principal difference manifests as a separate mount for the electric motor, which is often rectangular, less than 4 by 5 feet in area, and features four anchor bolts.

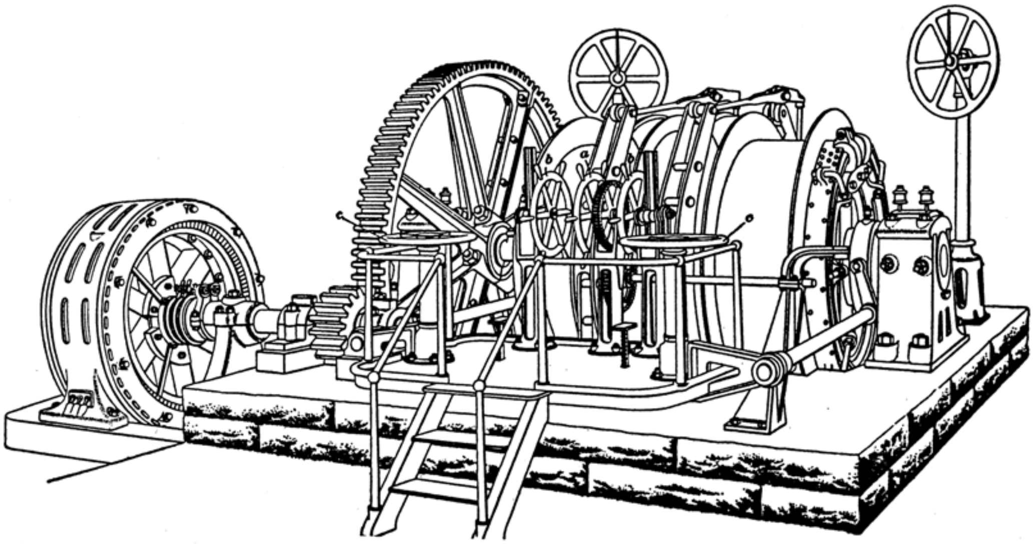

Fig. E.II.29 A rear quarter view of a double-drum electric hoist. The motor at left drove the dual cable drums via the large bull gear. Such hoists facilitated heavy production, saw use after the 1910s, and experienced mild popularity by the 1930s. Int. Textbook Co, *Hoisting, Haulage, Mine Drainage,* A50: 40.

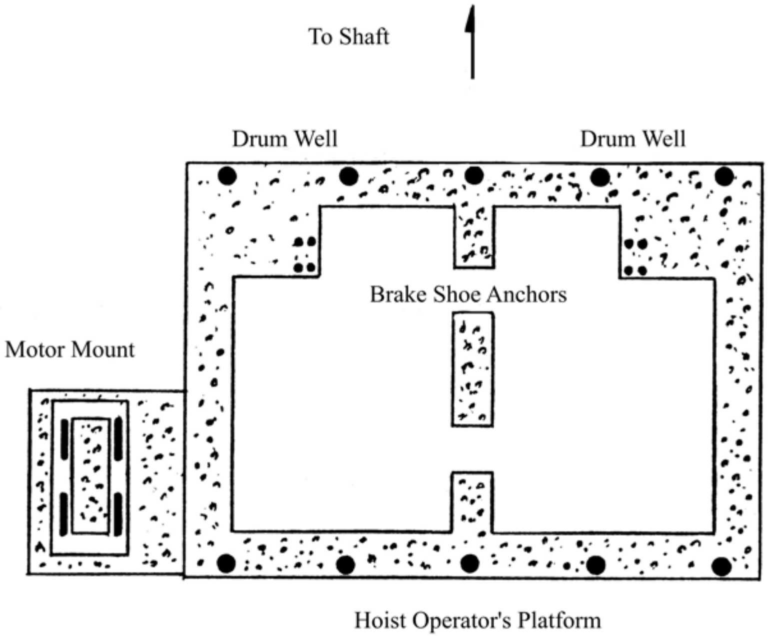

Fig. E.II.30 A foundation for a double-drum electric hoist. Such foundations may be found primarily at large mine sites active during or after the 1930s. Twitty, *Riches to Rust,* 280.

Foundations for *direct-drive double-drum steam hoists* are similar to enlarged versions of those for direct-drive single-drum types (Fig. E.II.31 and Fig. E.II.32).

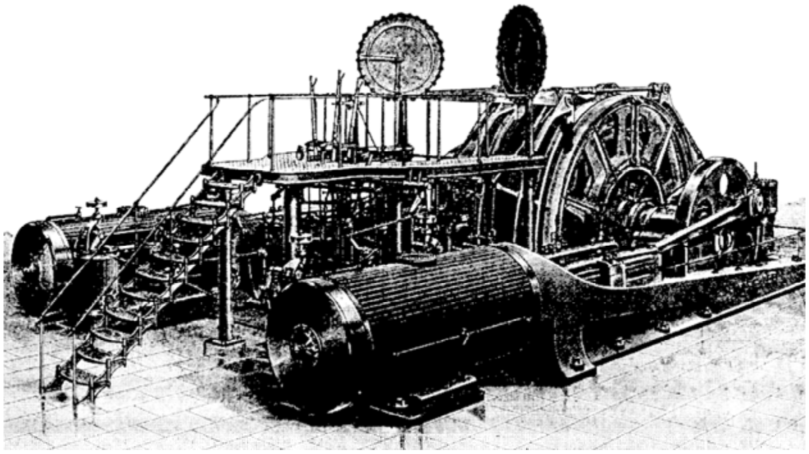

Fig. E.II.31 A rear quarter view of a direct-drive double-drum steam hoist. Powerful steam cylinders flank the operator's platform and small steam cylinders that powered the clutch and brake. The drive rods are coupled directly to the dual cable drums, which rest on bearing blocks. These types of hoists were the largest and most advanced. *Mining & Scientific Press*, Oct. 21, 1899: 470.

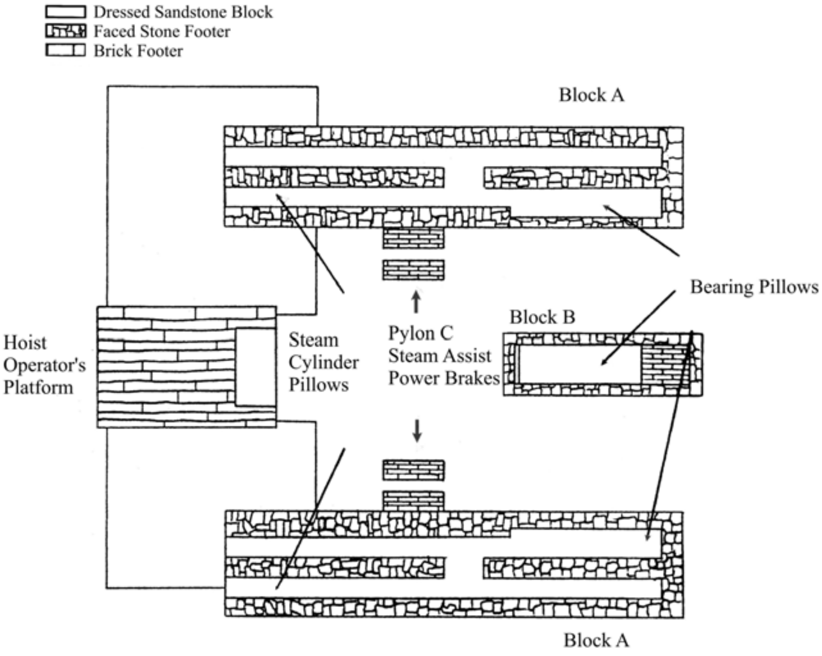

Fig. E.II.32 Foundation for a direct-drive double-drum steam hoist. Such foundations are rare and may be found primarily at large mine sites. Twitty, *Riches to Rust*, 243.

The foundation features a broad masonry footing with dual wells for the cable drums, and a depression or platform behind for the power-assist clutch and brake cylinders. Two clusters of dressed sandstone or granite blocks for the drum bearings stand on both sides of the wells and one stands between. Clusters of blocks stand at the foundation's rear, which once supported the steam cylinders. Parallel rows of blocks that supported the drive rods should extend along the foundation's sides. The various clusters of blocks almost always feature symmetrically arranged large anchor bolts, while small bolts that anchored the steam-assist cylinders and linkages lie between.

3.2.3 Steam Boilers

Steam boilers were a necessary component of nineteenth-century power hoisting systems. While specific designs of boilers evolved and improved over time, the basic principle and function remained unchanged. Boilers were iron vessels in which intense heat converted large volumes of water into steam under great pressure. Such specialized devices had to be constructed of heavy boilerplate iron riveted to exacting specifications, and they had to arrive in the mining West ready to withstand neglect and abuse. The problem that boilers presented to mining companies was that they were bulky, heavy, cumbersome, and required engineering to install.

During the 1880s, the *Pennsylvania boiler*, the *locomotive boiler*, and the *upright boiler* (also known as the *vertical boiler),* quickly gained popularity among Colorado's prospect operations. These boilers were well suited to the geographic and physical environment of Colorado because they were self-contained and freestanding, ready to fire, and able to withstand mistreatment. Because the above three types of boilers were designed to be portable at the expense of fuel efficiency, mining engineers declared them fit only for sinking duty.

In general, all of the above sinking-class boilers consisted of a shell that contained water, flue tubes extending through the shell, a firebox inside the shell at one end, and a smoke manifold. When the fireman stoked a fire in the firebox, he adjusted the dampers to admit enough oxygen to bring the flames to a steady roar. The flue gases, which were superheated, flowed from the fire through the flue tubes, imparting their energy to the surrounding water, and then flowed out the smoke manifold and up the smokestack.

Great danger lay in neglecting the boiler's water level. An explosion was imminent if the flue gases contacted portions of the shell that were not immersed in water on a prolonged basis. Usually the front of the boiler featured a glass sight tube much like the level indicator on a coffee urn. When the water began to get low, the fireman turned the valve on the main that had been connected to the boiler, or he operated a small hand pump if the plumbing had no pressure. Boiler tenders, often serving also as hoistmen, usually kept the boiler three-quarters full of water, the empty space being necessary for the gathering of steam. When the fire grew low the boiler tender opened the fire door (the upper of two sets of cast-iron hatches), and threw in fuel. Mining engineers recognized that cord wood was the most appropriate fuel in remote and undeveloped mining districts because poor roads and great distances from railheads made importing coal too expensive. However, coal was the most energy-efficient fuel, a half ton equaling the heat generated by a cord of wood, and as a result mining operations proximal to sources of the fossil fuel preferred it.

During the 1880s, mining companies came to appreciate the utility and horsepower of the locomotive boiler (Fig. E.II.33).

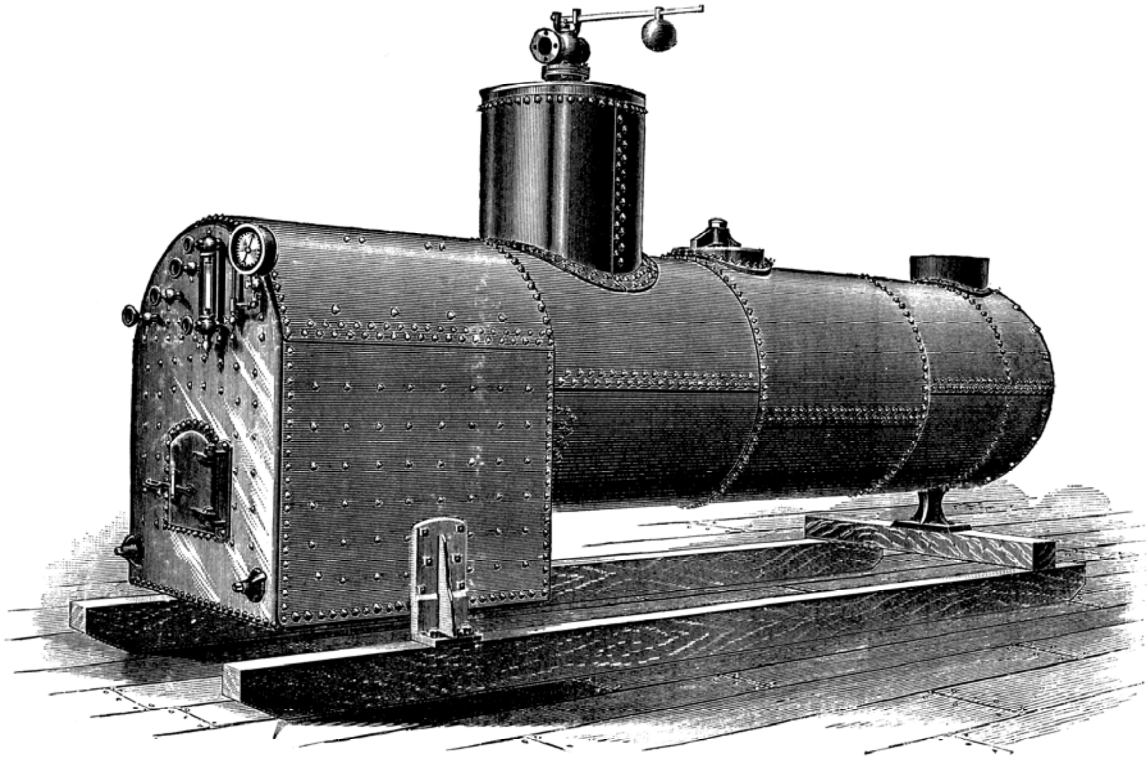

Fig. E.II.33 A locomotive boiler. This was perhaps the most common type of portable unit. Flue gases traveled from the firebox, surrounded by a water jacket at left, through flue tubes in the boiler shell, and out the smokestack at right. Most locomotive boilers stood on skids, which often left impressions or rock alignments near the hoist. Note the hardware above the firebox door. Rand Drill Co., *Illustrated Catalogue,* 45.

The locomotive boiler, so named because railroad engine manufacturers favored it for building locomotives, consisted of a horizontal shell with a firebox built into one end and a smokestack projecting out of the other end. Nearly all of the models used in Colorado stood on wood skids and were easily portable, but some units required a small masonry pad underneath the firebox and a masonry pillar supporting the other end. Locomotive boilers were usually 10 to 16 feet long, 3 feet in diameter, and stood up to around 6 feet high, not including the steam dome on top. These workhorses, the single most popular sinking-class source of steam into the 1910s, typically generated from to 30 to 50 horsepower, which was enough to run a sinking-class hoist.[39]

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[39] Twitty, *Reading the Ruins,* 204.

Upright boilers were the least costly of all boilers (Fig. E.II.34).

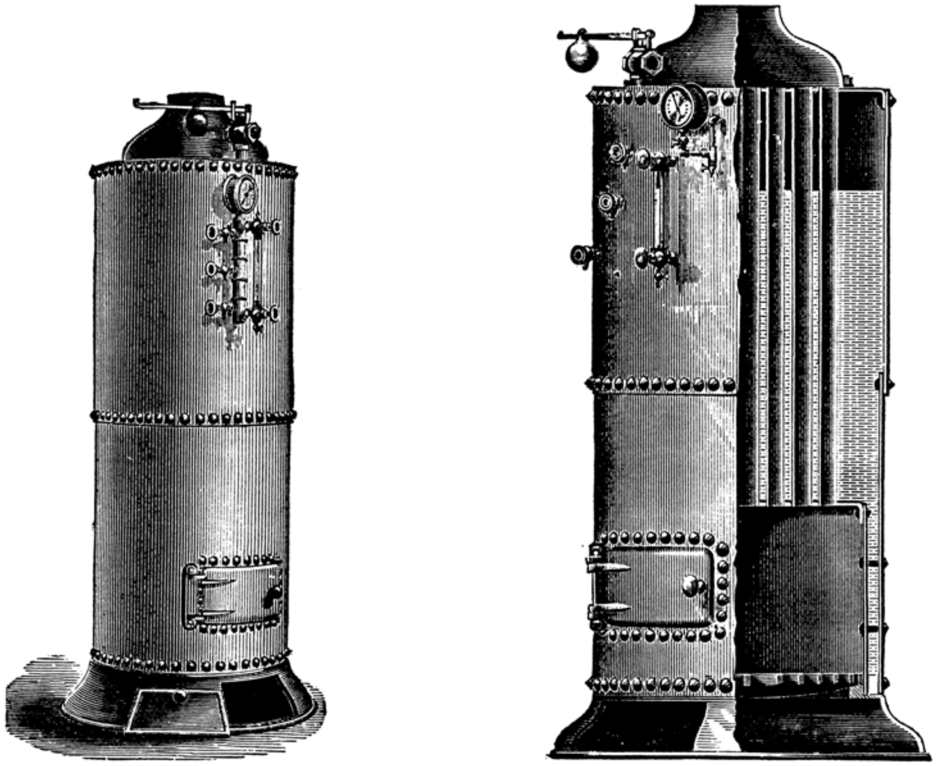

Fig. E.II.34 An upright boiler. These were the least expensive, least efficient, but most portable of the various boiler types. They usually stood on a platform near the hoist, and possibly over a circular pad of rocks or a depression. Flue gases rose from the firebox at bottom through the flue tubes and out the smokestack at top. Note the water-level sight tube, pressure gauge, and blow-off valve on the boiler's side. Rand Drill Co., *Illustrated Catalogue*, 47.

They tolerated abuse well and were the most portable. However, because upright boilers could not generate the same horsepower as locomotive or Pennsylvania units, they could not power large sinking-class hoists, let alone additional machines such as air compressors. Upright boilers consisted of a vertical water shell that stood over a firebox and ash pit that had been built as part of a cast-iron base. The flue tubes extended upward through the shell and opened into a smoke chamber enclosed by a hood and smokestack, which appeared much like an inverted funnel. The flue gases' path up directly up and out of the firebox made these steam generators highly inefficient, and the rapid escape of gases and the quick combustion of fuel caused great fluctuations and inconsistencies in the pressure and volume of steam. The short path for the gases and intense fire put heavy heat stress on the top end, causing it to wear out quickly and leak, and the firebox and doors also saw considerable erosion. However, upright boilers required little floor space and maintenance, and were so durable that they almost could have been rolled from site to site. Plenty of remote prospect operations saw great advantage in vertical boilers, and consequently these steam generators enjoyed substantial popularity into the 1910s.[40]

The third basic type of sinking-class boiler that prospect operations used in noteworthy numbers was the Pennsylvania boiler (Fig. E.II.35).

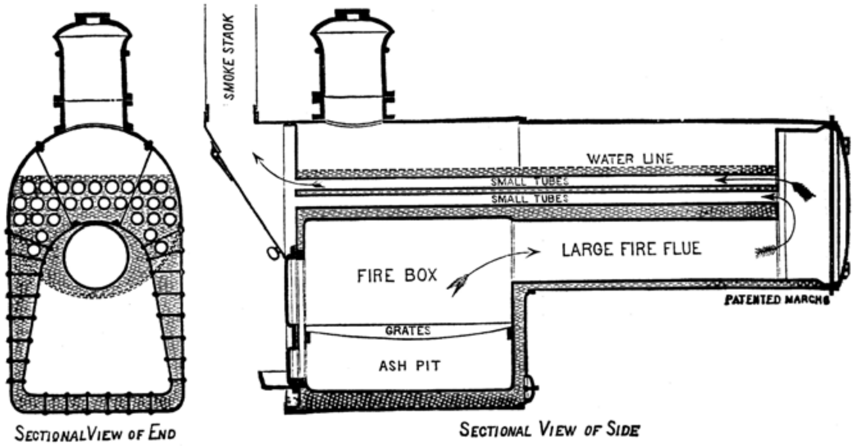

Fig. E.II.35 A Pennsylvania boiler. These were portable and provided greater economy than locomotive units. Pennsylvania boilers stood on skids like locomotive units and left similar forms of evidence at prospect sites today. Note the path traveled by the flue gases, which permitted prolonged contact between the flue gases and the boiler surfaces. Rand Drill Co., *Illustrated Catalogue*, 46.

This unit combined the form and portability of the locomotive boiler and the function of the Scotch marine boiler, discussed below. Like the other portable boilers, the Pennsylvania boiler featured an enclosed firebox that was surrounded by a jacket of water. The flue gases traveled through a broad tunnel in the shell, rose into a small smoke chamber, reversed direction and traveled toward the front of the shell through flue tubes, and escaped through a smokestack. The Pennsylvania boiler, which originated in the Keystone State's oil fields, proved to be remarkably efficient and saw use at a number of Colorado mining operations.[41]

Developed in Scotland for maritime purposes, the Scotch marine boiler was the least popular sinking-class steam generator in the West. Scotch marine boilers consisted of a large-diameter shell enclosing the firebox, and the path for the flue gases was similar to that of the Pennsylvania boiler. While this type of boiler was one of the most efficient portable units, it never saw popularity in Colorado primarily because convention dictated the use of the other types, and because it was heavy, large, and difficult to haul to remote locations.[42]

Engineers equipping production-class surface plants rarely relied on portable boilers to supply steam because of their inefficiency. Rather, engineers predominantly used *return-tube boilers* in masonry settings, or they erected *water-tube boilers*, which offered the ultimate fuel economy. The concept and design behind the return-tube boiler was brilliant (Fig. E.II.36 and Fig. E.II.37).

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[40] Croft, *Steam Boilers*, 48; Int. Textbook Co., *Steam and Steam-Boilers*, A18, 34; Kleinhans, *Locomotive Boiler Construction*, 12; Rand Drill Co., *Illustrated Catalogue*, 47; Tinney, *Gold Mining Machinery*, 50.
[41] Twitty, *Reading the Ruins*, 206.
[42] Colliery Engineer Co., *Coal & Metal Miners' Pocketbook*, 1893, 262; Int. Textbook Co., *Steam and Steam-Boilers*, A18: 28; Peele, *Mining Engineer's Handbook*, 2083; Thurston, *A Manual of Steam Boilers*, 31.

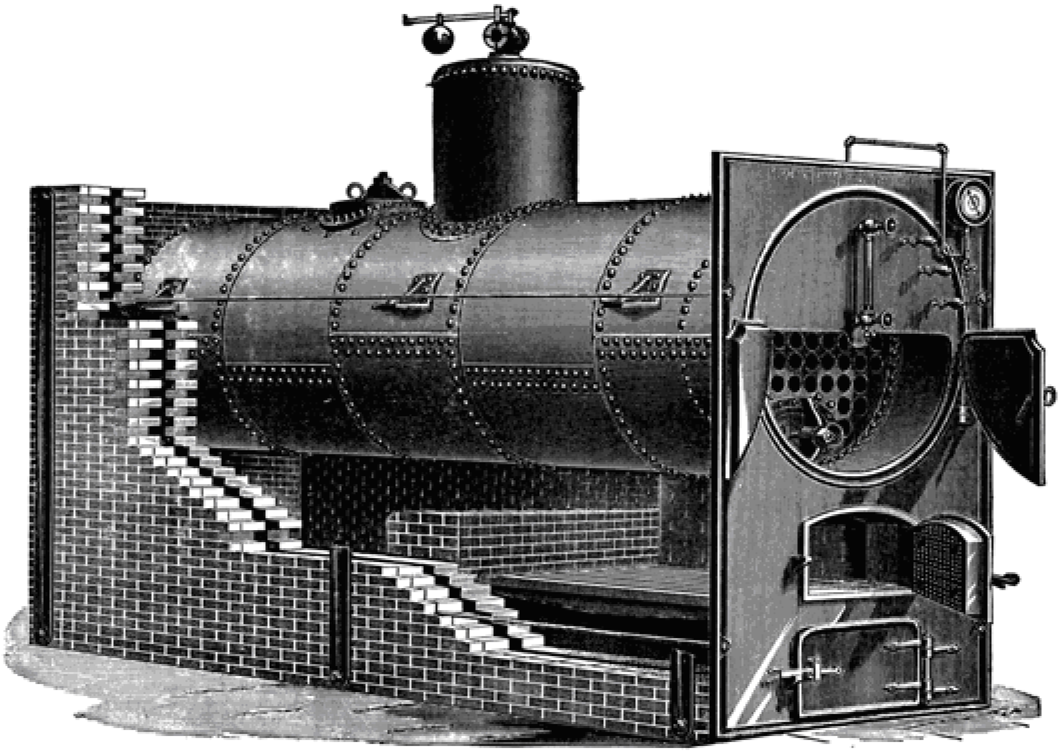

Fig. E.II.36 A return-tube boiler. This was the most popular industrial steam generator prior to the use of electricity in the 1900s and the 1910s. The boiler consisted of an iron shell encased in a masonry setting. Flue gases traveled from the firebox behind the façade and under the shell's belly. The gases rose into a smoke chamber at rear, reversed direction and returned through the flue tubes perforating the shell, and escaped out a smokestack over the façade. The top door permitted workers to swab out the flue tubes, the center door was for the firebox, and the bottom door accessed the ash pit. Rand Drill Co., *Illustrated Catalogue,* 44.

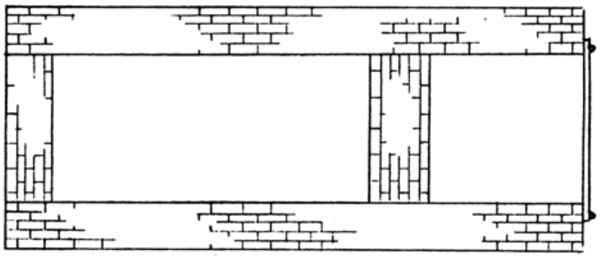

Fig. E.II.37 The footprint of a setting remnant of a return-tube boiler. Few of these boilers remain intact; most have been reduced to setting remnants and foundations. Twitty, *Riches to Rust,* 245.

The boiler shell, part of a complex structure, was suspended from legs known as *buckstaves*, so named because they prevented the associated masonry walls from bucking outward. Brick walls enclosed the area underneath the boiler shell, and a heavy iron façade shrouded the front. A firebox lay behind the façade underneath the boiler shell. Under the firebox lay an ash pit, and both were sealed off from the outside by heavy cast-iron doors. When a fire burned, the superheated flue gases traveled from the firebox along the belly of the boiler shell and rose up into a smoke chamber at the rear of the structure. They reversed direction and traveled toward the front through large flue tubes extending through the shell, and then exited through the smoke manifold. The path under and then back through the boiler shell offered the flue gases every opportunity to transfer energy to the water within and convert it into steam.

Return-tube boilers were workhorses that withstood the harsh treatment and neglect endemic to the mine as a workplace. However, boiler tenders and firemen had to attend to a few basic services to avoid the loss of life, disastrous explosions and ruptures. First, they had to keep the boiler at least two-thirds full of water. Second, the fireman had to clean the ashes out of the ash pit regularly to ensure that the fire did not suffocate. Third, the fireman ensured that the water and steam valves were operational, and that the pressure did not exceed the critical point. Last, the fireman had to feed the fire. Skilled firemen were able to add just enough fuel in an even distribution so that the fire kept a fairly constant glow. To ensure that firemen and boiler tenders had easy access to plenty of coal, the mining engineer usually had a coal bin built facing the firebox doors. In other circumstances cordwood may have been stacked in the bin’s place.

Mining engineers with access to plenty of capital installed additional devices designed to improve the energy efficiency and performance of their return-tube boilers. First, they may have elected to install feed water holding tanks to allow sediment and mineralization to settle out. Second, some engineers installed feed water heaters, which were small heat-exchanging tanks that used some of the boiler’s hot water or steam to preheat the fresh feed water. These had been proven to moderate the shock of temperature changes to the boiler, prolonging the vessel’s life, as well as increasing fuel efficiency. A few engineers working at the largest mines attempted to mechanize the input of coal into the fireboxes of heavily used boilers with mechanical stokers. While they were costly, mechanical stokers did a better job than laborers. Engineers also fitted heavily stoked boilers with rocking or shaking grates that sifted the ashes downward, promoting better combustion of the fuel. Last, many engineers had mineworkers wrap the heater, the steam pipes, and exposed parts of the boiler with horsehair or asbestos plaster as an insulation. Except for feed water heaters and insulation, only a few large mining companies employed these accessories because of the expense involved.[43]

At the time that boiler technology was nascent, in 1856 an American inventor named Wilcox devised a boiler radically different and much more efficient that the best return-tube models. Wilcox’s system consisted of a large brick vault capped with several horizontal iron water tanks. The vault contained a firebox, an ash pit, and a smoke chamber, all underneath 50 to 60 water-filled iron tubes. The tubes drew water from one end of the tanks and sent the resultant steam to the other end. By 1870, the design, known as the *water-tube boiler,* had been commercialized and was being manufactured by the firm Babcock & Wilcox.[44]

After Babcock & Wilcox’s water-tube boiler had proven itself in a number of industrial applications, mining engineers began to take an interest. The fact that the water ran through the tubes and not around them greatly increased the liquid’s heating area, which resulted in much greater efficiency than return-tube boilers. In

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[43] Ihlseng, *A Manual of Mining*, 581; Int. Textbook Co., *Mine Surveying*, A23: 53; Keystone Consolidated Publishing Co., *The Mining Catalog*, 115; Peele, *Mining Engineer's Handbook*, 2086.

[44] Croft, *Steam Boilers*, 18, 53; Greeley, et al., *The Great Industries;* Int. Textbook Co., *Steam and Steam-Boilers*, A18: 35; Linstrom and Clemens, *Steam Boilers*, 30; Peele, *Mining Engineer's Handbook*, 2083; Thurston, *A Manual of Steam Boilers*, 34; Tinney, *Gold Mining Machinery*, 63.

addition, the threat of a catastrophic explosion was almost nonexistent. By the 1890s, a number of mechanical engineers had devised other water-tube boilers that saw production, such as the Heine, the Sterling, the Wickes, the Hazelton, and the Harrisburg-Starr.

The problem with all of the above models, however, was that they required much more attention than the rugged return-tube boilers, were significantly more costly to purchase, and were beyond the understanding and field skills of average mining engineers. As a result, water-tube boilers saw use only at large, well-capitalized mines under the supervision of talented, professionally trained engineers. As the prices of water-tube boilers fell during the 1900s and capital became abundant following the Silver Crash of 1893, the popularity of the efficient steam generators began growing. However, the introduction of practical electricity in the 1910s prevented the widespread adoption of water-tube boilers.

3.2.4 Headframes

Nearly all mechanical hoisting systems in Colorado required that the mining operation erect a headframe over the shaft. The purpose of the headframe was to support and guide the hoist cable into the shaft and to assist the transfer of rock from and supplies into the hoisting vehicle. Professionally educated mining engineers recognized six basic structural forms of headframes, including the tripod and tetrapod used with horse whims, as well as the two-post gallows, four- and six-post derricks, and the A-frame (Table E.II.2).

Table E.II.2: Headframe Specifications: *Type, Material, Class*

Headframe Type	**Material**	**Class**	**Capital Investment**
Tripod	Hewn Logs	Sinking	Very Low
Tripod	Light Timber	Sinking	Very Low
Two Post (Gallows Frame): Small	Timber	Sinking	Low
Two Post (Gallows Frame): Large	Timber	Production	Low to Moderate
Two Post (Gallows Frame): Large	Steel	Production	Moderate to High
Four Post: Small	Light Timber	Sinking	Low
Four Post	Timber	Production	Moderate
Six Post	Timber	Production	Moderate to High
Four and Six Post	Steel	Production	High
A-Frame	Timber	Production	Moderate to High
A-Frame	Steel	Production	High

(Twitty, *Reading the Ruins*, 281).

The *two-post gallows* was one of the most common headframes erected in Colorado, and self-made and professionally educated engineers unanimously agreed that it was best for prospecting (Fig. E.II.38).

Fig. E.II.38 A four-post type headframe. This offers characteristic aspects, including four posts, cross-members joining the posts, and diagonal backbraces extending toward the hoist (out of view). The headframe features a second landing to use vertical space, and a rock pocket on the landing to receive loads from a skip. Eric Twitty, Joe Dandy Mine, taken 1998.

The variety used by small operations usually consisted of two upright posts, a cap timber and another cross-member several feet below, and diagonal backbraces, all standing at most 25 feet high (Fig.E.II.39).

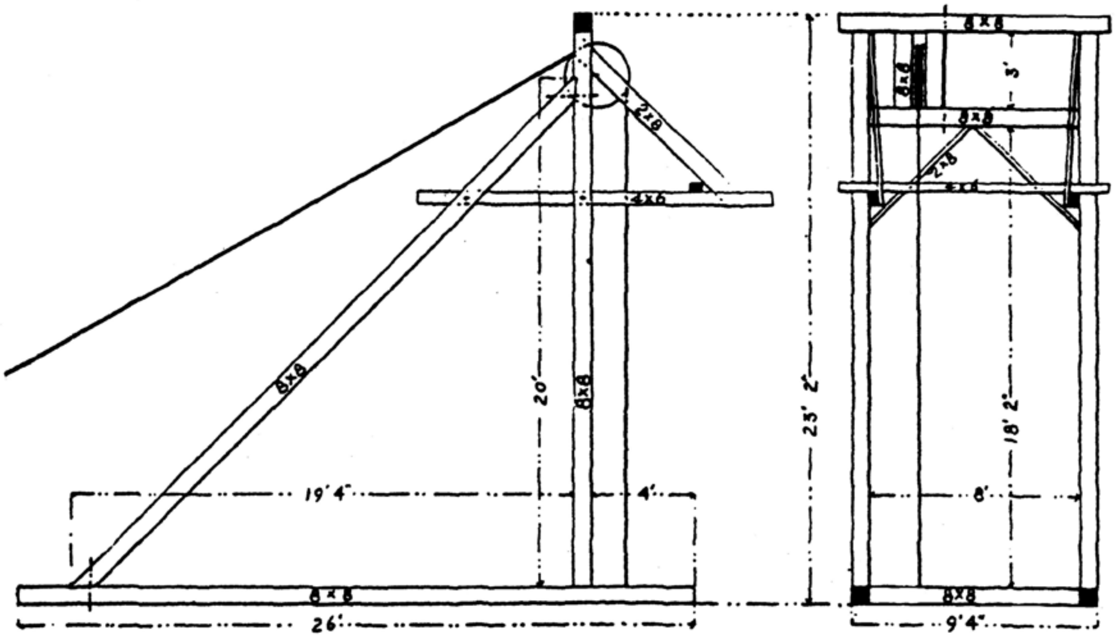

Fig. E.II.39 Because of their simplicity and low costs, prospect outfits usually erected two-post gallows headframes over their shafts. The diagram depicts side-and front views. Sinking-class headframes tended to be less than 25 feet high and stood on timber footers that straddled the shaft. Forsyth, "The Headframes," 366.

The cap timber and lower cross-member featured brackets that held the sheave wheel in place. The gallows portion of the structure stood on one end of a timber foundation equal in length to the headframe's height. The diagonal backbraces extended from the posts down toward the hoist, where they were tied into the foundation footers. The foundation, made of parallel timbers held together with cross-members, rested on the surface of the ground and straddled the shaft collar.

The four-post derrick erected for prospecting was similar in height, construction, and materials to two-post headframes, but featured four posts instead of two, and stood on a timber foundation (Fig. E.II.40).

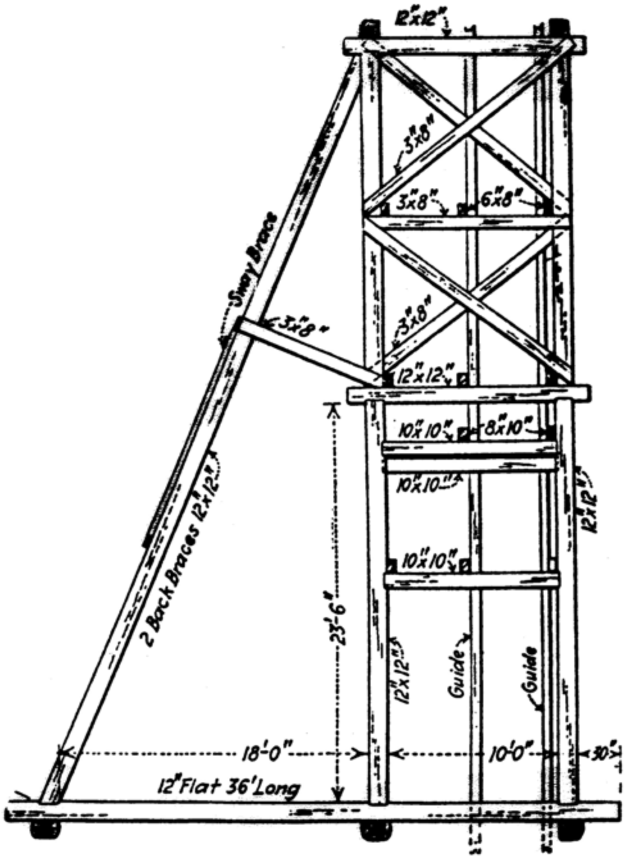

Fig. E.II.40 A four-post derrick headframe. A few prospect outfits erected four-post derrick headframes over their shafts. Sinking-class versions were less than 25 feet high. Four-post derricks were superior to two-post gallows types, and some outfits used small versions for ore production. Botsford, "Small Timber Headframe," 1215.

The A-frame was based on the same design as the two-post gallows. The difference between the two types of structures was that the A-frame featured fore and aft diagonal braces to buttress the structure in both directions. A-frames were not erected directly over an inclined shaft, rather they were placed between the hoist and shaft so that the angle of the cable extending upward from the hoist equaled that extending down the inclined shaft.

The common features shared by the above structures included a small size, simplicity, minimization of materials, ease of erection, and portability of materials. For comparison, a two-post gallows frame 20 feet high cost as little as $50 and a slightly larger structure cost $150, while a production-class A-frame cost $650, and a production-class four-post derrick headframe cost up to $900.[45]

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[45] Twitty, *Reading the Ruins,* 215.

Sinking-class headframes had to withstand only a few basic stresses that the mining engineer had to consider when designing the structure. The three most significant forces consisted of the live load, created by the weight of a full hoist vehicle and cable, the braking load, which was a surge of force created when the hoistman quickly brought the vehicle to a halt in the shaft, and the horizontal pull of the hoist. To counter these forces, mining engineers had workers build their headframes of 8x8 timbers, and they installed diagonal backbraces to counter the pull of the hoist. Usually carpenters assembled the primary components with mortise-and-tenon joints, 1-inch diameter iron tie rods, and lag bolts. Professionally trained mining engineers specified that the diagonal backbraces were most effective when they bisected the angle of dead vertical and the angle formed by the hoist cable ascending to the top of the headframe. By tying the backbraces into the foundation between the shaft and hoist, engineers had determined that the total horizontal and vertical forces put on the headframe would have been equally distributed among both the vertical and the diagonal posts. When a mining engineer attempted to find the mathematically perfect location for a hoist after erecting a headframe at a prospect shaft, he merely had to measure the distance from the shaft collar to the diagonal brace, double the length, and build the hoist foundation. Many prospect operations followed this general guideline and arranged their hoisting systems accordingly, but a few poorly educated engineers strayed and gave the diagonal braces either too much or too little of an angle.[46]

Unlike the simplicity of sinking-class headframes, production-class headframes were more complex and designing them was rigorous. Mining engineers had to account for a variety of stresses, consider the structure’s multiple functions, and coordinate the structure with other hoisting system components. They had to build a structure capable of withstanding vertical forces including an immense dead load, live load, and braking load. Engineers had to calculate horizontal forces including the powerful pull of the hoist and windshear, which could not have been underestimated in Colorado. Last, mining engineers had to plan for racking and swaying under loads, and vibration and shocks to the structure.[47]

Building a headframe that could stand under the sum of the above forces was not enough for service at a producing mine. Mining engineers had to forecast how they thought the headframe would interact with the mine’s production goals, and how it would interface with the rest of the hoisting system. The depth of the shaft, the speed of the hoist, and the rail system at the mine directly influenced the height of the structure. Deep shafts served by fast hoists required tall headframes, usually higher than 50 feet, to allow the hoistman plenty of room to stop the hoisting vehicle before it slammed into the sheave at top. Highly productive mining operations often utilized vertical space on their claims and constructed multiple shaft landings. Some companies using skips as hoist vehicles built rock pockets into the headframe, which required height.

Mining engineers found four basic headframe designs adequate for the needs of heavy ore production. These included the *four-post derrick*, the *six-post derrick*, an *A-frame* known also as the *California frame*, and a heavily-braced two-post structure known as the *Montana type* (Fig. E.II.41).

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[46] Ibid.

[47] Ihlseng, *A Manual of Mining*, 91; Int. Textbook Co., *Preliminary Operations*, A23:105; Int. Textbook Co., *Hoisting, Haulage, Mine Drainage*, A53: 31; Ketchum, *The Design of Mine Structures*, 41; Peele, *Mining Engineer's Handbook*, 926; Twitty, *Reading the Ruins*, 274.

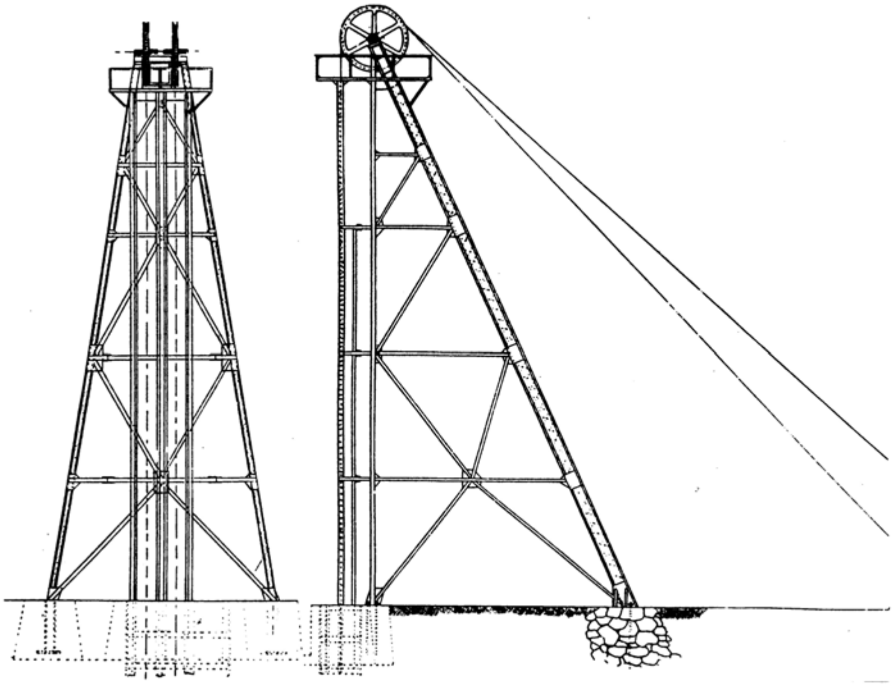

Fig. E.II.41 A production-class headframe. Mining companies erected production-class headframes to match the rest of the hoisting system. Many headframes were enlarged versions of the four-post derrick (Fig.E.II.40). The illustrated headframe is a production-class two-post gallows structure known as the Montana type. Production-class headframes are more than 25 feet high. Twitty, *Riches to Rust,* 233.

As the names suggest, engineers working in specific regions in the West favored certain headframe designs over others. While the above structures were intended to serve vertical shafts, two-post gallows headframes and a variety of A-frames up to 35 feet high were also erected to serve inclined shafts such as those at coal mines.[48]

To meet the combination of horizontal and vertical forces and the performance needs, nearly all mining engineers in the West built their headframes with heavy timber beams assembled with mortise-and-tenon joints, timber bolts, and iron tie rods. In general, they used lumber of at least 10x10 inch dimensions and attempted to allocate full-length, uncut timbers for the posts and backbraces because of the solidity they offered. Skilled carpenters assembled the materials into towers that featured cross-members and diagonal bracing spaced every 6 to 10 feet. All four- and six-post headframes featured stout backbracing anchored between the shaft and the hoist, and the entire structure stood on foundation footers straddling the shaft. The posts on A-frames, on the other hand, were set at an exaggerated batter, meaning they splayed out to absorb all of the vertical and horizontal stresses, and as a result A-frames used in association with both vertical shafts and inclines rarely had backbraces. Four- and six-post headframes were much more common among Colorado's metal mines than A-frames, even though

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[48] Twitty, *Reading the Ruins,* 275.

they were more materials-intensive and costly to build, because these vertical structures were within the technical means of most professionally educated and self-taught engineers. A-frames, on the other hand, required a greater knowledge of mechanics and physics, and they were difficult to build.[49]

Mining engineers determined that production-class headframes, which weighed dozens of tons, required sound and substantial foundations to remain stable. A pre-planned and well-built foundation was one factor that set these structures apart from sinking-class headframes. When an engineer erected a production-class surface plant from scratch, he simply put a crew to work clearing soil to bedrock around the proposed shaft, on which the crew built a timber framework for the headframe. The engineer who assumed a semi-developed prospect shaft inherited significant expense because workers had to clear off the unconsolidated waste rock dump left by the previous operation.

Engineers used one of three basic types of foundations to support production-class headframes. The first consisted of a squat timber cube featuring bottom sills, timber posts, and caps bolted over the posts. Construction workers stuffed logs, timber blocks, and boulders under the bottom sills to level them when the foundation was built on sloped ground. The other types of foundations included a group of hewn log cribbing cells assembled with notches and fastened with forged iron spikes, and a hewn log or timber latticework consisting of open cubes between 4 and 6 feet high, capped with dimension timbers. When any of the three foundation systems were built, workers sided the shaft walls with plank lagging and timbering, and filled the surrounding foundation framework with waste rock as quickly as the miners underground generated it. The problem with the above foundations was that the perishable wood rotted when covered with waste rock, especially when the rock was highly mineralized. A few progressive mining engineers attempted to substitute concrete or rock masonry for wood to gain a lasting foundation, but only well-financed companies anticipating lengthy operations spent the time and money to erect such foundations.[50]

In the 1890s, professionally trained mining engineers working for the wealthiest and largest mining companies began experimenting with steel girders for headframes as an alternative to timber. According to many prominent mining engineers, steel was the ultimate building material for production-class operations because it did not decay, was much stronger, was non flammable, and facilitated the erection of taller headframes. However, steel was significantly more expensive than timber, and as a result, only the most heavily capitalized and highly productive companies put up steel structures.

Mining operations active during and after the Great Depression had the same needs for headframes as their predecessors. Most Depression-era outfits tended to rehabilitate abandoned mines instead of sinking shafts anew to save capital, and some of the early mines already featured headframes. In such cases, the mining outfit merely had to effect necessary repairs to render the structure serviceable. If the mine lacked its original headframe, then the outfit had to erect another one, and the replacement structures differed according to the outfit’s nature.

Large mining companies under the guidance of formally trained engineers continued the practice of building four- and six-post derricks and A-frames to meet the rigors of ore production. Mining engineers still considered steel to be the ultimate answer for production-class headframes, although out of financial necessity they often resorted to timbers. But by the 1930s, a certain element of construction quality and craftsmanship had been lost. Workers no longer took the trouble to assemble the structure with intricate mortise-and-tenon joints. Instead, they simply butted the timbers against each other or created shallow square notch joints and bolted the frame together.

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[49] Int. Textbook Co., *Hoisting, Haulage, Mine Drainage*, A53: 35; Ketchum, *The Design of Mine Structures*, 7; Peele, *Mining Engineer's Handbook*, 935.
[50] Twitty, *Reading the Ruins*, 283.

Impoverished outfits with neither the funding nor the means to build substantial production-class headframes assembled small structures designed to be functional while incorporating little material. When possible, these mining companies relocated entire headframes from abandoned mines to their properties of interest. By nature, the headframes tended to be old sinking-class two-post gallows or four-post derrick structures because they were simple, easy to transport, and required no formal engineering. Poorly funded and well-capitalized mining companies both installed timber A-frames to serve inclined shafts.

