THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

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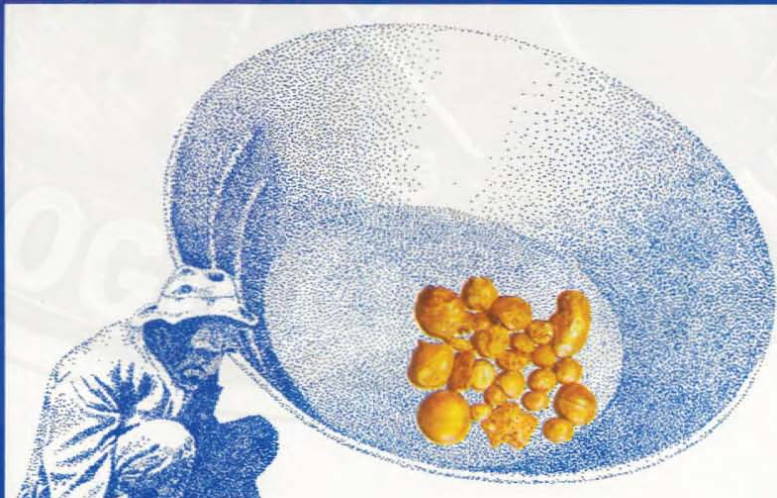
by
W. Dan Hausel



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Front Cover — Wyoming gold. Gold buttons in the prospector's pan were recovered by Dean Farris from mine dump waste in the Gold Hill district. The actual diameter of the button in the lower left is approximately ¼ inch. (Gold photographed by Alan J. VerPloeg; drawing by Phyllis A. Ranz.)

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Preface

Since *Gold districts of Wyoming* was published (Hausel, 1980a), gold, platinum, and silver prices have fluctuated radically. In early 1980 for example, gold prices soared above $800 an ounce, whereas in 1986, prices dropped to $320 an ounce.

When gold prices began to rise above $800, everyone became a weekend prospector. People crowded into my office and called at all times of the day and night at my office and house, looking for information and help on where to find gold and how to identify it. One prospector from Laramie brought in a bucket full of bronze colored mica and claimed his housetrailer was full of barrels of similar material he had panned in the icy cold waters of the Middle Fork of the Little Laramie River all winter long. Like everyone, he had gold fever, but months of work were unfortunately only good for several tons of potting soil.

Another prospector, from Cheyenne, showed me a sample from the Keystone district that contained abundant visible gold in altered quartz diorite. Other beautiful specimens have been collected in recent years from the South Pass region. Historic records claim that specimens recovered from the Hidden Hand mine in the South Pass region assayed more than 3,000 ounces per ton gold!

During the past several years, I have visited and mapped many of the historic precious metal and base metal mines and some mining districts. I am very optimistic that there is a potential for many precious metal ore deposits in this State, including one or more world-class deposits. Much of my optimism is due to similarities in the geologic environments of Wyoming and the gold-rich regions of Australia, Canada, and South Africa.

My recommendation to anyone beginning to prospect, to advanced prospectors, and to exploration geologists is to first stop at the Geological Survey of Wyoming Building on the University of Wyoming Campus and review our public files. The State Survey has numerous unpublished reports and maps that are not available anywhere else. Some of these mineral reports are listed as references in this bulletin and many others are listed in *Mineral resources of Wyoming* (Osterwald and others, 1966). Additionally, the Survey stocks topographic maps for the entire State and provides free mineral and rock identification services. You may also wish to visit the International Archive of Economic Geology on the University campus in the American Heritage Center and review some of their collections of information on mining properties worldwide.

I would like to thank Jon K. King of the Survey staff for his painstaking research of historic records and his critical review, which contributed significantly to this bulletin. I also greatly appreciate the editorial work by Sheila Roberts and the critical comments and suggestions by Gary B. Glass and Paul J. Graff. And as a final note, I wish to dedicate this bulletin to my wife, Pattie, and to my kids, Jessica and Eric, who seldom see me during the summer and fall field season because I am generally chasing after some historic mine or mapping in some relatively unpopulated area of the State. And to all prospectors, rock hounds, and exploration geologists, I wish you the best of luck!

W. Dan Hausel
Deputy Director and Division Head
(Metals and Precious Stones)
Geological Survey of Wyoming

January, 1989

Introduction

Comparisons have been made between the geology of Wyoming and some of the world's richest precious metal producing areas, especially in South Africa, Western Australia, and the Superior Province of Canada. These areas are all cratons and they contain some of the oldest rocks on the surface of the earth. Unlike the other areas, however, Wyoming has been affected by Laramide tectonics that resulted in the uplift of slices of the old cratonic terrane through younger Phanerozoic sedimentary rocks. Since the Laramide orogeny began in Late Cretaceous time, the valleys between the uplifted ranges have filled with erosional debris from the denudation of the mountains, and now these valleys are extensive broad basins covered by blankets of Tertiary sedimentary rocks.

Precious metals are known in some regions of the basins and in relatively young Tertiary volcanic and intrusive rocks, but the uplifted mountain ranges in Wyoming are the prime targets of prospectors and geologists seeking precious metals (**Figure 1**). Within the Precambrian granite-gneiss terrane, found throughout much of Wyoming's mountain ranges, are some of the oldest known metamorphosed volcanic, sedimentary, and plutonic belts in North America. These belts contain extensive regions of dominantly dark colored, amphibolite-grade schists that, in places, are pock-marked by numerous gold mines, attesting to their potential as precious metal provinces. For instance, the South Pass greenstone belt, at the southern tip of the Wind River Range, contains more than a hundred mines and prospects over a 200-square-mile region.

In southeast Wyoming, portions of the Medicine Bow Mountains and Sierra Madre contain thick successions of miogeoclinal metasediments that include metaconglomerates in a geologic setting similar to the Witwatersrand gold deposits of South Africa, which are the richest gold deposits in the world. Immediately south of these metasediments in the Medicine Bow Mountains are two large, layered mafic-ultramafic complexes similar to the Stillwater Complex in Montana and the Bushveld Complex in South Africa. Along the northern edge of one of these complexes in the Medicine Bow Mountains, some platinum and palladium was recovered in the early 1900s. Both the Stillwater and Bushveld are well known for platinum and palladium.

Gigantic base metal and precious metal deposits occur outside the Precambrian-cored mountain ranges in the Absaroka Volcanic Plateau in northwestern Wyoming. These porphyry copper deposits contain enormous tonnages of copper and have significant amounts of low-grade molybdenum, titanium, lead, zinc, gold, and silver.

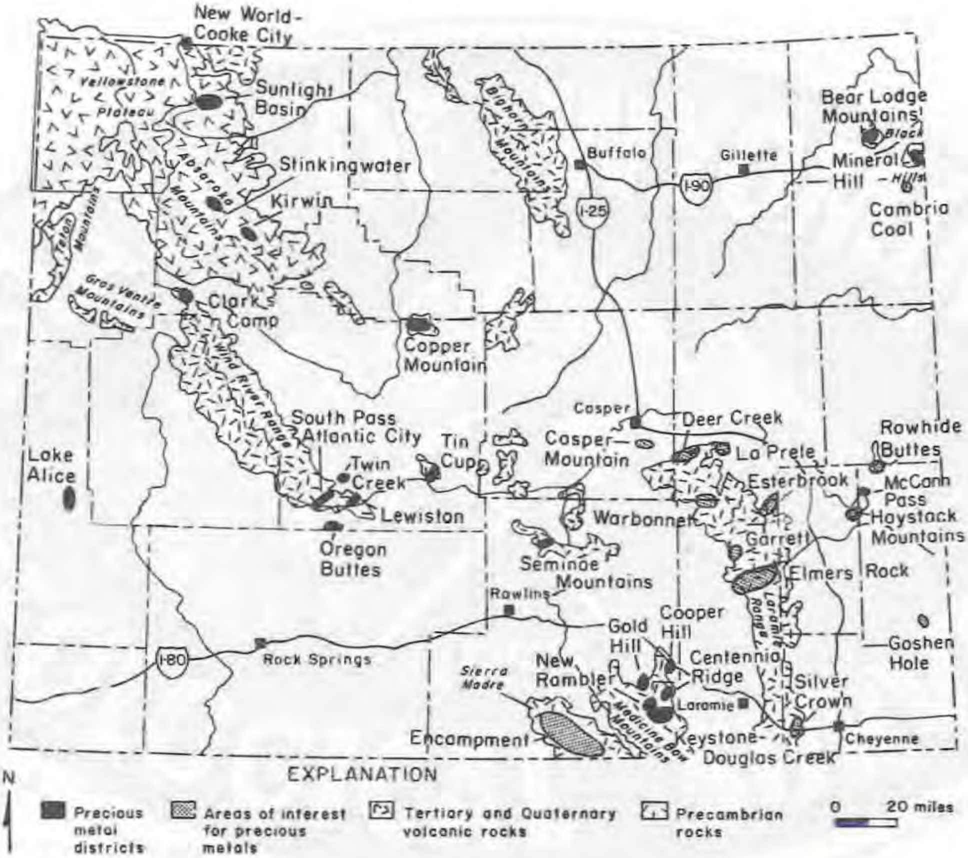


Figure 1. Principal metal districts and mineralized regions of Wyoming.

Some of these deposits were mined for silver and gold in the late 1800s.

In northeastern Wyoming, the Bear Lodge Mountains contain one of the largest low-grade rare-earth and thorium deposits identified in North America. As an added attraction, this deposit also has some low-grade gold mineralization. Deposits in this Tertiary alkalic complex are attractive not only because of gold, but also because of the associated rare earths that have important applications in superconductors.

The broad Wyoming basins have several gold occurrences that are essentially unexplored. In addition to these, there are numerous unexplained gold anomalies in the basins.

There is no question that the Archean rocks exposed in the cores of the Laramide uplifts represent a potentially important precious metal province. However, because of the lack of detailed information on the regional geology, subsurface geology, and mineral deposits in Wyoming, the Wyoming Province has been neglected by the mining industry and we probably know as much if not more about the geology and mineral deposits of the Australian outback. Within the past decade, the Geological Survey of Wyoming, various universities, and members of the U.S. Geological Survey have been filling these information gaps. As more data are accumulated and sound regional and site-specific studies are completed, and if precious metal prices remain favorable, companies may again develop precious and base metal mines in Wyoming.

The following pages are a synthesis of much of the available published and unpublished data on precious metals in Wyoming. Chemical symbols, other abbreviations used in the text, and conversion factors are listed on the inside back cover for quick reference. In the text, there are numerous chemical assay reports. Those assays that have not been credited to other sources are of samples that I collected during the course of my field work. This publication should provide a good starting point for any individual, prospector, consultant, or mining company searching for precious metals in Wyoming.

Historical Background

No one knows when either gold or silver was first discovered in Wyoming. Reports of some very ancient precious metal prospects in the State have been attributed to the Spanish explorers. Later, gold was reportedly found in Wyoming in 1842, but because of Indian hostilities, no serious prospecting occurred until two decades later. The site of this 1842 discovery may have been somewhere in the Lewiston district area at the southern tip of the Wind River Range because the Report of the Governor of Wyoming (Hale, 1883) states:

The first gold discovered in Wyoming was found on the old emigrant trail near the Sweetwater River, in the locality now known as the Lewiston mining district. . .

Years later, in 1867, gold was discovered in bedrock 15 miles west of the Lewiston district. This discovery was rich enough that it supplied the impetus to Wyoming's first gold rush. During the following winter, more than 400 oz of gold were recovered from what became known as the Carissa lode by using primitive hand mortars to pulverize the gold-bearing quartz. A short time later, three boom towns sprouted from the rush in the South Pass region, which collectively supported more than 2,500 people.

In the late 1860s to early 1870s, several mining districts were organized in Wyoming. The foremost of these was the South Pass-Atlantic City district located near the southern toe of the Wind River Range in the South Pass greenstone belt of Archean age (greater than 2.5 billion years old). Total production from the South Pass-Atlantic City district is unknown; however, it is estimated that 70,000 (Koschmann and Bergendahl, 1968) to as much as 335,000 oz (Hausel, 1987b) of gold with some by-product silver may have been produced from this district. Unfortunately, the amount of precious metals mined from this district will never be known because no production records were kept during the height of activity in the district, and the actual amount of recovered gold probably falls somewhere between these two extremes.

In addition to the South Pass-Atlantic City district, several other camps reported some historic gold production. These include the Lewiston district, located about 12 miles southeast of the South Pass-Atlantic City district; the Douglas Creek, Gold Hill, Keystone, New Rambler, and Centennial Ridge districts in the Medicine Bow Mountains; the Seminoe Mountains district; the Copper Mountain district in the Owl Creek Mountains; and the Mineral Hill (also known as the Negro Hill) district in the Black Hills region (Figure 1). Some gold and silver were also produced as a by-product of copper mining in several regions of the State.

The total gold production from Wyoming is unknown because no records were kept during the active mining years before 1900 and only a few estimates were made, which are in considerable disagreement. The estimated and reported metal production listed in Table 1 comes from more than one source, and it can be seen that there is little agreement. Undoubtedly, much of this lack of agreement is due to producers refusing to report production and in some cases providing erroneous reports. Silver production has never been significant in Wyoming although some was reported in the South Pass-Atlantic City, Cooper Hill, Encampment, and Lake Alice districts, and in the Hartville uplift. In the 1870s, some platinum was recovered from gold ore in the Centennial Ridge district, but as with gold, no production records were kept.

By the turn of the century, gold production in Wyoming had declined. Silver prices still had not rebounded from the crisis of 1893, when silver was demonetized by Congress, causing further declines in its value (see Appendix B) and resulting in the closure of most silver mines in the western U.S. Thus, mining interests turned to copper, which was in demand because of growth in the electrical industry. Copper prices at this time were so high relative to many other metals that copper was almost considered a precious metal. Wyoming began to mine the red metal.

The great Ferris-Haggarty mine in the Encampment copper district of the Sierra Madre attracted world attention with an engineering feat unsurpassed in the early 1900s — a 16¼-mile tramway was constructed in 1902 to haul ore from the mine site on the western slope of the Sierra Madre, over the 10,690-foot Continental Divide, and down the eastern slope to the town of Riverside adjacent to Encampment. The ore produced from the Ferris-Haggarty mine varied from 30 to 40 percent copper and carried some silver and 0.1 to 0.4 oz/ton gold (Beeler, 1905a; Hausel, 1986a).

The copper boom was short lived. In 1906 and then again in 1907, portions of the Boston-Wyoming smelter at Riverside burned to the ground, forcing the permanent closure of the Ferris-Haggarty and many other mines in the Encampment district by 1910. More copper was produced in Wyoming in later years in the Hartville uplift and at Copper Mountain in the Owl Creek Mountains, but never in the quantities recovered from the Encampment district. Unknown amounts of by-product gold and silver were also recovered from the Encampment district.

One mine in the Medicine Bow Mountains, the New Rambler, was developed as a copper and gold prospect during the copper boom at the turn of the century. In 1901, platinum and palladium were

Table 1. Estimated and reported precious metal and base metal (copper and lead) production for Wyoming. The sources for this information are (1) U.S. Bureau of Mines Yearbooks, (2) Wyoming Industrial Journals, (3) production figures reported by the State Geologist, H.C. Beeler (1899-1909), and (4) Engineering and Mining Journals. Where production is unknown, a slash is given. (lbs = pounds, f = fiscal year, e = estimate).

Year	Au[1] (oz)	Au[2] (oz)	Au[2] (oz)	Au[3] (oz)	Au[4] (oz)	Ag[1] (oz)	Ag[2] (oz)	Ag[2] (oz)	Pt[2] (oz)	Pd[1] (oz)	Cu[1] (lbs)	Cu[2] (lbs)	Cu[3] (lbs)	Pb[1] (lbs)
1867	416	0(f)	416(e)	–	–	70(e)	–	–	–	–	–	–	–	–
1868	3,750	0(f)	1,811(e)	–	–	620(e)	–	–	–	–	–	–	–	–
1869	7,500	322(f)	4,561(e)	–	–	1,240(e)	0(f)	–	–	–	–	–	–	–
1870	7,500	4,284(f)	4,838(e)	–	–	1,240(e)	56(f)	–	–	–	–	–	–	–
1871	7,500	1,237(e)	4,838(e)	–	–	1,240(e)	6(f)	–	–	–	–	–	–	–
1872	4,840	1,198(f)	4,838(e)	–	–	800(e)	4(f)	–	–	–	–	–	–	–
1873	2,420	887(f)	2,419(e)	–	–	400(e)	5,170(f)	–	–	–	–	–	–	–
1874	1,210		4,838(e)	–	–	200(e)		–	–	–	–	–	–	–
1875	485	498(f)	–	–	–	100(e)	0(f)	–	–	–	–	–	–	–
1876	485	891(f)	–	–	–	100(e)	0(f)	–	–	–	–	–	–	–
1877	485	20,653(f)	–	–	–	100(e)	4,198(f)	–	–	–	–	–	–	–
1978	485	2,560(f)	–	–	–	100(e)	0(f)	–	–	–	–	–	–	–
1879	485	1,319(f)	–	–	–	100(e)	0(f)	–	–	–	–	–	–	–
1880	970	443	–	–	–	100(e)	0	–	–	–	–	–	–	–
1881	240	189	–	–	–	100(e)	14	–	–	–	–	–	–	–
1882	240	119	–	–	–	240(e)	16	–	–	–	100,000	–	104,206	–
1883	195	206	–	–	–	1,440(e)	23	–	–	–	962,468	–	879,053	–
1884	290	254	–	–	–	100(e)	27	–	–	–	–	–	–	–
1885	485	739	–	–	–	100(e)	59	–	–	–	–	–	–	–
1886	360	352	–	–	–	100(e)	64	–	–	–	–	–	–	–
1887	360	330	–	–	–	100(e)	54	–	–	–	–	–	–	–
1888	360	921	–	–	–	420(e)	316	–	–	–	232,819	–	240,113	–
1889	360	417	–	–	–	240(e)	49	–	–	–	100,000	–	100,000	–
1890	360	734	–	–	–	100(e)	127	–	–	–	–	–	–	–
1891	360	486	–	–	–	100(e)	66	–	–	–	–	–	–	–
1892	360	250	–	–	–	100(e)	34	–	–	–	–	–	–	–
1893	360	486	–	–	–	100(e)	84	–	–	–	–	–	–	–
1894	360	1,171	–	–	–	100(e)	170	–	–	–	–	–	–	–
1895	360	1,464	–	–	–	100(e)	198	–	–	–	–	–	–	–
1896	690	769	–	–	–	100(e)	101	–	–	–	–	–	–	–
1897	542(e)	602	1,323(e)	–	–	100(e)	89	–	–	–	–	–	127,409	–
1898	257(e)	217	242(e)	–	–	100(e)	43	–	–	–	233,044	–	233,042	–
1899	1,410(e)	2,653	2,419(e)	48,534	–	400(e)	256	–	–	–	3,104,827	1,533,111	2,949,583	–
1900	1,655(e)	1,833	4,650(e)	54,345	–	200(e)	246	10,222(e)	–	–	4,203,776	6,904,540	335,006	–
1901	614(e)	620	2,000(e)	59,000	–	21,400(e)	47	25,000(e)	–	–	2,698,712	10,958,900	880,681	–
1902	1,879(e)	349	2,188(e)	53,265	–	5,000(e)	38	5,200(e)	–	–	889,228	14,166,700	–	–
1903	175(e)	192	401(e)	–	17,075(e)	200(e)	146	826(e)	–	–	1,023,189	–	977,700	–
1904	837	325	793(e)	38,700	–	4,647	32	4,494(e)	–	–	3,565,629	7,000,000	–	–
1905	1,294	1,179	1,147(e)	–	–	3,655	167	2,700(e)	–	–	2,530,531	–	–	–
1906	315	283	279(e)	5,175	–	136	25	1,100(e)	170	140	106,177	1,905,260	–	–
1907	452	159	–	4,840	–	3,715	18	–	–	–	3,026,004	2,250,000	–	–

1908	385	83	308(e)	5,800	—	3,998	9	3,500(e)	some	some	2,452,049	3,961,540	—	—
1909	198	158	189(e)	3,628	—	1,754	19	1,800(e)	—	—	492,539	76,920	—	—
1910	155	128	199(e)	—	—	1,478	9	1,300(e)	some	—	222,339	—	—	—
1911	929	1,134	1,030(e)	—	—	725	333	700(e)	some	—	130,499	—	—	—
1912	1,076	783	—	—	—	265	126	—	some	—	27,570	—	—	—
1913	1,170	347	—	—	—	957	40	—	0	—	385,239	—	—	—
1914	242	326	—	—	—	116	31	—	0	—	17,421	—	—	—
1915	706	859	—	—	—	840	320	—	some	—	447,246	—	—	—
1916	995	4,284	—	—	—	5,524	290	—	0	—	2,610,622	—	—	—
1917	182	2,336	—	—	—	3,415	48	—	some	—	2,027,857	—	—	—
1918	42	200	—	—	—	965	59	1,255(e)	some	—	852,777	—	—	—
1919	4	8	14(e)	—	—	151	5	300(e)	0	—	139,900	—	—	—
1920	—	8	10(e)	—	—	—	29	56,959(e)	0	—	—	—	—	—
1921	3	36	0(e)	—	—	111	4	65(e)	0	—	10,000	—	—	—
1922	58	54	—	—	—	57	828	163(e)	some	—	4,296	—	—	—
1923	14	11	24(e)	—	—	254	1	—	4.4	24	111,280	—	—	—
1924	0	8	10(e)	—	—	0	2	—	—	—	0	—	—	—
1925	0	—	—	—	—	0	—	—	—	—	0	—	—	—
1926	0	—	—	—	—	0	—	—	—	—	0	—	—	—
1927	58	—	—	—	—	5	—	—	—	—	—	—	—	—
1928	32	—	—	—	—	53	—	—	—	—	2,604	—	—	—
1929	48	—	—	—	—	26	—	—	—	—	4,301	—	—	—
1930	122	—	—	—	—	122	—	—	—	—	11,600	—	—	—
1931	17	—	—	—	—	17	—	—	—	—	9,000	—	—	—
1932	195	—	—	—	—	195	—	—	—	—	397	—	—	9,800(e)
1933	260	—	—	—	—	260	—	—	—	—	0	—	—	—
1934	710	—	—	—	—	710	—	—	—	—	3,500(e)	—	—	2,000(e)
1935	1,152	—	—	—	—	1,152	—	—	—	—	1,000(e)	—	—	5,000(e)
1936	1,113	—	—	—	—	1,113	—	—	—	—	—	—	—	—
1937	203	—	—	—	—	203	—	—	—	—	—	—	—	—
1938	328	—	—	—	—	328	—	—	—	—	—	—	—	—
1939	75	—	—	—	—	75	—	—	—	—	—	—	—	—
1940	114	—	—	—	—	114	—	—	—	—	4,000(e)	—	—	—
1941	94	—	—	—	—	94	—	—	—	—	8,000(e)	—	—	—
1942	52	—	—	—	—	52	—	—	—	—	—	—	—	6,977
1943	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1944	3	—	—	—	—	3	—	—	—	—	—	—	—	—
1945	31	—	—	—	—	31	—	—	—	—	—	—	—	6,000(e)
1946	26	—	—	—	—	26	—	—	—	—	2,000(e)	—	—	—
1947	95	—	—	—	—	95	—	—	—	—	—	—	—	—
1948	11	—	—	—	—	11	—	—	—	—	—	—	—	—
1949	21	—	—	—	—	21	—	—	—	—	—	—	—	—
1950	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1951	2	—	—	—	—	2	—	—	—	—	—	—	—	—
1952	0	—	—	—	—	0	—	—	—	—	—	—	—	—
1953	0	—	—	—	—	0	—	—	—	—	—	—	—	—
1954	0	—	—	—	—	0	—	—	—	—	—	—	—	—
1955	0	—	—	—	—	0	—	—	—	—	—	—	—	—
1956	0	—	—	—	—	0	—	—	—	—	—	—	—	—

identified in the copper ores after 4,000 tons of ore had been shipped from the mine. The smelter officials did not pay for platinum and palladium because they were not aware of the presence of those metals (McCallum and Orback, 1968). The New Rambler is one of the few historic platinum and palladium mines in the United States. Platinum nuggets were also recovered from the Douglas Creek district immediately south and downstream of the New Rambler mine.

In the early 1900s, gold was produced sporadically around the State. According to the *Wyoming Industrial Journals* (Table 1), significant quantities of gold were mined between 1899 and 1909. Much of this was recovered from the Carissa mine in the South Pass-Atlantic City district. From 1933 until the beginning of World War II, the South Pass-Atlantic City district was again a site of significant activity. Draglines working placer deposits produced more than 11,500 oz of gold. But following the second World War, only minor amounts of gold were produced, primarily because labor costs were too high compared to the value of gold. The total production for Wyoming is unknown; however, estimated and reported production indicate that the State was only a minor source compared to some of the neighboring states.

Every state in the west has a legend about a lost gold mine. Wyoming is no exception. Historical records report that a group of Swedish prospectors found a creek in the Bighorn (or possibly Owl Creek) Mountains that contained fabulous amounts of gold. According to the legend, the gold was so rich and plentiful that one could simply hand pick the metal off the ground. Unfortunately, the prospectors were killed by Indians before they could return to the mine with additional men. Nearly every year, at least one person researches historical records concerning this legend and attempts to retrace the trail of the prospectors. But the Lost Cabin mine is still only a legend.

Absaroka Mountains

Both mineralized and barren intrusive centers are the source of the great pile of volcanic rock that forms the Absaroka Mountains. The Absaroka Volcanic Supergroup covers an area of more than 8,000 square miles, forming a northwesterly trend of igneous rock along the eastern border of Yellowstone National Park that extends north into Montana (Figure 2). The trend of the volcanics is assumed to be structurally controlled by a deep-seated fracture system. The rocks consist of calc-alkaline intrusions, lava flows, flow breccias, breccias, and volcano-sedimentary units. A small volume of the flows in the northern Absarokas is more alkaline and shoshonitic in composition.

Several volcanic centers in the Absaroka Mountains of Park County exhibit disseminated, stockwork, and vein mineralization, and hydrothermal alteration characteristic of porphyry copper deposits (Hausel, 1982a). The porphyry copper deposits are included in this bulletin because they contain tremendous quantities of other metals such as Mo, Ti, Pb, Zn, Au, and Ag. Additionally, several

Figure 2. Principal known mineralized porphyries and mining districts in the Absaroka Mountains.

veins associated with these porphyries were worked during the late 1800s. Worldwide, porphyry copper deposits are important sources and major producers of low-grade gold and silver ores in addition to base metals. The age of the deposits is poorly known although mineralization is interpreted as post-Eocene or late Eocene (Fisher, 1981). A quartz monzonite dike that intrudes Wiggins Formation andesite on Bald Mountain in the Kirwin district yielded an age of 40.2 ± 1.4 Ma (Schassberger, 1972). Fission-track dates on a zircon from an altered dike in the Stinkingwater district yielded 26.3 ± 4.0 Ma and an apatite yielded 30.6 ± 4.2 Ma (Fisher, 1981).

The mineralized centers in the Absaroka Mountains are characterized by central intrusive complexes. Adjacent to the intrusive complex are vent-facies autoclastic flow breccias, lava flows, mudflows, avalanche debris, and tuffs. The vent-facies rocks commonly are domed, altered, and radially fractured and, in the southern Absarokas, grade laterally into volcaniclastics. These volcanic complexes appear to be deeply dissected stratovolcanoes or shield volcanoes.

Mineralization associated with these volcanic centers generally occurs as disseminations and stockworks in intensely altered rock and in fractures and veins that transect both the mineralized intrusive and the vent-series wallrocks. Hydrothermal alteration produced zoned mineralization around the central intrusive complex. Generally, copper, molybdenum, and traces of gold occur in the central portion of the complex. These metals grade into Zn-Pb-Ag ores laterally away from the center of the intrusive complex.

Hydrothermal alteration of varying intensity is also zoned and occurs with mineralization in all the districts. All of the districts exhibit widespread deuteric propylitic alteration. Near the intrusive centers, the deuteric alteration takes on the characteristics of hydrothermal propylitic alteration. The presence of veins or veinlets of calcite, epidote, chlorite, and pyrite in the propylitically altered rock indicates that the deuterically altered rock has been overprinted by hydrothermal alteration.

A halo of phyllic alteration (quartz-sericite-pyrite) is recognized near disseminated copper mineralization at all of the known mineralized areas except the Sunlight Basin. Argillic alteration has been identified at several of the intrusive centers although in most cases the described alteration appears to be supergene rather than hypogene. Potassic alteration has been identified in several of the districts although the potassic halo is generally poorly defined.

William H. Wilson, then of the Geological Survey of Wyoming, was the first to recognize the potential of the vent areas in the Absarokas as large-tonnage, low-grade, porphyry copper deposits. These deposits occur as (1) disseminated and stockwork mineralization in intensely altered stocks or composite stocks and, at a few localities, in country rock adjacent to mineralized stocks; (2) fracture-filled veins and veinlets extending outward from the mineralized centers; (3) fracture- and fissure-filled veins and replacement deposits hosted by Paleozoic carbonates (recognized only in the New World district); (4) supergene enriched deposits; and (5) placer gold deposits downstream from porphyry districts (Hausel, 1982a). In addition to these deposits, numerous stream-sediment samples collected in the Absarokas and adjacent Bighorn Basin have yielded anomalous gold (Albert, 1986).

Although disseminated epithermal gold deposits associated with jasperoids have not been reported, there appears to be potential in this region. For example, jasperoids were recognized in the Sunlight mining district by the U.S. Geological Survey (Nelson and others, 1980, p. 84-85), but unfortunately these have not been evaluated as potential gold targets.

Because of the presence of several large-tonnage, low-grade, porphyry copper centers, this region has the potential to be a base metal and precious metal mining district.

Kirwin district

Located in T.45N. and 46N., R.104W. (Figure 3), the Kirwin-Wood River area has three or four mineralized areas and associated north-northwest trending veins that lie on U.S. Forest Service and patented lands and within wilderness designated lands. Each of the mineralized areas exhibits varying degrees of Cu-Mo mineralization and hydrothermal alteration.

The intrusive complexes (Kirwin, Brown Mountain granodiorite, Meadow Creek granodiorite, and Yellow Ridge) penetrate volcanics of the Wiggins Formation (Eocene). The Wiggins Formation is one of a group of formations belonging to the Thorofare Creek Group (Smedes and Prostka, 1972). In the Kirwin district, the Wiggins Formation forms a series of deuterically propylitized hornblende-biotite and pyroxene-andesite porphyry flows, tuffs, breccias, and volcaniclastic sediments. The layered, vent-facies volcanics have been domed, hydrothermally altered, and radially fractured. Andesite

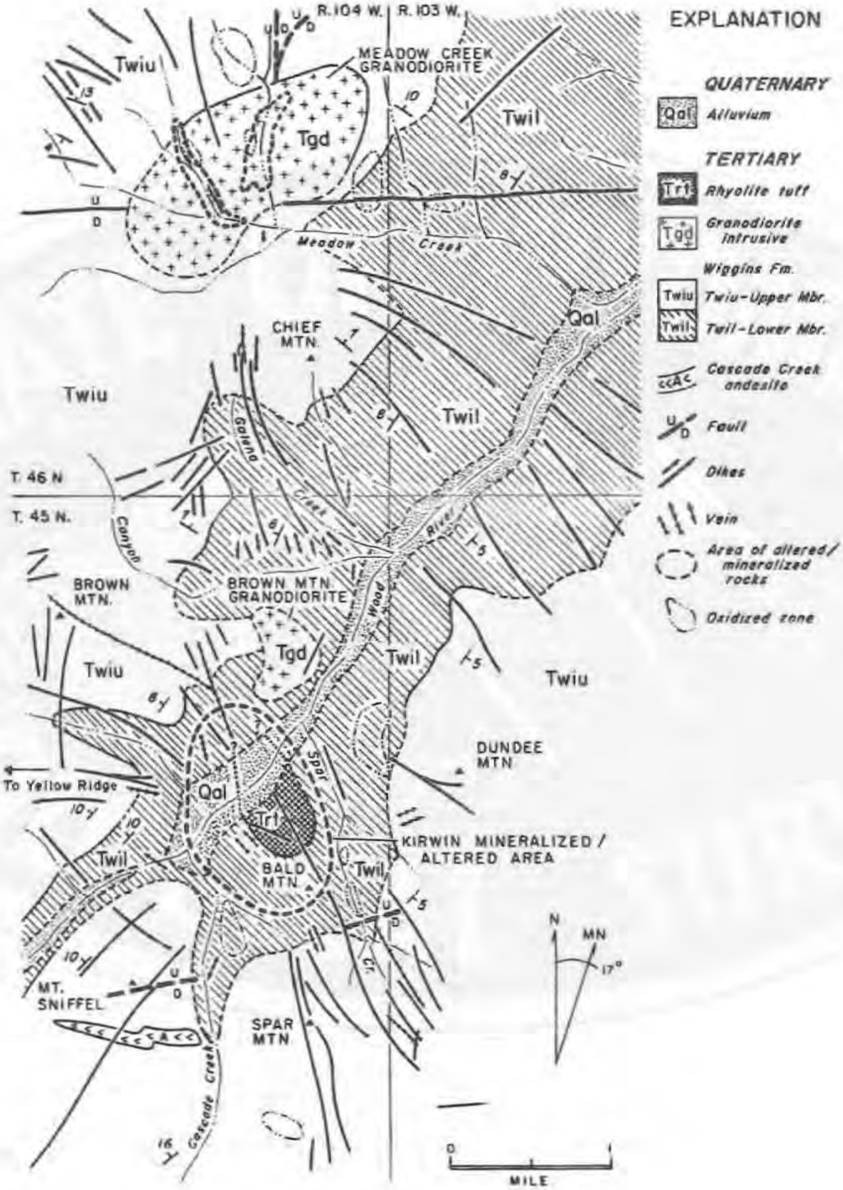


Figure 3. Generalized geologic map of the Kirwin-Wood River area (modified from Wilson, 1964, 1975; and Nowell, 1971).

porphyry dikes occupy radial fractures and also follow the dominant north-northwesterly structural trends recognized throughout the Kirwin-Wood River area. With few exceptions, mineralized veins are localized in north-northwesterly fractures and are dominantly Pb-Ag-Zn veins. In the Kirwin mineralized-altered zone on the northern flank of Bald Mountain, the veins are dominantly mineralized with copper and molybdenum.

Individual porphyries

Brown Mountain granodiorite. The Brown Mountain granodiorite is the least mineralized of the intrusive complexes (Figure 3). The intrusive consists of fine- to medium-grained equigranular granodiorite grading into porphyritic phases near its northern margin. Hydrothermal alteration is expressed as weak propylitization with disseminated pyrite. Although the strongest manifestations of mineralization are north-northwesterly trending veins along Galena Ridge north of the intrusion (Wilson, 1960a), it is not known if these veins are an expression of the Brown Mountain granodiorite or of the Kirwin mineralized complex (Nowell, 1971). Three prominent joint trends, (1) east-west, (2) northeast-southwest, and (3) northwest-southeast, have been measured in the central portion of the intrusive (Wilson, 1960a).

Kirwin-Bald Mountain. The Kirwin mineralized area, located on the northwest flank of Bald Mountain (Figure 4), is expressed by a roughly oval zone of intense hydrothermal alteration (Figure 3). The mineralized area is associated with a volcanic vent complex containing exposures of intrusive rhyolite tuff breccia (Wilson, 1964; Nowell, 1971). Brecciation appears more commonly along the edge of the vent.

This mineralized area exhibits hydrothermal alteration with increasing intensity toward the center of alteration. Outside of the altered zone, Wiggins Formation andesites are deuterically altered and contain an assemblage of propylitic minerals — calcite, chlorite, and clays. Within 1,500 feet of the mineralized center, the Wiggins andesites have been hydrothermally altered, and quartz, calcite, epidote, montmorillonite, chalcopyrite-bearing quartz-calcite veinlets, and disseminated chalcopyrite blebs are common. Nearer the volcanic center, alteration assemblages are characteristic of argillic and phyllic hydrothermal alteration. Major alteration products include sericite, illite-montmorillonite, quartz, and biotite, with lesser kaolinite and chlorite.

Figure 4. View east from Brown Basin toward Bald Mountain in the Kirwin district, Absaroka Mountains.

The potassic zone is not well defined, but is suggested by the presence of secondary orthoclase with quartz and veinlet sulfides. This zone lies nearest to the mineralized center (Nowell, 1971).

Drill-hole data in the Kirwin area show stockwork mineralization including pyrite, chalcopyrite, and molybdenite. A secondary enriched blanket of chalcocite, digenite, and covellite overlies a portion of the stockworks, which in turn is overlain by a barren leach cap (Wilson, 1964). Veins in the altered area are pyrite-chalcopyrite-molybdenite-quartz (Wilson, 1960a). Wilson (1964) reported assays from mine dump samples and veins that ranged from a trace to 0.25 oz/ton Au and a trace to 111.8 oz/ton Ag.

The U.S. Bureau of Mines reports that the Kirwin mineralized-altered area at Bald Mountain hosts a resource of at least 70 million short tons of 0.75 percent copper (Rosenkranz and others, 1979). Wilson (personal communication, 1982) believed the actual resource is much greater than reported by Rosenkranz and others (1979). In addition to copper, the Bald Mountain altered area contains large resources of Mo, Zn, Pb, Ag, and Au. Recently, it was reported the porphyry could yield at least 615,000 tons Cu, 13,500 pounds Mo, 121,000 oz Au, and 5.6 million oz Ag (Anonymous, 1985).

Meadow Creek granodiorite. The Meadow Creek granodiorite is a composite of at least two separate intrusives, which vary from granite to diorite and have an average composition of granodiorite. The older granodiorite (forming the western third of the intrusive mass) is propylitized, weakly pyritized, and relatively unmineralized. The later granodiorite (on the east) is propylitized with more intense alteration along two elongated zones (Figure 3). The intensely altered zone in the eastern portion of the complex extends across the intrusive along the projected trend of the north-south fault and is delineated by phyllic alteration with disseminated copper mineralization. A second intensely altered zone, outlined by intense silicification, iron-staining, and disseminated pyrite, is localized along the contact between the two granodiorite intrusives.

Spotty chalcopyrite and malachite occur as disseminations and fracture fillings in limited exposures in both the altered granodiorite and adjacent Wiggins Formation. Other expressions of mineralization include copper, lead, and molybdenum geochemical anomalies within the intrusive and mineralized quartz veins located north and south of the intrusive. These veins occur as silver-bearing galena, sphalerite, tetrahedrite, minor pyrite, and chalcopyrite mineralization in quartz-carbonate gangue (Wilson, 1975).

The Meadow Creek granodiorite is located at the intersection of two faults. The emplacement of the intrusive complex appears to have been controlled by this intersection. Dikes form roughly radial patterns around the intrusive, and vein mineralization occurs in a north-northwest trending zone between the Brown Mountain and Meadow Creek intrusives (Wilson, 1964, 1975).

Yellow Ridge porphyry. The Yellow Ridge porphyry lies within 3 miles west-northwest of Kirwin (43°54', 109°20'30"). Two stocks crop out through Wiggins Formation breccias and flows on Yellow Ridge (William H. Wilson, personal communication, 1982). These are rhyolite and a composite intrusive of granodiorite to diorite, andesite porphyry, and hornblende andesite porphyry. Much of the mineralization is associated with the andesite porphyry (dike?). The other intrusive masses are weakly mineralized (William H. Wilson, personal communication, 1982).

A narrow (200 to 300 feet) mineralized zone is exposed along a 2,500-foot northeasterly trending structure in the southeastern part of the stock. Malachite is abundant and occurs as fracture coatings and disseminated grains. Pyrite and lesser chalcopyrite, bornite(?), and molybdenite(?) are also found in the mineralized zone. No precious metal values are reported.

Hydrothermal alteration consists of an outer propylitic zone that includes the intrusive margin and adjacent extrusive rocks. Near the intrusive center, propylitic minerals grade into phyllic altered rock, and near heavily mineralized zones, potassic altered rock dominates (Fisher and others, 1977).

New World (Cooke City) district

Located on the Montana-Wyoming border (Figure 5), most of the district lies within Montana and only a small portion extends into Wyoming. The district is adjacent to Cooke City, Montana.

The ore deposits in the New World district are related to a deeply dissected intrusive-volcanic complex. Due to uplift, this complex has been more deeply eroded than any of the other mineralized centers in the Absarokas. With most of the volcanic rock eroded away, Paleozoic sedimentary rocks and Tertiary intrusives (diorite to syenite) are exposed throughout most of the district. On the southwestern and southeastern edges, andesitic flows are still preserved, unconformably overlying Paleozoic rocks (Nelson and others, 1980).

