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Mining History and Geology of Some of Wyoming's Metal and Gemstone Districts and Deposits

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Mining History and Geology of Some of Wyoming's Metal and Gemstone Districts and Deposits

W. DAN HAUSEL[1]

INTRODUCTION

It is difficult to determine when the region we now know as Wyoming was first prospected. Hints in the historic literature allude to Spanish prospectors entering this region in the 1700s, although the evidence is not conclusive. But at least by the early 1800s, gold was found by fur trappers in some regions of Wyoming. Even Father DeSmet reported seeing gold in the hands of Indians and Whites in the Bighorn Mountains possibly in the 1840s. But by far the most important early discovery was when a trapper found gold in the South Pass area in 1842. This eventually led to the development of Wyoming's most important gold district.

The discovery of gold at Sutters Mill in California in 1849, set our early nation on fire with gold fever. The discovery probably resulted in an influx of Forty-niners through the Wyoming-Dakota Territory on their way to the west coast, but the results of their endeavors went unrecorded. If any of these people took the time to sample the streams draining the northern flank of the Medicine Bow Mountains on there way to California, most likely they would have found gold. For, in a recent study of this area, gold was identified in nearly every drainage sampled (Hausel and others, 1992, 1993).

The 1860s were highlighted by several gold discoveries throughout the territory. In 1863, placer gold was discovered in the vicinity of Oregon Buttes along the Oregon Trail near the southern tip of the Wind River Mountains. Two years later, in 1865, a rich gold deposit known as the Lost Cabin, was found in the Bighorn or Owl Creek Mountains. In 1867, gold was discovered along Willow Creek in the South Pass region near the Oregon Trail several miles north of Oregon Buttes. The news of this discovery attracted hundreds of prospectors to the southern tip of the Wind River Mountains and within a short time the towns of South Pass City, Atlantic City, and Hamilton City were established. In the following year (1868), gold was discovered on Douglas Creek in the Medicine Bow Mountains.

In 1871, the discovery of diamonds commanded attention in the West. The site was originally reported in Arizona, but kept secret. However, by late 1872, the location south of the Union Pacific railroad along the border between Colorado and Wyoming was proven to be a hoax. This notorious scam left its scar in history that may have affected any serious prospecting ventures for diamonds in North America for decades to come.

Gold continued to attract attention in Wyoming, but in 1881, rich copper deposits were discovered in the Sierra Madre. This led to the first important copper mine in the Territory, and soon copper was being mined and shipped from the Doane-Rambler mine. Sixteen years later, in 1897, a spectacular copper deposit was discovered northeast of the Doane-Rambler mine. This was developed into the Ferris-Haggarty mine, which operated until 1908.

Near the turn of the century, our evolving industrialized nation needed iron to manufacture steel to fuel its growing economy. Wyoming had plenty of iron ore, but most was too low-grade to manufacture Bessemer steel and had to wait for technology to produce blast furnaces. However, some ore in the Hartville complex was of sufficient quality to mine. In 1899, iron ore was shipped from the Sunrise mine after several years of copper shipments, Mining continued until the recession of the 1980s when operations were terminated in 1981.

Wyoming never became a powerhouse hardrock mining State like our surrounding neighbors. Was this a fluke that Wyoming should be a poorly mineralized core surrounded by well mineralized terranes? This is a complex question to resolve, but based on our hardrock mining history and geology, Wyoming should expect more widespread resources.

BIGHORN MOUNTAINS

Early prospecting history of Wyoming alludes to prospectors entering the Bighorn Mountains in the early 1800s and possibly as early as the 1700s. In 1865, for instance, an expedition to the Bighorn Mountains commanded by General Connor reported finding foundations of old stone houses believed to be more than a century old along the shore of Lake DeSmet. In the following year of 1866, the decayed remains of an arrastra (believed to be of Spanish origin) were discovered 50 miles southwest of Fort Phil Kearney (Strahorn, 1877).

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Early reports in this region described Indians, as well as Whites living with the Indians, with gold from the Bighorn Mountains. Seeing many large nuggets in the hands of Indians (possibly in the 1840s), Father DeSmet claimed that the Bighorns contained the richest gold field in the world. Some early reports also described Indians trading gold dust and nuggets for supplies at Fort Phil Kearney (AJM, 1868, v.5, Ap.18, p. 245) (AJM=American Journal of Mining).

Trappers working the Bighorn Mountains also reported gold. One trapper by the name of La Pondre with the American Fur Company claimed to have found many nuggets in the Bighorn Mountains. Years later, in July, 1859, Captain Reynolds of the Topographic Engineers Corps also reported gold in the Bighorn Mountains (Strahorn, 1877).

Sporadic discoveries continued to attract attention to this region. Strahorn (1877) reported several small shipments of very coarse gold with nuggets of 0.02 to 0.5 ounce were made. Soon, nearly 3,000 prospectors were working various streams in the Bighorns.

Possibly, no other gold deposit stimulated the imaginations of gold hunters in Wyoming more the Lost Cabin prospect. Legend claims this deposit was discovered in 1865, and within 3 to 6 days, seven prospectors recovered nearly 22 pounds of gold prior to being attacked by Indians. Two of the prospectors escaped and traveled three nights on foot to Fort Reno east of the Bighorn Mountains. During the following spring, they organized another group of prospectors and were killed on the return trip to the Bighorn or possibly the Owl Creek Mountains. The location of this deposit was apparently known by some prospectors in the late 1800s, for Warren (1885) reported the Lost Cabin mine was situated near the Bighorn River, and samples from the prospect assayed 3.0 opt (ounce per ton) gold and a trace of silver. However, through time, the location has been forgotten.

At the turn of the century, the Bighorn Mountains were the site of a short lived gold rush. Gold was discovered along the western flank of the range. The town of Bald Mountain was organized and supported as many as 1,500 prospectors and related businesses. Three stamps mills were ordered, and the Bald Mountain district was organized west of present day Burgess Junction (Figure 1). Gold was discovered in modern placers and in basal Middle Cambrian Flathead conglomerates (reported as Deadwood Conglomerate due to its resemblance to the auriferous conglomerates in the Black Hills), but the values were too low to support extended commercial operations.

These same conglomerates incited interest in the 1950s. Instead of gold, interest was for a rare earth- and thorium-phosphate known as monazite. Portions of Bald Mountain were drilled by the U.S. Bureau of Mines, and a low grade zone of 20,000,000 tons of conglomerate with an average of 2.5 lbs/ton of monazite was outlined. A smaller, high-grade zone within this low-grade deposit was outlined that contained 675,000 tons averaging 13.2 lbs/ton of monazite. The average gold content of the rare-earth deposit was reported at 0.003 opt, however, only a small number of samples were tested and the drilling methods used were inefficient for gold recovery. Twenty two thousand tons of contained ilmenite were also identified in the high grade zone (King and Hausel, 1991).

It is interesting that the Bighorn Mountains commanded so much attention for gold. The geology of the Bighorns, a complex of Archean felsic gneiss and granite is not favorable for major metal deposits. To date, with the exception of the Bald Mountain deposit, only small, localized, metal deposits have been found. However, such Archean cratons are generally considered favorable targets for diamondiferous kimberlite. Yet, I know of only one company that has ever searched these mountains for diamonds.

MEDICINE BOW MOUNTAINS

The Medicine Bow Mountains in southeastern Wyoming, like the Bighorn Mountains, attracted the attention of early explorers. Following a discovery of gold flakes and thumbnail size nuggets in the northern Medicine Bow Mountains, Mullison (1909) became interested in the Brush Creek-Mullison Park area. According to Mullison, some Ute Indians described several ancient prospects in the upper North Brush Creek Basin to him in 1870. In 1886, Mullison investigated these and found prospects on North Brush Creek, Cortez Creek, and Mullison Creek which he interpreted to be of Spanish origin. At one of these prospects, a 67-foot-deep shaft sunk near the mouth of Cortez Creek cut older mine workings that contained a tunnel and a 4-foot-diameter shaft of unknown origin. The older workings were in very poor condition and an artifact found on the mine floor consisted of "elk's ivory" with a face carved in it (Mullison, 1909). Duncan (1990) suggested that it was possible that some of these prospects were dug by Forty-niners on their way to the Californian gold rush.

In the same general area, Mullison also found a group of prospect pits and the remains of a stone wall constructed to keep a steep bank along Mullison Creek from caving. A short distance from these prospects, Mullison found a 6-foot-diameter circular shaft sunk in the old creek bed. Trees growing on the mine tailings were estimated to be more than 175 years old suggesting the mine may have been of Spanish origin (Mullison, 1909, p. 32).

Douglas Creek district

In the early spring of 1868, rumors were circulating that gold had been discovered on the Little

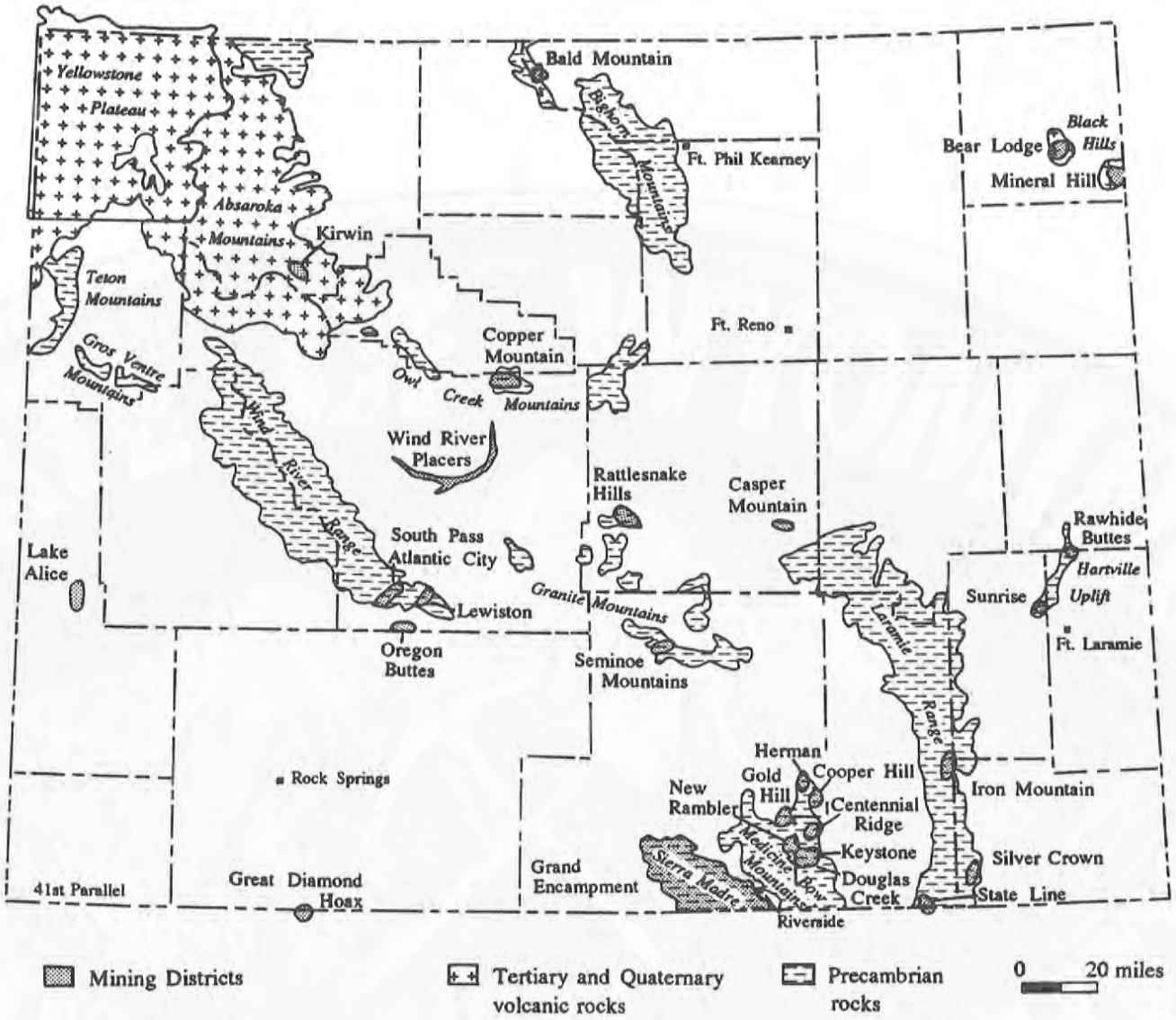

Figure 1. Historical mining districts of Wyoming.

and Big Laramie Rivers exiting from the Medicine Bow Mountains. A short time later, gold was discovered about 15 miles southeast of North Brush Creek Basin in the interior of the Medicine Bow range along what came to be known as Moores Gulch by Ira Moore. Soon the Last Chance gold camp was established at the present site of Rob Roy reservoir. Even earlier explorers in this region was evidence by the the words *"Antonia 1830"* carved in a tree trunk along Douglas Creek (Duncan, 1990).

Following the 1868 gold discovery, the Douglas Creek district (also known as the Foley district) was organized (Duncan, 1990). During the first year of heavy prospecting (1869) about 400 ounces of gold were recovered. The district continued to expand and by 1876, an elaborate system of ditches for hydraulic mining had been completed (Hausel, 1993a).