One practice that many mining companies shared was the utilization of salvaged timbers for building their headframes. Stout timbers were a precious and costly commodity during and after the Great Depression, and in hopes of saving capital, mining companies reused the heavy beams left by abandoned operations. As a result, headframes remaining from the 1930s and afterward may feature timbers differing in exact dimensions, weathering, and quality of the wood. In addition, salvaged timbers frequently exhibit abandoned mortise-and-tenon joint sockets, as well as abandoned bolt- and nail holes. The heavy use of such material for headframes, as well as for other structures, is typical of Depression-era construction

3.3 Additional Surface Plant Components

The above descriptions of adit and shaft mines account for the elementary surface plant components found at both types of operations. Productive mining companies, however, often installed additional surface facilities that enhanced their ability to increase production and sustain activities underground. Below are descriptions of these facilities, and one or all the components could have been erected at adit, shaft, open-pit, and coal mines.

3.3.1 Air Compressors

Blasting was of supreme importance to mining because it was the prime mover of rock underground. During much of the nineteenth century, miners traditionally drilled holes by hand, loaded them with explosives, and fired the rounds. Hand-drilling proved slow, but no practical alternative existed to take its place until mining companies began introducing mechanical rockdrills during the 1870s and 1880s. When drilling by hand, miners typically advanced tunnels and shafts only one to three feet per shift in hard rock. With the types of drills manufactured during the 1880s and 1890s, miners were able to advance a tunnel or shaft approximately three to seven feet per shift, instead. The mechanical drills permitted miners to bore greater numbers of deeper holes in the same length of time. Further, improvements in drilling technology during the 1890s and 1900s permitted miners to make even greater progress. The rates of work achieved with the greasy and noisy machines convinced many mining engineers that the relatively high costs of installing and running compressed-air systems to power the mechanical rockdrills was justified. The air compressor lay at the heart of the compressed-air system (Table E.II.3).[51]

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[51] Gillette, *Rock Excavation*, 15; Hoover, *Principles of Mining*, 150; Int. Correspondence Schools, *Rock Boring*, 13; Peele, *Mining Engineer's Handbook*, 184, 213; Young, *Elements of Mining*, 87.

Table E.II.3: Air Compressor Specifications: *Type, Popularity Timeframe, and Capital Investment*

Compressor Type	Age Range	Capital Investment
Upright: 2 Cylinders, Belt Driven	1900s-1940s	Low
Upright: 3 to 4 Cylinders, Integral Gasoline Piston	1930s-Present	Moderate
V Pattern	1930s-Present	Moderate to High
Straight-Line, Single Stage, Gasoline Engine Driven	1900s-1930s	Low
Straight-Line, Single Stage, Steam Driven	1880s-1920s	Moderate
Straight-Line, Two Stage, Steam Driven	1890s-1920s	High
Straight-Line, Triple Stage, Steam Driven	1890s-1920s	Very High
Straight-Line, Single Stage, Geared to Electric Motor	1900s-1920s	Moderate
Straight-Line, Various Stages, Geared to Electric Motor	1900s-1920s	High
Straight-Line, Single Stage, Belt Driven by Electric Motor	1900s-1940s	Low
Duplex, Single Stage, Steam Driven	1890s-1920s	Moderate
Duplex, Two Stage, Steam Driven	1890s-1920s	High
Duplex, Triple Stage, Steam Driven	1890s-1920s	Very High
Duplex, Two Stage, Belt Driven	1900s-1940s	Moderate
Duplex, Three Stage, Belt Driven	1900s-1940s	Moderate to High

(Twitty, *Reading the Ruins*, 130).

While air compressors manufactured between the 1880s and 1920s came in a variety of shapes and sizes, they all operated according to a single basic premise. Compressors of this era consisted of at least one relatively large cylinder, much like a steam engine, which pushed air through valves into plumbing connected to an air-receiving tank. The volume of air that a compressor delivered, measured as *cubic feet of air per minute* (cfm), depended on the cylinder's diameter and stroke, as well as how fast the machine operated. The pressure capacity, measured as *pounds per square inch* (psi), depended in part on the above qualities as well as how stout the machine was, its driving mechanism, and on check valves in the plumbing. Generally, high pressure, high-volume compressors were large, strong, durable, complex, and as a result, expensive.

The mechanical workings of the air compressors manufactured prior to around 1890 were relatively simple. The two most popular compressor types were *steam-driven straight-line* and the *steam-driven duplex* models, and both styles served as a basis for designs that served the mining industry well for over 60 years. The straight-line compressor, named after its physical configuration, was the least expensive, oldest, and most elemental of the two types of machines. Straight-line compressors were structurally based on the horizontal steam engine and featured a large compression cylinder at one end, a heavy cast-iron flywheel at the opposite end, and a steam cylinder situated in the middle, all bolted to a cast-iron bedplate. The steam cylinder powered the machine and the flywheel provided momentum and smoothed the motion (Fig E.II.42).

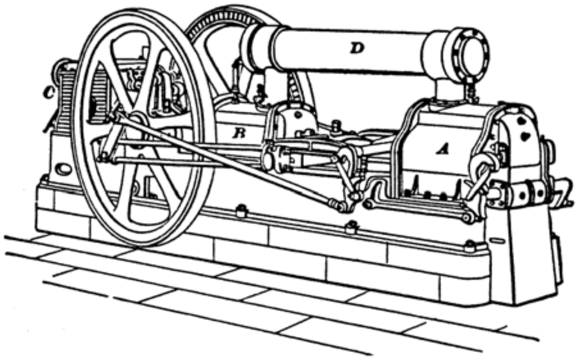

Fig. E.II.42 A typical straight-line steam compressor that provided two compound stages of compression. A compression cylinder is on the right, a high-compression cylinder in the center, and the steam-driven cylinder is on the left. Int. Textbook Co., *Steam and Steam Boilers,* A20: 32.

During the 1870s and early 1880s, mechanical engineers improved many of the inefficiencies attributed to early straight-line compressors. First, engineers modified the compression cylinder to make it double-acting, much like an old-fashioned butter churn, known as a duplex compressor (Fig E.II.43).

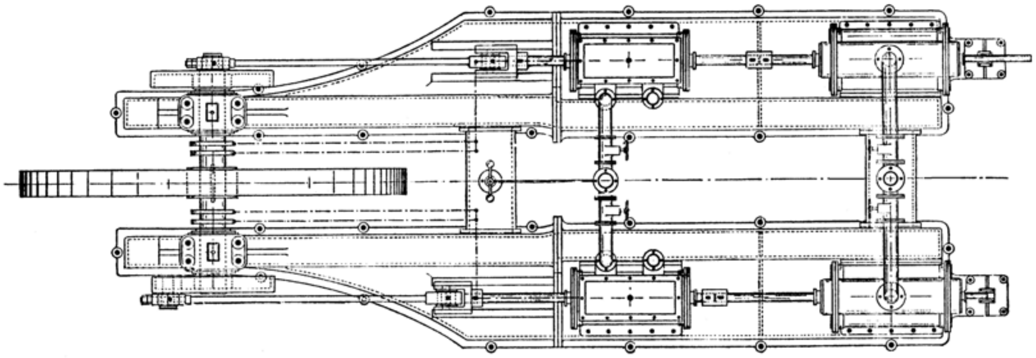

Fig. E.II.43 Plan view of a duplex steam compressor. The compression cylinders are at right, the steam-driven cylinders are in the center, and the flywheel is at left. Ingersoll, *Rock Drills,* 34.

In this design, which became standard, the compression piston was at work in both directions of travel, being pushed one way by the steam piston and dragged back the other way by the spinning flywheel. In so doing the compression piston devoted 100% of its motion to compressing air.

The other fundamental achievement concerned cooling. By nature, air compression generated great heat, which engineers found not only fatigued the machine but also greatly reduced efficiency. Early compressor makers added a water-misting jet that squirted a spray into the compression cylinder, cooling the air and the machine's working parts. While the water spray solved the cooling issue, it washed lubricants off internal working parts and humidified the compressed air, all of which significantly shortened the life of what constituted an expensive system. By the mid-1880s, American mining machinery makers replaced the spray with a cooling jacket, leaving the internal working parts dry and well oiled. Mining companies employing the machines had to include a water system for cooling, which was usually no more that a water tank plumbed to the compressor.

During the early 1880s, mechanical engineers forwarded several other significant improvements. Engineers found that coupling the compression piston to the steam piston with a solid rod, so that both acted in tandem, proved highly inefficient. The steam piston was at its maximum pushing power when it was just beginning its stroke, while the compression piston, also beginning its stroke, offered the least resistance. When the steam piston had expended its energy and reached the end of its stroke, the compression piston offered the greatest resistance because the air in the cylinder had reached maximum compaction. Mechanical engineers recognized this wasteful imbalance and designed an intermediary crankshaft that reversed the relationship between the pistons. Despite the superior efficiency of this design, mining companies usually selected the simpler compressors with solid shafting because it cost less.

During the late 1880s and early 1890s, mining engineers fine-tuned compressed-air technology used for hardrock mining. The most significant advance was a design that generated greater air pressure, which made drills run faster and improved the pressurization of the maze-like networks of plumbing in large mines. Mining machinery makers began offering straight-line and duplex compressors capable of achieving what the industry termed *multistage compression*. To increase pressure, mechanical engineers divided the compression between high and low-pressure cylinders in several stages, instead of in a single cylinder. They designed the low-pressure cylinder to be relatively large, and it forced semi-compressed air into the small high-pressure cylinder, which highly compressed the air and released it into a receiving tank.

Mining machinery makers released variations of multistage straight-line compressors with two and even three compression cylinders coupled onto the steam-driven piston, and they produced duplex compressors with several multistage cylinder arrangements. The most common multistage duplex compressor was the *cross-compound* arrangement, in which one side of the machine featured the low-pressure cylinder, and the air passed from it through an intercooler to the high-pressure cylinder on the other side. In general, companies with heavy air needs installed multistage compressors while operations with limited capital continued to rely on the less costly, conventional models.

As the 1890s progressed toward the turn of the century, mining machinery makers began to offer air compressors that were smaller, more efficient, and provided better service for the expense than the duplex and straight-line designs manufactured up to that time. Machinery makers adapted several designs to be run by electric motors and gasoline engines, which were energy sources well suited for remote mines. Progressive mining engineers working in regions where fuel was costly eagerly experimented with electricity and gasoline, while mining companies in areas where coal and cord wood were more plentiful continued to install steam compressors as late as the 1910s. Gasoline and electric compressors underwent gradual acceptance rather than being embraced overnight, but once they had proven their worth by the 1910s, many mining companies throughout Colorado replaced their aging steam equipment with electric and petroleum-powered machinery.

Motor-driven compressors were ideally suited for progressive mining districts wired for electricity, and because motor-driven compressors lacked steam equipment and needed no boilers, they cost less. The motor-driven compressors offered by machinery manufacturers around the turn of the century were based on belt-driven models made since the early 1880s (Fig E.II.44).

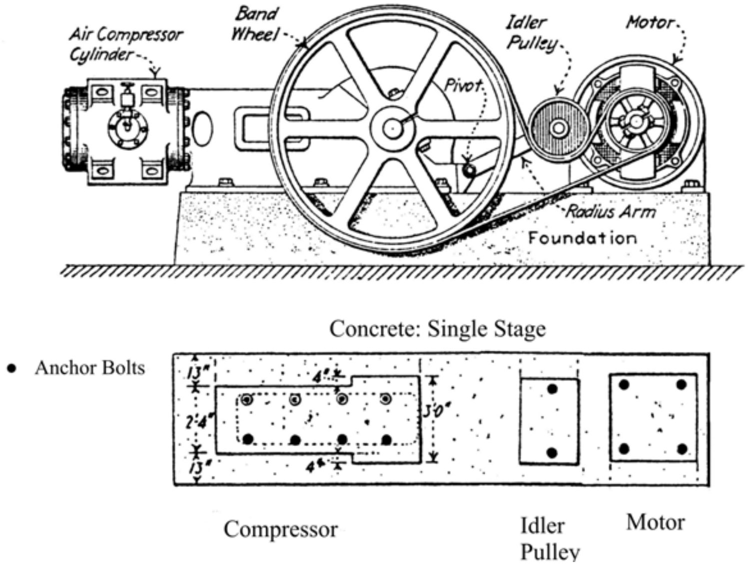

Fig. E.II.44 A type of small electric belt-driven straight-line compressor introduced during the 1900s, and popular between the 1910s and 1940s. The plan view underneath depicts a foundation for such a machine. These compressors were rarely longer than 9 feet. Twitty, *Riches to Rust*, 107; Croft, *Machinery Foundations and Erection*, 398.

By the late 1890s, mining machinery makers offered three basic types of electric compressors, including a straight-line machine that was approximately the same size as traditional steam versions, a small straight-line unit, and a duplex compressor. Duplex models, conducive to multistage compression, were most popular among medium-sized and large mining companies, while moderately sized mining operations favored the small straight-line units. Due to limited air output compared with a relatively large floor space, the large electric straight-line compressors never saw popularity.

Compressor makers also developed economically attractive gasoline units ideal for remote and inaccessible operations. The gasoline compressor, introduced in practical form in the late 1890s, consisted of a straight-line compression cylinder linked to a single cylinder gas engine. Most mining engineers considered gas compressors to be for sinking duty only. Large gasoline machines were capable of producing up to 300 cubic feet of air at 90 pounds per square inch, permitted mining companies to run up to four small rockdrills.[52]

The noisy gasoline machines had needs similar to their steam-driven cousins. Gasoline compressors required cooling, a fuel source, and a substantial foundation capable of withstanding intense vibration, and they came from the factory either assembled or in large components for transportation into the backcountry. The cooling system often consisted of no more than a water tank, and the fuel system could have been simply a large sheet-iron fuel tank connected to the engine by ¼ to ½ inch metal tubing.

By the 1910s, the use of rockdrills had rendered hand-drilling uneconomical except for special applications. The trend continued through the 1920s as rockdrill makers offered an ever widening variety of machines that accomplished even the limited specialized work previously completed by hand-drilling. Mining

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[52] Twitty, *Reading the Ruins*, 126.

during and after the Great Depression was no exception, and miners had come to rely on drills more than ever to achieve production.

The motor-driven duplex and straight-line compressors introduced during the 1900s and 1910s maintained supremacy among mining operations through the 1940s. Well-financed mining companies requiring high volumes of air at high pressures continued to favor belt-driven duplex compressors, while companies with slightly reduced air needs relied on relatively inexpensive single-stage belt-driven straight-line compressors.

Despite the common reliance on older designs, compressed-air technology had undergone dynamic changes since the 1910s. Mechanical engineers began to experiment with unconventional designs beginning in the 1900s, and during the 1910s several of these models experienced commercial production. By the 1930s, mining companies in Colorado became interested in some of the modern designs in hopes of maximizing efficiency. The popularization of automobile engines gave rise to several alternative forms of compressors based on engine mechanics. By the 1910s, an *upright two-cylinder compressor* with valves and a crankshaft like an automobile engine had become popular. Used on an experimental basis as early as the 1900s by prospect operations, these units were inexpensive, adaptable to any form of power, and weighed little. Further, mining machinery makers had mounted them onto four-wheel trailers or simple wood frames for mobility. *V-cylinder compressors*, also known as *feather-valve compressors*, were adaptations of large-displacement truck engines and featured 3 to 8 cylinders arranged in a "V" configuration (Fig. E.II.45). The new design relied on a grossly enlarged radiator for cooling and was powered by an electric motor directly coupled onto the crankshaft.

Fig. E.II.45 A three-cylinder V-cylinder compressor, belted to an electric motor, Gold King Mine, Cripple Creek. By the 1930s, capitalized mining companies in Colorado began to employ V-cylinder compressors, such as in this photograph. The compressor design was based on large-displacement truck engines and featured a radiator for cooling. Eric Twitty, taken 1998.

In most cases, when a mine was abandoned the compressor was removed, leaving the foundation as the machine's only representation, and based on a foundation's footprint, the researcher can often determine the exact type of compressor.

Straight-line steam compressors usually stood on foundations that featured a rectangular footprint and a flat top-surface studded with two rows of anchor bolts. In general, workers used masonry or concrete, although they bolted some machines less than 12 feet long to timber foundations (Fig E.II.46).

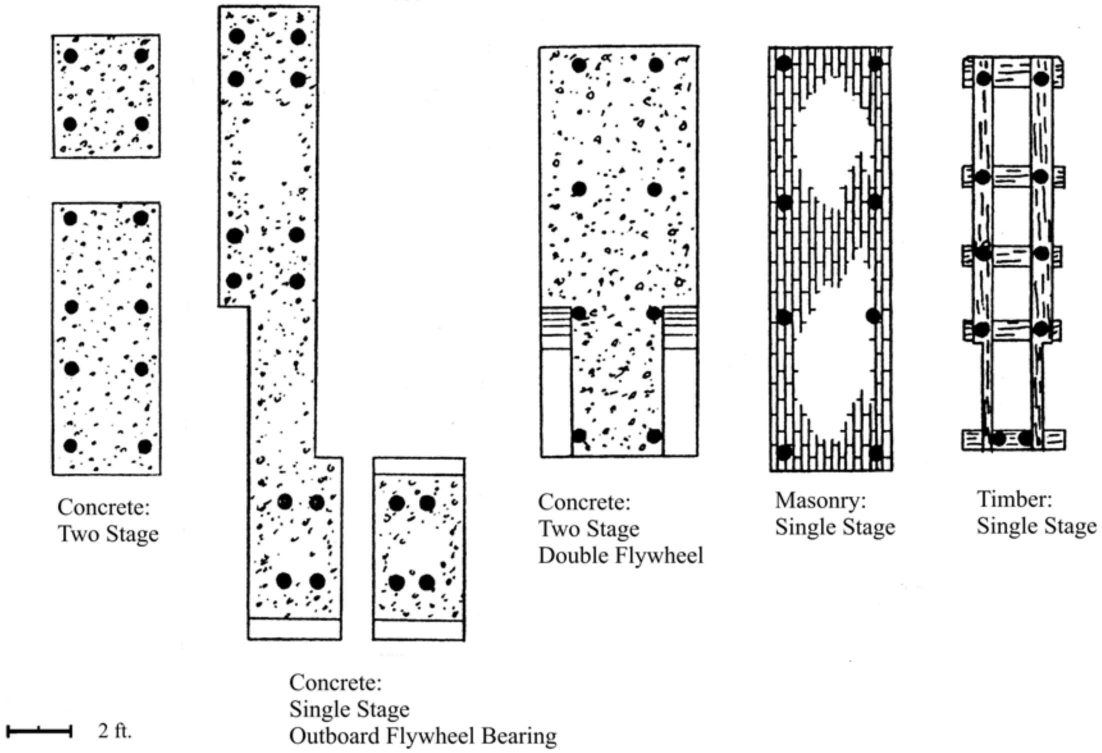

Fig. E.II.46 Plan views of foundations for straight-line steam compressors. Twitty, *Riches to Rust*, 107, 145.

Foundations for large compressors often featured individual blocks for the steam and compression cylinders and a separate pedestal adjacent to one end for an outboard flywheel bearing. Foundations for duplex steam compressors manufactured between the 1870s and 1890s consist of a pair of rectangular pads spaced several feet apart (Fig. E.II.47).

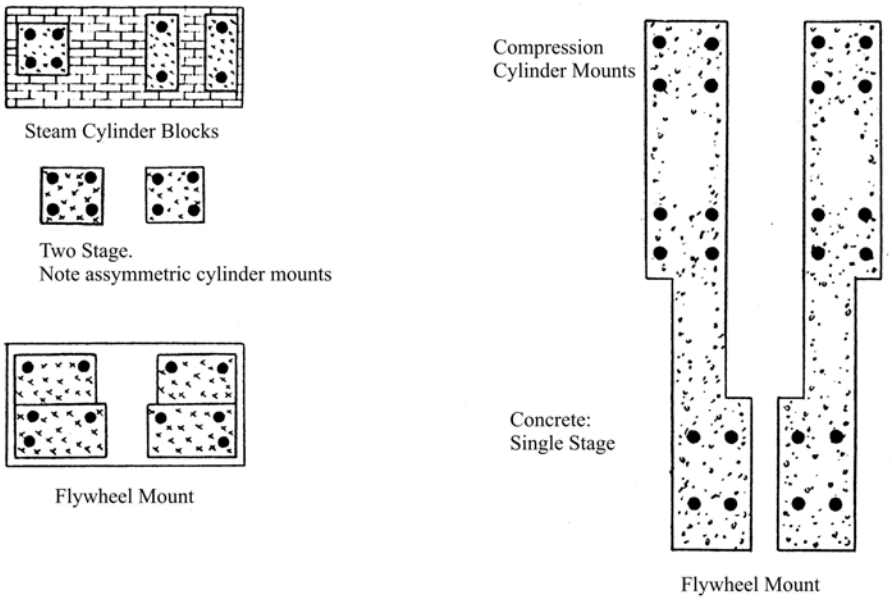

Fig. E.II.47 Plan views of foundations for duplex steam compressors. The foundation at left is for a compound unit that compressed air in several stages. The foundation at right is for a machine similar to that in Fig. E.II.43. Twitty, *Riches to Rust,* 108.

Workers almost always used masonry or concrete, and both pads feature a symmetrical arrangement of anchor bolts. Foundations for large machines often featured individual stone blocks for the steam and compression cylinders, and the flywheel, which rotated in the gap between. The smaller, compact duplex compressors introduced during the late 1890s were bolted to foundations easily identified today. Foundations for these machines are U-shaped, slightly rectangular, and tend to be several feet high.

Straight-line belt-driven compressors were bolted to foundations similar in appearance and size to those for their steam-driven counterparts (Fig. E.II.48).

Because belt-driven compressors usually featured a heavy, large flywheel, their foundations often featured a separate pedestal adjacent to one end for the flywheel's outboard bearing. A second, rectangular foundation for the drive motor, usually 3 by 3 feet in area or less, should be located nearby.

Compact duplex belt-driven compressors were bolted to the same type of foundation as their steam-driven cousins (Fig. E.II.49).

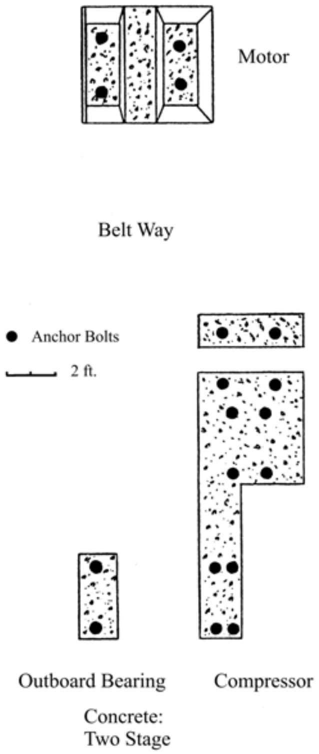

Fig. E.II.48 Plan view at right of a typical foundation for a two-stage belt-driven straight-line compressor. These machines fell out of favor by the 1910s. Twitty, *Riches to Rust*, 107.

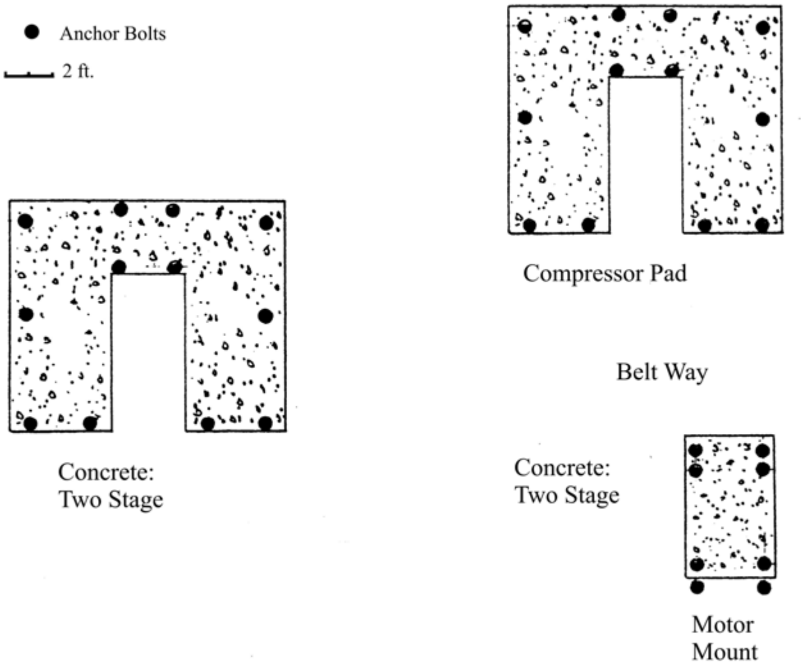

Fig. E.II.49 Typical foundations for compact duplex compressors introduced during the late 1890s. The foundation on the left anchored a steam-driven version. The foundation on the right anchored a unit driven by a motor via a belt. Steam models fells out of favor by the 1910s and belt-driven models were popular into the 1940s. Twitty, *Riches to Rust*, 108-9.

A small, rectangular foundation for the drive motor should be located nearby and directly aligned with the open end of the compressor foundation. Due to severe vibrations, petroleum compressors were usually bolted to stout concrete foundations often several feet high. The foundation is almost always rectangular, several feet wide, less than 9 feet long, and features two rows of anchor bolts.

Upright compressors, small in size, could have been bolted to either timber or concrete foundations rectangular in footprint. A pad for the engine or motor should be adjacent and aligned.

Foundations for V-cylinder compressors tend to be fairly distinct and often feature an adjacent mount for a motor or engine (Fig E.II.50).

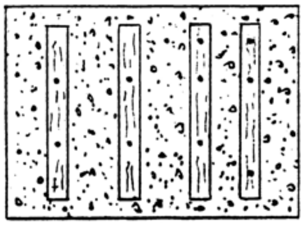

Fig. E.II.50 A typical foundation for a V-cylinder compressor. These types of compressors were introduced during the 1930s and saw popularity afterwards. Twitty, *Riches to Rust*, 275.

Compressors that featured several cylinders were often bolted to rectangular foundations between 4 by 5 feet and 3 by 3 feet in area, while the foundations for machines with numerous cylinders were several feet wide and up to 10 feet long. Workers often constructed foundations with a series of closely spaced timbers bolted to either an underlying concrete pad or buried timber footer.

3.3.2 Electricity

Mining engineers in the West began experimenting with electricity as early as 1881 when the Alice Mine & Mill in Butte, Montana attempted to illuminate its perpetually dim passages and buildings with light bulbs. At that time, electric technology was new and its practical application was limited primarily to lighting. During the 1880s, visionary inventors demonstrated that electricity was able to do mechanical work as well, which interested progressive mining engineers.[53]

During the late 1880s and into the early 1890s, engineers working for profitable and well-capitalized companies in developed mining districts attempted to turn their curiosity into practical use. They made their first attempts to run machinery in locations that featured a combination of water and topographical relief where they could generate hydropower. In 1888, the Big Bend Mine on the Feather River in California experimented with electricity, and the Aspen Mining & Smelting Company, in Aspen, Colorado, used electricity to run a custom-made electric hoist that served a winze underground. Two years later, progressive mining companies in Telluride and Rico adapted electricity to run machinery and illuminate the darkness. Colorado, and especially the San Juan Mountains, continued to be a proving ground for the application of electricity through the 1890s, although electric plants were a rarity in the greater West until the late 1890s. Inherent limitations in electrical technology were the main reason why the mining West was slow to embrace the power source at first.

Several factors came into play that excited interest in electrification during this time. First, the nation’s economy and the mining West were recovering from the severe economic depression associated with Silver Crash of 1893, and mining companies once again had capital to work with. Second, electrical and mining engineers had made great strides in harnessing electricity for the unique work of mining. The earliest electrical circuits wired during the 1880s and early 1890s were energized with Direct Current (DC) which had a unidirectional flow, and during this time mining engineers were experimenting with Alternating Current (AC), which oscillated.

Neither power source, as they existed during the 1890s, was particularly well suited for Western mining. AC current had the capacity to be transmitted over a dozen miles with little energy loss, but AC motors were incapable of starting or stopping under load. Therefore AC was worthless for running hoists, large shop appliances, and other machines that experienced sudden drag or required variable speed. AC electricity was effective, however, for running small air compressors, ventilation fans, and mill equipment because they were constant-rotation machines that offered little resistance. DC electricity, on the other hand, had the capacity to start and stop machinery under load, but the electric current could not be transmitted more than several miles without suffering debilitating power loss. Therefore DC current had to be used adjacent to its point of generation. In addition, DC motors were incapable of running the massive production-class machines that mining companies had come to rely on for profitable ore extraction.[54]

Based on the above, electrical technology as it existed during the 1890s offered mining companies little incentive to junk even small pieces of sinking-class steam equipment. However, enough progressive industrialists and engineers saw the benefits offered by electricity to keep the movement of application going. As a result, in the

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[53] Twitty, “From Steam Engines to Electric Motors.”

[54] Int. Textbook Co., *Steam and Steam-Boilers*, A23: 5; Peele, *Mining Engineer's Handbook*, 1126; Twitty, “From Steam Engines to Electric Motors.”

mid- and late 1890s a few capitalists formed electric companies that wired well-developed mining areas such as Cripple Creek, Telluride, Silverton, Central City, and Creede. More electric companies formed in districts of similar magnitude during and shortly after 1900. The characteristics that these mining districts shared was that they were compact and limited in area, lending themselves to DC power distribution, and they encompassed a high density of deep, large, and profitable mines, which constituted a potentially significant consumer base.

Around 1900, electrical appliance manufacturers made several important breakthroughs that rendered the power source useful for mining. Electricians developed the three-phase AC motor, which could start and stop under load while using a current that could be transmitted long distances. They also invented practical DC/AC converters, which permitted the use of DC motors on the distribution end of an AC electric line. The net result was that electricity became an attractive power source to a broad range of electric consumers.

Still, many Colorado mining companies were not yet willing to relinquish traditional steam technology because even the new three-phase AC motors were capable of only driving sinking-class hoists and small compressors. In addition, voltage, amperage, and current had not yet been standardized among machinery manufacturers or among the various power grids, which discouraged engineers from embracing the use of motors for critical mine plant components. Many pragmatic, professionally educated mining engineers felt that while electricity indeed offered benefits during the 1900s and 1910s, it was nowhere near ready to replace steam power.[55]

The rigors of mine hoisting proved to be one of the greatest obstacles electricity had to overcome, but by the 1900s mining machinery manufactures had developed a variety of small AC and DC models that were reasonably reliable. The early electric hoists were similar in design to sinking-class geared steam hoists, and they were manufactured by mining machinery makers with motors wholesaled from electric appliance companies such as General Electric. Even though the electric hoists were able to start and stop under load, they were very slow and had a limited payload capacity.[56]

By the 1910s, the application of electricity progressed to the point where mining engineers could not deny the potential savings in operating costs, and that the performance of electrical machinery was rapidly approaching that of all but the titanic direct-drive steam hoists. As steam machines began showing wear after years of use, the engineers in charge of large and medium-sized mines began replacing them with electric models, and some of the new apparatuses demonstrated that electricity was more efficient than steam. One engineer asserted that in well-developed mining districts, a steam-driven compressor cost up to $100 per horsepower per year to run while an electric model cost only $50. The cost savings were probably even greater for hoisting.[57]

Mining machinery makers had made the greatest advances with electric hoists during the 1910s. Not only had electrical engineers and machinery makers improved the performance and reliability of single-drum electric hoists, but also they introduced effective double-drum units for productive mines interested in achieving economies of scale through balanced hoisting. Within ten more years, except for remote and poorly capitalized operations, much of Colorado adopted electric power for hoisting as well as running other types of mining machinery.

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[55] Twitty, *Reading the Ruins*, 269.
[56] Ibid., 270.
[57] Ibid.

3.3.3 Architecture

Once a mining company had proven the existence of ore, the investors, who often had influence over management policy, fully expected the operation to perform throughout the year, during good weather and bad, until the ore had been exhausted. Attempting to comply with company wishes, mining engineers responded by using available capital to erect structures that sheltered important components of the surface plant against the weather. To this end, engineers understood that buildings served two purposes: mollifying the physical needs of the mine crew, and sheltering plant components that were intolerant of or performed poorly when exposed to adverse weather. The engineer and the mining company also had a tacit understanding that mine buildings possessed the ability to inspire investors and prominent figures in the mining industry. Large, well-built, and stately structures conveyed a feeling of permanence, wealth, and industrial might while small and poorly constructed buildings aroused little interest from investors and promoters.

Building materials, architectural styles, and structure layouts for mine buildings in Colorado changed between the 1890s and the 1920s. Perhaps small mining outfits in remote areas realized the greatest gain from changes in conventional construction practices as the expanding network of roads and railroads reduced the costs of importing building materials. Regardless of a mine's location, the buildings erected by well-financed, profitable, and large mining companies tended to be substantial and well-built while the buildings belonging to poorly funded and limited mining companies were crude, small, and rough.

Professionally trained mining engineers considered four basic costs that influenced the type, size, and constitution of the buildings they chose to erect. First, time had to be spent designing the structure. Second, basic construction materials had to be purchased and some items fabricated. Third, the materials had to be hauled to the site, and fourth, the mining company had to pay a crew to build the structure. Between the 1880s and around 1900, well-capitalized companies attempted to meet the above considerations by erecting wood frame structures sided with dimension lumber. In a few cases, small and poorly funded operations working deep in the mountains substituted hewn logs, but they understood that the log structures were intended to be impermanent, either to be replaced by dimension lumber should the mine prove a bonanza, or totally abandoned should the mine fail.

The introduction of steel and iron building materials to the mining industry in the 1890s changed the structures erected by mining companies. A number of steel makers began selling iron siding for general commercial and residential construction nationwide in the 1890s. While much of the siding was decorative, a few varieties were designed with industrial applications in mind. One of these types, corrugated sheet iron, found favor with the mining industry and its use spread rapidly. Engineers increasingly made use of the material through the 1900s, and by the 1910s it had become a ubiquitous siding for all types of mine and many commercial buildings in Colorado's mining districts. The advantages of corrugated sheet iron were that it cost little money, its light weight made it inexpensive to ship, it covered a substantial area of an unfinished wall, the corrugations gave the sheet rigidity, and it was easy to work with. These qualities made corrugated sheet steel an ideal building material where remoteness rendered lumber a costly commodity.[58]

The other significant use of steel in mine buildings occurred during the 1890s when a few prominent Western mines began to experiment with girders for framing large buildings such as shaft houses, paralleling the rise in the construction of steel headframes. Architects began using steel framing to support commercial and industrial brick and stone masonry buildings as early as the mid-1880s, but Western mining companies found that wood framing met their needs as well and for less money. By the 1890s architectural steelwork had improved, and steel makers offered lightweight beams, which mining engineers adapted to the framing of huge shaft houses. Further, engineers found that steel not only offered a sound structure able to rebuff high winds, but also it often

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[58] Ibid., 304.

cost less money than the thousands of board-feet of lumber required to erect the massive and imposing buildings, and steel had the added benefit of being fire-proof.

The general forms, types, and layouts of mine structures followed a few general patterns, regardless of the building materials the mining engineer used for construction. During the 1880s and 1890s, most mining engineers enclosed the primary surface plant components clustered around the shaft in an all-encompassing *shaft house*. The plant components associated with a tunnel were enclosed in a *tunnel house*. These buildings contained machinery, the shop, the mine entrance, and a workspace under one roof. The buildings therefore tended to be large, tall, and unmistakable edifices in a mining district. Relatively small shaft houses in Colorado were often constructed of stout post-and-girt frame walls, gabled rafter roofs, and informal or no foundations. Particularly spacious shaft houses required a square-set timber skeleton capable of supporting the roof independent of the walls. Regardless of the type of frame, carpenters clad the walls with board-and-batten siding or several layers of boards nailed either horizontally or vertically, and they used shakes for roofing material. During the 1880s and the 1890s, electric lighting was virtually unheard of, and mining engineers instead had carpenters install large multi-pane windows at regular intervals in the walls for lighting.

Most shaft houses conformed to a few standard footprints influenced by the arrangement of the mine machinery. Overall, the structures tended to be long to encompass the hoist, which the engineer had usually anchored some distance from the shaft, and they featured lateral extensions that accommodated the shop, a water tank, the boilers, and either coal or cord wood storage. Professionally educated mining engineers recommended that at least the boiler (and ideally the shop as well), be partitioned in separate rooms because they generated unpleasant soot and dust that took a toll on lubricated machinery such as compressors and hoists.[59]

The roof profile typical of most shaft houses featured a louvered cupola enclosing the headframe’s crown and a sloped extension descending toward the hoist, which accommodated the hoist cable and the headframe’s backbraces. Tall iron boiler smokestacks pierced the roof proximal to the hoist, the stovepipe for the forge extended through the roof near the shaft collar, and the shaft house may have also featured other stovepipes for the stoves that heated the hoistman’s platform and the carpentry shop. The tall smokestacks and stovepipes usually had to be guyed with baling wire to prevent being blown over by strong winds.

The mining engineer working at high elevations often had the shaft house interior floored with planks to improve heating. In some cases the shop and boiler areas, where workers dropped smoldering embers, hot pieces of metal, and nodules of fresh clinker were surprisingly also floored with planking, which presented an enormous fire hazard. Customarily the mining engineer designed the flooring to be flush with the top surfaces of the machine foundations, permitting the steam, air, and water pipes to be routed underneath and out of the way.

Shaft houses colossal enough to cover a bank of boilers, a large hoist, air compressor, and a shop were extremely costly to build and they required expensive upkeep. In addition, the heat generated by the shop forge, boilers, and a few woodstoves proved no match for the frigid winds of winter. In response to the economic drain posed by large shaft houses, during the 1900s and 1910s many mining companies began sheltering key surface plant components in individual buildings. The appearance of the surface plants of many mines changed to consist of a cluster of moderate-sized buildings surrounding the exposed headframe. Instead of a shaft house, particularly large and well-equipped mines featured a *hoist house* for the hoist and boilers, a *compressor house* for the compressor, and the shop in its own building. The mine plant may have also featured a miner's *change house* also known as a *dry*, a storage building, a stable, a carpentry shop, and an electrical substation (Fig E.II.13, Fig E.II.14, Fig E.II.15).

After a number of catastrophic fires where burning shaft houses trapped miners underground and suffocated them, during the 1910s the U.S. Bureau of Mines outlawed shaft houses made of flammable materials.

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[59] Ibid., 306.

Most mining companies were forced to dismantle their shaft houses, leave their headframes in the open, and enclose the surface plant components in separate buildings. Small and medium-sized mines often combined the hoist, compressor, change area, and shop in one large hoist house or several structures. Exceptions were made, however, for headframes enclosed in buildings limited only for that function.

The general construction methods and architectural styles of the 1930s and afterwards changed slightly from the practices of the late nineteenth century. Mining companies with funding tended to erect buildings that were spacious with lofty gabled or shed-style roofs, and appeared more formal and tidy than the structures built by companies with little capital. Engineers continued to take advantage of natural light by designing buildings with multi-pane windows at regular intervals in walls, and they provided broad custom-made doors at important points of entry. Engineers either floored principle structures with poured portland concrete, which was inexpensive due in part to the proliferation of the truck, or they stood the buildings on proper foundations and used wood planking. The materials the companies provided their workers included virgin lumber, virgin sheet iron, and factory-made hardware. The workers, often skilled in their trade, built lasting structures with a solid, tidy, and orderly industrial appearance. In most cases, mining engineers emphasized function and cost in their designs and added little ornamentation.

Poorly funded mining outfits, by contrast, were forced by economic constraints to keep construction within a tight budget, and also within their skills. These outfits could not afford quality construction materials and tools, were not able to hire an experienced engineer or architect, and lacked the funding to hire a skilled construction crew. As a result, the buildings that marginally funded companies erected tended to be small, low, made with high proportions of salvaged materials, and poorly constructed overall. The buildings fabricated by small outfits were personal and unique to each operation, being a true expression of the outfit’s nature, and assembled as the builder saw fit.

The structures erected by poorly capitalized mining companies during and after the Great Depression can be divided into two categories. Small outfits with at least some capital and a crew with modest carpentry skills built structures that consisted of a crude but sound frame, often of the post-and-girt variety, sided with salvaged, mismatched lumber and sheet iron. Doors and windows also were salvaged from elsewhere, such as abandoned residences. Some structures even had mismatched walls, each face of the building having been sided differently from the others. Overall, these buildings appeared rough and battered even when relatively new, but they were fairly well built and offered shelter for miners and equipment.

The quality of workmanship defines the second category of mine buildings, and they appeared even cruder and had less integrity than the structures described above. Laborers frequently built such buildings with no formal frame. Instead, they preassembled the walls, stood them up, and nailed them together, or established four corner-posts, added cross braces, and fastened siding to the boards. The builders may have used a patchwork of planks and sheet iron for siding, which was often layered to prevent being ripped apart by high winds. Many mining outfits favored the “shed” structural style, which featured four walls and a roof that slanted from one side of the building to the other, because it was simplest to erect. The architectural style of the mine buildings erected by such mining companies during the 1930s may be termed *Depression-era Western mining vernacular*.

3.3.4 Aerial Tramways

Colorado featured many productive mines in extremely hostile terrain, and some locations were so inaccessible that pack trains proved to be the only viable means of transporting in materials and hauling out ore. The carrying capacity of pack trains, however, was severely limited (approximately 11 burros or donkeys required per ton of ore), which greatly inhibited a mine’s production levels and, by direct association, profit. In some cases, mining engineers spent lavish sums to build circuitous wagon roads in hopes of mitigating the transportation problems. However, the steep and winding wagon roads proved to be only somewhat better than pack trails, economically squelching what could have otherwise been a highly profitable operation.[60]

Andrew S. Hallidie, an engineer and mining machinery maker in San Francisco, was the first to develop a practical solution to the impediments presented by high mountains and impassable winter snows. In the late 1860s, he combined his engineering skill and familiarity with wire rope to literally carry materials over impassable ground, which Hallidie patented as the aerial tramway. Hallidie's system consisted of a series of strong wooden towers featuring cross-members tipped with idler wheels that supported a continuously moving, endless loop of wire rope. The loop of rope conveyed a series of ore buckets that traveled a circuit between the system's top and bottom stations, and operated under gravity. The loaded buckets gently descended downslope, pulling the light empties back up to the mine.

Hallidie's design changed little from the 1870s, when mining companies began experimenting with it, until the 1910s when other designs dominated. Empty buckets entered the top terminal where workers loaded them with pay rock, the buckets passed around the sheave wheel, then traveled down the line to the bottom terminal. When the buckets entered the bottom terminal, a guide rail upset them and they dumped their contents into a receiving bin, then returned to the top terminal.

By the 1880s, enough mining companies had installed Hallidie aerial tramways to enable academic engineers to evaluate their economic worth and performance. The tramways remained unrivalled for moving large volumes of ore across untraversable terrain, but they possessed several limitations. In response, Theodore Otto and Adolph Bleichert, two German engineers, developed an alternative system first employed in Europe in 1874. The *Bleichert Double-rope* tramway utilized a *track rope* spanning from tram tower to tram tower, and a separate *traction rope* that tugged the ore buckets around the circuit (Fig. E.II.51).

Fig. E.II.51 The interior of the upper tramway terminal for a Bleichert Double-Rope system at the Mary Murphy Mine, Chaffee County. The timber structure at center encases a sheave wheel that accommodated the moving traction rope. Tram buckets entered the doorway at left, workers uncoupled them from the traction rope, and pushed the buckets along the hanging cable wrapping around the sheave. The workers filled the buckets at an ore chute right of the sheave, pushed the buckets to the exit, and recoupled them to the cable. Eric Twitty, taken 1998.

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[60] Ihlseng, *A Manual of Mining*, 1892, 137.

The track rope was fixed in place and the buckets coasted over it on special hangers featuring guide wheels. The traction rope was attached to the ore bucket's hanger via a mechanical clamp known as a *grip*. Like Hallidie Single-rope tramways, Bleichert Double-rope tramways incorporated top and bottom terminal stations where the buckets were filled and emptied, and they too usually ran by gravity.[61]

The principal difference lay with the grip, which was releasable and allowed workers to manually push the buckets around the interior of the terminal on hanging rails so they could be filled at leisure without spillage. The double-rope system also permitted the entire tramway circuit to be extended up to four miles in length and work at almost any pitch. Given this, even though Bleichert systems were up to 50 percent more expensive to erect than Hallidie tramways, they proved to be better for heavy production because they were able to handle greater payloads, which resulted in higher production for the mining company.

Mining companies began experimenting with Bleichert Double-rope systems in the 1880s, and due to superior performance, the popularity of Bleichert systems eclipsed the less expensive Hallidie tramways by the 1890s. Still, some companies with limited production and moderate amounts of capital continued to install Hallidie systems after the turn of the century.

Designing and building aerial tramways were beyond the skills of most mining engineers because the systems were complex, very expensive, and required advanced economic and engineering calculations. Even the most educated mining engineers installing aerial tramways usually required at least some direction from technicians dispatched by the tramway maker. While mining companies purchased standardized tramway equipment from manufacturers, rarely were two systems alike in Colorado, in part because the physical and economic conditions of each mine were different.

Tramway systems were very materials-intensive and required substantial structures. The basic components included a top terminal near the adit or shaft, a bottom terminal located adjacent to either a road, railroad grade, or an ore concentration mill, and a series of towers for the bucket-line.

Engineers recognized four basic types of towers for both Bleichert and Hallidie systems. These included the *pyramid* tower, the *braced hill tower*, the *through tower*, and the *composite tower*. The pyramid tower consisted of four upright legs that joined at the structure's crest. The through tower resembled an A-shaped headframe consisting of a wide rectangular structure stabilized by fore and back braces, and the tram buckets passed through the framing. Composite towers usually had a truncated pyramid base topped with a smaller frame supporting a cross-member. The braced-hill tower was similar to the through tower, except it had exaggerated diagonal braces tying it into the hillslope.

Towers for both Bleichert and Hallidie systems required stout cross-members that supported the wire ropes, which were far away enough so the buckets could swing in the wind and not strike the towers. Hallidie systems, with their single wire rope and fixed buckets, needed only one cross-member that featured several idler wheels or rollers. Because the buckets were suspended from a long hanger fixed onto the cable, the cross-member was bolted to the top of the tower. Bleichert systems, on the other hand, required a stout cross-member at the tower top to support the stationary track cable, and a second cross-member 3 to 7 feet below to accommodate the moving traction rope. The second cross-member almost always featured either idler wheels or a broad steel roller.

Tramway terminals presented engineers with numerous design problems to integrate the system with a mine's ore production. Terminals had to be physically arranged to permit the input and storage of tons of ore from the mine, to facilitate the transfer of pay rock into or out of the tram buckets, to resist the tremendous forces put on the sheave wheel by the traction rope, and in the case of Bleichert systems, also to anchor the track cables.

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[61] Ihlseng, *A Manual of Mining*, 1892, 138; Int. Textbook Co., *Coal and Metal Miners' Pocket Book*, 122; Lewis, *Elements of Mining*, 1946, 372; Peele, *Mining Engineer's Handbook*, 1563; Trennert, "From Gold Ore to Bat Guano," 6.

Mining engineers designing small-capacity tramways attempted to solve all of the above problems within a single structure, while the terminals for large-capacity tramways were enclosed in complex buildings.