The Goose Lake and Henderson Mountain stocks, located north of Cooke City (and north of Figure 5), are centers of mineralization in Montana. With a few exceptions, the major ore bodies are localized adjacent to the stocks.

The Goose Lake center, north of the Henderson stock, exhibits mineralization somewhat different than the Henderson lodes. The host rocks for the Goose Lake mineralization are mafic and felsic igneous rocks. The veins are localized adjacent to the intrusive and form principally chalcopyrite and galena-sphalerite vein deposits.

Mineralization at Henderson Mountain occurs as fissure-replacement deposits. The ore shoots and lodes are best developed at fracture intersections and in sheeted zones. Alteration associated with mineralization is expressed as silicification and dolomitization (Lovering, 1929).

The mineralization extends out from Henderson Mountain in irregular metallogenic zones. Contact-metamorphic Au-Cu deposits are developed adjacent to the stock and grade outward to Cu-Pb ore. At increasing distance from the stock, the Cu-Pb mineralization is

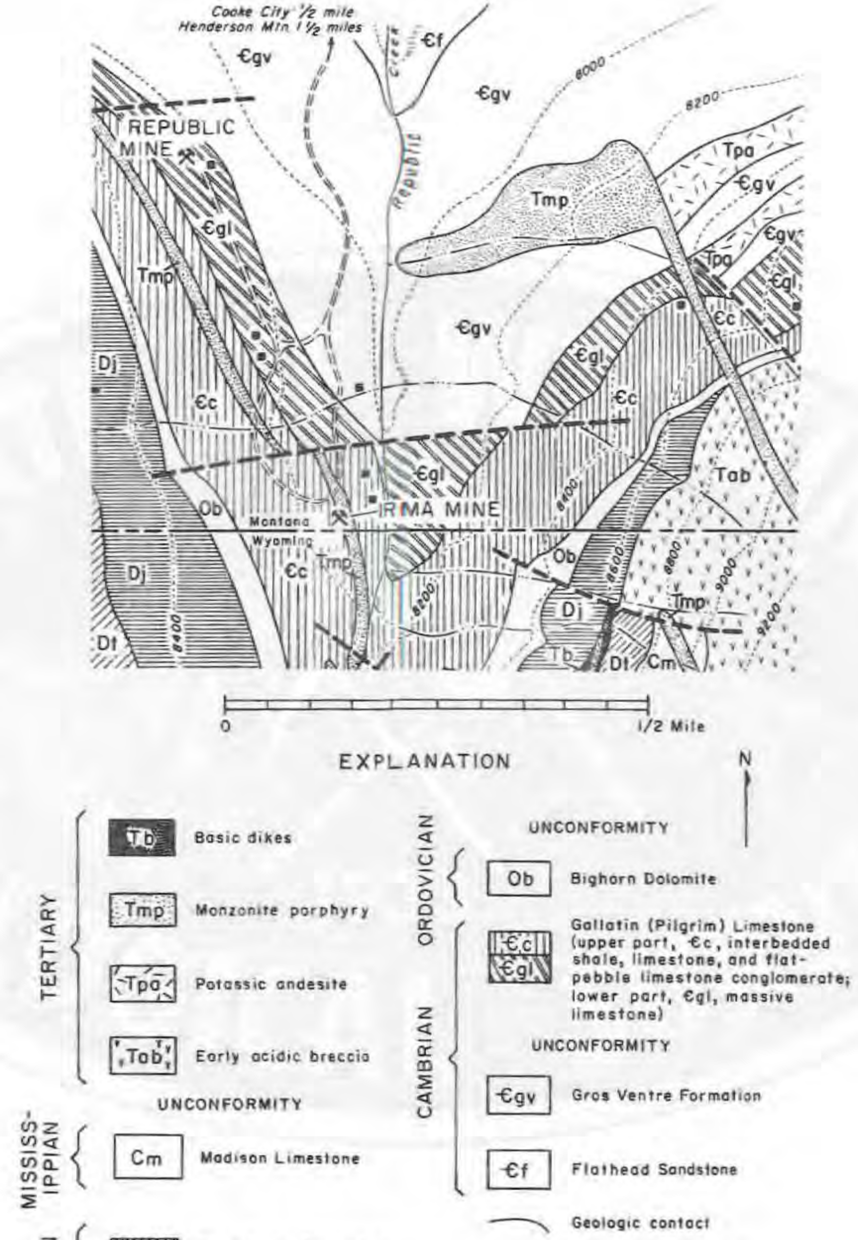


Figure 5. Generalized geologic map of the southern New World district (Wyoming portion in T.58N., R.109W.) (modified from Lovering, 1929).

zoned to Cu-Pb-Zn, to complex Pb-Ag-Zn, to an aureole of silver-bearing sideritic calcite veins, and finally to barren carbonate veins. The best deposits are developed where these zoned veins cut limestone beds of the Upper Cambrian Pilgrim Limestone (equivalent to Gallatin Limestone) to form replacement lodes. The underlying Gros Ventre Formation (Middle to Upper Cambrian) is an untested potential host (Lovering, 1929; Reed, 1950; Butler, 1965).

Irma-Republic mines. The Irma-Republic deposits occur as a vein system of the Henderson Mountain complex (Figure 5). These deposits are fracture fillings and replacements in oolitic beds of the Pilgrim Limestone. The lode is nearly vertical and strikes N30°W to N40°W. Mine workings are located in Montana, extending a short distance into Wyoming, and are over 2,700 feet long and 250 feet deep. Silver, lead, and zinc have been extracted from the deposits. These mines have produced more than 18,000 tons of silver, lead, and zinc concentrates with traces of gold and copper (Nelson and others, 1980).

Stinkingwater district

This district (Figure 2) includes three separate mineralized porphyries known as Birthday, Silver Creek, and Crater Mountain (commonly referred to as the Stinkingwater mineralized area).

Individual porphyries

Birthday porphyry; east of Crater Mountain (44°00', 109°36'15"). Exposures of the intrusive crop out at three localities and cover an area of less than 0.5 square mile. The largest intrusive is granodioritic and dacitic in composition and intrudes Wiggins Formation andesites and breccias.

Pyrite is disseminated, coats fractures, and occurs in quartz-pyrite veinlets. In some areas, pyrite comprises as much as 10 percent of the mineralized rock. Chalcopyrite occurs as disseminations and in veinlets forming stockworks. These stockworks are northwest trending zones from 10 to 14 feet wide that are developed in andesite dikes(?) and, to a lesser extent, in the dacite. Quartz-pyrite-calcite veins and altered rock occur adjacent to many of the dikes in the Birthday region. Oxidation is prominent, and zones of limonite, malachite, and azurite have replaced hypogene minerals. Both anomalous copper and molybdenum have been detected in assays (Fisher and Antweiler, 1980). The precious metal potential has not been determined.

Silver Creek porphyry (44°01′45″, 109°41′). Copper and molybdenum occur in altered rocks of an intrusive complex in the Silver Creek area. The complex is formed by dacite and rhyodacite rocks, which intrude volcanics of the Wapiti Formation, Trout Peak Trachyandesite, and Wiggins Formation. The intrusive and adjacent volcanics show effects of hydrothermal alteration (Fisher and others, 1977) that generally preceded mineralization. Widespread propylitic alteration grades laterally to localized phyllic and potassic alteration near the center of the intrusive. The major sulfides are localized within the phyllic and potassic alteration zones.

A well-developed pyrite halo is localized in the phyllic zone and encloses a highly mineralized 2,000- by 1,000-foot stockwork complex near the center of the intrusive. The stockwork contains disseminated malachite, chalcopyrite, bornite, and minor molybdenite, along with chalcopyrite-pyrite-magnetite quartz veinlets. Malachite-stained fractures in the stockwork trend roughly N35°W to N80°W and dip steeply (Fisher and others, 1977). Molybdenite is uncommon in rock exposures although drilling has intersected strong molybdenum mineralization in 300 feet of core.

Resource estimates of copper for this porphyry, based on only a few drill holes, include a minimum of 27 million tons of 0.5 percent copper (John Wells, personal communication, 1982). The precious metal potential of the stock has not been considered.

Stinkingwater mineralized area; sec. 18, T.47N., R.106W., on the confluence of Needle Creek and the South Fork of the Shoshone River near the center of the southern Absaroka volcanic field (Figure 2). Layered Eocene volcanic rocks in the district include, from oldest to youngest, the Wapiti Formation, the Trout Peak Trachyandesite, and the Wiggins Formation. These are composed principally of basalt and andesite flows, volcanic breccias, and flow breccias and are intruded locally by the Needle Mountain granodiorite and Crater Mountain dacite and numerous dikes that extend outward from the composite intrusive (porphyry) in a radial pattern (Figure 6). The Crater Mountain dacite intrudes the Needle Mountain granodiorite (Fisher, 1972).

The layered volcanic rocks adjacent to the composite intrusive are slightly domed, dipping gently (maximum 10°) away from the intrusive center (Fisher, 1972; Osterwald and others, 1966). Two distinct fracture sets are recognized in the district; these trend northwest and east to northeast and intersect at the intrusive complex. These fracture sets probably controlled emplacement of the intrusive and movement of the associated hydrothermal solutions (Fisher, 1972).

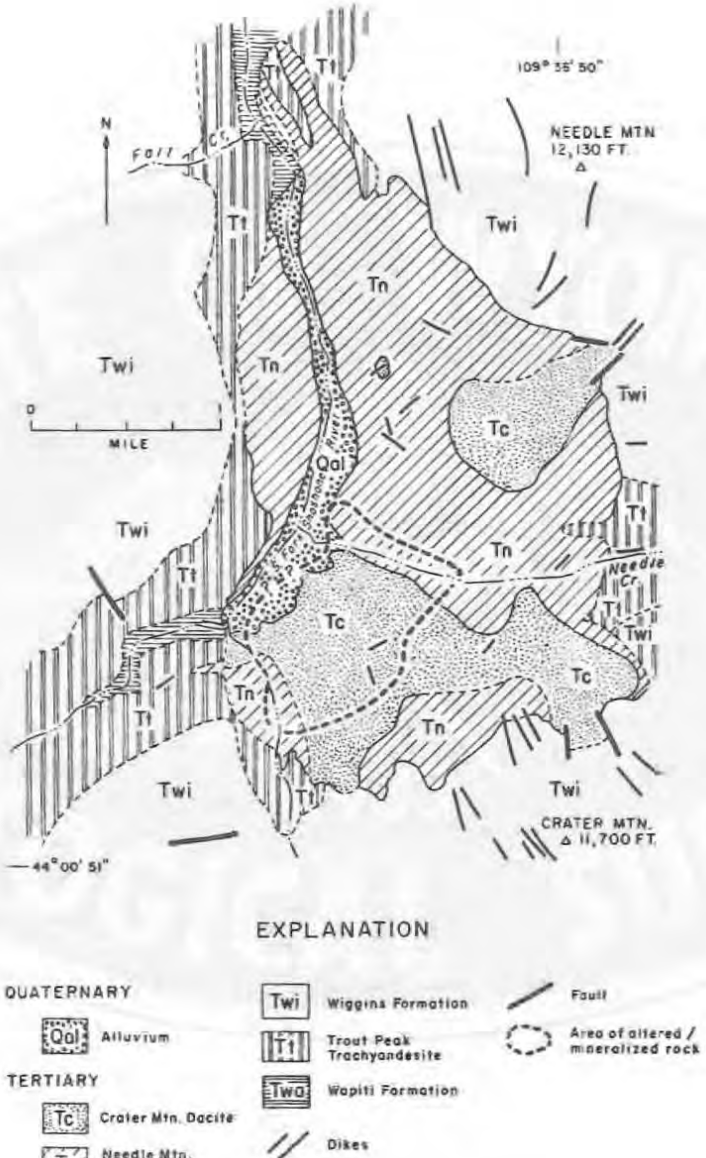


Figure 6. Generalized geologic map of the Stinkingwater mineralized area (after Fisher, 1972).

Mineralization in the district includes an altered area (approximately 0.75 square mile) of disseminated Cu-Mo near the southwestern edge of the porphyry. The greatest amount of mineralization is associated with a zone of intense hydrothermal alteration centered in the Crater Mountain dacite. The Needle Mountain granodiorite is poorly mineralized except along the northern edge of Needle Creek. All of the outcrops in the mineralized area are highly fractured and bleached. Narrow, steeply dipping veins occur near and, in places, as much as a mile away from the intrusive complex.

Chalcopyrite is the major ore mineral in the intensely altered zone, followed in abundance by molybdenite and minor bornite. Beyond the central chalcopyrite-molybdenite zone, pyrite is dominant and is associated with low Cu-Mo values. Chalcopyrite and molybdenite are disseminated in the altered zone; they occur in narrow quartz veinlets and coat fractures in this zone.

Mineralized veins are found mainly in relatively unaltered country rock a few hundred yards from the zone of disseminated mineralization. In places, they occur nearly a mile from the disseminated zone, but are also locally found in the disseminated zone. The veins are commonly 1 to 2 inches wide and reach a maximum of nearly 1 foot wide locally. These veins contain galena, chalcopyrite, sphalerite, pyrite, and minor arsenopyrite and tetrahedrite in quartz, calcite, dolomite, and minor siderite gangue. The veins are commonly crustiform and banded and are considered simple fracture fillings. Gold occurs sporadically in the veins, and the galena-rich portions of the veins are generally argentiferous (Fisher, 1972).

A supergene-enriched chalcocite blanket as much as 200 feet thick was intersected by drill holes near the center of alteration at Crater Mountain. The extent of the supergene zone is not known. This zone is overlain by a bleached and oxidized cap (Fisher, 1972).

Although an ore body of 65 million tons of 0.35 percent copper has been delineated by drilling (John Wells, personal communication, 1982), the extent of mineralization in the potassic core has not yet been entirely defined.

Hydrothermal alteration increases in intensity toward the center of disseminated mineralization. Propylitization of both the intrusive and layered rocks is common throughout the district. The intensity of the propylitization increases around the fringe area of disseminated sulfide minerals and grades into phyllically altered rock toward the center. The phyllic alteration produced highly altered, bleached, and silicified rock. The original porphyritic texture is preserved by sericitic pseudomorphs in the phyllic altered zone; however, the original texture has locally been destroyed by pervasive phyllic alteration. Potassic alteration (characterized by development of secondary biotite) is expressed in irregular ill-defined zones in the disseminated mineralized area. Within the areas of supergene enrichment, there is evidence of argillic alteration that probably is of supergene origin (Fisher, 1972).

Streams in the vicinity of the Stinkingwater mineralized area carry traces of gold (0.5-1 ppm in pan concentrates) and mercury (Fisher, 1972).

Sunlight district

This district is located 40 miles west of Cody along Sunlight Creek (Figure 2), on U.S. Forest Service lands surrounded by wilderness. Prospecting in the Sunlight area was first reported in 1890, and the only report of ore production was 100 tons of Au-Ag-Cu ore mined in 1903 (Nelson and others, 1980, p. 34). Several hundred feet of exploratory workings were developed along veins by shafts and adits at several sites in the district.

The geology of the area is shown in Figure 7. Two types of mineralization are recognized in the district — disseminated deposits and vein mineralization. The disseminated deposits consist of (1) pyrite in altered zones in all rock types, (2) chalcopyrite in intrusive rocks, and (3) copper-bearing stockworks (Nelson, and others, 1980). Fairly well-developed stockworks are found in a syenite stock at the headwaters of Sulphur Creek (Drier, 1967) and in andesites in contact with syenite (Figure 7) (William H. Wilson, personal communication, 1982). The stockwork consists of less than 1-inch-wide veinlets containing chalcopyrite, bornite, covellite, and chalcocite in quartz-calcite gangue.

Three alteration zones are recognized in the district — propylitic, argillic, and potassic. Propylitic alteration is widespread and increases in intensity near the intrusive stocks and veins, while potassic alteration is localized and restricted to the stocks. Argillic alteration appears to be supergene in origin and overprints other alteration assemblages.

Disseminated mineralization is localized in and around intrusives, and veins are controlled by joint sets and shear zones (Nelson and others, 1980). Vein mineralization is zoned, with copper-rich veins near the mineralized centers and Pb-Ag or barren veins at a distance from the stocks. Epithermal gold deposits associated with jasperoids

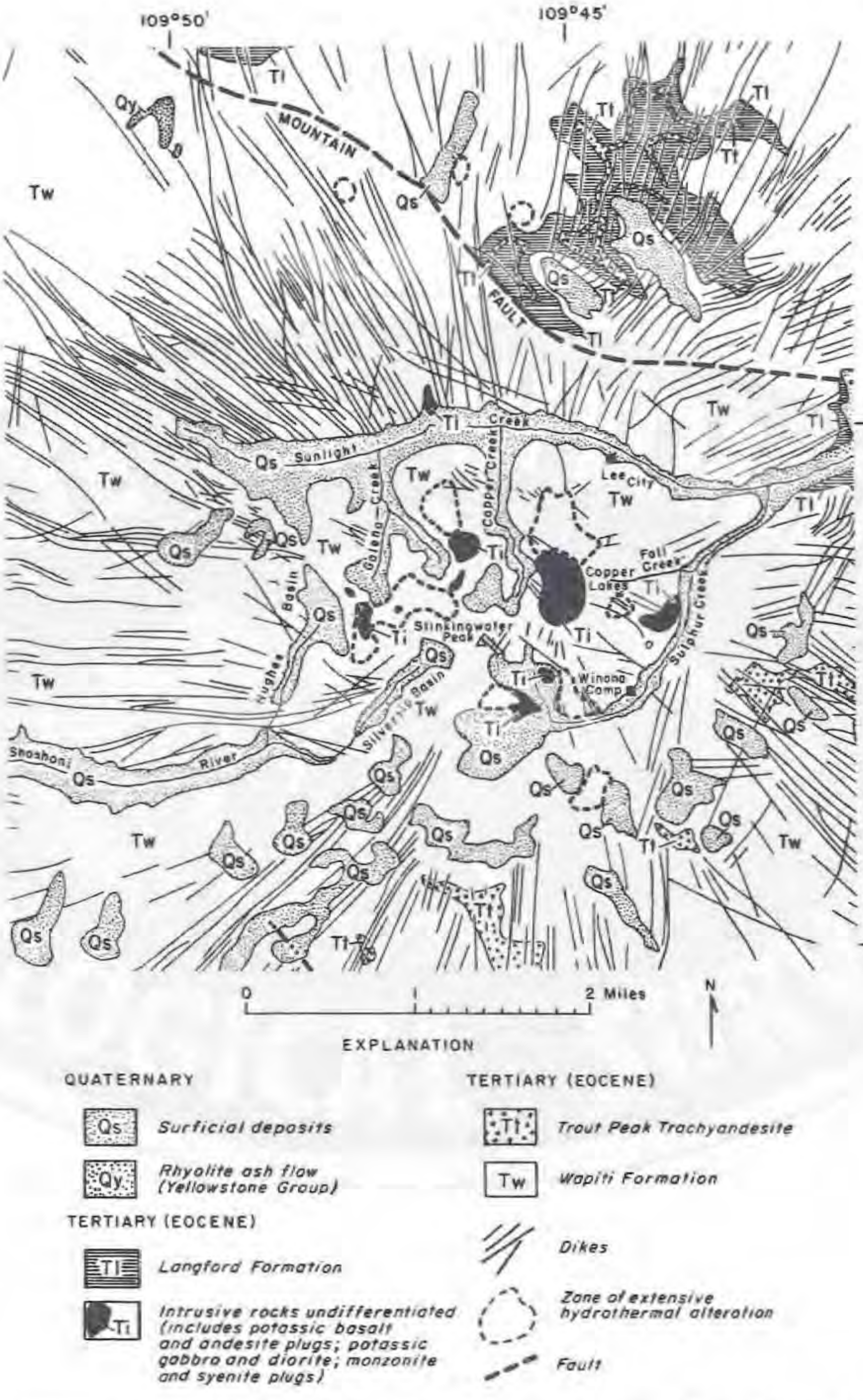


Figure 7. Geologic map of the Sunlight district (modified from Nelson and others, 1980).

have not been reported in the district even though the geologic setting may be favorable for these types of occurrences. Jasperoids were reported along the edge of the district during an appraisal of the Northern Absaroka Wilderness, but these were not evaluated for gold potential. However, a semiquantitative spectrographic analysis of one of the jasperoid samples collected during the study showed 0.04 ppm Au, 200 ppm Mn, 5,000 ppm Ba, 200 ppm Cr, 70 ppm Cu, 500 ppm Sr, and 300 ppm V (Nelson and others, 1980, p. 84).

Mine and prospect descriptions

Big Goose claim; (no location given). Parsons (1937) classified this vein as a chalcopyrite-pyrite-gold vein similar to the vein at the Winona mine. One assay of a sample collected from the outcrop by Parsons showed 0.82 oz/ton Au and a trace Ag.

Copper Creek adit; about 44°40′, 109°45′ (unsurveyed), 1.5 miles north of Stinkingwater Peak. The workings are about 200 feet long. The adit was driven into an andesite cliff in Copper Creek Basin (Figure 7) to intersect a sheared syenite dike. Three samples chipped from the shear assayed only a trace to 0.01 percent Cu, 0.02 to 0.04 percent Pb, 0.04 to 0.05 percent Zn, a trace to 0.10 oz/ton Ag, and a trace to 0.01 oz/ton Au (Nelson and others, 1980, p. 42-44).

Copper Lakes prospects (Kodiac claim); about 1 mile east of Stinkingwater Peak (Figure 7). Samples collected from a N5°E trending shear assayed a trace Cu, 0.028 percent Pb, 0.04 percent Zn, 0.5 oz/ton Ag, and 0.04 oz/ton Au. Another sample of selected cobbed-grade vein material from a small stockpile about 80 feet north of the northwestern end of Upper Copper Lake assayed 0.05 percent Cu, 0.76 percent Pb, 0.30 percent Zn, 0.02 oz/ton Au, and 24.32 oz/ton Ag (Nelson and others, 1980, p. 41).

Evening Star claims; patented claims on the southern ridge of the 11,040-foot peak located between Hughes and Silvertip Basins (Figure 7). The property was developed by a shallow shaft and two tunnels. A selected sample of vein material collected by Parsons (1937) assayed 91.44 oz/ton Ag, with 1.4 percent Cu, 1.3 percent Pb, and 0.02 oz/ton Au. Two grab samples of mine dump material assayed 3.19 and 4.2 oz/ton Ag, with 0.02 and 0.025 percent Cu, 0.04 and 0.06 percent Pb, 0.03 and 0.05 percent Zn, and a trace to 0.01 oz/ton Au (Nelson and others, 1980, p. 47-48).

Galena Creek basin prospects (Figure 7). Contact zones of syenite dikes with andesite country rock were targets of prospectors in Galena Creek basin. Samples collected by the U.S. Bureau of Mines from various prospects in the basin ranged from a trace to 0.01 percent Cu, 0.02 to 0.26 percent Pb, 0.05 to 0.12 percent Zn, a trace to 0.01 oz/ton Au, and 0.29 to 0.80 oz/ton Ag (Nelson and others, 1980, p. 44).

Hardees claim; (location unknown). A vein sample collected by Parsons (1937) from an outcrop, assayed 20.24 oz/ton Ag, 62.23 percent Pb, a trace Cu, and 0.04 oz/ton Au.

Hargrave-Newton-Lafond mine; somewhere on Sunlight Creek (Figure 7). A fissure cutting porphyritic rock contains some malachite, chalcocite, and chalcopyrite (Osterwald and others, 1966, p. 59).

Hoodoo claim; (location not given). Calcite and pyrite occur as secondary wallrock minerals with coarse argentiferous galena in iron-carbonate gangue. One sample of ore collected from the dump yielded 0.02 oz/ton Au, 1.98 oz/ton Ag, 9.4 percent Pb, and a trace Cu (Parsons, 1937).

Jasperoid occurrences; T.54N., R.104W. (approximately 44°40′, 109°25′). Nelson and others (1980, p. 84 and 85) described three jasperoid samples from Paleozoic sedimentary rocks that were collected east of the Sunlight mineralized area a short distance within the North Absaroka Wilderness along the eastern edge of the Absaroka volcanics. Unfortunately, the samples were not tested for Sb, As, Hg, or Ti, some of the characteristic trace metals of epithermal gold deposits, but Ba, Cu, and Mo were detected. The one jasperoid containing anomalous barium also contained 0.04 ppm Au.

Joe vein; on the divide between Fall Creek and Sulphur Creek (Figure 7). The vein crops out for 900 feet and contains Cu-Pb-Ag sulfides (Osterwald and others, 1966, p. 59).

Lee City prospect; at historic Lee City on Sunlight Creek (Figure 7). An adit was driven along a N20°E trend. A grab sample of dump material from the adit assayed a trace Au, 0.20 oz/ton Ag, 0.01 percent Cu, 0.02 percent Pb, and 0.02 percent Zn (Nelson and others, 1980, p. 51).

Malachite vein; on the divide between Fall Creek and Sulphur Creek, 1,500 feet southwest of the Joe vein (Figure 7). The vein is between 6 and 12 feet wide with an 18-inch-wide streak of high-grade chalcocite and crops out for 2,100 feet along strike (Osterwald and others, 1966, p. 59).

Marvin prospect; (location unknown). A 250- by 2,200- by 1,000-foot area uncovered by glacial erosion exhibits stockworks(?) consisting of east-west and north-south trending, low-grade, mineralized veinlets (Osterwald and others, 1966, p. 60). The veinlets carry gold, silver, and copper values (East, 1911).

McClung mine; at the base of Stinkingwater Peak and Bear Tooth Mountain. A 150-foot-long tunnel intersected a fissure vein cutting quartz porphyry. The vein carried galena, chalcopyrite, gold, and silver (East, 1911; Osterwald and others, 1966, p. 60).

Morning Star adit; on the northeast wall of Hughes Basin just south of the saddle between Hughes and Galena Creeks at an elevation of about 10,650 feet (Figure 7). A 273-foot adit was driven east in andesite to intersect a N10°W to N15°W trending, 83°E dipping, mineralized syenite dike. The dike was intersected 254 feet from the portal. Samples chipped from a shear zone exposed in crosscuts near the face of the main tunnel assayed a trace Cu, 0.02 to 0.04 percent Pb, 0.04 to 0.06 percent Zn, a trace to 0.01 oz/ton Au, and 0.30 to 0.77 oz/ton Ag (Figure 8) (Nelson and others, 1980, p. 45-46).

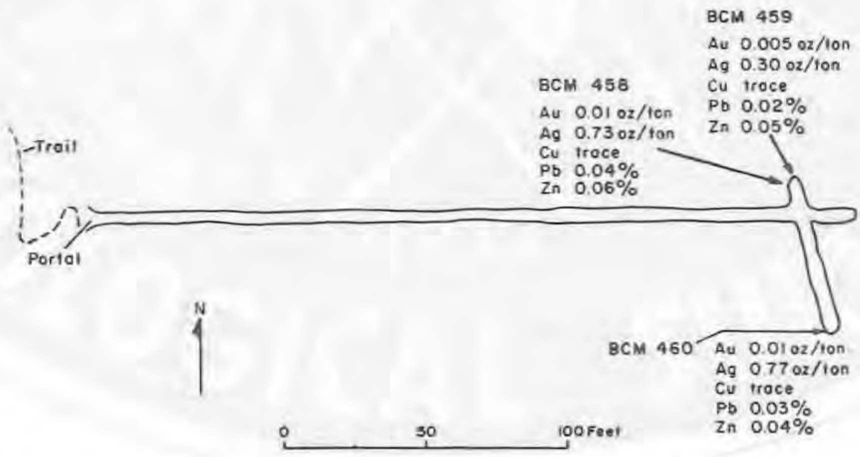


Figure 8. Sample location map of the Morning Star adit in the Hughes Basin of the Sunlight district (modified from Nelson and others, 1980).

Newton prospect; on the east side of Silvertip Basin (Figure 7) at 9,266 feet elevation, about 1 mile south of the Painter mine. A 67-foot adit follows a vertical shear zone in andesite porphyry that strikes N85°E. A grab sample from the mine dump assayed 0.03 percent Cu, 0.04 percent Pb, 0.02 percent Zn, a trace Au, and 0.49 oz/ton Ag (Nelson and others, 1980, p. 51).

Novelty adit; at 9,204 feet elevation, on the west fork of Galena Creek near the base of the Galena Glacier. A syenite dike in andesite country rock is sheared along the contact. The mineralized shear trends N24°E and dips 82°SE. Samples of the sheared rock assayed from a trace to 1.5 oz/ton Ag, 0.02 to 0.88 percent Pb, a trace to 0.03 percent Cu, 0.05 to 0.20 percent Zn, and a trace to 0.02 oz/ton Au (Figure 9) (Nelson and others, 1980, p. 45). A sample of mine dump material was reported by Parsons (1937, p. 847) to contain 19 oz/ton Ag and 0.06 oz/ton Au, with 13.1 percent Pb and 0.75 percent Cu.

Painter mine (Silvertip group); on the west flank of upper Silvertip Basin, to the east and below the Evening Star claim, at 9,370 feet elevation. According to Rich (1974), the mine shipped 100 tons of ore to an Omaha, Nebraska, smelter in 1903. The Painter vein trends N20°W to N15°E. It was tested by a 94-foot upper adit and a 806-foot lower adit. Seven samples collected from the mine dumps by the U.S. Bureau of Mines ranged from 0.12 to 3.53 percent Cu, 0.02 to 0.08 percent Pb, 0.04 to 0.10 percent Zn, a trace to 0.07 oz/ton Au, and 0.47 to 3.03 oz/ton Ag (Nelson and others, 1980, p. 49).

Assay values of dump samples reported by Rich (1974) included.

(1) Average of dump material tested in 1935 — 3.85 percent Cu, 0.06 oz/ton Au, and 4.62 oz/ton Ag.

(2) A dump sample collected in 1966 — 14.9 percent Cu, 10.6 percent Pb, and 5.6 oz/ton Ag.

(3) An average of eight random dump samples collected in 1969 — 5.16 percent Cu, 0.06 oz/ton Au, and 6.1 oz/ton Ag.

Rich (1974) estimated the 1-foot-thick vein to contain a minimum of 182,000 tons of Cu-Ag-Au ore.

Tip Top claim; (location not given). Gangue minerals include calcite, ankerite, siderite, and barite. Ore minerals include galena and argentiferous tetrahedrite associated with proustite and stromeyerite. Small amounts of chalcopyrite and pyrite are present and the wall-rocks are sericitized. An assay of dump material yielded 0.02 oz/ton Au, 7.14 oz/ton Ag, 0.60 percent Pb, and a trace Cu (Parsons, 1937). In 1938, nearly a ton of rock was shipped to the Bunker Hill Smelter at Kellogg, Idaho. That shipment assayed 0.01 oz/ton Au, 39.9 oz/ton Ag, 0.7 percent Cu, and 2.3 percent Pb (U.S. Bureau of Mines Mineral Resources Yearbook, 1939, p. 495).

Upper Silvertip Basin prospect; at an elevation of 10,000 feet, in the upper end and on the east side of Silvertip Basin (Figure 7). A 52-foot adit trends N85°W in andesite. One selected sample of dump

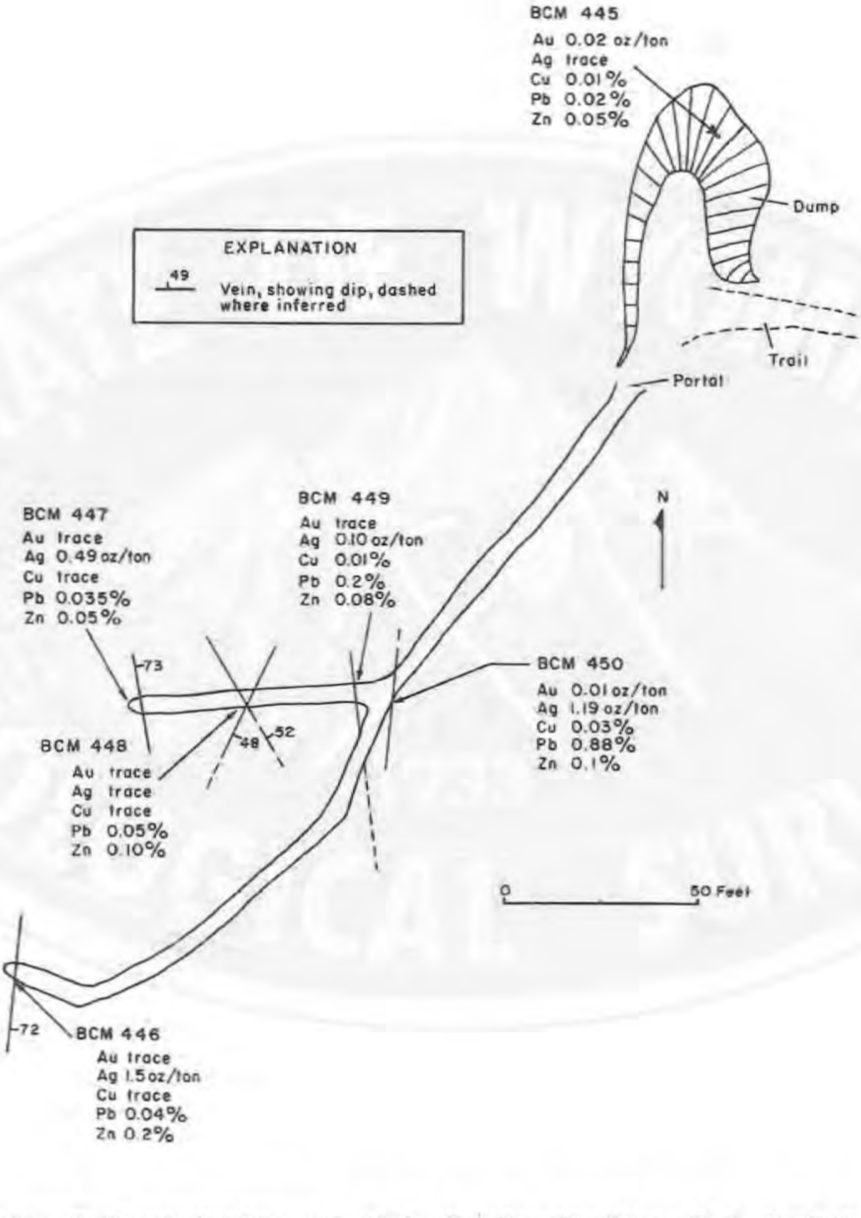


Figure 9. Sample location map of the Novelty adit, Galena Basin, Sunlight mining district (modified from Nelson and others, 1980).

material yielded only traces of Au, Ag, Cu, Pb, and Zn (Nelson and others, 1980, p. 51).

Wild Goose group; at the head of Sulphur Creek (Figure 7). Stringers of calcite and quartz contain copper sulfides (Osterwald and others, 1966, p. 60).

Winona claims group; near Winona Camp at the head of Sulphur Creek Basin (Figure 7), a group of claims including the Greenhorn, Uncle Frank, Malachite, Copper Queen, Copper King, Mohawk, Copperopolis, Granite Mountain, Butte, Doubtful, Gopher, Hidden Treasure, and B & S (Rich, 1974; Nelson and others, 1980, p. 36-41). Samples taken from some of these claims were assayed for base and precious metals (Table 2).

Table 2. Reported assays of samples collected from the Winona Claim group.

	Assay					
Name of claim	Cu (%)	Pb (%)	Zn (%)	Au (oz/ton)	Ag (oz/ton)	Comments and references
B & S	25.8	—	—	0.08	16.4	Assay report (see Rich, 1974, p. 41).
Butte	4.43	—	—	0.22	3.14	Vein outcrop (Parsons, 1937, p. 847).
Copper King	3.35	—	—	0.04	0.62	Average of ore found on dump (Parsons, 1937, p. 847).
Doubtful	29.2	—	—	0.28	19.0	Assay report (Rich, 1974, p. 41).
Gopher	6.7	—	—	0.24	1.76	Assay report (Rich, 1974, p. 41).
Greenhorn (Winona adit)	—	—	—	0.58	0.88	Average of ore found on dump by Parsons (1937, p. 847).
	0.01	0.04	0.02	0.01	0.06	Composite sample of dump material from the Winona adit (Nelson and others, 1980, p. 39). The Winona adit was reported to have 1,135 feet of workings.
Hidden Treasure	47.8 12.4	— —	— —	0.16 0.05	11.64 —	Assay reports (Rich, 1974, p. 41).
Malachite	34.8	—	—	0.08	30.5	Assay report (Rich, 1974, p. 41).
Malachite I	44.7	—	—	0.12	25.46	Assay report (Rich, 1974, p. 41).

Miscellaneous porphyries and prospects

Clouds Home Peak porphyry; near the top of the peak (44°15'00", 109°42'30") (Figure 2). An intrusive complex with rocks of compositions ranging from porphyritic dacite and rhyodacite to equigranular granodiorite and quartz monzonite crops out over an area of more than 1 square mile. Mineralization and alteration occur sporadically along a 1-mile-long north-south trend located within the composite intrusive.

According to Fisher and Antweiler (1980), about 5 percent pyrite and traces of chalcopyrite occur as disseminations and as fracture coatings in the intrusive and also in some dikes. Other expressions of mineralization include small pyrite-chalcopyrite-rhodochrosite quartz veins (2 inches or less wide) that cut granodiorite in a 3-foot-wide zone; and a 300-foot-wide stockwork hosting malachite, azurite, chalcopyrite, quartz, pyrite, chlorite, and epidote. Anomalous Cu, Mo, Pb, Zn, and Ag were detected in geochemical samples. Gold was not detected (Fisher and Antweiler, 1980).

Alteration includes both propylitic and phyllic assemblages. The phyllic alteration is restricted and closely associated with veins, fractures, and dikes. Propylitic alteration is widespread. Oxidation has produced limonite staining, minor malachite staining, and bleaching of the rocks (Fisher and Antweiler, 1980).

Crandall Creek placers; sec. 9, T.56N., R.106W. Gold placer diggings and some lode mines occur along Crandall Creek (Avon Brock, personal communication, 1986). No other information is available (see Clark Fork placers, Bighorn Basin, page 34).

Deer Creek porphyry; north of Stinkingwater and south of Clouds Home Peak along a linear trend. Granodiorite, dacite, and andesite dikes intrude vent-facies flows and breccias of the Wiggins Formation. Anomalous copper has been detected in rock outcrops (Fisher, 1981)

Eagle Creek mineralized area; T.51N., R.109W., near the Yellowstone National Park boundary, about 40 miles west of Cody, Wyoming. The porphyry is accessible by 12 miles of pack trail (Eagle Creek trail) into the wilderness.

The region was prospected in 1911 and, by 1955, 640 feet of drifts and 50 feet of shaft were dug on what is called the Crouch prospect near the south edge of the intrusive complex (Figure 10) (Osterwald and others, 1966; Wilson, 1955). The only recorded production was two ore shipments delivered to the Denver Mint in the 1930s that were collectively valued at $1,000 in gold (28 to 48 ounces) (Wilson, 1955).