Commercial gold deposits were reported in several tributaries of Douglas Creek. One company reported digging a 15 by 48 by 7 foot test pit on Muddy Creek in which they recovered 9.75 ounces of gold including nuggets weighing 0.2 to 0.4 ounce. The company also dug 1,000 feet of bedrock flume, 4,500 feet of ditches, with 600 feet of fluming (EMJ, 1896, Nov. 28, v. 62, p. 519). The Engineering and Mining Journal (EMJ) (1895, July 27, v. 60, p. 87) reported a partial cleanup from nearby Spring Creek produced 50 ounces of gold. Much of the gold from Spring Creek was coarse with nuggets weighing from 0.05 to 1.0 ounce. The quartz was still attached to some of the nuggets.

Henry Beeler, State Geologist, visited the district in 1906. Beeler reported gravels with values ranging from 0.017 to 0.085 oz/yd^3 were being mined, and that the gold ranged from flour to coarse nuggets. Some nuggets had considerable quartz attached indicating a proximal source. As much as 25% of the gold was coarse and jagged with nuggets weighing 5 to 20 pennyweights (1 ounce = 20 pennyweights). One nugget found early in the history of the district weighed 3.4 ounces (Beeler, 1906). The gold ranged from 0.890 to 0.960 fine (1.000 fine = pure gold). Impurities included as much as 10% silver and traces of platinum.

The gravels were reported to range from 3 to 20 feet thick with an average thickness of 5 feet. Gold was sparsely distributed throughout the gravel, but was concentrated on bedrock. Estimated gravel resources for portions of the district were reported by Beeler (1906) as follows:

Placer name	Estimated yds^3 of gravel	Average oz/yd^3 Au	Estimated Au resource
Douglas Creek	3,020,160	0.024	72,485 oz
Daves Creek	70,000	—	—
Moores Gulch	60,000	>0.048	>2,880
Elk & Bear Creeks	250,000	—	—

Decades later (1935-1946), the Medicine Bow Mining Corporation operated a dragline with floating washing plants south of Keystone. In 1935, the Medicine Bow Mining Corporation processed 48,176 yds^3 of gravel recovering 286.84 ounces of gold and 34 ounces of silver (Hausel, 1989, p. 108). In 1958, the Moe Brothers used a similar dragline to mine gravels about 1.5 miles north of Keystone village. Total gold production from the district is not known, although Currey (1965) estimated 4,000 ounces was recovered.

Centennial Ridge district

Gold was later discovered along the eastern flank of the Medicine Bow Mountains in 1874. In early 1875, the first claim staked in this area was named the Centennial. A sample taken from the Centennial vein assayed 47 opt Au (Au = gold) (Duncan, 1990, p. 19). After the assay results became public, a rush followed. By 1876, the Centennial Ridge district was established (Strahorn, 1877).

The Centennial mine began development in 1875. A 10 stamp mill was ordered in the summer and by early fall, a 425 foot tramway was operating and transporting ore from the adit downslope to the mill (Duncan, 1990, p. 22). In 1876. A sample of specimen grade ore shipped to the Denver Mint was reported to assay 2,263.02 opt Au and 209.98 opt Ag! (Ag = silver) (Duncan, 1990, p. 23). Another sample of specimen grade ore won first prize at the 1878 Paris Mining Exposition a few years later (Dart, 1929). A sample of auriferous garnet schist from the mine is also reported to be part of the Smithsonian collection.

Work continued until the summer of 1877 when the mine workings cut into fault gouge and the vein was lost. The vein was offset at the fault and the extension of the vein could not be found. Mine operations terminated with total production of about 4,500 ounces.

The Centennial lode was a N45°E trending vein and shear in iron-stained, hornblende gneiss and schist (McCallum, 1968). Several other mines were operated in the district most notable were the Cliff and Utopia mines.

Keystone district

A few years after the discovery of gold in Centennial Ridge, the Keystone district was established. The Keystone lode was staked on October 31, 1876, by Fletcher Dunham (Duncan, 1990, p. 109). This new district was within the interior of the Medicine Bow Mountains and within the boundaries of the Douglas Creek district. The district included several lode mines along the banks of Douglas Creek (Hausel, 1989).

The principal lode, the Keystone, occurred as an ore shoot in quartz biotite schist at the northwestern end of a well defined shear zone. The shear was traced more than a mile to the southeast where it cut across the Keystone quartz diorite. At the southeastern end of the shear was a second ore shoot. This shoot was developed into the Florence mine.

In 1877, a five stamp mill was moved from the Centennial Ridge district to the Keystone mine (Duncan, 1990, p. 109). In 1878, a 10 stamp mill was constructed at the mine. By 1890, a 40 ton stamp mill was operating on the property (Figure 2).

EMJ (1890, Jan. 25, v. 49, p. 118) reported the Keystone mine had produced about 10,000 ounces of gold from ore that averaged 0.84 opt Au. Several months later, EMJ (1890, Nov. 22, v. 50, p. 607) reported that the Keystone produced only 3,750 ounces of gold up to 1889. In 1891, EMJ (1891, Apr. 18, v. 51, p. 480) reported the Otras Mining Company was recovering about 50 ounces of gold per week from the milling operations. The shaft continued to be sunk on the shear until it reached a depth of 365 feet with 5,000 feet of drifts. The ore was reported to average 1.2 opt Au (Currey, 1965).

In 1893, mining operations ceased with 6,000 tons of ore on the dump and another 100,000 tons of reserves identified underground (Currey, 1965). During field examination of this property in 1990, I found that ore samples were very rare on the dump indicating the ore stockpile had been beneficiated sometime after the mine closure. Total gold production from the mine is unknown, although Currey (1965) estimated production at 5,000 ounces. In the 1950s, the mill was dismantled and the shaft was sealed.

The Florence shaft was sunk in Keystone quartz diorite near the southeastern extent of the Keystone

Figure 2. Early Keystone mine, mill, and village (University of Wyoming American Heritage Center photograph).

shear. By 1878, 30 miners resided in the Florence camp. Ore from the Florence was reported to average 0.82 opt Au (EMJ, 1890, Jan. 25, v. 49, p. 118) and was processed in a 10 stamp mill. The ore consisted of low-grade mineralized rock with sporadic pockets of pyrrhotite. These pyrrhotite pockets were typically rich in gold. Some pockets were reported to carry 16 to 30 ounces of gold (Currey, 1965). Some of the best auriferous boxwork specimens that I've found in Wyoming were collected at the Florence mine. Samples collected by Loucks (1976) also confirm the presence of significant gold values. Total gold production from the mine was estimated by Currey (1965) at 2,500 ounces.

Herman district

About the same time that gold was discovered in the Keystone district, gold was found along the northern edge of the Medicine Bow Mountains near the present site of Arlington. In the early part of 1876, gold had been discovered in loose dirt of the old Overland Trail, about a mile west of Rock Creek. In May, 1877, ditches were constructed to supply water for hydraulic mining operations to this area known as the Emigrant Gulch placer, but according to the Wyoming Industrial Journal (WIJ)(1907, v. 9, no. 4, p. 4) and Strahorn (1877) the activity subsided within a few years.

Twenty years later in 1897, placer operations began again in the Rock Creek area. By June of 1897, the Overland Gold Mining Company (reported to hold about 11,000 acres of placer ground near Rock Creek) had constructed at least three miles of ditches with 800 feet of flume with iron riffles that led from Foote and Wagon Hound Creeks to Rock Creek. The placer gravel was 4 to 9 feet deep with widely dispersed and granular gold (EMJ, 1897, v. 63, June 5, p. 583). Hydraulic operations were also reported on Strawberry and Emigrant gulches (EMJ, 1897, Mar. 7, v. 63, p. 315).

Later in June, 1897, an additional 500 feet of flume had been added to accommodate the large quantity of gravel being mined at Rockdale (Arlington ?). Two giants (hydraulic monitors) were operating day and night washing 20,000 yds^3 of gravel in a 20 foot face in the east bank of Emigrant Gulch. The gravel reportedly averaged \$0.75/yd^3 (0.036 oz/yd^3) Au, and additional giants were planned (EMJ, 1897, v. 63, June 26, p. 673). Samples recently panned by the Wyoming Geological Survey on Rock Creek, Wagonhound Creek, Foote Creek, and Emigrant Gulch yielded anomalous gold (Hausel and others, 1992, 1993).

Some lode deposits were also developed in the region in the late 1800s. The Laramie Mining and Stock Exchange in 1896 reported considerable work was being done on Threemile Creek a few miles east of Rock Creek. The ore bodies were described as strong and well defined, carrying gold and silver, and hosted by granite.

Cooper Hill district

Placer gold may have been found in Cooper Creek, a few miles southeast of the Herman district, as early as 1854. In 1877, the King Survey of the 41st Parallel also reported rumors of gold in Cooper Creek, but no apparent verification was made. In 1893, claims were staked following the discovery of gossaniferous outcrops on Cooper Hill and lode mining soon began. Three years later (1896) several thousand acres of placer ground were staked along the North and South Forks of Cooper Creek and on the South Fork (East Fork ?) of Dutton Creek (EMJ, 1896, v. 62, July 4, p. 15).

Over the next few years, high-grade ore was mined and stockpiled on Cooper Hill in anticipation of construction of a mill and smelter. In 1896, EMJ (1896, v. 62, Nov 21, p. 495) reported that the Carbon County and Gold Coin Mining Company had contracted for a 10 stamp mill to be built with concentrating tables, a large boiler and engine, and a 5 ton jacket smelter. In the following year of 1897, the stamp mill was delivered and placed at the south end of Cooper Hill and 300 tons of the stockpiled ore from the Albion and Emma G mines were processed,

yielding an average of $17.50 per ton (Duncan, 1990). According to Duncan (1990), the smelter was not delivered, thus the base metals (lead and copper) and refractory precious metals could not have been recovered unless the ore had been shipped to a smelter.

In 1906, Henry Beeler, Wyoming State Geologist, visited the Cooper Hill district. His report noted that the Emma G mine produced the richest float in the district, the Albion mine produced the greatest body of gold and galena, the Richmond mine produced the greatest amount of free milling gold, and the Cooper Hill mine produced the greatest amount of copper in the district (Beeler, 1906). Beeler also mentioned some ore (undoubtedly some selected specimen grade material) assayed as high as $84,000 per ton.

Activity in the district subsided after a few years. Unfortunately, the veins on Cooper Hill were typically narrow and of limited extent with little possibility of extending minable reserves at depth. Cooper Hill is interpreted as a allochtonous block of layered Proterozoic metasedimentary and metaigneous rock thrust over unmineralized Cretaceous sedimentary rock (Blackstone, 1973). The mineral deposits in the district include veins, breccia veins, replacement veins, and skarns (Hausel, 1992). Minor amounts of gold, silver, copper, and lead were recovered from the district.

Gold Hill district

In 1889, narrow, rich, quartz veins were discovered west of the Snowy Range between Douglas Creek and the North Brush Creek Basin. The first mining claim was staked in what was originally called the Brush Creek camp. Soon the camp became known as the Gold Hill district. Some spectacular specimens reportedly came from this area. For instance, a sample from the Acme mine yielded specimen grade material that assayed 2,100 opt Au!

Plans were made to extend a spur of the railroad to the district. By 1891 a 10 stamp mill was under construction to process ore from the Leviathan, Little Giant, and Wyoming mines (initial tests showed the ore to average 1.5 opt Au). A 20 stamp mill was being arranged for the Niagara claim (EMJ, 1891, Oct. 31, v. 52, p. 514). Unfortunately, the veins were narrow and the gold was localized in pods in the quartz. At $20.67 per ounce, it ore was not feasible to mine.

LaPlata district

The LaPlata district was developed as a small group of copper, silver, and gold prospects and mines immediately east of Gold Hill in the Snowy Range - none of which yielded much ore. EMJ (1891, Oct. 17, v. 52, p. 463) reported 1,000 pounds of ore from the Big Strike prospect in the district was shipped to Denver and yielded 40% Pb (lead), 31.7 opt Ag, and 0.9 opt Au. Other properties included Telephone, North American, Brooklyn, Red Bird, and Gray Copper.

The LaPlata district lies at the top of the Snowy Range underlain by metacarbonates and quartzites. Many of the mines and prospect pits in the district were developed on shears with traces of silver and copper. The known mineral deposits are typically weakly mineralized with the possible exception of the Billie Class gold deposit. The Billie Class deposit lies along the northern flank of Lewis Lake. Remains of a 3 stamp mill are found adjacent to an impressive gossaniferous shear zone 100 to 200 feet wide with strike length of 2,000 feet. Samples taken in the shear yielded 0.063 ppm to 4.8 ppm Au, and 16 ppm Ga (gallium) (Dersch, 1991; Wyoming Geo-notes, 1991, no. 30, p. 49).

New Rambler district

The New Rambler deposit was discovered a short distance west of Douglas Creek near Ira Moore's initial discovery site. Mine operations began and the town of Holmes was established about 1893 (Figure 3). From 1900 to 1918 the New Rambler produced at least 6,100 tons of copper ore with credits in Au, Ag, Pt (platinum), and Pd (palladium) (McCallum and Orback, 1968). Contained metals in this ore was reported by various sources to include 1,750,000 lbs of Cu, 170 oz Au, 7,350 oz Ag, 16,870 oz Pd, and 910 oz Pt (Hausel, 1989).

The New Rambler district lies along the northeastern edge of the Mullen Creek layered mafic complex which is a 60 mi^2, highly deformed, 1.8 Ga (billion years old), tholeiitic intrusive. The complex includes 21 cyclic units (Loucks and others, 1988).

Lake Owen Complex

The Lake Owen complex to the south of the Keystone and New Rambler districts never received much interest until recently. In the early 1980s, several companies explored the complex for platinum group metals and gold due to the similarities of the complex to the Stillwater complex (Hausel, 1993b).