Regardless of the type of tramway a mining company installed, the engineer had to design timber framing for sheave wheel that was strong enough to resist the significant horizontal forces of keeping the traction rope taught. The sheave in the top terminal was usually fixed to a heavy timber framework anchored to bedrock and partially buried with waste rock ballast. The wheel was canted at the same angle as the pitch of the bucket line so that the cable did not derail, which would have resulted in a costly and potentially fatal catastrophe. Typical sheave wheels, six feet in diameter for small systems and twelve feet for large systems, featured a deep, toothed groove for the rope, and they were fixed onto a heavy steel axle set in cast-iron bearings bolted to the timbers. Brake levers, usually installed in both terminals, were typically very long to provide great leverage, and were located adjacent to, or on a catwalk immediately over, the wheel. The lever controlled heavy wooden shoes that pressed against a special flange fastened to the sheave wheel.

At the bottom terminal, the sheave had to be moveable to take up slack in the bucket-line. In many cases, the wheel was fastened onto a heavy timber frame pulled backward by adjustable anchor cables or threaded steel rods.

As fine a solution as Hallidie and Bleichert tramways were for facilitating the flow of ore from a mine, they were too big and expensive for many small operations. Yet, rugged terrain and locations high on the sides of mountains presented no less of an access problem for these limited operations. In response, the smaller companies erected *single-rope reversible* and *double-rope reversible* trams.

Well-engineered single-rope trams typically consisted of simple components. A fixed line extended from an ore bin located high up at the mine down to another ore bin below. A hoist at the mine wound a second cable that pulled a bucket up, and when the bucket was full, a worker lowered it via a handbrake. Double-rope tramways featured two fixed lines and two buckets that operated in a balanced fashion (Fig E.II.52).

A worker lowered a full bucket down to the bottom terminal with a handbrake, and it pulled the lighter, empty vehicle up to the top terminal. Lengthy double-rope tramways often featured a series of towers similar to those for Bleichert systems that supported the fixed lines.

Fig. E.II.52 Aerial tramways featured towers that supported cables for tram buckets. The Pennsylvania Mine, Peru Creek, Summit County, featured a double-rope reversible system in which two buckets ascended and descended the cables in a balanced fashion. The towers are pyramid types. Eric Twitty, taken 1998.

3.3.5 Ore Storage

While capitalists, mining engineers, and miners often held differing opinions as to how to set up and run a mine, all were in agreement that the primary goal was the production of ore. Those mines with any measurable output usually featured an ore-storage facility to accommodate the production, and two basic types of facilities were popular among Colorado's hardrock mines. *Ore bins* were functionally different from *ore-sorting houses*, and the mining engineer based his choice on which structure he built on the type of ore being mined. Free gold and some silver and copper ores were fairly consistent in quality and rock type, and they warranted storage in an ore bin. The quality and consistency of telluride gold, most silver and industrial metals, and tungsten, on the other hand, varied widely in any single given mine, and they required sorting, separation from waste rock, and rudimentary concentration in an ore-sorting house. Both types of structures required a means of inputting ore from the mine and a means of extracting it for shipment to a mill for finer concentration. Mining engineers recognized three basic types of ore bins: the *flat-bottom bin*, the *sloped-floor bin*, and a structure that was a hybrid of the above two known as a *compromise bin*. Flat-bottom bins, which generally consisted of a flat floor, high walls made of heavy planks, and a plank gateway in one wall had a greater storage capacity per square foot than the other two types of structures. However, laborers had to stand on the pile of shifting pay rock and shovel it out into a waiting wagon or railroad car. Sloped-floor bins, on the other hand, were expensive to build, required proper engineering, and were conducive to automatically unloading the ore, which naturally flowed out of the structure through chutes. Compromise bins combined the above two designs, half of the floor being sloped and half being flat, to create a bin which automatically unloaded when full, and required shoveling when almost empty.[62]

Mining companies with capital and heavy ore production often erected large sloped-floor ore bins. These structures were lasting, strong, and had a look of permanency and solidity that inspired confidence. Well-built sloped-floor bins, which cost more than twice to build than flat-bottomed bins, typically consisted of a heavy post and girt frame made with 8x8 inch timbers sided on the interior with 2x6 to 2x12 inch planking (Fig E.II.53).

The structures generally stood on foundations of posts tied to heavy timber footers placed on terraces of waste rock. To ensure the structure's durability in the onslaught of the continuous flow of sharp rock coming from the mine, construction laborers often armored bin floors with salvaged plate iron. Small mines used sloped-floor bins consisting of a single cell, while large mines erected structures that included numerous bins to hold either different grades of ore, or batches of pay rock produced by multiple companies of lessees working within the same mine.

Mining companies with limited financing and minor ore production erected flimsy flat-bottomed bins because such structures were inexpensive to build. Rarely did these ore-storage structures attain the sizes and proportions of their large sloped-floor cousins because the walls were not able to withstand the immense lateral pressures exerted by the ore. Flat-bottomed bins had to contend with pressures on all four walls, while sloped-floor bins directed the pressure against the front wall and the diagonal floor.

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[62] Twitty, *Reading the Ruins*, 150.

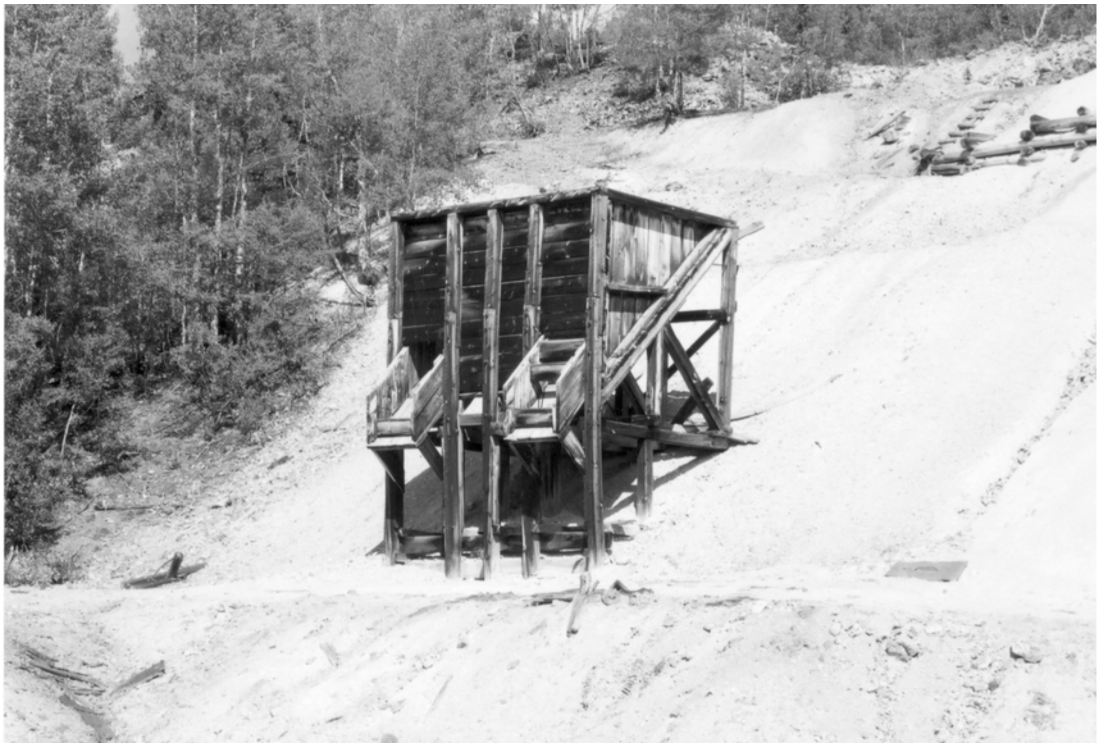
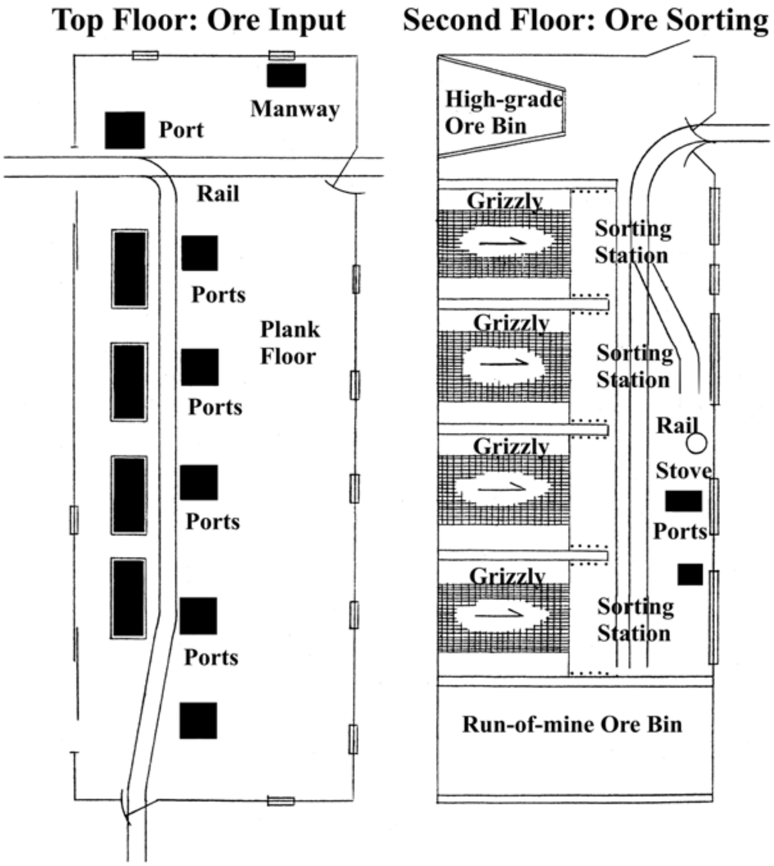


Fig. E.II.53 A typical sloped-floor ore bin. Miners emptied ore cars into the open top and workers extracted the ore through the chutes when hauling it away. Eric Twitty, Red Mountain Mining District, taken 1998.

By nature of their function, ore bins and ore-sorting houses had to be linked to the mine tunnel or shaft via a rail line for the input of fresh ore, and they had to provide for the removal of stored ore. Trammers and miners filled ore bins by pushing loaded ore cars from the mine, across a small trestle, and over the bin. To facilitate a rail connection featuring a level gradient, the rim of the ore bin had to be at the same elevation as the tunnel portal or shaft collar, and as a result mining engineers usually located sloped-floor bins on the flank of the mine's waste rock dump. Many flat-bottom bins, and some small, poorly built, flimsy sloped-floor bins, were located at the toe of the waste rock dump where stable ground lay. Trammers loaded ore into these structures by dumping the rock from the ore car into a chute that directed the rock into the open bin. Prior to the 1900s, some mining companies extracting very limited quantities of ore countersunk small flat-bottomed bins into the waste rock dump near the adit portal. Such bins, often no more than 20 by 20 feet in area, were accessed by a mine rail spur curving off the main line, and the trammer merely pushed a loaded ore car to the bin's edge and disgorged the car's contents.

Ore-sorting houses were generally more complex and required greater capital and engineering to erect than ore bins. The primary functions of ore-sorting houses were both the concentration and the storage of ore. In keeping with gravity-flow engineering typical of mining, engineers usually designed sorting houses with multiple levels for the input, processing, and storage of ore (Fig E.II.54).

Fig. E.II.54 The floor plan of the top two floors of a large ore-sorting house designed to accommodate significant output. Miners dumped full ore cars into the ports on the top floor, at left, and the ore dropped onto grizzlies on the second floor, at right. The rich fines sifted through and collected in holding bins comprising the bottom floor (not shown). Waste-laden cobbles rolled across the grizzlies and gathered at the sorting stations, where workers knocked off metalliferous material and dropped it through the ports in the floor. They pushed ore cars full of waste out along the track curving right. High-grade ore went into the high-grade bin at top, and ore requiring no sorting went into the run-of-mine bin at bottom. Twitty, *Riches to Rust*, 123.



These structures usually featured a row of receiving bins located at the top level, a sorting floor under the receiving bins, and a row of holding bins underneath the sorting floor. Receiving bins usually had sloped floors, and in most cases the holding bins below did too. A cupola sheltered the top level and the sorting floor was fully enclosed and heated with a wood stove. The holding bins at bottom were similar to the sloped-floor ore bins discussed above, and the structure usually stood on a foundation of heavy timber pilings, or a combination of pilings and hewn log cribbing walls.[63]

Like the processes associated with ore milling, mining engineers utilized gravity to draw rock through ore-sorting houses. The general path the ore followed began when miners underground characterized the nature of the ore they were extracting. They communicated their assessment of the ore's quality to the trammer via a labeled stake, a message on a discarded dynamite box panel, or a tag. The trammer subsequently hauled the loaded car out of the mine and pushed it into the sorting house, which stood on the flank of the waste rock dump. He emptied the car into one of several bins, depending on how impure the ore was. High-grade ore went into a small and special ore bin at one end of the structure. "Run-of-mine" ore, which was not particularly rich but required no sorting, went into another bin at the opposite end of the structure. Mixed ore that was combined with considerable waste rock went into one of several bins located in the center of the ore-sorting house. When

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[63] Ibid.,153.

released from the car, the mixed ore slid into a receiving bin that featured a heavy grate at the bottom known as a *grizzly*. The principle behind the grizzly was that the rich portions of telluride and silver ores fractured into fines and the large cobbles that remained intact through the blasting, shoveling, and unloading contained waste rock that needed to be "cobbed," or knocked off by surface laborers. The valuable fines dropped through the grizzly directly into holding bins at the bottom of the structure, while the waste rock-laden cobbles rolled off the grizzlies and into holding chutes that fed onto sorting tables. There, laborers worked by daylight admitted through windows, and by kerosene or electric lighting, to separate the ore from waste.

Coal mines featured a storage and processing counterpart to the sorting house known as a *breaker house*. These facilities were large timber structures built immediately adjacent to the headframe and usually had several floors. Workers input coal from either coal cars or a skip, depending on whether the mine was a tunnel or shaft operation, into a receiving bin at the structure's top. A chute directed the coal onto a sorting floor where workers removed slate and other rocks and broke the coal into lumps, which were screened, separated, and stored by size in holding bins. If the mining company was liberal with its capital, it may have employed mechanical breakers that completed most of the tasks automatically.

3.3.6 Explosives Magazines

Explosives were a fundamental tool for mining and the prime mover of rock in all types of mines. Miners relied on blasting powder and dynamite for a variety of purposes both above and below ground. Of note, blasting powder was the principle explosive used for hardrock mining until the 1870s, when it was phased out by dynamite, although blasting powder remained popular in coal mines into the 1920s. Mining companies had to store enough dynamite and blasting powder to carry them through the several weeks spanning freight deliveries, and they often informally stacked 50 pound boxes (the standard shipping container), in shaft houses, compressor houses, storage sheds, and in vacant areas underground. Worse, during cold months, which spanned much of the year at high altitude, mine superintendents had boxes of dynamite stored near boilers, in blacksmith shops, and near hoists where it remained in a thawed and ready state. Such storage practices were extremely dangerous, and in response, some mining engineers instituted explosives magazines where storage could be carried out in a more controlled and orderly manner.

Well-built magazines came in a variety of shapes and sizes, but they all shared the common goal of concentrating and sheltering the mine's supply of explosives away from the main portion of the surface plant. Academically trained mining engineers felt that magazines should be bulletproof, fireproof, dry, and well ventilated. They also felt that magazines should be constructed of brick or concrete but if of frame construction, the walls needed to be sand filled and sheathed with iron. These structural features not only protected the explosives from physical threats, but also regulated the internal environment, which was important, especially in summer. Extreme temperature fluctuations and pervasive moisture had been proven to damage fuses, blasting caps, blasting powder, and most forms of dynamite. This in turn directly impacted the miners' work environment, because degraded explosives created foul and poisonous gas byproducts that vitiated mine atmospheres.

Proper magazines manifested as stout masonry or concrete buildings around 12 by 20 feet in area with heavy arched roofs and iron doors in steel jambs. Usually these magazines were erected a distance away from the main portion of the mine's surface plant. In other cases, mining engineers had construction crews build concrete, masonry, or timber-lined bunkers with stout iron doors. Well-built vernacular magazines, on the other hand, often resembled root cellars. Generally they took the form of a chamber that workers excavated out of a hillside (often 8 by 10 feet in area), roofed with earth, rubble, and rocks. The interiors of well-built magazines had shelves for boxes of dynamite, while miners merely stacked the boxes up in vernacular magazines.

Regardless of degradation and the direct and obvious safety hazards, many small and medium-sized mining companies stored their explosives in very crude and even dangerous facilities. Miners erected sheds sided only with corrugated sheet iron that offered minimal protection from fluctuations in temperature and moisture. In other cases, small, capital-poor operations took even fewer precautions and stored their explosives in either sheet-iron boxes similar in appearance to doghouses, in earthen pits roofed with sheets of corrugated iron, or in abandoned prospect adits. Lack of funding appears to have been a poor excuse for improper storage practices, because most operations had the ability to erect fairly safe, inexpensive vernacular dugout magazines. Large mining operations, on the other hand, found it within their means to build proper magazines.

4. Beneficiation: Smelting, Ore Concentration, and Amalgamation

Mining companies in Colorado considered the ore they produced to be a crude product that required treatment, known as beneficiation, to separate the metal content from the waste. Beneficiation was not straightforward because Colorado featured a wide array of highly complex ores that resisted treatment, forcing metallurgists to apply advanced chemical and mechanical engineering. Gold and especially silver ores usually consisted of a blend of metal compounds mixed with host rock that required a variety of treatment stages and processes. Ores of purity or simplicity required fewer steps, while complex, refractory ores required time-intensive treatment and numerous steps. In general, the process began with crushing and grinding the ore, followed by separating metalliferous material from waste in a stage known as *concentration*. The resultant *concentrates* were roasted and smelted in a furnace, which furthered the separation and yielded a blend of metals known as *matte*. Advanced smelters, located in cities on the plains and in the Midwest, refined the matte into pure metals termed *bullion*.

A variety of facilities carried out one or all of the necessary processing steps, and many operated in mining districts as independent mills or in conjunction with a specific mine. Smelters were turnkey facilities that reduced crude ore into metals and matte, and nearly every principal mining district in Colorado had at least one independent smelter during its boom era.

4.1 Smelters

To produce metals, smelters incorporated mechanical, chemical, and roasting processes that a metallurgist had to tailor to a region's specific ore. Basic smelting began when wagons delivered crude ore to the facility, which workers dumped into receiving bins at the smelter's head. The ore had to be broken into consistently sized cobbles either by hand or with a mechanical crusher, then loaded into the smelting furnace. Common furnaces were cylindrical steel vessels 4 to 12 feet in diameter and lined with firebricks. They stood on stout rock or brick masonry foundations and featured tap spouts and tuyeres, which were ports that admitted air blasts, at graduated intervals. At center was a columnar charge of fuel, and workers dumped crude ore around the fuel column until the ore chamber was full. They usually admitted lead bullion, or lead or iron ore first, because these soft metals served as a flux, which, when molten, helped the rest of the ore to liquefy. After workers arranged layers of ore, sealed the spouts, and added more fuel, they started a blower that fed air to the smoldering fuel, bringing it to a great heat.[64]

As the lead or iron ore melted and the temperature increased, the liquid metals came into contact with harder metals and minerals, causing them to soften, melt, and trickle down into the base of the furnace. Over time, the lot of ore became molten and the heaviest material, usually the metals, settled to the bottom while the lighter

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[64] Bailey, *Shaft Furnaces*, 80; Meyerriecks, *Drills and Mills*, 173.

waste floated to the top. At this point, workers opened the upper slag spouts and tapped the liquid waste into slag carts, then did likewise for intermediate slag spouts. After they drew the waste off, the workers added more ore and fuel until the pool of liquid metal rose to the height of a lower slag spout. At this time, workers opened the lowest spout at the furnace base and tapped the molten metal into pots or molds until liquid slag made an appearance, indicating an end to the metal. Workers then repeated the process, keeping the furnace in continuous operation for days or weeks.[65]

Because metallurgists used gravity to draw ore through the processing stages when possible, they usually sited smelters on a slope. Smelting facilities usually required acres of flat space, a source of abundant water, and well-graded roads. In addition to the furnace, smelters often featured ore bins, large fuel bins, water tanks, storage, an assay office, and a vault. Successful smelters in productive mining districts usually had more than one furnace to process batches of ore simultaneously if the material was simple, or in stages if the ore was complex. Large smelters also featured roasters and mechanized concentration mills to prepare the ore and enhance separation prior to smelting.

4.2 Concentration Mills

Most mining companies rarely possessed sufficient capital or produced enough ore to warrant the erection of a dedicated smelter. Instead, they shipped their ores to custom smelters, which extracted the metals for a fee. The shipping charges and smelting fees often constituted a heavy expense, so in response, well-capitalized mining companies attempted to save money by building *concentration mills* near their workings. Concentration mills relied on mechanical and some chemical processes to reduce the ore, separate the metalliferous materials, and prepare the resultant concentrates for shipment to a smelter for final roasting and refining. In so doing, mining companies accomplished many of the steps that smelters charged for, and they did not have to pay to ship the worthless waste usually integral with crude ore. Concentration mills were not equipped, by definition, to produce finished bullion.

Concentration mills were usually built over a series of terraces incised into a hillslope so that gravity could draw the ore through the various processing stages (Fig. E.II.55).

Mills came in a variety of scales, and large facilities usually required stone masonry and concrete terraces to support the building and heavy machinery, while earthen terraces and substantial beamwork were sufficient for small facilities. Large mills were heavily equipped to process both high volumes of ore, and complex ore that resisted simple treatment. To do so, they often provided primary, secondary, and even tertiary stages of crushing and concentration, and may have featured several parallel sequences. Small mills, by contrast, usually provided several stages of crushing and concentration in a single, linear path.

Engineers and metallurgists tended to follow a general pattern when designing concentration mills. An ore bin stood at the mill's head and fed raw ore into a *primary crusher*, usually located on the mill's top platform. The crusher reduced the material to gravel and cobbles ranging from 1 to 4 inches in size, which descended to a *secondary crusher* located on the platform below. The secondary crusher pulverized the ore to sand and slurry, which went through a screening system. Oversized material returned for secondary crushing and material that passed the screen went on for concentration at small mills, or tertiary crushing then concentration at large mills. By around 1900, engineers favored using *trommel screens* or *shaking screens* to sort the rock (Fig. E.II.56).

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[65] Bailey, *Shaft Furnaces*, 82-3; Meyerriecks, *Drills and Mills*, 174.

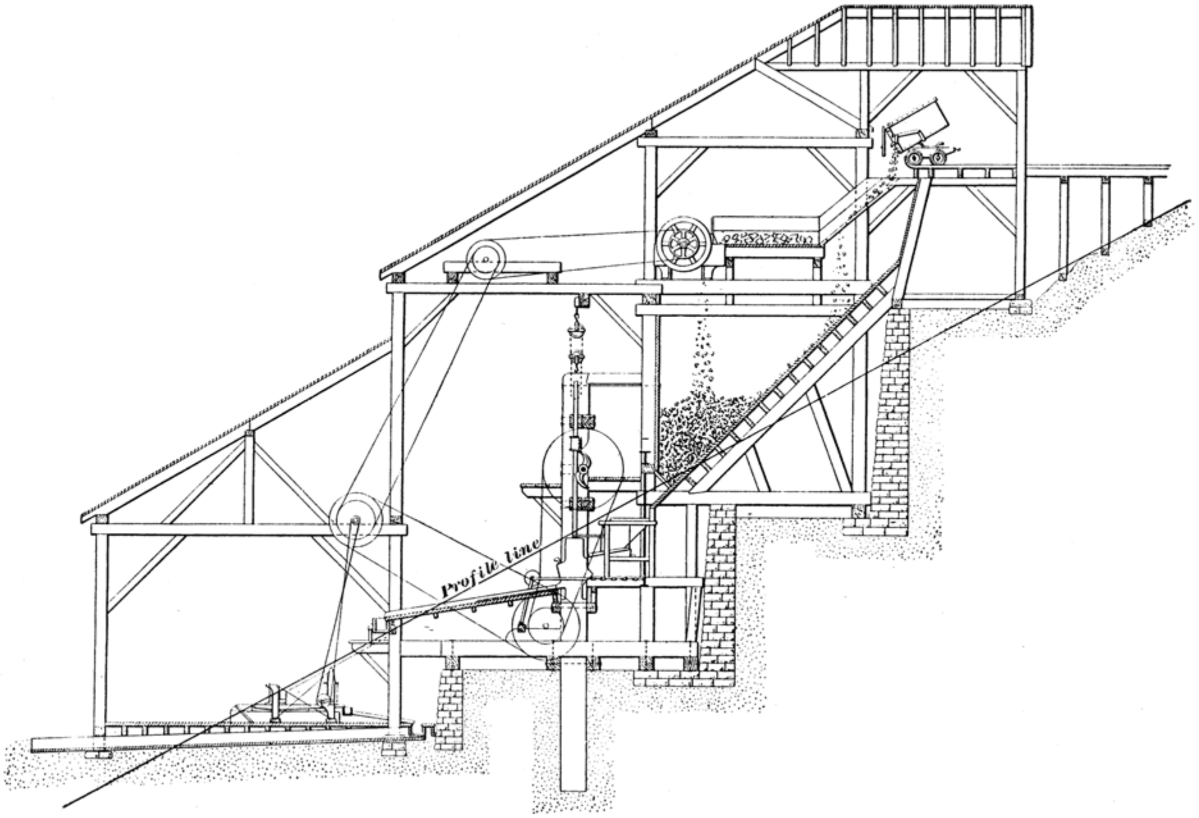
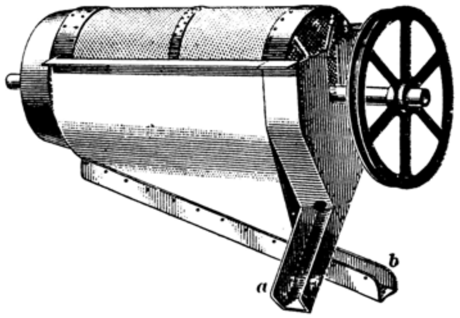


Fig. E.II.55 Profile of a concentration mill. The layout of a typical stamp mill and concentration mills were very similar. Miners dumped ore cars into the receiving chute at top, which fed the payrock into a jaw crusher. The pulverized material dropped into a holding bin then into the stamp battery on the platform at center. The resultant slurry passed over amalgamating tables at the battery's toe and descended to concentration machinery on the lower platform. Instead of amalgamating tables, concentration mills may have featured additional grinders and concentration machinery. The power source (not shown), would be on the lower platform. Int. Textbook Co., *Preliminary Operations*, A43: 214.

Fig. E.II.56 A trommel screen. Mills usually featured trommel screens that classified pulverized ore between each stage of crushing. Material that passed the screens proceeded for further crushing or concentration and oversized material returned for re-processing. Int. Textbook Co., *Preliminary Operations.* A43: 65.



A trommel consisted of a concentric series of cylindrical screens that rotated, allowing fine material to drop through, while the oversized cobbles rolled out of an open end. A shaking screen was a stack of rectangular pans with screen floors.[66]

Machinery manufacturers offered a wide array of crushers and grinders, which metallurgists selected according to the ore’s characteristics. Because no two mines featured the same ore and no two metallurgists were alike, each mill was a custom affair. However, engineers followed some patterns regarding the application of crushing machinery. Jaw crushers, also known as Blake crushers, provided primary crushing, while a few large operations employed gyratory crushers (Fig. E.II.57).

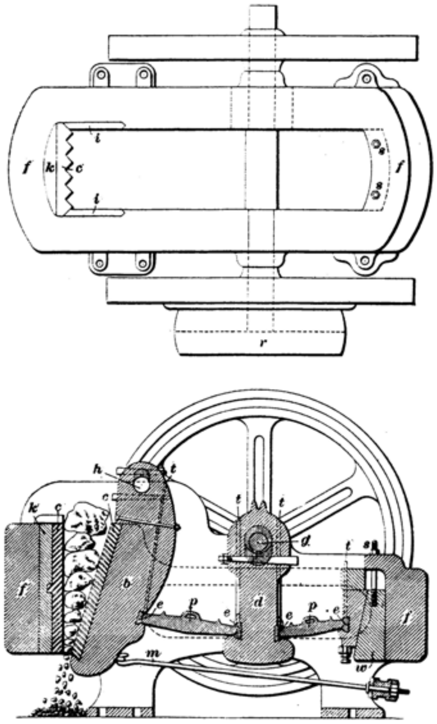


Fig. E.II.57 The plan view and profile (orientated sideways), of a jaw crusher. This was located on an upper platform below a mill’s receiving bin. Int. Textbook Co., *Preliminary Operations,* A43: 2.

Batteries of stamps were commonly employed for secondary crushing. A stamp battery consisted of a timber gallows frame with guides for heavy iron rods featuring cylindrical iron shoes (Fig. E.II.58). A cam lifted the rods in sequence and let them drop on the gravel being crushed.

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[66] Peele, *Mining Engineer's Handbook*, 1623, 1627; Tinney, *Gold Mining Machinery*, 191.

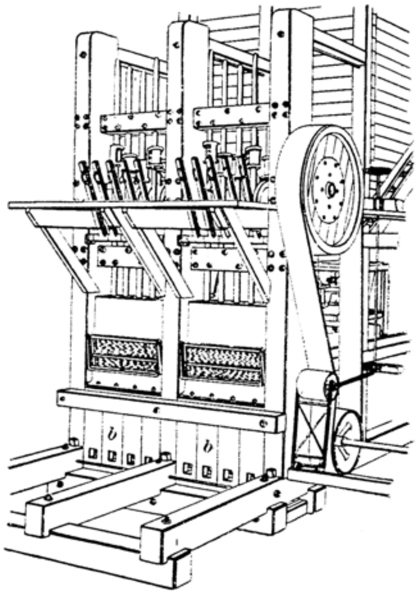

Fig. E.II.58 A quarterview of the front of a stamp battery. The stamp rods are visible between the timber posts, and the stamp shoes pounded ore in the battery boxes below, denoted by the finely perforated screens. The bull wheel at right turns a camshaft, which lets the stamps drop. The battery boxes are bolted to pedestals of upright timbers, which are often the only remnants of stamp batteries at some sites today. Int. Textbook Co., *Preliminary Operations,* A43: 27.

Crushing rolls often carried out secondary and tertiary crushing, and they consisted of a pair of heavy iron rollers similar to wheels in a stout timber frame (Fig. E.II.59).

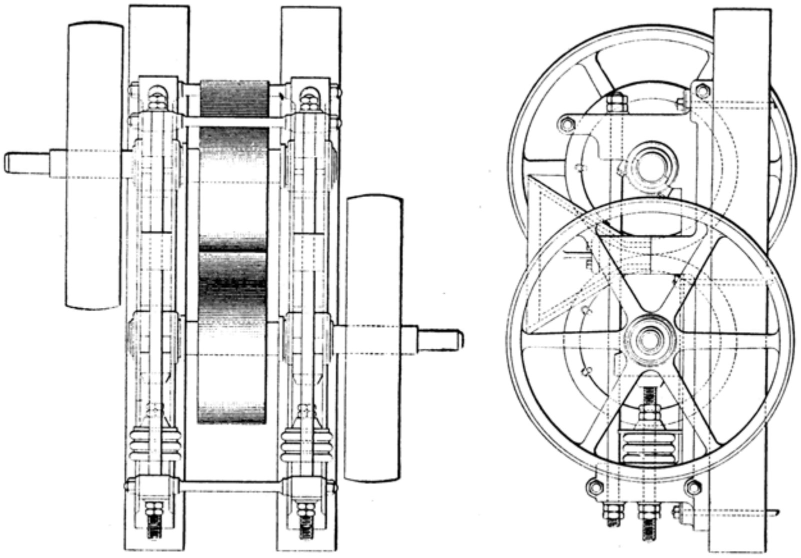

Fig. E.II.59 Crushing rolls. Some mills employed these to provide secondary and tertiary crushing. In the profile, pulverized ore dropped into the hopper, which fed the material into a gap between the two large rollers. The plan view at left illustrates the machine's width. These machines were bolted to timber frames supported by stout posts. Int. Textbook Co., *Preliminary Operations,* A43: 12.

A narrow gap between the rollers drew in clasts of sand and gravel and fragmented them. Grinding pans and Huntington mills were used for tertiary crushing, and both featured a heavy cast-iron pan and iron shoes or rollers that dragged across the floor, grinding the ore (Fig. E.II.60 and Fig. E.II.61).

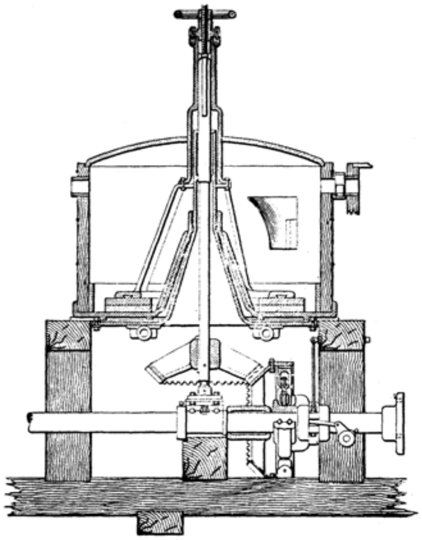

Fig. E.II.60 A profile of a grinding pan. Some mills used pans for tertiary crushing, which reduced ore to a slurry and many used pans to simultaneously grind and amalgamate simple gold and silver ores. Pans saw limited use and were located on one of a mill's lower platforms. A belt drove the pan, and the pan was bolted to a foundation of timbers. Int. Textbook Co., *Preliminary Operations,* A43: 172.

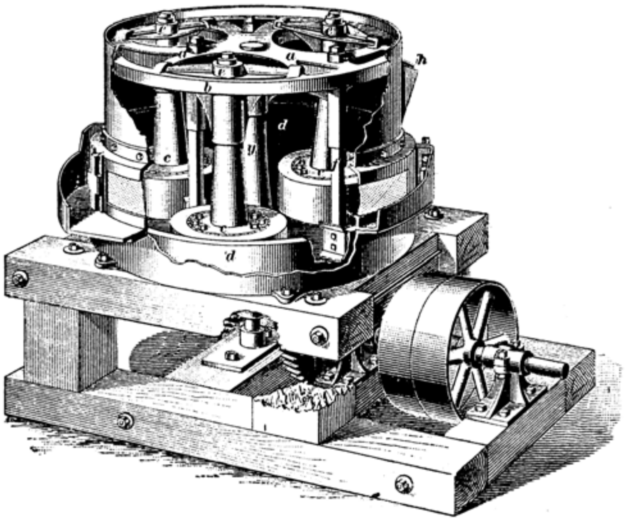

Fig. E.II.61 Huntington Mills saw two applications. Concentration mills used them for secondary or tertiary crushing, and amalgamation mills used them to simultaneously grind and amalgamate gold and simple silver ores. The drive shaft at right turned a capstan in the mill's plan, which caused the rollers to grind ore against the pan's walls. Note the foundation, which is similar to those for crushing rolls. Int. Textbook Co., *Preliminary Operations,* A43: 47.

When the ore was free-milling gold or silver, the metallurgist introduced mercury into the pan to amalgamate with the metals. *Tube mills* and *ball mills* offered the finest grinding (Fig E.II.62).

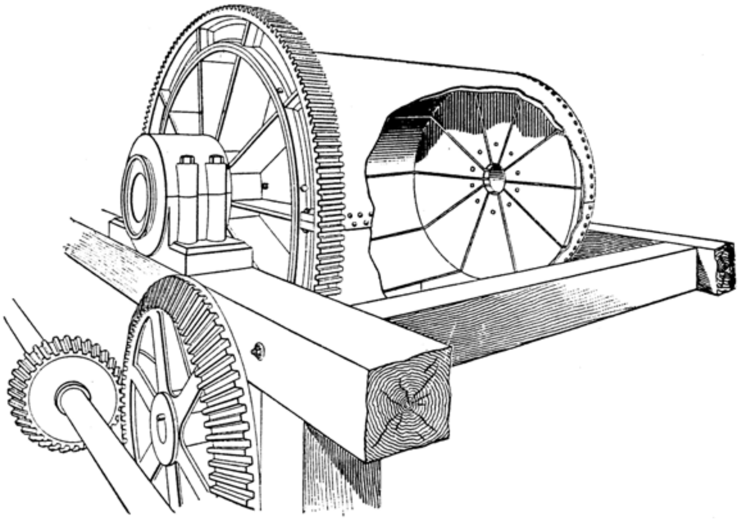

Fig. E.II.62 A ball mill. Ball mills saw limited application for secondary crushing until the 1910s, whey they became common. The large cylinder contained iron balls that pulverized ore as the cylinder slowly rotated. A belt connected to the gearing drove the machine. Ball mill foundations manifest as a raised L-shaped concrete structure often 8 feet long featuring anchor bolts. Int. Textbook Co., *Preliminary Operations,* A43: 55.

Each appliance consisted of a large cylinder that mill workers partially filled with sand, gravel, and water. The cylinder slowly rotated, and the iron rods in tube mills or the iron balls in ball mills tumbled in the chamber, reducing the material to a slurry. Both types of grinding appliances rose to popularity around 1900, and by the 1930s they were used in place of crushing rolls and stamp batteries. The end product of crushing and grinding were *fines* and *slurry*.[67]

Following another screening, the ore descended to subsequent mill platforms for concentration. Several devices proved relatively popular for separating metals, and many metallurgists assembled a concentration sequence involving more than one appliance. The *jig* relied on water currents and agitation to both separate heavy metalliferous material and classify particles by size (Fig. E.II.63).

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[67] Peele, *Mining Engineer's Handbook,* 1630.

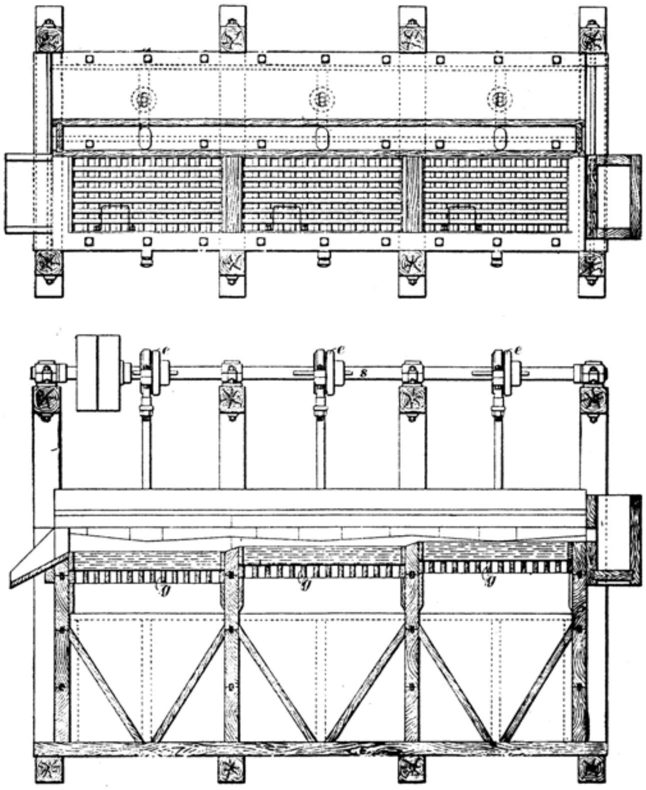

Fig E.II.63 A plan view (above) and profile (below) of a jig. The screens in the plan view agitated an ore slurry, which classified material by weight or size, depending on the application. Jigs required simple timber foundations, as illustrated by the profile. Int. Textbook Co., *Preliminary Operations,* A43: 86.

The jig consisted of a wooden trough, often 4 by 9 feet long and 4 feet high, divided into cells that opened onto a V-shaped floor featuring valves and drains. Plungers agitated the slurry of ground ore in the cells, causing the heavy or large fines to settle while a gentle current of water washed the waste away. Jigs were highly popular in Colorado from the 1870s until around 1900, when vibrating tables (discussed below) superseded them. Some mining companies, however, used jigs into the 1910s.

Vanners were a popular concentration appliance for silver ores between the 1880s and 1900s until they too were replaced by vibrating tables. A vanner featured a broad rubber belt on rollers mounted to an iron frame that vibrated (Fig E.II. 64).

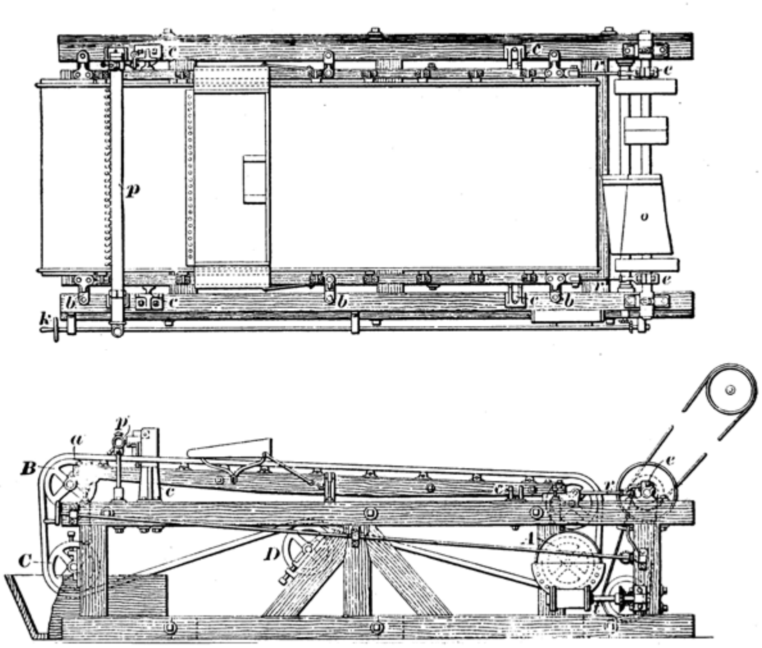

Fig. E.II.64 A vanner, depicted by a plan view at top and a profile at bottom. This was a popular concentration apparatus. As the machine vibrated, crushed ore settled against the broad rubber belt while water jets and a scraper removed light waste material. Note the timber foundation. Int. Textbook Co., *Preliminary Operations,* A43: 134.

The belt assembly, around 5 by 15 feet in area, was suspended by an oscillating mechanism from a chassis bolted to a timber foundation. The belt was kept wet and as the machine vibrated, the heavy metalliferous material settled against and stuck to the rubber while a jet of water washed off the waste. As the belt wrapped down around one of the rollers, the metalliferous material dropped into a flume and proceeded for further concentration.[68]

Vibrating tables were one of the most effective classes of concentration appliances and rose to prominence around 1900 (Fig. E.II.65).

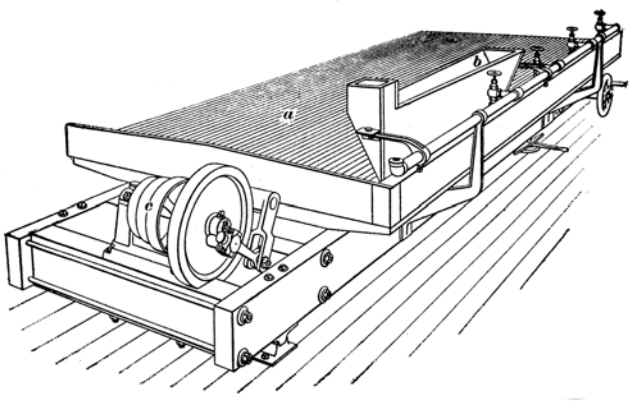

Fig. E.II.65 A vibrating table. This was one of the most popular concentration apparatuses. The eccentric cam at left imparted a vibrating motion, and the vigorous action caused heavy metalliferous material to settle against the riffles while the light waste was washed off. Note the foundation. Int. Textbook Co., *Preliminary Operations,* A43: 172.

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[68] Bailey, *Supplying the Mining World*, 64, 112; Tinney, *Gold Mining Machinery*, 204.

Arthur Wilfley designed the first model for his mill in Robinson, Summit County, Colorado, to treat silver ores, and by the 1910s, metallurgists adapted the concept for nearly all types of metal ores. A vibrating table featured a tabletop, often 5 by 15 feet in area, clad with rubber or linoleum held down with fine riffles. The tabletop was mounted at a slant on a mobile iron frame that rapidly oscillated, and the vigorous action caused heavy metalliferous material to settle against the higher riffles while the waste worked its way downward. Water playing across the tabletop washed the waste away.[69]

By the 1920s, *flotation cells* were proving their worth and operated according to principals that seemed to defy traditional concentration technology. By the 1930s flotation became common. A flotation machine consisted of a large rectangular tank divided into cells filled with water and slurry. Oils or detergent were introduced, which compressed air or agitators worked into a froth. In contrast to the above mechanical devices, the froth carried the metalliferous materials upward while wastes settled to the bottom of the cells. Revolving paddles then swept the metalliferous material into flumes.

While the above appliances proved highly effective for silver and industrial metal ores, they provided limited success for complex gold ores, such as telluride. During the 1900s, mining companies, primarily in Cripple Creek, began experimenting with *cyanidation* technology, which was pioneered in New Zealand. For cyanidation, the ore was crushed and ground as above, then concentrated as a slurry. A worker transferred the metalliferous material into *cyanide tanks*, which were large wooden vats that agitated the slurry in a dilute cyanide solution. The cyanide bonded with the gold, the waste was ejected, and a worker tapped the solution into *precipitating boxes* where he introduced zinc, which cyanide preferred over gold. The chemical reaction caused the precious metal to precipitate out. Cyanide mills could have featured one or a series of cyanide tanks, depending on the purity and volume of ore.

Most ore-concentration processes required water to mobilize the material being worked and to allay dust. However, water had to be removed from the concentrates at the process end and the concentrates dried for shipment. To separate the water from the concentrates, engineers installed various dewatering devices that ranged from conical and pyramidal settling boxes to Dorr thickeners. Mill workers introduced watery slurries into settling boxes where the fines accumulated and were drawn out through spigots in the bottom. The Dorr thickener, devised for high volumes of material, featured a tank at least 20 feet in diameter with a conical floor. Radial arms rotated slowly within the slurry and forced settled fines toward the tank's center, where the material passed through a large spigot.[70]

Gravity drew the metalliferous fines from one crushing and concentration stage to the next. However, each step had to make allowances for returning inferior material back for reprocessing, which meant defying gravity and sending heavy material uphill. To accomplish this, metallurgists used either a bucket-line or a spiral feed. Bucket-lines were a series of closely spaced sheet-iron pans stitched to an endless canvas belt, and they scooped material from one bin and deposited it into another. Spiral feeds, which were effective for moving fines short distances, typically featured an auger that rotated in a sheet-iron shroud. As the auger turned, it moved the material upward and deposited it into a bin. Material handled in such a way had to be moist enough to act as a solid and not emit dust.

Concentration mills relied on the same sources of power as mine surface plants, although the transition from steam to electricity at mills occurred slightly earlier. Through the 1890s, most mills relied on a single, large steam engine, which drove the various appliances through a system of overhead driveshafts and belts. The horizontal steam engine was most common, and small upright units powered additional appliances at large mills (Fig. E.II.66).

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[69] Peele, *Mining Engineer's Handbook*, 1680; Tinney, *Gold Mining Machinery*, 204.
[70] Peele, *Mining Engineer's Handbook*, 1669.