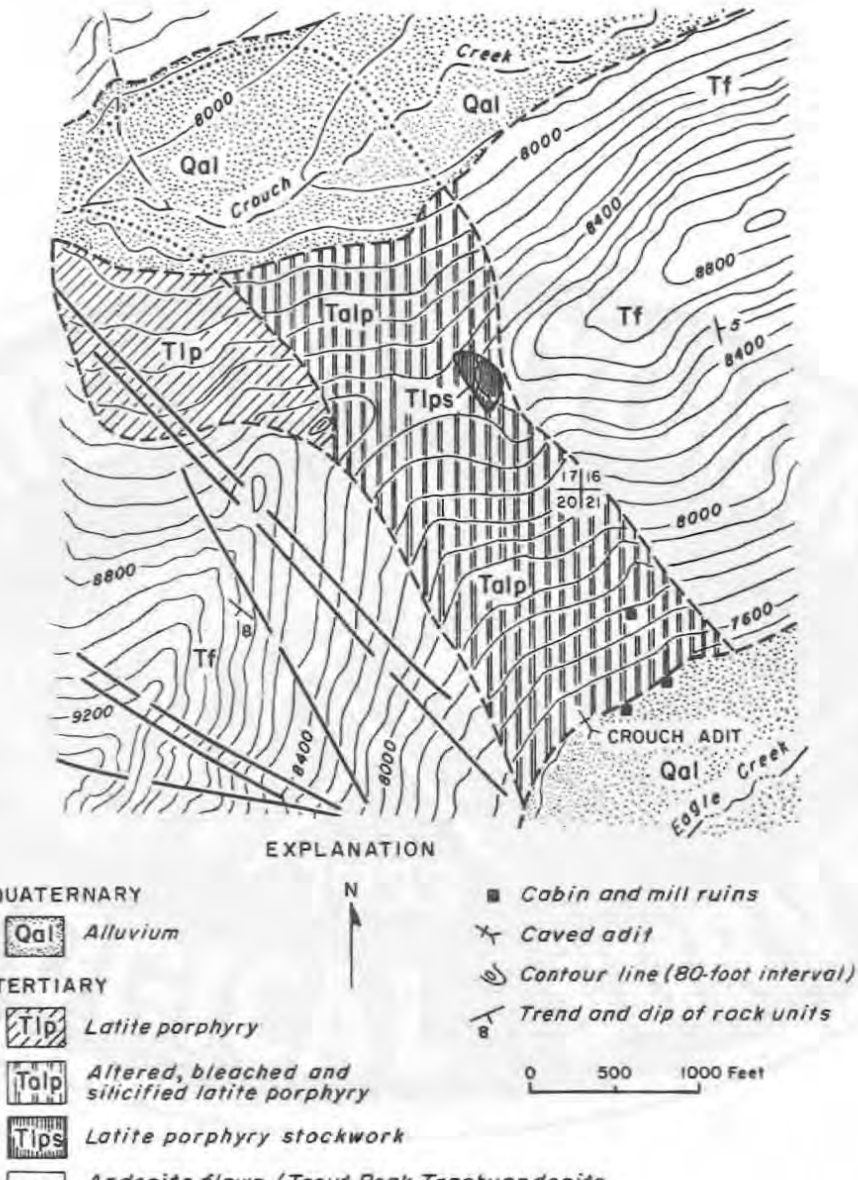


Figure 10. Generalized geologic map of the Eagle Creek porphyry, T.51N., R.109W., (after Galey, 1971). Base metal deposits of the Eagle Creek region are associated with intrusive latite porphyry. There is little evidence for supergene enrichment.

The country rock in the Eagle Creek region is formed of andesite flows and flow breccias of the Eocene Trout Peak Trachyandesite and Langford Formation. In the immediate area of interest, these two formations are vent-series facies mapped as undifferentiated andesites.

Mineralization is directly related to the emplacement of an irregularly shaped intrusive (post-Oligocene?) of mainly latite composition. This latite porphyry is fractured and mineralized and has a well-defined stockwork near the east-central edge of the intrusive, where it lies within a topographic saddle (Figure 10). The stockwork is expressed by narrow, N32°E and N64°W trending quartz veinlets carrying pyrite, chalcopyrite, and galena in a dominantly phyllic altered zone. A further expression of mineralization extends out from the stockworks into silicified and altered latite porphyry and into relatively fresh latite porphyry on the northwestern edge of the saddle. The mineralization occurs as pyrite disseminations; as narrow pyrite, galena, sphalerite, and chalcopyrite quartz veins (less than 1 inch wide) in the altered silicified latite; and as fine pyrite and chalcopyrite(?) disseminations in the gray latite porphyry. There is no evidence that supergene enrichment is important in the district (Galey, 1971). Some placer gold is reported along Eagle and Crouch Creeks (Wilson, 1955).

Hydrothermal alteration is intense near the central portion of the stockworks and is characterized by phyllic and potassic alteration assemblages. The intense alteration grades laterally to regional propylitic alteration (Galey, 1971).

Robinson Creek porphyry; nearly 50 miles southwest of Cody and 15 miles southwest of Valley at the headwaters of Robinson Creek (44°00′00″, 109°47′15″) (Figure 2). Access to the porphyry complex is by pack trail along the South Fork Shoshone River to Robinson Creek.

The mineralized area includes a roughly 1-square-mile, hydrothermally altered and mineralized, rhyodacitic to dacitic composite stock emplaced in flows and flow breccias of the Wiggins Formation. Texturally, the intrusive has both porphyritic and phaneritic phases.

Mineralization, coextensive with phyllic alteration, is exposed as discontinuous stockworks hosting chalcopyrite, pyrite, and malachite. Chalcopyrite is present as disseminated grains and malachite as fracture coatings. The mineralized rocks are intensely shattered; fracture zones trend from N20°W to N60°W, with a less well developed set trending to the northeast. Anomalous Pb-Zn-Ag-Mo mineralization has been detected by assays (Fisher and Antweiler, 1980).

Bighorn Basin

The Bighorn Basin is a large (approximately 10,000 square miles), relatively symmetrical, intermontane topographic and structural basin that extends south from Montana to the Owl Creek Mountains in central Wyoming. The eastern flank of the basin is bounded by Precambrian-cored Laramide uplifts known as the Bighorn and Pryor Mountains, and the western margin is covered by thick Tertiary calc-alkalic flows and flow breccias that make up the Absaroka Mountains. Farther north, the Beartooth Mountains form a portion of the western boundary of the basin.

The basin's margins are defined topographically and by outcrops of Paleozoic sediments overlain by shales and sandstones of Cretaceous age. Much of the central portion of the basin is overlain by Tertiary units, which include the Paleocene Fort Union Formation and the Eocene Willwood Formation. Some conglomerates of the Fort Union Formation contain anomalous gold (Antweiler and Love, 1967), and the Willwood includes local gold-bearing conglomeratic lenses (Love and Christiansen, 1985).

Information on gold in the Bighorn Basin is sparse. However, Albert's (1986) map shows several stream-sediment anomalies along the western flank of the basin and in the vicinity of the Bighorn River. One sample collected east of Lovell in T.56N., R.95W. contained 2.74 ppm Au.

Titaniferous black sandstone deposits hosted by Late Cretaceous sediments of the Mesaverde Formation are known at several localities in the Bighorn Basin and elsewhere in Wyoming (Houston and Murphy, 1962). These paleoplacer beach sands contain abundant heavy minerals including ilmenite, titaniferous magnetite, chromite, zircon, rutile, monazite, niobium-bearing minerals, and gold. Houston (1969), writes:

> *Gold is not abundant, but deposits of Wyoming and Colorado contain as much as 1.3 ppm. In Wyoming, the younger deposits contain the higher gold contents.*

Houston and Murphy (1962) examined several black sand occurrences in the Bighorn Basin and elsewhere in Wyoming, but unfortunately their report did not address gold. Thus only a brief summary of the locations of the black sands in the Bighorn Basin is given on Table 3. For information on black sand deposits elsewhere in Wyoming, refer to Houston and Murphy (1962) and Dow and Batty (1961).

Table 3. Black sand paleoplacer deposits in the Bighorn Basin (from Houston and Murphy, 1962).

Black sand deposit	Location and discussion
Cowley	Two miles south-southwest of Cowley in the NW¼ sec. 1, T.56N., R.97W.
Lovell	Six miles south-southeast of Lovell. The deposit crosses the township line between sec. 7, T.55N., R.95W., and sec. 12, T.55N., R.96W.
Dugout Creek	Fifteen miles south of Tensleep in secs. 34 and 35, T.45N., R.89W. and in secs. 2 and 11, T.44N., R.89W. Largest individual deposit of black sand known in Wyoming.
Mud Creek	Twenty miles east-northeast of Thermopolis in center of sec. 19, T.44N., R.91W.
Grass Creek deposits	Two isolated segments on the flanks of the Grass Creek anticline in secs. 8, 9, and 16, T.46N., R.98W. and in secs. 33 and 34, T.46N., R.98W. These are the largest deposits known in Wyoming.
Cottonwood Creek	SE¼ sec. 26, T.45N., R.97W.

Placer deposits

Clark Fork placers; Ts.57-58N., R.101W. Gold placers on the Clark Fork of the Yellowstone River were mined in the 1930s using sluices and a dragline. These placers apparently occur near the town of Clark along the western margin of the Bighorn Basin although the exact locations of the various placers are not clear from the discussions in the U.S. Bureau of Mines Minerals Yearbooks. According to the U.S. Bureau of Mines, a small amount of gold with an average fineness of 0.906 was recovered from the Dietrick placer on Clark Fork in 1931. In 1933, some additional gold was produced from a placer operation on Clark Fork (see Crandall Creek placers, Absaroka Mountains, p. 30).

Bighorn Mountains

The Bighorn Mountains form an elongate north-south uplift in north-central Wyoming with Paleozoic sedimentary rocks unconformably overlying Precambrian granite and gneiss. In general, the strata on the western flank of the range have relatively gentle, low-angle (locally steep) dips into the Bighorn Basin compared to the strata on the eastern flank, which dip steeply into the Powder River Basin and are overturned in places. Spectacular examples of the inclined Paleozoics are exposed in Shell Canyon and Tongue Creek Canyon along U.S. Highway 14 between Shell and Dayton, Wyoming. Precambrian rocks are exposed throughout much of the core of the Bighorn uplift.

The highest portion of the range is located west of Buffalo, Wyoming, where several peaks rise above 10,000 feet and culminate at Cloud Peak (elevation 13,175 feet). This high part of the range was extensively glaciated and now has many spectacular cirques. To the north and south of this region, gentle grass-covered and timbered slopes dip eastward and westward into the Powder River and Bighorn Basins, respectively.

At the southernmost tip of the Bighorn Mountains northeast of Lysite, schists crop out over a fairly large region, but little is known about the geology of the area. Farther north, the Precambrian core is buried by the Cambrian sedimentary rocks. Still farther north, the Precambrian core is exposed over a large area totaling more than 1,000 square miles. A portion of this Precambrian complex in the vicinity of Bald Mountain is separated from the main body of Precambrian rocks by a large area covered with Flathead Sandstone and younger Paleozoic rocks.

Osterwald (1959) separated the main body of Precambrian rocks of the Bighorns into northern granitic and southern gneissic terranes (Figure 11). The northern granitic terrane is largely pink to gray, medium- to coarse-grained plutonic rocks that range from granitic to quartz dioritic in composition. The gneissic southern terrane is gray quartzofeldspathic gneiss with minor tonalite and numerous concordant and disconcordant pods and lenses of amphibolite. At least one ultramafic complex has been identified in the southern gneissic complex west of Buffalo along Clear Creek (Luth, 1960).

Rubidium-strontium isochron ages of the northern granites and southern gneisses are essentially the same, 2,850 Ma (Heimlich and Banks, 1968; Stueber and Heimlich, 1977). This age is interpreted as the time of regional metamorphism and metasomatism that produced the gneissic and granitic rocks. Potassium-argon dating reported by Heimlich and Armstrong (1972) indicates that the event responsible for the formation of the Precambrian crystalline rocks ended 2,750 Ma ago.

However, more recent work by Arth and others (1980) indicates a more complex Archean history for the Bighorn Mountains. Their study of rocks in the southwestern portion of the range near Lake Helen indicated the gneisses in that region were older than previously reported and were also affected by at least two episodes of magmatism, deformation, and metamorphism. The first event occurred at about 3.0 Ga and the second event occurred at about 2.8 Ga. At 3.0 Ga, a bimodal suite of tonalitic to trondhjemitic and mafic (amphibolite) magmas were derived from an isotopically primitive source. These orthogneisses and amphibolites, which formed a primitive crust, were intruded by calc-alkaline rocks including quartz diorite, tonalite, granodiorite, and granite during the second episode,

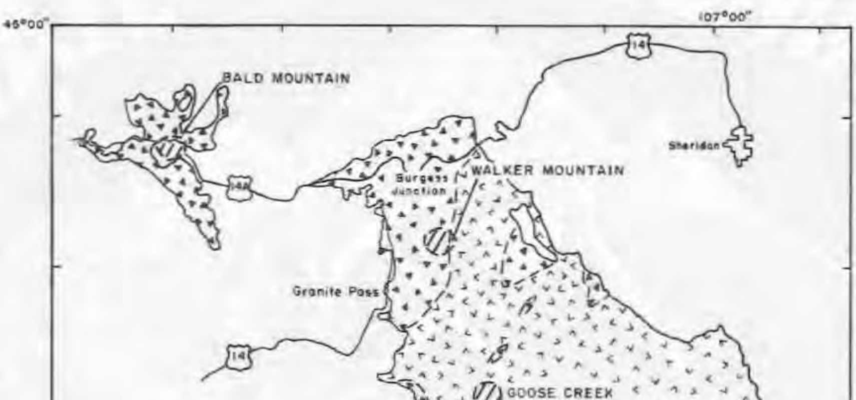


Figure 11. Regional geologic map of the Precambrian core of the northern Bighorn Mountains, showing locations of principal precious metal areas (modified from Heimlich, 1971).

at 2.8 Ga. The calc-alkaline rocks are isotopically distinct from the earlier bimodal suite (Arth and others, 1980).

More than one generation of mafic dikes occurs in the Bighorn Mountains. One group of dikes is approximately the same age as the granites and gneisses (Stueber and Heimlich, 1977) while a younger relatively unmetamorphosed generation of tholeiitic dikes yielded K-Ar dates of 1,910 to 2,110 Ma (Condie and others, 1969).

The Precambrian granites and gneisses of the Bighorn Mountains are not considered to be likely hosts for major precious metal occurrences. Scattered gold anomalies are reported, but no major precious metal discovery has ever been recorded. However, the legend of the Lost Cabin gold mine is enticing to treasure hunters and prospectors, and the possibility that a rich deposit may occur somewhere in the mountain range cannot be easily dismissed.

The known precious metal deposits are associated with mafic dikes, veins, and shear zones in the granites and gneisses and with paleoplacers in the overlying Flathead Sandstone and placers in modern drainages. In the late 1800s and early 1900s, several areas in the Bighorn Mountains were prospected for gold with little success, but paleoplacer gold prospects at two different localities in the Flathead Sandstone appeared to offer some potential. Additionally, argentiferous manganese deposits in the central part of the range are interesting although not much is known about them. The known gold prospects and mines in the Bighorns can be grouped into the following areas — Bald Mountain, Goose Creek, Hazelton Peak, Kelley Creek, and Walker Mountain (Figure 11). Only the Bald Mountain area has been extensively explored.

Bald Mountain

This deposit occurs within secs. 20, 21, 22, 23, 27, 28, 30, and 31, T.56N., R.91W. Near the turn of the century, this area had considerable gold mining activity. The town of Bald Mountain was organized to support about 1,500 people and three stamp mills. But the gold values in the conglomerates were too low to support commercial operations and the town was abandoned the following year (McKinney and Horst, 1953).

The Bald Mountain gold deposits are paleoplacers and placers. The basal Middle Cambrian Flathead Sandstone (reported as the Deadwood conglomerate by early workers) contains fine-grained free gold. According to Beeler (1908b), the gold occurs as flat grains with jagged edges. Based on the morphology of the grains, the source for the gold was probably nearby. But in addition to gold, the Bald Mountain conglomerates also contain other heavy minerals such as ilmenite, magnetite, zircon, and monazite. Because of their high specific gravities, the greater gold concentrations are often found with greater quantities of these heavy minerals.

Principally because of monazite (a rare earth- and thorium-bearing phosphate), this deposit has been the object of considerable interest by the U.S. Bureau of Mines and others during the past 40 years (McKinney and Horst, 1953; Wilson, 1951a; Borrowman and Rosenbaum, 1962; Kline and Winkel, 1952; King and Harris, 1987). In 1952, the U.S. Bureau of Mines drilled 92 holes to test the conglomerate for monazite, and estimated that 20 million tons of material contained an average of 2.5 pounds of monazite/ton (McKinney and Horst, 1953; Borrowman and Rosenbaum, 1962). Additionally, a high-grade zone outlined during drilling contains 675,000 tons of conglomerate averaging 13.2 pounds of monazite/ton (Borrowman and Rosenbaum, 1962).

During the testing of the conglomerate at Bald Mountain, the U.S. Bureau of Mines made gold assays on the material from six holes drilled within the best-grade monazite areas. Their assays showed gold contents to range from 0.001 oz/ton to 0.005 oz/ton, averaging 0.003 oz/ton (0.103 ppm) (McKinney and Horst, 1953). However, samples were reported by Darton (1906) to run as high as 0.10 oz/ton Au (possibly within recent unconsolidated placers in modern drainages).

Modern gold placers are reported in the Bear Creek drainage (sec. 31, T.56N., R.91W.), in Porcupine Creek (sec. 21, T.56N., R.91W.) in the Bald Mountain area (Cardinal, 1958), and to the east in a tributary of Dayton Gulch (SW¼ sec. 18, T.56N., R.90W.). East of Bald Mountain, Henderson (1934) reported a small amount of gold was recovered from the Rocky Fall placer.

Goose Creek area

The Goose Creek area, in T.52-53N., R.86W., includes several short adits and minor prospects along the East Fork of Big Goose Creek. Darton (1906) reported samples collected in this region contained as much as 0.58 oz/ton Au and 10.45 oz/ton Ag.

These prospects were developed on pyritic quartz veins in diabasic dikes and pegmatites in biotite gneiss and granite country rock. Kiilsgaard and others (1972) sampled several prospects in the region and found no significant precious metal anomalies.

Hazelton Peak area

Reported mine and prospect descriptions

Big Horn (Powder River) mine; NW¼ sec. 20, T.47N., R.85W. A 110-foot shaft was sunk on a quartz vein in hornblende schist in granite gneiss country rock. The vein contains gold and manganese. An amalgamation mill installed on the property proved to be worthless; after an hour of operation, the mercury plates became coated with manganese and would not attract gold (Osterwald and others, 1966). Vein material collected from the mine yielded no detectable gold to 1.22 oz/ton (Table 4).

Table 4. Assays on vein material from the Big Horn (Powder River) mine (Mathisrud, 1957).

Sample number	Description	Au (oz/ton)	Ag (oz/ton)
1	No. 2 vein, 75-foot level, face at 45 feet west of shaft.	0.004	0
2	No. 2 vein, 75-foot level, back at 38 feet west of shaft.	0	0
3	No. 2 vein, 75-foot level, grab sample from muckpile.	0.06	0
4	No. 2 vein, 75-foot level, back 28 feet west, 31-inch-wide vein.	1.22	trace
5	No. 2 vein, 75-foot level, face at 72 feet east of shaft.	0.014	0
6	No. 2 vein, 75-foot level, back 37 feet east.	0	0
7	No. 2 vein, 75-foot level, back at shaft.	0.01	0
8	No. 2 vein, 75-foot level, rib in shaft.	0	0
9	No. 2 vein, 50-foot level, face at 32 feet east of shaft.	0	0
10	No. 4 vein, dump sample of rusty quartz.	0.01	0
11	No. 3 vein, dump sample of selected Cu-stained quartz.	0.12	0
12	No. 1 vein, dump sample of selected rusty quartz.	0.23	0

Bull Camp group; sec. 26, T.47N., R.84W., 7 miles south of Hazelton. Red and gray granites host felsite dikes and schist layers. A quartz vein dips 60°N. and follows the contact between red granite to the north and gray granite to the south. The vein is 14 to 20 inches wide; several small stringers join it from the south. The north side of the vein contains limonite and copper carbonates at the surface and small bunches of chalcopyrite and bornite below a depth of 45 feet. A small amount of pyrite is distributed in the footwall granite in veinlets, lenses, and specks (Beeler, 1904a). Darton (1906, p. 114) reported minute veins widely scattered through the rocks. The *Engineering and Mining Journal* (1896, v. 62, p. 327) reported samples from this group yielded a trace to 10 percent Cu and 0.05 to 0.5 oz/ton Au.

Powder River Pass; SE¼ sec. 4, T.48N., R.85W., on a ridge just north of U.S. Highway 16 at Powder River Pass. A quartz vein (maximum thickness 6 inches) cuts strongly foliated, isoclinally folded, oligoclase-biotite-hornblende gneiss. The vein contains malachite at scattered intervals and isolated pyrite anhedra up to 3/8 inch in diameter. Fold axes and lineation in the gneiss plunge N30°E to N60°E; the vein strikes N65°E, parallel to gneissic layering (Osterwald and others, 1966, p. 54). Samples were not assayed for precious metals.

Taylor prospect; sec. 19, T.47N., R.85W. Psilomelane and pyrolusite occur as fracture fillings, streaks, and stains in Ordovician Bighorn Dolomite. A few handpicked specimens assayed as high as 45 percent Mn and 15 oz/ton Ag (Hagner, 1944).

Top Hand group; east of the Bull Camp group in sec. 31, T.47N., R.84W. (possibly R.83W.?). Red granite and lesser amounts of gray granite contain mafic dikes and layers of gneiss and schist. A biotite-rich layer strikes northwest and dips northeast. All rocks are cut by quartz veins, which are stained with limonite and malachite at intervals (Beeler, 1904b). No samples were analyzed for precious metals. Rare earths are reported from a 15-foot-deep shaft (Anonymous, 1987).

Kelly Creek area

The Kelly Creek area lies near the head of Kelly Creek in T.50N., R.83W. The basal Flathead Sandstone (reported as the Deadwood conglomerate by early workers) reportedly hosts gold (Darton, 1906). The *Engineering and Mining Journal* (1896, v. 62, p. 327) reported that gold values from Kelly Creek were from 0.15 oz/ton to 0.24 oz/ton, but only about 0.06 oz/ton could be saved by stamping the ore. Although it is not known how much ore was produced from this area, Maple (1959) indicated less than $5,000 in gold (less than 250 oz) had been recovered between 1900 and 1947.

Walker Mountain area

Mines and occurrences

Hamilton mine; NE¼ sec. 1, T.54N., R.88W. A several-foot-wide, sulfide-bearing, crushed quartz vein occurs in granite. Assays of ore specimens from the mine show between 0.024 and 0.32 oz/ton Au with a trace to 1.29 oz/ton Ag (Robert H. Hamilton; personal communication, 1987).

Mosaic claim; T.54N., R.87W. Samples of vein quartz in granite gneiss from the Mosaic claim contained scheelite and possibly wolframite and tungstite. A tunnel exposed a 2-foot-wide gouge zone containing tungsten, gold, and silver values. Knight (1939) reported assays of samples collected in the mineralized zone (Table 5).

Table 5. Assay results of samples taken from the Mosaic claim (Knight, 1939).

Sample number	Description	WO_3 (%)	Au (oz/ton)	Ag (oz/ton)
2	Average grab sample of 15-inch-wide rusty band.	0.26	—	—
4	Average grab sample of 5-foot zone.	—	0.04	0.36
5	Average grab sample of a 5-foot zone.	—	0.02	0.50
6	Average grab sample of 3-foot zone.	0.10	0.025	0.40

Taylor mine; sec. 5, T.54N., R.87W. The Taylor shaft was sunk on a 15-foot-wide altered diabase dike in pegmatitic granite country rock. The dike has fractures filled with magnetite, hematite, limonite, chalcocite, malachite, chrysocolla, and quartz (Osterwald and others, 1966). No assays were reported.

Walker mine; southwest of Walker Mountain. This mine was developed on a 15- to 25-foot-wide, malachite-stained quartz vein in granite by a 56-foot-deep shaft. Samples from the vein contained 0.15 to 0.20 oz/ton Au with some galena (Darton, 1906).

Miscellaneous

Roe Brothers group; sec. 15, T.49N., R.83W., 17 miles from Buffalo. Dark colored dike rock cuts red granite and contains quartz, limonite, hematite, and a few isolated green copper stains. Assays show small amounts of gold (Beeler, 1904c).

Lost Cabin gold mine

According to historical records, the Lost Cabin gold mine was never really developed into a mine, but was a placer or weathered vein or shear located in a park (treeless area) along a creek in the Bighorn Mountains. The deposit was reported to be so rich that gold could be picked up from the surface with little effort. Reports claim seven prospectors made the discovery in the fall of 1865 and worked the property for three to six days before they were attacked by Indians, who killed five of the seven men. Two men escaped with an estimated 350 oz of coarse gold. The only monuments to identify the discovery were a small log cabin (or lean-to), a flume, and at least one prospect pit 3 to 4 feet deep.

The survivors traveled for three nights on foot until they reached Fort Reno in the western Powder River Basin. In the spring, they hired eight to ten prospectors to return to their discovery, but the entire party was killed by Indians (*The Mining Record*, December 26, 1979, p. 4). Several people have examined the Bighorn and nearby Owl Creek Mountains looking for the Lost Cabin mine, but to this day it remains only a legend.

Black Hills uplift

The Black Hills region of Wyoming (Figure 12) represents part of a dome-shaped uplift that extends into South Dakota and is cored by a 2.6 Ga Precambrian basement complex surrounded by Paleozoic and Mesozoic limestone, shale, and sandstone. Tertiary alkalic and peralkalic igneous rocks in Wyoming intrude the older units at a number of locations. The principal intrusive centers are between 30 and 55 Ma, and include the Bear Lodge Mountains complex, Black Buttes, Devils Tower-Missouri Buttes, Inyan Kara Mountain, Mineral Hill complex, and Sundance Mountain (Lisenbee, 1985). Of these, mineralization is known to be associated with the Bear Lodge Mountains complex, Black Buttes, and the Mineral Hill complex.

Precious metals, base metals, tin, fluorite, uranium, thorium, columbite, and rare earths have been reported in this region (Hausel and Harris, 1983; King and Harris, 1987). Recently, anomalous gold (maximum 1.0 ppm) was detected in Cretaceous sandstones associated with uranium-vanadium mineralization along the western margin of the Black Hills uplift (Gordon Marlatt, personal communication, 1986), and anomalous gold was also detected in several stream-sediment samples collected near the margin of the uplift (Albert, 1986).

In the early 1900s, anomalous gold and silver were also reported in a coal bed of the Cretaceous Lakota Formation along the southern margin of the Black Hills uplift (Stone, 1912, p. 63). In this same region, it was reported that work was being done in 1897 to construct a canal and flume from Cold Springs to Beaver Gulch near Newcastle for use in hydraulic mining for gold (*Engineering and Mining Journal*, 1897, v. 64, p. 409). No other information is available about this hydraulic operation.

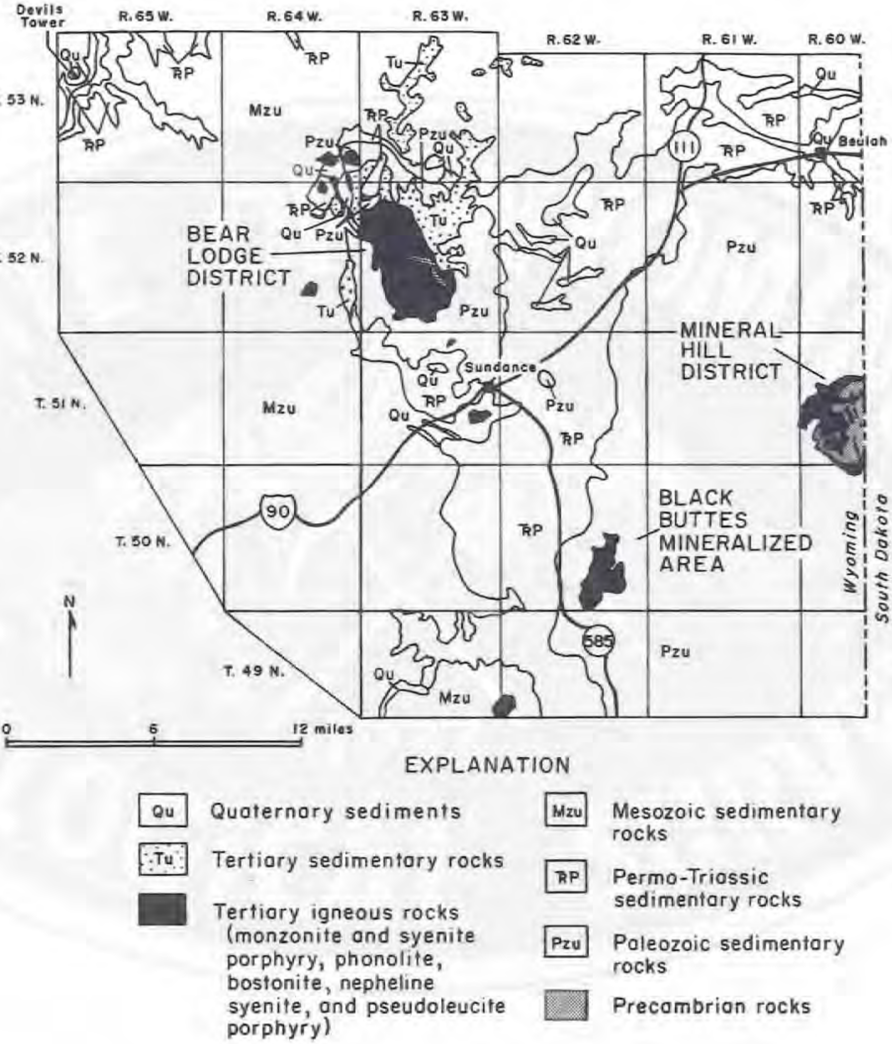


Figure 12. General geology of the Bear Lodge, Black Buttes, and Mineral Hill districts, Black Hills uplift, Wyoming (after Love and Christiansen, 1985; and Lisenbee, 1985).

Bear Lodge district

The Bear Lodge Mountains are located in northeastern Wyoming a short distance north of Sundance in Crook County (Figure 12). This district has attracted minor interest in the past for gold and fluorspar, but in recent years it has attracted greater attention for potential low-grade gold mineralization associated with potassically fenitized alkalic igneous rock (Jenner, 1984) and low-grade rare-earth and thorium resources in similar rock types (Staatz, 1983). According to early reports, assays of fluorite from veins in the district yielded as much as 5.8 oz/ton Au, and some pegmatites assayed up to 0.25 oz/ton Au (Osterwald and others, 1966).

The Bear Lodge Mountains represent a northwestern extension of the Black Hills. These mountains are completely surrounded by Paleozoic and Mesozoic rocks that dip radially away from the central dome core complex. Within this core complex are Tertiary alkalic igneous rocks that yielded K-Ar dates of 38.0 to 50.0 Ma (Staatz, 1983; Lisenbee, 1985). Large irregular xenoliths of Precambrian granite occur in the Tertiary dome (Jenner, 1984). The granite xenoliths are at least 2.6 Ga (Staatz, 1983).

Much of the mineralization reported in the Bear Lodge district is associated with potassic fenitization and with carbonatitic magmatism. Thorium, rare earths, copper, lead, and zinc are associated with fenitized and carbonatized rocks but gold appears to be localized only in the fenitized rocks (Jenner, 1984). Since many of the Tertiary gold deposits in the central Black Hills of South Dakota are accompanied by silicification and argillic alteration, gold may also be associated with similarly altered rocks in the Bear Lodge Mountains.

Four petrologic events are recognized in the Bear Lodge core complex: (1) early igneous activity, (2) potassic fenitization (metasomatism), (3) carbonatitic magmatism, and finally (4) late igneous activity (Jenner, 1984). According to Jenner (1984), hydrothermal alteration began during the early igneous event but the effects are restricted to the near surface and diminish with depth; this alteration has no economic importance other than the oxidation of near-surface ore minerals. It is unclear to the author what sort of hydrothermal activity would be restricted to the zone of oxidation. It may be, as suggested by Jon K. King (personal communication, 1988), that hydrothermal alteration has been confused with surface weathering and oxidation.

The early igneous activity is characterized by subvolcanic and plutonic alkalic igneous rocks. These rocks include latite, trachyte, and phonolite porphyries and natrolite-garnet syenites and malignites. The original textures and compositions of these rocks have been modified by potassic fentization so the exact nature of the early igneous activity is obscured.

Potassic fenitization was marked by potassium, iron, sulfur, fluorine, and carbon dioxide enrichment and silica depletion. Petrographically, this is manifested in a number of changes, the most obvious being the increase in K-feldspar and the removal of quartz. For example, the fenites exhibit increases in sanidine and hematite, and the granite xenoliths have been depleted in quartz, much of which was apparently reprecipitated as quartz pods and veins in the granite or as chalcedony in the surrounding fenites and alkalic igneous rocks. The metasomatism of the alkalic igneous rocks resulted in the formation of ultrapotassic igneous rocks, which include alkali trachyte, alkali trachyte porphyry, alkali metasyenite, alkali leucosyenite, psuedoleucite alkalic trachyte porphyry, and intrusive breccia (Jenner, 1984). These rocks show enrichments in rare earths, thorium, copper, lead, zinc, and gold (Staatz, 1983; Jenner, 1984). Jenner (1984) reported low-grade gold mineralization in the southeastern Bear Lodge Mountains associated with oxidized intrusive feldspathic breccia. According to Brown (1952), Jenney (1876) reported some gold occurred in trachyte and also in association with manganese. Manganese appears to be relatively common in the Bear Lodge complex, particularly in the vicinty of Bull Hill (sec. 17, T.52N., R.63W.) where manganese stains and replaces the host trachytes and occurs in veins. Brown (1952) reported gold was found in fissures in trachyte and along trachyte-Deadwood Formation contacts. Staatz (1983) indicated the fenites of the Bear Lodge Mountains could contain one of the largest low-grade thorium and rare-earth resources in the United States. For example, veins and veinlets in these metasomatized rocks, which are common near the surface, contain up to 1.2 percent thorium and 9.8 percent total rare earths (Staatz, 1983).

Copper-lead-zinc mineralization also occurs in the metasomatic and rheomorphic rocks. In subsurface, these metals occur in the sulfides chalcopyrite, galena, and sphalerite and are associated with pyrite and pyrrhotite. Sulfides are rare at the surface because of oxidation, but they increase with depth until chalcopyrite occurs in near-economic amounts locally (Jenner, 1984).

Following the episode of potassic fenitization, carbonatite dikes and veins intruded the fenites. Carbonatites have been found in the NW¼NE¼ sec. 20, T.52N., R.63W. and in the SE¼SE¼ sec. 7, T.52N., R.63W. (Wilkinson, 1982). They are believed to have been generated by differentiation of an alkalic igneous magma at depth

(Jenner, 1984). Jenner also reported that the carbonatites have carbon and oxygen isotopic compositions that suggest they were derived from the mantle. These rocks are enriched in thorium and rare earths and contain values of 54 to 1,510 ppm thorium and 0.58 percent to 6.6 percent rare earths (Staatz, 1983). The principal rare earths are cerium and lanthanum. Disseminated chalcopyrite, galena, fluorite, and sphalerite are also associated with these carbonatites.

According to Jenner (1984), carbonatites(?) are also exposed in the southeastern portion of the Bear Lodge Mountains in SW¼SW¼ sec. 27, T.52N., R.63W. and SE¼SE¼ sec. 28, T.52N., R.63W. These carbonate rocks are associated with fluorspar and have been interpreted in the past to be Precambrian marble xenoliths (Chenoweth, 1955) and Pahasapa Limestone xenoliths (Staatz, 1983). However, according to Jenner (1984), these rocks exhibit several dike-like igneous features and may have resulted from the assimilation of sedimentary limestone by an alkali magma. These rocks are poor in strontium, cerium, and lanthanum.

The final episode of Tertiary igneous activity in the Bear Lodge Mountains was marked by the intrusion of relatively unaltered analcime phonolite porphyry.

Much of the reported past exploration activity in the Bear Lodge district occurred in the central portion of the intrusive complex in secs. 17, 18, 19, and 20, and near its southeastern edge in sec. 27, T.52N., R.63W. (Hausel and Sutherland, 1988). Near the turn of the century, a four-stamp mill was constructed on Stamp Mill Creek to process gold ore mined along a phonolite-trachyte contact near the central portion of the intrusive complex but the mill was unsuccessful because of excessive manganese in the ore. The manganese occurs as psilomelane and pyrolusite in veins and fissures within highly fractured and altered igneous rock (Chenoweth, 1955).

On one group of claims known as the Hutchin's claims, Jamison (1912) reported a series of northwest trending, northeast dipping, limonite-stained, quartz-pyrite-fluorite veins. The veins were generally less than 4 inches wide and yielded gold values (Jamison, 1912). Hall (1911, 1914) described some wider veins. According to his reports, these veins ranged from a few inches to 30 feet wide and yielded gold values ranging from a trace to 6 oz/ton.

A few of these veins were explored underground. The Bock Mining Company cut one fluorite vein in a drift. Assays were reported to run

0.35 oz/ton Au (Anonymous, 1911a). The Warren Peaks Mining Company intersected a nearly 5-foot-wide fluorite-bearing vein 200 feet from their portal. The vein was reported to have assayed 0.34 to 0.58 oz/ton Au (Anonymous, 1909).

The mode of occurrence of the gold in these veins is not known. It is not clear if the gold occurred in the pyrite, quartz, fluorite, or manganese, or in a combination of minerals. Unfortunately, later reports by Hagner (1942e), Haff (1944b), Chenoweth (1955), Wilkinson (1982), Jenner (1984), and Staatz (1983) failed to mention a gold-fluorite association. Recently collected (1988) fluorite-limonite samples contained no detectable gold.

Mine and prospect descriptions

<u>Copper Prince mine</u>; 8 miles northwest of Sundance and a short distance from the Hutchins claims. Mine dump material contains malachite, chrysocolla, and scattered shows of native gold (Jamison, 1912). This may be the same prospect reported by Brown (1952) in the NE¼ sec. 18, T.52N., R.63W. In 1982, this area was visited by the author, and a reclaimed copper prospect with scattered rocks stained with copper carbonate and disseminated pyrite was found in NW¼NW¼ sec. 17, T.52N., R.63W.

<u>Hutchins claims</u>; secs. 17, 18, 19, 20, T.52N., R.63W. A Tertiary syenite porphyry intrudes Precambrian granite. The syenite porphyry is in turn intruded by phonolite. The Hutchins Consolidated Gold Mining Company located and identified a series of northwest trending, northeast dipping fissure veins mineralized with fluorite and pyrite containing limonite-stained quartz gangue. The mineralized veins are less than 4 inches wide and have gold values (Jamison, 1912).

<u>Ogden Creek</u>; SE¼ and SW¼ sec. 27, T.52N., R.63W. Brown (1952) showed gold prospects in trachyte porphyry on his map of the area. Abundant limonite boxworks encrusting fluorite and fluorspar occur in a small open cut in SW¼SW¼ sec. 27. Samples were examined under a binocular microscope, but no visible gold was found.

<u>Stamp Mill Creek</u>; NW¼ and SE¼ sec. 20, T.52N., R.63W. Gold prospects were reported near the contact of phonolite with trachyte by Brown (1952). According to Brown, a 4-stamp mill was constructed in this area but was commercially unsuccessful.

Warren Peaks; T.52N., R.63W. About 0.5 mile northeast of the central peaks, a gold-bearing ledge was discovered and traced to the northwest for several hundred yards. The country rock is described as a coarsely crystalline feldspar porphyry with a fine porcelain-like matrix. Specimens contained traces of gold (Osterwald and others, 1966).

NW¼NW¼ sec. 17, T.52N., R.63W. Jenner (1984) reported copper oxides were found in a prospect pit at this location (see Copper Prince mine, p. 47).

Sec. 20, T.52N., R63W. One sample of altered trachyte from this location was reported to have assayed 10.1 oz/ton Au (Hausel and Harris, 1983).

Black Buttes (Hurricane district) mineralized area

The Black Buttes mineralized area is located nearly 12 miles west of Mineral Hill and approximately 8 miles south of Sundance (Figure 12). Black Buttes is a Tertiary alkalic igneous complex similar to the Mineral Hill and Bear Lodge complexes. The complex consists of several separate intrusives that have been described as trachyte porphyry, nepheline syenite porphyry, alkali trachyte porphyry, aegirine-augite trachyte porphyry, phonolite, and nordmarkite (Elwood, 1978). At about 54.0 Ma, these magmas intruded and domed the Paleozoic cover (Lisenbee, 1985).

Wherever the Deadwood Formation (Cambrian) crops out around the intrusive complex, there are test pits, shallow shafts, and adits. The excavations were apparently dug in the search for gold (Elwood, 1978).

Locally (NE¼ sec. 26, T.50N., R.62W.), Pb-Ag-Zn mineralization occurs in a tabular zone along steeply dipping joints of the Mississippian Pahasapa Limestone a few feet above the contact with a Tertiary trachyte porphyry sill. Here the mineralization replaces limestone, fills cavities, and cements limestone breccia (Elwood, 1978; Hagner, 1942c). The mineralization was accompanied by strong silicification and a distinct jasperoid is present locally (Elwood, 1978).

Elwood (1978) reported that the most abundant ore mineral found in the area was white hemimorphite, which occurred in cavities and as replacement of algal structures in the limestone. Galena, sphalerite, and fluorite were less common. A 25-pound grab sample collected by Elwood assayed 6.0 percent Zn, 0.05 percent Pb, 0.09 percent Mn, and 10 ppm Ag. Hagner (1942c) and Osterwald and others (1966) emphasized galena and cerussite were common ore minerals. One assay from secs. 23 and 26, T.50N., R.62W. gave 0.002 oz/ton Au, 2.0 oz/ton Ag, 13.9 percent Pb, 0.02 percent Cu, and 5.7 percent Zn (Hagner, 1942c; Osterwald and others, 1966). Some galena in the Black Buttes area assayed 100 to 200 oz/ton Ag, but this rich ore is very restricted (Knight, 1893).