The Lake Owen complex is a relatively small layered mafic intrusive covering a surface area of about 20 to 25 mi^2. Historically, this region was ignored, although there are sporadic prospect pits scattered around the intrusive, principally on cumulate magnetite occurrences. Like the Mullen Creek layered complex, this intrusive is approximately 1.8 Ga. But unlike the Mullen Creek layered complex it is not intensely deformed, but is essentially undeformed.

At least 16 cyclic units have been mapped in the complex and cumulus sulfides have been identified in 12 stratigraphic horizons that yield zones of elevated gold, platinum, and palladium. Four of the horizons have laterally persistent precious metal anomalies of a few hundred to a few thousand parts per billion,

Figure 3. New Rambler mine, about 1902 (University of Wyoming American Heritage Center photograph).

and are as much as 15 feet thick with strike lengths of more than a mile (Loucks, 1991). Potentially commercial deposits of vanadiferous titanomagnetite cumulates are persistent in gabbronorite near the tops of some cyclic units (Loucks, 1991).

Jelm Mountain district

In the 1870s, copper and gold were discovered in the hills near the Laramie River in what became known as the Jelm Mountain district. The district however, gained much reputation through various mining scams (Duncan, 1990). Production was minimal.

SOUTH PASS

Records suggest gold may have been found in the South Pass region near the southern tip of the Wind River Mountains as early as 1842 by a trapper from the American Fur Company. According to Hale (1883), the discovery was along Strawberry Creek probably in the area presently known as the Lewiston district. Conflicting reports suggest the discoverer was killed by Indians during his return to Georgia, or that he was part of a later group of 40 prospectors that entered the South Pass region in 1855 and searched the Sweetwater River finding gold everywhere in the river and in many of its tributaries.

This group of prospectors travelled to Fort Laramie during the winter and was arrested for some unknown reason. Three years later, in 1858, one member of the group returned to the South Pass region, and in 1860 he and eight others commenced mining along Strawberry Creek. The decayed remains of their sluice boxes were found in 1870 (Anonymous, 1870). In the fall of 1861, another group of prospectors was reported mining placer gold on Willow Creek. However, these 52 prospectors were attacked by Shoshone Indians and driven out (Anonymous, 1870).

In 1863, placer gold was discovered in the vicinity of Oregon Buttes along the Overland Trail a few miles south of Willow Creek. Greene (1896) reported the discovery was rich enough to attract a "colony of prospectors". These prospectors worked the placers for three months before being attacked and killed by Indians. Because of the increased Indian hostilities, the Overland Trail was abandoned for a safer route farther to the south (Greene, 1896).

In 1866, another group of prospectors entered the South Pass region, and in the following summer on June 8, 1867, lode gold was discovered along Willow Creek 6 to 8 miles north of the Oregon Buttes placers. The lode was named the Carissa (also spelled Cariso). The American Journal of Mining (AJM) (1867, v. 4, Dec. 14, p. 373) attributed the discovery to Martin Keplinger. However, a later issue (AJM, 1868, v. 5, Feb. 22, p. 16), and several other references credited the discovery to Henry S. Redell (spelled Reedall in most references). Reedall and his partners worked the Carissa lode and were soon attacked by Indians. Three prospectors were killed and the remaining men fled, but returned again on July 28 (Anonymous, 1870).

During the ensuing winter, the handful of prospectors worked the lode with primitive hand tools and mortars and recovered more than 400 ounces of gold. An additional four tons of ore were hauled to Springville, Utah which yielded $28,000 in gold (about 1,400 ounces) (AJM, 1868, v. 5, Feb. 22, p. 16). And the development of the district seemed to be imminent following the pronouncement by Brigham Young from Salt Lake City of the richness of the gold deposits along Strawberry Gulch. The AJM (1867, Aug. 10, vol. 4, p. 83) stated,*"On Sunday last, Brigham Young in the course of his discourse is said to have declared his belief in their richness, and of all men who have not been there he is the most competent to pronounce an opinion on the matter"*. The news of the discovery spread and hundreds of people rushed to the region.

The district surrounding the Carissa was initially named the Shoshone district. To the northeast, the area surrounding Rock Creek was called the California district (AJM, 1867, v. 4, Nov. 23, p. 324). Four towns sprang from nothing in 1868. South Pass City in the Shoshone district grew to a population of 2,000 and was selected as the county seat of Carter County of the Dakota Territory, although the Kemmerer Gazette (August 11, 1933) later reported the population of South Pass City had actually been around 5,000. Some other reports inflated this number to 10,000.

Hamilton City (Miners Delight) and Atlantic City in the California district were reported to have populations of 1,500 (Kemmerer Gazette, 1933, Aug. 11) and 500 (AJM, 1868, v.5, Feb. 22, p. 117),

respectively. Pacific City in the Pacific district to the south had a population of 600 (AJM, 1868, v.5, Feb. 22, p. 117). Another district organized in 1868 was known as the Kentucky Gold and Silver Mining district (AJM, 1868, March 21, v. 5 , p. 181) near the present site of the Atlantic City iron mine. In 1869 the AJM (1869, Jan. 2, v.7, p. 4) reported South Pass City included about 100 houses, three stores, and a brewery; and Atlantic City and Hamilton each had about 75 houses and numerous tents. The variations in population statistics was undoubtedly due to the constant influx and turn over of prospectors in the area.

By July 1869, several arrastras and three mills with a total of 26 stamps were operating in the region. In 1870, 10 mills were operating with a total of 126 stamps (Raymond, 1873). In 1871, 12 stamp mills were operating in the South Pass region with a total of 121 stamps, and in 1872, 12 stamp mills with a total of 161 stamps were crushing ore. The Caribou mine near Atlantic City was producing ore averaging 0.5 to 1.5 opt Au. A short distance to the west, the Buckeye (Garfield) shaft had been in continual operation since 1868 (Raymond, 1873). At the bottom of the shaft, the vein was 10 feet wide and yielded ore that averaged $9 per ton (0.4 opt): milling and mining costs averaged $6 per ton. By 1870, the mine was producing 2,500 ounces annually.

Ore processed in the Miners Delight mill was estimated to average 1.0 opt Au. The western extension of the Miners Delight lode known as the Hartley mine processed 30 tons of ore in a new 20 stamp mill which yielded an average of 1.5 opt Au. The eastern extension of the Miners Delight also operated a 20 stamp mill and processed ore reported to yield 0.4 to 0.75 opt Au. The nearby placers employed about 100 miners (Raymond, 1873).

From 1872 to 1875, interest in the South Pass region began to decline until the district was nearly deserted. After 1875, the region showed several moderate resurges followed by hiatuses. The reason for the decline in interest in South Pass is probably complex since none of the mines were ever mined out. In fact recent studies indicate lode gold mineralization in the region is relatively widespread (Hausel, 1991).

Many factors affected the progress of the camps. Most notable was the continued hostilities between the miners and Indians. Few prospectors dared to stray far from the established gold camps and prospecting generally required a large group of associates. The AJM (1867, Oct 26, v. 4, p. 261) reported, *"...the Indians were so bad that we were compelled to prospect in large parties"*. Typically, many persons in the prospecting parties were required to stand guard while the rest of the partners dug for gold. In an early report following several Indian raids, it was stated by Raymond (1873),*"Miners cannot work and at the same time watch and fight Indians"* . By 1870, the U.S. Army had established Camp Stambaugh along Smith Gulch between Atlantic City and Hamilton City. Eight years later, in 1878, the army abandoned Camp Stambaugh, but continued to patrol South Pass.

The camps of South Pass had many other problems. The gold mills were poorly designed. EMJ (1870, Mar. 8, v. 9, p. 149) reported, *"Our quartz mills have been another great drawback. Many of them were bought by inexperienced men; the mills being old and useless... frequently failing to save a color of gold when the same rock crushed in an arrastra would yield forty dollars to the ton.... most of the rich ledges are owned by poor men..."* Another problem reported by EMJ was the abundant scam artists in the district, *"...certain men have gone East and sold ledges that had no value."*

Water was another problem. Many lode mines were developed in highly permeable shear zones that provided good access for water; in some cases the workings were flooded just a few feet below the surface. Just the opposite was true for many of the placer mines where many gulches could only be worked in the spring when runoff was plentiful. But in one case, the water problem of one operation turned out to be a blessing for another. In Spring Gulch below the Miners Delight shaft, placer miners used the water pumped from the shaft to work their claims. Several one and two ounce nuggets were taken from these gravels including one 6 ounce nugget. One lump of quartz as large as a water bucket was found filled with gold. According to Raymond (1873) it looked as if it could contain a pound of gold.

The gulches were reported to be every bit as rich as the famous Dutch Flat diggings in California, although the potential volume of South Pass auriferous gravels was comparatively miniscule. Nearly every gulch in the district yielded gold. Some gulches were extremely rich and gold fever struck thousands of miners looking for bonanzas. These people with their wild expectations soon drifted away because the rich placers soon played out (Strahorn, 1877), or were too small to accommodate but a few miners.

Still successes were reported. The AJM (1868, v.6, Aug. 8, p. 84) reported one company shipped $20,000 in gold dust in one week (~2,000 ounces). On March 22, 1869, W.C. Erwin arrived in Cheyenne from South Pass with 65 pounds of gold dust (Strahorn, 1877). The Wilson Company on Yankee Gulch near Miners Delight was taking out 8 to 15 ounces of gold per day including one nugget that weighed a little less than 5 ounces (AJM, 1868, Sept. 19, v. 6, p. 180).

Some impressive pieces of gold were also found in Rock Creek. One fist-size piece of quartz was filled with an estimated 24 ounces of gold. A boulder

found nearby contained an estimated 630 ounces of gold (WIJ, 1905, v. 6, no. 12, p. 18). Other nuggets (3 and 4.5 ounces) were recovered from Two Johns Gulch somewhere near Strawberry Gulch (Hausel, 1989, p. 164).

Several years later, in 1884, a French Company managed by Emile Granier obtained large blocks of claims on Willow, Rock, and Strawberry Creeks. To resolve the water shortage problems, the company planned a major undertaking to transport water for hydraulic mining to the South Pass area from Christina Lake more than 12 miles away. Ditches and flumes were built. The ditch on Rock Creek alone was nearly 7 miles long. The Christina Lake ditch was to be extended to a total of 5 miles. Some flumes built across valleys were 70 feet high with lengths up to 500 feet. Plans were made for an 1888 start up, but it appears the operation was delayed until 1890.

EMJ (1893, Jan. 28, v. 55, p. 87) reported gold production from the first year's (1890) operation of the Christina Lake placers amounted to about 1,500 ounces. In the following year, gold production from the placers amounted to more than 6,720 ounces (EMJ, 1891, Oct. 10, v. 52, p. 436), but it appeared the Christina Lake operation had been a failure. In 1895, the EMJ (1895, Oct. 12, v. 60, p. 355) reported more than $900,000 had been spent to put the Christina Lake placers in operation, and by 1895, the property had been leased to the Rock Springs Placer Company. The gold production from 1890 and 1891 was worth only about $170,000. Unless there had been significant production from 1892 to 1895, the operation would have been a financial failure.

Two lode mines that continued to attract attention were the Carissa and the Miners Delight. The Carissa was developed on a narrow shear ranging from 1 to 50 feet wide enclosed by an envelope of 100 to 200 feet of highly fractured and rehealed wallrock (Hausel, 1991). The fractured wallrock carried low-grade gold values too low to mine at $20.67 per ounce.

Some of the ore from the Carissa mine was refractory. Anthony (1872) reported large quantities of pyritiferous rock dumped on the tailings was assumed to be valueless by the miners. Analysis of some of this waste rock yielded 3.5 opt Au. The sulfides were then run through the stamps and amalgamators and only 0.75 opt Au was recovered, the rest reported to the tailings. There were no facilities to roast and smelt the sulfides to save the refractory gold.

From 1902 to 1906, the Federal Gold Mining Company extended the mine workings to five levels. In 1947, the mine was equipped with a 70 ton amalgamation-cyanide mill, and was later operated in 1954 by the Pioneer Carissa Gold Mines. In the 1970s, Anaconda Mining Company optioned the property, but the property was dropped in the 1980s following bankruptcy of the mining giant.

The Miners Delight mine several miles to the east, began operations in 1868. On February 15, 1869, gold shipped to the Denver Mint from a weeks run of the Miners Delight mill totaled 157 pounds and 3 ounces of gold bullion (AJM, April 17, 1869, v. 7, p. 245). The mine operated from 1868 to 1874 and idled until 1880. Operations began again from 1880 to 1882. In 1887, Warren (1887) reported the Miners Delight mine was sitting idle principally because of the high cost of living in Wyoming. EMJ (1891, Jan, 10, v. 51, p. 74) reported a new 10 stamp mill was constructed at Miners Delight in 1891.

Lewiston district

The region known as the Lewiston district, 12 miles southeast of Atlantic City, began to receive some interest in the 1870s. The date when the district was established is unclear. Weis (1974) reported Lewiston was founded in 1879. Pfaff (1978) noted that Martin Lewis discovered placer gold on Strawberry Creek in 1875, which led to the establishment of Lewis Town (later known as Lewiston).

Gold was found south of Strawberry Creek at Wilson Bar in 1878. According to early reports, some pockets in this placer were extremely rich. The Wilson Bar placer lies at the mouth of Burr Gulch where it intersects the Sweetwater River. Gold from Wilson Bar was traced upstream to the Burr lode, which may have been found as late as 1886 (*The Lewiston Gold Miner*, v. 1, no. 1, 1894). In 1893, EMJ (1893, Oct. 14, v. 56, p. 406) reported a pocket of ore had been intersected at the Burr mine that yielded 3,000 ounces of gold. The lode was reported to be 7 to 10 feet thick and to average 2.0 to 3.5 opt Au.