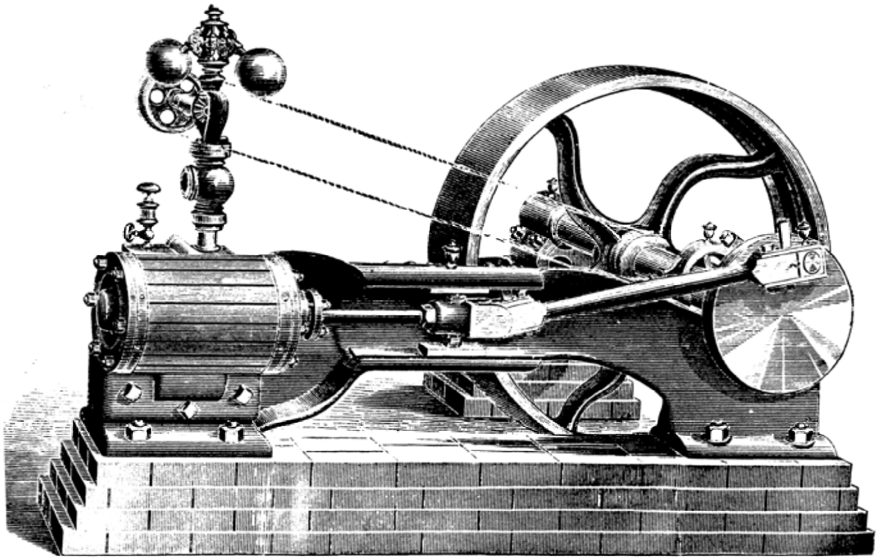

Fig. E.II.66 A horizontal steam engine. These powered most mills prior to the 1900s, when electricity became popular for such uses. The engine was bolted to a timber or masonry foundation usually located on a mill's lowest platform, which is often discernable at mills sites today. Note the outboard flywheel-bearing mount behind. Where electricity was available, milling companies installed motors to power their facilities. Ingersoll, *Rock Drills,* 53.

During the 1890s, engineers found that early motors were well suited to drive constantly operating mill machinery (Fig.E.II.67).

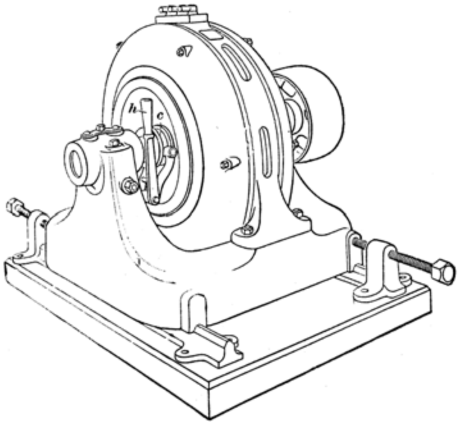

Fig. E.II.67 An early motor. Note the foundation. Motors were usually located on one of a mill's lower platforms, and large mills may have featured several on various platforms.

However, motors had trouble with machinery used at mines that came under sudden drag or had to operate at variable speeds. Motors capable of powering a mill had to be large and tended to be 4 by 5 feet in area or slightly smaller.

4.3 Amalgamation Stamp Mills

Two definitions apply to the term *stamp mill*. As noted above, concentration mills employed batteries of stamps to crush ore prior to other processing steps. In this case the term stamp mill refers to the stamp battery, which is a component of a concentration mill.

However, under the right mineralogical conditions, companies based an entire facility around a stamp battery to recover metals without smelting or advanced concentration. Specifically, the ore had to feature relatively simple gold or silver compounds and be easily crushed. A jaw crusher usually provided primary crushing, the stamps effected the rest of the physical reduction, and amalgamating tables at the battery's toe, coated with mercury, recovered the gold or silver. Workers periodically scraped off the amalgam and heated the mass in a retort, which volatilized the mercury and left the gold or silver.

Because stamp mills featured a fraction of the equipment installed at the more complex concentration mills, they tend to be smaller and simpler. Regardless, stamp mills shared with concentration mills a few fundamental components. First, the various stages of crushing and metals recovery, as well as other facilities were arranged on a series of platforms to use gravity to advantage. Second, they usually featured a receiving bin above the primary crusher to hold crude ore destined for processing. Third, the mid- or lower platform featured the power source, which was often a horizontal steam engine and boiler. Last, the mill required a source of water. It should be noted that metallurgists installed tertiary crushing and possibly a concentration appliance in some stamp mills, which better prepared the ore for amalgamation. When this is the case, the mill was known as an *amalgamation stamp mill*.

4.4 Arrastras

An arrastra was a simple, inexpensive, labor-intensive, and inefficient means of recovering metals from ore. Arrastras were primarily employed early in Colorado's history to treat simple gold and silver ores (See Section E.1.2.1). A few capital-starved outfits in remote locations continued to employ the technology through the nineteenth century. However, the availability of custom mills rendered these primitive treatment facilities obsolete by the 1870s.

A typical arrastra featured a circular floor of carefully fitted stones, low sidewalls, and a capstan at center. They ranged in size from around 6 to 20 feet in diameter, and all featured common characteristics. A beam was attached to the capstan's top, and as it rotated, the beam dragged between one and twelve muller stones across the floor, depending on the arrastra's size. Usually, the stones, chained to the beam, were staggered so they covered the floor's entire surface area. The early arrastras used by the Spanish relied on slave labor as motive power, which draft animals replaced in later decades. With the improvement of technology, scarcity of labor, and the desire for greater production, in a few cases engineers harnessed waterpower and steam engines. In Central and South America, and possibly the American Southwest, a few organized milling ventures adapted mechanized power to run batteries of arrastras, which is unusual in that other forms of milling technology proved more efficient. The simplest form of arrastra cost around $150 to build, much of which went to the labor necessary to dress and assemble the rockwork. The floor stones had to possess flat faces and tight joints, and the mullers had to feature convex bottoms and iron hooks hammered tight into drill-holes.[71]

To build an arrastra, a worker leveled a platform, excavated a pit at center, and installed the capstan, which had to be stout enough to resist great horizontal force. The worker paved the platform with a layer of fine clay and carefully fitted the floor stones together using more clay as mortar. With the floor complete, he erected

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[71] Meyerreicks, *Drills and Mills*, 194.

the sidewall, which consisted either of more stonework or planks on end. During the twentieth century, concrete became a popular substitute for rocks. Once the beam and mullers were in place, the arrastra was ready for operation.[72]

Running an arrastra required skill and experience with local ores, more than engineering and formal training in metallurgy. First, a worker scattered a *charge* of ore across the arrastra's floor, completely covering the stones, then introduced a little water. Then, the motive power began rotating the beam, dragging the mullers over the fragmented ore, slowly grinding it into sand. The worker periodically added more water to convert the material into a slurry, and sprinkled mercury into the material. The mullers continued to reduce the ore into a combination of sand and fine particles known as *slimes*, and the arrastra's sidewalls contained all on the floor stones. The purpose of adding mercury was to create an amalgam with the metals as they became exposed by the continued fracturing of the ore. Fine particles offered a greater surface area, facilitating amalgamation. Here, experience and familiarity with local ores came into play, and the arrastra operator added enough mercury to form an amalgam paste, but not to excess, as this would create a liquid difficult to recover. Generally, one ounce of mercury recovered an equal amount of gold, or one pound of silver. In some cases, the operator added lye to bind with oils and grease, which interfered with amalgamation.[73]

The next stage of processing ore was known as *cleanup*, where worthless *gangue* was removed and the amalgam recovered from the arrastra's interior. First, the operator had to drain the interior either by bailing, breaching the sidewall, or opening a port near the wall's base. With the water gone, the operator shoveled the exhausted sand and slime out, leaving a mud and sand layer on the flooring stones. The operator may have carefully washed additional material out of the arrastra's interior, exposing as much of the amalgam, smeared on the floor stones and deposited between the joints, as possible. Here heavy labor came into play. The operator disassembled the floor stones, if small, and washed and scraped off the amalgam, or merely scraped the amalgam off the stones if large. Lastly, he filled a retort with the precious material and heated the vessel to volatilize the mercury, leaving a sponge-like mass of metal. The retort's vapors were usually routed through cool pipes to condense the mercury for reuse. Afterward, the operator rebuilt the arrastra and repeated the process with another load of ore.[74]

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[72] Young, *Western Mining*, 69-71.
[73] Meyerreicks, *Drills and Mills*, 143, 195; Young, *Western Mining*, 71.
[74] Meyerreicks, *Drills and Mills*, 143, 195; Young, *Western Mining*, 71.

Property Types and Registration Requirements

The section provides a roster and descriptions of the historic property types common to Colorado's mining industry. The property types are categorized according to specific types of mining, as well as prospecting, beneficiation of ores, and settlement. The objective is to bring order and standardization to cultural resource work and historic preservation, and to format information for interpretation. To meet this goal, each property type features a list and description of archaeological, engineering, and architectural features commonly encountered at the property types today. The researcher should review the description of mining methods and equipment in Section E for context.

The following property types and subtypes are developed in this section:

- Placer Mine
  - Stream Placer
  - Gulch Placer
  - Hydraulic Placer
  - Dredge Placer
- Hardrock Prospect
  - Prospect Complex
  - Prospect Shaft
  - Prospect Adit
- Hardrock Mine
  - Shaft Mine
  - Tunnel Mine
- Open-Pit Mine
- Ore-Concentration Facility
  - Concentration Mill
  - Amalgamation Stamp Mill
  - Arrastra
- Smelter
- Coal Mine
- Mining Settlement and Residence
  - Prospectors' Camp
  - Worker Housing
  - Manager and Owner Housing
  - Isolated Residence
  - Unincorporated Settlement
  - Townsite

Property Type: Placer Mine

Placer mines were operations where interests ranging from individuals to capitalized companies processed stream gravel and soil for particles of gold. A difference exists between placer workings and placer mines. Some regions, such as the Blue River in Summit County, may feature thousands of feet of unbroken placer workings, indicated by characteristic tailings piles, pits, and infrastructure features. A placer mine, by contrast, was a property, usually defined by claim boundaries, which an individual or company worked for gold. Extensive placer workings may actually include several placer mines, although all may be recorded today as a single historic resource. The boundaries of small placer mines may be readily apparent where the overall workings are limited. Archival research and the physical examination of extensive workings may be necessary to identify specific mines. Usually, infrastructure features such as ditches, deep incisions, and dams can be traced to large mines. Colorado features several types of placer mines, which are discussed in the Property Subtypes below.

Placer Mine Subtypes

***Stream Placer*:** Both organized companies and individual miners created stream placers when they worked a streambed for gold. Streams are small waterways that usually flowed all year across broad, gently sloped drainage floors. Individual miners often dug pits down to bedrock in streambeds and used any combination of gold pans, cradles, and small sluices to recover gold. Organized companies often installed lengthy sluices to recover gold and created lengthy trenches or other large excavations when removing gravel for processing. Pits, trenches, piles of gravel and stream cobbles, and braided stream channels often denote a placer mine. If the stream flowed all year, miners may have piled tailings along the stream banks to maintain the waterway. Companies with lengthy sluices may have left rock piles and posts that supported the sluice and small, adjacent platforms that served as workstations. At substantial mines, companies often engineered networks of ditches and added other aspects of infrastructure such as residential buildings and blacksmith shops, usually represented today by platforms.

***Gulch Placer*:** Companies and individual miners created gulch placers when they worked a gulch, which was a narrow drainage, for gold. Because gulches tended to be narrow and steep, miners had to pile tailings in a linear fashion along one or both sides of the gulch. Over time, erosion reduced tailings piles to short linear segments, isolated piles, and deposits along the gulch sides, and the gulch floor often became braided. Extensive gulch placers operated by organized companies may offer the same infrastructure features as stream placers.

***Hydraulic Placer*:** Because hydraulic mining operations used jets of water to mobilize high volumes of gravel using economies of scale, sites remaining today tend to be expansive and feature broad deposits of tailings, piles of tailings, gullies, and abrupt, precipitous cut-banks. Hydraulic mining required an infrastructure to deliver water both for the monitors and for washing gravel through sluices. Ditches, pipelines, and flumes often directed water from regional drainages to a reservoir upslope from the site. Pipelines then carried the water under pressure to the monitors, and ditches and flumes directed water through the workings into sluices, where workers recovered gold. To support industrial activity, hydraulic mines also usually included a shop, other buildings, supports for pipelines, and roads. If the mine was more than one mile from the nearest settlement, the mining company often provided residences for the workers. In general, engineering and archaeological features represent most hydraulic mine sites today.

***Dredge Placer*:** Only a few relatively intact dredges remain in Colorado and dredge sites today are usually represented by archaeological and engineering features. Some dredge sites offer a rectangular hull in a pond while others may feature only the pond, industrial debris, and dredge tailings. One end of the pond may feature a cut-bank excavated into unaltered ground while piles of tailings, consisting of river cobbles and gravel, lie on the remaining sides. Because dredges moved at a glacial pace, dredge companies usually erected boardinghouses for the crew and shops to maintain machinery near the dredge pond. Electrified dredges received power through lines strung along utility poles.

Features Common to Placer Mines

Boom Dam: A dam intended to impound water for booming operations. Boom dams often featured a spillway or other form of breach that directed water into a boom ditch or drainage.

Boom Ditch: A ditch that directed water from a boom dam directly into placer workings.

Building Platform: A flat area that supported a building.

Building Remnant: The collapsed remains of a building.

Collection Ditch: A ditch that collected runoff from a placer mine for secondary uses or to impound sediments. A collection ditch should be located downstream from a placer mine.

Cut-Bank: The headwall of an excavation.

Dam: A water impoundment structure. Some dams for placer mines are earthen while others may consist of log cribbing filled with earth.

Ditch: An excavation that carried water to or from a placer mine. Ditches often tapped streams in adjacent drainages and featured a gentle gradient.

Dredge: A dredge, discussed above, consisted of a hull, a bucket line that scooped gravel, processing equipment, and a bucket line that dumped tailings behind. A frame structure on the deck enclosed the processing machinery and the powerplant. Only a handful of intact dredges remain, and most have been reduced to their hulls.

Dredge Hull: Salvage operations usually removed equipment off dredges, leaving the rectangular hull.

Dredge Hull Remnant: A dredge hull may be partially buried or decayed, leaving framing and partial walls.

Dredge Pond: The pond in which a dredge floated. Dredge ponds are usually surrounded by stacked tailings and may feature a cut-bank where the dredge ceased work.

Dredge Tailings: Dredges left telltale piles of tailings consisting of river cobbles and gravel. The piles may be pyramidal or arced and often lie in series along a riverbed.

Flume: A wooden structure that carried water to or from a placer mine, or carried a stream around a placer mine.

Flume Remnant: The structural remnants of a flume.

Monitor Station: A platform, tongue of earth, or perch where a hydraulic monitor was stationed. Monitor stations were usually strategically located amid hydraulic workings.

Penstock: A wooden or masonry structure, usually far upslope from a hydraulic mine, that directed water into a pipeline featuring a steep descent. The penstock's elevation and the pipeline's descent provided enough pressure for hydraulic mining.

Placer Pit: An excavation circular or ovoid in footprint where miners sought deep gravel.

Placer Trench: A linear excavation where miners sought deep gravel.

Placer Tailings: The hallmark of placer mining, tailings usually consist of ovoid or linear piles of gravel and rounded river cobbles.

Refuse Dump: A collection of industrial and structural debris cast-off during operations.

Reservoir: A void behind a dam for water storage.

Shop Platform: An earthen platform that supported a shop building, which can be defined by artifacts such as shop refuse and coal.

Shop Remnant: A collapsed shop.

Shop Refuse Dump: A deposit of shop refuse such as anthracite coal, forge-cut iron scraps, hardware, and forge clinker, which is a scorious residue generated by burning coal.
Sluice: Similar to a flume, a sluice was a lengthy wooden structure with a plank floor and walls, and the floor featured riffles for collecting gold. Piles of rocks and timber piers supported sluices, usually located at the bottom of a drainage.
Sluice Remnant: The remnants of a sluice, usually denoted by piers, posts, rock supports, and planks.
Supply Ditch: A ditch that delivered water to a placer mine.
Work Station: A platform alongside a sluice where workers supervised operations and maintained the sluice.

Placer Mine Significance

For a brief period of time, as an industry, placer mining was of great significance to Colorado. The Pikes Peak Gold Rush of 1858 brought the first large numbers of Euro-Americans to the region and gold strikes drew them deep into the mountains through the early 1860s. The result of the pursuit of placer gold was a permanent presence of Euro-Americans on the plains and in the eastern ranges of the Rocky Mountains. When miners exhausted the placer gold in most areas by the mid-1860s, many permanent residents turned to the gold's hardrock sources, which, when combined with discoveries of silver, became the foundation for Colorado's hardrock mining industry.

As a general category, placer mining holds significance in several other areas. One is the establishment of Colorado's system of water law, which miners devised to define and allocate rights for claimants. In later decades, other states adopted water laws similar to Colorado's. Placer mining also is significant in the area of *law* for association with the initiation of mineral claim laws, which were adopted across the Rocky Mountain West and modified for the 1872 Mining Law. The last area of significance is *social history,* in the establishment of a cultural and social climate that emphasized physical and economic mobility, opportunity, cooperation, and egalitarianism among Euro-Americans. After the mid-1860s, placer mining continued its significance in Colorado, but the significance narrows to the specific types of placer mining, which are discussed below.

Stream and Gulch Placers*:* As a subtype, stream and gulch placers were similar types of operations and therefore share aspects of significance. One aspect is the geographic regions where this type of placer mining was important, which includes Boulder, Clear Creek, Summit, Park, Lake, and the northwestern portion of Gunnison Counties. Several periods of significance apply to stream and gulch placers. The first is 1858 to 1865, when placer mining was a driving force for Euro-American exploration and settlement of Colorado. The second is 1929 to 1941, when impoverished people returned to many placer areas to eke out an income during the poor economic climate of the Great Depression. This movement maintained populations in gold mining areas, contributed to local economies, and allowed individuals and families to sustain income in the Rocky Mountains.

Hydraulic Placer*:* Because hydraulic placer mining developed after gulch and stream placer mining, its aspects of significance are different. Hydraulic mining required a combination of deep gravel deposits, consolidations of mining claims, capital, engineering, water, and a workforce. These qualities limited hydraulic mining to several regions of Colorado, primarily Summit, Park, the southern portion of Lake, and the northern portion of Chaffee Counties. Limited hydraulic mining also occurred along Clear Creek in Clear Creek County. The period of significance ranges from 1880 when capital, engineering, and a workforce were available, until 1910 when most hydraulic operations ceased.

Hydraulic mining was significant in economic, social, and engineering areas. In terms of economics, hydraulic mining contributed greatly to Colorado's placer gold production after that from stream and gulch operations waned. The income realized from hydraulic mining made its way into local and state economies as workers' wages, the acquisition of goods and supplies, and profits to investors.

In terms of social aspects, the profits gained from hydraulic mining reinforced the development of social classes; the mine owners and investors ascended to upper classes while the laborers, of whom there were many, formed a working class dependent on wages. The boom-and-bust nature of gold mining contributed to another social aspect. Gold booms created a pronounced employment market that drew workers from points throughout Colorado and other areas in the nation. The cycles of boom and bust required that the workers be mobile, which contrasted sharply with Colorado's sedentary farming and ranching societies. Each boom drew laborers from a variety of backgrounds while busts propelled them to other areas and economic sectors in Colorado and elsewhere in the nation. The result was a mobile, adaptable, and diverse society.

One of the most important and tangible areas of significance is engineering. Hydraulic mines required complex and advanced water distribution systems, the defensible allocation and use of water rights, and the consolidation of disparate placer claims. Hydraulic mining companies successfully coordinated these requirements and set a precedent followed by mining companies elsewhere, and by municipalities.

Dredge Placer: Gold dredging required a combination of deep river gravel, capital, and advanced and progressive engineering. Relatively few areas in Colorado offered the necessary river gravel deposits, which limited the geographic extent of the industry, and because dredging was not a uniform movement across Colorado, each center of dredging featured its own period of significance. Dredging mainly occurred in Summit County, the industry's birthplace in the Rocky Mountains, and the period of significance is 1897 to 1942. Park County hosted several dredges, and the period of significance there is 1915 to 1952. One dredge operated on the Arkansas River in Lake County, and the period of significance is 1905 to 1929. At least one dredge operated in Costilla County and the period of significance is 1910 to 1929. Colorado's first dredge worked Clear Creek downstream from and east of Black Hawk, and downstream from and east of Golden. The period of significance is 1895 until 1898, when the dredge was idled. Another dredge operated northwest of Tin Cup in Gunnison County, and the period of significance is 1908 to 1912.

Dredging in Colorado is significant primarily in the areas of engineering and economics. Colorado was the birthplace of dredging in the Rocky Mountains and saw some of North America's earliest successful operations. Given this, Colorado's dredging industry set some precedents and contributed greatly to the unique combination of marine, mechanical, and placer mining engineering. Further, Colorado presented the greatest environmental obstacles to dredging, including climate, gravel conditions, and short working seasons. This forced engineers to adapt existing technologies and methods and devise superior dredges, which were then employed in equally difficult areas such as Alaska.

Dredging in Colorado also stimulated the development of systematic assessment and sampling methods for placer deposits which were then used elsewhere. Like hydraulic mining, the dredging industry contributed to the development of water system engineering used by municipalities.

In terms of economics, dredging contributed greatly to Colorado's placer gold production after stream, gulch, and hydraulic operations were in decline. After around 1910, dredging was Colorado's principal producer of placer gold. The income realized from dredging made its way into local and state economies as workers' wages, the acquisition of goods and supplies, and profits to investors.

Placer Mine Registration Requirements

Stream and Gulch Placers: National Register-eligible stream and gulch placers must meet at least one of the NRHP Criteria and possess related integrity. Placer mines eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history,* as well as events, trends, and themes important to the specific region. Placer mines may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Most small placer mines will not qualify, although mines operated by organized companies may. For a placer mine to be eligible under Criterion C, the resource must clearly represent a type of placer mine and retain integrity from the period of significance. By nature, placer mine resources are located in an unstable physical environment prone to erosion, floods, and constantly shifting streambeds, leaving relatively few placer sites that retain integrity. Intact examples may be important because they represent one of Colorado's most fundamental types of mines. Under Criterion D, studies of the infrastructure features of large mines, including networks of ditches, sluice beds, and work areas, may enhance the current understanding of engineering applied to placer mining. If the resource possesses building platforms, testing and excavation of buried archaeological deposits may reveal information regarding workers' lifestyles and social structures of the workforce, as well as the functions of ancillary buildings.

These placer workings must possess physical integrity relative to the period of significance, which may vary by region. Because structures were usually removed when stream and gulch placers were abandoned, the integrity will probably be archaeological in nature. For a resource to retain archaeological integrity, the material evidence must clearly represent activities, work areas, engineering features, and structures. Placer mines operated by organized companies may also possess remnants of engineering features such as ditches, flumes, pipelines, and dams.

The most applicable of the seven aspects of historic integrity defined by the NRHP likely to be relevant for stream and gulch placers will be *setting*, *feeling*, and *association*. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance. In terms of *feeling*, the resource should convey the sense or perception of mining, both from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Hydraulic Placer: National Register-eligible hydraulic placers must meet at least one of the NRHP Criteria and possess related integrity. Hydraulic mines eligible under Criterion A should be associated with such areas of significance as *industry*, *engineering*, *economics*, or *social history*, as well as events, trends, and themes important to the specific region and the greater mining industry. Hydraulic mines hold a high potential to be eligible under Criterion B since they were usually designed and supervised by mining engineers. In the case of *engineering*, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies.

For a hydraulic mine to be eligible under Criterion C, the resource must clearly represent a hydraulic mine and retain integrity from the period of significance. The systems of water allocation and distribution must be evident, the workings should resemble those worked with hydraulic methods, and the locations of sluices should be evident. In general, hydraulic mines were uncommon and resources are therefore rare, which poor preservation conditions exacerbate. For this reason, relatively intact examples may be important representations of this key type of engineered placer operation. Hydraulic mines can offer contributions under Criterion D. Studies of the infrastructure features, including water allocation and distributions systems, sluice beds, and work areas may enhance the current understanding of engineering adapted to hydraulic mining. If the resource possesses building platforms, testing and excavation of buried archaeological deposits may reveal information regarding workers' lifestyles and social structures of the workforce, as well as the functions of ancillary buildings.

These placer workings must possess integrity relative to the period of significance, which may vary by region. Because structures were usually removed when hydraulic mines were abandoned, the integrity will probably be archaeological in nature. For a resource to retain archaeological integrity, the material evidence must clearly represent activities, work areas, engineering features, and structures. Hydraulic mines are expected to possess remnants of engineering features such as cut-banks, ditches, flumes, pipelines, sluice beds, penstocks, and reservoirs. For archaeological remains to retain integrity, the material evidence should convey its significance or permit the property to yield important information.

The most applicable of the seven aspects of historic integrity defined by the NRHP likely to be relevant for hydraulic mines will be *design*, *setting*, *feeling*, and *association*. For *design*, the resource must represent engineering, organization, and mining operations from the period of significance. A resource's overall feature assemblage, individual feature systems, and the landscape can represent *design*, and most of these characteristics will be archaeological in nature. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance. In terms of *feeling*, the resource should convey the sense or perception of mining, both from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Dredge Placer: National Register-eligible dredge sites must meet at least one of the NRHP Criteria and possess related integrity. Dredge sites eligible under Criterion A will associated with such areas of significance as *industry*, *economics*, or *social history*, as well as events, trends, and themes important to the specific region and the greater mining industry. Dredge sites are unlikely to be eligible under Criterion B even though they were usually designed and supervised by prominent mining engineers. The key mechanical and structural aspects of a dredge that could be readily attributed to the engineer will probably have been dismantled, leaving little to directly attribute to the important person. For a dredge site to be eligible under Criterion C, the resource must clearly represent the overall processes and activities of dredging and retain integrity from the period of significance. The dredge pond must be evident, portions of the dredge should be present, and tailings should remain. In general, dredges were uncommon and resources are therefore rare, which poor preservation conditions exacerbate. For this reason, relatively intact examples are important representations of dredge engineering and operations. Dredge sites can offer contributions under Criterion D. Studies of the infrastructure features, portions of the dredge, and support facilities such as shops, power transmission, and residences may enhance the current understanding of how mining companies conducted dredging. If the resource possesses building platforms, testing and excavation of buried archaeological deposits may reveal information regarding workers' lifestyles and social structures of the workforce, as well as the functions of ancillary buildings.

Dredge sites must possess integrity relative to the period of significance, which varies by region. Nearly all Colorado's dredges have been dismantled to some degree, leaving primarily archaeological and secondarily engineering features. For archaeological remains to retain integrity, the material evidence should convey its significance or permit the property to yield important information.

The most applicable of the seven aspects of historic integrity defined by the NRHP likely to be relevant for dredge sites will be *design*, *setting*, *feeling*, and *association*. For *design*, the resource must represent dredging engineering, organization, and operations from the period of significance. A resource's overall feature assemblage, individual feature systems, and the landscape can represent *design*, and most of these characteristics will be archaeological in nature. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance. The dredge pond should be clearly evident and it should feature piles of dredge tailings and a cut-bank. In terms of *feeling*, the resource should convey the sense or perception of dredging, both from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Hardrock Prospect

A prospect is the manifestation of an effort to locate economic ore. Prospects ranged in scale from shallow pits to extensive underground operations. In general, a lack of significant production serves as a unifying definition for prospects, although some may have yielded small volumes of ore. The absence of ore-storage facilities, minimal property development, inexpensive and portable equipment, and the investment of little capital often are hallmarks of prospect operations.

While most prospects tended to be simple, shallow, and lacked machinery, some were fairly advanced and possessed surface plants that required formal engineering and equipment. Given this, the researcher is likely to encounter a variety of prospect sites today with varying degrees of archaeological, engineering, and architectural integrity. While the researcher may be able to cipher out simple sites, interpreting the remnants of substantial operations can pose challenges. The substantial operations were usually centered on an adit or a shaft with an associated waste rock dump of some volume, which represents deep workings. While most prospects lacked machinery and were labor-intensive, deep operations employed some power appliances. Buildings, machinery, and other facilities usually shared the same orientation as the shaft or adit, and were clustered together around the opening. Because equipment for deep prospecting was intended to be portable, items were usually removed, leaving primarily archaeological evidence such as building platforms, machine foundations, and artifacts. Prospect sites can be grouped into three general subtypes.

Hardrock Prospect Subtypes

Prospect Complex: When prospectors attempted to locate mineral formations underlying soil, they often excavated groups of pits and trenches to expose bedrock. If the prospectors uncovered a promising lead, they drove adits and shafts to explore and sample the formation at depth. Collectively, groups of pits, trenches, adits, and shafts can be termed prospect complexes. Pits and trenches will be surfacial, shafts and adits should be shallow, and the sum represents mineral sampling and a search for ore. It should be noted, however, that some prospectors drove shallow adits and shafts merely to fulfill assessment obligations to retain title to mining claim. Experienced prospectors often followed an organized, strategic pattern when excavating their workings, which may become apparent when a prospect complex is mapped.

If a prospector invested an appreciable amount of time in a complex, which was necessary to drive adits and shafts, he usually constructed a few infrastructure components to support his work. One of the most common was a field forge where the prospector maintained his tools and fabricated basic hardware. Field forges were usually in the open and made with dry-laid rock masonry or small logs. Another was a residence, often either a simple log cabin or wall tent. Shafts required a hoist, and prospectors favored hand windlasses for their portability and low cost. A hand windlass was basically a wooden spool with a crank handle set in a frame over the shaft collar. Adits required wheelbarrows or ore cars to haul rock out. Because prospectors usually removed their equipment when they abandoned a site, archaeological features and excavations tend to represent prospect complexes.

Prospect Shaft: When prospectors discovered a mineral formation of promise, they often elected to sink a shaft to explore and sample it at depth. Initially, the prospectors would have installed a hand windlass to raise rock out of the shaft, and this primitive type of hoist had a depth capacity of around 100 feet. If they determined to continue sinking, the prospectors were forced to install a mechanical hoist, which is discussed in detail in Section E.II. At this point, most prospectors either sought capital for improvements or sold their property to an organized prospect outfit.

If the prospectors continued to sink the shaft themselves, they may have selected a horse whim, which was inexpensive and provided adequate depth capacity for further underground exploration. However, whims were too slow and limited in performance for many organized prospect outfits, which often installed power hoisting systems driven by steam or, by the 1900s, petroleum.

In addition to hoisting systems, prospectors and organized outfits had to install additional facilities to support work on the claim. Blacksmiths maintained tools and fabricated hardware in a shop, miners shuttled waste rock away from the shaft in ore cars on mine rail lines, and boilers provided steam power. The surface plant components were usually clustered around the shaft, and if the shaft was in a remote location, a residence stood nearby. All structures and equipment met temporary-class criteria, including low cost, portability, impermanence, and ease of construction. By definition, prospect shafts lacked evidence of ore-storage or processing facilities.

If the shaft failed to encounter ore in economical volumes, the outfit would have abandoned the site and removed all items of value. Given this, archaeological features and artifacts tend to represent prospect shaft sites today. The decay of timbering caused most shaft collars to collapse, leaving areas of subsidence that can appear similar to large prospect pits. For a site to be defined as a shaft, the volume of waste rock should exceed the area of subsidence.

Prospect Adit: When prospectors discovered a mineral formation of promise, they often elected to drive an adit to explore and sample it at depth. An adit was a horizontal entry underground usually 3 by 6 feet or less in-the-clear, and prospectors drove adits instead of sinking shafts because adits required less capital and effort. Prospect adits often featured surface plants equipped with little more than a blacksmith shop and a means of hauling waste rock out of the workings. Wheelbarrows were the simplest and least expensive device, and if the prospectors determined to continue driving, they may have used an ore car on a mine rail line. As the adit's length exceeded the penetration of fresh air, the prospectors may have installed either a hand-powered blower or bellows, or a windsock to force air underground through tubing. All the equipment noted above is discussed in detail in Section E.II.

The surface plant components were usually clustered around the adit portal, and if the adit was in a remote location, a residence usually stood nearby. All structures and equipment met temporary-class criteria, including low cost, portability, impermanence, and ease of construction. By definition, prospect adits lacked evidence of ore-storage or processing facilities.

If the adit failed to encounter ore in economical volumes, the outfit would have abandoned the site and removed all items of value. Given this, archaeological features and artifacts tend to represent prospect adit sites today. The decay of timbering caused most adit portals to collapse, leaving areas of subsidence that can appear similar to lengthy trenches. For a site to be defined as an adit, the volume of waste rock should exceed the area of subsidence.

Features Common to Hardrock Prospects

Boiler: A boiler was a vessel that generated the steam that powered machinery. Most boilers at prospect sites will be temporary-class upright, locomotive, and Pennsylvania types.

Boiler Foundation: Because portable boilers were self-contained and free-standing, prospect outfits usually stood them on platforms located near the hoist. Occasionally, however, workers erected rock or brick foundations or pads to support the boiler. The artifact assemblage around a foundation or platform can help the researcher identify it as that for a boiler. The assemblage should include clinker, which was a scorious, dark residue, as well as unburned bituminous coal, ash, water-level sight-glass fragments, and pipe fittings.

Some prospect outfits installed upright boilers on square or circular dry-laid rock pads or excavated a shallow pit underneath the boiler to allow ashes from the firebox to drop through. The pad's size should approximate the boiler's diameter.

Pennsylvania boilers and locomotive boilers stood on skids, which usually required no support. However, where the ground was soft or uneven, workers often laid parallel rock alignments to prevent the boiler from settling. In the absence of rock supports, the skids occasionally became embedded in the ground and left two parallel depressions the length and width of the boiler. For locomotive boilers without skids, which were rare, workers erected a rock or brick pylon to support the high rear, and laid a rock or brick pad that supported the firebox end.

Claim Marker: Prospectors erected claim markers at the corners of their claims, which were usually 500 by 1,500 feet in area. Markers ranged from cairns to blazes on trees to up-ended boulders. When a surveyor mapped and registered a claim, he usually etched the mineral survey number into a corner rock.

Claim Stake: A claim stake was the universally recognized form of claim marker. Claim stakes were usually 4x4 posts 4 feet high, and prospectors often substituted logs.

Draft Animal Track: A track walked by a draft animal that encircles a horse whim. Draft animal tracks tend to be around 20 feet in diameter and were cleared of major obstacles. Prospectors often graded semi-circular platforms adjacent to a shaft for a track.

Forge Remnant: Can manifest as a mound of gravel and rocks or the remnants of a gravel-filled wooden box, usually impregnated with coal and forge clinker. When coal burned at high temperatures, it left a scorious, dark residue known as *clinker*.

Headframe: A frame made of timber or logs that stood over a shaft. Headframes associated with horse whims were often large tripods or tetrapods. Power hoisting systems usually employed two-post gallows headframes.

Headframe Remnant: The collapsed remnants of a headframe.

Headframe Foundation: Headframe foundations usually manifest as parallel timbers that flank a shaft and extend toward the area where a hoist was located.

Hoist: Hoists at prospects were usually horse whims, steam, petroleum, or small electric models, as described in Section E.II.

Hoist Foundation: Nearly all mechanical hoists were anchored to foundations to keep them in place, and a foundation's footprint can reflect the type of hoist. Foundations are common at prospect shaft sites, and can usually be found aligned with and at least 20 feet from the shaft. Because of their ease of construction and low cost, prospectors usually assembled hoist foundations with timbers, and occasionally with stone or concrete. Timber foundations decay and become buried over time, and often manifest today as rectangular groups of four to six anchor bolts projecting out of a hoist house platform.

Horse whims were usually bolted to timber foundations 2 by 2 feet in area at the bottom of a shallow pit. The trench for the cable and linkages often extends from the pit to the shaft.

Foundations for single-drum steam hoists are usually rectangular, flat, and feature at least four anchor bolts. They can range in size from 6 by 6 feet to as little as 2 by 3 feet in area. Foundations for single-drum electric hoists appear very similar to those for steam hoists. Steam hoists often left behind plumbing and gaskets, and the site should possess evidence of an associated boiler. The use of electric hoists often generated electrical insulators and wires.

Foundations for gasoline hoists are fairly distinct. Their footprint is that of an elongated rectangle at least 2 by 6 feet in area oriented toward and aligned with the shaft. Due to the engine's severe vibrations, prospectors often bolted hoists to concrete foundations at least one foot high. Gasoline hoist foundations usually feature at least two rows of three anchor bolts, with the rear two closer together than the rest. Gasoline hoists can leave distinct artifact assemblages including thin wires, spark plugs, small pipes, and fine machine parts.

Hoist House: A structure that enclosed a hoist, the hoist's power source, and often a blacksmith shop. Hoist houses were usually located at least 20 feet away from the shaft.

Hoist House Platform: An earthen platform, usually graded with cut-and-fill methods, which supported a hoist house. The platform often features evidence of a hoist and a shop.

Hoist House Remnant: The collapsed remnants of a hoist house.

Horse Whim Pit: Prospectors often placed horse whims in shallow pits so the cable could pass through a trench to the headframe and pose no obstacle to the encircling draft animal. They often lined pits with planks or logs to retain soil, and over time these collapsed, leaving a concave depression. The pit should be at the center of a draft animal track, aligned with and at least 20 feet from the shaft, and feature the remnants of the cable trench.

Mine Rail Line: A track for ore cars.

Mine Rail Line Remnant: When prospectors dismantled a track, they often left in-situ ties, impressions of ties, and sections of rails.

Pack Trail: A path less than 8 feet wide that provided access to prospect workings.

Prospect Adit: A horizontal entry underground denoted by a waste-rock dump. When collapsed, adits appear as trenches.

Prospect Pit: A circular or ovoid excavation surrounded by a small volume of waste rock.

Prospect Shaft: A vertical or inclined opening underground. When intact, shafts tend to be rectangular and when collapsed, they manifest as circular areas of subsidence.

Prospect Trench: A linear excavation flanked by a small volume of waste rock.

Shop: A building that enclosed facilities where a worker fabricated and maintained tools and hardware. Simple shops usually featured a forge, a workbench, and possible hand-powered appliances such as a drill press.

Shop Platform: An earthen platform that supported a blacksmith shop. Shop platforms may feature forge remnants and often possess artifacts such as forge-cut iron scraps, anthracite coal, and clinker, which is a scorious, ashy residue created by burning coal.

Shop Remnant: The collapsed remnants of a shop.

Waste Rock Dump: The waste material removed from underground workings.

Hardrock Prospect Significance

In Colorado, prospectors first began subsurface exploration in 1859 in Boulder County, then Gilpin and Clear Creek Counties, and were rewarded with gold ore in the three regions. Despite the successes, hardrock prospecting remained primarily the domain of individuals with geological and mineralogical acumen until the early 1860s. At that time, the exhaustion of placer deposits combined with discoveries of gold veins stimulated a wave of hardrock prospecting, which progressed westward into the Rocky Mountains. The recognition of silver in Boulder, Clear Creek, Park, and Summit Counties during the mid- and late 1860s demonstrated that hardrock prospecting offered great potential that transcended only gold. During the following century, interest expanded to a variety of ores and minerals, most of which were discovered, proven, and developed through hardrock prospecting.

Several areas of significance surround hardrock prospecting and the associated resources remaining today. Because prospect complexes, adits, and shafts were similar in origin, purpose, and operation, the broad areas of significance apply to all. The first is the area of *industry* on the mining frontier. Individual prospectors, prospect parties, and prospect outfits were on the forefront of the mining frontier and laid the groundwork for the establishment of a regional mining industry. They were usually the first to conduct extensive physical and mineralogical exploration, and relayed information critical to subsequent mining interests and settlers. Prospectors and prospect outfits were often the first Euro-Americans to inhabit a region, especially when a rush developed, and brought political, economic, and social systems.

Engineering and prospecting methods constitute the second area of significance. Some prospect complexes represent the application of systematic, strategic sampling, which is a hallmark of educated and experienced prospectors. When necessary, individual and parties of prospectors applied just enough vernacular engineering and capital to prove the existence of ore, exemplified by simple prospect shafts and adits.

Mechanized operations, which tended to operate deep prospects, reflect another aspect of engineering. To find ore, they adapted known technology and engineering to the most primitive environmental conditions including difficult terrain, inaccessibility, unknown geological conditions, and an undeveloped landscape. Mechanized operations also adapted conventional geological knowledge and technology to make sense of and predict the occurrence of mineral formations and ore in uncharacterized regions. In so doing, they collectively made great contributions to the understanding of Colorado’s economic and structural geology and mineralogy.

Social history aspects are the third area of significance. Prospectors were an unusual cast of society and culture. To search and labor in the wilderness, they had to be adventuresome, independent, curious, physically robust, and skilled at survival. Most prospectors also possessed at least some formal education and many learned through a combination of experience and academics about geology and mineralogy. The very nature of wandering the mountains in search of wealth required individuals who did not conform to traditional Victorian cultural values. Prospecting distributed these characters throughout the Rocky Mountains, and they imparted some of their values and behaviors to the participants in the mining industry that followed prospecting, as well as to other settlers. Some of the values persist to the present.

Because prospecting is a subset of Colorado’s greater hardrock mining industry, it shares the same period of significance, which ranges from the first hardrock gold discoveries in 1859 until 1960 when most hardrock mining of substance ceased. Such a time frame is very broad, however, and should be applied to prospects only when the type of ore that prospectors sought is unknown. Instead, an accurate period of significance can be assigned according to two factors. The first is relative to a region’s history. The prospect should date to the development of the region’s mining industry. The second is relative to the type of ore that was important in a region, which can easily be determined through research. The periods of significance by ore type are:

Gold: 1859–1960
Silver: 1868–1960
Lead: 1868–1960
Zinc, Tungsten, Molybdenum, Vanadium: 1900–1960
Fluorspar: 1900–1960
Uranium: 1910–1970

Hardrock Prospect Registration Requirements

Prospect Complexes: National Register-eligible prospect complexes must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region. Prospect complexes may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Because it is extremely difficult to directly attribute a given complex to an important person, few complexes will be eligible under Criterion B.

Most prospect complexes will also not be eligible under Criterion C because they manifest as random groups of pits, adits, and shafts. Such resources offer few period-defining characteristics and attributes. However, if the organization pattern is clearly evident, then the resource may be eligible under Criterion C as a representation of a discernable, organized, and planned effort. Prospect complexes many also be eligible under Criterion C if the resource possesses intact architectural or engineering features reflecting a type, period or method of construction associated with prospecting.

Under Criterion D, if a single group of workings appears to follow a pattern, then recording surrounding groups may enhance the current understanding of sampling methods used by prospectors. If the resource possesses building platforms, testing and excavation of buried archaeological deposits may reveal information regarding prospectors' lifestyles and social structures, which is important because they were not extensively documented at the time.

Few prospect complexes retain important characteristics or features. Given this, most will be ineligible for the NRHP, although several exceptions exist. Eligible resources must possess physical integrity relative to the period of significance, which may vary by region and ore type. Because prospect complexes possessed few structures, most of which were usually removed when the site was abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the prospect operation such that it conveys its significance or yields important information.

The most applicable of the seven aspects of historic integrity defined by the NRHP likely to be relevant for prospect complexes will be *setting*, *feeling*, and *association*. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance. Usually, this requires a preserved natural landscape and environment. In terms of *feeling*, the resource should convey the sense or perception of prospecting from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Prospect Shaft: National Register-eligible prospect shafts must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region. Prospect shafts may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Because it is extremely difficult to directly attribute a given prospect shaft to an important person, few resources will be eligible under Criterion B.

Most prospect shafts will also not be eligible under Criterion C because they offer few important or period-defining characteristics and attributes, and usually possess integrity impaired by natural decay and modern disturbance. However, the resource may be eligible under Criterion C if it possesses intact structures and equipment, a high degree of integrity, or important engineering or architectural features. Important engineering and architectural features include intact buildings, structures, machinery, and shaft collars. Under Criterion C, the resource should represent deep prospecting, which was an important phase of mining.

Under Criterion D, accessible and intact underground workings are important because few formal studies have been carried out regarding the underground work environment, engineering, equipment, and practices of drilling, blasting, and removing rock. Currently, historical documentation is the principal body of information that researchers rely on for studying the above aspects of prospect development. If the resource possesses building platforms, testing and excavation of buried archaeological deposits may reveal information regarding prospectors' lifestyles and social structures, which is important because they were not extensively documented at the time.

As a property subtype, prospect shafts tend to be common, while examples retaining high degrees of engineering or architectural integrity or archaeological integrity are uncommon. For a prospect shaft site to be eligible, it must possess integrity relative to the period of significance, which may vary by region and ore type. Because structures and equipment were usually removed when shafts were abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the operation such that it conveys its significance or yields important information.

The most applicable aspects of the seven aspects of historic integrity defined by the NRHP likely to be relevant for prospect shafts will be *design*, *setting*, *feeling*, and *association*. For *design*, the resource must represent engineering, organization, and operations from the period of significance. A resource's overall feature assemblage and individual feature systems can represent design, and most of these characteristics will be archaeological in nature. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance, which usually requires an intact natural environment. In terms of *feeling,* the resource should convey the sense or perception of underground operations, both from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Prospect Adit: National Register-eligible prospect adits must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as industry or social history, as well as events, trends, and themes important to the specific region. Prospect adits may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Because it is extremely difficult to directly attribute a given prospect adit to an important person, few resources will be eligible under Criterion B.

Most prospect adits will also not be eligible under Criterion C because they offer few important or period-defining characteristics and attributes, and usually possess integrity impaired by natural decay and modern disturbance. However, the resource may be eligible under Criterion C if it possesses important engineering or architectural features reflecting a type, period or method of construction and sufficient integrity to convey this significance. Important engineering and architectural features include intact buildings, structures, machinery, and adit portals. Under Criterion C, the resource should represent deep prospecting, which was an important phase of mining.

Under Criterion D, accessible and intact underground workings are important because few formal studies have been carried out regarding the underground work environment, engineering, equipment, and practices of drilling, blasting, and removing rock. Currently, historical documentation is the principal body of information that researchers rely on for studying the above aspects of prospect development. If the resource possesses building platforms, testing and excavation of buried archaeological deposits may reveal information regarding prospectors' lifestyles and social structures, which are important because they were not extensively documented at the time.

As a property subtype, prospect adits tend to be common, while examples retaining high degrees of archaeological, engineering, or architectural integrity are uncommon and often important. For a prospect adit to be eligible, it must possess integrity relative to the period of significance, which may vary by region and ore type. Because structures and equipment were usually removed when adits were abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the operation. Features commonly encountered amid prospect adit sites are described under associated features above.

Not all the seven aspects of historical integrity defined by the NRHP are likely to be relevant for prospect adits. The most applicable aspects will be *design*, *setting*, *feeling*, and *association*. For *design*, the resource must represent engineering, organization, and operations from the period of significance. A resource's overall feature assemblage and individual feature systems can represent *design*, and most of these characteristics will be archaeological in nature. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance, which usually requires an intact natural environment. In terms of *feeling*, the resource should convey the sense or perception of underground operations, both from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Hardrock Mine

Hardrock mines were underground operations that produced ore. Usually company endeavors, mines ranged in scale from small and labor-intensive to extensive, mechanized operations. Not all mines were profitable, but most shared a few basic characteristics, such as substantial waste-rock dumps often at least 125 by 125 feet in area, ore-storage facilities, more than one structure, and roads to transport materials and ore.