A 1988 visit to this prospect found relatively common hemimorphite and galena, rare fluorite, and no sphalerite. A similar-appearing glassy, yellow-orange mineral was later identified as wulfenite ($PbMoO_4$) by x-ray diffraction. The deposit also has a narrow jasperoid zone as well as other evidence of silicification.

About $300 worth of ore had been shipped from this area before 1943 (Osterwald and others, 1966, p. 126). In 1942, one carload of ore shipped to the East Helena, Montana, smelter yielded 51 oz of silver and 6,977 pounds of lead (Henderson, 1943).

Cambria coal

According to Stone (1912) and Mapel and Pillmore (1963), the Cambria coal bed located near the heads of Camp and Coal Canyons, about 6 miles north of Newcastle, contains anomalous gold and silver. The Cambria bed at this location averages 5 feet thick (ranges from 3 to 10 feet thick) and occurs in the Upper Cretaceous Lakota Formation.

Coal was mined in the early 1900s in this area, and according to the early reports, precious metals were recovered from coke, ash, and sandstone from the Jumbo and Antelope 1 and 2 mines in secs. 20, 28, 29, 30, and 31, T.46N., R.61W., and secs. 25 and 26, T.46N., R.62W.

Assays of ash from the boiler house at Cambria showed 0.48 oz/ton Au. The sandstone roof of the coal bed yielded 0.1 oz/ton Au. Samples taken from 31 cars of coke from the mine averaged 0.12 oz/ton Au and 0.43 oz/ton Ag. The coal itself yielded 0.0 to 0.1 oz/ton Au (Stone, 1912).

A recent coal sample collected by Robert D. Odell from the Cambria coal mining district yielded the following (Jay T. Roberts, personal communication, 1987):

	Au (ppm)	Ag (ppm)
Dry coal —	0.019	1.1
Ash —	0.054	3.1

Mineral Hill district

The Mineral Hill district (also known as the Negro Hill district) is located in the Black Hills along the Wyoming-South Dakota border nearly 15 miles west of Lead, South Dakota, and 15 miles east of Sundance, Wyoming (Figures 12 and 13). The geology of the district is dominated by a Tertiary alkalic complex that intrudes Precambrian biotite-quartz schist and Paleozoic sedimentary rocks. This district adjoins the Tinton mining district of South Dakota on the east.

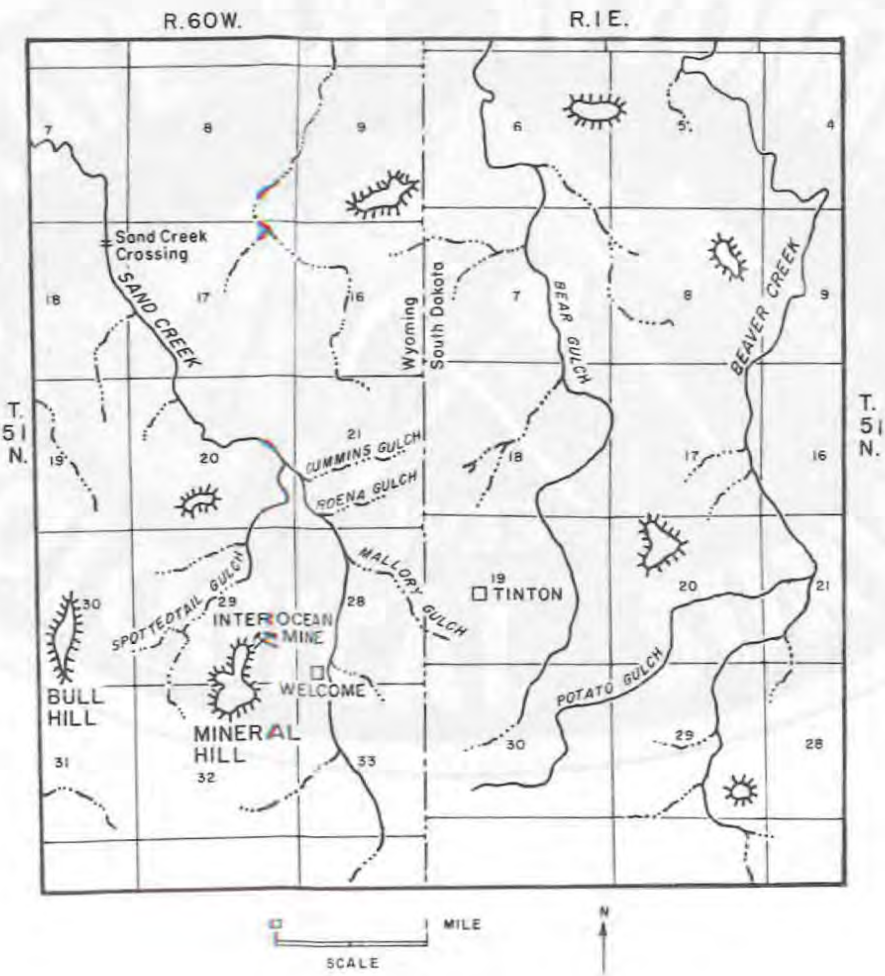


Figure 13. Map of the Mineral Hill district and adjacent area, Wyoming-South Dakota (modified from Hausel and Sutherland, 1988).

The Precambrian biotite-quartz schist has steeply dipping foliation and contains minor amphibolite and pegmatite. Tin-bearing pegmatite was mapped near Tinton in SE¼ sec. 21, T.51N., R.60W. by Welch (1974). The Paleozoic rocks are domed and dip gently away from the center of the alkalic complex.

The Deadwood Formation (Cambrian), the lowermost Paleozoic unit exposed in the Mineral Hill area, forms a semicircular outcrop around the Mineral Hill ring-dike complex. The Deadwood Formation crops out as a conglomerate and quartzite overlain by laminated carbonate-rich siltstones, sandstones, and flat-pebble conglomerate. Isolated pods and veins of jasper have been identified in these rocks (Welch, 1974).

The Mineral Hill alkalic igneous complex has an outer ring dike of alkali trachyte porphyry, a pyroxenite inner ring dike, and a core of feldspathic breccia intruded by diorite. Alkalic lamprophyre and pseudoleucite porphyry dikes related to the complex are scattered over a wide area (Welch, 1974).

On the west half of the Mineral Hill area, the alkali trachyte porphyry forms extensive sills at the base of the Deadwood Formation, intrudes various horizons of the Deadwood Formation, and occurs locally in younger Paleozoic rocks. East of Mineral Hill, the trachyte porphyry forms vertical sills intruding along the schistosity of the Precambrian schist. The central portion of the complex is crudely circular in outcrop and consists of pyroxenite and feldspathic breccia.

The complex exhibits varying degrees of alteration that Welch (1974) attributed to deuteric processes. Although some bleached rocks are completely replaced by K-feldspar and clay, Welch (1974) insisted that fenites do not occur in the igneous complex.

The Mineral Hill igneous complex was generated during the Laramide orogeny. A crustal fracture is believed to have tapped alkalic peridotitic magma from the mantle, which produced pyroxenitic magma that was emplaced into the Mineral Hill uplift (Welch, 1974). Welch also postulated a second magma, generated by partial melting of the crust by the pyroxenitic magma, was responsible for the alkalic trachyte porphyry.

Mineralization in the district includes copper and gold throughout the ring complex, Precambrian tin-bearing pegmatites, and tin and gold placers. Precambrian pegmatites contain columbite-tantalite as well as tin (Welch, 1974). Before 1893, more than 9,000 oz of gold were produced from placers in the area (Knight, 1893). During 1900, a 20-stamp mill was constructed at the site of Welcome (Figure 13), but no production records are available. In the past, there were a number of reports of gold nuggets discovered in this region, including a 2.45-oz nugget recovered in 1890 (*Engineering and Mining Journal*, 1890, v. 50, p. 555). In recent years, there have been unverified reports of walnut-size nuggets being found in the district along the edge of the ring-dike complex.

Mine and prospect descriptions

Bull Hill; E½,SE¼ sec. 30, T.51N., R.60W. A sample of brown jasperoid localized in pulaskite from this location assayed 470 ppm Cu, 4,300 ppm Pb, 5 ppm Au, and 7 ppm Ag (Welch, 1974, p. 71).

Interocean mine; S½ sec. 29, T.51N., R.60W. Mineralized diorite at the mine assayed 2,000 ppm Cu, 29 ppm Pb, 3 ppm Au, and 1 ppm Ag. Preliminary tests indicated the presence of an ore body of unknown size that averages between 0.08 and 0.14 oz/ton Au (Welch, 1974, p. 70 and 71).

Mallory Gulch placer; sec. 28, T.51N., R.60W. An estimated 1,200 oz of gold were recovered from this placer before 1893 (Knight, 1893).

Popular Gulch placers; T.51N., R.60W. An estimated 500 oz of gold were produced from these placers (Knight, 1893).

Roena Gulch; sec. 21, T.51N., R.60W. A sediment sample collected by Welch (1974) contained 12 ppm Au.

Sand Creek Crossing; sec. 18, T.51N., R.60W., in Sand Creek. This placer may have formed in a former lake bed. The sediments and gravels are over 2,000 feet long and are as much as 40 feet thick (Welch, 1974). Although no gold has been reported at Sand Creek crossing, Welch (1974) was impressed by its potential as a gold placer.

Sand Creek placers; T.51N., R.60W. The Sand Creek placers have an estimated 1,165,000 yds^3 of gravel over a 10,500-foot length of stream. These gravels are reported to average 0.008 oz of gold and 360 pounds of magnetite/yd^3. Some cassiterite was also reported (Welch, 1974). Additionally, 0.5 mile below the junction of Spottedtail and Sand Creeks, the gravel averaged 0.064 oz/yd^3 Au, 2.25 pounds/yd^3 cassiterite, 1.34 pounds/yd^3 columbite-tantalite, and 165 pounds/yd^3 magnetite (Welch, 1974). An estimated 7,500 oz of gold were produced from this placer before 1893 (Knight, 1893). Historic reports indicate that gold recovered in 1878 occurred mostly as coarse nuggets (often 0.25 to 0.5 oz).

Spottedtail Gulch placer; sec. 20 and 29, T.51N., R.60W. This placer has an estimated 140,000 yds^3 of gravel over a 6,000-foot length. The gravel is estimated to average 0.008 oz/yd^3 Au (Welch, 1974).

S½ sec. 29, T.51N., R.60W. A sample of silicified feldspathic breccia collected from an open cut assayed 11,000 ppm Cu, 5,700 ppm Pb, 6 ppm Au, and 115 ppm Ag (Welch, 1974).

N½NW¼ sec. 32, T.51N., R.60W. A quartz vein in altered igneous rock assayed 65 ppm Cu, 3,000 ppm Pb, 0.9 ppm Au, and 3 ppm Ag (Welch, 1974).

E½E½ sec. 29, T.51N., R.60W. Welch (1974) reported a sample collected at this locality in 1960 contained 17 oz/ton Ag, but he was unable to duplicate the results.

Mush Creek oil field

Drill core in the Lower Cretaceous Newcastle Sandstone was reported by Crowley (1951) to contain visible gold blebs up to 1 mm in diameter. The core was cut from the Updyke No. 13 oil well in sec. 21, T.44N., R.63W. in the Mush Creek Field. Several other heavy mineral separations from Newcastle Sandstone cores taken in the Mush Creek, Fiddler Creek, and Osage Fields contained cassiterite and tiny flakes of gold. Spectrometric analysis of the gold from the Updyke No. 13 well indicated a trace element similarity to gold mined from the central Black Hills. Results of the spectrometric analysis and the presence of cassiterite, which is associated with some gold deposits in the central Black Hills, suggested to Crowley (1951) that the gold in the Newcastle Sandstone was of placer origin.

Stream-sediment anomalies

Albert (1986) compiled National Uranium Resource Evaluation (NURE) stream-sediment sample information on a map showing anomalous gold values. These sediment samples were originally collected to test for the presence of uranium, with gold and other metal values being of secondary interest. Six samples from sites spread widely over the areas south of Black Buttes and north of Cambria show gold values between 0.20 to 0.29 ppm. Seven samples from the area lying between Moorcroft, Carlile Junction, and the west side of the Bear Lodge Mountains showed gold values averaging 0.21 ppm. Another nine samples from north of Carlile Junction in the vicinity of Devils Tower ranged from 0.20 to 0.28 ppm Au. Ten samples taken along the Little Missouri River and its tributaries, in the vicinity of New Haven and Hulett in northern Crook County, showed gold values ranging from 0.20 to 0.28 ppm.

Gordon Marlatt (personal communication, 1986) recently tested Cretaceous sandstones along the western flank of the Black Hills uplift to verify some of these NURE gold anomalies. His samples, collected in and adjacent to a uranium district in Cretaceous sandstones, were in agreement with those reported by NURE. Samples analyzed by Marlatt contained gold values as high as 1 ppm. The gold may have been leached from Tertiary volcanic ash falls and precipitated by organic material in the underlying sedimentary rock (Gordon Marlatt, personal communication, 1987), or it could have originated from the Bear Lodge and Mineral Hill districts.

Denver-Cheyenne Basin

The northern Denver Basin stretches from the Laramie Mountains to the Nebraska plains. A large region of alluvial gravels along Bear and Horse Creeks near LaGrange, in an area known as Goshen Hole, was reported in 1903 to contain no-see-um (invisible) gold. Both Bear and Horse Creeks originate in the Laramie Mountains about 50 miles to the west. Elsewhere in the basin, Albert (1986) indicated NURE stream-sediment samples collected between the Laramie Mountains and Hartville uplift several miles northwest of Goshen Hole contained anomalous gold.

Denson and Bergendahl (1961), reported samples collected from the White River Formation in the vicinity of the Hartville uplift along the northern edge of this basin contained gold. The greatest amounts of gold were collected in the vicinity of Slater, Young Woman, and Stoney Buttes Creeks. In places in this region, the White River Formation is several hundred feet thick.

Goshen Hole placers

The Goshen Hole area is underlain by shales and sandstones of the Lance Formation (Cretaceous) and claystones and tuffaceous sandstones of the Chadron Member of the White River Formation (Oligocene) on the north. Claystones of the Brule Member of the White River Formation and tuffaceous sandstones and claystones of the Miocene Arikaree Formation lie to the south. The Goshen Hole placers are located in T.19 and 20N., R.61W., about 50 miles northeast of Cheyenne and 6 miles west of the Nebraska State Line (Figure 1). The property is used principally as farmland.

In 1903, preliminary tests were conducted on placers in the Goshen Hole area, which were determined to be unusually rich in black sands that were extremely fine grained and difficult to save by panning (Stanton, 1903). Gordon Marlatt (personal communication, 1988) reported these black sands are grains of coal (or possibly shale), which would explain their loss during panning, since coal and shale have very low specific gravities. According to Stanton (1903), the Goshen Hole gravels cover as much as 10,000 acres of land and extend along Horse Creek from LaGrange to Hawk Springs 6 miles to the north. The gravels are a minimum of 5 feet thick, are covered by detritus from the surrounding rock formations, and are topped by a few inches to a few feet of soil. The top of the gravels contain black sand 6 inches to 2 feet thick.

Three samples taken from the overlying detritus and soil assayed 0.006, 0.007, and 0.02 oz/yd^3 Au. A group of samples taken from the underlying gravel and black sands averaged 0.013 oz/yd^3 Au and ranged from 0.006 to 0.043 oz/yd^3. The high value was obtained from black sand (Stanton, 1903). Stanton (1903) reported that because of the relatively high water table that caused flooding of prospect holes and trenches, the samples were taken from near the surface and not from bedrock. Flotation test results indicated to Stanton that the placers could average better than 0.048 oz/yd^3 Au. During panning tests of this material, it was discovered that the more the samples were panned, the lower they assayed. Apparently, the gold occurs as disseminated microscopic to submicroscopic grains adsorbed by clay and coal, making panning recovery very difficult (Gordon Marlatt, personal communication, 1988). Recent reconnaissance sampling in the area located several gold anomalies in black shales surrounding Goshen Hole (Gordon Marlatt, personal communication, 1986).

Stream-sediment anomalies

A small group of stream sediments collected west of the Hartville uplift contained anomalous gold. One sample, from T28N., R.68W., assayed 1.11 ppm Au, and another collected in T.27N., R.69W. contained 1.51 ppm Au (Albert, 1986). Nearby, gold was reported in sands of the Arikaree Formation near Uva (Osterwald and others, 1966, p. 92). Uva is a railroad siding located 6 miles north of Wheatland in T.25N., R.67W.

White River Formation anomalies

A study of the extent and distribution of the White River Formation and its petrography led to the discovery of gold in the heavy mineral fraction of this Oligocene tuffaceous formation. The dominant heavy minerals identifed in these rocks included hornblende and smaller amounts of zircon, garnet, rutile, epidote, orthopyroxene, and gold (Denson and Bergendahl, 1961).

According to Denson and Bergendahl (1961), gold occurs in greatest amounts in the Slater Creek (SE¼ sec. 19, T.22N., R.66W.) and Young Woman Creek (N½ sec. 35, T.35N., R.64W.) areas of Wyoming and the Stony Buttes section (secs. 2, 3, T.11N., R.55W.) of Colorado. Although it is not clear from this report, small amounts of gold may also have been found in samples collected at Bear Mountain (S½ sec. 17, T.20N., R.62W.) and along Horse Creek (E½ sec. 32, T.17N., R.69W.) in Wyoming.

Ferris Mountains

The Ferris Mountains in south-central Wyoming lie northwest of the Seminoe Mountains district. They form a spectacular east-west trending, Precambrian-cored, anticlinal uplift of Laramide age. Two blocks of Precambrian rocks are separated by a tightly folded syncline formed of Paleozoic and Mesozoic rocks. The southern flank of the range consists of Paleozoic and Mesozoic rocks that dip steeply to the south. Along the northern flank, the Paleozoics are truncated by faulting, and near the eastern extent of the range, the Precambrian terrane is onlapped by Tertiary strata.

The Precambrian terrane is dominated by igneous rocks including tonalite, granite, granodiorite, orbicular quartz diorite, monzonite, syenite, pegmatite, and mafic dikes. Many of these rocks are cut by calcite, quartz, and quartz-sulfide veins (Master, 1977).

Two types of sulfide mineralization were recognized by Master (1977). These are quartz-sulfide veins and disseminated sulfide mineralization in granodiorite porphyry associated with quartz veins. There is little evidence of significant gold in the Ferris Mountains although reports of anomalous silver are not uncommon.

Mine and prospect descriptions

Babbs mine; SE¼ sec. 26, T.27N., R.88W. Both quartz-sulfide veins and disseminated sulfide deposits occur in the immediate vicinity. The mine was driven on a 2.0- to 2.5-foot-wide quartz vein in a sheared mafic dike. The vein strikes north-south, dips 80°E, and pinches out 350 feet from the mine portal. Samples collected from the vein assayed greater than 10,000 ppm Cu, 50 ppm to greater than 10,000 ppm WO_3, 0.01 oz/ton Au, 1.5 to 15 ppm Ag, 10 to 50 ppm Sn, 5 to 100 ppm Ni, and 20 to 100 ppm Pb. The mine was last operated in 1949 (Master, 1977).

Master (1977) was impressed by the disseminated sulfide deposit and believed it had the greatest economic potential of the deposits he examined in the Ferris Mountains. Of five chip samples taken from the deposit, the average value was 0.18 percent copper. An assay of a narrow northwest striking vein (<1.5 feet wide) in this disseminated sulfide deposit yielded 32 percent Cu, 0.17 oz/ton Au, and 10 ppm Ag (Master, 1977).

<u>Spanish Trails group</u>; secs. 5 and 6, T.26N., R.86W. Galena- and chalcopyrite-bearing quartz veins carry precious metals. Samples collected from this area assayed 31.7 percent Pb and 18.2 oz/ton Ag. Other samples contained values in lead and zinc with a trace gold (Osterwald and others, 1966, p. 125-126).

<u>NW¼ sec. 36, T.27N., R.88W</u>. An irregular-shaped malachite-stained vein less than 5 feet wide was sampled. The chip sample yielded 7,000 ppm WO_3, 0.30 ppm Au, 7 ppm Ag, and 3,000 ppm Cu (Master, 1977).

<u>SE¼ sec. 32, T.27N., R.87W</u>. A 4-foot-thick quartz-sulfide vein assayed greater than 10,000 ppm Cu, 3,000 ppm Co, 100 ppm Pb, 5 ppm Ag, and 0.20 ppm Au. A small amount of cobaltite occurs with chalcopyrite in this vein (Master, 1977).

<u>NW¼ sec. 30, T.27N., R.88W</u>. A 1- to 2-foot-wide quartz-sulfide vein was sampled. The chip yielded >10,000 ppm Cu, 10 ppm Ag, 200 ppm Ni, 100 ppm Co, and 0.03 ppm Au (Master, 1977).

Granite Mountains

The Granite Mountains are located near the center of the State and are accessible by various dirt roads from U.S. Highway 287 and from Jeffrey City. The known gold occurrences are in the Tin Cup district near the western edge of the Granite Mountains and in scattered veins and fissures outside the district. The Granite Mountains form a belt of east-west trending Precambrian rocks submerged in a sea of upper Cenozoic sedimentary rocks and unconsolidated sediments. The complex Cenozoic history of the Granite Mountains was studied by Love (1970).

The Precambrian rocks are divided into three major units: (1) a complex belt of amphibolite-grade metamorphic rocks exposed along the northwestern and northern margins of the Granite Mountains, (2) granites (2,640 and 2,600 Ma) exposed in the center of the uplift (Stuckless and Peterman, 1977), and (3) late-intruding tholeiite diabase dikes that cut both the granites and metamorphic rocks. The dominant trend of these dikes is northeast (Stuckless and Peterman, 1977). Along the northern edge of the Granite Mountains, Tertiary (40 to 44 Ma) alkalic phonolites and related volcanics cut Precambrian rocks in the vicinity of the Rattlesnake Hills (Pekarek, 1977).

The metamorphic belt in the Granite Mountains consists of a group of metavolcanic schists and gneisses that were metamorphosed to amphibolite grade at about 2.9 Ga (Peterman and Hildreth, 1978). However, according to Peterman and Hildreth (1978), the Sr^{87}/Sr^{86} ratios are unusually high for rocks of this age, and in order to account for these ratios they suggested the rocks may have formed 3.2 to 3.3 Ga. These rocks also exhibit local effects of retrograde metamorphism.

The metamorphic rocks have steep, southerly dipping, northeasterly to easterly foliation trends. Several rock types form the complex, including quartzofeldspathic gneiss, augen gneiss, epidote gneiss, biotite gneiss (metagreywacke), amphibolite, and minor serpentinite and banded iron formation (Peterman and Hildreth, 1978). In the Barlow Gap area near the Rattlesnake Hills along the northern flank of the Granite Mountains, both oxide- and silicate-facies banded iron formation have been reported (Bickford, 1977). In the Tin Cup supracrustal belt, massive sulfides occur in hematitic iron formation(?).

In addition to gold, the Granite Mountains have scattered copper and iron occurrences and a number of exotic ornamental stones and gemstones. Agates, jade, sapphires, and rubies have been reported at scattered localities (Osterwald and others, 1966; Love, 1970).

Along the northern and southern margins of the Precambrian terrane are two major uranium districts (Gas Hills and Crooks Gap-Green Mountain) localized in Tertiary strata (see Wilson, 1960b; Hausel and Glass 1980; Harris and others, 1985). Uranium (and possibly other metals) in these districts may have been mobilized from granite of the Granite Mountains since there is evidence of two separate episodes of uranium loss. Uranium mobilization between 1,400 and 1,700 Ma was due to a poorly defined metamorphic event (Stuckless and Nkomo, 1978).

Tin Cup (Black Rock-Long Creek) district

The district is located along the northwestern part of the Granite Mountains in T.30 and 31N., R.92 and 93W. (Figure 1). It is underlain by amphibolite-grade gneiss, schist, and amphibolite that were metamorphosed at 2,860 ± 80 Ma (Rb-Sr whole-rock analysis by Peterman and Hildreth, 1978). The supracrustal (metamorphic) complex was intruded by granite 2,550 ± 60 Ma, which was followed by intrusion of diabase dikes and jade (nephrite) veins a short time later (Peterman and Hildreth, 1978).

Beeler (1907a) reported gold assays from the district to run from 0.08 oz/ton to greater than 5 oz/ton. Some prospects in the district produced copper values as high as 15 percent. Banded jasper contained 0.14 oz/ton Au.

Mine and prospect descriptions

Anderson mine; SE¼SE¼ sec. 13, T.31N., R.93W., a mile north of Tin Cup Springs. Gold values were detected in N80°E trending, south dipping quartz veins in schist country rock (Love, 1935).

Cedar Reef claim; (location not given). A mineralized diorite carries gold. Assays run from 0.01 to 0.2 oz/ton Au (Beeler, 1907a).

King Solomon claim; sec. 36, T.31N., R.92W. Limonite- and malachite-stained veins trend northeast. Gold assays were reported to range between 0.10 to 0.88 oz/ton (Beeler, 1907a).

Lone Tree claims; east of the Queen of Sheba claims (no legal description given). A shallow shaft cut a wide ledge of oxidized iron and quartz. Both copper and iron sulfides were noted in the 20- to 30-foot-wide ledge. One sample assayed 15 percent Cu and 3.5 oz/ton Au (Beeler, 1907a).

Queen of Sheba claims; Beeler (1907a) reported this property to lie somewhere on the west end of the district. A shallow shaft was sunk on a huge copper- and iron-stained quartz ledge. No assays were given by Beeler.

Red Boy (Sutherland) mine; sec. 36, T.31N., R.93W. Massive pyrite occurs in hematite iron formation. According to the *Prospectus of the Emigrant Mining Company* of June 12, 1938, ore from the mine assayed 0.04 to 0.46 oz/ton Au. Samples collected at the bottom of the 130-foot shaft contained 0.4 oz/ton Au and 23 oz/ton Ag (Love, 1970). Several samples of the massive pyrite collected by the author in 1983 contained no detectable gold.

Rattlesnake Hills-Barlow Gap

The Rattlesnake Hills lie north of the North Granite Mountains east-west trending normal fault and form the northern extension of the Granite Mountains. The Rattlesnake Hills are a northwest plunging, Laramide anticline that is cored by Precambrian rock and intruded by Tertiary igneous rocks. This area covers about 150 square miles and contains at least 42 discrete peraluminous alkaline and calc-alkaline volcanic vents and intrusive bodies, which cut Precambrian, Paleozoic, Mesozoic, and Cenozoic rocks. K-Ar dates of these igneous rocks are 44.0 ± 2.6 and 43.6 ± 1.0 Ma, and lithologies include rhyolite, quartz latite, latite, trachyte, soda trachyte, alkali meta-trachyte, and phonolite (Pekarek, 1977). No mineralization is known to be associated with these Eocene igneous rocks. Some precious metals occur in the Precambrian terrane, which includes amphibolite, hornblende schist, banded iron formation, and granite gneiss. The banded iron formation is both silicate and oxide facies (Bickford, 1977).

Banded oxide-facies iron formation was reported in this region (in T.31N., R.88W.) by Houston (1974) and described by Bickford (1977) and Pekarek (1977); recently, some of these rocks have received interest for gold. Jasperoids have been reported in the Rattlesnake Hills, but no assay information is available (Hank Hudspeth, Jr., personal communication, 1988).

Mine and prospect descriptions

Cowpie prospect; SW¼NE¼ sec. 21, T.32N., R.87W., in UT Creek. Copper-stained hornblende schist assayed 1.5 percent Cu, 8 ppm Ag, and 800 ppm Pb (Pekarek, 1977).

Lost Muffler mine; SW¼ sec. 16, T.32N., R.87W., on a tributary at UT creek. A tunnel was driven along the strike of a contact between a quartz vein (metachert?) and sheared hornblende schist. The mineralized zone can be followed along strike for nearly 500 feet.

The vein at the portal is about 1.5 feet wide, but it widens to 3.5 feet along strike. Chip samples were taken horizontally across the vein and shear zone above the collapsed adit and down the vein parallel to the dip, and pyritized vein samples were collected from the dump (Table 6).

Table 6. Assay results of samples taken at the Lost Muffler mine (Hausel and Jones, 1982).

Sample number	Au (oz/ton)	Ag (oz/ton)	Sample description
LMP 82-1	0.22	—	Chip sample parallel to dip of vein, 44 inches long.
LMP 82-2	0.13	—	Chip sample (horizontal) across vein and shear, 44 inches long.
LMP 82-3	0.03	0.03	Selected dump sample of pyritized quartz.
LMP 82-4	0.04	—	Grab sample of dump material.

Greater Green River Basin

The Great Divide, Green River, and Washakie structural basins in southwestern Wyoming form a much larger geographic basin known as the Greater Green River Basin. To the west, the Green River Basin is covered by a thick section of Tertiary strata that include the Bridger, Green River, and Wasatch Formations. This basin is structurally separated from the other two basins by the north-south trending Rock Springs uplift. On the east, the Great Divide and Washakie Basins are separated by the east-west trending Wamsutter arch. The Great Divide Basin is overlain by Tertiary sedimentary rocks including the Battle Spring, Green River, and Wasatch Formations; and the Washakie Basin to the south contains rocks of the Washakie, Green River, and Wasatch Formations. Enigmatic gold anomalies have been reported in some of these rocks. Also along the divide between the Greater Green River Basin and the Hanna Basin, gold was apparently found in a coal mine near Walcott. The coal assayed up to 0.29 oz/ton Au (*Mining Reporter*, March 1, 1906, v. 53, p. 229).

Great Divide Basin

Several significant gold anomalies have been reported in this basin. For example, one NURE stream-sediment sample collected in T.27N., R.96W. contained 1.07 ppm Au. Another sample, from T.25N., R.93W., yielded 6.55 ppm Au (Albert, 1986).

Green River Basin

Gold anomalies are associated with the Green River Formation. Also, according to Houston (1969), as much as 1.3 ppm Au has been detected in some titaniferous black sandstone (paleoplacer) deposits of the Upper Cretaceous Mesaverde Group. Because Houston (1969) did not identify which sandstones are anomalous, these will not be discussed further, but individual deposits were described by Dow and Batty (1961) and Houston and Murphy (1962).

The Eocene Green River Formation has been subdivided into three members that are well exposed near Green River, Wyoming (Bradley, 1964). The Tipton Shale Member is overlain by the Wilkins Peak Member (the principal trona-bearing unit), which is capped by the Laney Shale Member. All three contain oil shales and tuffaceous units. The Laney Shale and Tipton Shale contain relatively rich oil shale units. The oil shales in the Tipton Shale are located near the top of the member.

Varley (1922) described a U.S. Bureau of Mines' investigation into recovering both oil and gold from some oil shales in this region. Gold values in some Green River oil shales were reported by the U.S. Bureau of Mines to have ranged up to 0.03 to 0.04 oz/ton. No sample location sites were given by Varley (1922).

Albert (1986) showed numerous gold anomalies in NURE stream-sediment samples in the Eden Valley area to the north, which encompasses a 300-square-mile region. Many of these samples were collected on the Green River Formation and could be associated with shales and sandstones. In fact, Gordon Marlatt (personal communication, 1987) recently outlined a 120-square-mile regional anomaly in the Eden Valley associated with the Wilkins Peak Member. Samples collected in this region (T.24N., R.105W.) contained a trace to 1.3 ppm Au. One sample of unconsolidated sand contained a piece of microscopic native gold that was angular with jagged edges, suggesting minimal transport.

"Flour gold" has also been reported in the upper Green River. At one location, a manganese outcrop cut by Jim Creek, Porcupine Creek, and the Green River was reported to yield gold values as high as 0.34 oz/ton (*Wyoming Industrial Journal*, 1905, v. 6, no. 12, p. 7).

Washakie Basin (Fourmile Creek placers)

Along the Colorado-Wyoming border west of Baggs, Wyoming, in T.12N., R.92-93W., is an extensive gold placer that is reported to be continuous from Wyoming to Blevins, Colorado, about 18 miles south into Colorado (Gale, 1907).

These placers are reported to lie along the trend of the Little Snake River and Fourmile and Timberlake Creeks, but the gold-bearing gravels occur on the uplands and mesas 10 to 150 feet above the stream valleys rather than in the gulches. The beds are from 2 to 20 feet thick and average 9 feet thick (Snow, 1895).

The gold-bearing gravels consist of unconsolidated light colored sand and clay with rounded pebbles and boulders. Black sands are notably absent. Gold appears to be intimately associated with clay and occurs as very fine and well-rounded grains (Gale, 1907). Gale estimated the grains would average 1,000 to the cent (1907 prices).

Gold values in the gravels are reported to be fairly consistent and to run upward from 0.01 oz/yd^3 (Snow, 1895). In 1901, a dredge operating 10 miles south of Baggs in Timber Lake Gulch, Colorado, was reported to have recovered an average of 0.036 oz/yd^3 Au. After four years, about 3,500 oz of gold were produced from this dredge (Gale, 1907).

Hartville Uplift

The Hartville uplift is located near the eastern border of Wyoming, north of the town of Guernsey and south of Lusk (Figure 1). Good roads run through the area although accessibility is limited by private property.

The Hartville uplift has scattered copper, pegmatite, and iron deposits and is well known for its iron ore. In the Hartville district, in the Haystack Mountains near the south end of the uplift, iron ore was mined from rich hematite deposits for nearly a century (Osterwald and others, 1966). In the late 1800s and early 1900s, both silver and copper were mined from this region (Table 7). Ball (1907a) reported that gold values were closely associated with copper in Precambrian hematite schist at many localities in the uplift. Woodfill (1987) supported Ball's observation and reported anomalous gold in the Precambrian Silver Springs Schist from the southern end to the northern end of the uplift. Based on these reports, there is some potential for stratiform gold and massive sulfides in the Hartville uplift. Further evidence for gold in the Hartville uplift comes from a report that the Silver Glance mine (location not known) contained copper, gold, and silver values in a 3-foot-wide vein. Some specimen ore recovered from the mine reportedly contained large amounts of gold (*Wyoming Industrial Journal*, 1902, v. 4, no. 7, p. 154).

Table 7. Reported silver and copper production in the Hartville uplift (from U.S. Bureau of Mines Mineral Resources Yearbook, 1912).

Year	Ag (oz)	Cu (pounds)
1882	140	100,000
1883	1,340	962,468
1888	320	232,819
1889	140	100,000
1907-1912	342	172,875
Total	2,282	1,568,162

The Hartville uplift is a north trending uplift of Precambrian rock. Eugeoclinal metasedimentary and metavolcanic rocks form the core of the uplift and Paleozoic rocks dip gently to the west. The Precambrian rocks include quartzite, hematite schist, metadolomite, slate, phyllite, metagreywacke, and metabasalt (Houston and Karlstrom, 1979; Snyder, 1980). Millgate (1965) reported the age of these rocks as Proterozoic; however, Snyder (1980) reported them to be Archean.

Hartville district

Iron deposits of the Hartville district occur as hematite lenses within the Silver Springs Schist near its contact with the underlying Precambrian Wildcat Hills Dolomite. These Precambrian rocks are unconformably overlain by Guernsey Formation (Devonian-Mississippian) limestones and dolomites.

The hematite deposits were noted by early workers to contain some copper in the form of chrysocolla, malachite, chalcocite, azurite, and native copper. Much of the copper was discovered concentrated at the contact of the hematite schist and overlying Paleozoics but some was also found in fractures in the underlying hematite (Ball, 1907b). The copper does not continue at depth but is localized along the unconformity and particularly in the overlying Guernsey Formation.

The Silver Springs Schist contains some disseminated pyrite and pyrrhotite generally as hematite pseudomorphs. The sulfides conform to schistosity and occur in association with graphite. Some assays of sulfide-bearing hematite schists have produced traces of gold and anomalous silver. Woodfill (1987) reported anomalous gold (>0.02 oz/ton) was detected from iron formation at the Sunrise and Good Fortune mines. Colorado Fuel and Iron Company (C.F. & I.) drilled one sulfide-rich zone that reportedly contained as much as 30 percent sulfides.

Initially, the Hartville district was mined for copper between 1880 and 1887. During this period, the Sunrise mine was an important copper mine, but was later developed into one of the most important iron mines west of the Mississippi (Ball, 1907a, p. 99). The exhaustion of copper ore in the mine was followed by production of iron ore beginning in 1898 (Ball, 1907b; Frey, 1947a). Production continued in the district until the closure of the Sunrise mine in 1980. Production of iron ore in the district totaled at least 45 million tons. Ore was produced from the Central, Chicago, Good Fortune, and Sunrise mines.

Mine and prospect descriptions

Central mine; SW¼ sec. 5, T.27N., R.65W. This deposit was a blind hematite ore body discovered in 1931 between the Sunrise and Chicago ore bodies. Mining was accomplished by underground block-caving methods (Carter, 1963). No precious metal values have been reported.

Chicago mine; NE¼ sec. 5, T.27N., R.65W. This mine was developed by a 400-foot-deep shaft and a small open pit. The underground workings have been flooded since 1916 (Harrer, 1966, p. 42). In 1974, C.F. & I. explored the Chicago deposit for additional hematite ore reserves (Anonymous, 1974). No precious metal values have been reported.

Good Fortune mine; E½ sec. 7, W½ sec. 8, T.27N., R.65W. The Good Fortune property was developed by underground workings and by a large open pit. The ore body occurred as specularite and earthy hematite in the Silver Springs Schist. Channel samples collected from the schist assayed 50 to 60 percent iron, 3 to 18 percent silica, and 0.1 to 0.3 percent phosphorus (Frey, 1947b; Ebbett, 1954). Woodfill (1987) reported the iron formation contained anomalous gold.

Green Mountain Boy mine; about 0.5 mile east of Guernsey. Copper production from the mine was reportedly between 300 and 500 tons of ore averaging 37 percent. According to Ball (1907a), the ore contained about 0.3 to 0.5 oz/ton Ag for each percent of copper.

The mine was developed in limestone of the Devonian-Mississippian Guernsey Formation. The ore body occurs as chalcocite-malachite replacements of limestone. Chrysocolla also occurs replacing lenticular masses of flint. The deposit is distinctly limited at depth and scarcely a copper stain is visible 20 feet beneath the chalcocite blanket (Ball, 1907a).

Sunrise mine; N½ sec. 7, T.27N., R.65W. The Sunrise mine was initially developed by conventional open pit mining, but evolved into an open-pit glory hole (Figure 14). When open pit mining became uneconomical due to excessive overburden thickness, the mine was converted to an underground block-caving system (*Engineering and Mining Journal*, 1974). The iron ore lies in a steeply plunging synform within the Silver Springs Schist near the contact with the Wildcat Hills Dolomite, and continues to a depth of 1,000 feet and covers 2,100 feet by 50 to 600 feet of surface area (Anonymous, 1974). At the closing of the mine in 1980, the Sunrise shaft was 860 feet deep and the ore haulage level was on the 700-foot level.

The total remaining reserves at the Sunrise mine are not definitely known; however, James Brooks (personal communication, 1982)

Figure 14. The Sunrise mine, showing massive hematite in the Silver Springs Schist (Precambrian) unconformably overlain by Guernsey Formation limestones and dolomites (Devonian-Mississippian). (Photograph by Ray E. Harris.)

reported that about ten years of reserves remained underground. In 1974, the *Engineering and Mining Journal* reported the mine to contain about 25 million tons of iron reserves. Assays of the ore are given in Table 8.

Table 8. Reported assays of hematite ore from the Sunrise mine (Osterwald and others, 1966, p. 117).

Metallic Fe (%)	Al_2O_3 (%)	SiO_2 (%)	S (%)	P (%)
67.55	1.42	1.50	0.054	0.008
68.41	1.86	1.82	0.019	0.035
55.92	—	10.76	—	0.013
56.44	—	—	—	0.068

Copper output from the mine was at least 1,395,290 pounds, and the ore averaged 15 percent Cu with 2 to 3 oz/ton Ag. The lenticular masses of copper occurred only near the top of the hematite masses and in the overlying Guernsey carbonates. Field evidence indicates the copper was introduced by low-temperature descending waters long after the hematite ores were formed and fractured. Hematite probably acted as a precipitant for copper. The copper appears to be post-Guernsey in age and may have been derived from the Guernsey Formation (Ball, 1907a).

SW¼NW¼ sec. 13, T.27N., R.66W. A small prospect pit exposes an unconformity between underlying Precambrian dolomites and overlying Devonian quartzite and Devonian-Mississippian Guernsey Formation limestone. Rocks along the unconformity are stained by copper. In the early 1980s, Kerr McGee Corporation explored this unconformity and intersected some local silver-rich zones. Cerargyrite ($AgCl$), unmangite (Cu_3Se_2), electrum, and native gold were all identified in samples (William P. Leedy, written communication, 1988).