The Hidden Hand lode north of the Burr was probably discovered shortly after the Burr. Miners at the Hidden Hand in the 1930s intersected a rich shoot that produced several sacks of specimen-grade ore with 75 to 1,650 ounces of gold per ton (Pfaff, 1978) and a few rare specimens that reportedly contained 10% Au (3,100 opt)!

During the Great Depression, people turned to mining make a living. In 1932, it was reported that more people were panning gold in the South Pass region than had been for many years. From 1933 and 1941, the E.T. Fisher Company dredged 6 miles of Rock Creek using a dragline and two-story washing plant (Ross and Gardner, 1935). This operation was continuous until the United States entered World War II. A minimum of 11,500 ounces of gold (possibly as much as 30,000 ounces) including nuggets up to 3.4 ounces were recovered (Hausel, 1991).

After the Second World War, only minor amounts of gold were mined as the main focus shifted from gold to iron. Serious exploration of banded iron formation began in 1954, north of Atlantic City. In August 1962, U.S. Steel Corporation shipped the first

iron pellets from the Atlantic City open pit to Geneva, Utah (Bayley, 1968). From 1962 until operations ceased in 1983, more than 90,000,000 tons of iron ore were mined.

Gold mining activities were minimal during much of this time. But when Congress eliminated the gold standard in 1969, gold prices were free to rise; by early 1980, gold prices were the highest in history and they continued to rise stimulating exploration in the district. A few small placer mines began production, but by the early to mid 1980s, the worldwide recession crippled the U.S. mining industry as well as interest in South Pass. In 1986, interest in South Pass picked up again with nearly a dozen companies exploring for gold, but this was soon attenuated by the 1987 stock market panic.

Total gold production from the South Pass region is unknown and few statistics were ever recorded. EMJ (1893, Jan. 28, v. 55, p. 87) reported gold production from the district totalled from 600,000 to 700,000 ounces. The U.S. Geological Survey later estimated production for the region probably amounted to only about 70,000 ounces (Koschmann and Bergendahl, 1968). Later work in the district produced a figure of 348,000 ounces based on production statistics and historic estimates (Hausel, 1991).

Very generally, the South Pass area is interpreted as a greenstone belt floored by ultramafic and mafic metaigneous rocks that include primitive, alkali-poor, ultramafic lavas and subvolcanics and tholeiitic lavas and sills. This lower unit is overlain by a thin metasedimentary-metavolcanic unit of metatholeiite, metapelite, quartzite, and banded iron formation, which is overlain by a relatively thick metatholeiite unit. The youngest supracrustal unit includes ultramafic, tholeiitic, and calc-alkaline metaigneous rocks capped by a fining-upward metasedimentary sequence. These rocks are intruded by granite, granodiorite, and tonalite, and are intercalated with augen gneiss (gneiss complex) along the northern margin of the belt (Hausel, 1991).

Today, we recognize two mining districts at South Pass: the South Pass-Atlantic City district along the northwestern flank of the South Pass synclinorium, and the Lewiston district along the southeastern flank. Auriferous paleoplacers eroded from the greenstone belt occur in Tertiary conglomerates and fanglomerates in the Oregon Buttes area south of the greenstone belt and in the McGraw Flats area northeast of the greenstone belt. Paleoplacers are also present within the greenstone terrane.

DIAMONDS

The Great Diamond Hoax

In 1870, the diamond fields of South Africa had eclipsed diamond production from India and Brazil. But no commercial diamond source had yet been found in North America. One enterprising prospector, Philip Arnold, decided to correct this problem. Arnold had been employed by the Diamond Drill Company of San Francisco from 1869 to 1871 (which manufactured diamond pointed rock drills) and attempted to learn as much as possible about diamonds from his employer. In 1871, Arnold left the company to prospect with an old friend John Slack, and returned with a handful of diamonds, sapphires, and rubies that he claimed he had found in Arizona. Actually, Arnold had journeyed to London where he had purchased $12,000 worth of gems (Liebling, 1940). Arnold realized that the time was ripe for a swindle: information on the host rock for diamond was virtually nonexistent and essentially no one knew anything about uncut diamonds and their mineral associations in North America.

To finance their scam, Arnold and Slack took their gems to some prominent businessmen in San Francisco. At this time in history, North American jewelers were inexperienced in uncut gemstones. The lack in experience showed when the $12,000 worth of gems had been appraised by the San Franciscan jewelers at $100,000. These jewels were later appraised at Tiffany's of New York at a value of $150,000 (Liebling, 1940). The financiers gave the prospectors $200,000 towards the final purchasing price of $650,000 for the diamond fields. Arnold and Slack immediately went prospecting in London where they purchased another $50,000 in uncut gems.

After their shopping spree, they returned to North America to plant the salt. They selected an inconspicuous ferruginous sandstone outcrop 50 miles south of Rock Springs near the 41st Parallel. The actual site was two miles south of the Wyoming border in Colorado near what is now known as Diamond Field Draw in Moffat County, and 180 miles due west of what today is known as the State Line diamond district. Over the next few months, Arnold guided representatives of the investors including a professional mining engineer by the name of Janin to the deposit. These people were blind-folded throughout much of the journey, and after digging several gems from the salted outcrop, they were all convinced of the validity of the discovery.

The deposit was salted with ruby, sapphire, pyrope garnet, emerald (possibly chromian diopside), and diamond. The site was so well salted with gemstones that about 5 years ago, I was able to still pan 17 rubies, 24 pyrope garnets, and 4 diamonds from the site in one afternoon. The occurrence of pyrope garnet in the salt was an unbelievable coincidence in that this is a heavy mineral commonly associated with diamonds; a fact that was unknown to Arnold and Slack in 1871. The garnets (and possibly chromian diopside) were apparently acquired in

northern Arizona as rubies and emeralds (Lowell Hilpert, pers. comm., 1986).

The diamond deposit received so much attention between 1871 and 1872, that Congressman Ben Butler, a stockholder in the diamond property, engineered an amendment through Congress known as the Placer Mining Act designed to protect his investment in the diamond lands (Liebling, 1940). At this time in history, Clarence King and his staff had been surveying the 41st Parallel. Two members of the Survey ran into Janin and others after a return trip from the diamond fields. Emmons and Gardner of the King Survey began questioning Janin and his associates about the geography in the vicinity of the diamond deposit. Based on this information, they were able to determined its location within 15 square miles.

In late October of 1872 accompanied by Clarence King, they searched the suspected area and discovered several claim notices and the diamond site. After searching for a considerable time, it was realized that the only place diamonds and rubies could be found was where the ground had been disturbed. Digging a 10 foot deep trench, they also discovered that the precious stones did not continue below the surface. The property was shortly exposed as a salt (Emmons, 1872).

State Line diamond district

The affects of this swindle may have delayed the discovery of diamonds 180 miles to the east along the 41st Parallel. For nobody in their right mind would have believed diamonds could have been found anywhere in this region for many decades. However, more than 100 years later, diamonds were actually discovered *in situ* in Wyoming and Colorado. This event began in 1960 and 1961 when two unusual oval-shaped 'outliers' of Cambrian, Ordovician, and Silurian limestone were discovered south of Tie Siding in southeastern Wyoming a few miles north of the Colorado-Wyoming border (Chronic and Ferris, 1963). The structures were highly enigmatic, in that they were only about 250 feet across, completely surrounded by 1.4 Ga Sherman Granite, and no similar outcrops of Silurian and Ordovician rock were known within many miles of this locality. For instance, the closest outcrop of Silurian age rock is more than 300 miles from the State Line district.

A few years later, in 1964, the origin of these outliers was solved. A similar outlier was discovered in Colorado by Professor M. E. McCallum at Colorado State University. Not only did the outlier contain Silurian and Ordovician sediments, but it also contained outcrops of kimberlite.

Research on the kimberlites continued for several years. Then in 1975, a serpentinized garnet peridotite nodule collected from a Wyoming kimberlite by Dr. McCallum scratched a carborundum grinding wheel during thin section preparation at the U.S. Geological Survey lab in Denver (carborundum has a hardness of 9.5 compared to 10 for diamond). Suspecting the presence of diamond, the nodule was dissolved in hydrofluoric acid and several microdiamonds were recovered (McCallum and Mabarak, 1976).

For the next few years, this diamond occurrence remained an interesting geologic phenomenon. However, in 1977, Dr. Dan Miller, Jr., State Geologist for the Wyoming Geological Survey, recognized that the diamond deposits had potential commercial possibilities and worked with the State Land Commissoner's office and Rocky Mountain Energy Company (Union Pacific) to attract mining companies to test the deposits. In 1979, Cominco America Incorporated was granted a permit to explore for diamonds on State and Union Pacific land in the State Line district of Wyoming. Within a short time, exploration was also initiated by Superior Minerals Company in Colorado.

Diamond recovery plants were constructed by Cominco American in Ft. Collins, Colorado, and by Superior Minerals in the Prairie Divide area, Colorado. Testing by Cominco American, Superior Minerals, and later by Mobile, and Lac Minerals yielded grades from 0.005 to 1.351 carats per ton (South African pipes typically average about 0.1 carat per ton) (McCallum and Waldman, 1991). In total, more than 100,000 gem and industrial diamonds were recovered from the Colorado-Wyoming State Line district. But the diamonds are small: the largest stone found to date is only 2.6 carats in weight (McCallum and Waldman, 1991; McCallum, 1991).

Several companies explored the district for diamonds. These companies have included Cominco American Inc., Superior Minerals, Lac Minerals, Mobil, Diamond Company, N.L., and Ashton. Dia Met purchased the Prairie Divide diamond recovery plant, the Cominco plant in Ft. Collins was dismantled. In 1992, Diamond Company N.L. permitted a diamond recovery plant in Wyoming south of Tie Siding (Howard Coopersmith, pers. comm., 1992).

To date, only kimberlite in the State Line district has yielded diamonds. Another kimberlite district to the north of the State Line district in Wyoming known as the Iron Mountain district was explored by Cominco American Incorporated in the early 1980s. However, the mineral chemistry of kimberlite from Iron Mountain suggests low probability of diamond preservation (McCallum and Waldman, 1991).

Elsewhere, Superior Minerals, Cominco American, and Lime Creek conducted reconnaissance surveys of the Cortez Creek area in the northern Medicine Bow Mountains where a prospector found two diamonds in 1977. In the Green River Basin, an area several miles northwest of the diamond hoax was discovered that contained anthills with pyrope

garnet and chromian diopside (McCandless, 1984). This area was explored by several companies including Superior Minerals and AMSELCO in the mid 1980s. Rumors of diatremes in this region have never been verified.

To the north of Rock Springs, a large lamproite field known as the Leucite Hills contains several 1.0 million year old lamproitic volcanoes similar to the diamondiferous lamproites in the Kimberley region of Western Australia (Carmichael, 1967). This area has only received minor attention. Limited testing of the lamproites by at least two companies and the Wyoming Geological Survey have not produced any diamonds.

GRAND ENCAMPMENT DISTRICT

In 1874, rich copper deposits were discovered in the Sierra Madre of southeastern Wyoming which led to the development of a cupriferous gossan on the western flank of the range. The gossan was developed into the Doane-Rambler mine (Figure 4).

The development of the mine was relatively slow due to the harsh environment: the copper ore was loaded in wagons, transported across the Sierra Madre on a narrow and rocky trail cut through the forest, and loaded at Walcott Junction more than 50 miles away to be shipped to smelters in the East. Development was understandably slow, but the arduous task was lessened by the rich ore.

In 1897, Ed Haggarty found another cupriferous gossan in quartzite along a creek later to bear his name. This deposit was even more impressive than the Doane-Rambler. In the following year, a shaft was sunk on the gossan and intersected massive copper at a depth of 30 feet. The ore was hauled by wagon to the nearest Union Pacific rail junction and shipped to the Copper Refining smelter at Chicago. The first 14 ton shipment averaged 33.18% Cu! This led to the development of the greatest copper mine in Wyoming. According to Houston (1992), this was also one of the most important copper mines in the West at this time in history (Figure 5).

Figure 4. Historical Doane-Rambler mine in 1904 (University of Wyoming American Heritage Center photograph).

EMJ (1899, Feb. 4, v. 67, p. 155) reported ore from the Ferris-Haggarty was mixed chalcocite and bornite, and shipments often yielded more than 35% Cu. In 1899, the Ferris-Haggarty was shipping 40 tons of ore daily (EMJ, 1899, Aug. 12, v. 68, p. 199). By 1900, the Ferris-Haggarty mine was averaging about 550,000 pounds of copper per month (EMJ, 1900, May. 12, v. 69, p. 570).

A mill and smelter were constructed at Riverside in 1902, adjacent to Encampment along the eastern flank of the Sierra Madre (Figure 6). But to get the ore to the smelter complex, a major engineering feat had to be accomplished. This involved the construction of a more than 16-mile-long tramway from Riverside at an elevation of less than 7,200 feet across the eastern flank of the Sierra Madre and over the Continental Divide at more than 10,600 feet above sea level, and down the western slope to the Ferris-Haggarty mine at an elevation of about 9,700 feet (Figure 7).

The Boston-Wyoming smelter at Riverside operated from 1902 to 1907. But in 1908, mine operations terminated following a series of financial disasters. The mill was partially destroyed by fire in 1906 followed by destruction of the smelter in the following year. The final nail in the coffin occurred in 1908 when copper prices dropped 35% (Hausel, 1993b). Production records indicate more than 21,000,0000 pounds of copper were mined in the Encampment district with credits in gold and silver - most of which was produced by the Ferris-Haggarty (Hausel, 1989).