While small, marginal mines were similar in scale and content to advanced prospects, many operations featured substantial surface plants to support intensive work underground. To facilitate the extraction of ore, expedite materials handling, and accommodate various activities, mining companies often employed machinery and erected buildings larger than those at prospects. Some companies attempted to produce ore using economies of scale while minimizing energy consumption and costly labor. Such operations relied on advanced, costly machinery and efficient ore handling systems arranged in complex, spacious surface plants.

Mines shared the same needs as deep prospects, and so their surface plants possessed the same set of facilities. In addition, mines often possessed several types of facilities and other characteristics not found at prospects, which are discussed in Section E.II. First, mines usually had ore-storage or processing facilities. Ore bins permitted mining companies to store ore between shipments, and companies that mined complex ore often erected ore-sorting houses where workers manually separated waste and segregated the ore according to quality.

Substantial, productive mines begin to differ from prospects and small mines in the scale and content of their surface plants. Shaft operations in particular featured hoisting systems that permitted high tonnages of payrock to be raised from deep workings. The general layout and types of components were similar, only larger in scale and structurally superior. Prior to the 1910s, substantial mines employed steam hoists and afterward used electric models, and rarely installed gasoline hoists. To match the duty of the hoist and hoisting vehicle, mining companies usually erected well-built headframes. Mining engineers deemed the portable boilers used by small operations insufficient to generate enough steam in a cost-effective manner and instead turned toward stationary units. The return-tube boiler was by far the most common, and a few of the wealthiest companies employed water-tube boilers.

In addition to production-class hoisting systems, highly productive, large-scale shaft mines included additional facilities amid their surface plants, which tunnel operations equally employed. The compressed-air system was one of the most common, and it permitted miners underground to use mechanical rockdrills to bore blast-holes. Prior to 1900, steam powered most compressors while motors became common afterward in the principal mining districts.

The shop was a key facility that differed in size, scale, and complexity for small, moderate, and large operations. In general, the employment of machinery created a heavy demand for advanced metalwork and carpentry. To meet such needs and to increase the volume and scale of work, substantial mining companies erected spacious shops equipped with power-driven appliances. Further, particularly large companies constructed separate buildings for blacksmithing and sharpening of drill steels, machine work, and carpentry. Where possible, companies located the shop adjacent to the mine opening to minimize the undue handling of heavy materials. Many shops featured a basic array of power appliances, including a drill-press, lathe, trip hammer, and pipe cutter. The late 1890s saw a number of mining companies employ electric motors to power their shop appliances, while they used upright steam engines in prior years. Power hammers were often no more than a worn rockdrill mounted to a heavy timber post, furnished with compressed air. By the 1910s, machinery manufacturers offered mechanical drill-steel sharpeners to increase the volume of work completed by blacksmiths. Most power appliances had to be anchored to foundations, which ranged from timbers to concrete pads.

The need for efficient transportation gave rise to another form of facility which productive companies constructed. To overcome the impediments of winter weather, snow, and hostile terrain, companies built aerial tramways that descended from a mine to a shipping point or concentration mill. Small, impoverished operations installed single-rope reversible systems, which were the simplest. Companies with moderate financing strung double-rope reversible systems, which consisted of two track cables and a pair of tram buckets linked by a cable loop. The Bleichert double-rope system, with its endless loop of buckets, was the most efficient and most costly, which limited the system to heavily capitalized companies.

In many cases, the surface plants erected by advanced, highly productive companies required more than the several structures typical of small outfits. For efficient servicing, to minimize plumbing, and for better engineering, substantial companies generally clustered their mechanical components and shops together in either large tunnel houses or shaft houses. Ancillary facilities, such as separate shops, electrical transformers, explosives magazines, offices, and quarters for draft animals were enclosed in individual buildings. In general, the surface plants for substantial operations featured the primary shaft house or tunnel house surrounded by several smaller structures.

Hardrock Mine Subtypes

Shaft Mine: Shaft mines were operations that produced ore from vertical or inclined shafts. Companies almost always arranged critical surface plant components around the shaft collar. Large shaft mines possessed complex, mechanized surface plants with multiple structures, and small operations were simple and may have featured similar facilities to those erected at deep prospects. The presence of an ore bin or sorting house, or the evidence thereof, can distinguish a mine from a deep prospect.

Small to moderate shaft mines retaining limited integrity are common while sites retaining high degrees of archaeological, engineering, or architectural integrity are uncommon and possibly important. Large, complex shaft mines are uncommon and those retaining any form of integrity are rare and important.

Tunnel Mine: Like shaft mines, tunnel mines were usually company endeavors that produced ore. The difference, however, is that the company drove a horizontal tunnel or adit (see Feature Descriptions below for definitions) to work an ore body. Companies almost always arranged critical surface plant components around the tunnel portal. Large tunnel mines possessed complex, mechanized surface plants with multiple structures, and small operations were simple and may have featured similar facilities to those erected at deep prospects. The presence of an ore bin or sorting house, or the evidence thereof, can distinguish a mine from a deep prospect.

Small to moderate tunnel mines retaining limited integrity are common while sites retaining high degrees of archaeological, engineering, or architectural integrity are uncommon and possibly important. Large, complex tunnel mines are uncommon and those retaining any form of integrity are rare and important.

Features Common to Hardrock Mines

Mine sites often possess an array of archaeological, engineering, and architectural features that were originally components of the surface plant. To help researchers identify system components and organize their data, the Feature Types below are organized under the common systems that comprised mine surface plants. The associated feature noted below are in addition to those also found at prospects, and so the researcher should review prospect site features and see Section E for a complete context.

General Features

Adit: A horizontal opening usually less than 3 by 6 feet in-the-clear. Collapsed adits manifest as linear areas of subsidence. Tunnels were larger horizontal openings and greater than 3 by 6 feet in-the-clear.

Building Platform: A flat area upon which a building stood. If possible, specify the type of building.

Cribbing: A latticework of logs usually intended to be filled with waste rock or earth. Some cribbing structures served as retaining walls for platforms and waste rock dumps.

Explosives Magazine: Organized mining outfits erected magazines to store explosives away from a mine's surface plant. Some magazines were dugouts, some were stout stone structures, while others were no more than small sheds much like dog houses.

Machine Foundation: A timber, masonry, or concrete foundation for an unknown type of machine.

Mine Rail Line: A track that facilitated the movement of ore cars around a mine site.

Mine Rail Line Remnant: When a mine rail line was dismantled, workers often left ties, impressions from ties, portions of rails, and the rail bed.

Pipeline: An assembly of pipes usually intended to carry water. Pipelines should not be confused with compressed-air mains, which extended from a compressor into underground workings.

Pipeline Remnant: Evidence of a disassembled pipeline.

Privy: Most mines of substance featured a privy for the crew's personal use. Privies usually are small frame structures with a door and a bench featuring between one and several cutouts for toilet seats.

Privy Pit: A pit that underlay a privy. Pits tend to manifest as depressions less than 5 feet in diameter, often with artifacts and other materials in their walls and bottoms.

Refuse Dump: A collection of hardware, structural materials, and other cast-off items.

Road: Roads were graded for wagons and trucks and were usually at least 8 feet wide.

Shaft: A vertical or inclined opening underground usually at least 4 by 8 feet in area. Some shafts were divided into compartments. The largest compartment was the *hoisting compartment* and the smaller, usually less than 3 feet wide, was the *utility compartment*. Highly productive mines may have featured shafts with two hoisting compartments and a utility compartment. Evidence of a double-drum hoist should be associated with a three-compartment shaft. Collapsed shafts manifest as areas of subsidence.

Shaft House: A shaft house was a large building that enclosed the shaft collar, the hoisting system, and usually a shop. Mine rail lines usually extended away from the shaft and passed out the building. Large shaft houses may have also encompassed an air compressor.

Shaft House Platform: The platform that supported a shaft house. Large shaft houses often stood on rock foundations, which can define the structure’s perimeter. Differences in soil types and consistencies can reflect a shaft house’s footprint.

Shaft House Remnant: The collapsed remains of a shaft house.

Stable: A building that housed draft animals used for both underground and surface transportation. Stables were often crude and featured wide doorways, feed mangers, and oat boxes.

Stable Remnant: The collapsed remnants of a stable.

Timber Dressing Station: Timber dressing stations tend to be represented by collections of raw logs and numerous cut wood scraps, usually on flat or gently sloped ground near the mine opening.

Timber Stockpile: A stockpile of mine timbers, often located near the mine opening.

Trestle: A structure that supported a mine rail line, walkway, or pipeline. Workers often built small trestles on the flanks of waste-rock dumps to support dead-end rail lines.

Trestle Remnant: Posts, single piers, or partial stringers left from a trestle.

Tunnel: A horizontal opening underground usually more than 3 by 6 feet in-the-clear. Collapsed tunnels often manifest as linear areas of subsidence, possibly with pipes or rails projecting outward.

Tunnel House: A tunnel house was a structure that enclosed the tunnel portal and usually a shop. A mine rail line usually passed out of the tunnel portal and through the tunnel house, as did a trench or flume to divert drainage water. Large tunnel houses often encompassed a mechanized shop and work area where miners dressed timbers.

Tunnel House Platform: The platform that supported a tunnel house. Workers usually graded a cut-and-fill platform around the tunnel portal for the building, and large versions often stood on rock foundations, which can define the structure’s perimeter. The platform, as well as differences in soil types and consistencies, can reflect a tunnel house’s footprint.

Tunnel House Remnant: The collapsed remains of a tunnel house.

Utility Pole: A pole that supported an electrical or communication line.

Ventilation Blower: Many mining operations employed ventilation blowers to force fresh air underground. They usually located the blower adjacent to the mine opening and attached an assemblage of ventilation tubes that extended underground. Large blowers had to be anchored to foundations, and as most were belt-driven, they featured an adjacent motor or steam engine.

Ventilation Blower Foundation: Large blowers were anchored to simple foundations usually consisting of timbers embedded in the ground adjacent to the mine opening. The foundations tend to be 3 by 4 feet in area or less and feature four anchor bolts. A motor or small steam engine that powered the blower was usually bolted to an adjacent foundation.

Compressed-Air System Features

Air Compressor: An air compressor was a machine that compressed air piped underground to power rockdrills. Mining companies employed a variety of types that rose and fell in popularity between the 1870s and 1940s. For a list of types, their descriptions, and popularity age ranges, see Section E.II.

Air-Compressor Foundation: Because of their great weight and powerful motion, air compressors had to be anchored to solid foundations. Workers often constructed timber foundations for small compressors and used either rock or brick masonry, or concrete for large models. In most cases, when a mine was abandoned the compressor was removed, leaving the foundation as the machine’s only representation, and based on a foundation's footprint, the researcher can often determine the exact type of compressor. The foundations for the types of compressors are described in Section E.II.

Compressed-Air Main: A pipeline that carried compressed air from a compressor into the underground workings.

Compressor House: Mines with expansive surface plants occasionally included a compressor house, which enclosed an air compressor and receiving tank. If the compressor was steam driven, then the building also usually enclosed a boiler, unless the mine featured one elsewhere.

Compressor-House Platform: The platform that supported a compressor house. Compressor house platforms should feature a compressor foundation, a motor mount or boiler setting remnant, and an artifact assemblage consisting of machine parts and pipe fittings.

Compressor House Remnant: The collapsed remains of a compressor house.

Hoisting System Features

Headframe: Mining operations erected four general types of headframes to meet the needs of ore production. The first is an enlarged version of the two-post gallows discussed above with Prospect Shafts. The second was the *four-post derrick*, which consisted of four posts joined with cross-members and diagonal beams, all supported by two backbraces. The third is the *six-post derrick*, which featured six posts instead of four. The last is a large *A frame*. Production-class headframes were more than 30 feet high and stood on well-built timber foundations.

Headframe Foundation: Foundations for production-class headframes consisted of a timber frame usually embedded in the waste rock surrounding a shaft. The timbers flanked the shaft and extended toward the area where the hoist was located.

Headframe Remnant: The collapsed remnants of a headframe.

Hoist: To meet the needs of ore production, mining companies engaged in production almost always employed power hoists. See Section E.II for types, descriptions, and age ranges for hoists.

Hoist Foundation: Few shaft mines retain their hoists and instead feature foundations, which are distinct today. Foundations typical of specific types of hoists are discussed in Section E.II.

Hoist House: See Prospect Site Feature Types.

Hoist House Platform: See Prospect Site Feature Types.

Hoist House Remnant: See Prospect Site Feature Types.

Power System Features

Boiler: Many small, marginal mining operations employed portable boilers to power hoists and minor pieces of equipment, as did prospect outfits. However, mining companies wishing for a permanent, efficient source of steam usually installed return-tube boilers. For descriptions of boilers, see Section E.II.

Boiler Foundation: When small mining operations removed portable boilers, they occasionally left simple rock or brick supports for the unit, which are discussed under Prospect Site Feature Types. Dismantling a return-tube boiler and its masonry setting, however, resulted in more substantial, distinct structural remnants in the form of a foundation. Return-tube boiler foundations were usually flat, 10 by 18 feet in area, and consisted of rock or brick masonry. In many cases a foundation may retain a bridge wall, which is a low row of bricks between the walls that forced flue gases against the boiler's belly. If more than the rock or brick pad remains, such as collapsed brick walls, then the feature is a boiler setting remnant.

Boiler Setting Remnant: When salvage efforts extracted a return-tube boiler shell, they almost always left the masonry setting in some degree of collapse, which can be described as a boiler setting remnant. Collapsed settings range in appearance from mostly intact masonry walls to piles of rubble. If the walls are intact, setting remnants may feature the cast-iron façade or the masonry bolts that anchored the façade, and they may also feature the posts that supported the boiler shell. Most setting remnants also feature a bridge wall, which was a low brick divider in the setting's interior. Most return-tube boiler settings consisted of red bricks or rocks and featured a cleaning port near ground level at the rear.

Setting remnants for water-tube boilers possess several differences from those for return-tube units. They may feature ornate façades, girders that supported the tube and shell assemblage, large-diameter pipes, and cleaning ports with iron jambs on the sides and at the rear.

Boiler Clinker Dump: When workers shoveled residue out of a boiler's firebox, they usually dumped the material on the waste-rock dump near the boiler. Boiler-clinker dumps tend to be distinct and consist primarily of boiler clinkers, which are dark, scorious, ashy clasts created by burning coal. Boiler-clinker dumps also usually include slate fragments, unburned bituminous coal, and structural and industrial hardware.

Motor: The common motor consisted of a cylindrical body, a belt pulley, and electrical wiring. Most motors were less than 4 by 5 feet in area.

Motor Foundation: Due to great weight and stresses created by motion, workers usually anchored motors to stout concrete foundations usually less than 4 by 5 feet in area. Foundations tend to be slightly rectangular, feature four to six anchor bolts, and are aligned with the machine that the motor powered.

Transformer House: Companies that employed electricity for lighting and power circuits often erected transformer houses to shelter electrical equipment. They usually located the structures away from the rest of the surface plant in case of fire. Transformer houses are relatively small, rarely exceeding 30 by 30 feet in area, and usually feature brackets and mounts on posts for the transformers, as well as ports in the walls for wires, and numerous insulators.

Transformer House Platform: Workers usually erected transformer houses on cut-and-fill platforms that appear generic, except for a telltale artifact assemblage consisting of a high proportion of electrical items. Examples include cast-iron transformer cases, porcelain or slate switch panel fragments, fuses, porcelain insulators, high-voltage porcelain insulators, glass insulators, and wires.

Transformer House Remnant: The collapsed remnants of a transformer house.

Ore-storage and Processing Features

Ore Bin: Mining outfits erected ore bins to contain payrock for shipment. Ore bins could be of the sloped-floor variety or open, flat-bottom structures. For a description of ore-bin types, see Section E.II.

Ore-Bin Platform or Foundation: A platform or foundation that supported an ore bin. Open, flat-bottom bins usually stood on a platform located on the flank of a waste-rock dump so workers could dump payrock from an ore car. Sloped-floor bins usually stood on a combination of a platform, which supported the bin's head, and log or timber pilings that supported the remainder.

Ore-Bin Remnant: The collapsed or partial remnants of an ore bin.

Ore Chute: A chute that directed payrock into an ore bin or into a vehicle.

Ore-Chute Remnant: The collapsed remnants of an ore chute.

Ore-Sorting House: Ore-sorting houses, discussed in Section E.II, were complex structures that featured an ore bin at bottom, an overlying sorting room, and bins or chutes at top to receive raw ore.

Ore-Sorting House Platform or Foundation: Platforms and foundations for sorting houses usually appear similar to those built for ore bins. The difference can manifest as discrete piles of large waste cobbles flanking the foundation. The piles are often different in appearance from the rest of the mine's common waste rock, and often consist of rough cobbles of a uniform size.

Ore-Sorting House Remnant: The collapsed remnants of a sorting house.

Shop Feature Systems

Backing Block: Some shops featured backing blocks to help workers sharpen drill steels for rockdrills. A backing block consisted of an iron rod 4 by 4 inches or less in cross-section and up to 8 feet long embedded in the shop floor near the forge. The block's surface featured a series of deep divots where the worker rested the drill-steel's butt, and he leaned the drill-steel's neck against an anvil to brace the item for sharpening. Many mining outfits substituted a railroad rail for the iron rod.

Drill-Steel Sharpening Machine: Most sharpeners were upright units 2 by 3 feet in area, 3 to 5 feet high, and featured an assemblage of clamps and power hammers mounted on a cast-iron pedestal. Sharpeners are always located in a shop or on a shop platform.

Drill-Steel Sharpening Machine Foundation: Because drill-steel sharpening machines destroyed unpadded concrete foundations over time, they were usually bolted to foundations consisting of timbers or timber footers over concrete. Sharpener foundations are always located in a shop or on a shop platform, are usually 2 by 3 feet in area, and possess four to five anchor bolts.

Forge: Almost every mine shop featured a forge where blacksmiths heated iron. Several types of forges proved popular, and most were 3 by 3 feet in area and 2 feet high. The *gravel-filled rock forge* consisted of dry-laid rock walls filled with gravel. The *wooden box forge* consisted of plank walls retaining gravel fill. The free standing *iron pan forge* featured an iron pan supported by iron legs. Companies that required high volumes of work also installed cylindrical iron and square iron box forges usually 4 by 4 feet in area.

Forge Remnant: Over time, wooden box and rock forges decay, leaving mounds of gravel that often feature anthracite coal, clinker, and forge-cut iron scraps.

Lathe Foundation: Some mechanized shops featured a lathe to facilitate metalwork and woodwork. Lathes were usually bolted to parallel timbers around 2 by 8 feet in area or less.

Power Hammer Foundation: Advanced, mechanized mining companies installed power hammers in their shops to expedite metalwork. Many power hammers consisted of obsolete rockdrills bolted to timber posts, which pounded items clamped to an underlying table. When removed, power hammers can be denoted by a heavy timber post up to 6 feet high and an adjacent timber stump where the table was located.

Shop: Shops at mines featured facilities for the manufacture and repair of tools, hardware, and machinery. Some shops also facilitated carpentry. Nearly all shops included blacksmith facilities at the least and some were equipped with power-driven appliances.

Shop Platform: The platform that supported a shop. An artifact assemblage including forge clinker, pieces of hardware, forge-cut iron scraps, cut pipe scraps, and cut wood scraps can help identify a shop platform.

Shop Remnant: The collapsed remains of a shop.

Shop Refuse Dump: A deposit or scatter of forge clinker, forge-cut iron scraps, cut pipe scraps, and pieces of hardware. Carpentry shops left an abundance of cut wood scraps, sawdust, and hardware.

Hardrock Mine Significance

In Colorado, hardrock mining began in 1859 in Boulder County and spread to Gilpin and Clear Creek Counties within the year. Despite proof that gold could be won from hardrock veins, most miners in Colorado focused on placer deposits, leaving hardrock mining primarily to individuals with geological and mineralogical experience. However, in the early 1860s, the exhaustion of placer deposits combined with the popularization of gold veins stimulated a wave of hardrock mining, which progressed westward into the Rocky Mountains. The recognition of silver in Boulder, Clear Creek, Park, and Summit Counties during the mid- and late 1860s demonstrated that more than merely gold could be realized through hardrock mining. During the following century, interest expanded to a variety of ores and minerals, creating a mining industry known worldwide for profitability, cutting-edge and progressive engineering and technology, and a high volume of production.

Several areas of significance surround hardrock mining and the associated resources remaining today. Because tunnel mines and shaft mines were similar in origin, purpose, and operation, the broad areas of significance apply to all. The first is the theme of *industry* in the mining frontier. Mining companies, often on the heels of prospectors, were on the forefront of the frontier and brought social, economic, government, and transportation systems to the wilderness. If a region featured ore deposits that lasted more than a few years, a mining industry developed and it usually resulted in permanent settlement that outlived the industry.

The second areas of significance involve themes in *economics*, *commerce*, and *social history*. On a broad scale, mining companies were part of and contributed to complex regional, statewide, and national economic and financial systems. For example, most of the capitalists who invested in Colorado's companies were of regional and statewide importance, while a few were based outside of Colorado. Implementation of investments, associated communication, banking, and the acquisition and shipment of supplies and food occurred on inter-state and intrastate levels. It should be noted that large mines had a greater association than the small operations.

As another example, mining companies diverted money into local economies by paying wages to their workers, hiring consultants for various services, and purchasing smaller items from sources mostly in major towns. Productive companies acquired large machinery and other industrial goods from manufacturers mostly in Denver, and to a lesser degree from outside of Colorado. The manufacturers in Denver in turn purchased their materials from sources within and outside of Colorado. Given this, mining companies supported primarily Colorado's and secondarily other economies. Further, between the 1880s and 1930s, Denver hosted one of the nation's most prolific mine-supply industries, and by acquiring goods and machinery from Denver, mining companies ensured the continued success of Denver's mine supply industry.

For a third example, the thousands of workers employed by Colorado's mining companies consumed food and other domestic goods purchased from a variety of sources. Preserved food was shipped from packing companies in the Midwest and on the West Coast, while fresh foods had to come from Colorado farms and ranches. By consuming preserved and fresh foods, mining company employees not only supported a complex national food transportation network, but also helped the development of farming and ranching in Colorado. Merchants in the major towns handled most of the food and goods, and the acquisition of such therefore contributed to their local economies.

Large, highly profitable companies saw the consumption of volumes of goods, services, and machinery, and are therefore more closely allied with the above trends than small operations. Cumulatively, however, the small companies, which outnumbered substantial operations, had a significant impact.

Themes related to *politics/government* constitute the third area of significance. Mining in Colorado was integrally tied to and a direct function of political systems on statewide, national, and international scales. In terms of silver, Federal programs proved crucial for the metal's demand and inflated silver's values to levels that rendered mining economical. The Bland-Allison Act of 1878 and the Sherman Silver Purchase Act of 1890 instituted price supports and acquisition quotas for silver. In response, mining companies across the West, including in Colorado, prospected for and some actually produced the metal. Repeal of the Sherman Silver Purchase Act and the subsequent collapse of silver's value brought silver mining and prospecting to a temporary halt. Passage of the Silver Purchase Act of 1934 increased the metal's value again, resuscitating mining. Federal programs related to the world wars and defense influenced the production of many industrial metals such as zinc, tungsten, and molybdenum. In terms of uranium, Cold War programs during the 1950s and 1960s fostered a high demand for the radioactive mineral, which stimulated widespread prospecting and mining.

On an international scale, until 1893 the British pursued a pro-silver policy, and many Europeans followed the same trend during World War I, which stimulated mining in Colorado. With the return to normalcy in 1919, silver values returned to low levels, which caused mining to return to a torpid state.

On a regional scale, Colorado's hardrock mining industry (mostly in the form of workers, mining capitalists), and companies provided political and economic support for senators, representatives, and lobbyists who fought for the federal programs that kept the value of crucial metals high. Further, some of Colorado's mining elite, such as Jerome Chaffee, the Wolcotts, Henry Teller, David H. Moffat, and others held public office and directly influenced federal policy.

While few individual mine sites can be directly tied to specific political acts and policies, as whole, Colorado's mining industry played heavily into statewide and federal policies.

The fourth area of significance involves *social history* themes. The participants in Colorado's hardrock mining industry contributed to the development and evolution of regional, statewide, and national social structures. One social structure was the development of classes in Colorado. When mining companies began production during the 1860s, their profits contributed to the initial development of social classes in Colorado. The owners and investors began their ascent to upper classes while the laborers, of whom there were many, formed a working class dependent on wages. As mining continued from the early 1890s into the 1910s, two general categories of capitalists then acquired the productive properties and financed exploration. The first and by far largest category consisted of local investors of limited means primarily in nearby commercial centers, and the second category consisted of an already wealthy elite based in Denver and in the Midwest. The profits realized from the mines reinforced the fortunes of the few elite while contributing heavily to the formation of a middle class, which ultimately became one of the country's economic and political backbones. Because the mining companies depended on wage laborers, company operations ensured the continuation of a working class.

The very nature of the workforce that made mining in Colorado possible constituted another form of social structure. Activity in the various mining districts created an insatiable employment market that drew workers from points throughout Colorado and other areas in the nation. Some of those workers were immigrants, mostly from European countries. The cycles of boom and bust inherent to gold, silver, and industrial metals mining required that the workers be mobile, which contrasted sharply with Colorado's sedentary farming and ranching societies. Each boom drew laborers from a variety of backgrounds while busts propelled them to other areas and economic sectors in Colorado and elsewhere in the nation. The result was a mobile, adaptable, and diverse society.

Large mine sites can be strongly allied with the themes of class, workforce, and demography because they supported major workforces. Small mine sites, on the other hand, tend to be associated primarily with mobility, lower classes, and a demography of independent individuals.

Engineering related to mining methods constitutes the last but not least area of significance. As a whole, Colorado's hardrock mining industry rendered a wide variety of important technological and engineering contributions that rippled outward to other industries and public sectors. While specific contributions are too numerous to note, many of Colorado's mines were proving grounds for advances in electricity, steam power, compressed-air systems, aerial tramways, rockdrilling, hoisting, and surveying. Colorado was also on the forefront of the evolution of mining from simple and labor-intensive to advanced, highly mechanized operations. This involved the coordination of complex mechanical systems and hundreds of workers in dozens of miles of workings within a single mine. In Colorado, many companies quickly transcended the haphazard practice of developing underground workings and building surface facilities on an as-need basis and instead employed planning and organization. Some of this was based on economic calculation, including applying science to the estimation of ore reserves and production costs. Overall, Colorado's mining industry demonstrated those practices and applications of engineering and technology that were effective, which varied by region, climate, and environment.

Some mining engineers also credit Colorado's mining industry (especially in the San Juan Mountains), with introducing then improving the strategy of producing low-grade ore using economies of scale.[1] This proved crucial for the national mining industry because it rendered previously uneconomical ores profitable, which extended the viability of many individual mines as well as overall mining districts.

Given that most of Colorado's hardrock mines were points along a spectrum of engineering and technology, from small and simple to large and complex, no single operation encapsulated all the above trends. Particularly large mines may have witnessed some of the contributions and developments, which must be verified on an individual basis through archival research. Small mines, as a group, played roles in identifying, defining, and demonstrating those technologies and methods that were effective in regional conditions.

The body of metamorphic and igneous geological formations forming the bulk of the Rocky Mountains constitutes the area of geographic significance for hardrock mining. The region extends southwest from the Manhattan Mining District (located west of Fort Collins), to the San Juan Mountains, and extends northwest from Custer County to the town of Eagle, in Eagle County. The period of significance for Colorado's hardrock mining industry ranges from the first hardrock gold discoveries in 1859 until 1960 when nearly all underground hardrock mining of substance ceased. Such a timeframe is very broad, however, and should be applied to mines only when the type of ore that companies produced is unknown. Instead, an accurate period of significance can be assigned according to two factors. The first is relative to a region's history. The mine should date to the principal period of the region's mining industry, which was often a function of overall increases in the value of silver and industrial metals. The second is relative to the type of ore that was important in a region, which can easily be determined through research. The periods of significance by ore type are:

Gold: 1859–1960
Silver: 1868–1960
Lead: 1868–1960
Zinc, Tungsten, Molybdenum, Vanadium: 1900–1960
Fluorspar: 1900–1960
Uranium: 1910–1970

Hardrock Mine Registration Requirements

The property subtypes of shaft and tunnel mines form a spectrum ranging from small, simple, and unimportant to large, complex, and significant. In Colorado, small and simple mines were common and tended not to be involved with major engineering and technological contributions on an individual basis, although they could have been important to a specific region. Large and complex mines were uncommon and often participated in the development of engineering and technology, and tended to be associated with multiple themes of importance. Many small mines will be ineligible for the NRHP, although several exceptions exist.

National Register-eligible mine sites must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history,* as well as events, trends, and themes important to the specific region.

Mines may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some mines, especially large complexes, often can be traced to important individuals such as engineers, and in these cases, they can be eligible under Criterion B. In the case of

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[1] "Obituary: Edward Stoiber," 865; Ransome, "A report on the economic geology," 23.

engineering, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies. It should also be noted that mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Most small mines will probably not be eligible under Criterion C because they offer few important or period-defining characteristics and attributes, and usually lack integrity. However, if the organization pattern is clearly evident, or structures and machinery are present, then the resource may be eligible under Criterion C. In general, intact structures and machinery are uncommon and important representations of engineering and technology. The resource should clearly reflect a small or moderately sized mine, which were important because they made up the bulk of Colorado's hardrock mining industry. Large mines can be eligible under Criterion C if the resource possesses intact archaeological, architectural or engineering features that clearly convey aspects of the mining operation. The features must represent the application of engineering, technology, and methods during the period of significance.

Under Criterion D, if the mine site possesses building platforms, privy pits, and boiler-clinker dumps, testing and excavation of these buried archaeological deposits may reveal information regarding miners' lifestyles, social structures, and the workplace, which are important because they were not extensively documented at the time. Accessible and intact underground workings are important because few formal studies have been carried out regarding the underground work environment, engineering, equipment, and practices of drilling, blasting, and removing rock. Currently, historical documentation is the principal body of information that researchers rely on for studying the above aspects of mining. Detailed studies of structures and machinery can contribute information regarding engineering and architectural practices, and the application of technology.

Eligible resources must possess physical integrity relative to the period of significance, which may vary by region and ore type. Because most small mines possessed few structures and little machinery, which were usually salvaged when a site was abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the mining operation. Large and complex mines were subject to the same predation as small mines; however, at least a few engineering and architectural features can remain. Therefore, large mines often retain primarily archaeological and occasionally engineering and architectural integrity. Common features encountered at mine complexes are noted under the feature types above.

Most of the seven aspects of historic integrity defined by the NRHP apply to mine sites. Some mine sites may possess standing structures and intact machinery, which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the structure or machine at the site should be that present during the period of significance. For a resource to retain the aspect of *design*, the resource's material remains, including the archaeological features, must convey the mine's organization, planning, and engineering. In many cases, mines were worked periodically and the surface facilities changed and adapted to new operations, leaving evidence of sequential occupation. In such cases, a resource can retain the aspect of *design* if the material remains reflect the evolution of the surface facilities over time. By studying archival information and material evidence, the researcher can determine when specific surface facilities were built and abandoned, thereby building a chronology for the resource's evolution. To retain the aspect of *setting,* the area around the resource, and the resource itself, must not have changed a great degree from its period of significance. If the resource is isolated, then the natural landscape should be preserved. If the resource lies in a mining landscape, then the surrounding mines and industrial features should retain at least archaeological integrity. In terms of *feeling,* the resource should convey the sense or perception of mining from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Open-Pit Mine

Open-pit mines were surface operations that produced ore. Almost always company endeavors, open-pit mines ranged in scale from small and labor-intensive to extensive, mechanized operations. At small mines, companies usually worked limited bodies of high-grade metal ore, often gold, silver, or tungsten. At large mines, such as Climax, heavily capitalized companies employed advanced mechanization to produce low-grade ore using economies of scale. Most open-pit operations shared a few basic characteristics such as exposed workings, substantial waste-rock dumps, ore-storage facilities, efficient transportation systems within the workings, and support facilities similar to those at underground mines. Many open-pit mines were parts of greater operations that included underground workings.

Open-pit mining began in Colorado during the 1860s when a few companies mined the surface expressions of gold and silver veins in Clear Creek and Gilpin Counties and grew in popularity during the early 1880s with the discovery of a few massive silver, lead, and iron formations in Custer, Lake, and Chaffee Counties. As low-grade ore and fluorspar became profitable during the late 1890s, open-pit mining spread on a limited basis to other counties such as Teller, Boulder, and Summit. Most of these operations were labor-intensive and employed some mechanization limited primarily to ore trains and compressed-air systems. The introduction of earth-moving equipment and drill rigs capable of boring deep, large-diameter blast-holes permitted production using economies of scale necessary to render ores of very low grades profitable, which ushered in a wave of open-pit mining beginning in the 1930s. As the costs of underground mining increased through the 1940s and 1950s, open-pit mining became increasingly attractive until it dominated Colorado's mining industry.

While small open-pit mines were similar in scale and equipment to labor-intensive underground operations, large open-pit mines were very different. Small open-pit mines always featured surface workings, which were usually limited in shape and size to the ore body. Prior to the 1930s, miners often worked the ore body in benches and hauled ore out of the pit in single ore cars or trains drawn by animals. A shop where a blacksmith maintained tools and fabricated hardware stood near the pit entrance, and ore bins were often located nearby. To allow miners to push ore cars to the bin edge, the bin rim had to be concurrent in elevation with the pit floor. Mechanized operations may have included an electric or steam-powered air compressor.

The introduction of earth-moving equipment during the 1930s and 1940s changed mining practices in open pits and required a revision of support facilities and ore handling. First, the scale of pits increased since earth-moving equipment reduced the costs of production per ton of rock. Drill rigs were able to bore deep blast-holes that contained a high volume of explosives, which brought down greater volumes of rock than with labor-intensive methods. As a result, the headwalls around pits increased in height. Second, loaders scooped the blasted material into trucks, and they required a broad, even floor and the maintenance of wide access avenues. Third, because large blasts generated boulders that were unmanageable to transport, many mining companies had to install crushing stations over their ore bins. Fourth, repair shops had to accommodate the complex equipment and workers needed to be versed in vehicle mechanics. Last, productive open-pit mines necessitated well-built roads for concentration mills and large haul trucks. Like most mines, large open-pit operations concentrated their facilities together for ease of servicing and coordination.

Features Common to Open-Pit Mines

Open-pit mine sites often possess an assemblage of archaeological, engineering, and architectural features that represent the mining operation and its support facilities. To help researchers identify system components and organize their data, the associated features below are organized under the common groups that comprised open-pit mines. These features are in addition to those also found at hardrock mines, and so the researcher should review shop, compressed air, electricity, and transportation feature types for both prospects and hardrock mines above.

General Features

Access Road: A road that provided light-duty vehicles access in and around the workings.
Bench: Companies worked large and deep open-pit mines in benches, which were discrete terraces subjected to drilling and blasting.
Conveyor: Some open-pit mines featured conveyor belts that shuttled ore to a crusher, ore bin, or mill.
Crushing Station: By the 1950s, many open-pit mines featured rock crushers that reduced boulders and large cobbles for storage or treatment. The crusher was installed in a building with a receiving bin at the head and a conveyor or holding bin at the bottom.
Fuel Tank: Heavy equipment and haul trucks required fuel, which was often stored in tanks elevated on steel frames. Some tanks also stood on platforms near the pit entry.
Generator: By the 1950s, some open-pit mines featured generators to provide electricity for lighting and to run machinery. A generator was similar in form to a motor and many models were powered by petroleum engines.
Generator Station: A frame building that enclosed a generator and electrical substation.
Grizzly: A grizzly was a screening structure that separated blasted rock by size. Earth-moving equipment dumped mixed rock onto the grizzly, which usually consisted of heavy iron rods, and fine material passed through while boulders rolled off.
Headwall: The exposed rock face in an open pit.
Haul Road: A road that accommodated dump trucks. Many mines featured at least one haul road through the pit to a crusher or ore bin, and at least another to the waste-rock dump.
Loading Area: Two forms of loading areas existed. One was the location on a pit floor where heavy equipment loaded dump trucks with rock. The other was at the toe of an ore bin where trucks or wagons were loaded with ore.
Office: Most open-pit mines featured an office where workers and superintendents administered to operational affairs.
Open Cut: A relatively small open pit or a narrow excavation where the surface expression of vein was removed.
Open Pit: A broad and deep incision in the ground where ore was removed.
Pit Floor: The floor in an open pit where workers loaded dump trucks or wagons and maneuvered and parked heavy equipment.
Portable Air Compressor: By the 1940s, portable compressors were popular in open-pit mines because they could be towed to points of work. Portable compressors usually featured an upright compressor, a petroleum driven engine, and an air receiving tank on a four-wheel trailer.
Rock Crusher: A machine that reduced large cobbles and boulders to a manageable size.

Open-Pit Mine Significance

Several areas of significance surround open-pit mining and the associated resources remaining today. The first area of significance involves themes in *economics*, *industry* and *commerce*. On a broad scale, open-pit mining companies were part of and contributed to complex regional, statewide, and national economic and financial systems. Most of the capitalists who invested in Colorado's companies were of regional and statewide importance, while a few were based outside of Colorado. Implementation of investments, associated communication, banking, and the acquisition and shipment of supplies and food occurred on inter-state and intrastate levels. As another example, mining companies diverted money into local economies by paying wages to their workers, hiring consultants for various services, and purchasing smaller items from sources mostly in major towns. This was very important in Colorado because many of the mines developed during and after the 1940s were in historic mining districts in decline. Open-pit mining, therefore, helped such communities to remain economically solvent.

Productive companies acquired machinery and other industrial goods from suppliers throughout the nation, which supported heavy manufacturing. Further, many of the suppliers historically served the mining industry, and by acquiring machinery from them, open-pit companies supported the manufacturers' transition from equipment for use underground to that for surface work. The transition was key because underground mining declined and the market shrank.

Open-pit mining companies made significant contributions to Colorado's mineral production, which offset the dwindling offerings of the underground sector. The mineral production proved to be an important part of the state's economy.

Themes in *politics/government* constitute the second area of significance. Because open-pit mining was an important economic engine for Colorado, state and federal legislators supported policies that favored both the industry and its market conditions. In association with this, a synergistic relationship developed between important federal agencies and mining companies that produced strategic metals and minerals, such as molybdenum, uranium, vanadium, and fluorspar. The Defense Department's direct support of the Climax molybdenum mine serves as an example.

Open-pit operations contributed heavily to the development of laws and regulations new to the mining industry. In response to a series of chemical spills, leaking cyanide facilities, and heavy metals contamination, the Environmental Protection Agency and the Colorado Department of Public Health and the Environment drafted a sweeping suite of regulations and laws that governed the practices of open-pit mining.

The third area of significance involves *social history*. The open-pit mining industry contributed heavily to the maintenance of social structures in Colorado's mountainous areas. By the 1940s, most historic mining districts were in deep decline because underground mining largely ceased. The development of open-pit mines in such districts, however, created jobs that maintained populations and some level of culture in these areas. Further, open-pit mining attracted a workforce similar to underground mining, which kept the demography close to a community's original. Related to this is the continuation of the industrial class system in Colorado's mountainous areas. Like underground operations, the profits realized from open-pit mines reinforced the fortunes of the elite while contributing heavily to middle- and working-class groups.

Engineering and mining methods constitute the last major area of significance. As a whole, Colorado's open-pit industry contributed a wide variety of technological and engineering advances to surface mining. Colorado was the site of an evolution from simple, labor-intensive mining to highly mechanized operations that produced massive volumes of ore using economies of scale. In relationship, some of Colorado's open-pit mines such as at Climax, Cripple Creek, and Summitville were proving grounds for new types of equipment and innovative applications of technology. Machinery manufacturers adapted wheeled and tracked vehicles to the unique conditions of Colorado's open-pit mines, creating a fleet of specialty devices. Manufacturers provided, and open-pit companies used, multi-ton haul trucks and loaders, as well as large power shovels and rapid drill rigs. Colorado's open-pit companies also contributed to the improvement of blasting practices that involved great tonnages of explosive agents unlike the dynamite used in underground mines. A few companies also forwarded the management and coordination of extensive surface operations and the necessary infrastructure, such as at Climax. The open-pit industry participated in the development of innovative materials treatment and handling methods such as heap leaching, the concentration of uncommon metals such as molybdenum, and the disposal of millions of tons of waste rock.

Because open-pit companies targeted primarily gold and industrial metals in historic mining districts, the areas of geographic significance are the same as for underground hardrock mining. The period of significance for Colorado's open-pit mining industry ranges from the first surface mining of hardrock gold in 1859 through 1990, when most open-pit mines were idle. It should be noted, however, that the Cripple Creek Mining District features an open-pit mine projected to continue until around 2010. The overall period of significance is very broad and should be applied to mines only when the type of ore that companies produced is unknown. Instead, an accurate period of significance can be assigned according to the type of ore that was important in a region, which can easily be determined through research. The periods of significance by ore type are:

Gold: 1859–1990
Silver: 1868–1950
Lead: 1868–1960
Zinc, Tungsten, Molybdenum, Vanadium: 1900–1980
Fluorspar: 1900–1960
Uranium: 1910–1980

Open-Pit Mine Registration Requirements

The Property Type of open-pit mines forms a spectrum ranging from small, simple, and unimportant endeavors to large, complex, and significant operations. While open-pit mining was never common throughout Colorado, small and simple mines were the most abundant and tended not to be involved with major engineering and technological contributions on an individual basis, although they could have been important to a specific region. Large and complex mines were uncommon, often participated in the development of engineering and technology, and tended to be associated with multiple themes of importance.

National Register-eligible mine sites must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, as well as events, trends, and themes important to the specific region. Mines may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some mines, especially large complexes, often can be traced to important individuals such as engineers, and in these cases, they can be eligible under Criterion B. In the case of *engineering*, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies. Mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Most small mines will probably not be eligible under Criterion C because they offer few distinguishing or period-defining characteristics and attributes, and often lack integrity. However, if the organization pattern is clearly evident or structures and machinery are present, then the resource may be eligible under Criterion C. In general, intact structures and machinery are uncommon and important representations of engineering and technology. Large mines can be eligible under Criterion C if the resource possesses intact archaeological, architectural or engineering features that clearly convey aspects of the mining operation. The features must represent the application of engineering, technology, and methods during the period of significance. However, because most equipment used in open-pit mines was portable, little direct evidence remains, which dilutes the archaeological integrity.

Under Criterion D, large mines may be eligible because relatively few have been studied in detail and can provide information regarding open-pit engineering, mining practices, and the workplace. Detailed studies of structures and machinery can contribute information regarding engineering and architectural practices, and the application of technology.

Eligible resources must possess physical integrity relative to the period of significance, which may vary by region and ore type. Because most small mines possessed few structures and little machinery, which was usually salvaged when a site was abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the mining operation. Large and complex mines were subject to the same predation as small mines; however, at least a few engineering and architectural features can remain. Therefore, large mines often retain primarily archaeological and occasionally engineering and architectural integrity. Common features encountered at mine complexes are noted under the feature types above.

Most of the seven aspects of historic integrity defined by the NRHP apply to open-pit mines. Some resources may possess standing structures and intact machinery, which must retain the aspect of *location* to contribute to a site's integrity. To retain integrity of *location*, the structure or machine must be in its original place of installation. For a resource to retain the aspect of *design*, the resource's material remains, including the archaeological features, must convey the mine's organization, planning, and engineering. By studying archival information and material evidence, the researcher can determine when specific surface facilities were built and abandoned, thereby building a chronology for the resource's evolution. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance. Open-pit mines usually lie in a mining landscape, requiring that the surrounding mines and industrial features retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of mining from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Ore-Concentration Facility

One of the main objectives of mining was to reduce ore to its constituent metals. In general, the process began with crushing and grinding the ore, followed by separating metalliferous material from waste in a stage known as concentration. The resultant concentrates were roasted and smelted in a furnace, which furthered the separation and yielded a blend of metals known as matte. Advanced smelters, located in cities on the plains and in the Midwest, refined the matte into pure metals. In general, ores of purity or simplicity required fewer steps while complex, refractory ores required time-intensive treatment and numerous steps.

A variety of facilities carried out one or all of the necessary processing steps, and many operated in mining districts as independent mills or in conjunction with a specific mine. Some mining companies erected *concentration mills* to complete the crushing and concentration steps ordinarily carried out by smelters, which saved the companies costs in two areas. First, mining companies did not incur high transportation costs by shipping waste-laden ore, and second, they avoided paying the fees charged by smelters for complete treatment. Concentration mills, also known as *reduction mills*, produced only concentrates and no refined metals, and processed gold, silver, and industrial metal ores.

Concentration mills ranged in scale from small facilities to sprawling industrial complexes, and metallurgists based the treatment processes on specific types of ore. Colorado saw the application of three general categories of concentration mills, which are described in detail in Section E.II. The historic mining industry termed the first and most popular the concentration mill, the second was the amalgamation stamp mill, and the third, rarely used after the 1860s, was the arrastra.

Often, concentration mills employed batteries of stamps to crush ore prior to other processing steps. However, under the right conditions, companies were able to employ *stamp mills* as a simple means of recovering metals without smelting. Specifically, easily crushed, free-milling gold and silver ores, uncommon in Colorado, were able to be treated by a stamp mill. In this instance, battery stamps crushed the raw ore, and amalgamating tables at the battery's toe recovered the gold or silver. Because of their simplicity and relatively low cost, stamp mills were within economic reach of many mining companies. However, the complex nature of most of Colorado's ores rendered them ineffective, and as a result, stamp mills as a sole treatment facility were uncommon.

Ore-Concentration Facility Subtypes

Concentration Mill: A concentration mill was a facility that employed primarily mechanical and occasionally chemical means to separate metalliferous materials from waste. Mills came in a variety of scales and were usually built over a series of terraces incised into a hillslope so that gravity could draw the ore through the processing stages. Small mills, often built by mining companies as dedicated facilities, usually featured only several stages of crushing and concentration. Large mills, often built as independent facilities or by highly productive mining companies, were heavily equipped to process both great volumes of ore, and complex ore that resisted treatment.

Engineers usually followed a general template when designing concentration mills. An ore bin stood at the mill's head and it fed crude ore into a primary crusher, usually located on the mill's top platform. The resultant gravel descended to a secondary crusher located on the platform below, then through a screening system. Oversized material returned for secondary crushing and material that passed the screen went on for concentration at small mills, or tertiary crushing at large mills. Following another screening, the ore descended to subsequent mill platforms for concentration.

As can be surmised, concentration mills were complex facilities equipped with a variety of crushing and concentration appliances, and the specific flow path was a function of the type and volume of ore being treated. When intact, concentration mills were substantial industrial structures that descended a hillslope and enclosed the various terraces. When a mill was abandoned, the structures and machinery were usually removed, leaving stair-step platforms, machine foundations, and hardware. Tailings left from ore processing were usually flumed to an area downslope from the mill and today manifest as substantial deposits of finely ground sand and rock flour. Mill sites lacking tailings may not have processed much ore.

Today, concentration mill sites may be perceived as somewhat common, and most productive mining districts feature at least several. However, due to salvage efforts, tailings removal, alteration, and natural decay, few mill sites remain intact. Given this, sites retaining only partial engineering and architectural integrity, and high degrees of archaeological integrity, are uncommon to rare and may be important. Sites retaining high degrees of engineering and architectural integrity tend to be very rare, and Colorado features only a handful of completely intact mills. On an individual basis, some concentration mill sites can be argued as being important since many were custom affairs where general engineering was adapted to specific environmental or mineralogical conditions. Further, mills engineered to treat rare ores, such as tungsten, and telluride gold and silver, are by association uncommon and often important.