McCann Pass

McCann Pass is located within five miles northeast of the Hartville district (Figure 1). The pass is in an east-west trending valley that marks the location of the McCann Pass fault. North of the fault, granites intrude mica schist; to the south, steeply dipping mica schist crops out (Millgate, 1964).

Mine and prospect descriptions

Charter Oak mine; SE¼ sec. 26, T.28N., R.65W., on the south side of McCann Pass. Cupriferous gossans occur in muscovite schist and quartzite. Malachite, chrysocolla, and chalcocite occur in fractures and in a 4-foot-wide vein that crosscuts the vertical schist. Samples of the altered schist adjacent to the vein assayed 0.04 to 1.3 oz/ton Au and 2.0 to 5.0 oz/ton Ag (Ball 1907a, p. 96).

McCann Pass prospects; SW¼ sec. 23, NE¼ sec. 26, and E½ sec. 27, T.28N., R.65W. A group of prospects marked by gossans are located along the McCann Pass fault. The largest exposed gossan (in sec. 27) is a 3,000-foot-long by 300-foot-wide lens-shaped area consisting of various fragments of rock cemented by spongy to massive iron oxides. The other two gossans are smaller, less brecciated, but likewise stratabound in character. Another extensive gossan in sec. 26, nick-named 'gossan hill', has a group of shafts with common massive sulfides on the mine dumps.

Outcrop and shallow drill hole samples from the largest gossan yielded 20 to 300 ppm Cu, 200 to 900 ppm Zn, and 500 to 7,000 ppm As (Zahony, 1976). At one locality, massive pyrrhotite, disseminated pyrite, and malachite were found in graphitic schist.

Two strong electromagnetic anomalies lie parallel to the McCann Pass fault, with one of the anomalies overlying the fault. Exxon Minerals drilled the anomalies. One hole intersected a 10-foot zone averaging 0.8 percent Zn. Another hole cut through a 2-foot mineralized zone, which averaged 1.2 percent Zn and 0.08 oz/ton Au (Woodfill, 1987). The geophysical, geochemical, and geological evidence available on the McCann Pass prospects indicate the presence of a hidden massive sulfide deposit hosted by metasedimentary rocks. Such a massive sulfide could contain significant amounts of Zn, Cu, Ag, Pb, and Au (Zahony, 1976; Woodfill, 1987).

Muskrat Canyon area

Mine description

Michigan mine; NW¼ sec. 24, T.30N., R.65W. A 300- to 350-foot-thick hematitic iron formation (Precambrian) is structurally underlain by sericitic chert. The hematite schist, in turn, is unconformably overlain by Guernsey Formation limestone. Copper carbonates and oxides are localized along the unconformity and also extend down along fractures into the underlying Precambrian hematite schist.

The deposit was divided into two ore bodies by Colorado Fuel and Iron Corporation. The northern ore body was estimated to contain 75.5 million tons averaging 25.3 percent iron, and the southern ore body was estimated to contain 41 million tons averaging 24 percent iron (Wilson, undated). Significant magnetic and conductivity anomalies were identified in association with the ore bodies (Woodfill, 1987). Woodfill (1987) described similarities between this deposit and the Broken Hill and Black Mountain massive sulfides in South Africa. The South African deposits are giant stratiform massive sulfides of Pb, Ag, Zn, and Cu associated with isoclinally folded Proterozoic quartz schists and iron formation.

Two grab samples of the iron formation collected in 1983 assayed 14 percent Fe with 0.76 percent Cu, and 21 percent Fe with 1.08 percent Cu, respectively (Hausel, 1983a). No gold was detected. Copper production from the mine was valued at $40,000 (200,000 to 400,000 pounds) according to Knight (1893) and only a small unknown amount of iron has been mined from the deposit.

Rawhide Buttes district

Located in the northern part of the Hartville uplift, this district includes a group of mines in secs. 2 and 11, T.30N., R.64W. (Figure 1). These are the Gold Hill, Omaha, and Lucky Henry mines and the Emma open cut (Copper Belt mines). The country rock consists of Precambrian metadolomite with interbedded mica schist and quartz sills(?) unconformably overlain by tuffaceous rocks of the Tertiary Arikaree Formation (Figure 15). The mines occur along the flanks of a synform in the Precambrian section (Millgate, 1966).

Mine and prospect descriptions

Emma open cut; (exact location unknown). No gold or silver assays are reported for this prospect. Quartz lenses in fractures parallel schistosity and contain a zone that averages 3 to 30 percent copper. Masses of chalcocite weighing as much as 47 pounds were recovered from the open cut (Ball, 1907a).

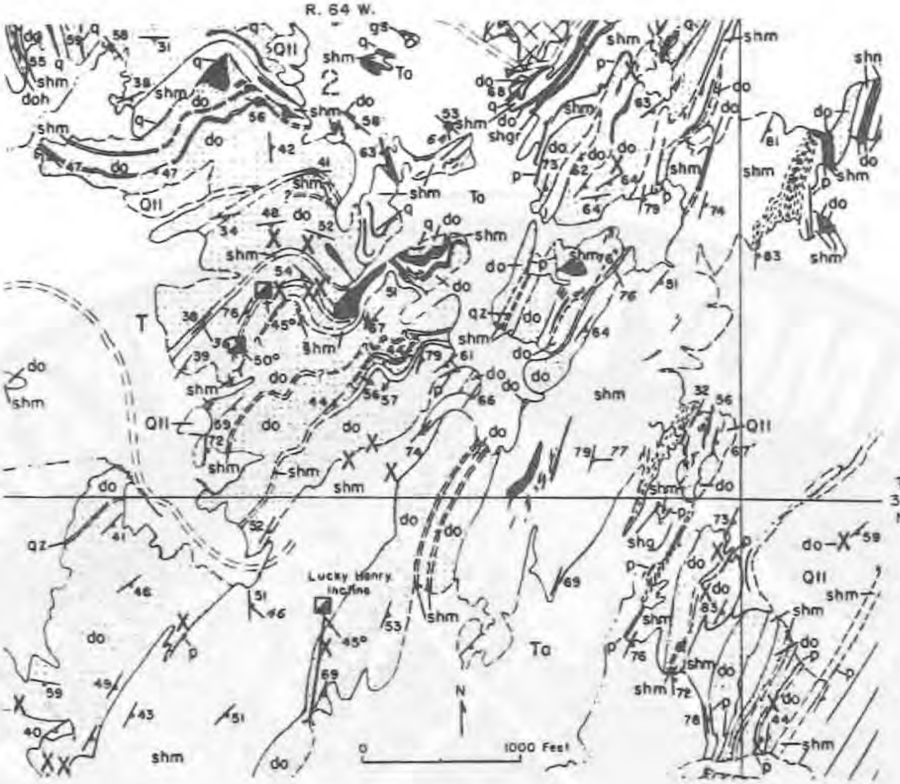
Gold Hill and Omaha mines; (probably the S½ sec. 2, T.30N., R.64W.). The Gold Hill and Omaha shafts are located on a 7- to 20-foot-wide band of schist between two limestone(?) beds (probably metadolomite). A distinct "S" fold separates the two shafts. In 1905, the Gold Hill shaft was only 60 feet deep (*The Mining Reporter*, October 26, 1905, p. 431).

In the Gold Hill workings, a crosscutting 6-foot-wide quartz vein with 2 feet of mineralized, iron-stained, footwall schist was mined. According to Ball (1907a) the ore assayed 0.2 oz/ton Au. The *Mining Reporter* (October 26, 1905, p. 431), reported the ore to assay 6 percent Cu and 0.3 oz/ton Au. Both mines have stringers of copper sulfides, carbonates, and silicates in the veins. Some barite gangue was reported at the Omaha mine (Ball, 1907a).

Lucky Henry incline; N½ sec. 11, T.30N., R.64W. The Lucky Henry incline is at least 288 feet deep (Ball, 1907a, p. 107); the president of the Copper Belt Mining Company reported the shaft to be 640 feet deep with 3,500 feet of drifts (Osterwald and others, 1966). The hanging wall in the mine is metadolomite and the footwall is iron-stained schist. The metadolomite trends N20° to 30°E and dips 50° to 70°SE.

The ore occurs in the schist and lies against the hanging wall metadolomite in two lens-shaped masses separated by barren schist. The lenses are 1 to 6 feet thick and continue from the surface downward to the bottom of the incline. At the bottom of the shaft, the mineralized zone is greater than 15 feet thick.

The mineralized lenses consist of ramifying veinlets and stringers of malachite, chrysocolla, and minor chalcopyrite. Chalcopyrite does



EXPLANATION

QUATERNARY

Qtl — Talus and landslide debris

TERTIARY

Ta — Arikaree Formation (Miocene-Oligocene)

PALEOZOIC

Cg — Guernsey Formation (Devonian-Mississippian)

Eq — Cambrian (?) quartzite

PRECAMBRIAN

q — Quartz dike or sill

p — Granite pegmatite, showing dip

gs — Granite

shh — Hornblende schist

shm — Mica schist

shgr — Graphite schist

do — Dolomite

qz — Quartzite

62 — Contact showing dip, dashed where approximately located

Zone of intensive quartz and pegmatite layering in mica schist

35 46 Inclined, Vertical — Strike and dip of foliation of metamorphic rocks showing trend and pitch of lineation due to mineral parallelism

79 — Minor fold axis in rocks of Precambrian age, showing plunge

18 — Generalized trend and plunge of fold axes in rocks of Precambrian age

45 — Shaft, showing direction and dip of incline

Adit

X — Prospect pit

Figure 15. Geologic map of the Rawhide Buttes district (modified from Millgate, 1964).

not occur in the upper 50 feet of workings. The lenses assayed 2 to 8 percent Cu, and the iron-stained schist surrounding the lenses assayed 0.05 to 0.58 oz/ton Au (averaged 0.15 oz/ton) and 2.0 to 5.0 oz/ton Ag (Ball, 1907a).

Wildcat Hills area

Mine and prospect descriptions

Copper Bottom; SE¼ sec. 23, T.29N., R.65W. A vertical, N20°W-striking vein cuts yellowish, silicified, Precambrian carbonate rocks. The vein is 2 to 4 inches wide and contains chrysocolla, malachite, and irregular masses of tennanite. Assays of average material collected across the vein showed a trace Au, 2 oz/ton Ag, and 24.64 percent Cu (Ball, 1907a, p. 96).

Green Hope mine; NW¼ sec. 26, T.29N., R.65W. The mine was developed in a coarse conglomeratic sandstone at the base of the Guernsey Formation (Devonian-Mississippian), where it overlies a rough uneven surface of Precambrian dolomite with sink holes and other solution features. Malachite, chrysocolla, azurite, and chalcocite replace the cement of the conglomerate and locally replace carbonate pebbles. These minerals and olivenite fill fractures in the conglomerate (Ball, 1907a, p. 102-103; Osterwald and others, 1966, p. 54).

The mineralized sandstone and conglomerate unit averages 3 feet thick, but in some places the mineralization extends 20 feet below the normal contact into solution features developed on the Precambrian surface. It was estimated that 400 to 525 tons of ore averaging 17 percent copper were mined from the property (Ball, 1907a, p. 102-103). One sample of cupriferous conglomerate collected from the property assayed 9.74 percent Cu, 0.93 oz/ton Ag, and 0.04 percent Zn.

Miscellaneous mines and prospects

Silver Cliff mine; sec. 7, T.32N., R.63W., on a low-lying (150 feet high) hill along the western edge of the Lusk townsite. Following the discovery of rich Ag-Au-Cu ores in 1879, a 285-foot shaft was sunk and a 1,200-foot inclined adit was driven to the bottom of the shaft. Five levels were established with at least 1,600 feet of drifts.

Mineralization consists of native copper, native silver, chalcocite, malachite, azurite, cuprite, chrysocolla, metatorbernite, uranophane, gummite, and pitchblende in calcite, limonite, and clinozoisite gangue. The mineralization occurs in the gouge zone of a high-angle, N25°E trending reverse fault and in highly fractured calcareous sandstone in the footwall.

The hill in which the mine is located consists of Precambrian quartzite, mica schist, hematite mica schist, actinolite schist, granite gneiss, and pegmatite cut by a siliceous carbonate vein and capped by about 60 feet of Paleozoic calcareous conglomeratic sandstone (Osterwald, 1950; Wilmarth and Johnson, 1954). Osterwald (1950) reported the sandstone (or quartzite) to be the basal conglomerate of the Guernsey Formation (Devonian-Mississippian), whereas Wilmarth and Johnson (1954) reported the sandstone to be equivalent to the Deadwood Formation (Cambrian).

According to historic reports, development of the mine was based on assay reports indicating the value of the gold and silver ore ran as high as $6,000/ton (1879 prices?) (Wilmarth and Johnson, 1954). However, the mine contained lower than expected values and was operated only until 1884. Years later, uranium was discovered on the property, and between 1918 and 1922, six carloads of high-grade uranium ore (>3 percent U_3O_8) were shipped to Denver for radium research. Following this short period of operation, the Silver Cliff was closed until 1951. During 1951 to 1953, minor amounts of uranium were recovered (Bromley, 1953).

Most of the available published assays are for uranium; however, Osterwald (1950) reported some selected samples contained 0.5 oz/ton Au. Wilmarth and Johnson (1953) collected several samples for assay. These ran <0.02 to 10.88 percent Cu and 0.16 to 15.04 oz/ton Ag (Table 9).

Woodfill (1987) reported four strong electromagnetic anomalies north of the Silver Cliff mine and a 250-gamma magnetic anomaly in the vicinity of Duck Creek. In 1984, Exxon Minerals, Inc. drilled south of these anomalies and intersected 10 feet of mineralized rock that averaged 0.8 percent Zn. Two feet of section averaged 1.2 percent Zn and 0.07 oz/ton Au (Woodfill, 1987).

Silver Springs prospects; secs. 26, 27, and 34, T.32N., R.64W. and sec. 3, T.31N., R.64W. In 1984, Exxon Minerals, Inc. drilled a gossan in the Silver Springs Schist. Anomalous zinc was detected between 244 and 425 feet depth with a 5-foot zone averaging 950 ppm Zn and 0.03 oz/ton Au. The mineralization is closely associated with a strong electromagnetic anomaly (Woodfill, 1987).

NW¼ sec. 6, T.33N., R.63W.; A 3-foot-wide mineralized zone, is conformable to the attitude of Precambrian mica schists. The deposit

Table 9. Sample analyses, Silver Cliff mine, Niobrara County, Wyoming (from Wilmarth and Johnson, 1954).

Sample	Type of material	Equivalent uranium[1] (%)	Uranium (%)	Cu (%)	Ag (oz/ton)
W- 6	6-foot channel in sandstone	0.003	0.001	–	–
W- 7	6-foot vertical channel in sandstone	.004	.001	–	–
W- 8	6-foot channel in sandstone perpendicular to fault	.005	.001	–	–
W- 9	3.5-foot channel across face of adit in sandstone	.006	.004	–	–
W-10	6-foot channel across fault zone	.000	.001	–	–
W-11	6-foot vertical channel in sandstone	.001	.001	–	–
W-12	6-foot channel across face of adit in sandstone	.001	.001	–	–
W-13	6-foot vertical channel in sandstone	.029	.033	–	–
W-14	6-foot vertical channel in sandstone	.017	.029	–	–
W-15	4-foot channel in sandstone	.004	.004	–	–
W-16	4-foot vertical channel in sandstone	.12	.10	–	–
W-17	4-foot channel in fault zone	.11	.12	–	0.28
W-18	4-foot channel in fault zone	.014	.009	–	–
W-19	6-foot channel across face of pit in sandstone	.002	.001	–	–
W-20	6-foot vertical channel in sandstone	.001	.001	–	–
W-21	6-foot vertical channel up faced adit in sandstone	.002	.003	–	–
W-22	4-foot vertical channel in sandstone	.023	.020	–	–
W-23	5-foot vertical channel in sandstone	.005	.004	–	–
W-24	6-foot channel in sandstone	.008	.008	–	–
W-25	6-foot vertical channel in sandstone	.001	.001	–	–
W-26	Composite dump sample	.020	.020	–	–
W-51	5-foot channel across hematite-stained fault zone	.006	.003	0.37	.98
W-52	Chip sample of radioactive sandstone	.56	.61	10.88	15.04
W-53	Chip sample of radioactive sandstone	1.38	1.48	2.60	1.23
W-54	Chip sample of radioactive sandstone	1.59	1.41	1.97	.16
W-55	6-foot channel across back of drift in fault zone	.007	.004	.27	.92
W-56	Grab sample of biotite-muscovite schist	.004	.001	.02	.98
W-57	5-foot channel across fault zone	.015	.008	.16	1.06
W-58	5-foot channel across fault zone	.004	.002	.21	1.00
W-59	Grab sample of hematite sandstone near fault zone	.006	.002	.03	.98
W-61	3-foot channel across actinolite layer in fault zone	.006	.002	.03	.97
W-63	Grab sample from dump of old Silver Cliff mine	.014	.002	$<$ .02	.94
W-64	5-foot channel across carbonate vein	.001	.001	$<$ .02	.96
W-65	Selected dump material	3.80	3.39	2.85	1.41
W-66	Selected dump material	.90	1.03	2.05	.72
W-69	Grab sample of pegmatite	.004	.001	$<$ .02	.97
W-70	Representative sample from uranophane-bearing sandstone from dump	.080	.095	–	–
W-71	Typical sample of uranophane-bearing sandstone	.17	.19	–	–
W-72	Grab sample of hematite-stained schist	.012	.007	–	–
W-73	3-foot channel across fault zone	.006	.002	–	–
W-74	3-foot channel across fault zone	.003	.002	–	–

[1]Equivalent uranium is "the amount of uranium in equilibrium with its daughter elements required to give the same counting rate as the sample in that particular type of instrument" (Johnson, 1954, p. 238).

has been prospected for 150 feet along the strike exposing malachite and sparse chrysocolla (Osterwald and others, 1966, p. 56). No precious metals are reported.

Laramie Mountains

Several historic mining districts occur in the Laramie Mountains of southeastern Wyoming (Figure 1), but most are dominated by copper with little or no reported gold and silver. However, a great majority of copper prospects have never been tested for precious metals. The known mineralized areas include Casper Mountain, Deer Creek, the Elmers Rock greenstone belt, Esterbrook, Garrett (Sellers Mountain), LaPrele, Silver Crown, and Warbonnet (Figure 1).

The Laramie Mountains form an elongate north-south anticlinal uplift cored by Precambrian rock and flanked by upwarped Phanerozoic sedimentary rocks. Along the western flank of the range, the Phanerozoics unconformably overlie the Precambrian basement and dip at low angles into the Laramie and Shirley Basins. On the eastern flank, pre-Tertiary sedimentary rocks generally dip steeply into the northern Denver Basin and in places are overturned and locally overthrust by Precambrian rocks. In addition to industrial and construction materials, the Phanerozoic rocks along the flanks of the range host scattered low-temperature Cu-Ag replacement deposits (Harris and Hausel, 1984).

The Precambrian terrane of the Laramie Mountains is divisible into a southern Proterozoic province and a northern Archean province. These two provinces meet near the center of the Laramie Mountains, where a 350-square-mile anorthosite batholith intrudes along the projected trend of the Mullen Creek-Nash Fork shear zone. The anorthosite is dated at 1.42 Ga (Subbarayudu, 1975) to 1.53 Ga (Smithson and Hodge, 1972).

The Proterozoic province to the south consists of amphibolite-grade mafic to intermediate metavolcanic rocks and associated metasediments that are about 1.8 Ga (Peterman and others, 1968). The volcanogenic metamorphics are host to Cu-Ag mineralization in the Silver Crown district (Klein, 1974). These rocks are intruded by 1.39 to 1.45 Ga granite, which includes the Sherman Granite and related phases (Peterman and others, 1968).

Rocks north of the anorthosite include gneiss, granite, and supracrustal successions. The gneisses have been radiometrically dated at about 2.9 to 3.0 Ga (Johnson and Hills, 1976) and were invaded by granite between 2.54 to 2.65 Ga. Metavolcanic and metasedimentary supracrustal successions interpreted to overlie the gneisses were later intruded by granite. Thus the age of the supracrustals is bracketed by the older gneisses that they overlie and the younger granites that intrude them (Graff and others, 1982). Granites that fold and dome the supracrustals have been dated at 2.54 Ga (Hills and Armstrong, 1974) and migmatites and gneisses of the central Laramie Mountains have been dated at 3.0 Ga (Johnson and Hills, 1976). Precious metal mineralization north of the anorthosite is associated with the supracrustal rocks.

Casper Mountain

The metamorphic terrane at Casper Mountain is part of a fragmented supracrustal belt. The metamorphic assemblage includes mica-quartz-feldspar gneiss; quartz-feldspar gneiss; amphibolite; quartzite; serpentinite and related ultramafic schists intruded by mafic sills and dikes; and granodiorite, granite, and related pegmatites. Amphibolite-grade metamorphism possibly affected the terrane at 2.7 to 2.8 Ga (Burford and others, 1979).

Mineralization includes chrysotile asbestos and chromite schist in the metamorphic sequence (Beckwith, 1939; Hausel, 1987a), beryl pegmatites, and copper-stained Cambrian Flathead Sandstone and Mississippian Madison Limestone (Burford and others, 1979; Hausel and Glass, 1980).

A gold mining camp named Eadsville was established in the late 1800s in sec. 19, T.32N., R.79W., but little remains of the historic camp and very little information is available about it. Free-milling gold was recovered from a quartz vein near the northeast slope of Casper Mountain in the vicinity of the headwaters of Goose and Hat Six Creeks. The vein reportedly pan tested at 0.15 to 0.19 oz/ton Au, but was soon abandoned. There were also reports of ore containing more than 600 oz/ton Ag (Molker, 1923). A diabase dike in granite country rock in this region reportedly carries some gold and silver values (Osterwald and others, 1966). In 1906, the *Wyoming Industrial Journal* (v. 7, no. 9, p. 3), reported numerous mines were operating, including the Blue Cap, Red Dog, Red Jacket, Quaken Asp, and Silver Leaf.

Mine description

<u>Blue Cap mine</u>; (location not given). The Blue Cap mine was developed by a 215-foot shaft with drifts. The mine intersected a

40-foot-wide mineralized zone with some rock that assayed 0.2 to 0.77 oz/ton Au (*Wyoming Industrial Journal*, 1906, v. 7, p. 21).

Deer Creek-Boxelder Canyon area

The area includes portions of T.31N., R.76 and 77W. and T.32N., R.75 and 76W. According to Spencer (1916), there are abundant schists and less abundant granites in the Deer Creek-Boxelder Canyon area. Serpentinite also occurs in many places in the area and mapping by Gable (1987) supports the interpretation that the Deer Creek-Boxelder Canyon supracrustals are a fragmented greenstone belt.

Gable (1987) reported the Deer Creek region to contain a supracrustal succession of metamorphosed sediments, volcanic flows, volcanic detritus, and tuffs that was probably deposited in a near-shore to offshore subsiding basin. Metasedimentary rocks include micaceous quartzite, sillimanite-quartz-mica schist, garnet quartzite, hornblende schist, and hornblende gneiss. Metaigneous rocks include amphibolite, serpentinite, ultramafic schist, gneiss, and granite. The entire sequence has been cut by diabase dikes (Gable, 1987).

A minimum Rb-Sr age of layered sillimanite migmatitic gneiss exposed in Boxelder Canyon (T.32N., R.75W.) east of Deer Creek Canyon is 3,020 ± 221 Ma (Johnson and Hills, 1976). Granite gneiss in the Boxelder Canyon area yielded a Rb-Sr date of 2,759 ± 152 Ma, and a leucogranite was dated at about 2,776 ± 35 Ma (Johnson and Hills, 1976).

Although very little information is available for precious metals in the district, there still appears to be some potential. For example, one brief report described an auriferous iron deposit at the head of Deer Creek (*Wyoming Industrial Journal*, 1903, v. 5, p. 163). Spencer (1916) reported both copper and chromite deposits to occur in the district and Osterwald and others (1966) reported some asbestos. Of several mines and prospects in the district, gold has only been reported at the Swede Boy.

Mine description

Swede Boy mine; approximately sec. 21, T.31N., R.76W., between Boxelder and Deer Creeks. A quartz vein in granite strikes N5°W and dips 60°E (Osterwald and others, 1966). Some ore recovered from the 200-foot level contained free gold (*Wyoming Industrial Journal*, 1906, v. 7, no. 8, p. 4).

Elmers Rock greenstone belt

The Elmers Rock greenstone belt is a northeasterly trending belt of metamorphic rocks located in the central Laramie Mountains. The belt extends across the width of the Laramie Mountains and is bounded on the north by a granite-gneiss complex. The belt is truncated along the south by the Laramie Mountains anorthosite batholith.

The metamorphic rocks were divided into two groups by Graff and others (1982). A lower group of ultramafic, mafic, and amphibolite rocks underlies an upper group of metasedimentary rocks. The belt is dominated by amphibolites of igneous or volcanogenic origin with lesser amounts of metasediments that include metapelite, banded iron formation, quartzite, metaconglomerate, and marble. The ultramafic and mafic metaigneous rocks have chemistries that are similar to komatiites and tholeiitic basalts, which typically form the bases of supracrustal rocks in greenstone belts elsewhere in the world (Graff and others, 1982; Smaglik, 1987).

No formal mining districts or camps were established within the greenstone belt, and only scattered gold occurrences are reported. Some low-grade chromite schist and some asbestos have been identified in the greenstone belt; copper and uranium have also been reported (Graff and others, 1982).

Mine and prospect descriptions

Big Mac claim; sec. 19, T.23N., R.69W. Pyrite, chalcopyrite, malachite, and azurite were exposed in a pit dug into Precambrian graphite schist (Osterwald and others, 1966, p. 217). No assays were reported.

Bluegrass Creek placer; sec. 21 and 28, T.22N., R.72W. This placer contains abundant black sand with some gold. According to Robert E. Jones (personal communication, 1984), the gold is easily recoverable. However, early reports about the placers along Bluegrass Creek indicated the gold was fine grained and too difficult to recover economically (Osterwald and others, 1966).

Dodge Ranch; sec. 34, T. 23N., R.73W. A stream-sediment sample taken on a tributary draining into the Laramie River by staff members of the Geological Survey of Wyoming in 1987 yielded several microscopic flakes of gold, more than two dozen pyrope garnets, and two sapphires.

Emerald group; sec. 8, T.23N., R.70W. Quartz-calcite stringers in folded schists contain copper sulfides and carbonates (Osterwald and others, 1966, p. 61). No assays were reported.

Independence group; on Slate Creek about 22 miles west of Wheatland. A nearly 1-mile-wide layer of schist intruded by granite trends northeast and dips 30° to 40°NW. It consists of fine-grained biotite schist, garnet-mica schist, muscovite schist, and hornblende schist. Several quartz veins in the schist conform to regional foliation and have limonite, malachite, and azurite stains with bornite, marcasite, and pyrrhotite. Assays show copper, nickel, gold, and silver in anomalous amounts (Osterwald and others, 1966).

Precious Honor No. 1 mine; NW¼SE¼ sec. 20, T.23N., R.69W., at 5,491 feet elevation in the Cooney Hills along the eastern edge of the Elmers Rock greenstone belt. Two shafts were sunk on a N61°W trending vertical shear. The shear is 6 feet wide at the collar of the shaft and stained with limonite and copper. In 1985, both copper carbonates and disseminated pyrite were found on the mine dump. The shear occurs in granite and gneiss.

At 155 feet deep, the mineralized zone was 4 feet wide and impregnated with chalcopyrite and bornite. Approximately 65 tons of ore were produced in 1901, which averaged $9.00 per ton (1901 prices). The ore contained small amounts of gold (Osterwald and others, 1966).

Whippoorwill mine; NE¼SW¼ sec. 20, T.23N., R.69W., at an elevation of 5,386 feet in the Cooney Hills. Two shafts were sunk in a 15-foot-wide pyritized quartzite in mica schist country rock. At the surface, the quartzite is stained by abundant limonite and minor malachite. At a 40-foot depth, the mine workings cut primary sulfides (pyrite, chalcopyrite). Assays produced anomalous Cu and Ag with 0.32 oz/ton Au (Osterwald and others, 1966).

Woods mine; NE¼ sec. 13, T.19N., R.73W. A northerly trending pyritized shear in amphibolite was tested by a short adit. Local residents reported several tons of gold ore were once shipped from this mine to Denver (Mike Bintner, personal communication, 1982).

Esterbrook district

The Esterbrook district is located north and west of Laramie Peak in the northern Laramie Mountains (Figure 1). The village of Esterbrook is centered in the district and the town of Douglas is located 20 to 25 miles to the north. The district is accessible by State Route 94 from Douglas.

Archean metasediments and metavolcanics were intruded by late Archean granite in the Esterbrook region. These supracrustal rocks host several fissure-filling veins and apparent replacement deposits. Four groups of deposits were identified by Greeley (1962): (1) pyrrhotite-quartz-minor chalcopyrite and sphalerite; (2) galena-pyrite-calcite-quartz; (3) quartz-pyrite; and (4) quartz-feldspar-mica-beryl. These were all considered epithermal deposits by Greeley (1962).

Esterbrook is a base metal district although anomalous gold and silver have been detected in some mineralized zones. Only those mines and prospects that have reported precious metals or a potential to host precious metals are discussed.

Mine and prospect descriptions

Ashenfelder prospect; sec. 8, T.27N., R.71W. This property was the center of some activity during the latter part of the 19th Century and then again in 1932. The prospect was developed by a 70-foot-long adit driven north on a limonite-stained shear. At the end of the drift, a winze was sunk and a drift driven north from the winze.

Ten samples were collected for assay — five from the adit and five from the dump and adjacent prospects. One sample of hematite-stained granite assayed 0.17 oz/ton Au, but the remaining samples were poorly mineralized (Segerstrom and others, 1977).

Esterbrook mine; SE¼ sec. 9, T.28N., R.71W., on the Douglas claim west of Esterbrook townsite. Part of the mine workings are covered by Esterbrook's landfill dump.

The Esterbrook mine was developed by a 350-foot shaft with a 300-foot drift driven to the south and a 100-foot drift driven to the north from the 335-foot level. The drifts followed a nearly vertical, northeast trending, tabular body of quartz with calcite and cerussite near the surface. Cerussite disappears at depth, where galena is the primary sulfide. It was reported that ore shoots of massive galena 6 feet wide were intersected at depth (Spencer, 1916)!

Approximately 50 tons of ore were mined, averaging \$15/ton (1902 prices). Nearly 18 tons of hand-sorted carbonate ore from the mine contained an average of 34.65 percent Pb, 1.3 oz/ton Ag, and 0.035 oz/ton Au (Osterwald and others, 1966). In 1945, some high-grade Pb-Ag ore was shipped from the property.

Eureka prospect; secs. 9 and 16, T.28N., R.71W. A quartz vein at a schist-diabase contact trends northerly. The vein is 8 to 20 feet wide and is stained by limonite. Masses, disseminations, and streaks of pyrrhotite with variable widths were found near the surface. Gold was found in the limonite gossan (Osterwald and others, 1966).

Maggie Murphy mine; W½W½ sec. 22, T.28N., R.71W., about 2 miles south of Esterbrook on the north side of Horseshoe Creek. The shaft was developed on a northeast trending limonite- and copper-carbonate-stained gossan in amphibolite schist. The mineralized zone is traceable for several hundred feet on strike over a 10- to 20-foot width.

A few feet below the surface, a 5-foot-wide pyrrhotite-rich vein was intersected by the Maggie Murphy shaft. At 50 feet deep, the vein contained little pyrrhotite (Spencer, 1916). Traces of sphalerite (Greeley, 1962) and coffinite (Guilinger, 1956) were also detected. Five of eight samples collected from the Maggie Murphy mine by the U.S. Bureau of Mines contained anomalous copper and one sample assayed 5.6 oz/ton Ag (Segerstrom and others, 1977).

Sauls Camp; NE¼SE¼ sec. 22, T.29N., R.71W. The country rock is dominantly hornblende schist with a foliation trend of N45°E. The mine workings intersected lenses of chalcocite, chalcopyrite, pyrite, and native copper in a copper-carbonate-stained gossan.

Samples of high-grade ore were reported to contain 30 percent Cu, 6 to 8 oz/ton Ag, and 0.03 oz/ton Au. About 100 tons of ore containing 9 percent Cu were shipped from the property.

Four hundred feet east of the main shaft, a highly magnetic zone greater than 1,000 feet long is continuous along a southeasterly trend. The anomaly is strong enough to disturb a compass needle (Spencer, 1916).

Snowbird group; NW¼NE¼ sec. 21, T.29N., R.71W., on the north slope of Elkhorn Mountain east of LaBonte Creek. Two greenish schist layers in granite strike north-south. Quartz veins in the schist are 6 to 8 feet wide; they are stained by limonite, hematite, and copper carbonates and contain anomalous gold (Osterwald and others, 1966).

Tenderfoot group; S½ sec. 3, T.28N., R.71W. According to Spencer (1916), the Tenderfoot group is outlined by a 2,000-foot-wide belt with prospect pits and shafts on scattered limonite-stained gossans. The principal sulfide found in this belt is pyrrhotite (Greeley, 1962). Some chalcopyrite containing gold and silver was discovered below the gossan (Osterwald and others 1966).

Three Cripples prospect; NW¼ sec. 15, T.28N., R.71W. This prospect was located on a northeast trending, limonite-stained, mineralized zone in schist. Samples collected from the 96-foot shaft contained pyrrhotite and chalcopyrite. A composite sample of mine dump material assayed 0.23 percent Cu with a trace Co (Spencer, 1916). Hall (1909) reported samples with copper, gold, and silver values, and traces of nickel. Traces of sphalerite were also reported (Greeley, 1962).

Garrett (Sellers Mountain)

The Garrett region (also known as Sellers Mountain) is a fragment of an Archean supracrustal belt located in the central Laramie Mountains. It is accessible by an improved dirt road, which runs northeasterly from U.S. Highway 30/287 two miles north of Rock River.

This supracrustal belt contains amphibolite, hornblende gneiss, biotite gneiss, biotite schist, iron formation, calc-schist, quartzite, and mafic and ultramafic schists enclosed by a "basement" of migmatite and granite (Karlstrom and others, 1981; Langstaff, 1984). The ultramafic and mafic schists are interpreted by Langstaff to represent metamorphosed komatiites, tholeiitic basalts, and gabbros.

Talc schist and asbestos prospects occur near the Garrett ranch. A few select samples of banded iron formation collected by George Langstaff in 1983 were assayed for gold by the Geological Survey of Wyoming, but contained no detectable precious metals. In 1984, samples of antimony- and arsenic-rich quartzite schist collected by the Geological Survey of Wyoming contained detectable gold. Roger Garrett (personal communication, 1984) reported some placer gold was recovered during the historic past from the Laramie River adjacent to his ranch house.

Prospect description

N½ sec. 28, T.25N., T.73W. A few hundred yards east of the Garrett ranch house, along the north bank of the North Laramie River, is a prospect pit that contains arsenopyrite-berthierite-bearing quartzite. One select sample assayed at the Geological Survey of Wyoming in 1984 yielded 0.25 oz/ton Au. The mineralization occurs along a micaceous quartzite-amphibolite contact. Similar mineralization occurs along the same contact 1 mile to the northeast, in SW¼ sec. 22 (Roger Garrett, personal communication, 1984). The contact appears to continue under the river between these two mineralized zones.

In 1984, Anaconda Minerals Company was actively exploring the Garrett region for stratiform gold along this contact (Craig S. Bow, personal communication, 1984).

Silver Crown district

The Silver Crown district is located in the foothills of the Laramie Mountains 20 miles west of Cheyenne (Figure 1). The mining district was organized on April 4, 1879, and a mill and smelter were constructed and operated on a small scale from 1880 to 1900. The amount of ore produced is unknown, but is thought to have been minimal. During the 1950s, the Copper King mine in the southern portion of the district was extensively drilled, outlining a relatively large-tonnage, low-grade, copper-gold ore body with anomalous titanium and silver values. In 1987, Caledonia Resources drilled 25 holes and identified a smaller, higher grade ore deposit.

The Silver Crown district is located within a narrow belt of northeast trending, foliated, calc-alkaline, metaigneous rocks along the eastern flank of the Laramie Mountains from 6 miles north of Highway 210 (Happy Jack Road) to as far south as northern Colorado. Segments of these rocks are crossed by Interstate 80 a short distance west of Granite, Wyoming. Within the Silver Crown district, large areas are covered by Tertiary gravels. The eastern flank of the district is marked by outcrops of steeply dipping Phanerozoic sedimentary rocks that are unconformably overlain by the Tertiary Chadron Formation, and the western margin is bounded by Precambrian Sherman Granite (Figure 16).

The oldest rocks recognized in the district are quartzite, quartz-biotite schist, and amphibolite, which are fragments of a Proterozoic volcano-sedimentary terrane. These rocks were intruded by gray foliated granodiorite (exposed throughout much of the district) and now occur as xenoliths and roof pendants in the granodiorite (Klein, 1974). South of the district, in T.13N., R.70W., large segments of this Proterozoic terrane are preserved.

The ages of the Proterozoic granodiorite and earlier volcano-sedimentary rocks are unknown. They are older than the Sherman Granite (1,390 to 1,450 Ma) and were probably metamorphosed during the regional metamorphic event at 1.7 Ga (Peterman and others, 1968, p. 2294), when they acquired gneissic and schistose foliations. The foliation trend of the granodiorite in the district averages about N25°E and bends to about N75°E in the southern portion of the district near the Copper King mine (Klein, 1974). The emplacement of the Sherman Granite along the western flank, the intrusion of quartz monzonite dikes and pegmatites, and the development of shear-zone cataclastics and faults were all controlled by the gneissic foliation in the Silver Crown granodiorite.

Where the amphibolite-grade metamorphosed Silver Crown granodiorite is in contact with Sherman Granite and later irregular bodies

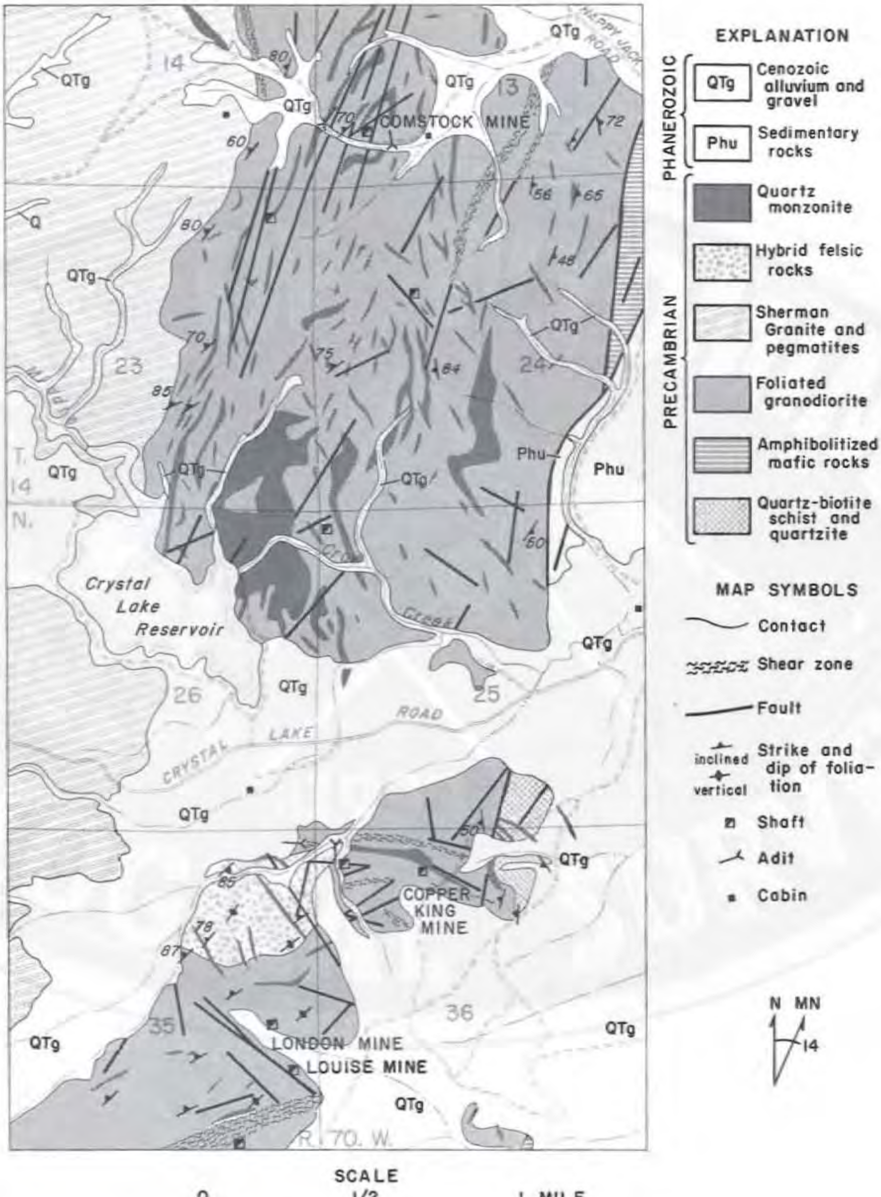


Figure 16. Geologic map of the Silver Crown district (modified from Klein, 1974).

and dikes of pink quartz monzonite, it has been affected by K-silicate alteration. The effect of the potassium enrichment has been to produce secondary microcline at the expense of plagioclase.