The geology of the Sierra Madre is favorable for significant mineral deposits (Houston, 1992). The northern Sierra Madre is formed by a thick clastic wedge of Early Proterozoic (2.5 to 1.8 Ga) miogeoclinal metasedimentary rock including quartzite, metaconglomerate, metalimestone, metadolomite, and phyllite with lesser metavolcanics. The southern Sierra Madre is underlain by late Early Proterozoic (1.9 to 1.6 Ga) eugeoclinal metavolcanics, volcaniclastics, and gneisses. These two distinct geologic terranes are separated by cataclastics and mylonites forming a major tectonic east-west trending suture known as the Cheyenne Belt (locally known as the Mullen Creek-Nash Fork shear zone). There are numerous historic mines in the district, although some of the more interesting deposits include the

Figure 5. Historical Ferris-Haggarty mine, about 1904 (University of Wyoming American Heritage Center photograph).

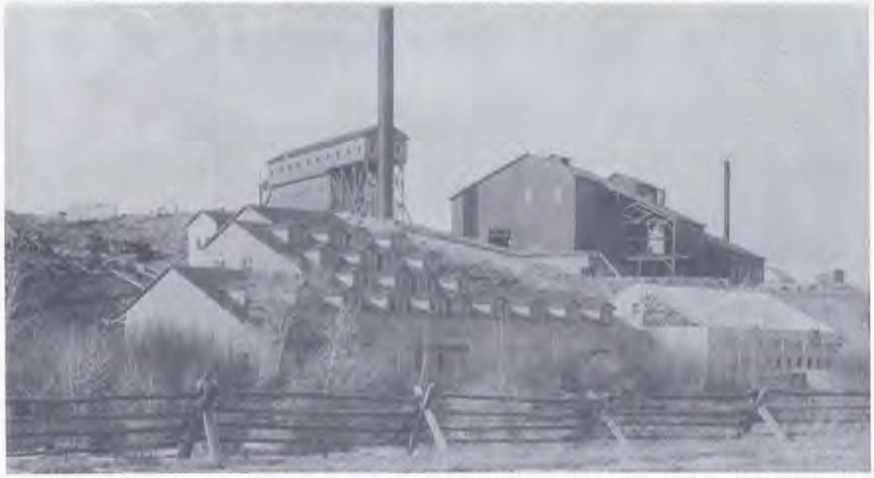

Figure 6. Boston-Wyoming mill and smelter at Riverside about 1905 (University of Wyoming American Heritage Center photograph).

Figure 7. Ferris-Haggarty tramway power station no. 3 (about 1905) (University of Wyoming American Heritage Center photograph).

Ferris-Haggarty, Broadway, and Kurtz-Chatterton mines.

Ferris-Haggarty mine: The Ferris Haggarty mine is located in Magnolia Formation quartzite of the Deep Lake Group in the Proterozoic miogeoclinal terrane north of the Cheyenne Belt. Mineralization near the surface occurs in a steeply dipping quartzite breccia capped by schist. The ore occurs as massive chalcocite and bornite with lesser chalcopyrite filling quartzite breccia along the contact of the quartzite with a hanging wall schist. Ore shoots greater than 20 feet thick were selectively mined and the lower grade material was left in place. Some of the high grade ore yielded as much as 30 to 40% Cu. Large blocks of low grade ore (average 5% Cu) were left unmined (Ralph Platt, pers. comm.). The ore was followed downdip for 400 feet.

Broadway mine: The Broadway mine along the eastern flank of the southern Sierra Madre has had a long period of exploration activity. The property was initially staked by Bill Sodder in 1904 who sunk a 20 foot deep shaft in search of gold. In 1942, the U.S. Bureau of Mines examined the property and five character samples and one channel sample were collected. The assay results showed 0.02% Cu, none to 12.5% Zn, and 0.5 to 1.9% Pb (Osterwald, 1947).

Frank Osterwald with the Wyoming Geological Survey examined the Broadway mine in 1947, and reported the property had been previously explored by geologists with New Jersey Zinc. The ore zone according to Osterwald (1947) was at least 1,000 feet long and 50 feet wide and continued under a heavily wooded area. The ore mineralogy included massive sphalerite, minor galena, with local disseminated chalcopyrite, chalcocite, and covellite, with minor secondary malachite and chrysocolla. The ore content was described to range from 3 to 35% throughout the property.

The ore was localized along the granite contact with a complex of gneiss, amphibolite, gabbro, diorite, and granite pegmatite. The gneiss and amphibolite were fractured and recrystallized near the contact, and ore was found replacing the amphibolite where shearing occurred (Osterwald, 1947). Analyses of grab

samples reported by Forrest Root of the Wyoming Geological Survey showed 0.003 to 0.82% Cu, 0.52 to 1.2% Pb, 0.03 to 6.9% Zn, 0.11 to 9.1 opt Ag, and 0.1 to 0.5 ppm Au.

Bunker Hill Mining Company explored the property in 1966 and 1967. Nine shallow drill holes totaling 850 feet were completed, two of which intersected significant mineralization. The best drill intercept encountered 20.5 feet of 8% Zn. Based on limited data, ore in a 150 x 8 foot area to a depth of 100 feet was estimated to total 12,000 tons of 10% Zn.

Petrographic work by DeNault (1967) identified the host rock as pyroxenite (rather than amphibolite) and to consist of diopside with minor enstatite replaced entirely or partially by spessartine. One sample contained 35% olivine.

In 1976, AMSELCO examined the property and completed Zn, Pb, and Cu soil geochem surveys over a relatively large area. The surveys identified a 3,000 foot long copper soil geochem anomaly, a 2,200 foot long, 100 to 1,000 foot wide zinc anomaly, and a 1,500 foot long lead anomaly. The mineralization was described as a massive zinc, lead, and copper sulfide associated with a lens of tightly folded pyroxene-garnet rock. The pyroxenite was traced for nearly 1,400 feet on the surface.

On June 3rd, 1992, I briefly examined the property and collected a suite of samples. The specimens included banded massive sphalerite with lesser galena in a matrix of tremolite-actinolite and spessartine, and granodiorite with disseminated chalcopyrite and chalcocite. The host rock of the massive sulfide is a pyroxene-spessartine (?) hornfels typical of skarn. Five samples yielded 0.02 to 8.17% Zn, 0.30 to 5.66% Pb, 0.05 to 1.82% Cu, 0.1 to 3.28 ppm Au, 0.2 to 12.18 opt Ag, no detectable platinum, and only a trace (2 ppb) palladium.

Kurtz-Chatterton mine; S/2 sec. 29, T.14N., R.84W.; The Kurtz-Chatterton mine lies along the eastern flank of the Sierra Madre in a subsidiary shear of the Cheyenne Belt. The property is located along Copper Creek, 5 miles southwest of Riverside. This was one of the three most productive mines in the Encampment district and was developed by more than 1,700 feet of tunnel and several hundred feet of drifts by 1901 (Armstrong, 1970, p. 9) (Figure 8).

Widespread copper mineralization is associated with veins and shears in Sierra Madre granite. Locally, the granite exhibits weak potassic alteration (secondary biotite, muscovite, and chlorite) where it is sheared and rehealed. The mineralized zone was traced over a strike length of 2,500 feet, and possibly extends to a total length of 3,500 to 4,000 feet. The width swells to nearly 1,000 feet near the center of the property. The average value of 10 samples collected in 1991 was 5.96 ppm Au, 2.1 ppm Ag, and 4.43% Cu. The values ranged from 0.0 to 28.10 ppm Au, 0.0 to 7.24 ppm Ag, 0.70 to 12.55% Cu, 3.1 to 150.9 ppm Pb, 0.0 to 4.45 ppm Zn, and 0.0 to 0.80% TiO_2.

Figure 8. Turn of the century Kurtz-Chatterton mine (University of Wyoming American Heritage Center photograph).

HARTVILLE UPLIFT

The Hartville uplift in eastern Wyoming began to attract early attention because of copper, iron, and onyx deposits. Some interest for precious metals was also stimulated by reports of rich silver discoveries. In 1880, for example, the EMJ (1880, Mar 20, v. 29, p. 205) reported ore near Rawhide Buttes yielded 125.0 opt Ag and 0.4 opt Au.

But copper seemed to dominate much of the early attention. A smelter was ordered to reduce the ore mined from the Platte Canyon district south of Rawhide Buttes. The smelter was erected on the north bank of the North Platte River at the mouth of the canyon, and on December 1, 1882, the first run was made. Up to October 1, 1883, over 1,000,000 pounds of copper bricks had been produced and shipped by the Wyoming Copper Company (Warren, 1885). Copper ore from the Michigan and Sunrise mines was reported to net $150 per ton (EMJ, 1882, Aug. 19, v. 34, p. 100). By 1883, regular shipments of copper matte were reported from the Hartville mines (EMJ, 1883, Sept. 8, v. 36, p. 156).

In 1884, EMJ (1884, Jan. 19, v. 37, p. 50) reported about 4,000 tons of ore averaging 15% Cu had been mined from the Sunrise mine, and 3,500 tons had been smelted. In 1888 the EMJ (1888, Mar. 24, v. 45, p. 222) reported the Sunrise smelter had a maximum capacity of 30 tons of ore per day and that a new 120 ton per day smelter was planned by the owners. In the same year, it was reported that the Michigan Copper Mining Company in Muskrat Canyon had

contracted to furnish the smelter at Fairbanks (Sunrise smelter ?) located 25 miles away with 50 tons of ore per day (EMJ, 1888, Aug. 4, v. 46, p. 93).

In 1899, with the copper deposits near depletion, the hematite became the object of mining. Warren (1890) reported that the Sunrise mine had been worked for copper found in irregular pockets entirely surrounded by hematite, and the hematite had only been partially developed. For many subsequent decades, the hematite was mined by C.F.&I. Corporation at the Sunrise, Good Fortune, and Chicago mines in the Sunrise district until operations ceased 82 years later in 1981 (Figure 9). The hematite has been interpreted to be secondary in origin and to have originated from groundwater oxidation and enrichment of originally ferruginous beds (Bayley and James, 1973; Snyder and others, 1989).

Figure 9. Sunrise mining camp, April 6th, 1912 (University of Wyoming American Heritage Center photograph).

Unconformity deposits also occur in the region. In the northern portion of the uplift, the Silver Cliff shaft was driven on a Precambrian-Phanerozoic unconformity and in fault gouge. Available assays indicate the ore contained none to 10.88 % Cu, none to 15.04 opt Ag, 0.001 to 3.39% U_3O_8, and anomalous gold (Wilmarth and Johnson, 1954). In the southern portion of the uplift, Kerr McGee explored a Cu-stained Precambrian-Paleozoic unconformity and recovered samples with cerargyrite, unmangite, electrum, and native gold (Kerr McGee Corp., 1988).

South of the Silver Cliff mine, at the Copper Belt Group at Rawhide Buttes, a contact between hanging wall dolomite and footwall schist was reported to be mineralized over a 1 to 15 foot thickness. Lenses from the Group assayed 2 to 8% Cu and the adjacent altered iron-stained schist contained 0.05 to 0.58 opt Au and 2 to 5 opt Ag (Ball, 1907).

In the southern portion of the uplift east of Sunrise, an extensive gossan at "gossan hill" along the McCann Pass fault, yielded elevated Cu, As, and Zn in outcrop and shallow drill holes. Deeper drilling intersected anomalous zones of mineralization including 10 feet of 0.8% Zn, and 2 feet of 1.2% Zn and 0.08 opt Au (Woodfill, 1987).

The Hartville uplift is interpreted as an Archean eugeoclinal terrane formed of a succession of hematite schist, metadolomite, metabasalt, and pelitic schist unconformably overlain by Paleozoic carbonates. Past production amounted to more than 45,000,000 tons of iron ore, more than 5,000,000 lbs of Cu, and some silver, uranium, and onyx. The onyx was discovered and quarried in 1895 (EMJ, 1895, July. 13, v. 60, p. 39).

BLACK HILLS

An expedition into the Black Hills in 1875 by the U.S. Army under the command of General George Armstrong Custer gave the western prospector a brief look at this mineral rich terrane. Soon the region was invaded by hundreds of prospectors. Today, the region hosts several mines including the Homestake mine and several open pit gold mines operated east of the Wyoming border. However, the geology in the Black Hills uplift in Wyoming is similar and suggests the possibility of the discovery of similar epithermal gold deposits.

Bear Lodge district

The Bear Lodge Mountains north of Sundance are located along the western extent of the Black Hills uplift. This terrane is host to a variety of mineral resources. The region was initially explored for gold and copper, but many decades later the district attracted interest for thorium and rare earths. In recent years, exploration has been directed at low-grade disseminated gold deposits similar to those epithermal deposits currently mined in South Dakota.

Near the turn of the century, a four stamp mill was constructed on Stamp Mill Creek in the Bear Lodge Mountains to process gold ore from phonolite-trachyte. The mill was unsuccessful partly because of the excessive manganese in the ore.

In 1912, Jamison reported the discovery of northwest-trending quartz-pyrite-fluorite veins (less than 4 inches wide) that yielded some gold. Other veins reported by Hall (1911) ranged from a few inches to 30 feet that yielded gold contents ranging from a trace to 6 opt. A few of these veins were explored by the Bock Mining Company. The company also reported assays of a fluorite vein to run 0.35 opt Au. The Warren Peaks Mining Company intersected a nearby 5 foot wide fluorite vein which yielded 0.3 to 0.6 opt Au. Samples of fluorite collected in this region in the late 1980s contained no detectable gold.