***Amalgamation Stamp Mill**:* Two definitions apply to the term *stamp mill*. Often, concentration mills employed batteries of stamps to provide secondary or tertiary crushing prior to the separation of waste. In this case the term stamp mill refers to the stamp battery, which is a component of a concentration mill.

However, some types of ore lent themselves to being pulverized in a stamp battery then treated with mercury to recover metals without smelting. Specifically, the ore had to feature relatively simple gold or silver compounds and be easily crushed. A jaw crusher usually provided primary crushing, the stamps affected the rest of the physical reduction, and the resultant slurry washed over amalgamating tables at the battery's toe. The tables were coated with mercury, which amalgamated with the gold or silver and allowed the spent tailings to continue out of the mill. Workers periodically scraped off the amalgam and heated the mass in a retort, which volatized the mercury and left the impure gold or silver, which had to be refined. These treatment facilities are generally termed amalgamation stamp mills and as such may be recorded as specific resources.

Because stamp mills featured a fraction of the equipment installed at the more complex concentration mills, they tend to be smaller and simpler. Regardless, stamp mills shared with concentration mills a few fundamental components. First, because they relied on gravity to draw the ore through the stages of crushing and metals recovery, metallurgists usually erected stamp mill facilities over terraces cut out of a slope. Second, amalgamation stamp mills usually featured a receiving bin above the primary crusher to hold crude ore destined for processing. Third, the mid- or lower platform featured the power source, which was often a horizontal steam engine and boiler. Last, the mill required a source of water. It should be noted that engineers installed tertiary crushing and possibly concentration appliances in some stamp mills, which better prepared the ore and recovered any metal that escaped amalgamation.

***Arrastra**:* An arrastra was a simple and inefficient apparatus for recovering metals from ore. An arrastra consisted of a circular stone floor usually less than 30 feet in diameter with low sidewalls and a capstan at center. A draft animal, tethered to a harness beam fastened to the capstan, walked a path around the stone floor. Drag-stones, chained to the harness beam, ground the ore on the stone floor. Some outfits substituted waterpower for draft animals.

Features Common to Ore-Concentration Facilities

Mill sites often possess an array of archaeological, engineering, and architectural features that were components of the crushing, concentration, power, and support facility systems. To help researchers identify components and organize their data, the associated features below are organized according to the general flow path employed at mills.

General Features

Arrastra: An arrastra consisted of a circular stone floor ringed with low sidewalls, and a capstan at center. A draft animal tethered to a harness beam bolted to the capstan walked around the floor, dragging stones chained to the beam.

Arrastra Remnant: Arrastra remnants may retain portions of the floor, sidewalls, and capstan.

Assay Shop Platform: Mills usually featured assay shops to track the efficiency of metals recovery and concentration, and the buildings often stood on platforms. Such platforms may feature foundations or other remnant of an assay furnace, as well as clinker, bricks, assay crucibles, and laboratory artifacts.

Cistern: A concrete, masonry, or timber chamber that contained water for mill use. Because mills usually relied on gravity to pressurize plumbing, cisterns tend to be located upslope from a mill.

Conveyor: Conveyors lifted ore from one mill appliance or process to another. Early conveyors consisted of a bucket-line or spiral feed while later conveyors consisted of belts on rollers.

Conveyor Remnant: A partially disassembled conveyor.

Ditch: An excavation that carried water to a mill.

Flume: A wooden structure usually constructed with plank walls and a plank floor. Workers built flumes to convey water to or tailings away from the mill, and to transfer slurry from one process to another.

Flume Remnant: The collapsed or buried remnants of a flume.

Machine Foundation: A foundation that anchored an unknown mill machine.

Mill Building: The structure that enclosed a mill. Mill buildings tend to be large, based on stout frames, and conformed to stair-step terraces or foundations.

Mill Building Remnant: A collapsed mill building.

Mill Platform: One of the main platforms or flat areas that supported a stage of crushing or concentration. Platforms should be numbered from the top down and described according to function.

Mill Tailings Dump: A deposit of finely ground rock flour and sand usually downslope or downstream from a mill.

Pipeline: An assembly of pipes that carried water.

Pipeline Remnant: The evidence left by a disassembled pipeline.

Privy: Most mill complexes included a privy for the crew's personal use.

Privy Pit: The pit that underlay a privy. Privy pits are often less than 5 feet in diameter and may feature artifacts visible in the walls and floor.

Pump Foundation: Often of concrete, pump foundations are rectangular, less than 2 by 4 feet in area, and may feature pipes.

Receiving Bin: An ore bin located at the mill's head that received crude ore for processing.

Receiving Bin Platform or Foundation: Foundations and platforms for receiving bins can be similar to those for ore bins at mine sites.

Receiving Bin Remnant: Remnants of receiving bins can be similar to those for ore bins at mine sites.

Refuse Dump: A collection of hardware, structural materials, and other cast-off items.

Reservoir: Some milling operations erected dams in drainages to impound water for use.

Utility Pole: A pole that carried electrical or telephone lines.

Water Tank: A large vessel, usually cylindrical, made of planks or sheet iron. To pressurize plumbing, water tanks were usually located near the head of a mill.

Water Tank Platform: Often a circular or semi-circular platform for a tank. The platform's floor may feature a pipe.

Crushing System Features

Jaw Crusher: A mill apparatus located on the mill's upper terrace that pulverized crude ore into gravel. Crushers usually featured jaws and dual flywheels powered by a belt. Small units were around 2 by 4 feet in area and large units were up to 4 by 8 feet in area.

Crusher Foundation: Due to severe vibrations, crushers were often anchored to stout timber or masonry foundations with timber footings. Small piles of crushed gravel often underlie crusher foundations.

Stamp Battery: A stamp battery consisted of a heavy timber gallows frame, stamps that dropped into a battery box, and a cam shaft that raised and let the stamps drop. Batteries usually featured stamps in groups of five, and so a fifteen stamp battery had three groups. The timber frame for a single group tended to be 7 feet wide, up to 15 feet high, and stood over a cast-iron battery box bolted to a timber pedestal. The frame featured guides for the stamps and a cam shaft fitted with a large bull wheel.

Stamp Battery Frame: In many cases salvage efforts dismantled the iron hardware from a stamp battery, leaving the frame.

Stamp Battery Pedestal: Often, stamp mills were dismantled for use elsewhere, leaving a pedestal as the principal representation today. Stamp battery pedestals were rectangular, often 2 by 5 feet in area and 2 feet high, and consisted of timbers set on end. The pedestal anchored a cast-iron battery box in which the stamps crushed the ore.

Screening Station: Screens, often cylindrical trommels, were usually located below each crushing stage and classified the material by particle size.

Crushing Rolls: Crushing rolls provided secondary or tertiary crushing for ore already reduced to gravel. The apparatus featured a pair of large iron rollers set slightly apart in a cast-iron or heavy timber frame. As they rotated, the rollers drew gravel into the gap and fractured it. Small units were around 4 by 4 feet in area while common units were 6 by 6 feet in area. Crushing rolls were usually located on an upper mill terrace below the primary crusher.

Crushing Rolls Foundation: Crushing rolls were often anchored to a rectangular timber foundation consisting of heavy horizontal beams bolted to posts that leaned slightly inward.

Huntington Mill: A Huntington mill was an apparatus that finely ground previously crushed ore, and some were used for amalgamation. The machine was based on a cast-iron pan approximately 6 feet in diameter and 3 to 4 feet deep ringed with a channel. A set of heavy iron rollers rotated across the pan floor and ground the ore to a slurry. Fine particles passed through screens breaching the walls and left via the channel.

Huntington Mill Foundation: Huntington mill foundations were factory-made and the timbers often feature beveled edges. The foundation usually consist of a rectangular timber footer 6 by 9 feet in area. The machine stood on heavy posts forming a 6 by 6 foot cube at one end, and the other end featured a raised block with a brace for the drive shaft.

Concentration System Features

Amalgamation Table: Amalgamation tables were only used in mills that processed simple gold and silver ores. The tables stood on heavy timber frames at the toe of stamp batteries and sloped away from the battery box. The tabletops were usually copper, which workers coated with mercury, and around 6 by 12 feet in area.

Amalgamation Table Frame: Amalgamation tables were usually removed from mills when the facilities were abandoned, leaving a heavy timber frame around 6 by 12 feet in area and at least 4 feet high.

Jig: A jig was an appliance that enhanced the separation of metalliferous particles from waste. Common jigs consisted of a wood body with a V-shaped bottom that featured drain ports, and wood walls dividing the interior into cells. Most tended to be around 4 by 9 feet in area and 4 feet high.

Vanner: A vanner was a concentration apparatus between 4 by 8 and 6 by 13 feet in area. The machine featured a broad rubber belt that passed around rollers at both ends of a mobile iron frame. An eccentric cam bolted to a chassis imparted a vibrating motion.

Vanner Foundation: Vanners were usually bolted to timber foundations that featured cross-members at both ends, stringers linking the cross-members, and additional braces. A flume that carried off slurry usually passed by the vanner's head.

Vibrating Table: A vibrating table was an apparatus that concentrated crushed ore. Vibrating tables featured a slanted tabletop, often 5 by 15 feet in area, clad with rubber and narrow wooden riffles. Tabletops were often mounted at a slant on a mobile iron frame set in motion by an eccentric camp. Vibrating tables were usually located on mid- or lower terraces.

Vibrating Table Foundation: Vibrating table foundations featured six pairs of anchor bolts projecting out of three timber footers totaling around 12 to 15 feet in length.

Flotation Cells: Flotation cells were based on a large rectangular wooden tank divided into compartments. Paddles agitated a slurry solution in each cell and swept a froth of metalliferous material over the cell's sides. The froth either flowed into a flume or into a second set of cells for additional concentration. A plank walkway often extended along the tank, and the assemblage stood on timbers on one of the mill's lower terraces.

Cyanide Tank: Similar to a water tank, cyanide tanks were usually located on a mill's lowest terrace and were surrounded by mill tailings. In the tank, a cyanide solution leached gold out of finely crushed ore.

Settling Tank: Some concentration mills featured settling tanks on the lowest platform where heavy metalliferous fines gravitated out of spent slurry. Settling tanks were similar to wooden water tanks and often featured a revolving arm at center to exacerbate the settling process.

Power System Features

Boiler: See Hardrock Mine Feature Types.

Boiler Foundation: See Hardrock Mine Feature Types.

Boiler Setting Remnant: See Hardrock Mine Feature Types.

Boiler Clinker Dump: See Hardrock Mine Feature Types.

Motor: See Hardrock Mine Feature Types.

Motor Foundation: See Hardrock Mine Feature Types.

Overhead Driveshaft: Sets of overhead driveshafts transferred motion from the engine or motor to the mill appliances. Overhead driveshafts featured belt pulleys over each mill appliance and rotated in bearings usually bolted to the mill building's frame.

Steam Engine: Prior to the 1910s, steam engines were a common source of power for mills. Usually located on the mill's lowest terrace, the engine transferred motion to a system of overhead driveshafts via a canvas belt. Most engines were horizontal units between 2 and 3 feet in width and 8 to 12 feet long. A steam engine required a boiler.

Steam Engine Foundation: Steam engine foundations are often rectangular, studded with anchor bolts, and between 2 and 3 feet in width and 8 to 12 feet long. Workers built engine foundations with heavy timbers, brick or rock masonry, or concrete, and the foundations often featured a pylon for the outboard flywheel bearing.
Transformer Station: See Hardrock Mine Feature Types.
Transformer Station Platform: See Hardrock Mine Feature Types.
Transformer Station Remnant: See Hardrock Mine Feature Types.

Ore-Concentration Facility Significance

As an industry, ore concentration was of great significance to Colorado. The hardrock mining industry hinged on the success of ore concentration, since concentration facilities reduced crude ore from the mines to an economic commodity. Without the concentration industry, hardrock mining in Colorado would probably have failed, rendering the state's history very different. Therefore, the concentration industry can be viewed as a cornerstone of the state's growth and settlement, as well as social, industrial, and economic patterns. The concentration industry also directly supported Colorado's worldwide reputation as a center of innovation and technology in mining. From the late 1860s to the 1940s, the industry repeatedly found solutions to Colorado's notoriously difficult and complex ores, which sustained mining and allowed companies to pursue a wide variety of minerals. Additional narrow areas of significance can be attributed to the concentration industry, which are best divided among the three principal categories of concentration facilities.

Concentration Mill: Several areas of significance surround ore-concentration mills and the associated resources remaining today. *Engineering* may be the most pronounced and fundamental. Colorado's complex ores defied conventional metallurgical practices and those methods proven to be effective for metals in other regions. To render the complex ores economically viable, metallurgists in Colorado combined their experience with calculation and devised processes that prevailed. For example, Colorado's metallurgists matched exact crushing methods and specific particle sizes to types of concentration appliances, and where this failed, they modified existing equipment or invented new apparatuses. Such was the case with the Wilfley vibrating table, which Arthur Redman Wilfley devised around 1896 to concentrate ore from his mines in Summit County. Because Colorado was an epicenter of metallurgical practices and inventions, mining industries elsewhere imitated Colorado companies and metallurgists with great success. This is why the Wilfley table became universal in mills across the mining West.

While specific contributions are too numerous to note, many of Colorado's concentration mills were proving grounds for advances in electricity, crushing, grinding, concentration, roasting, assay and mineralogy, and identification and separation of metal constituents from single ores. Colorado was also on the forefront of the evolution of concentration processes from simple and labor-intensive to advanced and highly mechanized, which permitted the separation of multiple metals using economies of scale. This involved the coordination of testing and treatment methods, complex mechanical systems, and hundreds of workers in massive facilities that featured multiple buildings. Some mining engineers credit Colorado's milling industry, especially in the San Juan Mountains, with introducing then improving the strategy of concentrating low-grade ore using economies of scale.[2] This proved crucial for the national mining industry because it rendered previously uneconomical ores profitable, which extended the viability of many individual mines as well as overall mining districts. Given that most of Colorado's concentration mills were points along a spectrum of engineering and technology, from small

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[2] "Obituary: Edward Stoiber," 865; Ransome, *A Report on the Economic Geology*, 23.

and simple to large and complex, no single facility encapsulated all the above trends. Particularly large mills may have witnessed some of the contributions and developments, which must by verified on an individual basis through archival research. Small mills, as a group, played roles in identifying, defining, and demonstrating those technologies and methods that were effective for the ores of a specific region. Properties associated with these activities and advances could be eligible in the areas of significance for *industry*, *engineering*, or *science*.

The second area of significance involves themes in *economics* and *commerce*, which are the same for mills as mines, since the two property types were integrally tied. On a broad scale, mining and milling companies were part of and contributed to complex regional, statewide, and national economic and financial systems. For example, most of the capitalists who invested in Colorado's companies were of regional and statewide importance, while a few were based outside of Colorado. Implementation of investments, associated communication, banking, and the acquisition and shipment of supplies and food occurred on interstate and intrastate levels. It should be noted that large mills had a greater association than the small operations.

As another example, mining and milling companies diverted money into local economies by paying wages to their workers, hiring consultants for various services, and purchasing smaller items from sources mostly in major towns. Productive companies acquired large machinery and other industrial goods from manufacturers mostly in Denver, and to a lesser degree from outside of Colorado. The manufacturers in Denver in turn purchased their materials from sources within and outside of Colorado. Given this, mining and milling companies supported primarily Colorado's and secondarily other economies. Further, between the 1880s and 1930s, Denver hosted one of the nation's most prolific mine supply industries, and by acquiring goods and machinery from Denver, mining and milling companies ensured the continued success of Denver's mine supply industry.

For a third example, the thousands of workers employed in Colorado's mills consumed food and other domestic goods purchased from a variety of sources. Preserved food was shipped from packing companies in the Midwest and on the West Coast, while fresh foods had to come from Colorado farms and ranches. By consuming preserved and fresh foods, mining company employees not only supported a complex national food transportation network, but also helped the development of farming and ranching in Colorado. Merchants in the major towns handled most of the food and goods, and the acquisition of such therefore contributed to their local economies.

Large, highly profitable companies saw the consumption of volumes of goods, services, and machinery, and are therefore more closely allied with the above trends than small operations. Cumulatively, however, the small companies, which outnumbered substantial operations, had a significant impact.

The third area of significance involves *social history*. The participants in Colorado's hardrock mining and concentration industry contributed to the development and evolution of regional, statewide, and national social structures. One social structure was the development of classes in Colorado. When mining and milling companies began production during the 1860s, their profits contributed to the initial development of social classes in Colorado. The owners and investors began their ascent to upper classes while the laborers, of whom there were many, formed a working class dependent on wages. As mining continued from the early 1890s into the 1910s, two general categories of capitalists then acquired the productive properties and financed the construction of concentration mills. The first and by far largest category consisted of local investors of limited means primarily in nearby commercial centers, and the second category consisted of an already wealthy elite based in Denver and in the Midwest. The profits realized from the mines and mills reinforced the fortunes of the few elite while contributing heavily to the formation of a middle class, which ultimately became one of the country's economic and political backbones. Because the mining and milling companies depended on wage laborers, company operations ensured the continuation of a working class.

The very nature of the workforce that made mining in Colorado possible constituted another form of social structure. Activity in the various mining districts created an insatiable employment market that drew workers from points throughout Colorado and other areas in the nation. Some of those workers were immigrants, mostly from European countries. The cycles of boom and bust inherent to gold, silver, and industrial metals mining required that the workers be mobile, which contrasted sharply with Colorado's sedentary farming and ranching societies. Each boom drew laborers from a variety of backgrounds while busts propelled them to other areas and economic sectors in Colorado and elsewhere in the nation. The result was a mobile, adaptable, and diverse society.

Large mill sites can be strongly allied with the themes of class, workplace, and demography because they supported major workforces. Small mill sites, on the other hand, tend to be associated primarily with mobility, lower classes, and a demography of independent individuals.

Because ore-concentration facilities were a subset of hardrock mining, the geographic area of significance is the same. The area extends southwest from the Manhattan Mining District, located west of Fort Collins, to the San Juan Mountains, and extends northwest from Custer County to the town of Eagle, in Eagle County. The period of significance for concentration mills ranges from the first successful facilities built around 1880 until 1960 when nearly all hardrock mining of substance ceased. Such a timeframe is very broad, however, and should be applied to mills only when the type of ore that companies treated is unknown. Instead, an accurate period of significance can be assigned according to two factors. The first is relative to a region's history. The mill should date to the principal period of the region's mining industry, which was often a function of overall increases in the value of silver and industrial metals. The second is relative to the type of ore that was important in a region, which can easily be determined through research. The periods of significance by ore type in relation to concentration mills are:

Gold: 1880–1960
Silver: 1880–1960
Lead: 1880–1960
Zinc, Tungsten, Molybdenum, Vanadium: 1900–1960
Fluorspar: 1900–1960
Uranium: 1910–1970

Amalgamation Stamp Mill: These concentration facilities were some of the earliest in Colorado and saw successful applications through the 1930s. Because of their overlap in time and geography with the concentration mill property subtype, amalgamation stamp mills shared many of the same economic and social areas of significance. However, because Colorado featured fewer amalgamation stamp mills, their contributions were limited.

One principal area of difference between amalgamation stamp mills and concentration mills lay in the role that each played in Colorado's history. Amalgamation stamp mills were the first mechanized ore-treatment facilities built in Colorado, primarily because the first hardrock ore bodies mined were gold veins. As a group, amalgamation stamp mills were instrumental in the success of Colorado's early mining industry and directly fostered the transition from placer gold to hardrock gold during the 1860s. Without amalgamation stamp mills, Colorado's nascent hardrock mining industry would have floundered and carried down the region, which depended on mining. During the 1870s, miners exhausted most of the simple gold ore that could be easily processed in amalgamation stamp mills, which lost favor to concentration mills and smelters. However, through the 1910s, amalgamation stamp mills continued to play key roles in mining districts known for gold ore.

Amalgamation stamp mills are associated with some *engineering* significance. Specifically, they contributed to the understanding of how to win metals from Colorado's ores during the first years of hardrock mining in the state, both through the successes and the failures. As miners exhausted the simple gold ores, metallurgists adapted amalgamation milling and combined it with roasting and concentration methods to render complex gold ore economical. This contribution proved important to the mining West because companies in other regions experienced similar mineralogical problems and could look to Colorado's amalgamation facilities for solutions.

Because amalgamation stamp mills were a subset of hardrock gold mining, the geographic area of significance is the same. The area extends southwest from the Manhattan Mining District, located west of Fort Collins, to the San Juan Mountains, and extends northwest from Custer County to the town of Eagle, in Eagle County. In particular, Boulder, Gilpin, Clear Creek, Summit, Chaffee, Lake, and Gunnison Counties, and the Summitville area featured the greatest concentrations of gold mines. The period of significance for Colorado's amalgamation stamp milling industry ranges from when the first went up in Boulder County in 1859 until 1920, when stamp mills fell out of favor. Such a timeframe is very broad, however, and should be considered in relationship to the principal period of a region's mining industry.

***Arrastra*:** These concentration facilities were Colorado's first type of ore-treatment facility, and while they were succeeded by amalgamation stamp mills within a few years, arrastras saw limited application in Colorado's gold mining regions through the 1930s. Because of an overlap in time and geography, arrastras shared a few areas of significance with the amalgamation stamp mill property subtype. The areas of significance are fairly narrow, however, because arrastras saw limited application and were important for only a brief time.

The main area of significance for arrastras is the facility's role in early Colorado mining. Between 1859 and around 1870, a variety of mining interests, from partnerships to small companies, built arrastras to recover gold from hardrock ore. While most arrastras served specific mines, as a group they were instrumental in the success of Colorado's early mining industry and directly fostered the transition from placer gold to hardrock gold. Without arrastras, Colorado's nascent hardrock mining industry would have collapsed and carried down the region, which depended on mining.

Arrastras also facilitated the confirmation of ore and initial development of some of Colorado's gold and silver mining districts. Because arrastras required little capital or formal engineering and could be constructed with local materials, they were ideal for remote, frontier mining districts. Between the 1860s and 1880s, many mining districts deep in the mountains qualified as remote because transportation systems were absent. Arrastras served as primitive treatment facilities for prospectors and partnerships and permitted them to reduce simple gold and silver ores to impure metal compounds that could be transported to commercial centers. Prospectors and partnerships also used arrastras to determine whether amalgamation was effective for specific ores, which was information important to subsequent milling enterprises.

Arrastras are associated with some engineering significance in Colorado's first years. Specifically, they were a vernacular form of ore-treatment facility within the realm of small outfits lacking capital or engineering skills. In the compressed span of around ten years, mining outfits improved arrastra engineering by harnessing water power and steam power, and honed the application of processing methods to Colorado's gold ores.

Because arrastras were associated with the exploration and development of many of Colorado's mining districts between the 1860s and 1880s, their geographic significance is the same for the overall hardrock mining industry. The area extends southwest from the Manhattan Mining District, located west of Fort Collins, to the San Juan Mountains, and extends northwest from Custer County to the town of Eagle, in Eagle County. The period of significance ranges from when the first arrastras were constructed in Boulder County in 1859 until around 1900, when portable mills became popular. Such a timeframe is very broad, however, and should be considered in relationship to the principal period of a region's mining industry.

Ore-Concentration Facility Registration Requirements

The property subtypes of concentration mills, amalgamation stamp mills, and arrastras form a spectrum ranging from small, simple, and unimportant to large, complex, and significant. In Colorado, small and simple mills were common and tended not to be involved with major engineering and technological contributions on an individual basis, although they could have been important to a specific region. Large and complex mills were uncommon and often participated in the development of engineering and technology, and tended to be associated with multiple themes of importance. Because concentration mills, amalgamation stamp mills, and arrastras were different facilities, their Registration Requirements are discussed individually below.

Ore-concentration Mills: National Register-eligible concentration mill sites must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region. Concentration mills may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some mills, especially large complexes, often can be traced to important individuals such as engineers and metallurgists, and in these cases, they can be eligible under Criterion B. In the case of *engineering*, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies. However, mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Most small mills will probably not be eligible under Criterion C because they offer few important or period-defining characteristics and attributes, and usually lack integrity. However, if the organization pattern is clearly evident or structures and machinery are present, then the resource may be eligible under Criterion C. In general, intact structures and machinery are uncommon and important representations of metallurgical engineering and technology. Under Criterion C, the mill should clearly represent small or moderately sized facilities, which were important because they constituted the bulk of Colorado's concentration industry. Large mills can be eligible under Criterion C if the resource possesses intact archaeological, architectural or engineering features that clearly convey the ore-treatment processes. The features must represent the application of engineering, technology, and methods during the period of significance.

Under Criterion D, if the mill site possesses building platforms, privy pits, and boiler-clinker dumps, testing and excavation of buried archaeological deposits may reveal information regarding workers' lifestyles, social structures, and the workplace, which are important because they were not extensively documented at the time. Detailed studies of structures and machinery can contribute information regarding metallurgical engineering and architectural practices, and the application of technology, which are poorly understood at present.

Eligible mills must possess physical integrity relative to the period of significance, which may vary by region and ore type. Mills were prime targets for the salvage of structural materials and machinery when abandoned, and so their integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the milling operation. Archaeological evidence can be expected to represent the general infrastructure and approximate the crushing and concentration processes, which may be sufficient for eligibility. Common features encountered at mill complexes are noted under the feature types above.

Most of the seven aspects of historic integrity defined by the NRHP apply to concentration mill sites. Some resources may possess standing structures and intact machinery, which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the structure or machine at the site should be that present during the period of significance. For a resource to retain the aspect of *design*, the material remains, including archaeological features, must convey the ore-crushing and concentration processes, the flow path of ore, the arrangement of buildings, and the infrastructure. In many cases, companies retrofitted mills with equipment that improved processing, and in such cases, resources can retain the aspect of *design* if the material remains reflect the evolution of the facilities over time. By studying archival information and material evidence, the researcher can determine when specific facilities were built and abandoned, thereby building a chronology for the resource's evolution. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance. If the mill was isolated, then the natural landscape should be preserved. If the mill operated in a mining landscape, then the surrounding mines and industrial features should retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of mining and ore treatment from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Amalgamation Stamp Mills: National Register-eligible amalgamation stamp mill sites must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region. Amalgamation stamp mills may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some mills, especially large complexes, can often be traced to important individuals such as engineers and metallurgists, and in these cases they can be eligible under Criterion B. In the case of *engineering*, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies. Mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Because Colorado possessed few deposits of ideal ore, amalgamation stamp mills were uncommon; however, in those regions with ideal ore, such mills were highly important, especially during Colorado's first thirty years. The stamp mill was one of the earliest means of treating ore in Colorado and fell out of favor only after some of the concentration appliances and methods discussed above proved to be effective. Given this, resources with at least archaeological integrity may be eligible under Criterion C as examples of an early and important form of treatment technology and engineering. The material remains must clearly reflect the crushing and metals recovery methods and processes, as well as the arrangement of buildings and structures and the content of the infrastructure.

Under Criterion D, if the mill site possesses building platforms, privy pits, and boiler-clinker dumps, testing and excavation of buried archaeological deposits may reveal information regarding workers' lifestyles, social structures, and the workplace, which are important because they were not extensively documented at the time. Detailed studies of structures and machinery can contribute information regarding metallurgical engineering and architectural practices, and the application of technology, which are poorly understood at present.

Eligible mills must possess physical integrity relative to the period of significance, which may vary by region and ore type. Mills were prime targets for the salvage of structural materials and machinery when abandoned, and so their integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the milling operation. Archaeological evidence can be expected to represent the general infrastructure and approximate the crushing and concentration processes, which may be sufficient for eligibility. Common features encountered at mill complexes are noted under the feature types above.

Most of the seven aspects of historical integrity defined by the NRHP apply to amalgamation stamp mill sites. Some resources may possess standing structures, appliances, and intact machinery, which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the structure or machine at the site should be that present during the period of significance. For a mill site to retain the aspect of *design*, the material remains, including archaeological features, must convey the ore-crushing and concentration processes, the flow path of ore, the arrangement of buildings, and the infrastructure. In many cases, companies retrofitted mills with equipment that improved processing, and in such cases, resources can retain the aspect of *design* if the material remains reflect the evolution of the facilities over time. By studying archival information and material evidence, the researcher can determine when specific facilities were built and abandoned, thereby building a chronology for the resource's evolution. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance. If the mill was isolated, then the natural landscape should be preserved. If the mill operated in a mining landscape, then the surrounding mines and industrial features should retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of mining and ore treatment from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Arrastras: National Register-eligible arrastra sites must meet at least one of the NRHP Criteria and possess relegated integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region. Arrastra sites tend to possess few clearly dateable artifacts and were not thoroughly documented at the time, rendering their dates of operation difficult to confirm. For these reasons, few arrastras will be eligible under Criteria A or B, which is a direct, documented association with important individuals.

Because arrastras were important and uncommon in Colorado, many resources with at least archaeological integrity may be eligible under Criterion C. The material remains must clearly reflect the aspects of the arrastra floor, the power train, other infrastructure components, and waste disposal methods.

Some arrastras will be eligible under Criterion D for several reasons. First, arrastra engineering was poorly documented at the time, leaving ample room for detailed studies of surface evidence to contribute meaningful information. Second, radar surveys, testing, and excavation of buried deposits, features, and soil strata hold a high potential to render meaningful information for similar purposes.

Eligible arrastras must possess physical integrity relative to the period of significance, which may vary by region. Arrastras were often dismantled and the surrounding ground excavated and processed for gold amalgam, leaving most resources as archaeological sites. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the operation. Archaeological evidence can be expected to represent the general infrastructure and approximate the arrastra floor and associated components, which may be sufficient for eligibility.

Several aspects of historical integrity defined by the NRHP can be expected to apply to arrastra sites. Arrastra sites may possess standing structures and components of infrastructure which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the components should be that present during the period of significance. In some cases, arrastras have been moved from their original location to places accessible by the public for historical interpretation, losing their *location* integrity. For an arrastra to retain the aspect of *design*, the material remains, including archaeological features, must represent the arrastra floor, portions of the power train, and waste disposal methods. To retain the aspect of *setting*, the area around the arrastra, and the arrastra site itself, must not have changed a great degree from its period of significance. In general, arrastras were usually isolated, which requires the preservation of the surrounding natural landscape. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Smelters

Smelters were some of the most important facilities for metals mining in Colorado. They were the final recipients for crude ore delivered from mines and the concentrates generated by concentration and amalgamation mills. Smelting began in Gilpin County in the late 1860s as an answer to problematic gold ores that resisted treatment in amalgamation mills, and rendered silver bonanzas found in Boulder and Clear Creek Counties at this time profitable. When the mining frontier progressed westward into the Rocky Mountains during the 1870s and 1880s, smelters proved key in treating the various ores, which consisted mostly of silver and industrial metals. Most of the principal mining districts during this timeframe featured at least one smelter that generated blends of metals that required refining by superior facilities on the plains. The 1880s saw Colorado's smelting industry evolve into two groups. One group consisted of individual smelters in the principal mining districts, which relied primarily on local ore production. The second group featured some of the most modern and efficient smelters known to the greater mining industry in cities on the plains, such as Denver and Pueblo. One such smelter also opened in Durango, in Colorado's southwest corner. During the 1880s, several factors conspired against the first group of smelters. The smelters on the plains and in Durango posed serious competition and subsumed much of the ore generated along the Front Range and in the San Juan Mountains. When mining companies began erecting concentration mills in the 1880s, they bypassed the local smelters and shipped their concentrates directly to the advanced facilities. With high operating costs and shrinking sources of ore, the local, independent smelters either closed or adapted their processes to specific, difficult ores.

Smelters used a combination of mechanical, chemical, roasting, and smelting processes to convert ores and concentrates to metals. Most smelters usually required acres of flat space, a source of abundant water, and well-graded roads, and because they consumed high volumes of fuel and ore, they were often served by railroads. Independent smelters that operated in mining districts tended to be limited in scale and variety of components, and often featured several large buildings, high-volume coal and coke bins, and at least one characteristic furnace. Large facilities often included a mill to concentrate complex ore, multiple furnaces to treat different ores or smelt single batches of ore in stages, and bins for ores of different types or grades. To organize the buildings and infrastructures, companies usually built smelter complexes according to a master datum, and as a result, the various components shared a common orientation. Slag, the waste produced by smelting ore, almost always lies around a smelter site and it manifests as fine-grained or glassy cobbles dark gray to black in hue. In general, smelter sites are rare and only a few in the West retain high degrees of integrity. Sites existing today usually offer a complex array of archaeological features such as foundations, industrial structures, and debris.

Features Common to Smelter Resources

The features listed below are an abbreviated list of those expected at smelter sites. Smelters also included many of the same features as concentration mills, which are described in detail under ore-cent ration facility property types.

Blower: Smelters relied on blowers to force an air blast into a furnace. A typical blower featured a ring of vanes encased in a wood or sheet-iron shroud with a port for the outflow. A motor or steam engine powered the blower, and it often stood nearby. Blowers ranged from 8 to 3 feet in diameter.

Blower Foundation: A foundation that anchored a blower. Foundations were usually rectangular, less than 6 by 8 feet in area, and consisted of masonry, concrete, or timbers.

Coal Bin: Because smelters consumed high volumes of fuel, they almost always featured substantial bins for coal or coke. The bins were usually sloped-floor structures that facilitated a gravity-drawn flow of fuel from the structure.

Coal Bin Remnant: The collapsed remnants of a coal bin.

Coal Bin Foundation: Due to their great weight, coal bins usually stood on masonry or timber foundations. Scatters of coal or coke strongly suggest that a given foundation supported a coal bin.

Furnace: Furnaces were usually made of brick masonry lined with firebricks or sandstone blocks. The masonry should feature evidence of intense heat and slag. Furnaces for smelting often featured steel vessels lined with firebrick in which ore was melted. Smelting furnaces tended to be cylindrical and ranged from 20 to 6 feet in diameter.

Furnace Remnant: The collapsed remnant of a furnace.

Furnace Foundation: Furnaces stood on masonry foundations slightly larger than the heating chamber. The foundation often features slag and evidence of heat.

Furnace Platform: Furnaces usually stood on dedicated platforms within the smelter building. Free-standing steel furnaces often left little more than a foundation surrounded by slag flows while masonry units may have left structural remnants. Most furnace platforms should feature in-situ slag deposits and flows.

Slag Dump: Smelting companies disposed of their slag in dumps downslope from the smelting complex.

Slag Flow: Uncontrolled releases of slag from a furnace created flows that appear similar to lava or smooth concrete.

Smelter Significance

As an industry, smelting was of prime importance to Colorado. The hardrock mining industry depended on effective smelting, since smelters reduced ore to its constituent metals. With successful concentration and amalgamation mills, mining could have continued in Colorado in the absence of smelters, although the mining companies would have shipped their concentrates to distant facilities at great cost. Given this, without the smelting industry, mining in Colorado would have been severely stunted and the state would have experienced a very different history. The smelting industry directly supported Colorado's worldwide reputation as a center of innovation and technology in mining and metallurgy. From the late 1860s to the 1960s, the industry repeatedly found solutions to Colorado's notoriously difficult and complex ores, which sustained mining and allowed companies to pursue a wide variety of minerals. Additional, narrow areas of significance can be attributed to the smelting industry, which are best divided among principal themes below.

Great importance can be attached to the area of significance of *engineering*, specifically the theme of metallurgical engineering. Colorado's complex ores defied conventional metallurgical practices and those methods proven to be effective for metals in other regions. To render the complex ores economical, metallurgists in Colorado combined their experience with calculation and devised processes that proved effective for compound gold, silver, and industrial metal ores. While specific contributions are too numerous to note, Colorado's smelters were proving grounds for advances in assay and mineralogy, furnace engineering, smelting methods for both crude ore and concentrates, roasting, separation of metal constituents, forced-air systems, and power and heating systems. Colorado was also on the forefront of the evolution of smelter operations and organization from simple and labor-intensive to advanced and highly mechanized operations. This involved the coordination of testing and treatment methods, complex mechanical systems, and hundreds of workers in massive facilities that featured multiple buildings. Given that most of Colorado's concentration mills were points along a spectrum of engineering and technology, from small and simple to large and complex, only a number of facilities encapsulated all the above trends. Particularly large smelters certainly witnessed some of the contributions and developments, which must by identified on an individual basis through archival research. Small smelters, as a group, played roles in identifying, defining, and demonstrating those technologies and methods that were effective for the ores of a specific region.

The second area of significance involves *industry* and the development of Colorado's industrial geography. Both the smelters on the plains, in the southwest, and in mining districts anchored railroad systems that in turn fostered the growth of and reinforced the greater mining industry. The smelters on the plains and in the southwest contributed to the economic and population stability of their host cities, and to the rise of these cities as industrial, commercial, and economic centers.

Themes in *economics* form the third area of significance. On a broad scale, smelting companies were part of and contributed to complex regional, statewide, and national economic and financial systems. For example, most of the capitalists who invested in Colorado's smelting companies were of regional and statewide importance, while a few were based outside of Colorado. Implementation of investments, associated communication, banking, and the acquisition and shipment of supplies occurred on interstate and intrastate levels. It should be noted that large smelters had a greater association than the small operations. As another example, smelting companies diverted money into local economies by paying wages to their workers, hiring consultants for various services, and purchasing machinery and other industrial goods from manufacturers mostly in Denver and to a lesser degree from outside of Colorado. The manufacturers in Denver in turn purchased their materials from sources within and outside of Colorado. Given this, the smelting companies supported primarily Colorado's and secondarily other economies. Further, between the 1880s and 1930s, Denver hosted one of the nation's most prolific mine-supply industries, and by acquiring goods and machinery from Denver, the smelting companies ensured the continued success of Denver's mine-supply industry. For a third example, the smelting companies purchased their ore from mining outfits across the greater Rocky Mountains. Such business directly supported the hardrock mining industry and disbursed money throughout the Rocky Mountains.

The large, high-capacity smelters had a greater economic impact and are therefore more closely allied with the above trends than small smelters. Cumulatively, however, the small smelters, which outnumbered the substantial facilities during the 1870s and 1880s, had a significant impact during this time.

The fourth area of significance involves *social history*. The participants in Colorado's smelting industry contributed to the development and evolution of regional, statewide, and national social structures. One social structure was the development of classes in Colorado. When smelting companies began production during the late 1860s, their profits contributed to the initial development of social classes in Colorado. The owners and investors began their ascent to the upper classes while the laborers, of whom there were many, formed a working class dependent on wages. As mining continued through the 1870s and 1880s, two general categories of capitalists invested in the variety of smelters. The first and by far the largest category consisted of investors of limited means from Colorado's principal commercial centers. The second category consisted of an already wealthy elite based in Denver and the Midwest. The profits realized from smelting reinforced the fortunes of the elite while contributing heavily to the formation of a middle class, which ultimately became one of the country's economic and political backbones. The domination of the large smelting companies at the expense of the small, independent facilities in the 1880s reinforced the formation of a middle class because the large companies employed a high number of middle management and skilled workers. Both large and small smelting companies ensured the continuation of a working class, which formed the bulk of the smelting industry's workforce.

The very nature of the workforce that made smelting in Colorado possible constituted another form of social structure. The large smelting companies on the plains offered numerous jobs for unskilled workers, which attracted immigrants mostly from European countries. The workers, who were many, first established ethnic communities near the smelters then left when their economic conditions permitted. Many remained in Colorado and disbursed to find employment in other industries.

Large smelters can be strongly allied with the themes of class, workplace, and demography because they supported major workforces. Small smelters, on the other hand, tend to be associated primarily with class structures.

The themes of *politics/government* constitutes the fifth area of significance. Mining in Colorado was integrally tied to, and was a direct function of, political systems on statewide, national, and international scales, and smelting directly depended on mining. Further, nearly all of Colorado's smelters relied on the production of silver ore, which was the focus of numerous political decisions. On a national scale, federal programs proved crucial for the metal's demand and inflated silver's values to levels that rendered mining economical. The Bland-Allison Act of 1878 and the Sherman Silver Purchase Act of 1890 instituted price supports and acquisition quotas for silver. Repeal of the Sherman Silver Purchase Act and the subsequent collapse of silver's value brought silver mining and smelting to an abrupt halt for several years. Passage of the Silver Purchase Act of 1934 increased the metal's value again, resuscitating mining and smelting. Federal programs related to the world wars and defense influenced the production of key industrial metals such as zinc and lead, which required smelting.

On a regional scale, Colorado's hardrock mining industry, mostly in the forms of workers, mining capitalists, and companies provided political and economic support for senators, representatives, and lobbyists who fought for the federal programs that kept the value of crucial metals high. Further, some of Colorado's mining elite, such as Jerome Chaffee, the Wolcotts, Henry Teller, David H. Moffat, and others held public office and directly influenced federal policy.

On an international scale, until 1893 the British pursued a pro-silver policy, and many Europeans followed the same trend during World War I, which stimulated mining and smelting in Colorado. With the return to normalcy in 1919, silver values returned to low levels, which caused mining to return to a torpid state.

While few individual smelters can be directly tied to specific political acts and policies, as whole, Colorado's smelting industry played heavily into statewide and federal policies.

The geographic significance of the smelting industry can be divided into three general regions, which are coupled with specific periods of significance. The small, independent smelters local to the principal mining districts share an area of geographic significance similar to the greater hardrock mining industry. In terms of these smelters, the area extends southwest from Boulder County to the San Juan Mountains, and extends northwest from Custer County to Aspen, in Pitkin County. The period of significance ranges from the first successful smelter built in Gilpin County in 1867 to 1900, when most of the mountain facilities closed. The period of significance should, however, be considered in the context of local history. The second region encompasses the plains smelters and forms a belt extending from Denver south to Pueblo. The period of significance ranges from 1873, when the Denver Smelting Company built a facility in Denver, until 1960, when most smelters closed. The third region lies around Durango and its period of significance spans from 1882, when a smelter opened there, until 1963, when the last facility closed.

Smelter Registration Requirements

National Register-eligible smelter sites must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region.

Smelters may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some smelters, especially large complexes, often can be traced to important individuals such as engineers and metallurgists, and in these cases, they can be eligible under Criterion B. In the case of *engineering*, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies. Mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Large and small smelter sites may be eligible under Criterion C provided the organization pattern, the flow path for ore, the smelting processes, and aspects of the infrastructure are clearly evident. Clear representation through archaeological evidence may be sufficient, but they must reflect the application of engineering, technology, and methods during the period of significance. If structures and machinery are present, they reinforce the site's eligibility under Criterion C because structures and machinery are uncommon and important representations of metallurgical engineering and technology.

Under Criterion D, if the smelter site possesses building platforms, privy pits, and boiler-clinker dumps, testing and excavation of buried archaeological deposits may reveal information regarding workers' lifestyles, social structures, and the workplace, which are important because they were not extensively documented at the time. Detailed studies of structures and machinery can contribute information regarding metallurgical engineering and architectural practices, and the application of technology, which are poorly understood at present.

Eligible smelter sites must possess physical integrity relative to the period of significance, which may vary by region. Smelters were prime targets for the salvage of structural materials and machinery when abandoned, and so their integrity will probably be primarily archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the smelting operation. Archaeological evidence can be expected to represent the general infrastructure and approximate the smelting processes, which may be sufficient for eligibility. Common features encountered at smelter complexes are noted under the feature types above as well as under the ore-concentration property type.

Most of the seven aspects of historical integrity defined by the NRHP apply to smelter sites. Some resources may possess standing structures and intact machinery, which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the structure or machine at the site should be that present during the period of significance. For a resource to retain the aspect of *design*, the material remains, including archaeological features, must convey the flow path of ore, the arrangement of buildings, and the infrastructure. At sites with lengthy histories, companies retrofitted smelters with equipment that improved processing, and in such cases, resources can retain the aspect of *design* if the material remains reflect the evolution of the facilities over time. By studying archival information and material evidence, the researcher may be able to determine when specific facilities were built and abandoned, thereby building a chronology for the resource's evolution. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance, except for the removal of structures and machinery. If the smelter was isolated, then the natural landscape should be preserved. If the smelter operated in a mining or urban landscape, then the surrounding mines, industrial features, and urban aspects should retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of mining and ore treatment from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Coal Mines

Coal mines were underground operations that produced coal used for a variety of industrial purposes. Most of Colorado's mines yielded bituminous coal, which powered industry and railroads and saw extensive use in heating stoves. Some coal companies roasted their product in ovens to create coke, which was the principal fuel consumed by smelters and steel mills. Municipalities also roasted coal to produce gas for lighting. A few companies in select portions of Colorado, primarily around Crested Butte and Trinidad, generated anthracite coal, which was important for blacksmithing and assaying. Usually company endeavors, coal mines ranged in scale from small and labor-intensive to extensive, mechanized operations.

Coal mines held many similarities to and differences from their hardrock counterparts. Unlike hardrock mineral bodies, coal occurred in the soft, sedimentary rock formations that flanked the Rocky Mountains and manifested as broad, gently pitching beds known as seams. Such geological conditions facilitated mining because a company merely had to drive a horizontal tunnel into the seam, if it was exposed, or sink a shallow inclined shaft to penetrate overlying rock layers. From the principal tunnel, miners drove feeder tunnels into the seam and removed the coal in large blocks that left rooms between supporting pillars.

Like hardrock operations, coal mines required the support of surface facilities known as surface plants. To facilitate the extraction of coal, expedite materials-handling, and accommodate various activities, coal companies often employed machinery and erected buildings, although nearly all operations relied primarily on labor. Some companies, however, attempted to produce coal using economies of scale while minimizing energy consumption and costly labor through advanced, costly machinery and efficient coal handling systems arranged in complex surface plants. Overall, because coal lay relatively close to the surface, the machinery tended to be lighter in duty than that used in hardrock mines.

Coal mines shared the same needs as hardrock operations, and so their surface plants possessed similar facilities. One fundamental surface plant component was a transportation system that brought high volumes of coal out of the mine. Nearly all companies installed mine rail lines, and by the 1950s some even used conveyors in their main workings. The track usually terminated at a coal bin, where the coal was stored, or at a breaker house, where workers extracted impurities such as slate and sorted the lumps by size. Because coal was a relatively light mineral, draft animals were able to pull short trains of coal cars out of the mine, and by the 1910s, a few large companies also used electric locomotives.

Shaft operations featured hoisting systems that drew vehicles out of the underground workings. If the shaft featured a steep pitch, a skip on rails carried the coal, and if the shaft featured a gentle pitch, the hoist may have pulled short trains of cars. The general layout and types of components were similar to those at hardrock mines, discussed in Section E.II. Prior to the 1910s, coal companies employed steam hoists and afterward used electric models. Since the steam hoists at many coal mines were relatively light in duty and fuel was readily available, portable boilers saw extensive use despite their inefficiency. In keeping with sound mining engineering, however, well-capitalized companies relied on return-tube boilers. Because most shafts in coal mines were inclined, mining engineers favored the A-frame type headframe, which was also known as a tipple.

The coal mining industry adopted compressed-air machinery such as drills much more slowly than the hardrock sector, although by the 1900s well-capitalized companies introduced some equipment. Coal companies never completely replaced hand-labor until the 1960s, although they increasingly relied on compressed-air augers, drills, and winches. Because the application of compressed air was relatively limited, the air compressors at coal mines tended to offer a limited capacity relative to the mine's size.

The shop was a key facility that differed in size, scale, and complexity for small, moderate, and large operations. The primary duties of shop workers included sharpening picks and coal augers and manufacturing hardware. Large, mechanized companies also retained specialty workers who repaired and maintained equipment and conducted carpentry. To facilitate such work, substantial companies erected spacious shops equipped with power-driven appliances. For a detailed description of shops, see Section E.II.