Mineral deposits in the Silver Crown district are structurally controlled and parallel regional foliation or occur in tensional fractures. Klein (1974) recognized two types of deposits, which he designated the Comstock type and the Copper King type. The Comstock type is typified by the mineralization exposed at the Comstock mine in the northern portion of the district. Narrow, clay-filled, shear-zone cataclastics and mylonites often host massive, white, cupriferous quartz veins and lenses. Economically, these are unattractive because of their narrow widths and limited tonnages. The Copper King type of deposit, exemplified by the Copper King mine in the southern part of the district, occurs as a low-grade, large-tonnage, disseminated Cu-Au deposit hosted by granodiorite and quartz monzonite. The largest concentrations of metal occur in rehealed silicified fractures in the granodiorite and to a lesser extent in the quartz monzonite. Mineralization is intimately associated with potassic alteration enclosed by a narrow zone of hydrothermal propylitic alteration (Nevin, 1973). Propylitic alteration is difficult to distinguish from regional retrogressive greenschist metamorphism, however it can be identified by the more intense and pervasive alteration associated with sulfides.

The timing of at least some of the mineralization is syn- to post-Sherman Granite. Mineralization, for example, occurs in the younger quartz monzonite at the Copper King mine and also occurs in fractures in the Sherman Granite adjacent to Crystal Lake in the Curt Gowdy State Park. At the Rambler prospect in the State Park, chalcopyrite and sphalerite are localized at fracture intersections in the Sherman Granite where it has been pervasively propylitized (Hausel and Jones, 1982).

Mine and prospect descriptions

<u>Comstock mine</u>; SW¼ sec. 13, T.14N., R.70W. The Comstock mine was developed on mineralized fracture intersections in pink quartz monzonite and foliated gray Silver Crown granodiorite near the northern edge of the Silver Crown district (Figure 16). One set of mineralized fractures trends N20°E, and the second trends N40°E to N65°E (see Hausel and Jones, 1982, Plate 3). According to Ferguson (1965), the Comstock shaft was sunk to a depth of 240

feet on the northernmost fracture intersection, and levels were established at 172 and 205 feet below the surface. In this shaft, a supergene chalcocite blanket was intersected that produced a mass of solid chalcocite "the size of a woodburning stove" (Ferguson, 1965). In 1981, the accessible workings of the mine consisted of 500 feet of drifts. The primary shaft and a winze continue below this level, but the lower workings were inaccessible because of flooding (Hausel and Jones, 1982).

Several small shears, veins, and gouge zones stained with copper silicates and oxides were intersected by the drifts. Available assays show significant copper with low-grade silver and gold (Table 10).

Table 10. Gold, silver, and copper assays reported for the Comstock mine, Silver Crown district (from Ferguson, 1965).

Sample description		Au (oz/ton)	Ag (oz/ton)	Cu (%)
2-3-11	Assay sample	.00	.00	66.60
4-18-15	Assay sample	.03	.66	4.80
4-6-15	Assay sample	.12	7.08	6.00
4-7-15	Assay sample	.02	9.70	41.35
6-7-15	Assay sample	.02	.50	2.01
7-25-17	Assay sample	.04	.70	14.70
5-6-18	Assay sample	.08	1.60	3.10
5-3-18	Assay sample	.04	11.56	6.50
5-16-18	Assay sample	trace	2.80	6.90
6-13-49	Assay sample	.02	1.20	4.00
6-13-49	Assay sample	.02	1.00	6.00
6-13-49	Assay sample	.02	1.00	3.50
5-13-55	Assay sample	.04	1.02	5.85
Samples assayed by American Smelting and Refining Company's Omaha plant:				
North drift, cross section of vein		.05	5.15	9.70
South drift, winze		.07	1.93	8.70
North drift, wallrock		.00	.40	1.70
Bottom of shaft, 240 feet		.04	2.66	12.90
North drift, 20 feet from shaft		trace	14.00	18.20
South drift		.00	.20	.98
Shaft, 210 feet		.00	.50	.78
No description		.07	1.13	8.80
7-19-15 48,217 lbs. to AS&R Company		.83	11.02	.74
3-14-16 25,113 lbs. to AS&R Company		.00	1.35	8.00
10-11-18 Car control		.04	1.25	5.74
6-29-29 Concentrates		.20	21.80	31.26
7-10-56 Selected ore		—	—	21.41
8-31-56 Selected ore		—	—	19.34
11-16-63 Selected ore		3.75	—	45.00

<u>Copper King (Arizona) mine</u>; NW¼ sec. 36, T.14N., R.70W. The Copper King shaft was sunk to 157 feet deep with levels at 80 and 130 feet. Approximately 400 feet of drifts and crosscuts were driven from the levels.

The Copper King property exhibits both K-silicate and propylitic hydrothermal alteration associated with disseminated sulfide mineralization in quartz monzonite and granodiorite. The deposit is characteristic of a dissected Proterozoic copper porphyry (Nevin, 1973, Hausel and Jones, 1982). Sulfides include chalcopyrite and pyrite with minor bornite. An oxidized and leached zone does not appear to be extensive, but according to Soule (1955) it may extend 100 to 150 feet deep. Several million tons of low grade Cu-Au ore were outlined by drilling (Table 11).

Table 11. Reported in-place reserves at the Copper King mine (after Nevin, 1973).

Tons (millions)	Au (oz/ton)	Cu (%)	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

Drilling by the U.S. Bureau of Mines indicated the ore body continues to a depth of at least 1,024 feet over a fairly extensive width and length. Spectrographic analyses also showed traces of Pb, Zn, W, and 0.5 to 3 percent Ti (Soule, 1955). Other nearby geochemical and geophysical anomalies suggest the extent of mineralization could be much greater than that outlined by drilling (Klein, 1974).

Caledonia Resources, Ltd., of Canada, leased the Copper King mine in 1987 to test the property for potential as a large-tonnage disseminated Au-Cu deposit. Drilling results are reported in Table 12.

The company reported preliminary gold reserve estimates to be on the order of 4.5 million tons, averaging 0.044 oz/ton, or about 200,000 contained oz of gold. Sampling suggests the deposit has a minimum strike length of 600 to 700 feet with a 300-foot width and is open at depth (Stockwatch, 1987).

<u>Eureka lode</u>; just north of the King David mine (the location of the King David mine is unknown). The Eureka vein carries chalcopyrite and assayed as high as 0.58 oz/ton Au. Aughey (1886) reported one sample that assayed 8 percent Pb, and 2.9 oz/ton Au.

Table 12. Results from drilling by Caledonia Resources, Ltd., on the Copper King property in 1987 (from Stockwatch, 1987).

Drill hole no.	Interval (feet)	Au (oz/ton)	Drill hole no.	Interval (feet)	Au (oz/ton)
CK 87-1	0-60	0.138	CK 87-12	130-390	0.043
	60-100	0.040			
	100-220	0.016	CK 87-13	130-470	0.054
	0-220	0.050			
			CK 87-14	190-520	0.050
CK 87-2	0-30	0.039			
	30-100	0.177	CK 87-15	50-320	0.076
	100-180	0.044			
	180-300	0.027	CK 87-16	250-390	0.019
	0-300	0.068			
			CK 87-17	170-450	0.043
CK 87-3	0-60	0.102			
	60-140	0.039	CK 87-18	0-190	0.050
	140-300	0.020			
	0-300	0.041	CK 87-19	0-170	0.051
CK 87-4	0-110	0.011	CK 87-20	0-250	0.043
	110-230	0.029			
	230-270	0.064	CK 87-21	130-180	0.028
	270-350	0.034		180-330	0.047
				330-420	0.025
CK 87-10	160-270	0.050			
	270-310	0.038	CK 87-22	60-140	0.023
	310-340	0.057			
	340-380	0.026	CK 87-23	0-40	0.032
	380-440	0.057		40-60	0.049
	440-500	0.034		60-80	0.027
	160-500	0.045			
			CK 87-24	0-30	0.027
CK 87-11	200-230	0.024		30-50	0.014
	230-360	0.011		50-210	0.031
	360-400	0.026			
	400-420	0.063	CK 87-25	60-80	0.024
	420-450	0.016		110-220	0.022
	450-490	0.034			

Hecla group; secs. 23 and 24, T.14N., R.70W. (see also Rambler prospect below). The Hecla consists of the Rambler, Coming, Day, Big Elephant, and Monte Cristo claims (Osterwald and others, 1966). Copper associated with zinc, gold, and silver occurs in a 4-foot-wide vein. Twenty tons of ore valued at $413 (after freight and smelter fees were deducted) were shipped from the property in 1916. An assay showed 0.62 percent Zn, 0.08 percent Cu, 0.01 percent Pb, 0.15 oz/ton Au, and about 4 oz/ton Ag. Other average assays show 5.2 percent Zn with lesser amounts of Ag, Pb, and Cu. The Monte Cristo claim also contained molybdenum (Osterwald and others, 1966, p. 240).

Lenox mine; according to Aughey (1886), this mine was located on Middle Crow Creek. The vein was 6 inches wide at the surface and 2.5 feet wide 40 feet below the surface. Mineralization consisted of argentiferous cerussite and galena with minor gold. The ore assayed 10 to 60 percent Pb, 40 to 60 oz/ton Ag, and 0.3 oz/ton Au (Osterwald and others, 1966, p. 127).

London mine; E½ sec. 35, T.14N., R.70W. Quartz was exposed in a shaft sunk on a gossan in foliated granodiorite. A selected sample of the pyrite-bearing quartz collected from the dump assayed 0.02 oz/ton Au (Hausel and Jones, 1982).

Louise mine; E½SE¼ sec. 35, T.14N., R.70W. This shaft was sunk to a depth of at least 150 feet on a small stockwork-like breccia in granodiorite (Figure 17). Two samples collected from the mine dump assayed 0.59 percent Cu with 0.01 oz/ton Au, and 0.22 oz/ton Ag with 0.01 oz/ton Au (Hausel and Jones, 1982). Some high-grade ore mined from the shaft was reported to assay 12 to 15 percent Cu, 3 oz/ton Ag, and 0.34 oz/ton Au (*The Mining Reporter*, July 16, 1903, p. 53).

Figure 17. Stockwork fracturing and veining at the Louise mine, Silver Crown district.

Rambler prospect; E½ sec. 22, T.14N., R.70W. A shaft sunk at the intersection of N60°W and N75°E trending fractures in granite exposed pyrite, chalcopyrite, sphalerite, and specularite. One sample yielded 0.28 percent Cu and a trace Au (Hausel and Jones, 1982).

Willadsen placer; sec. 10, T.13N., R.70W. A gold placer on the South Fork of South Crow Creek was mined during the Great Depression. According to the present landowners, some nuggets were recovered (Hausel and Jones, 1982).

Warbonnet district

The Warbonnet district lies west of the Esterbrook district in Archean granite cut by diabasic dikes. Most of the production in this district was derived from small copper deposits associated with the dikes. Little is known about the precious metal potential of this district.

Mine descriptions

Copper King mine; sec. 12, T.29N., R.75W. Chalcopyrite and oxidized copper minerals were discovered in a quartz vein in granite and a quartz lens in schist. Spencer (1916) reported the deposit was in a diabase dike. Two 600-foot-long tunnels were driven to develop the property (Osterwald and others, 1966, p. 38). Assays yielded good copper values and gold values as high as 0.35 oz/ton (Spencer, 1916, p. 75).

Oriole mine; sec. 10, T.29N., R.75W. In 1979, the author collected ore specimens from the mine dump that contained pyrite, malachite, and chalcopyrite. According to the *Wyoming Industrial Journal* (1905, v. 6, no. 10, p. 7), the ore from the Oriole mine carried gold and silver values in addition to copper.

Medicine Bow Mountains

The Medicine Bow Mountains of southeastern Wyoming lie 30 miles west of Laramie and a few miles east of Saratoga. This range has had an extensive history of mining and logging as described by Thybony and others (1985). Much of the Medicine Bow Mountains occurs within U.S. Forest Service boundaries and large segments are included in the Savage Run and Snowy Range Wildernesses.

The Precambrian core of the Medicine Bow Mountains is divided into two distinct provinces by a major east-northeast trending suture locally known as the Mullen Creek-Nash Fork shear zone. The shear zone consists of mylonites and cataclastic augen gneisses and is as much as 4 miles wide (Houston and others, 1968).

North of the shear zone, an Archean basement of >2.5 Ga quartz-ofeldspathic gneiss and granite is noncomformably overlain by an 8-mile-thick section of epicontinental and miogeoclinal metasediments. These metamorphics consist of quartzite, quartz-pebble conglomerate, phyllite, and lesser metacarbonate and metavolcanics deposited 2.5 to 1.7 Ga (Hills and others, 1968).

South of the shear zone, quartzofeldspathic gneiss, hornblende gneiss, layered mafic complexes, and granite form much of the Proterozoic terrane. The gneisses are interpreted as eugeoclinal metasediments and metavolcanics deposited 2.0 to 1.8 Ga (Houston and others, 1968). The age of the granites is about 1.7 to 1.4 Ga (Hills and Houston, 1979). Two large layered mafic complexes (Lake Owens and Mullen Creek) are estimated to be approximately 1.8 Ga (Houston and others, 1968).

Movement along the Mullen Creek-Nash Fork shear zone occurred between 1.73 and 1.64 Ga (Hills and Houston, 1979). The shear zone is interpreted to represent the boundary between Proterozoic island-arc metasediments and metavolcanics to the south and a cratonic continental margin to the north.

Several mining districts are found in the Medicine Bow Mountains. These include the Big Creek, Centennial Ridge, Cooper Hill, Douglas Creek, Gold Hill, Jelm Mountain, Keystone, and New Rambler districts (Figure 1). Some copper and gold have been reported in all of these districts, and anomalous palladium and platinum in the New Rambler district has led to speculation of possible platinum mineralization associated with the 1.8 Ga Mullen Creek layered mafic complex.

Placer deposits occur at a number of localities in the Medicine Bows. Douglas Creek and its many tributaries are the best known placers in the range. A number of other streams have also been reported to carry placer gold, including One Mile, Three Mile, Foote, Rock, Mill, Brush, Mullison, Cortex, North and South Forks of Dutton, North Fork of Cooper, North Basin, Fox, and Wagon Hound Creeks; and the Middle Fork of the Little Laramie River.

Big Creek district

The Big Creek district is located along the Platte River on the southwestern flank of the Medicine Bow Mountains within T.13N., R.80 and 81W. at the southern edge of the Savage Run Wilderness. The district lies immediately south of the Mullen Creek-Nash Fork shear zone (Houston, 1961; McCallum and Kluender, 1983). Mineralization includes cupriferous and rare-earth-bearing pegmatites and a few, narrow but rich, auriferous veins. Both the Big Creek and Platte pegmatites are known for their copper and rare-earth mineralization (Houston, 1961; Harris and Hausel, 1986).

The area is underlain by interlayered Precambrian feldspar-quartz-biotite gneiss and hornblende gneiss and schist, which are folded into a series of northeast trending folds with near-vertical limbs. The folds are displaced along east-west and northeast trending faults and shears. The layered rocks are also intruded by mafic rock in the northeast corner and by foliated granite in the northwest corner of the district. Tertiary rocks of the North Park Formation unconformably overlie this terrane in the southwestern part of the district (Houston, 1961).

Mine and prospect descriptions

Golden Eagle prospect; N½N½ sec. 30, T.14N., R.80W., along the southern edge of the Savage Run Wilderness. A northwest trending milky quartz vein in gabbroic country rock is as much as 2 feet wide and filled with limonite pseudomorphs after pyrite with some primary pyrite. Specimens with visible gold are relatively common in the boxworks. A selected high-grade sample containing visible gold assayed 280 ppm (8.16 oz/ton) Au, 2.5 ppm Ag, and 5,000 ppm As (McCallum and Kluender, 1983). A 2-foot channel sample taken across the vein by Geological Survey of Wyoming personnel in 1985 assayed 1.4 oz/ton Au. More recently, a sample of the gabbroic country rock was tested at the Geological Survey of Wyoming and yielded 6.2 ppm Au (Jay T. Roberts, personal communication, 1987).

Natures Mint mine; center sec. 30, T.14N., R.80W., southwest of the Golden Eagle prospect. The Natures Mint mine was developed by an adit and ventilation shaft on the northern slope of the Boat Creek valley. A northwest trending milky quartz vein in metagabbro parallels the Golden Eagle vein and carries visible gold (McCallum and Kluender, 1983). Donnelly (1979) reported chalcopyrite, arsenopyrite, and free gold in limonite in the Natures Mint vein. A selected high-grade quartz vein sample assayed 800 ppm (23.3 oz/ton) Au and 24 ppm Ag (McCallum and Kluender, 1983). McCallum and Kluender (1983) reported most samples from the Golden Eagle prospect and Natures Mint mine contain less than 80 ppm (2.3 oz/ton) Au!

Centennial Ridge district

The Centennial Ridge district was organized in 1876, after gold was discovered in stream gravels of the Middle Fork of the Little Laramie River. Several lode discoveries followed the placer discovery on the Middle Fork. The district later had renewed activity following the discovery of platinum at the New Rambler mine 5 miles to the southwest in 1901. The district is located a mile west of the town of Centennial, and the mines can be reached by dirt roads leading from Highway 130 (Figure 18).

Dart (1929) reported at least $90,000 (about 4,500 oz) gold was produced from the Centennial mine. At least 100 tons of the ore was milled from the Free Gold claim (Hess, 1926), and the Utopia mine also realized some production. But production records for the district are incomplete at best, and actual total production is not known.

Both primary lode and secondary placer gold and platinum deposits are reported in the district. Primary lode deposits are of two types: (1) auriferous quartz veins that parallel foliation and schistosity of biotite and hornblende gneisses and schists; and (2) Au-Pt veins that occur as fracture fillings and replacements in shear zones and faults cutting the biotite and hornblende gneisses and schists. The Pt-group metals are associated with sulfides and arsenides in the fracture fillings.

The richest ores in the district are associated with sulfide-rich zones in the mafic host rocks. The greatest sulfide concentrations are generally found in graphitic fault gouge, brecciated mafic mylonites, and strongly chloritized wallrock. Sulfide veins up to 4 inches thick have been reported in drifts developed into the upper Middle Fork Creek shear zone. Pyrite is the dominant sulfide except where it is oxidized to limonite. Small amounts of arsenopyrite and cobaltian pyrite are sometimes present. Chlorite, epidote, calcite, dolomite, siderite, alum, and minor quartz occur with the sulfide masses. Chalcopyrite occurs locally along with small amounts of malachite, azurite, and chrysocolla (McCallum, 1968).

The gold and Pt-group minerals are believed to have been derived from the leaching of mafic rock sulfides during a Precambrian hydrothermal event. The metalliferous solutions were deposited as fracture fillings in faults and fractures. The mafic rocks are the most probable source of the metals because of the intimate relationship of the metals with the mafic schists and gneisses (McCallum, 1968). However, sampling at the Independence mine showed that the gold occurs in the massive mafic rock and that the shears are relatively unmineralized. These relatively unmineralized shears may have developed during Laramide deformation or sometime after the Precambrian hydrothermal activity.

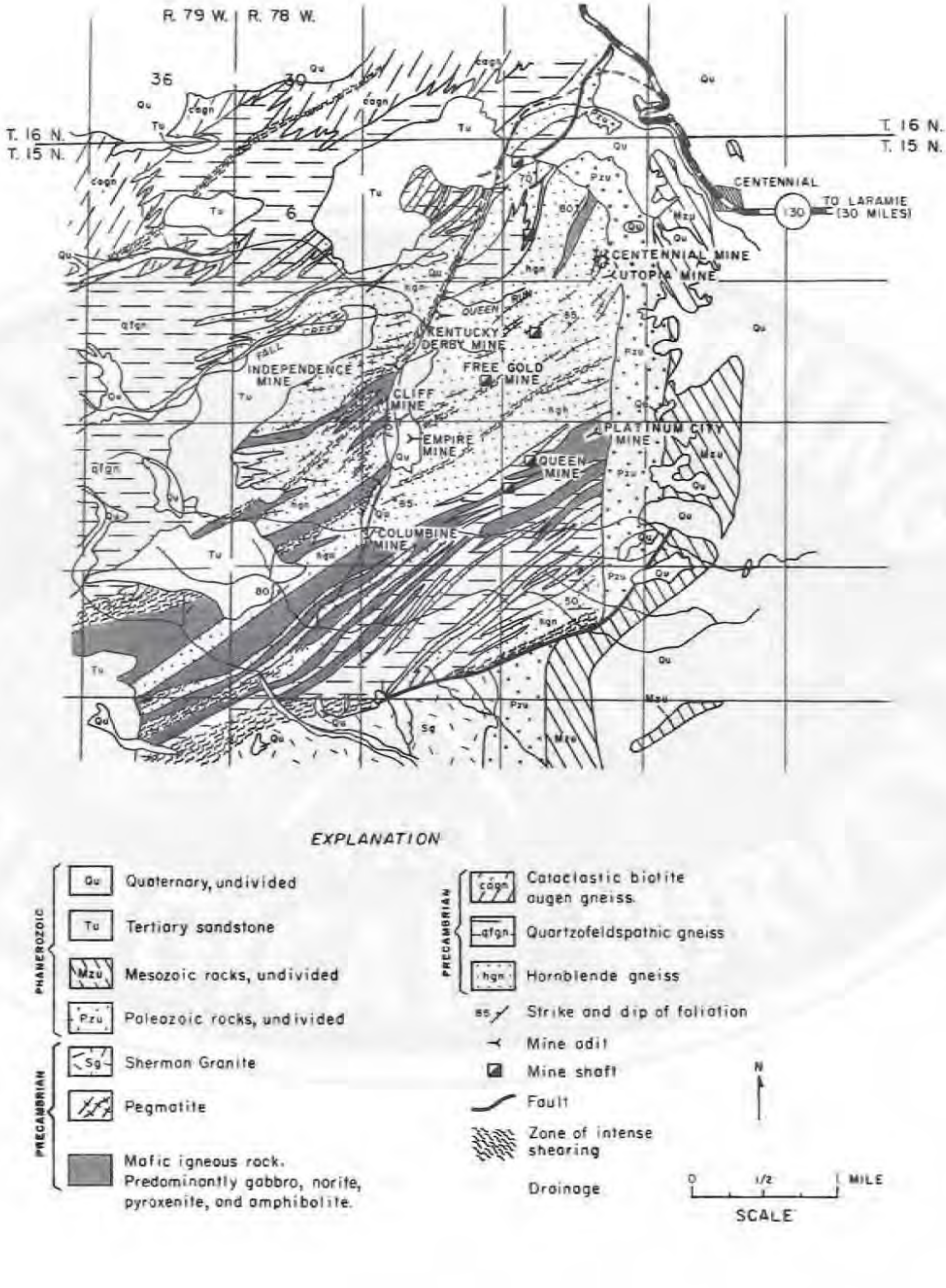


Figure 18. Generalized geology of the Centennial Ridge gold-platinum district (after Houston and others, 1968: McCallum, 1968).

Placer gold and platinum occur in alluvial gravels along the Middle Fork of the Little Laramie River and along Queen Mill Run and Fall Creek. Some spots on Mill Creek yielded 0.25-oz gold nuggets with a number of 0.1-oz nuggets (*Wyoming Industrial Journal*, 1905, v. 7, no. 1, p. 17). No production records are available for the placer deposits. According to E.K. Burhans (personal communication to McCallum *in* McCallum, 1968) some gravels carried gold, Pt-group metals, galena(?), and free mercury.

Mine and prospect descriptions

Centennial mine; SE¼ sec. 4, T.15N., R.78W. The gold ore at the Centennial mine was reported to average 1.5 oz/ton. Production records indicate that about $90,000 (4,500 oz) of gold were milled in the late 1860s. The ore from the Centennial mine was reported to be rich; for example, an ore sample from the Centennial mine won first prize at the Paris Mining Exposition in 1878 (Dart, 1929). A gold-bearing garnet schist from the Centennial mine is also presently in the mineralogy collection of the Smithsonian Institute.

The ore occurs as free-milling gold associated with N45°E trending quartz veins and in shear zones in iron-stained mafic hornblende gneiss and schist country rock (McCallum, 1968). Mining terminated when the vein abruptly ended at a fault. Later attempts to locate the displaced vein failed (Hausel, 1980a).

Cliff mine; S½SW¼ sec. 8, T.15N., R.78W. This mine was developed by a 775-foot tunnel that followed the schistosity of the country rock. Near the end of the main drift, a 325-foot crosscut tunnel running northwest intersected four quartz- and sulfide-bearing fracture zones. The wallrocks are mafic schist and submylonite (McCallum, 1968).

The first mineralized zone was intersected a few feet from the main drift, and this quartz-sulfide vein reportedly carried gold values of 0.58 oz/ton over a 15-foot width. The number 3 vein, located 140 feet from the main drift, was reported to contain platinum, but Hess (1926) was unable to duplicate this finding.

Columbine mine; SW¼ sec. 17, T.15N., R.78W. This mine was driven only 50 feet into amphibolite-biotite schist along the schistosity and cataclastic foliation in the mafic schist and submylonite country rock. The mine was mapped by the Geological Survey of Wyoming in 1980 (Hausel, 1980b; Hausel and Jones, 1982). Iron-stained shear planes and finely disseminated sulfides in submylonite were found in the tunnel. Only copper and iron were detected in mine dump samples (McCallum, 1968).

Empire mine; NE¼NW¼ sec. 17, T.15N., R.78W. Two adits were developed on iron- and copper-carbonate stained shear planes parallel to the schistosity and foliation of mafic schist country rock (McCallum, 1968). The two drifts extended 100 to 175 feet into the shear zone. The lower adit contained platinum-bearing sulfides.

Assays of iron-stained sulfide-bearing fractures ranged from a trace to 0.99 oz/ton Ag, a trace to 0.06 oz/ton Au, a trace to 1.04 oz/ton Pt, a trace to 63.72 oz/ton Pd, and a trace to 2.84 oz/ton Ir (Hess, 1926).

Fall Creek placer; sec. 7, T.15N., R.78W. Some placer gold and platinum have been reported in Fall Creek (McCallum, 1968).

Free Gold (Billy Waters) claims; SE¼ sec. 8, SW¼ sec. 9, T.15N., R.78W., near the top of Centennial Ridge (Figure 19). The Free Gold claims were developed by a 30-foot exploratory shaft and nearly 800 feet of trenches on a 2.5-foot-wide quartz vein. The vein contains free gold in limonite boxworks.

The Free Gold vein parallels regional foliation in the amphibolite and chlorite schist country rock. Hess (1926) estimated that at least 100 tons of ore were produced from the property and that mining was difficult due to excessive water in the mine workings.

Several samples collected from the property for assay included four from the Free Gold shaft (Figure 19): (1) a surface vein sample (no. 53) that assayed 1.84 oz/ton Au; (2) a vein sample (no. 54) at 15 feet depth that assayed 1.06 oz/ton Au; (3) a vein sample (no. 55) at 20 feet depth that assayed 0.52 oz/ton Au; and (4) a vein sample (no. 56) at 30 feet depth that assayed 0.62 oz/ton Au. Within 500 feet and to the northeast of the discovery shaft, a 10-foot deep trench was dug on the vein. Eight samples of quartz from the trench assayed from 0.08 to 2.84 oz/ton Au averaging 0.89 oz/ton Au (Sample numbers 61-68, see Figure 19) (Dart, 1930).

Six samples (sample numbers 69-74) were also collected from hornblende schist in contact with the quartz vein. These samples yielded from 0.10 to 0.46 oz/ton Au, averaging 0.22 oz/ton Au (Dart, 1930). A single sample (no. 77) of quartz from a 3-foot-wide vein exposed in an open cut located west of the Free Gold shaft assayed 2.54 oz/ton Au (Dart, 1930).

Golden Crown Mining Syndicate; N½ sec. 9, T.15N., R.78W., a series of claims on the east slope of Centennial Ridge a few hundred

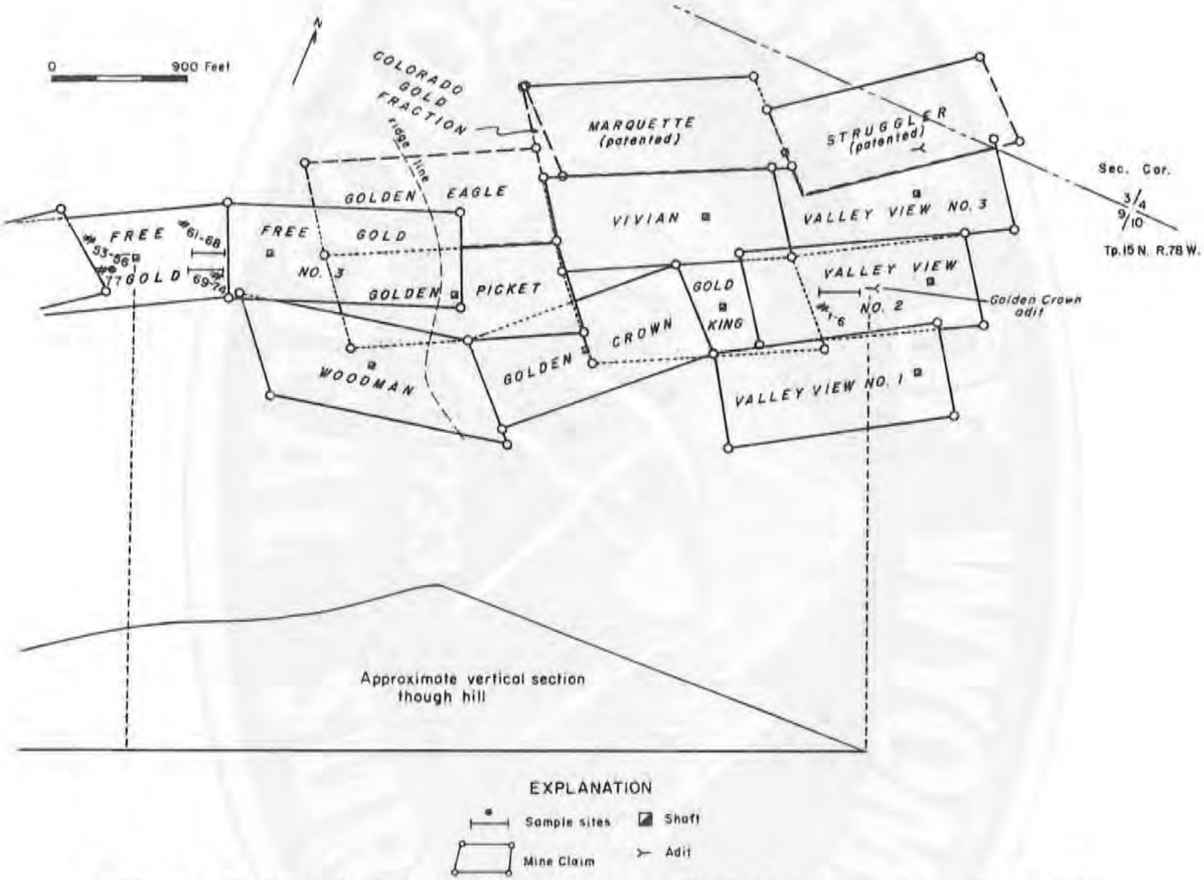


Figure 19. Free Gold claim and other mining claims in the Golden Crown Group (Dart, 1930).

feet south of the Utopia mine along a northeasterly trend with the Free Gold claims (Figure 19).

The vein on the Golden Crown property contained free gold in honeycombed quartz hosted by amphibolite schist. Six samples were collected from the vein by Dart (1930) (Table 13).

Table 13. Samples collected from the Valley View number 2 claim (Golden Crown Mining Syndicate) (Dart, 1930).

	Sample description	Au (oz/ton)	Pt (oz/ton)
1.	Golden Crown tunnel entrance face.	0.52	0.72
2.	Ledge outcrop, 50 feet from entrance.	0.32	not detected
3.	Old tunnel, 150 feet west of Golden Crown adit.	0.40	0.84
4.	Ledge outcrop, 250 feet on strike above tunnel entrance.	0.24	not detected
5.	Red quartz and schist from ten-foot shaft located on strike above tunnel entrance.	0.56	not detected
6.	Altered rock, same location as number 5	trace	0.40

Golden Eagle claim; W½ sec. 9, T.15N., R.78W., about 900 feet east of the Free Gold claims discovery shaft and a little more than 100 feet north of the Free Gold-Golden Crown mineralized trend (Figure 19). Two samples from the Golden Eagle discovery shaft yielded 0.72 and 2.49 oz/ton Au. A third sample collected at the bottom of the shaft assayed 3.12 oz/ton Au and 0.20 oz/ton Ag (Dart, 1930).

Independence mine; sec. 8, T.15N., R.78W., on the west bank of the Middle Fork of the Little Laramie River. The Independence adit was driven N35°W and crosscut five separate shears within 80 feet of the portal (Figure 20). At 30 feet from the portal, a 110-foot drift was driven parallel to a N68°E trending shear. The shears are very permeable, as is evidenced by persistent water flow through the fractures in late spring and early summer. The nonsheared amphibolite country rock is a competent impermeable rock (Hausel and Jones, 1982).

Reported assays for the Independence mine suggest the property contains gold and platinum values. For example, an analysis of ore reportedly gave 0.27 oz/ton Pt, 0.46 oz/ton Ir, 0.03 oz/ton Rh and 0.10 oz/ton Os (Osterwald and others, 1966, p. 151). However, none of the chip or channel samples collected in the mine by Hausel and Jones (1982) contained detectable platinum. It is also important to note that channel samples taken in the shears contained only trace amounts of gold, whereas some of the adjacent competent

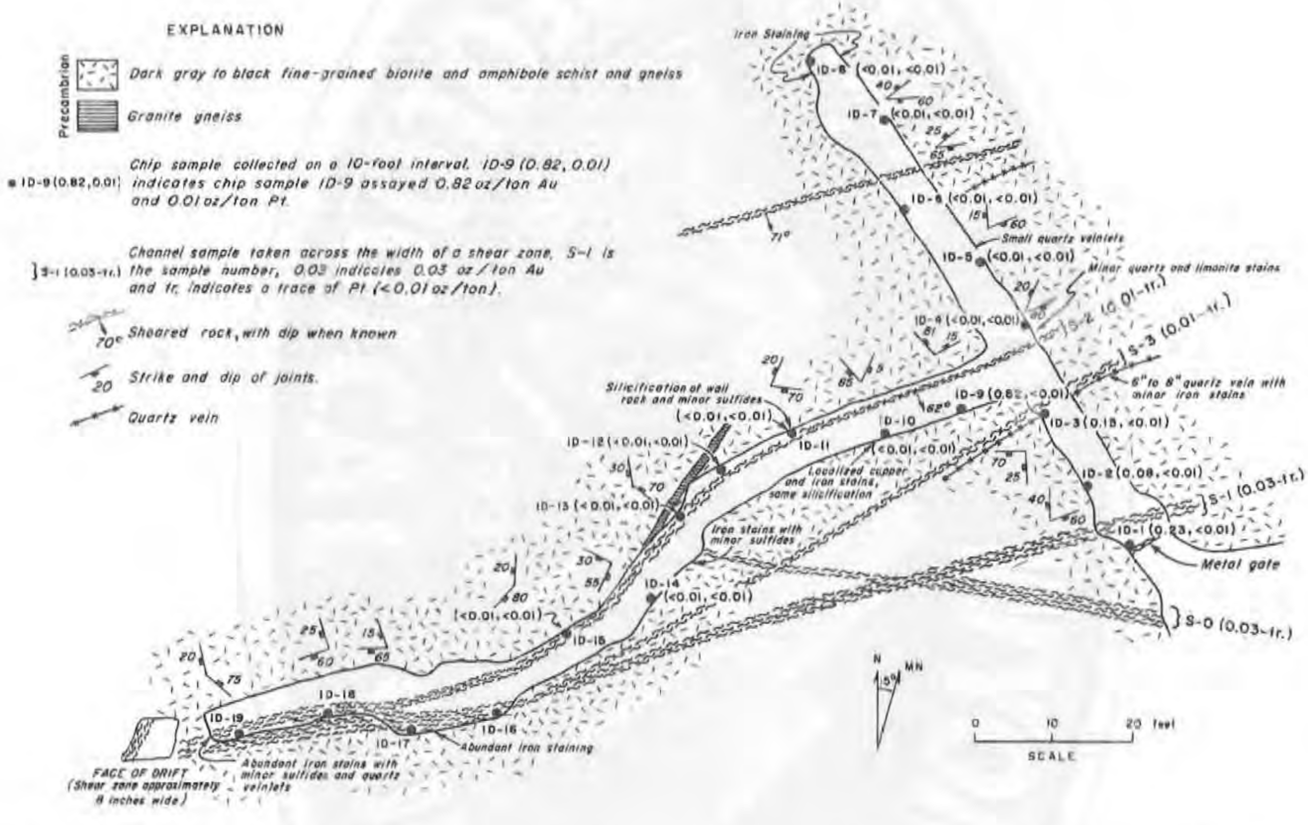


Figure 20. Geologic map of the Independence Mine, Centennial Ridge district, showing sample locations and assay values (after Hausel, 1980b).

wallrock contained anomalous gold. This observation suggests that the main mineralizing event occurred before shearing and subsequent metal remobilization was not a significant factor at the mine. This indicates that the Independence shears developed some time later, well after the main Precambrian mineralizing event. One sample of arsenopyrite-bearing gneiss recently collected above the mine portal assayed 0.5 oz/ton Pt (Bill K. Rogers, personal communication, 1983).

Kentucky Derby prospect; sec. 8, T.15N., R.78W. The Kentucky Derby prospect is developed by a few short prospect crosscuts. The workings penetrate strongly shattered, sulfide-enriched, dark, dense, shear-zone tectonities. The mineralized zone is oxidized and the sulfide masses are coated with films of limonite and alum. According to personal communications to McCallum (1968), Pt-group metals and gold were found in samples taken from this prospect. However, McCallum reported that grab samples assayed by the University of Wyoming Natural Resource Research Institute showed only a trace of Cu, Au, and Ag, and no Pt. One sample assayed by Theobald and Thompson (1968) assayed only 0.1 oz/ton Pt.

Middle Fork placers; W½ sec. 17, and S½ sec. 8, T.15N., R.78W., along Middle Fork Creek. Gold and platinum have been reported from Quaternary stream-sediment deposits in the Middle Fork and its tributaries. Two of the best prospects include two flat areas in secs. 8 and 17 consisting of floodplain gravel and terrace deposits.

The west side of the stream in the northern flat was reported to carry considerable gold. However, McCallum (1968) did not substantiate this claim. The early reports suggest the gold and platinum were concentrated on bedrock at the base of stream gravels.

Mother Lode prospect; sec. 1, T.15N., R.79W., along Middle Fork Creek. The prospect consists of sulfide-rich alluvial and eluvial boulders and cobbles. The mineralized rocks are pyritized quartz and pyritized amphibolite, which occur in boulders on a stream bank. The pyritized rocks extend several hundred feet upslope from a prospect pit in the stream bank.

One sample of pyritized amphibolite yielded no detectable gold or platinum (Hausel, 1982b). Theobald and Thompson (1968) assayed a sample for platinum, but none was detected.

Platinum City mine; NW¼NE¼ sec. 16, T.15N., R.78W. The Platinum City mine was dug in pegmatite, quartz, and sulfide veins, and in mylonite in amphibolitized metaigneous rock. The quartz veins carried some free gold, and the sulfide veins and pods commonly carried gold and platinum values (McCallum, 1968).

Queen Mill Run placer; NE¼ sec. 8, T.15N., R.78W. Some gold and platinum metals were reported in stream sediments (McCallum, 1968).