The Bear Lodge Mountains consist of a central dome complex of 38 to 50 Ma (million years old) alkalic igneous rock intruded into 2.6 Ga granite. The Tertiary complex consists of multiple trachyte and

phonolite intrusions that were subsequently intruded by carbonatite dikes, syenites, and alkalic intrusive breccias during a late igneous event.

Low-grade disseminated gold was reported by Jenner (1984) in intrusive feldspathic breccia in the southeastern portion of the mountains. Four main phases of alteration were recognized at the Sundance deposit in association with the gold mineralization. Desilication, deposition of fluorite as replacement grains and disseminations, potassium-silicate alteration resulting in fine-grained secondary orthoclase, and clay alteration. The clay alteration forms a cap over the gold (Hahn and Bauer, 1991). In addition to gold, fenites in the complex contain one of the largest, low-grade, porphyry-like thorium and rare earth deposits in the United States (Staatz, 1983).

The Sundance prospect in the Bull Hill area was explored and drilled in 1988. International Curator Resources Ltd. reported the results from 30 holes showed widespread gold mineralization in an elongate intrusive breccia 2,000 feet long with an average width of 120 feet. Gold values ranged from 0.01 to 0.05 opt (0.021 opt average). Five holes drilled in this prospect by Coca Mines in 1990 showed gold mineralization at 30 to 195 feet deep that averaged 0.025 opt (EMJ, 1990, Oct., p. 43). The drilling program increased the geologic resources to 8,200,000 short tons averaging 0.02 opt Au. Metallurgical tests indicated a 70% recovery was possible (EMJ, 1991, Apr.).

Copper, lead, and zinc was also found in the district in metasomatically altered and rheomorphic rocks. In subsurface, these rocks contain chalcopyrite, galena, sphalerite, pyrite and pyrrhotite. The sulfides are rare at the surface because of oxidation, but increase with depth until chalcopyrite occurs in near economic amounts (Jenner, 1984).

Black Butte district

The Black Butte district south of the Bear Lodge Mountains and west of Mineral Hill, was never developed beyond the prospect stage principally because very little mineralization shows at the surface. But because of the intrusion of Tertiary alkalic subvolcanic rocks into the Pahasapa Limestone, there is a possibility of extensive replacement deposits below the surface.

At the surface, mineralization is localized in a few replacement pods and occurs as replacements along joints in the Pahasapa Limestone (Mississippian) accompanied by silicification including jasperoid (Elwood, 1978). Mineralization includes hemimorphite, galena, sphalerite, wulfenite, and fluorite. The galena is weakly argentiferous.

In 1942, one carload of ore was shipped from Black Buttes to the East Helena Montana smelter. The ore yielded 51 ounces of silver and 6,977 pounds of lead (Henderson, 1943).

Mineral Hill district

The Mineral Hill district east of Sundance, lies along the Wyoming-South Dakota border. The district was explored for gold and tin in the 1800s and 1900s. Placers generated much of the early interest, and by 1882, construction of a 40(?) mile ditch was reported to be underway to supply water to the placers (EMJ, 1883, June 23, v. 35, p. 369). In 1883, a 20 stamp mill was ordered (EMJ, 1883, May 5, v. 35, p. 259).

Several gold nuggets were recovered from the Mineral Hill placers including a 2.45 ounce nugget (EMJ 1890, v.50, p. 555). The gold on Sand Creek, one of the principal placers in the district, was reported to be mostly coarse with nuggets from 0.25 to 0.5 ounce. Prior to 1893, more than 9,000 ounces of gold were recovered from the Mineral Hill placers (Knight, 1893).

In 1900, a 20-stamp mill was constructed at the site of Welcome along Sand Creek and on the western flank of Mineral Hill. In addition to gold, tantalite and cassiterite were recovered in the district. In 1936 and 1937, the Fansteel Mining Corporation placered Mallory Gulch and reported the gravel to carry an average of 1.7 pounds cassiterite, 0.31 pounds tantalite, and from 0.07 to 0.21 oz/yd^3 Au (Johnson, 1958).

In 1990, I visited the district and collected samples for assay and found some amethyst at the Artic #2 adit. Samples collected for assay included:

Sample description	Au(ppm)	Ag(ppm)	Cu(%)
Pyroxenite, Birdseye mine	0.168	—	—
Pyritiferous quartz, Birdseye mine	15.0	120.0	0.29
Trachyte, Artic # 1 adit	0.060	2.4	—
Quartz, Treadwell mine	130.0	330.0	—
Silicified trachyte, Treadwell mine	1.39	9.0	—
Quartz vein, Treadwell mine	0.360	<5.0	—
Quartz, Treadwell mine	21.0	65.0	—

The Mineral Hill Tertiary alkalic ring complex consists of multiple intrusions emplaced in Precambrian biotite-quartz schist and Paleozoic sedimentary rocks. This district adjoins the Tinton district of South Dakota on the east.

CASPER MOUNTAIN DISTRICT

Casper Mountain has been prospected for gold, silver, copper, asbestos, feldspar, beryl, chromite, and

magnetite. Much of the early interest in this region was for copper and precious metals. Gold was reported on Casper Mountain and the town of Eadsville was established. Although nothing much came of the gold reports, some precious metal was found in veins and in a diabase dike. Quartz assaying 0.07 to 0.12 opt Au was reported at the east end of Casper Mountain.

In 1897, EMJ (1897, Jan. 9, v. 63, p. 51) reported that the Casper Mountain Range Company was mining copper from an open cut and had contracted to have a tunnel driven on their Galena Claim and a shaft sunk on a gold vein. A foundation for a 40 ton jacket smelter was constructed on their claims.

Cumulate-textured chromatite was described on Casper Mountain as early as 1911. Trenching and drilling by the U.S. Bureau of Mines several years later delineated inferred reserves of 575,000 tons of 8.7% Cr_2O_3 chromite ore and a low-grade deposit of 4,160,000 tons averaging 2.5% Cr_2O_3 (Julihn and Moon, 1945). These ultramafic schists also carry magnetite cumulates. One report indicated the chromite schist occurred in a body one mile long and 40 to 100 feet wide.

COPPER MOUNTAIN DISTRICT

Copper Mountain located in the Owl Creek Mountains of central Wyoming was intruded, folded, and metamorphosed at about 2.6 to 2.7 Ga (Giletti and Gast, 1961). Mafic dikes later intruded the belt at about 2.0 Ga. The district is interpreted to lie within a Archean high-grade supracrustal terrane which forms the Owl Creek Mountains. These rocks consist of isoclinally folded, amphibolite-grade metamorphics in which most rock textures have been destroyed. Rocks consists of amphibolite, quartzofeldspathic gneiss, quartzite, metapelite, and banded iron formation. Mineralization includes uranium, copper, gold, silver, tungsten, iron, feldspar, and beryl (including aquamarine) (Hausel and others, 1985). Some copper, gold and silver was recovered from the DePass mine along the eastern edge of the district, and some gold was recovered from the Gold Nugget mine at the western edge.

DePass mine. The DePass mine was developed on cupriferous-quartz breccia zones in a Proterozoic mafic dike. More than 11,000 feet of tunnels, crosscuts and shafts were developed. Total production is not known, but available records indicate at least 568,000 pounds of mill concentrates were shipped between 1906 and 1918.

Gold Nugget mine: The Gold Nugget mine was developed on a 3 foot wide, shallow-dipping quartz vein in pelitic schist. In 1935, the mine was 400 feet deep with 1,190 feet of drifts. Prior to 1935, production amounted to more than 1,700 tons of gold ore. The vein was reported to yield a trace to 2.37 opt Au. Some rare specimen grade ore assayed 1,450 opt Au (WIJ, 1906, v.7, no.8, p. 4).

Romur, Commet, Whippet and Stardust mines: Scheelite was discovered on the Romur property on the southern flank of the district in 1941. In 1942, a few tons of the tungsten ore were shipped that averaged 2% WO_3. In 1943, another 40 tons of 3% WO_3 ore were shipped followed by three carloads of ore that averaged 1.47%, 0.16%, and 2.56% WO_3.

IRON MOUNTAIN DISTRICT

The Iron Mountain district in the central Laramie Range of southeastern Wyoming was noted for its iron resources as early as 1859 when visited by General Raynolds and Robert Strahorn. Strahorn (1877) later quoted Professor Hayden, *"near the sources of the Chugwater are some very rich iron mines which may prove of great value to the country in the future."*

The titaniferous magnetite deposits have been subjected to numerous investigations concerning their commercial potential, the most notable were the studies by Union Pacific in the 1950s, 60s, and 70s. These indicated the deposits could successfully be mined and milled for iron, titanium dioxide, and vanadium pentoxide.

Hagner (1968) described more than 30 deposits of massive titaniferous magnetite in the 350 mi^2 anorthosite complex. In addition to the massive ore, the complex contains huge resources of disseminated titaniferous magnetite. Published analyses indicate the ore to range from 26.26% to 83.43% Fe_2O_3, 10.75% to 28.0% TiO_2, 0.03% to 2.45% Cr_2O_3, and 0.07 to 0.46% V_2O_5. The deposits are assumed to have formed either by magma unmixing or as cumulates (Frost and Simons, 1991). The massive ore is concentrated near the fold axis of a antiform in the anorthosite. The anorthosite (1.4 Ga) was emplaced along the trace of the Cheyenne Belt shear zone.

Ore mined from the district was used as a heavy weight aggregate and for the manufacture of cement. Total production of massive titaniferous magnetite during the late 1950s to early 1970s amounted to 1,091,452 tons.

Titaniferous magnetite resources at the Iron Mountain mine were estimated at 178,000,000 tons of ore based on drilling, mapping and magnetics (Pinnell and Marsh, 1957). However, a large portion of this estimate was based on interpretation of a large positive magnetic anomaly and may not be reliable, thus the actual resource associated with this deposit may be closer to 28,000,000 tons (John Simons, pers. comm.).

The Strong Creek deposit to the west is a disseminated deposit hosted by gabbroic to noritic rocks of the anorthosite complex. The deposit consists of disseminated ore with about 5% Fe-Ti-oxides with layers up to 2 inches thick of massive Fe-

Ti oxides (Frost and Simons, 1991). The deposit has a width of about 500 feet and a strike length of nearly 1 mile and extends to a depth of at least 650 feet based on drilling. Drilling has identified at least 100,000,000 tons of disseminated ore at an average grade of 6.0% TiO_2, 14% FeO, and 0.25% V_2O_5 (Frost and Simons, 1991).

KIRWIN DISTRICT

In 1890, claims were staked following the discovery of veins with gold, silver, copper, lead, and zinc along the North Fork of the Wood River in the southern Absaroka Mountains of northwestern Wyoming by Will Kirwin. After considerable prospecting and some development work, most properties in the Kirwin district were consolidated into two ownerships: the Galena Ridge Mining Company organized in 1902, and the Shoshone Mountain Mining Company organized in 1903.

Between 1903 and 1907, the Galena Ridge Mining Company drove a 2,327 foot crosscut at the base of Galena Ridge north of the Kirwin townsite in order to explore veins at depth found higher on Galena Ridge. The crosscut intersected the Little Johnnie, Mendota, and Manilla veins, stopping short of the Oregon vein. The Shoshone Mountain Mining Company concentrated on the Bryan and Pickwick veins south of Kirwin. However, most exploration and development terminated in 1907 following an avalanche that killed three people and destroyed several buildings.

A hiatus followed and very little work was done for many years. Then in 1942, Charles F. Wolf leased some patented property near the base of Bald Mountain and sunk the Wolf shaft. Samples collected from the Wolf dump contained bleached and altered porphyry with stockwork veinlets mineralized in molybdenite and chalcopyrite. Wolf dropped his lease option in 1947, and between 1948 to 1953, some of the property in the district was leased by the Anaconda Lead and Silver Company. However, no significant work was done.

From 1951 to 1953, William H. Wilson of the Wyoming Geological Survey mapped the district recognizing stockwork-type mineralization and the potential for a porphyry-type, copper-molybdenum deposit. A few years later in 1960, R. J. Wright, Western United States exploration manager of AMAX Exploration, asked W.H. Wilson about molybdenum resources in Wyoming. Wilson described Kirwin as the most promising prospect. As a result of this discussion, Ora Rostad and Jon Browne, geologists with AMAX visited the property in the Fall of 1960, and Rostad recommended further study of the district. Thus the porphyry was found by follow-up of public information obtained from the Wyoming Geological Survey and could not be described as either a geochemical or geophysical discovery (Rostad, 1985).

AMAX began drilling at Kirwin in 1963, and significant secondary-enriched porphyry-copper mineralization was intersected (Rostad, 1983a). Drilling over the next several years proved a significant porphyry deposit. AMAX's drilling program resulted in 150 holes totaling 86,861 feet. The project outlined geologic reserves totalling 196,000,000 tons of ore averaging 0.505% Cu and 0.022% MoS_2 at a 0.3% Cu cutoff grade with by-product credits in silver and gold. Pitable reserves were calculated at 160,800,000 short tons with a very favorable stripping ratio of 0.57:1 of waste to ore (Rostad, 1983b). Feasibility studies have also indicated the deposit is amenable to *in situ* leaching. A recent 1991 study on *in situ* leaching indicated possible recovery costs of $0.309/pound Cu (Ora Rostad, pers. comm., 1992).