One of the main differences between coal mines and hardrock mines was the need for effective ventilation. By nature, coal seams and sedimentary geology emitted natural gases that displaced oxygenated air, rendering mine air unbreathable. To remediate such problems, coal companies installed high-capacity ventilation systems that forced air underground. The common system usually featured a massive fan driven by either a steam engine or motor, ducting that shunted the air underground, and bulkheads over mine openings to control the flow of air currents. For ease of plumbing, the blower usually stood near the mine opening.

In general, the surface plants erected by the advanced, highly productive companies required more than the several structures typical of small outfits. For efficient servicing and better engineering, substantial companies generally clustered their mechanical components and shops together in either large tunnel houses or shaft houses. Ancillary facilities such as separate shops, electrical transformers, explosives magazines, offices, and quarters for draft animals were enclosed in individual buildings. In general, the surface plants for substantial operations featured the primary shaft- or tunnel house surrounded by several smaller structures.

Features Common to Coal Mines

Adit: A horizontal opening usually less than 3 by 6 feet in-the-clear. Collapsed adits manifest as linear areas of subsidence. Tunnels were larger horizontal openings and greater than 3 by 6 feet in-the-clear.

Building Platform: A flat area upon which a building stood. If possible, specify the type of building.

Cribbing: A latticework of logs usually intended to be filled with waste rock or earth. Some cribbing structures served as retaining walls for platforms and waste rock dumps.

Explosives Magazine: Organized mining outfits erected magazines to store explosives away from a mine’s surface plant. Some magazines were dugouts, some were stout stone structures, while others were no more than small sheds much like dog houses.

Machine Foundation: A timber, masonry, or concrete foundation for an unknown type of machine.

Mine Rail Line: A track that facilitated the movement of ore cars around a mine site.

Mine Rail Line Remnant: When a mine rail line was dismantled, workers often left ties, impressions from ties, portions of rails, and the rail bed.

Pipeline: An assembly of pipes usually intended to carry water. Pipelines should not be confused with compressed-air mains, which extended from a compressor into underground workings.

Pipeline Remnant: Evidence of a disassembled pipeline.

Privy: Most mines of substance featured a privy for the crew’s personal use. Privies usually are small frame structures with a door and a bench featuring between one and several cutouts for toilet seats.

Privy Pit: A pit that underlay a privy. Pits tend to manifest as depressions less than 5 feet in diameter, often with artifacts and other materials in their walls and bottoms.

Refuse Dump: A collection of hardware, structural materials, and other cast-off items.

Road: Roads were graded for wagons and trucks and were usually at least 8 feet wide.

Shaft: A vertical or inclined opening underground usually at least 4 by 8 feet in area. Some shafts were divided into compartments. The largest compartment was the *hoisting compartment* and the smaller, usually less than 3 feet wide, was the *utility compartment*. Highly productive mines may have featured shafts with two hoisting compartments and a utility compartment. Evidence of a double-drum hoist should be associated with a three-compartment shaft. Collapsed shafts manifest as areas of subsidence.

Shaft House: A shaft house was a large building that enclosed the shaft collar, the hoisting system, and usually a shop. Mine rail lines usually extended away from the shaft and passed out the building. Large shaft houses may have also encompassed an air compressor.

Shaft House Platform: The platform that supported a shaft house. Large shaft houses often stood on rock foundations, which can define the structure's perimeter. Differences in soil types and consistencies can reflect a shaft house's footprint.

Shaft House Remnant: The collapsed remains of a shaft house.

Stable: A building that housed draft animals used for both underground and surface transportation. Stables were often crude and featured wide doorways, feed mangers, and oat boxes.

Stable Remnant: The collapsed remnants of a stable.

Timber Dressing Station: Timber dressing stations tend to be represented by collections of raw logs and numerous cut wood scraps, usually on flat or gently sloped ground near the mine opening.

Timber Stockpile: A stockpile of mine timbers, often located near the mine opening.

Trestle: A structure that supported a mine rail line, walkway, or pipeline. Workers often built small trestles on the flanks of waste-rock dumps to support dead-end rail lines.

Trestle Remnant: Posts, single piers, or partial stringers left from a trestle.

Tunnel: A horizontal opening underground usually more than 3 by 6 feet in-the-clear. Collapsed tunnels often manifest as linear areas of subsidence, possibly with pipes or rails projecting outward.

Tunnel House: A tunnel house was a structure that enclosed the tunnel portal and usually a shop. A mine rail line usually passed out of the tunnel portal and through the tunnel house, as did a trench or flume to divert drainage water. Large tunnel houses often encompassed a mechanized shop and work area where miners dressed timbers.

Tunnel House Platform: The platform that supported a tunnel house. Workers usually graded a cut-and-fill platform around the tunnel portal for the building, and large versions often stood on rock foundations, which can define the structure's perimeter. The platform, as well as differences in soil types and consistencies, can reflect a tunnel house's footprint.

Tunnel House Remnant: The collapsed remains of a tunnel house.

Utility Pole: A pole that supported an electrical or communication line.

Ventilation Blower: Many mining operations employed ventilation blowers to force fresh air underground. They usually located the blower adjacent to the mine opening and attached an assemblage of ventilation tubes that extended underground. Large blowers had to be anchored to foundations, and as most were belt-driven, they featured an adjacent motor or steam engine.

Ventilation Blower Foundation: Large blowers were anchored to simple foundations usually consisting of timbers embedded in the ground adjacent to the mine opening. The foundations tend to be 3 by 4 feet in area or less and feature four anchor bolts. A motor or small steam engine that powered the blower was usually bolted to an adjacent foundation.

Compressed-Air System Features

Air Compressor: An air compressor was a machine that compressed air piped underground to power rockdrills. Mining companies employed a variety of types that rose and fell in popularity between the 1870s and 1940s. For a list of types, their descriptions, and popularity age ranges, see Section E.II.

Air-Compressor Foundation: Because of their great weight and powerful motion, air compressors had to be anchored to solid foundations. Workers often constructed timber foundations for small compressors and used either rock or brick masonry, or concrete for large models. In most cases, when a mine was abandoned the compressor was removed, leaving the foundation as the machine's only representation, and based on a foundation's footprint, the researcher can often determine the exact type of compressor. The foundations for the types of compressors are described in Section E.II.

Compressed-Air Main: A pipeline that carried compressed air from a compressor into the underground workings.

Compressor House: Mines with expansive surface plants occasionally included a compressor house, which enclosed an air compressor and receiving tank. If the compressor was steam driven, then the building also usually enclosed a boiler, unless the mine featured one elsewhere.

Compressor-House Platform: The platform that supported a compressor house. Compressor house platforms should feature a compressor foundation, a motor mount or boiler setting remnant, and an artifact assemblage consisting of machine parts and pipe fittings.

Compressor House Remnant: The collapsed remains of a compressor house.

Hoisting System Features

Headframe: Mining operations erected four general types of headframes to meet the needs of ore production. The first is an enlarged version of the two-post gallows discussed above with Prospect Shafts. The second was the *four-post derrick*, which consisted of four posts joined with cross-members and diagonal beams, all supported by two backbraces. The third is the *six-post derrick,* which featured six posts instead of four. The last is a large *A frame*. Production-class headframes were more than 30 feet high and stood on well-built timber foundations.

Headframe Foundation: Foundations for production-class headframes consisted of a timber frame usually embedded in the waste rock surrounding a shaft. The timbers flanked the shaft and extended toward the area where the hoist was located.

Headframe Remnant: The collapsed remnants of a headframe.

Hoist: To meet the needs of ore production, mining companies engaged in production almost always employed power hoists. See Section E.II for types, descriptions, and age ranges for hoists.

Hoist Foundation: Few shaft mines retain their hoists and instead feature foundations, which are distinct today. Foundations typical of specific types of hoists are discussed in Section E.II.

Hoist House: See Prospect Site Feature Types.

Hoist House Platform: See Prospect Site Feature Types.

Hoist House Remnant: See Prospect Site Feature Types.

Power System Features

Boiler: Many small, marginal mining operations employed portable boilers to power hoists and minor pieces of equipment, as did prospect outfits. However, mining companies wishing for a permanent, efficient source of steam usually installed return-tube boilers. For descriptions of boilers, see Section E.II.

Boiler Foundation: When small mining operations removed portable boilers, they occasionally left simple rock or brick supports for the unit, which are discussed under Prospect Site Feature Types. Dismantling a return-tube boiler and its masonry setting, however, resulted in more substantial, distinct structural remnants in the form of a foundation. Return-tube boiler foundations were usually flat, 10 by 18 feet in area, and consisted of rock or brick masonry. In many cases a foundation may retain a bridge wall, which is a low row of bricks between the walls that forced flue gases against the boiler's belly. If more than the rock or brick pad remains, such as collapsed brick walls, then the feature is a boiler setting remnant.

Boiler Setting Remnant: When salvage efforts extracted a return-tube boiler shell, they almost always left the masonry setting in some degree of collapse, which can be described as a boiler setting remnant. Collapsed settings range in appearance from mostly intact masonry walls to piles of rubble. If the walls are intact, setting remnants may feature the cast-iron façade or the masonry bolts that anchored the façade, and they may also feature the posts that supported the boiler shell. Most setting remnants also feature a bridge wall, which was a low brick divider in the setting's interior. Most return-tube boiler settings consisted of red bricks or rocks and featured a cleaning port near ground level at the rear.

Setting remnants for water-tube boilers possess several differences from those for return-tube units. They may feature ornate façades, girders that supported the tube and shell assemblage, large-diameter pipes, and cleaning ports with iron jambs on the sides and at the rear.

Boiler Clinker Dump: When workers shoveled residue out of a boiler's firebox, they usually dumped the material on the waste-rock dump near the boiler. Boiler-clinker dumps tend to be distinct and consist primarily of boiler clinkers, which are dark, scorious, ashy clasts created by burning coal. Boiler-clinker dumps also usually include slate fragments, unburned bituminous coal, and structural and industrial hardware.

Motor: The common motor consisted of a cylindrical body, a belt pulley, and electrical wiring. Most motors were less than 4 by 5 feet in area.

Motor Foundation: Due to great weight and stresses created by motion, workers usually anchored motors to stout concrete foundations usually less than 4 by 5 feet in area. Foundations tend to be slightly rectangular, feature four to six anchor bolts, and are aligned with the machine that the motor powered.

Transformer House: Companies that employed electricity for lighting and power circuits often erected transformer houses to shelter electrical equipment. They usually located the structures away from the rest of the surface plant in case of fire. Transformer houses are relatively small, rarely exceeding 30 by 30 feet in area, and usually feature brackets and mounts on posts for the transformers, as well as ports in the walls for wires, and numerous insulators.

Transformer House Platform: Workers usually erected transformer houses on cut-and-fill platforms that appear generic, except for a telltale artifact assemblage consisting of a high proportion of electrical items. Examples include cast-iron transformer cases, porcelain or slate switch panel fragments, fuses, porcelain insulators, high-voltage porcelain insulators, glass insulators, and wires.

Transformer House Remnant: The collapsed remnants of a transformer house.

Coal Storage and Processing Features

Coal Bin: Mining outfits erected bins to contain coal for shipment. Coal bins could be of the sloped-floor variety or open, flat-bottom structures.

Coal Bin Platform or Foundation: A platform or foundation that supported an ore bin. Open, flat-bottom bins usually stood on a platform located on the flank of a waste-rock dump so workers could dump payrock from an ore car. Sloped-floor bins usually stood on a combination of a platform, which supported the bin's head, and log or timber pilings that supported the remainder.

Coal Chute: A chute that directed payrock into an ore bin or into a vehicle.

Coal Washing Facility: A structure used to wash dirt and loose rock from mined coal prior to shipment.

Shop Feature Systems

Backing Block: Some shops featured backing blocks to help workers sharpen drill steels for rockdrills. A backing block consisted of an iron rod 4 by 4 inches or less in cross-section and up to 8 feet long embedded in the shop floor near the forge. The block's surface featured a series of deep divots where the worker rested the drill-steel's butt, and he leaned the drill-steel's neck against an anvil to brace the item for sharpening. Many mining outfits substituted a railroad rail for the iron rod.

Drill-Steel Sharpening Machine: Most sharpeners were upright units 2 by 3 feet in area, 3 to 5 feet high, and featured an assemblage of clamps and power hammers mounted on a cast-iron pedestal. Sharpeners are always located in a shop or on a shop platform.

Drill-Steel Sharpening Machine Foundation: Because drill-steel sharpening machines destroyed unpadded concrete foundations over time, they were usually bolted to foundations consisting of timbers or timber footers over concrete. Sharpener foundations are always located in a shop or on a shop platform, are usually 2 by 3 feet in area, and possess four to five anchor bolts.

Forge: Almost every mine shop featured a forge where blacksmiths heated iron. Several types of forges proved popular, and most were 3 by 3 feet in area and 2 feet high. The *gravel-filled rock forge* consisted of dry-laid rock walls filled with gravel. The *wooden box forge* consisted of plank walls retaining gravel fill. The free standing *iron pan forge* featured an iron pan supported by iron legs. Companies that required high volumes of work also installed cylindrical iron and square iron box forges usually 4 by 4 feet in area.

Forge Remnant: Over time, wooden box and rock forges decay, leaving mounds of gravel that often feature anthracite coal, clinker, and forge-cut iron scraps.

Lathe Foundation: Some mechanized shops featured a lathe to facilitate metalwork and woodwork. Lathes were usually bolted to parallel timbers around 2 by 8 feet in area or less.

Power Hammer Foundation: Advanced, mechanized mining companies installed power hammers in their shops to expedite metalwork. Many power hammers consisted of obsolete rockdrills bolted to timber posts, which pounded items clamped to an underlying table. When removed, power hammers can be denoted by a heavy timber post up to 6 feet high and an adjacent timber stump where the table was located.

Shop: Shops at mines featured facilities for the manufacture and repair of tools, hardware, and machinery. Some shops also facilitated carpentry. Nearly all shops included blacksmith facilities at the least and some were equipped with power-driven appliances.

Shop Platform: The platform that supported a shop. An artifact assemblage including forge clinker, pieces of hardware, forge-cut iron scraps, cut pipe scraps, and cut wood scraps can help identify a shop platform.

Shop Remnant: The collapsed remains of a shop.

Shop Refuse Dump: A deposit or scatter of forge clinker, forge-cut iron scraps, cut pipe scraps, and pieces of hardware. Carpentry shops left an abundance of cut wood scraps, sawdust, and hardware.

Coal Mine Significance

It would not be an understatement to claim that the Rocky Mountains are surrounded by coal. The eastern piedmont region offers a series of coal fields for nearly the entire length of the state. Coalfields wrap around the southern and western slopes of the San Juan Mountains and continue north beyond Grand Junction. Much of Colorado's northwestern quarter features coalfields and a belt of additional fields extends northwest from Montrose to Glenwood Springs. Coal mining began in the Denver and Boulder areas during the 1860s and intensified the following decade in response to the growth of the mining, smelting and railroad industries. During this time, coal mining spread south along the eastern piedmont and to the coal fields around Durango. As industrial and railroad activity increased through the 1880s, mining spread to much of the rest of the state, except for the northwest, which lagged by around ten years. Colorado offered enough coal to sustain mining well into the twentieth century. The 1950s and 1960s saw a significant decline in production as coal beds were exhausted, the costs of mining increased, and alternative energy sources presented competition. However, mining continued in the northwest, around Trinidad, and near Paonia into the 1990s to provide coal for the state's power plants.

Coal mining in Colorado was of great importance on many levels, and several broad areas of significance surround the industry. Specific areas of significance include *industry*, *transportation*, *exploration/settlement*, and *social history*. Colorado's coal mines literally fueled industry, railroad transportation, and domestic heating stoves not only across the state, but also in plains states and portions of the South. Industries and railroad companies from as far away as Texas and Louisiana purchased Colorado coal, which was reputed to be of an excellent quality.[3] Colorado's coal mining companies continued their interstate contributions into the 1950s when the demand for coal contracted for the reasons noted above. Within Colorado, coal continues to fuel the powerplants that provide electricity to most of the state.

On a statewide level, coal mining was an engine that drove the settlement, industrialization, and urbanization of the piedmont areas surrounding the Rocky Mountains. These areas offered little for hardrock mining or logging and were able to support primarily disbursed ranching and agriculture. The development of the coalfields brought population, railroad networks, commerce and business, other forms of industry, and a greater presence of local and state government. Most of the coal mines are abandoned, but many of the towns and settlements remain today.

Several narrower and more specific areas of significance can be assigned to the coal mining industry. The first involves themes in *economics* and *commerce*. On a broad scale, coal mining companies were part of and contributed to complex regional, statewide, and national economic and financial systems. Most of the capitalists involved with coal mines also played roles in railroad companies, and they were of regional and statewide importance while a few were based outside of Colorado. Implementation of investments, associated communication, banking, and the acquisition and shipment of supplies and food for workers occurred on interstate and intrastate levels.

Coal mining companies diverted money into local economies by paying wages to their workers, hiring consultants for various services, and purchasing smaller items from sources mostly in major towns. The companies acquired large machinery and other industrial goods from manufacturers mostly in Denver and to a lesser degree from outside of Colorado. The Denver manufacturers in turn purchased their materials from sources within and outside of Colorado. Given this, coal mining companies supported primarily Colorado's and secondarily other economies. Further, between the 1880s and 1930s, Denver hosted one of the nation's most prolific mine-supply industries, and by acquiring goods and machinery from Denver, coal mining companies ensured the continued success of Denver's mine-supply industry.

The thousands of workers employed by Colorado's coal mining companies consumed food and other domestic goods purchased from a variety of sources. Preserved food was shipped from packing companies in the Midwest and on the West Coast while fresh foods had to come from Colorado farms and ranches. By consuming preserved and fresh foods, coal company employees not only supported a complex national food transportation network, but also helped the development of farming and ranching across Colorado. Merchants in the major towns handled most of the food and goods, and the acquisition of such therefore contributed to their local economies.

Large, highly profitable companies saw the consumption of volumes of goods, services, and machinery, and are therefore more closely allied with the above trends than small operations. Cumulatively, however, the small companies, which outnumbered substantial operations, had a significant impact.

Themes in *politics/government* constitute a second area of significance. Coal mining was a hotbed of political activism, labor unrest, and unionization, especially after the turn of the century. A number of violent strikes and the Ludlow Massacre of 1913 forced the state government to become involved in labor issues, which then drew the interest of the Federal Government. Over the course of several decades, both the federal and state governments passed a variety of laws intended to limit work hours, eliminate indentured servitude, and increase pay. Likewise, both the state and federal governments regulated mine safety and practices following numerous catastrophic explosions and fires.

Government interference in the coal industry did not go unchallenged by the directors, investors, and managers of the mining companies. Either by economic contribution or direct participation through lobbying and

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[3] Stone, *History of Colorado,* 454.

public office, some individuals greatly influenced the laws and regulations passed and enforced by the state and federal governments.

While few individual mine sites can be directly tied to specific political acts and policies, as whole, Colorado's coal industry played heavily into statewide and federal policies.

The third area of significance involves *social history*. The participants in Colorado's coal mining industry contributed to the development and evolution of regional, statewide, and national social structures. One social structure was the development of classes in Colorado. When mining companies began significant production during the 1870s, their profits contributed to the development of social classes in Colorado. The owners and investors began their ascent to the upper classes while the laborers, of whom there were many, formed a working class dependent on wages. The domination of the large coal companies during the 1890s reinforced the formation of a middle class because they employed a high number of middle management and skilled workers. Both large and small coal companies ensured the continuation of a working class, which formed the bulk of the industry's workforce.

The very nature of the workforce that made coal mining in Colorado possible constituted another form of social structure. The large coal companies offered numerous jobs for unskilled workers, which attracted Hispanics and immigrants mostly from European countries. The workers, who were many, first established ethic communities near the mines then left when their economic conditions permitted. Many remained in Colorado and disbursed to find employment in other industries.

Engineering and mining methods constitute the last and least area of significance. Given that coal mining in Colorado was primarily imitative of the more advanced coal industries in the Eastern and Midwestern states, Colorado companies rendered relatively few highly important engineering contributions. In general, however, Colorado's coal industry fostered the application of Eastern mining engineering and methods to the unique geological and environmental conditions of the Rocky Mountain West.

The geographic significance for coal mining can be divided among Colorado's main groups of coalfields, which feature individual periods of significance that must be considered in terms of a region's history. The plains region extends south from Longmont to Raton Pass on the New Mexico border. Within this region lies the Northern Coalfield, which includes Weld, Boulder, and Jefferson Counties. Its period of significance ranges from 1865, when organized production began, until 1960. The Central Coalfield extends south from Colorado Springs to Pueblo and includes El Paso, Fremont, and Pueblo Counties. Its period of significance ranges from 1875, when the Denver & Rio Grande Railroad began mining, until 1960. The Southern Coalfield extends south from Walsenberg to Raton Pass and includes primarily Huerfano County. Its period of significance ranges from 1880 until 1990.

The southwestern region forms an east-west belt extending between Pagosa Springs to Cortez and includes La Plata and Montezuma Counties. Its period of significance ranges from 1875 until 1960.

The central region forms a belt extending northwest from Montrose through Crested Butte to Glenwood Springs and includes portions of Montrose, Gunnison, Pitkin, Eagle, and Garfield Counties. Its period of significance ranges from 1880 to 1990, although mining continues around Paonia today.

The western region extends northwest from Montrose to Grand Junction and includes Montrose, Delta, Mesa, and Garfield Counties. The period of significance ranges from 1880 to 1960.

The northwestern region encompasses most of Colorado's northwestern quarter and includes Garfield, Rio Blanco, Moffat, and Routt Counties. Its period of significance ranges from 1890 to 1990.

Coal Mine Registration Requirements

In Colorado, small and simple coal mines were common and tended not to be involved with major engineering and technological contributions on an individual basis, although they could have been important to a specific region. Large and complex mines were uncommon and often participated in the fuel production, social, political, and economic themes of importance.

National Register-eligible coal mines must meet at least one of the NRHP Criteria and possess related integrity. Mines eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region.

Coal mines may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some mines, especially large complexes, often can be traced to important individuals such as engineers, and in these cases, they can be eligible under Criterion B. In the case of *engineering*, if the significance is related to an important individual's design of the mining structure or complex, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the mining structure or complex, then Criterion B applies. As with other mining resources, mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Most small coal mines will probably not be eligible under Criterion C because they offer few important or period-defining characteristics and attributes. However, if the organization pattern is clearly evident or structures and machinery are present, then the resource may be eligible under Criterion C. In general, intact structures and machinery are uncommon and important representations of coal mining engineering and technology. Under Criterion C, such resources should clearly represent small to moderately sized operations, which were important because they constituted much of Colorado's coal mining industry. Large mines can be eligible under Criterion C if the resource possesses intact archaeological, architectural or engineering features that clearly convey aspects of the mining operation. The features must represent the application of engineering, technology, and methods during the period of significance.

Under Criterion D, if a coal mine site possesses building platforms, privy pits, and boiler-clinker dumps, testing and excavation of buried archaeological deposits may reveal information regarding miners' lifestyles, social structures, and the workplace, which is important because they were not extensively documented at the time. Accessible and intact underground workings are important because few formal studies have been carried out regarding the underground work environment, engineering, equipment, and practices of drilling, blasting, and removing coal. Currently, historical documentation is the principal body of information that researchers rely on for studying the above aspects of coal mining. Detailed studies of structures and machinery can contribute information regarding engineering and architectural practices, and the application of technology.

Eligible resources must possess physical integrity relative to the period of significance, which may vary by region. Because small coal mines usually possessed few structures and little machinery, most of which were usually salvaged when the site was abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the mining operation. Large and complex coal mines were subject to the same predation as small mines; however, at least a few engineering and architectural features can remain. Therefore, large mines often retain primarily archaeological and occasionally engineering and architectural integrity. Common features encountered at mine complexes are noted under the coal mine property type above.

Most of the seven aspects of historical integrity defined by the NRHP apply to coal mine sites. Some mine sites may possess standing structures and intact machinery, which must retain the aspect of *location* to contribute to a site's integrity. To retain integrity of *location*, the structure or machine at the site should be that present during the period of significance. For a coal mine to retain the aspect of *design*, the resource's material remains, including archaeological features, must convey the mine's organization, planning, and engineering. In many cases, mines were worked periodically and the surface facilities changed and adapted to new operations, leaving evidence of sequential occupation. In such cases, a resource can retain the aspect of *design* if the material remains reflect the evolution of the surface facilities over time. By studying archival information and material evidence, the researcher can determine when specific surface facilities were built and abandoned, thereby building a chronology for the site's evolution. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance. If the resource is isolated, then the natural landscape should be preserved. If the resource lies in a mining or urban landscape, then the surrounding mines, industrial features, and urban aspects should retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of coal mining from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where mine structures, machinery, and other visible features remain to convey a strong sense of connectedness between mining properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Property Type: Mining Settlement and Residence

Because many of Colorado's mines and prospects were distant from established settlements, prospectors, miners, and other workers had to live near their points of work. Prospectors established temporary camps, mining companies erected company housing, and other workers provided their own residences. Many mining districts featured enough activity and people to support both organized and unincorporated settlements. Most of these forms of residence and settlement may exist as individual resources or as components of other sites, in which case they should be included with their parent resources. Because a wide variety of settlements and residences were associated with the mining industry, they are discussed below as individual property subtypes.

Mining Settlement and Residence Subtypes

Prospector's Camp: When examining an area or developing a claim, prospectors usually established camps intended to be impermanent. Prospectors' camps were simple, may have lacked formal buildings, and were abandoned after brief occupation.

Because prospect camps were intended to be impermanent, they have often left only the barest of material evidence remaining today. For example, some camps are represented by a tent platform, a sparse scatter of food cans, and little else. In some cases groups of prospectors established camps that are represented today by several tent platforms. Occasionally, one or several prospectors intending to spend time intensely examining an area erected a log cabin as a base of operations. For such assemblages of features to be defined as prospectors' camps, they must be either directly associated with localized prospect workings or be located in an area subjected to prospecting. If a prospector's camp is recorded as a component of a prospect complex, then the resource would qualify as a prospect complex property type.

Workers' Housing: By definition, workers' housing is almost always associated with, and a residential component of, the property types discussed in the pages above. In such instances, workers' housing would rarely be a resource in of itself. Workers' housing may be classified as an independent resource under several conditions:

1. The associated industrial or commercial complex has been destroyed, leaving only the residential features. In such a case, the lost or damaged industrial complex should be noted with the site description.
2. Workers' housing features cannot be tied to a single industrial complex. For example, residential features may lie near a cluster of mines, yet far enough away so that the residential features cannot be attributed to one specific operation. In general, if workers' housing features are associated with an industrial operation, then the operation defines the overall resource type.

As a resource, workers' housing includes all features associated with workers' residences and other domestic activities. Such resources typically consist of at least one residential building or remnant, a refuse scatter or dump, a privy or privy pit, and possibly activity areas. When associated with a substantial industrial operation, workers often lived communally in a boardinghouse.

Isolated Residence: Isolated residences are places of developed inhabitation not directly tied to, or associated with, an industry or other pattern of subsistence. Such sites would lack obvious characteristics that represent prospecting, mining, logging, or transportation. Determining whether a site in a mining district is an isolated residence can be somewhat subjective, as it may have served as a base of operations for prospectors, hunters, or homesteaders. Isolated residences are very simple and usually consist of a few residential features with no industrial or commercial attributes. Since the site is not directly tied to a form of subsistence, occupation was usually brief and the volume of artifacts low.

Unincorporated Settlement: Unincorporated settlements were often informal collections of residences that arose to serve a combination of purposes and usually grew in response to several stimuli. One of the most common was in response to mineral booms. Often, congregations of prospectors and miners established residences in a common area that offered flat ground, open space, and water. Another stimulus was a primary industry that required a substantial workforce, such as a group of large mines or a mill. Mining companies and individual workers erected residences near points of employment, usually in the most favorable building environment possible.

Popularly known as mining camps, unincorporated settlements usually possessed no formal organization and tended to be disbursed. When enough of a population base existed, some unincorporated settlements featured a few basic services such as a post office, mercantile, saloon, and combination restaurant and hotel. The architecture tended to be vernacular and emphasized local building materials, such as logs, in the absence of a local sawmill. Mature unincorporated settlements often featured at least several frame buildings and log structures sided with planks or boards-and-battens for a formal appearance. Some buildings may even have had false-fronts, and nearly all offered gable roofs. The residents of most buildings installed privies behind their residences and places of business.

Unincorporated settlements featured crude, unimproved infrastructures. As centers for working populations, unincorporated settlements were usually the hub of a local transportation network that often consisted of several main roads and packtrails fanning out to points of work. Sanitation was limited to privies and water came from both streams and wells. By the 1900s, some settlements enjoyed electricity for lighting, which was wired from nearby mines or mills.

Townsite: When a mineral boom evolved into a sustained mining industry that drew a stable population, unincorporated settlements often developed into organized towns usually platted with lots and blocks laid out according to a grid. Large towns tended to be more complex and diverse than small boomtowns that were occupied for a short time, but both forms of settlement shared a few basic characteristics. An identifiable business district was the most elementary and offered an array goods and services proportional to the population and demography. Towns in early stages of growth may have featured a few mercantiles, saloons, restaurants, hotels, butchers, bakeries, assayers, and laundries, as well as a livery and blacksmith. As the population increased in number and sophistication, additional businesses arrived such as a newspaper, gaming houses, lawyers, confectioneries, dentists, barbers, tailors, shoe stores, doctors, and combination stationary and book stores. Although not extensively documented, women and families were an essential and present component of mining town demography, and they demanded institutions such as schools, churches, and public meeting halls. Towns with populations large enough to afford some anonymity and a clientele also drew prostitution.

The organization patterns of small and large towns were similar. Business districts, however small, usually served as town centers, and they were surrounded by formal residences usually occupied by members of an upper socioeconomic status. In many towns, business proprietors often lived in their commercial buildings, which could have been one or two stories in height. Outlying residences may have been scattered and haphazard in organization, and were usually inhabited by workers and other members of a low socioeconomic status. Additional workers often rented space in boardinghouses and family homes anywhere in town. As the town and population grew, both the business and residential districts divided along socioeconomic lines.

The architecture in towns was a function of several factors, including community maturation, success of the mining industry, timeframe, and distance from other shipping and manufacturing centers. In nascent towns, the architecture tended to be vernacular and utilitarian. Commercial buildings ranged from wall tents to frame structures with false-fronts, and residences were assembled from logs, lumber, or combinations of both. The buildings usually featured gabled roofs, informal foundations, and ranged from single to two stories in height. Roofs tended to be sided with shingles and walls with boards-and-battens, planks, or clapboards. By the late 1890s, corrugated sheet iron became a popular construction material. Members of the upper classes added some ornamentation to their residences such as gingerbread trimming as a display of their socioeconomic status and to render their houses similar to those in established cities. Contiguous business districts also often offered boardwalks to spare patrons from mud.

Architectural improvements were usually hallmarks of the maturation of mining towns. New buildings tended to be larger than the old, commercial structures were substantial, and elements of architectural style began to appear. Residents and business owners belonging to the upper socioeconomic ranks built in Greek Revival, Italianate, and Queen Anne styles to embellish both their homes and commercial buildings. Even though some business owners did not attempt a specific architectural style, they still decorated their buildings with lathed columns, molding, ornamental brickwork or woodwork, and polychromatic effects.

Construction material, an aspect of architectural improvement, changed as mining towns grew economically and in terms of population and sophistication. Towns in early stages of life usually featured a combination of log and frame buildings, but as the towns grew, the log structures came down. An increase in value of the underlying lot, obsolescence of log buildings, and the attraction of designed frame buildings of greater sizes all contributed. If a given town continued to grow, brick and stone replaced lumber for some construction, primarily among commercial buildings. Fires, a widespread but certainly not universal phenomenon, expedited the transition from frame to stone in commercial districts. In response to the popularity of masonry, sheet-iron manufacturers introduced imitation brick and stone siding, which imparted the appearance of masonry from a distance.

Most mining towns possessed infrastructures that catered to transportation, communication, and some forms of public utilities. Transportation infrastructures usually featured trunk roads that accommodated freight and passenger traffic to the town, and feeder roads that extended to the surrounding mines. Streets and footpaths directed traffic within the town, and even though many towns were arranged according to a grid, the roads and paths did not always conform. The largest towns that featured successful mining industries and smelters usually had rail service. Early in Colorado's history, communication systems were limited primarily to postal service and newspapers. By the 1870s, the principal towns had access to telegraph communication, was followed by telephone systems by the 1880s. By around 1900, many towns of lesser importance also subscribed to telephone service. Water systems were one form of public utility that were installed in both towns as well as workers' housing erected by mining companies. They made an appearance during the 1870s in the largest and wealthiest towns and spread to smaller settlements during the subsequent twenty years, although most moderately scaled towns never saw water systems. The proliferation of flush toilets, bathtubs, and sinks during the 1880s and 1890s fostered a demand for sewer systems in large towns. Common systems consisted of little more than pipes and culverts that drained into local waterways. One of the most popular forms of public utility was electricity, which became common in the most productive and technologically advanced mining districts by around 1900. The ability to subscribe to domestic and commercial service was based on socioeconomic status, and most mining districts in Colorado lagged behind by around twenty years.

Features Common to Mining Settlements and Residences

Not all settlement and residential property subtypes are equally likely to include the features listed below. The features are, instead, listed under the most likely subtypes. The researcher should review the entire list because most subtypes share a few similar features.

Prospectors' Camp Features

Fire Hearth: An outdoor ring or rock structure where prospectors kept fires for cooking and heating.

Pack Trail: The traffic from a prospector's camp to areas under examination resulted in the development of pack trails, which are no wider than 8 feet.

Tent Platform: Prospectors often graded small platforms for wall tents. In some cases, prospectors placed rocks on the platform's edges or corners to support a tent's wood pallet floor and drove stakes along the edges to guy the walls. A paucity of structural artifacts, the presence of tarpaper washers, and disbursed domestic artifacts characterize tent platforms.

Worker Housing Features

Boardinghouse: A large residential structure intended to house a number of workers. Workers may have shared sleeping quarters and usually consumed meals together, which were prepared in the building. As a result, domestic refuse dumps or scatters and privies are usually associated with boardinghouses.

Boardinghouse Platform: A platform where a boardinghouse stood. The platform may feature a root cellar and often represents the structure's size and footprint.

Boardinghouse Remnant: The structural remnants of a boardinghouse.

Bunkhouse: A residential structure where workers slept and spent leisure time, but did not regularly prepare food. Given this, bunkhouses often feature few food-related artifacts relative to the number of inhabitants.

Bunkhouse Platform: A platform where a bunkhouse stood. The platform should feature few food-related artifacts and the platform usually represents the structure's size and footprint.

Bunkhouse Remnant: The structural remnants of a bunkhouse.

Cabin: A small residential structure, often less than 20 by 25 feet in area. Workers built some cabins of logs and others with lumber. Because cabins were often self-contained households, they usually offer a wide array of domestic artifacts. Privies are also often associated with cabins.

Cabin Remnant: The collapsed remains of a cabin.

Cellar Pit: A pit excavated for storage, often surrounded by backdirt or a foundation that supported a building.

Chimney Remnant: A collapsed chimney, usually consisting of rocks or bricks. Chimneys are usually components of building platforms.

Cistern: Organized, well-capitalized residential complexes occasionally included cisterns that stored fresh water. Cisterns at residential complexes resemble those at mill sites.

Corral: Due to a need for transportation, large residential complexes often included a corral. Corrals may feature formal and informal fences constructed from a variety of materials, and often utilized natural features.

Corral Remnant: Fences, fence remnants, linear rock piles, linear arrangements of stumps, and changes in vegetation often represent corrals.

Domestic Refuse Dump: A substantial volume of domestic refuse, usually located downslope from a residential feature. Domestic refuse dumps consist primarily of food-related and other domestic artifacts, including food cans, fragmented bottles and tableware, and personal articles.

Domestic Refuse Scatter: A disbursed scatter of domestic refuse, usually located downslope from a residential feature.

Privy: The structure that served as a toilet facility. Privy buildings were like those at mine sites.

Privy Pit: The pit that underlay a privy. Privy pits often feature a small pile of backdirt and some domestic refuse in the pit, and may be surrounded by more refuse. Privy pits are often less than 5 feet in diameter and may retain footers for the privy structure.

Residential Building: A building, confirmed by artifacts, which served as a residence. Buildings may be classified as residential if they do not possess the characteristics of boardinghouses, bunkhouses, or small cabins.

Residential Building Platform: A platform, confirmed by artifacts, to have supported an unspecified residential building.

Residential Building Remnant: The structural remnants of a residential building.

Road: Residential complexes usually required roads to accommodate traffic. Roads are at least 8 feet wide.

Root Cellar: Root cellars often manifest as collapsed dugouts located near residential buildings. They were independent structures used for food storage, and were usually made of rocks, logs, or lumber.

Stable: Mining companies often erected stables to house draft animals used for wagon drayage. Stables feature wide doorways, mangers, and stalls, and consisted of lumber or logs.

Stable Remnant: A collapsed stable.

Townsite and Unincorporated Settlement Features

Assay Shop: An assay shop was a facility where trained metallurgists tested ore samples for their mineral content. Assay shops usually featured stout workbenches, coal bins, a small furnace, and possibly a tall brick chimney.

Assay Shop Platform: A platform where an assay shop stood. Assay shop platforms may be identified by artifacts such as crucibles, cupels, fire clay fragments, laboratory ware, ore specimens, and bricks.

Commercial Building: Commercial buildings housed businesses and ranged in construction from small log buildings in nascent settlements to formal brick buildings. Most commercial buildings featured an open floor, a back room, and a storage area.

Commercial Building Platform or Foundation: A platform on which a commercial building stood. Commercial building platforms may be identified by a substantial platform or foundation and associated privy pit with little evidence of actual residence, such as food-related items.

Ditch: Some towns often featured ditches that delivered fresh water for consumption and other uses.

Hotel: A hotel was a temporary housing business and often featured a common room, an office, private quarters, and rented rooms. Small hotels may have consisted of logs and featured only several rooms while businesses in major towns may have been substantial and complimented by a dining and drinking establishment.

Hotel Platform or Foundation: A platform where a hotel stood. Hotel platforms tend to be large and may feature a cellar pit. Artifact assemblages usually include small personal items, food-related artifacts, furniture parts, and lamp parts and fragments. Hotel platforms may be difficult to distinguish from other residential structure platforms, and may be identified through archival research. Large and numerous privy pits are often associated, and the quantity of ornate artifacts may be high.

Livery: A livery was an establishment where draft animals were temporarily boarded. Liveries may be defined by large stable remnants or platforms associated with broad corrals. Earth packed by animal traffic, manure deposits, collapsed fences, and artifacts such as tack straps and hardware can define a livery complex.

Mercantile: A mercantile was a retail establishment that ranged in construction from small log buildings in nascent settlements to formal brick buildings. Most mercantiles featured a sales floor, a back room, and a storage area.

Mercantile Platform or Foundation: A platform on which a mercantile stood. Mercantiles were primarily retail establishments often located in a moderate to large building. Based on this, mercantiles may be identified by a substantial platform or foundation and associated privy pit with little evidence of actual residence, such as food-related items.

Restaurant: A restaurant was a dining business that ranged in construction from small log buildings in nascent settlements to formal brick buildings. Most restaurants featured a dining room, a kitchen, a storage area, and a root cellar. Work areas also usually existed behind the restaurant building.

Restaurant Platform or Foundation: A platform or foundation where a restaurant stood. Restaurant platforms are almost always denoted by large quantities of food cans, fragmented tableware, fragmented bottles, butchered bones, and kitchen implements.

Saloon: A saloon was a business that served primarily alcoholic beverages and possibly light dining fare. Most saloons ranged in construction from small log buildings in nascent settlements to formal brick buildings. They usually featured a bar room, a storage area, and a root cellar.

Saloon Platform or Foundation: A platform where a saloon stood. High proportions of fragmented bottles relative to other types of artifacts often denote a saloon platform.

Mining Settlement and Residence Significance

Because of its key role in Colorado's overall mining industry, the property type of settlement and residence holds great significance. On a broad and fundamental level, settlements and residences were the very places of inhabitation for prospectors, workers, miners, and many other participants of Colorado's mining industry. The residences provided shelter and granted the inhabitants an environment where they could attend to the basic necessities of life. Both residences and settlements served as bases for cultural practices, leisure, socializing, communication, transactions between individuals, education, and numerous other activities. In sum, settlements and residences were the support system for the people that constituted Colorado's mining industry. By providing for such needs, settlements and residences were a direct support system that allowed Euro-Americans to bring mining and permanent inhabitation to nearly all points west of the plains. In addition to a broad significance, the individual property subtypes are associated with narrower areas of significance, which are outlined below.

Prospectors Camp: These temporary encampments served as bases of operations for prospectors engaged in activities key to the mining frontier. Camps allowed prospectors to search for ore, characterize a region's geology, and conduct general exploration. When inhabited by groups of prospectors, camps served as frontier meeting and communication centers where individuals exchanged information and news. Camps also served as primitive social centers for a segment of the mining industry that often went without human contact for long periods of time.

The geographic area of significance for prospectors' camps encompasses the greater Rocky Mountains, and the period of significance ranges from 1858 until 1920. By this time, prospecting in Colorado decreased and most mining activity was limited to areas that already had been explored. The period of significance for a given resource should be considered in terms of regional history.

***Worker Housing*:** The areas of significance for worker housing fall into several categories. The first is *architecture*, which primarily includes boardinghouses built by well-capitalized, progressive mining companies and excludes simple and basic forms of housing. Well-capitalized companies, especially in high altitude environments, erected handsomely appointed accommodations for their workers for several reasons. The most common was to attract quality, skilled workers and entice them to live under a company atmosphere in severe environmental conditions. Less common reasons were to provide comfortable housing out of humanitarian concerns and to make a statement to the mining world of a company's productivity and progressiveness. Between around 1890 and 1920, mining companies often installed plumbing and electric lighting, and a few even provided showers, flush toilets, steam heat, and complete kitchens. Such appointments and the necessary infrastructures were well in advance of the rest of rural and mountainous Colorado.

In terms of architecture, well-capitalized companies working at high altitude had to combine conventional building practices with structural engineering to meet the rigorous conditions of mountain winters. They erected boardinghouses capable of withstanding extreme cold, hurricane-force winds, and even avalanches.

The simpler, mundane boardinghouse and bunkhouses are associated with some architectural significance. When made of logs or stone masonry, they reflect the adaptation of local building materials to the residential needs of workers. In a few cases, mining companies combined local materials and lumber to build accommodations with elements of architectural style, such as accents that contribute to a Classical Revival impression.

Economics serves as another area of significance for workers' housing, and they can be divided into scales of within residences and outside. Residences, especially boardinghouses and bunkhouses, were microcosms of important economic activity. They were the sites of personal financial transactions such as the exchange of time and labor for pay, and the exchange of pay for room, board, and goods.

Cumulatively, residences were an important economic foundation for regional, statewide, and national economic systems. The thousands of workers employed by Colorado's mining companies consumed food and other domestic goods purchased from a variety of sources. Preserved food was shipped from packing companies in the Midwest and on the West Coast, while fresh foods had to come from Colorado farms and ranches. By consuming preserved and fresh foods, mining company employees not only supported a complex national food transportation network, but also helped the development of farming and ranching in Colorado. Merchants in the major towns handled most of the food and goods, and the acquisition of such therefore contributed to their local economies.

Another important area of significance attributed to workers' housing involves social themes. Communal residences were centers of communication between individuals, company officials, and the outside world. They were also the place of cultural practices, traditions, and diffusion, be the culture American or from other countries and ethnicities. Last, residences were places where workers could attend to the necessities of life outside of the workplace. On a broad scale, the sum of workers' housing sheltered much of the mining industry's workforce and saw it fed. Workers' housing also was a direct manifestation of and instrument for permanent settlement of mountainous Colorado.

Because hardrock, coal, and placer mining, as well as the milling and smelting industries employed thousands of workers across the state, the area of geographic significance for workers' housing is very broad. The area encompasses all portions of Colorado that saw mining and smelting, which extends west of the eastern piedmont. The period of significance ranges from the first company operations of note in 1859 until 1960, when most mines closed. In western Colorado, the period of significance extends until 1970, when uranium mining ceased. Overall, the period of significance for a given resource should be considered in terms of regional history.

Isolated Residence: By definition, isolated residences cannot be directly attributed to an industry or other pattern of subsistence. For this reason, areas of significance remain unknown until detailed studies or archaeological investigations of a given site provide clarifying information.

Townsites and Unincorporated Settlements: Because these forms of settlement were complex and were tied to numerous themes and systems, they are associated with several important areas of significance. The first is *architecture*. Building construction in townsites and unincorporated settlements contributed to the adaptation of utilitarian vernacular and formal architecture to the materials and construction practices of the Rocky Mountains. Townsites also were the prime vehicle for the application of defined architectural styles to the types of commercial and residential buildings erected in mining towns. It should be noted that when architectural styles changed, they continued to make a fresh presence in mining towns, which continues today.

On a broad scale, towns, and to a lesser degree unincorporated settlements, were nodes and centers of infrastructure important to the mining industry. In this role, they were vehicles that brought infrastructures and primitive urban planning to the Rocky Mountains far in advance of typical rural communities.

The theme of economics serves as another area of significance for townsites and unincorporated settlements. The two forms of settlement were centers of commerce, banking, business, and trade. They also were transportation nodes and transfer points for the movement of goods and people. Goods, supplies, equipment, and services required by mining companies and industry participants often flowed into settlements prior to their distribution to consumers, and ore and mill products flowed out. The transportation occurred on several levels that depended on a region's remoteness and development, and ranged from rail service to pack trains.

Established townsites and unincorporated settlements served as anchors and conduits for capital and investment. The presence of established settlements, especially towns, lent legitimacy to a localized mining industry, which fostered confidence among potential investors. Investors were more likely to visit a mining district if it featured an established settlement. In general, the settlements were the points through which capital flowed from investors to associated mines and mills.

On a broad scale, settlements were part of and contributed to complex regional, statewide, and national economic and financial systems. For example, the inhabitants of Colorado's settlements consumed food and other domestic and commercial goods purchased from a variety of sources. Preserved food was shipped from packing companies in the Midwest and on the West Coast while fresh foods came from Colorado farms and ranches. Domestic and commercial produces were acquired from manufacturers in the East, Midwest, and the West Coast. By consuming preserved and fresh foods, settlement residents not only supported a complex national food transportation network, but also helped the development of farming and ranching in Colorado. The consumption of domestic and commercial goods had a similar impact.

Townsites and unincorporated settlements were associated with social themes of significance. Settlements were important communication centers for the residents and businesses within a region, as well as with the outside world. They also were centers for both passive and active cultural practices and traditions. For passive practices, inhabitants followed their cultural patterns, traditions, and ways almost unconsciously in daily life. For active practices, inhabitants engaged in cultural traditions such as reading, as well as attending performances, lectures, salons, and community events. Through passive and active practices, settlement residents imprinted their culture on a surrounding region.

In addition, the interaction of the mining industry, wilderness landscapes, and frontier ambiance fostered a culture of its own, which became pronounced in mining settlements. The mining culture then diffused into most of Colorado.