Queen shaft; NW¼ sec. 16, T.15N., R.78W. The Queen shaft was sunk to a depth of 90 feet in fault gouge in amphibolitized metapyroxenite. The shaft exposed numerous small faults and veins of calcite and pegmatite. The faults contained up to an inch of gouge, some of which was rich in sulfides and calcite veinlets (McCallum, 1968). A sample of gouge collected by Hess (1926) assayed 0.03 oz/ton Pt, 0.05 oz/ton Ir, less than 1.0 oz/ton Ag, and a trace Au. Dump samples assayed in 1961 contained some copper (McCallum, 1968).

Utopia mine; N½NE¼ sec. 9, and S½SE¼ sec. 4, T.15N., R.78W. (Figure 18). This property was developed by three adits in the early 1900s. Gold was found associated with quartz veins and shear zones and as inclusions in garnet in hornblende schist country rock (Dart, 1929). The veins were offset by faulting and lost, which resulted in closure of the mine (Hess, 1926). Assays reportedly ranged from a trace to 1.64 oz/ton Ag and a trace to 3.46 oz/ton Au (Figure 21) (Dart, 1929).

Vivian claim; sec. 9, T.15N., R.78W., in the Golden Crown Group south of the Utopia mine (Figures 18 and 19). One sample of schist from the claim assayed 0.46 oz/ton Au (Dart, 1930).

Woodman claim; E½ sec. 8 and W½ sec. 9, T.15N., R.78W., adjacent to the Free Gold claims (Figure 19). A sample of schist from the discovery hole assayed 0.94 oz/ton Au (Dart, 1930).

Wyoming Gold and Platinum Mining Company; based at Centennial (property location not given). U.S. Bureau of Mines' assays showed 11 oz/ton Pd with traces Ni from this property. The ore occurred in small cross fractures that cut mafic metamorphic country rock at right angles to the foliation (Osterwald and others, 1966, p. 151).

SW¼SW¼ sec. 17, T.15N., R.78W. An unnamed mine at this location was driven along a N35°W trend parallel to two weakly mineralized shears. The shears are stained with minor hematite and limonite. Several small barren quartz veins were cut by the tunnel. The mine was mapped by the Geological Survey of Wyoming in 1980 (see Hausel, 1980b; Hausel and Jones, 1982).

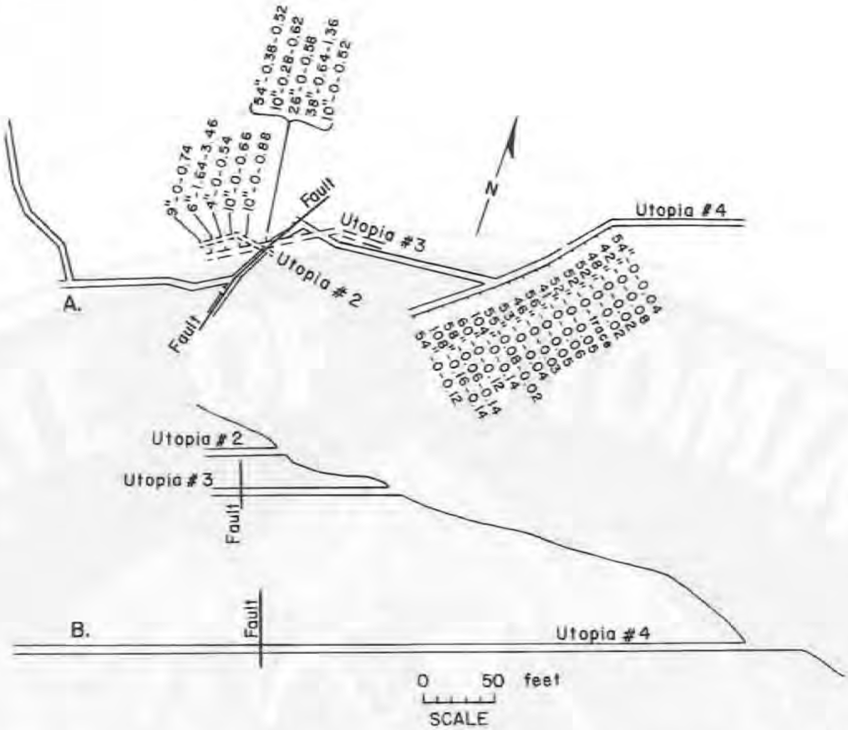


Figure 21. Utopia Mine, showing sample locations and assay values: (A) plan view; (B) cross section (after Dart, 1929). (6"-1.64-3.46 describes a 6-inch channel sample that assayed 1.64 oz/ton Ag and 3.46 oz/ton Au.)

Cooper Hill district

The Cooper Hill district is located 6 to 8 miles south-southeast of Arlington (**Figure 1**), a short distance south of Interstate 80 along the northeastern edge of the Medicine Bow Mountains (see Hausel and Jones, 1984). The area is underlain by folded Precambrian gneiss, marble, schist, quartzite, and amphibolite, which are unconformably overlain along the northern and eastern flanks by alluvium and sedimentary rocks of the Tertiary Ferris and Hanna Formations (**Figure 22**).

Two periods of vein emplacement were recognized in the district by Schoen (1953). The first-stage veins were emplaced in steeply dipping to vertical north-south and east-west trending joints or foliation and are commonly displaced by faults. These early milky quartz veins are generally barren of mineralization other than pyrite. However, where these veins occur in marble or calcic schist, they often contain disseminated chalcopyrite and chalcocite.

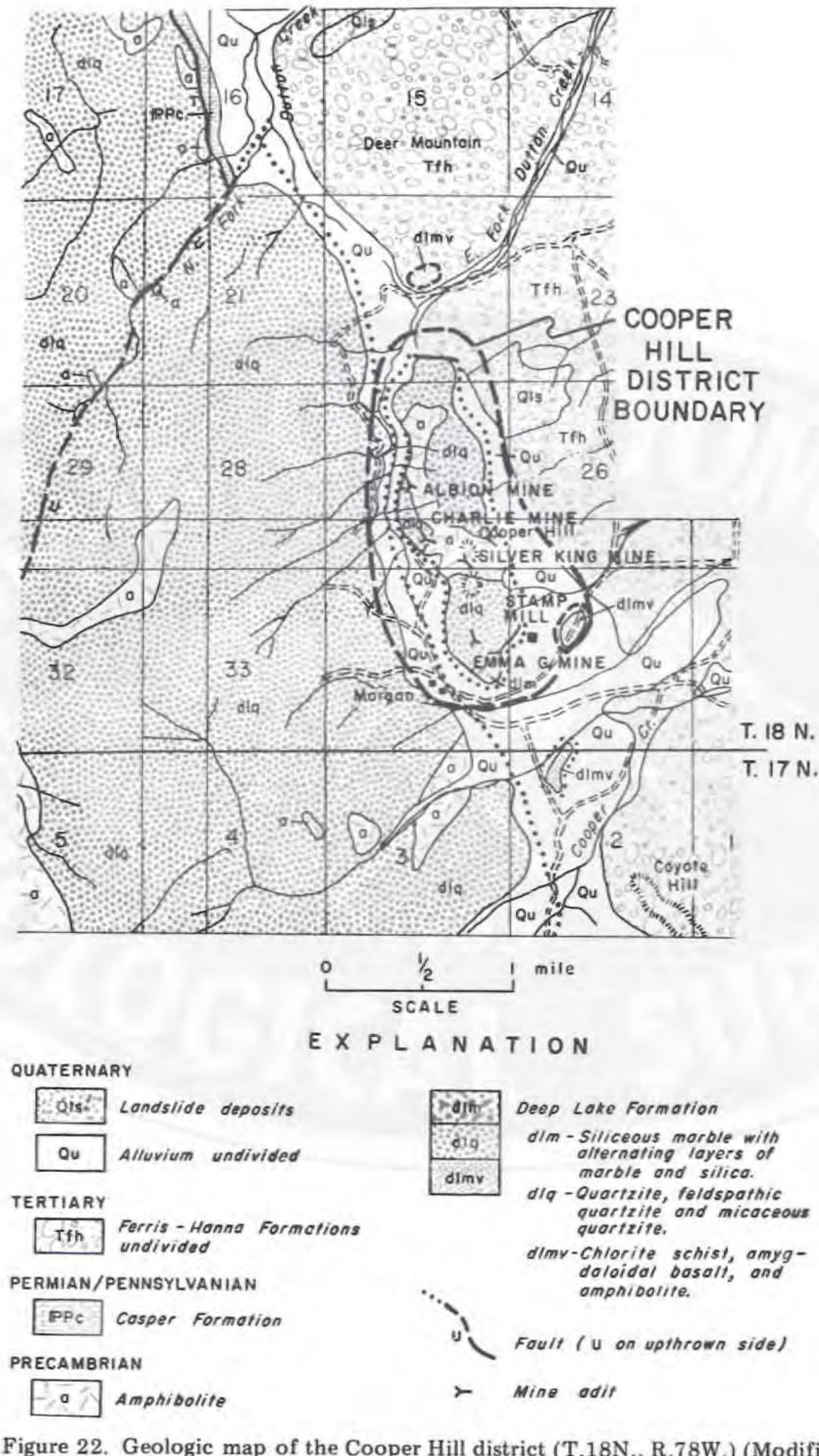


Figure 22. Geologic map of the Cooper Hill district (T.18N., R.78W.) (Modified from Houston and others, 1968).

Only one second-stage vein was identified by Schoen (1953). This vein is concordant to foliation and mineralized. Where the vein occurs in quartzite, it hosts argentiferous galena, polybasite, pyrite, and gold. In calcic schist host rock, the vein contains chalcocite and chalcopyrite (Schoen, 1953). In places, the mineralization has the appearance of open-space filling (Schoen, 1953).

According to Beeler (1906a), the Emma G mine along the south end of Cooper Hill produced the richest float in the district. The Albion mine on the west side of the hill produced the greatest body of gold and galena. The Richmond mine near the northern end of the hill produced the largest amount of free-milling gold, and the Cooper Hill mine (location unknown) produced the greatest amount of copper in the district. Some rare ore mined in the district was reported to have a value of $84,000 per ton! (1906 prices, Beeler, 1906a). Beeler also reported that an immense vein of sugar quartz runs along the west side of Cooper Hill and carries free-milling gold. Gold in the vein consistently averaged 0.1 to 0.12 oz/ton (Beeler, 1906a).

Mine and prospect descriptions

<u>Albion mine</u>; NE¼SW¼ sec. 27, T.18N., R.78W., on the western flank of Cooper Hill (see Hausel, 1980a, p. 42, for mine map). Two adits follow a subhorizontal, 3- to 5-foot-thick, milky quartz vein at the contact between quartzite and calcic schist. Where the vein enters the schist, it frays out and contains disseminated chalcopyrite, chalcocite, and bornite. Where the vein occurs at the contact between the two host rocks and enters quartzite, it contains argentiferous galena.

Along most of the length of the tunnel, the vein dips slightly to the west. At two localities, approximately 70 and 100 feet from the portal, the vein rolls (changes dip to the east) and forms ore shoots. An assay at the second roll gave 0.83 percent Pb, 0.70 oz/ton Au, and 2.2 oz/ton Ag (Schoen, 1953). Osterwald and others (1966) reported select samples from a 5- to 9-foot-wide, cerussite-bearing quartz vein contained 4.0 to 5.3 oz/ton Au and 50 oz/ton Ag in addition to Pb.

<u>Charlie mine</u>; S½S½ sec. 27, T.18N., R.78W. The Charlie mine is a short adit developed on a horizontal vein containing specular hematite. The geology of this mine is similar to the Albion, but no ore minerals are reported (Schoen, 1953).

<u>Emma G mine</u>; N½SE¼ sec. 34, T.18N., R.78W. Beeler (1906a) reported this property to contain some of the richest ore in the

district. The property is developed by both a vertical and a short inclined shaft. The wallrock is porphyroblastic biotite schist. Near the bottom of the incline, a 15-foot-thick quartz vein was intersected, but according to Schoen (1953), it was unmineralized. Schoen apparently did not investigate the vertical shaft.

Fox group; (location unknown). A 70-foot shaft was sunk on a 12-foot sulfide "body." Black sulfides and a thin layer of tellurium(?) were discovered at the bottom of the shaft. Reported assays were 1.15 to 2.5 oz/ton Au (Osterwald and others, 1966, p. 43).

Douglas Creek district

The Douglas Creek district lies within the interior of the Medicine Bow Mountains about 6 to 8 miles west of Albany (Figure 1). The district includes all placer deposits along Douglas Creek and its tributaries from Rob Roy Reservoir on the north to below Lake Creek 6 miles to the south (Figure 23). Total gold production from

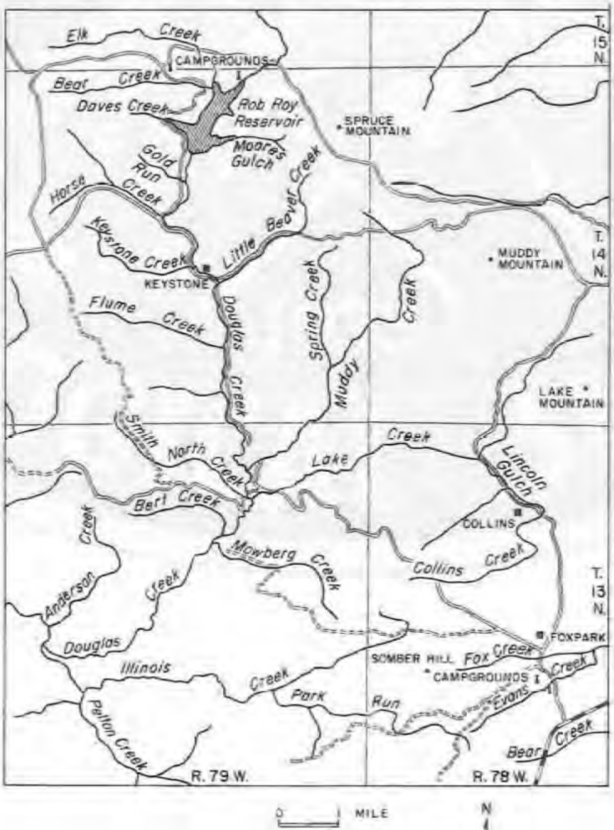


Figure 23. Principal drainages of the Douglas Creek placer district.

the placers is not known; however, Knight (1893), estimated early production at about 2,000 oz and Currey (1965) estimated production to have been at least 4,000 oz.

The district was established in 1868, after Iram Moore discovered placer gold in Moore's Gulch (also known as the Last Chance Camp) (Figure 23). During the first year of heavy prospecting (1869), about 400 oz of gold were recovered. Many washings were reported to have yielded 0.10 to 0.12 oz gold to the pan.

By 1876, about 8 years after Iram Moore's discovery, an elaborate system of hydraulic ditches had been constructed and placer operations were expanded. Decades later, in 1936 and 1946, gasoline-operated draglines with floating washing plants were utilized by the Medicine Bow Mining Corporation south of Keystone on Douglas Creek. In 1958, the Moe Brothers used a similar dragline and washing plant about 1.5 miles north of Keystone (Currey, 1965).

Gravels with gold values ranging from 0.017 to 0.085 oz/yd^3 Au were reported from various localities in the district. The gold ranged from flour and flakes to coarse jagged nuggets. Some of the nuggets had considerable quartz attached, suggesting they were derived from a nearby source. As much as 25 percent of the gold recovered from the district was coarse and jagged. Beeler (1906a) reported nuggets weighing 5 to 20 pennyweights were commonly found and that the largest reported nugget found before 1906 weighed 68 pennyweights (3.4 oz). More recently, Eugene F. Clark (personal communication, 1981) recovered several small nuggets in the range of 0.25 to 0.5 inch long.

Gold recovered from the placers ranged from 0.890 to 0.960 fine, with some gold containing as much as 10 percent silver and traces of platinum. Both platinum and lead have also been recovered from placer operations in the area (Currey, 1965).

Stream gravels along Douglas Creek range from 3 to 20 feet thick and average about 5 feet thick. Except for a thin soil cover, the gravels are easily washed, but many small boulders interfere with placer operations. The gold is sparsely distributed throughout the gravels and is concentrated along the bedrock surface at the base of the gravels.

The coarseness of the recovered gold led prospectors up the stream banks to search for lode sources. Several lodes were discovered and developed that are included in the Keystone and New Rambler districts.

Placer descriptions

Albany placers; begin in sec. 16, T.14N., R.79W. and extend north up Douglas Creek for about 5 miles. These placers include Moores Gulch, Elk Creek, Bear Creek, and Daves Creek (Figure 23). Rob Roy Reservoir, constructed on Douglas Creek below the mouth of Moores Gulch, floods large portions of the Albany placers. Stream gradients for these placers were reported by Beeler (1906a) to average 62 feet/mile in Douglas Creek, 120 feet/mile in Moores Gulch, and 80 feet/mile and greater in the remaining smaller gulches. Gradients much greater than 70 feet/mile are generally considered too high for good placer development.

Beeler (1906a) reported that much of the gold recovered from these placers was coarse and jagged with considerable "flour gold" and traces of platinum and palladium. Twenty-five yds^3 of the rimrock gravel between the confluence of Daves and Douglas Creeks were tested and yielded about 1.5 oz gold and \$5 to \$6 platinum (1906 prices?).

The Moores Gulch placers were the first placers worked to any extent in the Douglas Creek district. Knight (1893) reported these gravels were exhausted in 1870 after yielding about 500 oz of gold. However Beeler (1906a), reported that between 1869 and 1870, 4,000 yds^3 of gravel were worked on Moores Gulch that yielded about 435 oz of gold, and that another 60,000 cubic yards of gravel, which should average greater than 0.048 oz/yd^3, remained unmined (Table 14).

Table 14. Estimated gold-bearing gravel resources for the Albany placers, Douglas Creek district (Beeler, 1906a).

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 oz
Elk and Bear Creeks	250,000	—	—

On Douglas Creek proper, the gravels were reported to average 6 feet thick. It was estimated this portion of the Albany placers contained 3,020,160 yds^3 of gravel, with gold values averaging 0.024 oz/yd^3. On Elk and Bear Creeks combined, 250,000 yds^3 of gravel were estimated to lie in the drainages (Beeler, 1906a).

About 2,200 yds^3 of gravel were mined on Daves Creek. These gravels averaged 0.077 oz/yd^3 Au and yielded about 170 oz of gold. Beeler (1906a) reported another 70,000 yds^3 of gravel remained unmined in the creek (Table 14).

Bear Creek; T13N., R.78W., south of Fox Park. Several gold nuggets, ½ to 1 inch long, were recovered from this drainage near Highway 230 in the past (Robert E. Jones, personal communication, 1988).

Douglas Creek Consolidated placers; a group of placer claims extending from sec. 10, T.13N., R.80W. to sec. 2, T.13N., R.79W., a distance of about 8 miles. The placers also extended about 5 miles along Muddy Creek to the south line of sec. 18, T.14N., R.78W. (Figure 23).

A number of tests were conducted in these placers. One test in 1896, on an area 15 feet wide by 48 feet long with an average gravel depth of 7 feet, yielded 9.75 oz of gold, including nuggets weighing 0.2 to 0.4 oz (*Engineering and Mining Journal*, November 28, 1896, p. 519). Beeler (1906a) reported pan tests on several claims within the Douglas Creek Consolidated placers obtained favorable results. Near the intersection of Douglas Creek with Pelton Creek (sec. 19, T.13N., R.79W.) (Figure 23), pan tests in a 160-foot traverse ranged from 0.034 to 0.085 oz/yd^3 Au. Average thickness of these gravels was reported as 5 feet (Beeler, 1906a).

A 150-foot traverse along Douglas Creek north of Keystone, in the SW¼SW¼ sec. 15, T.14N., R.79W., pan tested at 0.045 oz/yd^3 Au. (Although Beeler, 1906a, reported this to be part of the Douglas Creek Consolidated placers, the location places it within the Home placers.) About 900 feet above this traverse, a crosscut traverse averaged 0.05 oz/yd^3 Au. The average gravel depth is approximately 6 feet. In sec. 25, T.14N., R.79W. on Muddy Creek, a pit measuring 48 by 15 feet pan tested 0.06 oz/yd^3 Au. Other pan tests on Muddy Creek ranged from 0.019 to 0.029 oz/yd^3 (Beeler, 1906a). Muddy Creek was reported to average 4 feet deep and to have a gradient between 20 and 120 feet/mile. Average tests on Douglas Creek gave 0.04 oz/yd^3 Au with a minimum value of 0.017 oz/yd^3 Au. Gold sent to the Denver Mint from Douglas Creek was 0.940 fine and gold from Muddy Creek was 0.911 fine (Beeler, 1906a).

Fox Creek; T.13N., Rs.77 and 78.W. Some gravel mined from the Fox Creek placer yielded 0.12 oz/yd^3 Au (*Engineering and Mining Journal*, 1896, v. 62, July 11, p. 38).

Home placers; secs. 10, 15, 16, 21, 22, 27, and 34, T.14N., R.79W., on Douglas and Little Beaver Creeks (Figure 23), north of the Douglas Creek Consolidated placers. The largest known nugget discovered on Douglas Creek before 1906 (3.4 oz) was found in the Home placer. Above the mouth of Little Beaver Creek, the gravel contains 1- to 4-foot-diameter granitic boulders, and the drainage is 80 to 200 feet wide and not favorable to work. Below Little Beaver Creek, the gravel is not as coarse and the drainage opens up into Willow Flat (an open area 600 to 800 feet by 2,000 feet) with gravels varying from 3 to 8 feet thick. The gravel mined from Willow Flat averaged 0.008 to 0.012 oz/yd^3 Au (Beeler, 1901a, 1906a).

Between May 25th and September 14th, 1935, the Medicine Bow Mining Corporation processed 48,176 yds^3 of gravel on the Home placers and recovered 286.84 fine oz gold and 34 fine oz silver (Henderson and Martin, 1936).

Lincoln gulch; extends about 3 miles in the E½ secs. 5, 9, and 16, T.13N., R.78W. (Figure 23). Before 1906, 20 to 80 oz of gold were taken annually from the Lincoln Gulch placers. In places, the auriferous gravels are 20 feet thick (Beeler, 1906a). Gold mined from Lincoln Gulch was reported to be 0.950 fine and to contain some platinum (Beeler, 1906a).

Small placer; approximately sec. 2, T.13N., R.79 W., above the mouth of Muddy Creek on Douglas Creek (Figure 23). Gold in the gravel averaged 0.1 oz/yd^3 (Beeler, 1906a).

Spring Creek placer; secs. 24, 25, and N½ sec. 36, T.14N., R.79W. (Figure 23). Spring Creek, with an average gradient of 150 feet/mile, is an intermittent creek that carries sufficient water for placer prospecting only during the spring. In 1895, 1,200 yds^3 gravel were processed, returning 50 oz of gold. The gold in Spring Creek is coarse and jagged. About 40 percent of the 1895 gold production was in the form of nuggets weighing from 1 to 17 pennyweights (Beeler, 1906a). Recently, a 2.5-oz nugget was recovered (Robert E. Jones, personal communication, 1988).

Elk Mountain district

The Elk Mountain district came into prominence near the turn of the century after rich auriferous and argentiferous chalcocite ore bodies were discovered in the Madison Limestone (Mississippian) along the south flank of Elk Mountain (secs. 22, 23, and 28, T.19N., R.82W.). In 1901, a shaft was sunk on the ore body, which contained copper, gold, and silver (*Wyoming Industrial Journal*, 1901, v. 2, no. 10, p. 274). In 1903, the shaft reached a depth of 175 feet.

The main ore body is in a series of north trending fractures in limestone and was described as a 2-foot-wide breccia containing bunches, streaks, and disseminations of iron oxide, copper oxides and carbonates, and gold- and silver-bearing chalcocite. Along the north side of Pass Creek, bunches of chalcocite with chalcopyrite were discovered along the unconformity between the overlying Madison Limestone and underlying Precambrian granite and schist (Osterwald and others, 1966, p. 43).

Gold Hill district

The Gold Hill district lies near Slash Ridge on the western flank of the Snowy Range of the central Medicine Bow Mountains (Figure 1). The Gold Hill district was organized following the discovery of fabulously rich gold specimens in quartz veins in 1889. The gold was free milling and reported to occur as sylvanite and as native gold (*Laramie Boomerang*, July 27, 1901). The area is accessible by a rugged jeep trail from Highway 130 and has been mapped at 1:48,000 scale (Karlstrom and Houston, 1979a).

The district is centered on a north-northeast plunging anticline in Proterozoic metasediments (Figure 24). The core of Gold Hill anticline consists of metavolcanics and metasediments of the Upper Phantom Lake Suite intruded by a mass of mafic metaigneous rock. The Upper Phantom Lake Suite contains radioactive quartz-pebble conglomerate, arkosic quartzite, pebbly quartzite, pyritic black phyllite, micaceous quartzite, and metavolcanic rocks. The metavolcanic rocks rest on the metasedimentary rocks and include interbedded massive metabasalt, amygdaloidal metabasalt, volcaniclastic paraconglomerate, and garnet schist.

These metavolcanic rocks are overlain by rocks of the Magnolia Formation, the oldest unit of the Deep Lake Group. Here, the lower member is an arkosic radioactive conglomerate that directly overlies metabasalt of the Phantom Lake Suite. The conglomerate contains clasts of poorly sorted micaceous quartzite, phyllite, and metavolcanic rock in a pyritic arkosic matrix. This conglomerate grades upward into a quartzite member, which is coarse grained with rounded quartz grains. The Magnolia Formation is overlain by the Lindsey Quartzite, which is medium grained with lenses and layers of pebbles.

The majority of the mines in the Gold Hill district were developed on gossan-stained quartz veins associated with mafic dikes (orthoamphibolite). Some of these veins contain considerable visible and microscopic gold. Some placers in the district were worked on a

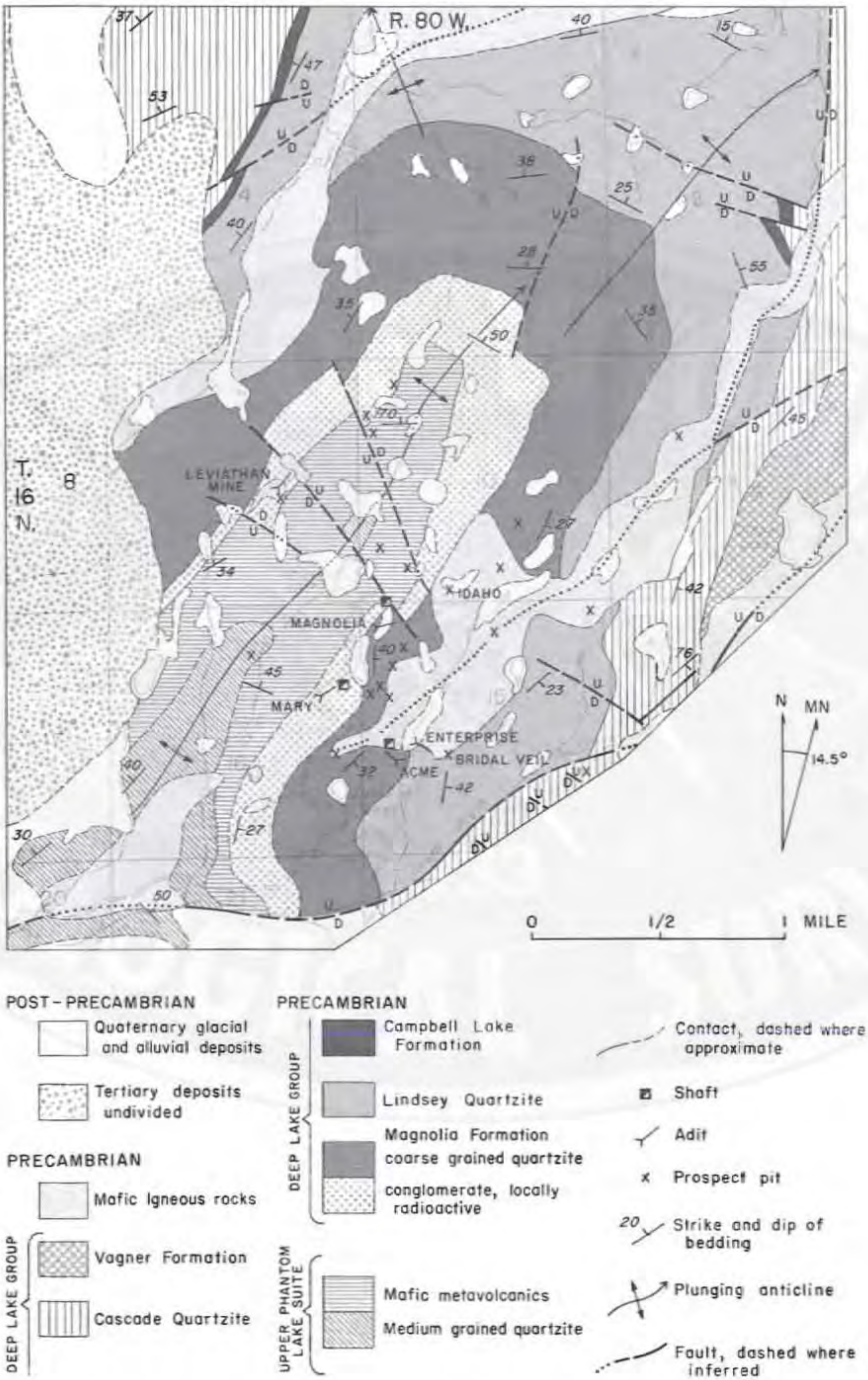


Figure 24. Geologic map of the Gold Hill district (modified from Karlstrom and Houston, 1979a).

minor scale and reported to run 0.012 to 0.04 oz/yd^3 Au. Total production is unknown, but at least 145 oz were recovered by 1893 (Knight, 1893). In recent years, anomalous amounts of gold have been found in the district (cover photograph).

West of Gold Hill, gold placers have been reported in Mullison, Brush, and Cortex Creeks. Some very early placer workings occur in this area (Thybony and others, 1985, p. 94). In 1977, placer diamonds were recovered with gold in the Boden placer on Cortex Creek (Hausel and others, 1979; Hausel, McCallum, and Roberts, 1985).

Mine descriptions

Acme mine; N½SW¼ sec. 15, T.16N., R.80W. (Figure 24). The Acme mine was developed by an adit collared in coarse-grained quartzite of the Magnolia Formation and continued into orthoamphibolite a short distance from the portal. The tunnel was driven at least 300 feet with 150 feet of crosscuts.

The number 1 shaft collared in a 4-inch-wide vein that widened to 10 inches at 65 feet deep. The number 2 shaft collared in a N17°W trending, 28°NE dipping, 6-inch-wide vein. At 76 feet deep, the vein widened to 20 inches (*Laramie Boomerang*, April 18, 1896; and author's observation, 1983). One of the shafts was sunk to a 265-foot depth (*Laramie Boomerang*, January 28, 1908).

One shipment of ore from the number 1 shaft gave a gold return of 1.28 oz/ton. Some rare pockets of specimen-grade ore encountered in the Acme mine yielded as much as 2,100 oz/ton Au! Because of these rich pockets of ore, optimism was high in the early stages of development in the district, and Gold Hill became relatively well known to many miners in the West.

Leviathan mine; N½SE¼ sec. 9, T.16N., R.80W. (Figure 24). The Leviathan was developed by an adit in orthoamphibolite on a N25°E trending vein with a 85°NW dip. The surface exposure of the gossan-stained milky quartz vein is only 10 inches wide. At 600 feet from the portal, a ventilation shaft intersected the workings.

The Leviathan vein-shear zone system can be traced on the surface for 900 feet to the northeast before it disappears under a shallow pond. The shear system penetrates orthoamphibolite and continues into quartzite to the northeast, thus demonstrating that the vein is clearly epigenetic.

Magnolia mine; NW¼NW¼ sec. 15, T.16N., R.80W. (Figure 24). This property was developed by an adit driven into orthoamphibolite. The size of the mine dump indicates at least 200 to 400 feet of drifts were cut into the hillside.

Mary mine; S½NE¼ sec. 16, T.15N., R.80W. (Figure 24). An adit and shaft were developed on a N60°E trending vein. No production or assay data are available.

Mohawk mine; (location unknown). Some rich ore was recovered from this property. For example, the *Mining Reporter* (1900, v. 41, p. 238) claimed that specimen-grade quartz samples were found in this mine that were studded with gold nuggets and assayed as high as 1,450 oz/ton Au. About 300 sacks of free milling gold ore recovered from one ore shoot contained gold values ranging from 0.68 to 2.4 oz/ton (*Mining Reporter*, July 30, 1903, p. 110).

Jelm Mountain district

In 1872, the Bramel Mining district (better known today as the Jelm Mountain district) was organized to include Jelm Mountain and the Boswell Creek area to the west (Figure 1). Several prospects and mines were developed on auriferous quartz veins and shears, and three stamp mills were constructed near the present site of Woods Landing (Michalek, 1952). As the gold was depleted in the near-surface weathered portion of the veins, the district began producing increasing amounts of copper from the deeper, sulfide-bearing veins.

The early prospects were developed on oxidized veins, which were dominantly iron-stained gold-quartz veins near the surface. At shallow depths, the veins were enriched in supergene copper, which became the most important ore. Assays as high as 30 percent copper were commonly reported in the district, but the supergene ore was restricted to small tonnages. In a short time, the district was abandoned.

The Jelm Mountain district lies 30 miles west-southwest of Laramie along the southern face of Jelm Mountain. The western portion of the district continues west of the Laramie River near Old Jelm (Cummings City) (see Hausel and Jones, 1984, p. 9).

Jelm Mountain is an uplifted block bounded on the western and eastern flanks by westward dipping thrust faults. On the eastern flank, the thrust dips 60°W and may have more than 2,000 feet of displacement — Precambrian rocks have been thrust over Paleozoic sedimentary rocks. Near the southeastern edge of the district, mine dumps contain Precambrian gneiss and schist as well as fragments of

Color Plates 1 through 4

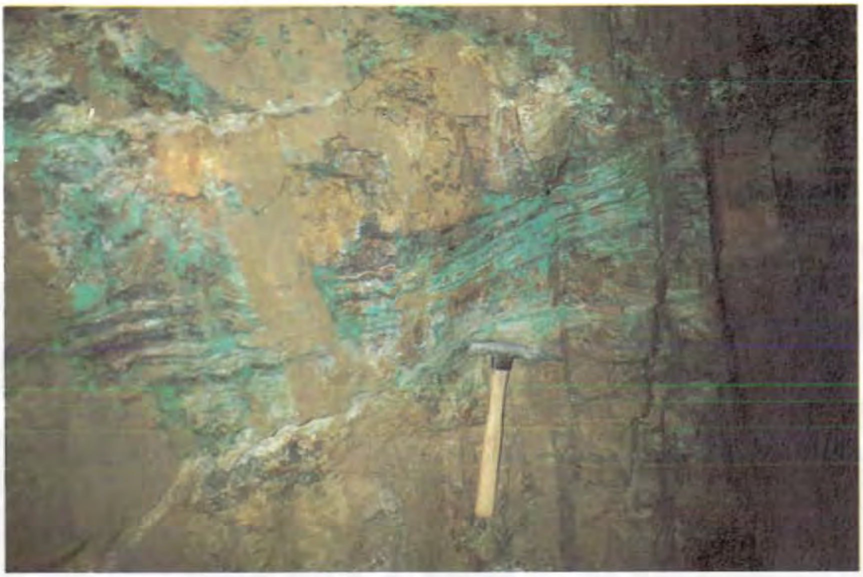


Plate 1A. Stratiform copper-silver-zinc mineralization in the Nugget Sandstone exposed in the rib of the Griggs upper adit, Lake Alice district, Lincoln County.

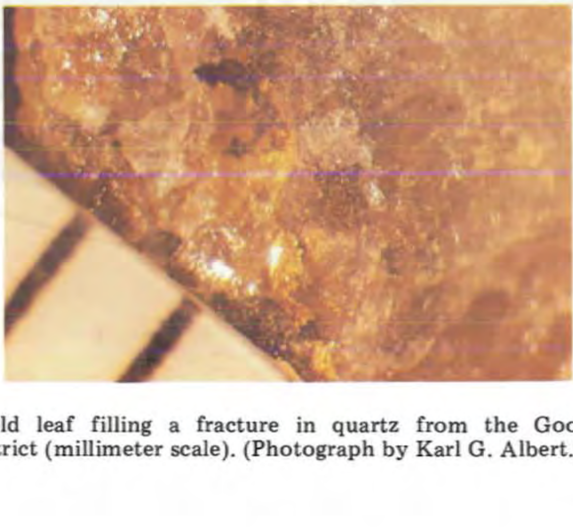


Plate 1B. Gold leaf filling a fracture in quartz from the Goodhope mine, Lewiston district (millimeter scale). (Photograph by Karl G. Albert.)

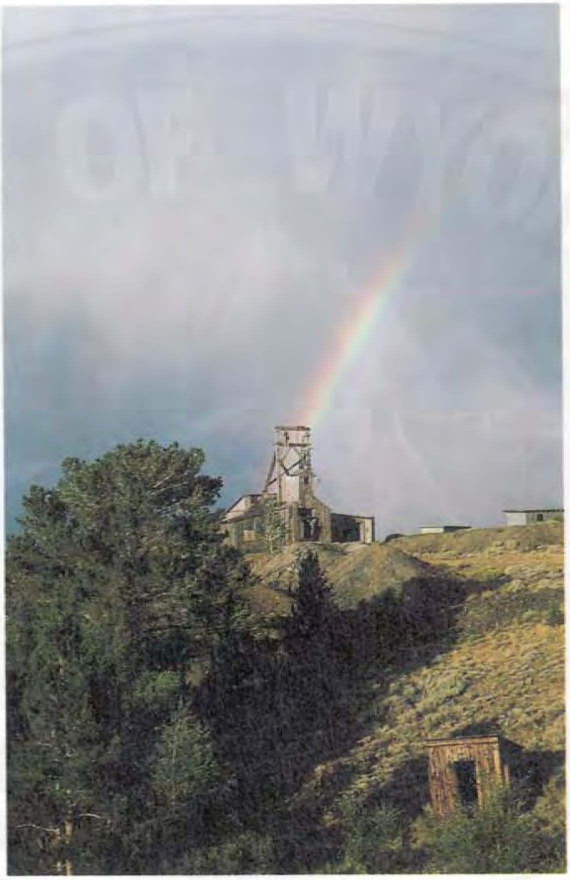


Plate 2. The Duncan headframe near Atlantic City, South Pass-Atlantic City district.

Plate 3A. Some gold recovered from the Stout placer operation on Rock Creek in the South Pass-Atlantic City district (gold pan base is 6 inches in diameter).

Plate 3B. Gold nugget from Rock Creek, South Pass-Atlantic City district (0.74 oz). (Photograph by Jack Adams, 1987).

Plate 4. Clean-up on Smith Gulch in the South Pass-Atlantic City district. Note the gold trapped behind the riffles in both the sunlit and shaded portions of the photo. (Courtesy of Hank Hudspeth, Jr., and Buddy Presgrove.)

Pennsylvanian Fountain Formation, suggesting the mine workings penetrated the thrust and bottomed out in the Paleozoic section (Michalek, 1952).

The rocks of Jelm Mountain are dominantly Precambrian schist, gneiss, pegmatite, and granite. These rocks are completely surrounded by Paleozoic, Mesozoic, Tertiary, and Quaternary rocks and sediments. The schistosity of the Precambrian metasediments strikes dominantly east-west.

Copper and gold prospects occur in strike quartz veins, strike shear zones, pegmatites, and gneissic bodies (Osterwald and others, 1966, p. 37). Many of the prospects contain rock stained by hematite, limonite, malachite, and azurite. Ore minerals include cuprite, tenorite, chalcopyrite, pyrite, native gold, native copper, pyrite, and galena. One prospect, located in sec. 24, T.13N., R.77W., was reported to contain bismuthinite and native bismuth. Some samples near the surface showed 60 to 80 percent bismuth, but at the bottom of a 200-foot shaft very little ore was found (Osterwald and others, 1966, p. 22). Michalek (1952) proposed the gold originated from soda-rich granites and the copper originated from amphibolites. However, it is possible that both metals originated from the amphibolites.

Mine and prospect descriptions

Annie mine; NE¼ sec. 26, T.13N., R.77W. The mine was developed on three chalcopyrite-bearing quartz veins in granite. The veins are about 150 feet apart, dip steeply to the south, average 3 to 6 feet wide, conform to regional foliation, and can be traced for nearly 3,000 feet in an east-west direction.

In 1906, developments included a 140-foot shaft connected by an adit with 138 feet of drifts. The host granite is interlayered with diabase, hornblende, and tourmaline schist. Limonite, hematite, malachite, and azurite stain the veins at the surface and red "talcose" material borders the veins. Some of the quartz contains gold (Beeler, 1906a).