There are several unexplored targets in the district. Explosive conditions occurred in the district as is evidenced by the volcaniclastics that form the Kirwin Formation. Thus there is a possibility of breccia pipes missed by AMAX's 300 foot drill spacing. Additionally, the pervasively talus covered Spar Mountain, immediately south of Bald Mountain could represent a separate mineralized center with possible secondary enrichment. Data indicate the presence of a limonitic anomaly over a significant area, and native copper has been recovered from rock on the divide between Smuggler Basin and Spar Creek. There is also a good possibility of skarn and replacement deposits in the sediments underlying the volcanic section at Kirwin. AMAX drilled a hole near a wildcat oil well that penetrated the sedimentary section and showed strong pyritic and biotitic alteration plus some copper mineralization to its bottom (Rostad, 1982).

Veins have received only limited exploration in the district, although some are traceable for more than 2,500 feet. The veins are narrow, but some have ore grade values. Some of the better assays in two adits were obtained from samples at or adjacent to the mine face. For example, in the Oregon mine, a 3-foot channel sample at the face yielded 17.8 opt Ag, and 0.08 opt Au, and a 1.5-foot channel in the Johnnie mine assayed 64.7 opt Ag, and 0.12 opt Au. Samples collected from the Oregon mine dump contained wire silver and acanthite and yielded 100 opt Ag and 0.3 opt Au (Rostad, 1982).

Alluvial gravel is abundant in the Wood River downstream from Kirwin. The gravels range in depth from 60 to 150 feet and are estimated to form a total potential resource of more than 100,000,000 yds^3 of unexplored gravel. There is little evidence that the gravels have ever been explored for gold, even though geologic evidence suggests some has to be mineralized (Rostad, 1982).

Geologically, the Kirwin mineralized area on Bald Mountain is expressed by a roughly oval-shaped zone

of intense hydrothermal alteration. The mineralized area is associated with a volcanic vent complex containing exposures of Tertiary age intrusive rhyolite tuff breccia (Wilson, 1964; Nowell, 1971).

The hydrothermal alteration increases in intensity toward the center of mineralization. Outside of the altered zone, Wiggins Formation andesites exhibit propylitic deuteric alteration mineral assemblages. Within 1,500 feet of the mineralized center, the andesites are hydrothermally altered and contain secondary quartz, calcite, epidote, montmorillonite, chalcopyrite-bearing quartz calcite veinlets and disseminated chalcopyrite. Nearer to the volcanic center, alteration assemblages are more characteristic of argillic and phyllic alteration. Principal alteration assemblages include sericite, illite-montmorillonite, quartz, and biotite with lesser kaolinite and chlorite. The potassic zone is not well defined but suggested by the presence of secondary orthoclase with quartz and veinlet sulfides. This zone lies near the intrusive center (Nowell, 1971).

Sulfide mineralization in the central zone is dominated by pyrite with lesser amounts of chalcopyrite and molybdenite in stockworks and veinlets and disseminations. The stockworks is surrounded by a high pyrite halo. The most noticeable alteration mineral in the central zone is abundant very fine grained biotite. Sericite and minor amounts of K-spar are also present in this potassic zone. Propylitic alteration has been widespread from the pyrite halo and outwards.

Some veins with gold and silver cut portions of the stockworks, but most veins are peripheral to the stockworks and the pyritic halo and are concentrated to the north and south of the mineralized center. The precious metal veins contain pyrite, sphalerite, galena, tetrahedrite, argentite, pyrargyrite, chalcopyrite, and gold in a gangue of quartz and carbonate.

Weathering of the stockwork on Bald Mountain produced a leached cap over a blanket-like deposit of supergene copper. Chalcocite is the principal sulfide with some covellite and digenite. The deposit is about 3,900 feet across (Rostad, 1983a).

LAKE ALICE DISTRICT

The Lake Alice district near Cokeville in the Overthrust Belt of western Wyoming produced some copper in the 1900s. In the late 1800s, the EMJ (1896, Nov. 28, v. 62, p. 519) also reported that some onyx had been discovered in the region.

Copper ore was shipped from the district between 1914 and 1920, and in 1942. By 1919, the Griggs mine (the principal mine in the district) consisted of five tunnels, nine shafts, and an assortment of exploration pits (Love and Antweilter, 1973). Ore shipped from the mine in 1942 contained none to 0.01 opt Au, 0.1 to 62.8 opt Ag, 0.64 to 20.95% Cu, and none to 2.6% Pb (Allen, 1942). It is interesting that there was no report of zinc recovery.

The Lake Alice deposits are localized in an anticline formed of bleached redbeds of the Nugget Sandstone capped by the Gypsum Spring Member of the Twin Creek Limestone. The Lake Alice deposits were drilled by Bear Creek Exploration in the 1970s.

At the Griggs mine in the northern part of the district, the mineralized sandstone is at least 300 feet thick. Samples collected by Love and Antweiler (1973) ranged from 0.02 to 6.7% Cu, a trace to 0.5% Pb, a trace to 3.2% Zn, and a trace to 1,200 ppm Ag. The average mine ore ran 3.5% Cu and 254 ppm Ag (Allen, 1942).

The mineralizing fluids are interpreted as intraformational or derived from a similar low temperature source and were structurally trapped (in anticlines and faults) during thrusting and folding of the Overthrust Belt (Boberg,1986; Loose and Boberg, 1987). Boberg (1984) suggested that the Lake Alice district has potential for a deposit or series of deposits containing over 100,000,000 tons of ore with a grade of 0.5 to 1.0% Cu, and 2 to 5 opt Ag.

RATTLESNAKE HILLS

Early reports indicate some interest was generated for asbestos, iron, copper, and gold in the Rattlesnake Hills area west of Casper in the late 1800s and early 1900s. The Wyoming Industrial Journal reported the discovery of asbestos was followed by the discovery of a vein with free milling gold by A. E. Minium in 1904. The report also mentioned the presence of an immense vein of Bessemer iron ore was found in the area (WIJ, 1904, Jan., vol.5, p. 232). The iron ore was reported to yield 66% iron and only 4% silica with a million tons in site.

In 1982, Hausel and Jones (1982) sampled pyritiferous metachert with minor galena and jasperoid in the district which yielded anomalous gold. Gold values in the sulfide zone ranged from 0.03 to 0.22 opt Au. This zone was recently mapped and traced 2,500 feet along strike and appears to continue eastward another 500 to 1,000 feet under Tertiary cover. Several other gold anomalies have recently been identified including gold in iron formation and in gneiss (Hausel, in progress). The Rattlesnake Hills were explored from 1983 to 1987 by American Copper and Nickel who identified gold anomalies in structurally prepared Archean metamorphics and in Tertiary volcanics (John T. Ray and Dick Fruchey, pers. comm.).

The Rattlesnake Hills form a Archean supracrustal belt of metasedimentary and metavolcanic rock that has been intruded by more than 40 Tertiary alkalic plugs and dikes. Recent mapping by the author shows the supracrustal belt to consist of a refolded, isoclinally folded greenstone belt

fragment with a lower (?) metasedimentary unit of metapelite, quartzite, banded iron formation, and amphibolite overlain (?) by pillowed metatholeiites, which in turn is overlain (?) by metagreywacke with intercalated metacherts, and further to the north by amphibolites and metabasalt. The alkalic plugs intruding the Precambrian succession include phonolites and quartz latites. Precambrian rock adjacent to phonolite is typically unaltered and coherent. Rocks adjacent to the quartz latites usually are iron-stained, brecciated, and may offer potential for large tonnage, low-grade gold deposits.

SEMINOE MOUNTAINS

For more details, refer to the paper on the geology of the Seminoe Mountains in this guidebook. The Seminoe Mountains attracted interest for gold as early as 1871 when troops under the command of General Bradley and General Thayer, entered the area to search for reported rich deposits of argentiferous galena. Instead of finding silver, gold-quartz veins were discovered, and the Ernst mining district was established. The ore was reported to assay as high as 12 opt Au (Morrow, 1871).

In 1873, many fatalities resulted from an Indian raid on the camp, and the few survivors were driven from the district (Reed, 1874). Five years later, a congressional report stated that the camp was still abandoned (Reed, 1878). Litigation against the Seminole Gold and Silver Mining Company occurred in the following year when company representatives were arrested and indicted by the U.S. Grand Jury for using the U.S. mail to defraud the public in a stock scam (EMJ, 1879, Feb. 22, v. 27, p. 139).

Some years later in 1885, the Penn Mining Company purchased several mines in the district (EMJ, 1885, v. 39, April 18, p. 269) and constructed a 10 stamp mill with concentrator (Aughey, 1886). The Penn mines included the King mine which was extended from 120 feet in 1886 to 700 feet in 1896. The vein varied from 1 to 4 feet wide, and assays averaged 1.2 opt Au (EMJ, 1896, Aug. 8, v. 62, p. 135). The *"Penn mine"* tunnel was extended to 165 feet with a 135 foot deep winze on the 3 to 5 foot wide vein. The ore was reported to average 1.0 opt Au and to carry some copper.

In 1902, Hendricks examined some high-grade iron deposits in the Patterson Basin area along the southwestern flank of the district for the Lake Superior iron company. It was estimated 1,000,000 tons of ore averaging 60% Fe occurred in the basin south of Bradley Peak. Many years later, Harrer (1966) estimated 100,000,000 tons of banded iron formation occurred in the vicinity of Bradley Peak north of the Basin.

In 1981, Timberline Minerals Company and Kerr McGee Corporation explored the Seminoe district following the recovery of several quartz vein samples with visible gold by the author. The samples assayed as high as 2.87 opt (the more highly mineralized samples were not assayed).

MINERS CANYON DISTRICT

In the nearby Miners Canyon area of the Ferris Mountains, the EMJ (1883, Nov. 10, v. 36, p. 30) reported that considerable work was being done on the Pride of the West, Columbia, Leonidas, and other claims. The ore showed argentiferous galena, carbonates, and chlorides.

Miners Canyon represents a small, previously unmapped, Archean supracrustal fragment of metasedimentary, metavolcanic, and intrusive rocks (Nancy Bowers, pers. comm., 1990). The area contains some impressive gossans, numerous prospect pits, and a few mines. Samples collected by the author from these mines yielded <5 to 390 ppb Au, <0.1 to 313.9 ppm Ag, 0.87 to 6.65% Cu, 0.004 to 7.67% Pb, 190 to 5,797 ppm Zn, and 126 to 1,330 ppm As.

SILVER CROWN DISTRICT

The Silver Crown district was organized on April 4, 1879 following the discovery of Cu-Au-Ag, and Cu-Zn lodes. A few years later in 1885, a smelter was constructed which ran successfully for one and a half years until the water supply ran out. Overall, the district was slow to develop: the effects of a salting scheme in the mid-1880s probably did irreparable damage to the reputation of the district and may have kept it from developing to its full potential.

According to the WIJ (1899, v. 1, no. 5, p. 98-99), *"one of the most memorable attempts at mine salting in the West occurred in 1885"*. The fraud involved the Carbonate Belle prospect. According to the Journal, Professor Samuel Aughey, the Wyoming Territorial Geologist, claimed to have developed an unique process for extracting gold from the refractory ore of the Carbonate Belle which would yield not less than 10 opt Au. Other assayers could only extract traces of gold from the ore.

Some wealthy cattlemen were taken into his confidence, and a large block of claims were staked along a 20 mile belt along the edge of the Silver Crown district in 1886. One report in the EMJ about this time was possibly related. The EMJ (1887, July, 9, v. 44, p. 31) reported gold had been found at Horse Creek in *"hematite quartzite and sand rock infiltrated with lime"*. Gold assays were reported to run 3.0 opt Au with some specimens as high as 7.0 opt.

When assayers were consulted in the East and even in England on how to extract gold from the refractory ore, no more than a trace of gold could be recovered. To unravel the mystery, A. H. Swan of the Swan Land and Cattle Company (regarded as one of

the wealthiest stockmen in the West) sent Aughey to the Hartzfeld Smelter in Kentucky with a carload of Carbonate Belle ore to refine the process of gold extraction. Upon returning to the Territory, Aughey deposited his formula in a safety deposit box in the First National Bank of Cheyenne. While at the smelter in Kentucky, Aughey was apparently poisoned by antimony and arsenic from the ore. It was arranged that a large sum of money would be paid to his family in case of his untimely death, prior to anyone opening the envelope containing the formula.

The owners of the Carbonate Belle then sent Aughey to Arkansas for his health. Upon returning, A. H. Swan and others insisted that Aughey demonstrate the value of the Carbonate Belle ore. A test was arranged in which a committee of cattlemen would observe Professor Wilbur C. Knight apply the "Aughey process" to the Carbonate Belle ore. The test was conducted such that neither Aughey nor anyone else interested in the Carbonate Belle would be allowed into the assay office, and all instructions would be given to Knight by Aughey from the adjoining office.

Aughey insisted that the ore in his possession be tested. Knight refused and instead used some samples he had previously collected in the presence of Thomas Swan. Aughey then stated that his process required the ore to be roasted in an air tight crucible. Since Knight didn't have any fire clay in the office, he had to leave for a short period to get the clay. Upon returning, the test was made in duplicate and Knight recovered two gold buttons equivalent to 250 and 300 opt Au.

The committee was ecstatic, but Knight knew the samples had somehow been compromised. Knight informed Mr. Davis one of the committee members that he had been tricked but he did not know how. At that point, Mr. Davis remembered Aughey entered the assay office when Knight left to get the fire clay under the pretext that he needed some water to take some medicine.

Knight spent the next two hours working through the samples until he found evidence of the salt. Gold filings from a coin had been thrown into the sample. Davis then demanded Aughey's resignation as Territorial Geologist and told him to leave town. Subsequently, it was discovered that Aughey and associates had obtained bonds on a number of claims in the Carbonate Belle trend and were ready to sell them had the scheme been successful. According to the Journal, Aughey later traveled to Missouri where he was accused of another scam involving the salting of a mine with graphite.