Townsites and unincorporated settlements were the population centers for localized mining industries and attracted a variety of individuals who did not work directly in mines or mills. This included most of the mining industry's women, families, and businessmen, and all were critical. Their arrival fostered a demand for cultural and social institutions that were both embraced and distained. Institutions readily acknowledged by communities included schools, churches, meeting halls, and union halls. Institutions tacitly accepted at best included prostitution businesses, dens of substance abuse, a drug trade, and saloons.

The theme of politics is another area of significance that settlements shared. Settlements were natural centers of law enforcement and judicial systems, created in response to social and mining disputes and crimes. Administrative and regulatory bodies developed in towns, and they oversaw local government activities, claim registration and regulation, and records keeping. Settlements also served as polling stations, and overall populations proved instrumental in the election of government officials.

Because hardrock, coal, and placer mining, as well as the milling and smelting industries, supported settlements across the state, the area of geographic significance is very broad. The area encompasses all portions of Colorado that saw mining and smelting, which extend west of the eastern piedmont. The period of significance ranges from the first unincorporated settlement at the confluence of Cherry Creek and the South Platte River in 1858 until 1960, when mining ceased to be a major influential factor. In western Colorado, the period of significance extends until 1970, when uranium mining ceased. Overall, the period of significance for a given settlement should be considered in terms of regional history.

Mining Settlement and Residence Registration Requirements

***Prospectors' Camp**:* National Register-eligible prospectors' camps must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, such as *industry* or *social history*, as well as events, trends, and themes important to the specific region. Because it is extremely difficult to directly attribute a given camp to an important person, few camps will be eligible under Criterion B. Prospectors' camps hold the highest likelihood of being eligible under Criterion C because they represent the typical residences associated with mineral examinations and discoveries, the beginnings of mineral booms, and general exploration of the mining frontier. Clearly definable resources with integrity are uncommon and offer important characteristics and attributes. Prospectors' camps many also be eligible under Criterion C if the resource possesses intact architectural features and facilities necessary for prospecting, such as field forges and cabins. These were important aspects of prospecting and few survive today. Under Criterion D, few resources are likely to be eligible as occupation was brief and archaeological deposits are unlikely. However, in cases where camp sites possesses building platforms, privy pits, and refuse dumps that feature buried archaeological deposits, testing and excavation may reveal information regarding the lifestyles, social structures, and demography of workers, as well as the presence of families and women. Such studies are important because these subjects were not extensively documented at the time.

Because they were occupied briefly and were ephemeral, clearly defined prospectors' camps are uncommon resources today and few retain integrity. Resources that can be confirmed as prospectors' camps are important and may be eligible provided they possess physical integrity relative to the period of significance, which may vary by region and ore type. Because prospectors' camps possessed few structures, most of which were usually removed when the site was abandoned, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the camp. Features common to prospectors' camps are noted under the feature types above.

Not all the seven aspects of historic integrity defined by the NRHP are likely to be relevant for prospectors' camps. The most applicable aspects will be *setting, feeling,* and *association*. The *setting* around the resource, and the resource itself, must not have changed to a great degree from its period of significance. Usually, this requires a preserved natural landscape and environment. In terms of *feeling*, the site should convey the sense or perception of prospecting and residence from a historical perspective and from today's standpoint. Integrity of *association* exists in cases where artifacts other visible features remain to convey a strong sense of connectedness between mining-related properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Worker Housing: Worker housing forms a spectrum ranging from small, simple, and unimportant to large, complex, and significant resources. In Colorado, small and simple workers' housing complexes were common and tended not to be involved with major engineering or architectural contributions on an individual basis, although they could have been important to a specific region. Large complexes were uncommon and often participated in the development of engineering and architecture, and tended to be associated with multiple themes of importance.

National Register-eligible worker housing resources must meet at least one of the NRHP Criteria and possess related integrity. Resources eligible under Criterion A must be associated with at least one area of significance noted above, as well as events, trends, and themes important to the specific region.

Resources may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some buildings and complexes can be traced to important individuals such as engineers or architects, and in these cases, they can be eligible under Criterion B. In the case of *engineering* or *architecture*, if the significance is related to an important individual's design of the worker housing, then Criterion C applies. In cases where the individual's significance is related to the supervision and operational control of the housing, then Criterion B applies. However, mere investment in a property or involvement with a company is too indirect an association for Criterion B. The individual of note must have either been present on-site or played a fundamental role in its physical development.

Many small complexes will not be eligible under Criterion C because they offer few important or period-defining characteristics and attributes, and often lack integrity. However, if standing structures are present, then worker housing may be eligible under Criterion C. In general, intact buildings are uncommon and important representations of engineering, architecture, and residence associated with Colorado's mining industry. Large complexes can be eligible under Criterion C if the resource possesses intact archaeological, architectural or engineering features and artifacts that clearly convey the organization and infrastructure of the housing and aspects of the residents and their lifestyles.

Workers' housing complexes offer a high potential to be eligible under Criterion D because they may contribute meaningful information. An analysis of the complex and any architectural features may enlighten the existing understanding of workers' housing and the residential environment associated with the mining industry. Workers' housing complexes often possess building platforms, privy pits, and refuse dumps that feature buried archaeological deposits. Testing and excavation may reveal information regarding the lifestyles, social structures, and demography of workers, as well as the presence of families and women. Such studies are important because these subjects were not extensively documented at the time.

Eligible resources must possess physical integrity relative to the period of significance, which may vary by region and ore type. Because most buildings either collapsed or were dismantled, the integrity will probably be archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the locations and arrangements of buildings, and reflect aspects of the residents and their lifestyles. Due to their commonality and relative unimportance, many small complexes will be ineligible unless they possess standing structures. Features commonly encountered at workers' housing complexes are noted under the feature types above.

Most of the seven aspects of historic integrity defined by the NRHP apply to worker housing. Some complexes may possess standing buildings, which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the housing should be that present during the period of significance. For a resource to retain the aspect of *design*, the material remains, including archaeological features, must convey organization and planning applied to workers' housing. Resources may feature standing buildings that were reoccupied periodically. Residents may have altered a building and constructed additions, and in such cases, the building can retain the aspect of *design* if the material remains reflect the changes during the period of significance. Integrity of *materials* and *workmanship* will be important where architectural styles and types are characterized in part by specific *materials* and *workmanship*. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance. If the resource lies in a mining landscape, then the surrounding mines and industrial features should retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of residence from the period of significance. Integrity of *association* exists in cases where visible features remain to convey a strong sense of connectedness between mining-related properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Isolated Residence: Isolated residences are common and since they can not be tied to a specific industry or means of subsistence, they lack defined significance. However, buried archaeological deposits may clarify industrial associations. If this seems likely and such clarifications are important, the site may be eligible under Criterion D.

Townsite or Unincorporated Settlement: These property types form a spectrum ranging from small and simple to large and complex. In Colorado, small and simple unincorporated settlements were common and tended not to be involved with major engineering or architectural contributions on an individual basis, although they were often important to a specific region. Large towns were uncommon and often participated in the development of engineering and architecture, and tended to be associated with multiple themes of importance.

National Register-eligible settlements must meet at least one of the NRHP Criteria and possess related integrity. Settlements eligible under Criterion A should be associated with at least one area of significance noted above, as well as events, trends, and themes important to a specific region.

Resources may be eligible under Criterion B provided that they retain integrity from the important person's period of occupation or participation. Some buildings and complexes can be traced to important individuals such as engineers or architects. In the case of *architecture*, if the significance is related to an important individual's design of buildings in the settlement or to the overall settlement design, then Criterion C applies. In cases where the individual's significance is related to occupying a building in the settlement, then Criterion B might apply if the building best conveys the individual's significance. The general inhabitation of a settlement by an important person is too indirect an association for Criterion B. The specific place of occupation by the individual of note must be identified, or they must have played a fundamental role in the settlement's physical development.

Settlements can be eligible under Criterion C if they possess intact archaeological, architectural or engineering features and artifacts that clearly convey key aspects. Examples of important aspects include the settlement's organization and infrastructure; the makeup and arrangement of residences and businesses; divisions of socioeconomic status, gender, ethnicity, and modes of employment; and characterizations of lifestyle such as diet, health, substance abuse, and consumerism. Of note, many of these aspects can be charted through a careful study of artifacts and architectural characteristics. For Criterion C, the resource should clearly represent a specific type of town or unincorporated settlement associated with mining. The presence of standing structures contributes to a resource's eligibility under Criterion C because they are uncommon and important representations of engineering, architecture, business, and residence associated with Colorado's mining industry.

Settlements offer a high potential to be eligible under Criterion D because they may contribute meaningful information. An analysis of architectural features may enlighten the existing understanding of commercial architecture, housing, and the residential environment associated with the mining industry. Broad scale studies of settlements often reveal aspects of community development, distribution of gender, modes of employment, socioeconomic status, and businesses. Settlements often possess building platforms, privy pits, and refuse dumps that feature buried archaeological deposits. Testing and excavation may reveal information regarding types of businesses, the lifestyles, social structures, and demography of residents, as well as the presence of families and women. Such studies are important because these subjects were not extensively documented at the time.

National Register-eligible townsites or unincorporated settlements must possess physical integrity relative to the period of significance, which may vary by region. Because most buildings either collapsed or were dismantled, the integrity will probably be primarily archaeological. For archaeological remains to constitute integrity, the material evidence should permit the virtual reconstruction of the locations and arrangements of buildings and infrastructure, and reflect aspects of the residents and their lifestyles. Features commonly encountered at settlements are noted under the feature types above.

Most of the seven aspects of historical integrity defined by the NRHP apply to settlements. Some may possess standing buildings, which must retain the aspect of *location* to contribute to a resource's integrity. To retain integrity of *location*, the settlement should be that present during the period of significance. For a resource to retain the aspect of *design*, the material remains, including archaeological features, must convey organization and planning applied to a settlement. Settlements may include standing buildings reoccupied periodically. Residents may have altered a given building and constructed additions, and in such cases, the building can retain the aspect of *design* if the material remains reflect the changes during the period of significance. Integrity of *materials* and *workmanship* will be important where architectural styles and types are characterized in part by specific *materials* and *workmanship*. To retain the aspect of *setting*, the area around the resource, and the resource itself, must not have changed a great degree from its period of significance, except for the removal of structures. If the settlement is isolated from the mining activity, then the natural landscape should be preserved. If the resource lies in a mining landscape, then the surrounding mines and industrial features should retain at least archaeological integrity. In terms of *feeling*, the resource should convey the sense or perception of settlement from the period of significance. Integrity of *association* exists in cases where visible features remain to convey a strong sense of connectedness between mining-related properties and a contemporary observer's ability to discern the historic activity that occurred at the location.

Notes on Research Sources

The descriptions of the property types, as well the mining methods and technologies already discussed in Section E, will certainly help the researcher identify, define, and interpret specific sites. The descriptions, however, are necessarily brief. Cultural resource specialists unfamiliar with the nuances of mines, mills, and the mining industry are strongly urged to review existing popular literature for a greater understanding of mining-related sites. The following publications, listed in order of relevance, can provide insight.

Twitty, Eric. *Riches to Rust: A Guide to Mining in the Old West*. Montrose, CO: Western Reflections, 2002.
Discusses in detail the constitution, layout, development, and equipment of mining. Focuses on mine surface plants and how to interpret today's remains.

Meyerriecks, Will. *Drills and Mills: Precious Metal Mining and Milling Methods of the Frontier West*. Tampa, FL: Self Published, 2001.
Provides accurate and comprehensive coverage of common mining and milling practices.

Twitty, Eric. *Blown to Bits in the Mine: A History of Mining and Explosives in the United States*. Montrose, CO: Western Reflections, 2001.
Discusses conventional mining practices with an emphasis on underground work and artifacts.

Hardesty, Donald. *The Archaeology of Mining and Miners: A View from the Silver State.* Ann Arbor, Michigan: Society for Historical Archaeology, 1988.
Discusses mining-related sites as archaeological resources.

Francaviglia, Richard. *Hard Places: Reading the Landscape of America's Historic Mining Districts*. Iowa City, IA: University of Iowa Press, 1991.
Focuses on reading and interpreting mining landscapes.

Young, Otis E. *Western Mining*. Norman, OK: University of Oklahoma Press, 1989 [1970].
Discusses hardrock prospecting, mining, and milling methods employed prior to 1893. The timeframe is limited and discussion of methods broad.

Bailey, Lynn. *Supplying the Mining World: The Mining Equipment Manufacturers of San Francisco, 1850-1900*. Tucson, AZ: Westernlore Press, 1996.
Discusses various types of mill and mine machines.

Bailey, Lynn. *Shaft Furnaces and Beehive Kilns: A History of Smelting in the Far West, 1863-1900*. Tucson, AZ: Westernlore Press, 2002.
Presents a comprehensive history of smelters, charcoal manufacturing, and related technology.

Sagstetter, Bill, and Beth Sagstetter. *The Mining Camps Speak: A New Way to Explore the Ghost Town of the American West.* Denver, CO: Benchmark Publishing, 1998.
Discusses the examination of mine sites through remaining material culture. The authors make a few inaccurate generalizations and dates of artifacts.

Many mine sites, both in Colorado and throughout the Rocky Mountain West, were recorded as part of the Historic American Engineering Record (HAER). The National Park Service, the American Society of Civil Engineers, and the Library of Congress established HAER in 1969 to document historic sites and structures related to engineering and industry. This agreement was later ratified by four other engineering societies: the American Society of Mechanical Engineers, the Institute of Electrical and Electronic Engineers, the American

Institute of Chemical Engineers, and the American Institute of Mining, Metallurgical and Petroleum Engineers. Appropriate subjects for documentation are individual sites or objects, such as a bridge, ship, or steel works; or larger systems, like railroads, canals, electronic generation and transmission networks, parkways and roads, and mining and milling sites.

HAER developed out of a close working alliance between the Historic American Buildings Survey (HABS) and the Smithsonian Institution's (SI) Museum of History and Technology (now the Museum of American History). From its inception, HAER focused less on the building fabric and more on the machinery and processes within, although structures of distinctly industrial character continue to be recorded. Mining-related buildings have also been recorded under the companion program, the Historic American Building Survey (HABS). HAER and HABS records may be accessed through the Library of Congress. An increasing number of these records are being posted on the library's website.

Fig F.1 Paramount Mine, Saint Elmo, Chaffee County, Colorado. Remains of the mine are across the road from the extant Cyanide Plant building. View from south. HAER COLO, 8-STEL, 1-5.

Another important source of mining site information is the Site Files collection at the Office of Archaeology and Historic Preservation in the Colorado Historical Society. The office is the state's primary depository of historical and archaeological survey materials on all types of cultural resources, including those related to mining. Materials include individual site survey forms and survey reports.

Researchers should also consult other National Register multiple property listings related to mining in Colorado. These include:

- Metal Mining and Tourist Era Resources of Boulder County
- Railroads in Colorado, 1858-1948
- Hinsdale County Metal Mining
- Lafayette Coal Mining Era Buildings

GEOGRAPHICAL DATA

The geographical area encompasses the entire State of Colorado.

SUMMARY OF INDENTIFICATION AND EVALUATION METHODS

The primary intent in preparing this multiple property document was to establish a broad historical context for mining activities and technology in Colorado and to establish associated property types and related National Register registration requirements to assist those doing field survey of mining properties and for those interested in nominating these properties for listing in the National Register. It is hoped that future research and survey projects will provide subcontexts related to specific mining districts or technologies to deepen the understanding of mining activities in Colorado.

The two authors of the document brought considerable experience in Colorado mining history and technology derived from research, writing, teaching, and field survey. Of particular note in this project, James Fell previously authored the book, *Ores to Metals: the Rocky Mountain Smelting Industry*, and Eric Twitty wrote the treatise on mining technology, *Riches to Rust.* James Fell also served for a period as the National Register coordinator in Colorado's Office of Archaeology and Historic Preservation (OAHP). Little original research and field survey were needed to produce this document. A few mining sites were visited in 2004 to observe and record ongoing open pit mining operations and recent examples of mine site reclamation projects. The authors' accumulated knowledge on the topic supplemented by existing general and specialized mining histories and engineering texts, plus the data available from previously recorded mining sites in the collections of OAHP, provided the intellectual and analytical foundation for this effort.

Few if any broad-scale National Register Multiple Property Documentation Forms (MPDF) or other resource contexts have been produced for mining industries anywhere in the western United States at the time of this writing.[1] As a result, no adequate models or examples were available. The National Register bulletin, *Guidelines for Identifying, Evaluating, and Registering Historic Mining Properties*, provided basic information regarding issues of significance, integrity, and property types. Three existing Colorado MPDFs provided material for context development, property type definitions and evaluation criteria: *Hinsdale County Metal Mining*; *Metal Mining and Tourist Era Resources of Boulder County*; and *Railroads in Colorado, 1858-1948*. The nomination forms for existing National Register-listed mining properties in Colorado also provided context materials, property type examples and registration models. A list of these National Register properties concludes this document.

The authors also drew extensively from two resources for the definition of property types, their associated features, and their registration requirements. The first resource was Eric Twitty's personal experience identifying, recording, and evaluating hundreds of mining resources over the course of more than eight years. During this time, Twitty also produced several archaeological mining contexts. The second was Twitty's *Riches to Rust,* which helped clarify property types and subtypes and establish associated character-defining features.

A grant from the State Historical Fund of Colorado through the Colorado Historical Society partially funded the project. Dale Heckendorn, National and State Register coordinator, reviewed project deliverables.

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[1] According to a search of State Historic Preservation Offices and state historical societies.

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Associated Listings

The previously listed National Register properties below meet the registration requirements established in this document. Properties are shown only once, although some include more than one property type.

Hardrock Mines

Shaft Mines

GOLCONDA MINE NRIS 99001234
Gunnison Resource Area, Lake City vicinity Hinsdale County
National Register 9/28/1999, 5HN.454
The property illustrates the extreme conditions of altitude, climate, and isolation faced by mining operations in the area. The complex includes an unusual two-story log boarding house constructed at an elevation of 12,400 feet. Extracting lead, zinc, copper, and some gold and silver, the operation encompassed over 7,000 feet of underground workings as of 1947.

Tunnel Mines

CRESCENT MINE NRIS 03001005
Vicksburg vicinity
State Register 9/10/2003, National Register 10/11/2003, 5CF.683
Dating to the 1930s, the Crescent Moly Mine #100 and Mining Camp are associated with the Molybdenum boom and the Climax mine phenomenon. An excellent example of early 20th century expedient mountain cabin construction, the Crescent Mine cabins are representative of a simple utilitarian design driven by economic necessity, illustrative of mining construction with local materials.

LEBANON & EVERETT MINE TUNNELS NRIS 71000214
Adjacent to I-70, northeast of Silver Plume, Clear Creek County
National Register 10/7/1971, 5CC7
The Lebanon Tunnel was driven into Republican Mountain by the Lebanon Mining company in 1870. An exact year of construction for the Everett Tunnel is unknown, but the mine was in operation through the mid- 1880s. In recent years, portions of the tunnels have been reopened as an interpretive exhibit in conjunction with the Colorado Historical Society's reconstruction of the Georgetown Loop Railroad.

LITTLEJOHN MINE COMPLEX NRIS 78000835
North bank of Pine Creek, vicinity of Granite, Chaffee County
National Register 12/27/1978, 5CF138
Located in the Pine Creek mining district, structures in the complex include a cabin, a burro shed/bunk house, a forge, and several related outbuildings. All date from the 1880s and are constructed of hand hewn logs with A and V joints. Low pitch gabled roofs were made of logs, mud, dirt, and grass. Such intact examples of early log mining camps are rare as many were quickly abandoned or replaced with wood frame or masonry structures. Harry Littlejohn, who acquired the property in 1920 and lived and worked there until his death in 1952, is credited with maintaining the integrity of the complex.

SMUGGLER MINE NRIS 87000194
Smuggler Mountain, Aspen vicinity, Pitkin County
National Register 5/18/1987, 5PT.479
In 1879, the Smuggler was among the first strikes made by Charles Bennett when he and other Leadville miners first came to the Roaring Fork Valley, and the Smuggler Mining Company was incorporated in November 1881. As one of the top silver and lead producers in the Aspen area, the mine was among the few that continued to operate after the Silver Crash of 1893. Active mining ceased in 1918, and the substantial wood frame buildings associated with the operation were dismantled. In addition to numerous underground tunnels, early tailings piles remain visible on the site. Mining resumed after World War II, and most of the wood frame and metal buildings now on the site were constructed after 1950. Listed under Historic Resources of Aspen Multiple Resource Area.

SNOWBOUND MINE NRIS 89000998
Boulder County Rd. 52, Gold Hill vicinity, Boulder County
National Register 8/3/1989, 5BL.448
This collection of buildings located in the Gold Hill Mining District dates from as early as 1877. The years 1917-1936 represent the greatest period of development and production for the Snowbound.

Ore-Concentration Facilities

Concentration Mills

ARGO TUNNEL AND MILL NRIS 78000836
Idaho Springs to Central City, Clear Creek County
National Register 1/31/1978, 5CC.76
Begun in 1893, the Argo Tunnel extends approximately five miles toward Central City at an average depth of 1,800 feet. It was designed by local mining entrepreneur Sam Newhouse to transport ores from area gold mines. The Argo Mill dates from 1913. The hillside location of the sprawling complex's interconnected structures is clearly visible from Interstate Highway 70. Primarily constructed with a steel frame surfaced with corrugated iron panels, portions of the mill rise to a height of nearly seven stories. The operation closed after a mine disaster in 1943, and the mill has been operated as a museum/tourist attraction since the late 1970s.

EMPIRE CHIEF MINE AND MILL NRIS 99001237
Gunnison Resource Area, Lake City vicinity Hinsdale County
National Register 9/28/1999, 5HN.375
The complex includes a 150-ton flotation mill, the mine tunnel, several associated buildings, and the ruins of several buildings that were destroyed by the county's deadliest avalanche in 1929. The complex serves as a vivid reminder of the hazards associated with high altitude mining.

INDEPENDENCE MINE AND MILL NRIS 93000054
Junction of Rangeview Rd. and Colo. Hwy. 67 Victor, Teller County
National Register 3/4/1993, 5TL.340
The Independence Mine and Mill complex is located on the south slope of Battle Mountain at an altitude of approximately 9,780 feet. In 1891, Winfield Scott Stratton made the first major strike of gold in the Cripple Creek/Victor area. The most intensive period of development of the mine coincided with the repeal of the Sherman Silver Purchase Act and the restoration of the gold

standard of currency. By 1895, it was the premier mine in the area. Stratton, also noted for his civic and charitable contributions, remained active as a leader in the local mining industry until his death in 1902. The mill, often referred to as the Peck Mill, began operating in 1908 and closed in 1928. The headframe, orehouse, and powderhouse are among the structures and buildings remaining on the site.

MODOC MILL NRIS 78000833
Adjacent to Duck Lake, 4 miles north of Ward, Boulder County
National Register 12/27/1978, 5BL.359
The circa 1890 Modoc Mill is a good example of industrial architecture associated with Boulder County's mining history. This concentration mill of wood and metal reaches four stories in height. The uppermost story of hewn logs received the ore. Here gravity bins held the ore until it was fed into a crusher and the stamping apparatus below. The 18 foot high stamping apparatus, manufactured by Griffen and Wedge of Zanesville, Ohio, consists of 30 stamps each weighing 950 pounds that are arranged in three banks of ten. Both the mill and nearby mine closed for the last time in 1920.

ORE PROCESSING MILL & DAM / LEBANON MILL NRIS 71000213
Off I-70, 1 mile southwest of Georgetown, Clear Creek County
National Register 5/6/1971, 5CC.68
Located on Republican Mountain, midway between Georgetown and Silver Plume, the facility was a key component in the early development and prosperity of Georgetown. The mill was patented in 1872 by Julius G. Pohle, Superintendent of the Lebanon Mining Company. Few mills of its size survived past 1880 due to the influx of eastern capital and the rise of large corporate mining complexes. The two-story wood frame structure contained machinery driven by a horizontal water wheel, and the mill dam spanned Clear Creek.

Smelter

HOLDEN MINING AND SMELTING COMPANY NRIS 90000867
1000 Block W. Colo. Hwy. 82, Aspen, Pitkin County
National Register 6/22/1990, 5PT.539
From 1891 to 1893, this smelting facility, also known as the Holden Lixiviation Works, played a significant role in the production of silver during Aspen's silver mining boom. The approximately 2½-acre district encompasses the most important components associated with the operation. The lixiviation process employed salt in the leaching of silver from the ores extracted from nearby mines. The 1½-story wood frame sampling works building, measuring 77 in length and 42 feet in width, and a portion of a one-story salt shed remain on the site. Large portions of the sandstone foundation are all that remain of the multi-story mill building which appears to have been over 250 feet in length.

OHIO-COLORADO SMELTING & REFINING CO. SMOKESTACK / SMELTERTOWN NRIS 76000548
1401 J St., Salida vicinity, Chaffee County
National Register 1/11/1976, 5CF.143
Completed in 1917, the brick and tile smokestack reaches a height of 365 feet. Its concrete foundation extends 30 feet into the ground. The structure was built to replace two shorter smokestacks at the Ohio-Colorado Smelting and Refining Company's smelter facility located one mile west of Salida. Although the facility closed in 1920, the smokestack remains as a highly visible monument to the mining industry and its workers.

Coal Mines

FOX MINE OFFICE NRIS 76000168
1226 S. Cherryvale Rd., Marshall vicinity, Boulder County
National Register 2/23/1996, 5BL.460
The 1883 Fox Mine Office Building is associated with coal mining in the Marshall area. Coal mining activities at Marshall were significant in terms of making immediate and lasting contributions to the economic, industrial, and demographic character of the region.

Mining Settlements and Residences

Workers' Housing

DERRY MINING SITE CAMP NRIS 00000782
Leadville vicinity, Lake County
National Register 7/14/2000, 5LK.1341
Although a large rambling, log and wood frame building on the approximately 8½-acre site dates from earlier ranching operations, the property primarily reflects its association with the mining activities occurring there from 1906 to 1923. Ditches, ponds, and tailings piles continue to dot the landscape. The circa 1916 log cabins were constructed to house workers hired in conjunction with the operation of the Derry Dredge. This large "mountain boat" was assembled at the site in 1915 to operate along Corske Creek. Circa 1923, it was relocated to Box Creek. The dredge was dismantled in 1926 and subsequently shipped to South America.

HEALY HOUSE NRIS 70000164
912 Harrison Ave., Leadville, Lake County
National Register 8/25/1970, 5LK.44
Originally built as a two-story residence in 1878, a third floor was added in 1888. This architecturally significant wood-frame house has been restored and is operated as a museum by the Colorado Historical Society.

KULLGREN HOUSE NRIS 83001299
209 E. Cleveland St., Lafayette, Boulder County
National Register 5/20/1983, 5BL.817
Nearly square in plan, with a steeply pitched hip roof, the house was built with enough rooms to accommodate coal miners as boarders, a common practice which helped supplement the owner's income.

LAFAYETTE HOUSE NRIS 83001300
600 E. Simpson St., Lafayette, Boulder County
National Register 5/20/1983, 5BL.823
In 1900, the large two-story Lafayette House opened its doors for business, accepting both overnight guests and boarders. It also provided quarters for Baldwin-Felts detectives who were brought to Lafayette by mine owners to break the strike of 1910-1914.

LEWIS HOUSE NRIS 83001301
108 E. Simpson St., Lafayette, Boulder County
National Register 5/20/1983, 5BL.819
One of the original miner's homes constructed in the 1890s at the Gladstone Mine near Lafayette, it was moved to its present site after the start of the strike in 1910.

MARTIN MINING COMPLEX NRIS04000384
6350 County Road #2, Silverton vicinity
National Register 5/13/2004, 5SA.1056
The Martin Mining Complex is associated with the mining industry in the San Juan Mountains and the Eureka Mining District. The complex displays the development of industrialized hard rock mining and the transportation infrastructure needed to make such mining profitable in a rugged region. The Martin Mining Complex is representative of the boom and bust cycle that was always present with industrialized mining. The 1929 Martin Boardinghouse is one of the best-preserved and largest boardinghouses still standing in the San Juan Mountains. More precisely, the Martin Boardinghouse can be called a "miners' hotel" and is one of the largest and best preserved examples of its type. Boardinghouses typically contained one large room where supplies and materials jostled with double wood bunks three tiers high. Sometimes twenty or more men lived in this single large room. Miners' hotels represented a step up in accommodations. The type generally contained individual bedrooms with two men to a room. Each man slept on his own bunk or bed. Indoor bathrooms offered hot water for showers. Other amenities might include a library stocked with books, magazines, and newspapers, hotel china in the dining room, and a better quality of food.

MILLER HOUSE NRIS 83001291
409 E. Cleveland St., Lafayette, Boulder County
National Register 5/20/1983, 5BL.818
Constructed circa 1888, the house is associated with Mary Miller, the founder of the town of Lafayette. In 1884, coal was discovered on the 1280 acre Miller farm. Miller platted the 150 acre townsite in 1888 and named it Lafayette after her late husband.

REDSTONE INN NRIS 80000920
0082 Redstone Blvd., Redstone, Pitkin County
National Register 3/27/1980, 5PT.553.1
The inn originally functioned as part of the model community built by John C. Osgood for the workers associated with his nearby coke producing and coal mining operations. The 2½-story wood frame building was constructed in 1902 for the primary purpose of housing bachelor miners in somewhat elegant surroundings. A large square clock tower, which incorporates a red sandstone base; extensive cross-timbering; and a steeply pitched pyramidal roof, rising a full story above the apex of the building's roof are among the distinctive architectural details.

Unincorporated Settlements

ARGENTUM MINING CAMP NRIS 99001235
Gunnison Resource Area, Lake City vicinity, Hinsdale County
National Register 9/28/1999, 5HN.300
Although little remains today, the camp site is representative of the boom and bust cycles typical of many Colorado mining communities. With a history paralleling the Tellurium/White Cross Mining Camp, it was never formally platted as a town site. The population reportedly reached a peak of 500, and the camp served as a commercial center during periods of prosperity. Listed under Hinsdale County Metal Mining Multiple Property Submission.

DUTCHTOWN NRIS 76002292
Ditch Rd., Rocky Mountain National Park, Grand County
National Register 1/29/1988, 5GA.807
The site consists of four recognizable cabin ruins that were built starting in approximately1879 in answer to a promising silver strike. Racial differences subsequently caused some of the miners to leave Dutchtown and move to Lulu City. .

INDEPENDENCE & INDEPENDENCE MILL SITE NRIS 73000484
Colo. Hwy. 82, White River National Forest, east of Aspen, Pitkin County
National Register 4/11/1973, 5PT.18
The cluster of log cabins and cabin ruins remaining on the site are associated with early mining history in the Upper Roaring Fork area of eastern Pitkin County. Most of the buildings in the settlement, which extended along the Roaring Fork River, have collapsed or lack roofs. Located on the Independence Pass wagon road between Aspen and Leadville, the town served as a good stopping point for travelers. Population reportedly grew from 150 miners in 1881 to approximately 2,000 residents during the mid-1880s. By the late 1880s, fewer than 100 residents remained, and most commercial enterprises had either closed or relocated to Aspen.

LITTLE ROME NRIS 99001233
Gunnison Resource Area, Lake City vicinity, Hinsdale County
National Register 9/28/1999, 5HN.593
Little Rome is the site of an historic mining camp that was occupied by Italian immigrants who worked at the Ute-Ulay Mine and Mill from 1889 to 1899. Listed under Hinsdale County Metal Mining Multiple Property Submission.

LULU CITY SITE NRIS 77001562
Rocky Mountain National Park, Grand County
National Register 9/14/1977, 5GA.302
A silver strike in 1879 prompted the arrival of prospectors and entrepreneurs such as Benjamin F. Burnett and William Baker from Fort Collins. They organized the Middle Park and Grand River Land Improvement Company for the purpose of establishing Lulu City, which was named for Burnett's daughter. By 1881, there were forty cabins and a variety of businesses. High transportation costs and the generally low grade ores resulted in a rapid decline. In 1949, the site became part of Rocky Mountain National Park. There are only three recognizable cabin ruins, with lesser remains of six other buildings, and it is the only platted ghost town within the park.

TELLURIUM / WHITE CROSS MINING CAMP NRIS 99001232
Gunnison Resource Area, Lake City vicinity, Hinsdale County

National Register 9/28/1999, 5HN.302
Although little remains today, the camp site is representative of the boom and bust cycles typical of many Colorado mining communities. With a history paralleling the Argentum Mining Camp, it was never formally platted as a town site. The population reportedly reached a peak of 500, and the camp served as a commercial center during periods of prosperity.

VICKSBURG MINING CAMP NRIS 77000364
Pike & San Isabel National Forest, Chaffee County
National Register 3/8/1977, 5CF.136
Located eight miles from the Arkansas River, the camp is associated with early mining history in the Clear Creek Canyon area. By 1882, the camp consisted of nearly forty buildings. Population apparently peaked in 1885, with the total estimated to have been between 150 and 600. Seven of the original log cabins remain intact on the site. The silver market crash of 1893 temporarily halted mining in the canyon. Mining activity resumed in the early 1900s, and the last ore was hauled out of the canyon in 1918.

LUDLOW TENT COLONY SITE NRIS 85001328
Del Aqua Canyon Rd., south of Aguilar, Las Animas County
National Register 6/19/1985, 5LA.1829
The 40-acre parcel comprises the site of the Ludlow tent colony and represents the event known as the Ludlow Massacre. On April 20, 1914, after shots were fired between the striking mine workers at the Ludlow colony and the Colorado militia, fires destroyed the entire tent colony. Two women and eleven children suffocated in a cellar under one of the tents. The Ludlow Massacre is considered a major event in American labor history. The site also includes a monument erected in 1918 by the United Mine Workers of America, who own and maintain the property.

Townsites

ASHCROFT NRIS 75000533
White River National Forest, south of Aspen, Pitkin County
National Register 5/12/1975, 5PT.37
The townsite is significant as the remains of a prosperous Roaring Fork Valley mining camp of the 1880s. Originally known as Castle Forks, the town of Ashcroft was incorporated in 1882. Its peak population of approximately 1,000 supported a variety of commercial enterprises. By the end of 1883, much of the population, and many of the buildings, began moving to Aspen. The post office remained open until 1912, and the last permanent resident left in 1925. Fewer than a dozen of the original log and/or wood frame buildings remain in place. The most prominent is a two-story false front commercial building that housed the Hotel View. The townsite is now interpreted for visitors under the auspices of the Aspen Historical Society.

BRECKENRIDGE HISTORIC DISTRICT NRIS 80000927
Breckenridge, Summit County
National Register 4/09/1980, 5ST.130
Located in the Rocky Mountains approximately 100 miles west of Denver, Breckenridge is an example of a mining boom town that experienced a new era of prosperity as a result of the post World War II boom in the ski industry. Settlement in the area began in 1859. The district contains approximately 180 structures and includes excellent examples of the late 19th- and early 20th century-commercial, residential and religious architecture associated with Colorado mountain mining communities.

CENTRAL CITY-BLACK HAWK HISTORIC DISTRICT NRIS 66000246
Off Colo. Hwy. 119, includes commercial and residential areas in both communities, Gilpin County, National Historic Landmark 7/4/1961, National Register 10/15/1966, Boundary increase: 9/17/1991, 5GL.7
Were it not for the discovery of gold in 1859, there is hardly a more unlikely location for the establishment of a "boomtown" than the rugged and inhospitable terrain of the surrounding mountainsides. From a humble collection of mining camps, hard work brought good fortune and led to the construction of substantial brick and stone buildings. Most of the surviving buildings are vernacular in their design, although many include Italianate detailing.

COKEDALE HISTORIC DISTRICT NRIS 85000083
Church, Maple, Pine, Elm, & Spruce Sts., Cokedale, Las Animas County
National Register 1/18/1985, 5LA.5782
Cokedale is a significant example of a company-owned coal camp and is associated with the coal mining and coke industry that served as the predominant basis of the southern Colorado economy around 1900. While most similar coal camps were dismantled as mines ceased operation in the Las Animas-Huerfano district beginning after World War I, Cokedale continued to thrive as a company town until 1946. Constructed in 1906-07, it was long heralded as a model camp, with housing, educational and recreational facilities provided for its inhabitants by their employer, the American Smelting and Refining Company. Most of the houses, as well as the public and commercial buildings, survive essentially intact. Also important are the surviving coke ovens. The two rows of double sided units are the largest surviving group of coke ovens in the state.

CRESTED BUTTE HISTORIC DISTRICT NRIS 74002279
Crested Butte, Gunnison County
National Register 5/29/74, 5GN.271
Although settlers looking for precious metals were in the area as early as 1874, the town was incorporated in 1880. As the number of mining camps grew, Crested Butte thrived as a supply center. Of the 339 major structures within the district, 85 percent date from the late 19th and early 20th century. After 1885, as the gold and silver played out, the surrounding area was mined for high quality bituminous coal. Since the major coal mines shut down in 1952, Crested Butte has become a tourist center for sightseers in the summer and skiers in the winter.

CRIPPLE CREEK HISTORIC DISTRICT NRIS 66000939
Colo. Hwy. 67, includes the entire commercial and residential area, Teller County
National Historic Landmark 7/04/1961, National Register 10/15/1966, 5TL.2
The Cripple Creek mining district, originally pronounced worthless by mining experts, produced an estimated $400,000,000 in gold. At its peak, there were over five hundred mines. When fires in the late 1880s destroyed most the town's original wood buildings, they were replaced with structures of stone and brick, many of which remain in place.

DURANGO MAIN AVENUE HISTORIC DISTRICT NRIS 80000907
Bounded roughly by 5th St., the Durango and Silverton RR right-of-way, 12th St. & the alley between Main & 2nd Aves., La Plata County
National Register 8/7/1980, 5LP.304
The district consists of 86 contributing buildings which collectively reflect the late 19th and early 20th century history and architecture of the downtown area. Since its founding in the early 1880s, with the arrival of the railroad, Durango grew first as a mining supply and smelter center. It soon became a focal point for agriculture and logging in southwestern Colorado. Notable buildings in the district include the 1895 Palace Hotel, the 1902 General Palmer House, the 1887 Strater Hotel, and the 1897 Newman Building.

ELDORA HISTORIC DISTRICT NRIS 89000978
Huron, Washington, Klondyke, Eldora Sts., Eldora, Boulder County
National Register 10/4/1989, 5BL.758
The district includes surviving examples of the Pioneer Log, Commercial Vernacular, and Rustic Tourist building traditions associated with the mountainous portion of Boulder County. Beginning with a mining boon in 1878, development in Eldora reflected a pattern commonly found in similar communities as mining declined and local economies shifted toward tourism.

GEORGETOWN-SILVER PLUME HISTORIC DISTRICT NRIS 66000243
Off I-70 at Georgetown and Silver Plume, includes the entire commercial and residential areas of both communities, as well as the railroad grade connecting them. Clear Creek County.
National Register 11/13/1966, National Historic Landmark 11/13/1966, 5CC.3
Prior to the Leadville strike of 1878, the district was the most important silver camp in Colorado. The initial boom period dates from the discovery of gold by George and David Griffith in 1859. The Georgetown portion of the district includes a rich variety of substantial Late Victorian style buildings. Because the wealth of the mining district was centered in Georgetown, the architecture reflects the attempt by families to reproduce the lifestyle of their more established home states. In contrast, Silver Plume developed as the work center where the ore, as well as the wealth, was mined. As a result, the surviving buildings tend to be simple wood frame structures. The reconstructed Georgetown Loop Railroad, with its famous Devil's Gate Viaduct rising more than 90 feet above Clear Creek, is also located within the district.

GOLD HILL HISTORIC DISTRICT NRIS 89000979
Main, Pine, College, Horsfal Sts., Gold Hill, Boulder County
National Register 8/3/1989, 5BL.769
Organized in 1859, Gold Hill was one of Colorado's earliest mining camps and remains an excellent example of the pattern of settlement and community development within the 19th

century metal mining communities of Boulder County. Several examples of Pioneer Log construction remain intact. After 1900, few precious metal ores were recovered in Gold Hill, and the local economy shifted toward tourism during the first decades of the 20th century.

GOLDFIELD CITY HALL & FIRE STATION NRIS 84000897
Victor Ave. & 9th St., Goldfield, Teller County
National Register 5/17/84, 5TL.119
The simple two-story wood frame building has a flat roof. The community erected the building in 1899. By 1900, Goldfield was the third largest town in the booming Cripple Creek mining district. The building served as a city hall and fire station until 1940. It is the only remaining public building in what is now virtually a ghost town.

IDAHO SPRINGS DOWNTOWN COMMERCIAL DISTRICT NRIS 84000801
Bounded by Center Alley, Riverside Dr., and Idaho St., Idaho Springs, Clear Creek County
National Register 1/5/1984, 5CC.201
The district has been the commercial center of the community since its development in the late 19th century. The district's superb collection of Late Victorian-Era structures, such as the Hanchett Building, Mining Exchange, and Queen Hotel, forms the core of a city that is historically significant as the site of the first major discovery of placer gold in Colorado, and as an important milling and supply center for the mining region which accelerated the settlement of Colorado.

LAKE CITY HISTORIC DISTRICT NRIS 78000859
Colo. Hwy. 149, Hinsdale County
National Register 12/01/78, 5HN.68
Established in 1875 as a supply center for the heavy mining activity in the area, people found their way to Lake City via the Saguache-San Juan Toll Road built by Enos Hotchkiss, one of the town founders. A major fire in 1879 destroyed much of the downtown area. Many of the rebuilt buildings of brick and stone remain intact. An economic depression hit Lake City in 1884, and times were hard until the arrival of the railroad in 1889. Subsequently, trade flourished until the silver crash of 1893.

LEADVILLE HISTORIC DISTRICT NRIS 66000248
Roughly bounded by Hazel St., W. Second St., James St., & Tenth St., Lake County
National Historic Landmark 7/4/1961, National Register 10/15/1966, 5LK.40
The district encompasses a scattered collection of architecturally distinctive and historically important masonry buildings supported by numerous residential and commercial buildings that contribute to the overall appearance associated with late 19th century western mining towns. The Leadville mining district ranks as one of the country’s richest mineral regions. The first gold mining boom occurred in 1860, bringing approximately 10,000 miners to the area. The second boom began in 1878 with the discovery of extensive silver deposits. By 1880, the population was estimated to be between 25,000 and 40,000. The fortunes of Leadville’s best known silver king, H.A.W. Tabor, crashed along with silver prices in 1893.

OURAY HISTORIC DISTRICT NRIS 83003537
US Hwy. 550, Ouray County
National Register 10/06/1983, 5OR.585
Located in the San Juan mountains, the district encompasses almost the entire historic townsite and reflects Ouray's importance as a supply center for the nearby mining regions from 1886 to 1915. The buildings within the district represent a variety of styles, with brick Italianate structures predominating in the commercial area. Primarily frame residential structures are found on the hillsides overlooking the town.

REDSTONE HISTORIC DISTRICT NRIS 89000934
Along Crystal River, Hawk Creek to 226 Redstone Blvd., Pitkin County
National Register 7/19/1989, 5PT.553
Redstone is a rare, intact Colorado example of an industrial company town, with examples of buildings ranging from worker's cottages to the large estate of the industrial magnate John Cleveland Osgood. Osgood, as head of the Colorado Fuel and Iron Company from 1892 until 1903, regarded Redstone as his personal project and saw the town's development as a model and standard for the industry. The district survives as a major body of work by architect Theodore Boal. Boal adapted popular Victorian styles to a mountain setting utilizing unique combinations of wood and stone in his picturesque designs.

SILVERTON HISTORIC DISTRICT NRIS 66000255
US Hwy. 550, includes the entire city boundaries, San Juan County
National Historic Landmark 7/4/1961, National Register 10/15/1966
Boundary Increase: National Register 4/3/1997, 5SA.59
The town is situated at the center of the San Juan mining district. Prospecting began in the 1860s, but it was not until 1871 that the first profitable silver vein was discovered in nearby Arrastra Gulch. The late 19th and early 20th century residential and institutional buildings within the district reflect the prosperity brought about by one of Colorado's richest mineral producing regions. The boundaries of the district were expanded to include the Shenandoah-Dives (Mayflower) Mill complex, an intact example of a selective flotation mill and its aerial tram; the office/assay building of Crooke's Polar Star Mill that reflects Silverton's early mining history; the Animas Power and Water Company that diverted electrical power to the mining and milling operations in the Silverton area; and the Hillside Cemetery that illustrates the impact of the mining industry on the town's working class community.

ST. ELMO HISTORIC DISTRICT / FOREST CITY NRIS 79000577
Pitkin, Gunnison, lst, Main & Poplar Sts., St. Elmo, Chaffee County
National Register 9/17/1979, 5CF.139
St. Elmo owes its existence to the development of silver mining, which began in the Chalk Creek area in the 1870s. Originally platted as Forest City, its brief era of prosperity occurred during the 1880s with the coming of the Denver South Park & Pacific and the Denver & Rio Grande railroads. The district consists of a group of primarily wood frame commercial buildings and several clusters of residences dating from the 1880s and 1890s. The small vernacular buildings are representative of the type of construction found in early mining camps. The district is flanked by groves of pine and aspen growing on the mountain slopes that rise sharply above the townsite.

TELLURIDE HISTORIC DISTRICT NRIS 66000256
Colo. Hwy. 145, roughly includes all the commercial and residential area as well as the

Lone Tree Cemetery to the east San Miguel County
National Historic Landmark 7/4/1961,National Register 10/15/1966, 5SM752
The district encompasses most of the original town and is significant for its association with the settlement of the western frontier and the development of metal mining. The architecture of its approximately 300 contributing buildings is representative of 19th century western mining "boom town" construction.

VICTOR DOWNTOWN HISTORIC DISTRICT NRIS 85001463
Bounded roughly by Diamond Ave., 2nd, Portland & 5th Sts., Victor, Teller County
National Register 7/3/1985, 5TL.134
The district contains many relatively unaltered and contiguous commercial, public, fraternal and religious buildings of late 19th- and early 20th-century design. They form the commercial core of an important mining community that composed part of the Cripple Creek-Victor Mining District. The area is one of the richest in gold deposits in the state, and it played a prominent role in the development of Colorado's mining industry. Downtown Victor still reflects the great wealth and prosperity that resulted from the gold mining operations.

WINFIELD MINING CAMP NRIS 80000883
County Rd. 390, 15 miles north of Buena Vista, Chaffee County
National Register 3/10/1980, 5CF.137
Located four miles further into Clear Creek Canyon than the Vicksburg Mining Camp, the property is important for its association with early mining history in the area. Winfield’s formal history began in 1881 when the 120-acre townsite was laid out. Population peaked at an estimated 1,500 in 1890. Four of the original log buildings remain. One, with a false front of horizontal weatherboard, served as a school. Five circa 1930s cabins are also on the site. The silver market crash of 1893 temporarily halted mining in the canyon. Mining activity resumed in the early 1900s, and the last ore was hauled out of the canyon in 1918.

EAST THIRD AVENUE HISTORIC RESIDENTIAL DISTRICT NRIS 84000024
E. 3rd Ave. between 5th & 15th Sts., Durango, La Plata County
National Register 10/11/1984, 5LP.1411
In 1880, Durango was platted by employees of General William Jackson Palmer of the Denver Rio Grande Railroad. East Third Avenue, known prior to 1893 as the "Boulevard", remains a prestigious residential area located along the bluffs overlooking the downtown commercial district. The quality of design and the variety of styles establish the district as the best local collection of late 19th and early 20th century residential architecture.