This unfortunate incident checked the development of the district. Several potentially commercial deposits were found, but none were developed to any great extent. For example, in 1885, Warren reported that the Metcalf prospect was opened on a 2 to 3 foot wide vein. A sample of the vein yielded 30% Cu, 9.8 opt Ag, and 0.5 opt Au. Another assay performed by the Denver Mint gave 46% Cu, and 19.1 opt Ag.

The two most promising properties in the district in the late 1800s were the Copper King (Arizona) and the Comstock (King David). The Comstock lode was located in 1882 a few miles north of the Copper King. The shaft was sunk 126 feet and several hundred tons of copper, gold, and silver ore were recovered including one large mass of chalcocite about the size of a cook stove. From 1914 to 1917 the Comstock shaft was extended to a depth of 240 feet and drifts driven on two levels. In 1956, the Good Venture Mining Company produced some high grade copper ore from the mine (Ferguson, 1965).

The mine was developed on narrow veins and mineralized fracture intersections in quartz monzonite and granodiorite. The shaft was sunk on the northernmost intersection and levels were established at 172 and 205 feet. In 1981, the Wyoming Geological Survey mapped 500 feet of the 172 foot level. The 205 foot level was not mapped because of flooding. Samples of the Comstock ore reported by Ferguson (1965) yielded from 0.74% to 66.6% Cu, none to 21.8 opt Ag, and none to 3.75 opt Au.

Another property which showed potential in the late 1800s and still shows promise is the Copper King. This property was explored and drilled by several groups. According to Ferguson (1965), the Copper King was located in 1881 and developed by the Adams Copper Mining Company. A high grade streak of ore intersected in the shaft was reported to yield 14% Cu and 3.0 opt Au. In 1883, the EMJ (1883, Sept. 8, v. 36, p. 156) reported the deposit was 5,000 to 6,000 feet long, and 40 feet wide. Sometime later, the property was explored by the Hecla Consolidated Mining Company. In 1937, the American Smelting and Refining Company drilled five holes on the property for a total of 1,400 feet. In 1952, the Copper King Mining Company was formed and drilled a total of 2,630 feet outlining a 6,000,000 ton, low-grade, ore body with a high-grade core that averaged 0.76% Cu, 0.14 opt Au, 0.43 opt Ag.

Following a drilling program by the U.S. Bureau of Mines, Soule (1955) reported the Copper King ore body continued to a depth of at least 1,024 feet and had an oxidized and leached zone which extended to a depth of 100 to 150 feet below the surface. Later, Henrietta Mines outlined a substantial low-grade copper-gold ore body in 1973 and reported the following reserves (after Nevin, 1973):

Tons (millions)	Gold (oz/ton)	Copper (%)	Stripping Ratio (waste/ore)
2.8	0.044	0.36	0.5
6.0	0.038	0.32	1.2
13.5	0.028	0.26	1.8
35.0	0.022	0.21	2.0

The results showed a substantial ore body of 35,000,000 tons of low-grade Cu-Au mineralization with the possibility of extending the reserves laterally and at depth.

In 1987, Caledonia Resources optioned the property and explored the higher grade core. The results of their drilling program outlined gold reserves on the order of 4,500,000 tons of ore averaging 0.044 opt (or about 200,000 ounces of contained gold). In 1989, Royle Gold Inc., optioned the property and later reported reserves of 3,600,000 tons of ore averaging 0.4% Cu and 0.04 opt Au.

The Copper King is interpreted as a dissected, Proterozoic age porphyry with disseminated Cu-Au mineralization localized in an area 300 feet wide by 600 to 700 feet long. The mineralization occurs in quartz monzonite and foliated granodiorite and shows strong correlation with K-silicate alteration and hydrothermal propylitic alteration. Sulfides include chalcopyrite and pyrite with minor bornite (Nevin, 1973; Hausel, 1989). Similar anomalies have been reported in the area (Klein, 1974).

The porphyry lies within a narrow belt of northeast-trending, foliated, calc-alkaline metaigneous rocks between the Happy Jack road and I-80 west of Cheyenne. The eastern edge of this belt is marked by steeply dipping Phanerozoic sedimentary rocks unconformably overlain by Tertiary Chadron Formation. The western margin is marked by exposures of the Sherman Granite (1,390 to 1,450 Ga). The oldest rocks in the district are quartzite, quartz-biotite schist, and amphibolite which are fragments of a Proterozoic volcano-sedimentary terrane. These were intruded by granodiorite (locally known as the Copper King granodiorite).

The entire succession was metamorphosed to amphibolite grade at about 1.7 Ga (Peterman and others, 1968). The emplacement of the Sherman Granite along the west, the intrusion of quartz monzonite dikes and pegmatites, and the development of shear zone cataclastics and faults were all controlled by gneissic foliation in the granodiorite (Klein, 1974). Mineral deposits in the district are structurally controlled and parallel regional foliation or occur in tensional fractures. Regional retrogressive greenschist metamorphism overprinted amphibolite facies rocks producing secondary chlorite and epidote.

WIND RIVER PLACERS

Reports of rich placers in the Wind River were published as early as 1868 (AJM, 1868, v.5, April 11, p. 229). The Wind River placers cover a giant region along the Wind River, Little Wind River, and Popo Agie River in the Wind River Basin. The placers include gravel in the river beds and the adjacent terrace gravels, and cap benches, buttes, and the uplands for several miles. The deposits vary considerably in lateral and vertical extent and may average 12 to 14 feet thick over widths of 3 to 4 miles.

Past production from the area has been limited because of the very fine tablet like particles smaller than a pinhead that make gold recovery by conventional gravity methods uneconomic. In 1913, gravel tested in the Wind River Reservation ranged from no gold to 0.016 oz/yd^3, averaging less than 0.0025 oz/yd^3 (Schrader, 1913). In 1910, a gold rush to this area led to the construction of at least two dredges. The Neble dredge owned by the Shoshoni Gold Mining Company operated about 7 miles northeast of Riverton was a 40 by 85 foot dredge with 64 buckets and had a capacity of 2,000 yds^3 per day. Operations terminated after 6 weeks of mining even though the gravel averaged 0.014 oz/yd^3 Au. The Riverton Mining and Dredging Company's Clark dredge periodically operated about 7 miles west of Riverton for several years. Gravel was treated that averaged 0.037 to 0.039 oz/yd^3 (Hausel, 1989).

CONCLUSIONS

During the early mining and prospecting history of Wyoming, conditions were very primitive. The weather in the high Wyoming plains and mountains was (and still is) a deterrent as many people froze to death. While the neighboring territories and states were being tamed, Wyoming was still a wilderness where people succumbed to the weather, Indian raids, and attacks by outlaws. Additionally, poorly funded mining ventures and inexperienced prospectors made Wyoming a scam artist's dream.

The literature is particularly filled with the hopelessness of operating mining ventures in the Wyoming-Dakota territory and provides many reports of raids on the camps. Strahorn (1877) wrote,*"Such hope and opinion received a sharp check by the unfriendly action of the United States government in its persistent, though tacit sanction and support of American savages in their hostile incursions upon the miners in established camps. These marauders compelled not only the abandonment of work begun, but also total cessation of all prospecting... The mining interests of Wyoming have been crippled for more than a decade".*

Strahorn (1877) additionally wrote about South Pass, *"Constant Indian depredations frightened away both miners and capital until the once noted region was almost unheard of".* Emmons and Becker (1885) wrote that Wyoming's *"...resources have as yet, however, been scarcely developed partly because the broad plain areas offer little inducement to the prospector, and partly because he has hitherto been debarred from the northern mountain areas by the Indian tribes to whose reservation they belonged".*

In 1875, General Custer's military expedition trespassed on Indian lands of the Black Hills which signaled a change in the U.S. policy toward the Indian nations. This expedition gave the American public a glimpse of rich gold deposits on sacred Indian lands, and triggered off more widespread violence and problems for both the Indians and the Western prospectors.

Besides Indian confrontations, the early prospectors experienced other problems. The cost of living in the 1800s was very high in Wyoming because of the lack of support by a well-developed agriculture and transportation industry (Warren, 1887). Promoters, swindlers, and bad press practices were also prevalent. In an article about problems in the Encampment district, the EMJ (1897, Dec. 4, v. 64, p. 679) reported that, *"...articles refer to numerous veins of gold ore of great width assaying from few to many thousand dollars per ton. Nothing so unfortunate could have befallen this new camp. These articles may induce the unsophisticated to visit it and spend a small amount of money. On the other hand, how foolish it is for a man to pose before the mining world and say that he has a large vein of ore that will average $2,000 or $3,000 per ton, and in the same breath state that capital is needed to develop it. In fact, such ore can be mined hauled to the railroad, freighted to Denver and smelter for $50 per ton, in which case the $2,000 ore would net the owner not less than $19,500 per car of 10 tons. The press has made such extravagant statements that mining men understanding their business would not even visit the district."*

The geology of Wyoming has also added to the complexity of the problem. Much of the Wyoming is underlain by an Archean craton that is dissimilar to much of the remaining U.S. and few economic geologists in this country have been trained to work in this type of terrane. As a result, many companies avoid this region.

There is no question that Wyoming had and still has some important ore and mineral deposits and has the potential for the discovery of others. But Wyoming has never been developed into the powerhouse hard rock mining state like its neighbors. Many historians have suggested this is simply because Wyoming lacks ore deposits and that all of the historic mines have been mined out. Such conjectures are based solely on opinion completely unsupported by scientific fact. The fact is that Wyoming has several potential ore deposits including some very large metal resources and there is little evidence to support that more than a handful of historic metal mines were ever mined out.

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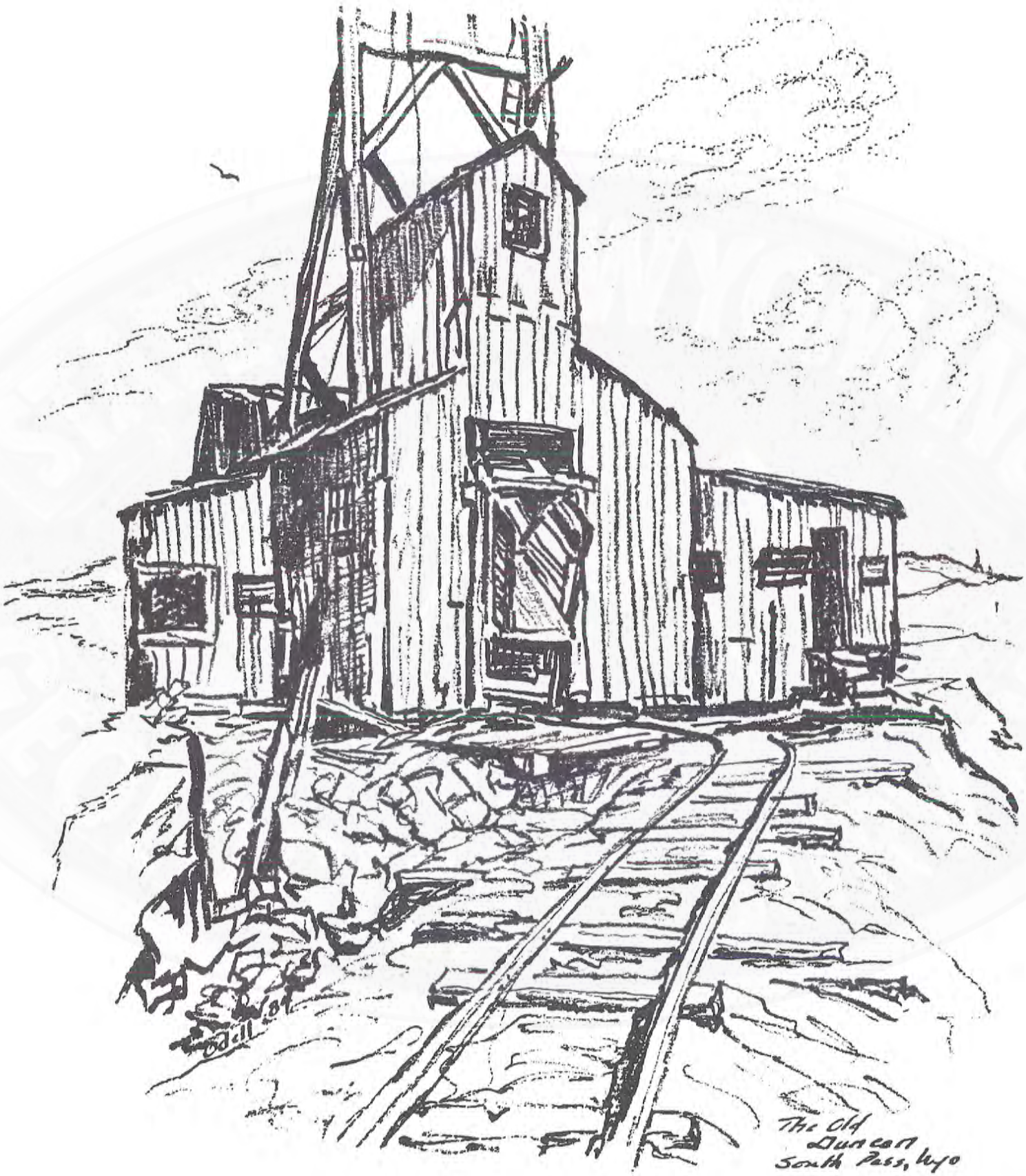
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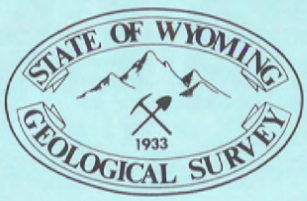
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