Five hundred pounds of ore recovered from 100 feet deep yielded 6.3 percent Cu. A 2-foot streak of high-grade material at 135 feet assayed 29 percent Cu and 0.11 oz/ton Au (Beeler, 1906a).

Boston shaft; 3,000 feet north of the Colorado shaft. It was developed by a 80-foot shaft on an auriferous vein (Beeler, 1906a). Samples recovered from the mine assayed as high as 0.86 oz/ton Au (*Wyoming Industrial Journal*, 1903, v. 4, no. 11, p. 269). At 15 feet deep, the vein contained bornite (*Mining Reporter*, July 9, 1903, p. 32).

Colorado shaft; (location not given). A body of chalcopyrite with stringers of native copper was discovered in gneiss and schist at the bottom of the 250-foot shaft (Beeler, 1906a). The vein carried a trace of gold and silver (*Mining Reporter*, July 9, 1903, p. 32).

Copper Queen; about 0.5 mile southwest of the former settlement of Cummings City. The Copper Queen was developed by an 80-foot shaft into a mineralized zone containing chalcocite, cuprite, tenorite, and chalcopyrite. At the bottom of the shaft, native copper was discovered. One 18-inch-thick streak of ore assayed 65 percent copper with some gold and lead (Aughey, 1886, p. 8).

Rising Sun claim; northeast of the Boston shaft (exact location not given). This vein parallels the strike and dip of the Boston and Colorado veins and carries some galena with gold and silver values in addition to copper (Beeler, 1906a). In 1903, a 100-foot shaft was sunk on the vein, but the vein was lost at 60 feet deep. Assays were reported as high as $19.40 in lead (1903 price) with minor copper (*Mining Reporter*, July 9, 1903, p. 32).

NW¼ sec. 10, T.13N., R.77W. A cupriferous quartz vein is hosted by hornblende gneiss (Orback, 1960).

SE¼ sec. 21, T.13N., R.77W. A quartz-copper vein lies along the contact of pink aplite with pink coarse-grained granite (Orback, 1960).

E½ sec. 26, T.13N., R.77W., about 500 feet north of the Jelm Mountain observatory road on a southerly drainage. A now-collapsed adit was developed into a N56°W trending, near-vertical, silicified, epidotized, cupriferous breccia in amphibolite schist. In addition to epidote, the rock adjacent to the breccia exhibits localized K-silicate alteration. The adit trends in the direction of a shaft, and possibly connects to the shaft about 200 feet to the west.

Visible ore minerals on the mine dump and in the outcrop include malachite, tenorite, and minor azurite and pyrite. A copper-stained chip sample from the breccia zone assayed 0.23 percent Cu, 0.09 oz/ton Ag, and no Au (Hausel, 1983b). This may be the Annie mine (see page 118).

W½ sec. 25, T.13N., R.77W. A selected sample of copper-bearing amphibolite schist was collected from a prospect pit developed on a N83°W trending vertical shear zone. The sample contained visible chalcopyrite, cuprite, malachite, and azurite and assayed 0.22 percent Cu, 0.07 oz/ton Ag, and $<$0.01 oz/ton Au (Hausel, 1983b).

Keystone district

The Keystone district surrounds the village of Keystone adjacent to Douglas Creek in the Medicine Bow Mountains (Figure 1), and is considered to include all lode deposits adjacent to and within the Keystone quartz diorite (Figure 25). Most base and precious metal deposits in the Keystone region consist of gold- and copper-bearing, pyritic, quartz-carbonate veins in N60°W trending tensional faults subsidiary to the Mullen Creek-Nash Fork shear zone. Sparse mineralization also occurs within some northeast trending shears (Currey, 1965).

The Keystone district is dominated by a circular, 5-mile-diameter, quartz diorite intrusive. The intrusive, known locally as the Keystone quartz diorite, intrudes amphibolite gneiss and quartz-biotite schist. The intrusive contacts are comformable with the older metamorphic rocks except along the eastern border, where the quartz diorite locally crosscuts the regional foliation at a high angle. Near these contacts, the medium-grained quartz diorite becomes generally finer grained and more strongly foliated. Along the southeastern flank of the intrusive, the quartz diorite has been intruded by mafic rock interpreted as part of the Lake Owens layered mafic intrusion. Foliation in the quartz diorite adjacent to this mafic intrusion parallels its contact, suggesting the younger intrusive was forcefully emplaced (Currey, 1965).

Several structural trends have been recognized in the district. These include a persistent joint set that has vertical dips and trends N30°E. According to Currey (1965) this joint set was responsible for localizing several small intrusive bodies and dikes.

Shear zones in the district include a broad east-west trending set that is roughly parallel to the southern border of the Keystone quartz diorite and narrow northwest trending shears in the northern portion of the district. The northwest (approximately N60°W) trending shears are loci for Cu-Au mineralization. These have been regarded as mineralized trends by Currey (1965). The mineralization was accompanied by silicification in the form of small, irregular quartz veinlets and the wallrock is altered to a reddish color and enriched in epidote.

The ore minerals include malachite, azurite, cuprite, native copper, and native gold in the supergene zone. The underlying hypogene minerals include chalcopyrite, bornite, pyrite, pyrrhotite, and native gold.

In recent years (1983), some rich samples of gold-bearing quartz diorite have been found near Keystone. One of the less spectacular samples containing visible gold assayed 18 oz/ton Au. The village of

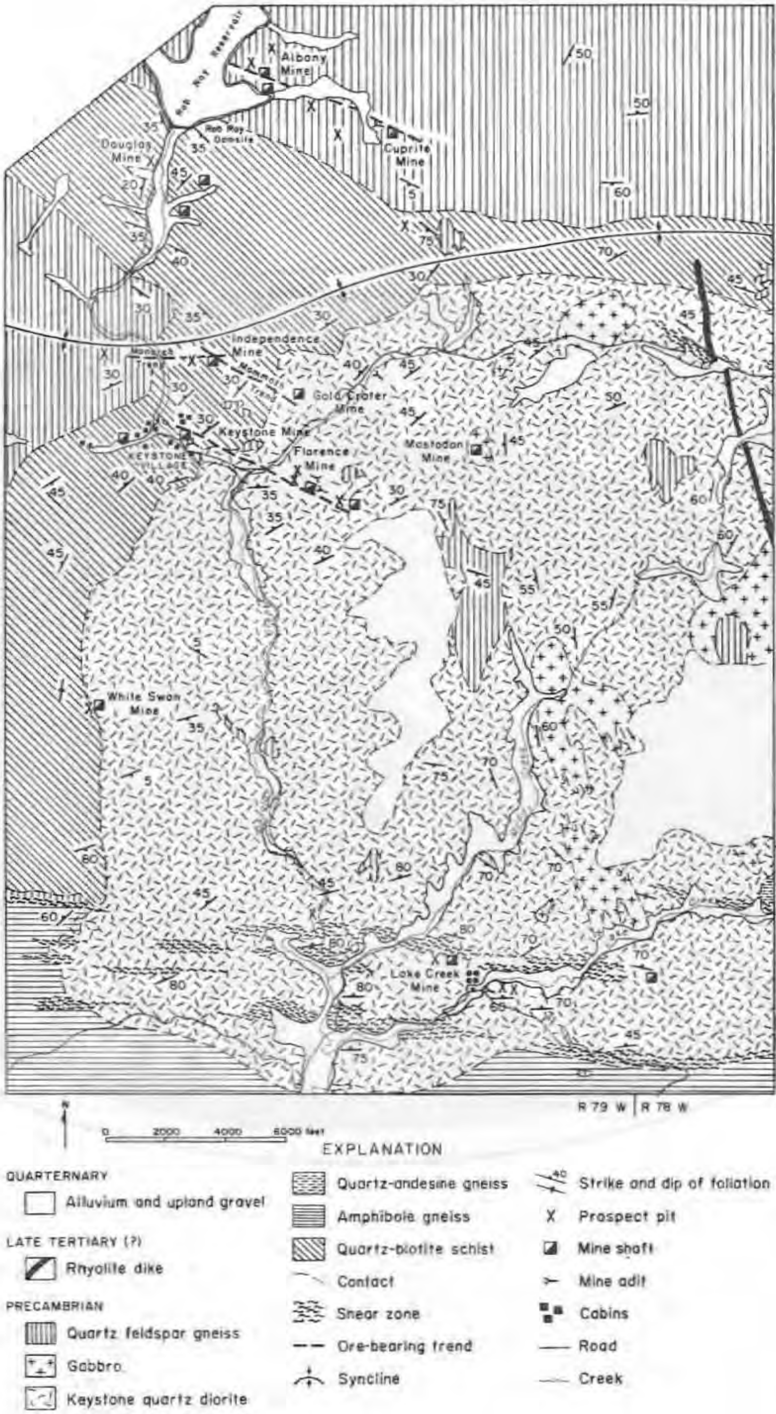


Figure 25. Geologic map of the Keystone district (modified from Currey, 1965).

Keystone lies near the west-central edge of the district on the east bank of Douglas Creek.

Currey (1965) reported the following gold production for the district:

Keystone mine	5,000 oz
Florence mine	2,500 oz
Placer mines (see Douglas Creek district)	4,000 oz
Other lodes	1,000 oz

Mine and prospect descriptions

Albany mine; NE¼ sec. 10, T.14N., R.79W. (Figure 25), on a northwest mineralized trend that extends through Moores Gulch. By 1903, the Albany mine shaft was sunk 360 feet deep and intersected a covellite-rich supergene zone at 150 feet below the surface (Currey, 1965). The shear occurs over a width of 30 to 50 feet in quartz feldspar gneiss, and the mineralized fault is occupied by an intensely sheared and hydrothermally altered mafic dike (Loucks, 1976). The *Mining Reporter* (1902, August 21, p. 61) indicated the ore carried gold values.

Albatross claim; in the Lake Creek region of the southern portion of the Keystone district. A 7-foot-wide vein of "jasper quartz" assayed 4 percent Cu and 0.3 oz/ton Au. A 30-foot shaft was sunk on the property (Osterwald and others, 1966).

Cuprite mine; NW¼ sec. 11, T.14N., R.79W., along the Albany-Cuprite mineralized trend (Figure 25). A 954-foot drift was driven off of a 65-foot-deep shaft in 1900. The mineralized zone contained native copper, cuprite, pyrite, chalcopyrite, gold, and silver. The vein assayed 3 to 28.0 percent Cu, a trace to 2.56 oz/ton Au, and a trace to 2.0 oz/ton Ag. Some cobalt and chromium were also detected (Currey, 1965; Osterwald and others, 1966).

Douglas (Morning Star) mine; in the SE¼ sec. 9, T.14N., R.79W., along the west bank of Douglas Creek (Figure 25). A 150-foot-deep shaft encountered a 7-foot-wide mineralized zone on the 35-foot level. Eighty feet of drifts and crosscuts were developed on the mineralized zone. The zone contained native copper, copper carbonates, chalcopyrite, chalcocite, cobaltite, and gold. Three veins, 6 inches to 2 feet, 2 to 3 feet, and 1 foot thick, were intersected on the deeper levels (Currey, 1965). The surface workings were destroyed by construction of the road on the west bank of Douglas Creek (Hausel, 1980a).

Fairview claim; sec. 6, T.13N., R.79W. A 3.5-foot-wide vein contained some rock that assayed 28.5 percent Cu and 0.8 oz/ton Au. The sample was taken 8 feet below the surface (Osterwald and others, 1966).

Florence mine; SE¼ sec. 22, T.14N., R.79W., near Keystone along the Keystone-Florence mineralized trend, which strikes northwest (Figure 25).

Gold occurs in pyrrhotite (Loucks, 1976, reported the primary sulfide to be pyrite) hosted by a 3- to 5-foot-wide quartz vein. Much of the ore was finely divided and not free milling (Beeler, 1906a), making ore concentration difficult. The ore was not amenable to concentrating but was considered better suited to treatment by chlorination or cyanidation. Auriferous pyrrhotite "kidneys" were exceedingly rich, sometimes containing from 7.5 oz/ton Au to more than 48 oz/ton Au; however, this ore was very discontinuous. A 160-foot shaft was developed with stopes and drifts on both the 30-foot and the 100-foot levels (Currey, 1965). In seven samples collected by Loucks (1976) from the mine dump, values ranged from 0.06 to 23.3 oz/ton Au.

Gold Crater mine; NE¼ sec. 22, T.14N., R.79W., at the eastern extension of the Mammoth trend (Figure 25). Several small quartz veins and sheared wallrock carried free-milling gold, pyrite, and chalcopyrite. The average ore tenor was reported to be equivalent to 1 foot of 20-dollar ore (1905 prices) (Beeler, 1905a). The mine was last worked in 1937 (Currey, 1965). Two samples collected from the mine dump yielded 0.1 and 0.2 oz/ton Au (Loucks, 1976).

Golden Key mine; sec. 19, T.14N., R.79W. A shaft of unknown depth was sunk on an intensely fractured, southeast trending, pyritized, milky quartz vein on the eastern flank of the Mullen Creek mafic complex. The vein is hosted by metagabbro. When examined by the author in 1978, the shaft was plugged a few feet below the collar.

Mine dump samples contained rehealed quartz with abundant limonite and lesser pyrite, chalcopyrite, and malachite. Samples filled with limonite boxworks were common. Donnelly (1979) reported some samples to contain small amounts of gold. Gold was also identified as disseminated grains in quartz and as gold leafs in microfractures (Loucks, 1976).

Hub Lode claim; sec. 15, T.14N., R.78W. Values of 0.12 oz/ton Au have been reported for a pegmatite at this location (Osterwald and others, 1966).

Independence mine; sec. 15, T.14N., R.79W., at the intersection of the Mammoth and Monarch mineralized trends (Figure 25). The Mammoth trends N60°W and the Monarch runs approximately east-west. In the early 1900s, an 80-foot shaft with 100 feet of crosscuts was sunk at the intersection of two large, 6- to 20-foot-wide mineralized quartz veins within quartz-biotite schist country rock. A 125-foot drift was driven along the Monarch trend ¼ mile west of the shaft. The ore contained chalcanthite and averaged 13.5 percent copper with as much as 0.97 percent bismuth (Currey, 1965).

Vein material contains disseminated pyrite, chalcopyrite, a little gold, and locally abundant ankerite. However, principal interest focused on a large number of small rich veins on each side of the primary vein. These veins dip into the primary vein, vary from 6 to 18 inches wide, and carry from 0.5 to 14.5 oz/ton Au (Loucks, 1976).

Kansas group; sec. 12, T.13N., R.79W., on Lake Creek about 6 miles southeast of Keystone. A 6-foot-wide quartz ledge trends N70°W and dips southerly. The ledge contains limonite with copper stains and assays show trace amounts of gold (Beeler, 1907b).

Keystone mine; NW¼ sec. 22, T.14N., R.79W., on the Keystone-Florence trend (Figure 25). The shear was developed from a 365-foot-deep shaft with about 5,000 feet of drifts. In 1890, a 40-ton stamp mill was built on the property, and in 1893, operations ceased with 6,000 tons of ore on the dump ready to process and an additional 100,000 tons of identified reserves underground. The vein was reported to average 1.2 oz/ton Au.

Gold occurred as free gold associated with quartz and also in pyrite and pyrrhotite in mylonite selvages adjacent to the quartz vein. The vein is hosted by a sheared diabase dike that intrudes quartz-biotite gneiss (Currey, 1965). The shear ranges from 2 to 6 feet wide, but locally splays to 300 feet wide (Loucks, 1976). Total reported gold production from the mine was about 5,000 oz. In the 1950s, the mill was dismantled and the shaft sealed (Currey, 1965). Presently, Keystone Village lies adjacent to the historic mine.

Eight samples collected from the mine dump by Loucks (1976) contained gold values from 0.19 to 8.75 oz/ton and averaged 3.41 oz/ton.

Lake Creek mine; SE¼ sec. 2, T.13N., R.79W. (Figure 25), near the junctions of Muddy and Lake Creeks with Douglas Creek. Copper-gold mineralization occurs in silicified mylonite within a broad east-west trending shear zone. A sheared metapyroxenite dike occurs in the shear zone (Loucks, 1976). Assays for gold, silver, and copper ranged from $4.00 to $140.00/ton. This mine was developed by a 75-foot shaft with 715 feet of crosscuts and drifts that were intersected by a 335-foot adit (Currey, 1965). Vein material on the dump consists of coarse-grained quartz and microcline with chalcopyrite, pyrite, copper carbonates, chlorite, and minor barite. Samples yielded 1.5 ppm to 84 ppm Ag, 0.25 ppm Pt, 0.04 ppm Pd, and a trace Rh (Loucks, 1976).

Mastodon mine; E½E½ sec. 23, T.14N., R.79W., east of the Florence mine (Figure 25). This mine was developed in a gabbro hosted by Keystone quartz diorite.

Maudem group; SW¼SW¼ sec. 1, T.13N., R.79W., on Lake Creek. Assays of limonite- and copper-stained quartz vein material indicated considerable gold values according to Beeler (1904d). Samples of chalcocite and chalcopyrite were found on the mine dump (Osterwald and others, 1966). Three shafts and two adits were developed on the property.

Rosebud claim; on Muddy Creek about 1.5 miles southwest of Tenderfoot Mountain. Material found in a 55-foot vertical shaft assayed a maximum of 50 percent Cu and 1 oz/ton Ag (Osterwald and others, 1966, p. 41).

White Swan mine; N½N½ sec. 33, T.14N., R.79W. (Figure 25), south of White Swan Creek. The mine is on the contact of the Keystone quartz diorite with quartz-biotite schist country rock.

Sec. 15, T.14N., R.78W. Loucks (1976) reported a short trench was used to explore limonite fault breccia in a mafic xenolith rafted in Sherman Granite near its contact with the Lake Owen mafic complex. Both magnetite and limonite are abundant in the fault breccia. Limonite concentrates from this prospect yielded a maximum of 0.12 ppm Pt, 1.4 ppm Pd, and 1,500 ppm Zn (Loucks, 1976).

Sec. 7, T.14N., R.78W., near the eastern termination of the Albany-Cuprite trend. A gentle swerve in the fault trend is accompanied by broadening of the shear to form a submylonitic to mylonitic lens in quartzofeldspathic gneiss. Two samples collected from prospect pits in the gneiss contained 0.07 and 3.2 oz/ton Ag, 0.02 and 0.07 oz/ton Au, 0.01 and 16.5 percent Cu, 0.03 and 0.87 oz/ton Pd, and 0.16 and 1.17 oz/ton Pt (Loucks, 1976). Loucks noted the perplexing association of platinoids with felsic gneiss host rock.

Mullison Park

A number of historic gold placers occur in the Mullison Park area along the western slope of the Medicine Bow Mountains about 15 miles east of Encampment. Thybony and others (1985, p. 93-94) briefly described some of the placer diggings found along Brush Creek and Cortex Creek. Low-grade gold values occur in stream gravels and in conglomerates of the Ferris and Hanna Formations. On Cortex Creek in 1977, two octahedral diamonds were recovered from a placer mining operation (Paul Boden, personal communication, 1977; Hausel, McCallum, and Roberts, 1985). Later searches in this area did not find any additional diamonds although pyrope garnets were apparently found on Iron Creek several miles to the south.

New Rambler district

The New Rambler district (Figure 26) is located north of the Douglas Creek and Keystone districts (Figure 1). The district was initially developed for copper, but Pt-group metals were later identified in the copper ores.

The district occurs within cataclastic rocks of the Mullen Creek-Nash Fork shear zone where the cataclastics truncate the northern edge of the 60-square-mile Mullen Creek mafic complex. The Mullen Creek mafic complex is a Proterozoic (1.8 Ga), layered, tholeiitic mafic body that has been hydrothermally altered along the shear zone.

Platinum-group metals and associated copper may have been leached during shearing from the adjacent mafic intrusives or possibly from a platinum reef in the layered mafic complex. This latter possibility would make the Mullen Creek layered mafic complex a very attractive exploration target.

Mine and prospect descriptions

Blanche mine; SE¼ sec. 32, T.15N., R.79W., immediately west of the New Rambler workings (Figure 26). A shaft was sunk in sheared felsic gneiss, metagabbro, and metadiorite in an effort to locate the westward extension of the New Rambler ore body (McCallum and Orback, 1968). The main shaft was 160 feet deep. At 120 feet, it intersected a zone containing copper carbonates, chalcocite, and chalcopyrite (Beeler, 1902; 1906a). The copper minerals occur primarily in quartz veins with pyrite, hematite, and limonite, and in quartz associated with shear-zone gouge (McCallum and Orback, 1968).

Two samples of limonite with abundant malachite collected from the dump also contained cuprite with traces of chalcocite and sperry-

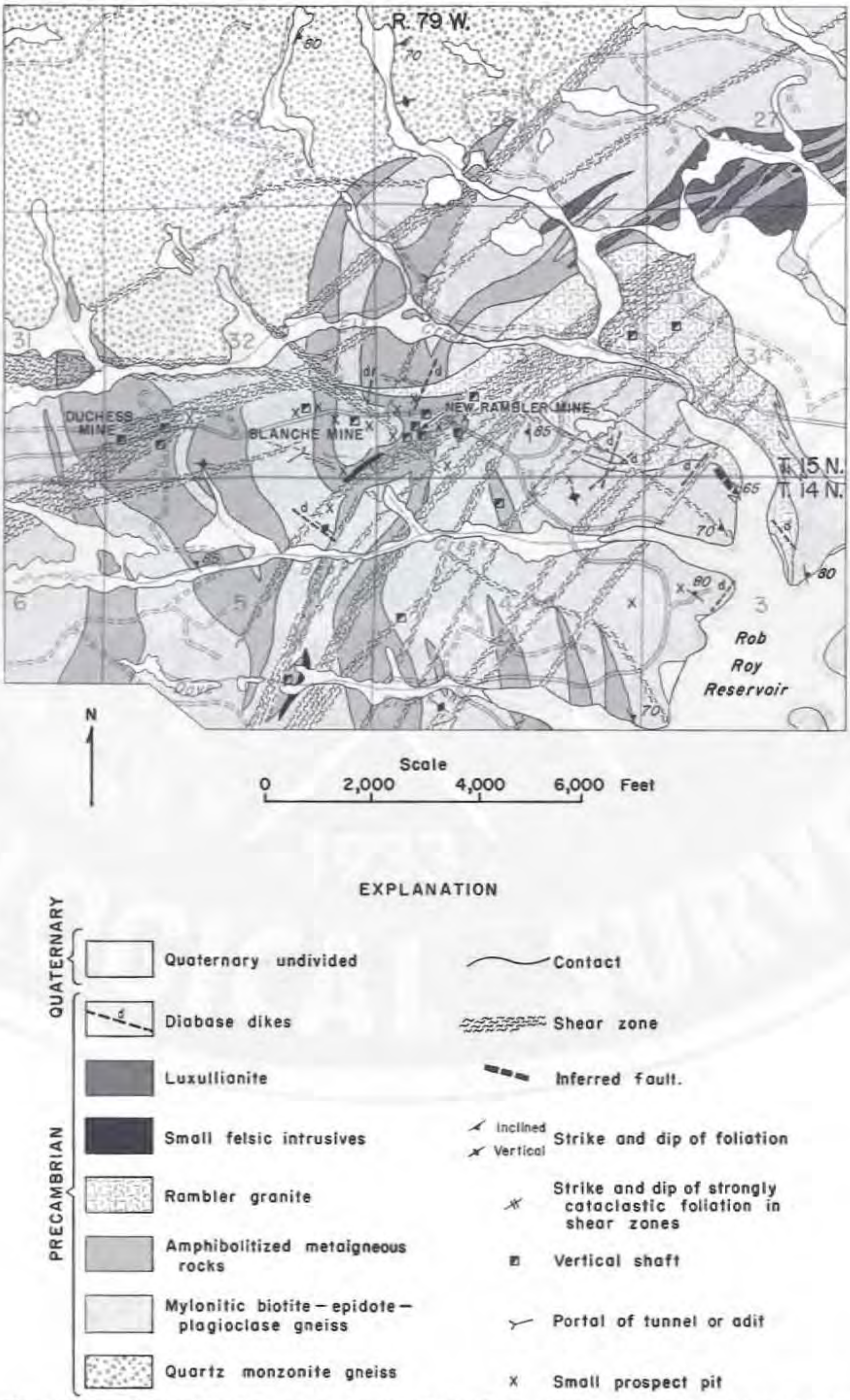


Figure 26. Generalized geologic map of the New Rambler district, Albany and Carbon Counties (modified from McCallum and Orback, 1968).

lite. Assays of these two samples gave 6 and 17 ppm Pt, 30 and 20 ppm Pd, and 20 and 17 percent Cu (Loucks, 1976).

Duchess mine; SW¼ sec. 32, T.15N., R.79W., west of the Blanche mine (Figure 26). Several exploratory shafts were sunk in shear-zone cataclastics and strongly sheared metagabbro and metadiorite. Traces of copper, pyrite, hematite, and limonite and gold-bearing tetrahedrite were detected in the cataclastics (McCallum and Orback, 1968; Loucks, 1976).

Medicine Bow Mines Company; in the New Rambler mine area. A 954-foot tunnel cut a number of mineralized zones containing anomalous copper, gold, and cobalt (Beeler, 1906a).

New Rambler mine; SW¼ sec. 33, T.15N., R.79W., west of Rob Roy Reservoir (Figure 26). The New Rambler mine was sporadically operated from 1900 to 1918 and produced about 6,100 tons of copper ore that carried values in Au, Ag, Pt, and Pd. At least 4,000 tons of the total production contained 25 to 30 percent copper. It is estimated that high-grade ore and concentrate from the mine averaged 2.41 oz/ton Pd and 0.12 oz/ton Pt. Production may have included 16,870 oz palladium and 910 oz platinum (Silver Lake Resources, Inc., 1985). However, the U.S. Bureau of Mines (1942) reported that production from the mine in the early 1900s was about 1.75 million pounds Cu, 170 oz Au, 7,350 oz Ag, 170 oz Pt, and 451 oz Pd.

The New Rambler shaft was sunk to a depth of 170 feet and more than 5,000 feet of drifts and crosscuts were driven in amphibolitized rock that is part of the Mullen Creek layered mafic intrusion. The most common rock types in the mine area include metadiorite and metagabbro that grade downward at shallow depths into metapyroxenite and metaperidotite. Some diabasic and granitic rocks also occur in the mine area (McCallum and others, 1976).

Intense regional shearing is responsible for the high permeability of the host rock, and in turn for the emplacement of the ore body. Historic mine reports indicate that the mine workings cut four well-defined northwest trending fault planes that were intersected by a broad east-west zone of shear-zone tectonites (Kasteler and Frey, 1949; McCallum and others, 1976).

Two hydrothermal mineral assemblages that show overprinting by supergene alteration are recognized. Greenschist propylitic alteration assemblages are widespread throughout the district, but intensify at the mine site. This assemblage includes chlorite-epidote-clinozoisite-albite-magnetite (± pyrite). In most propylitically altered samples from the mine dump, hornblende and calcic plagioclase are partially altered, but biotite is unaltered. Magnetite and epidote veinlets are common.

Phyllic alteration resulted in the pervasive replacement of calcic plagioclase and albite, whereas the mafic minerals are only partially affected. Sericite and quartz dominate as replacement minerals, with lesser amounts of pyrite as disseminations, veinlets, and magnetite overgrowths (McCallum and others, 1976).

The New Rambler ore body is considered to be a classical supergene enriched deposit, with an overlying porous spongy limonite and jaspilite gossan that caps a 75-foot-thick oxidized zone. Oxidized ore minerals form an extremely diverse assemblage containing abundant malachite and azurite with lesser amounts of cuprite, tenorite, chalcotrychite, and chalcopyrite. Dendrites and nuggets of native copper with atacamite, chalcanthite, tetrahedrite, and bornite are sparsely distributed. This oxidized assemblage grades downward from 75 to 100 feet into the supergene enriched zone consisting of platinum-bearing covellite and chalcocite. Orpiment, realgar, and lorandite reported by Rogers (1912) are probably products of supergene enrichment. Below 100 feet, the supergene minerals grade into the primary mineralized rock containing quartz-pyrite-chalcopyrite veins with minor sperrylite (McCallum and Orback, 1968).

A series of assays run in 1910 on various grades of ore samples showed 0.60 to 5.8 oz/ton precious metals and 0.5 to 31.07 percent copper (Anonymous, 1911b). In 1949, the U.S. Bureau of Mines sampled the mine waste with 5-foot channel samples and low-grade copper and platinum were detected (Table 15). Theobald and Thompson (1968) also sampled the tailings (Figure 27) and obtained similar results (Table 16).

Other assays of the New Rambler ore include (1) composite samples of dump material that assayed 0.06 oz/ton Pt, 0.04 oz/ton Ir, 0.04 oz/ton Pd, 0.10 oz/ton Ag, and a trace Au; (2) various copper minerals from the mine that contained 0.10 to 0.70 oz/ton Pt; and (3) seven carloads of covellite ore that contained 0.40 to 1.4 oz/ton Pt (Knight, 1902).

<u>Silver prospects</u>; SE¼SE¼ sec. 34, T.15N., R.80W. McCallum and Kluender (1983) reported several galena samples collected from prospect pits in this area contained significant silver. The samples ranged from 1.17 oz/ton to 46.6 oz/ton Ag with 1.0 to 2.0 percent Pb. One sample also contained 0.13 oz/ton Au. All of the samples contained detectable zinc (0.05 to 0.5 percent).

Table 15. Copper-platinum assays of 5-foot mine-dump channel samples, New Rambler mine (after Kasteler and Frey, 1949).

U.S. Bureau of Mines sample number	Cu (%)	Pt-group metals (oz/ton)
1	0.92	0.10
2	1.22	0.02
3	0.15	trace
4	0.18	trace
5	0.67	trace
6	0.12	trace
7	0.24	trace
8	0.15	trace
9	0.09	none
10	0.08	trace
11	0.10	trace
12	0.05	none
13	0.31	0.01
14	0.80	0.04
15	0.81	0.02
16	0.85	0.05
17	0.75	0.04
18	0.47	trace
19	0.47	0.01
20	0.37	trace
21	0.40	trace
22	0.54	0.02
23	0.24	trace

Sunset mine; secs. 35 and 36, T.14N., R.80W. The 95-foot-deep shaft was developed on a vein in a persistent east-southeast trending fault. The deposit is hosted by cataclastic metagabbro and meta-diorite of the Mullen Creek mafic complex. The quartz vein varies from a few inches to 3 feet wide and hosts sporadic copper and traces of gold.

Mineralization includes chalcopyrite, pyrite, subordinate hematite and bornite, and traces of molybdenite and gold (Loucks, 1976).

Miscellaneous mine

American mine; sec. 16, T.12N., R.78W., south of the Keystone and Douglas Creek districts, immediately south of U.S. Highway 230. The mine was developed on a N15°W trending silicified shear in granite. A sample of cupriferous granite collected by the author assayed 1.4 percent Cu and 3.0 oz/ton Ag (Hausel and Jones, 1984, p. 4).

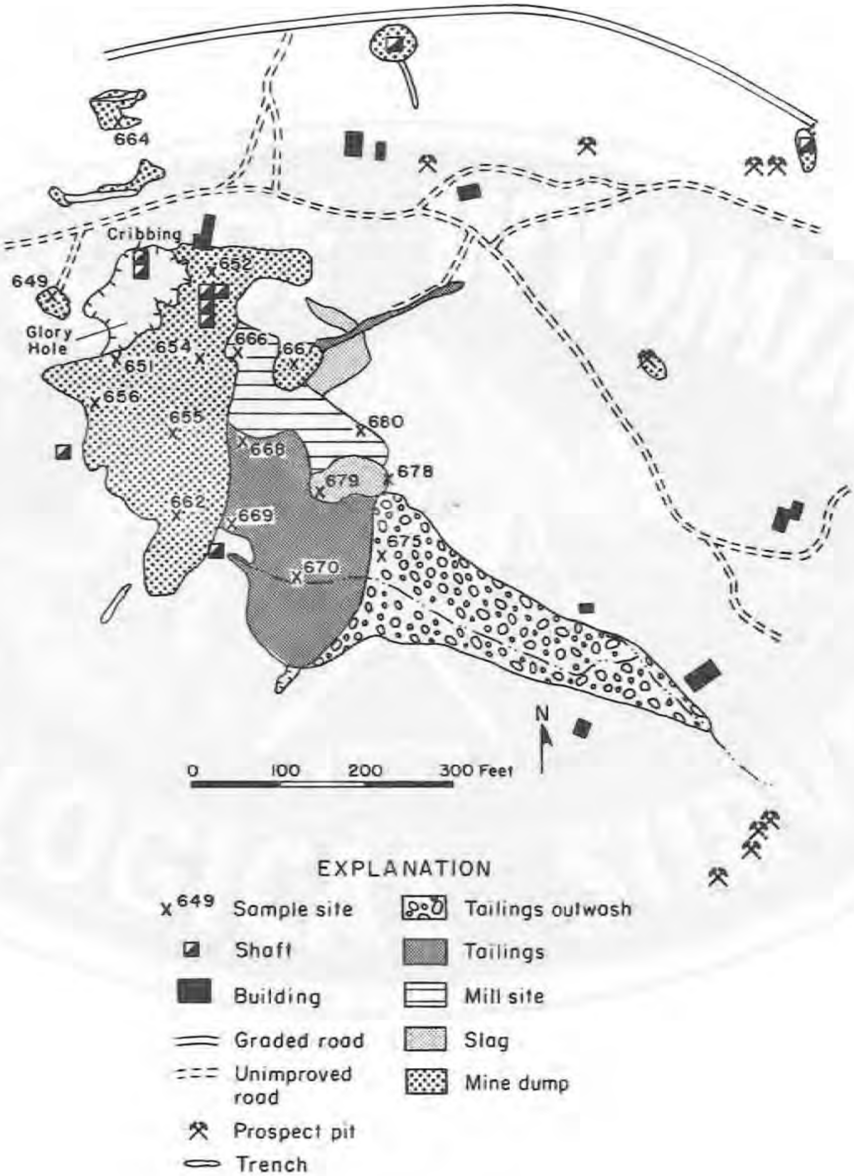


Figure 27. Plan of mine waste and sample locations from the New Rambler mine area (after Theobald and Thompson, 1968).

Table 16. Analyses of mine waste from the New Rambler mine – see Figure 27 for sample locations (after Theobald and Thompson, 1968). (Analyses reported in ppm.)

Sample number	Cu	Ag	Pt+Pd	Au 2-g sample	Au 10-g sample	As	Te	Mo	Pb	Zn
Coarse mine tailings in main mine area										
AAE 651	2,000	7.8	3.5	<0.1	1.3	40	8	15	<25	25
AAE 652	1,200	55	3	.9	3.0	10	25	15	50	<25
AAE 654	>6,000	1.5	.1	.3	.4	60	1	<5	25	50
AAE 655	2,000	1.0	.4	<.1	.2	30	2.5	<5	<25	25
AAE 656	1,000	14	1.7	.9	2.5	30	2	10	<25	25
AAE 662	3,000	2.0	.5	.8	.5	40	20	<5	<25	25
AAE 667	1,200	1.8	6	.7	.2	30	2.5	5	25	50
Coarse mine tailings in outlying piles and mines										
AAE 664	80	1.0	0.2	0.2	0.04	10	0.25	<5	25	25
AAE 649	>6,000	2.8	.4	.9	1.0	30	2.5	<5	<25	50
Millsite debris										
AAE 666	2,000	7.2	1.0	2.6	0.3	120	13	5	750	25
AAE 680	2,000	4.2	1.6	.1	.5	160	15	<5	25	25
Mill tailings										
AAE 668	2,000	4.5	2.5	0.3	0.9	80	13	10	<25	25
AAE 669	2,000	2.2	.3	1.6	.2	30	4	5	25	25
AAE 670	1,000	2.8	1.0	.6	.3	60	7	5	<25	25
Outwash from mill tailings										
AAE 675	2,000	1.8	0.8	0.8	0.3	40	7	<5	<25	50
AAE 678	1,000	.5	.4	.5	.02	10	.1	<5	<25	25
Slag										
AAE 679	>6,000	3.8	0.7	1.5	0.08	<10	1.3	5	<25	75
Average	3,000	7	1.1	.8	.7	–	–	–	–	–
Outwash from mill tailings on Bear Creek floodplain										
AAE 737	600	0.8	0.6	0.3	0.06	20	0.5	<5	<25	50
AAE 738	2,000	4.8	2.0	.1	1.0	80	7	5	<25	50

Overthrust Belt

Along the western edge of Wyoming, the Overthrust Belt in Lincoln, Teton, and Sublette Counties has several sandstone and phosphorite-related metal occurrences. Copper, silver, and zinc mineralization has been detected at scattered localities in bleached redbeds of the Nugget Sandstone and less often in other sandstone units. Within the Lake Alice district, mineralization is locally well developed in the Nugget Sandstone and Gypsum Spring Member of the Twin Creek Limestone (**Figure 28**). The source of the mineralization may have been metalliferous petroleum, metal-rich fluids from the black shales of the Phosphoria Formation, or interformational

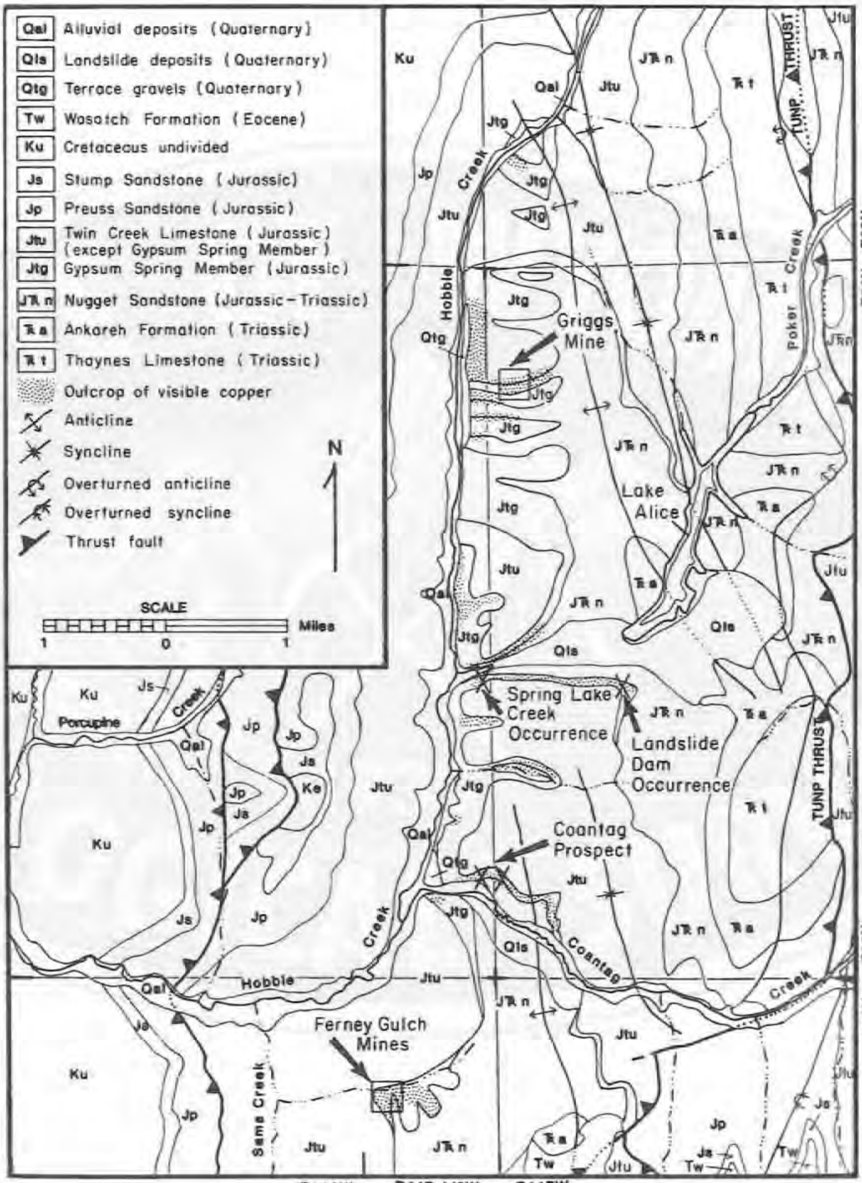


Figure 28. Geologic map of the Lake Alice district (modified from Loose and Boberg, 1987).

fluids. Black shales and crude oil are well-known hosts for a variety of metals. For example, the Phosphoria Formation black shales and phosphorites contain anomalous Ag, Au, Cr, Zn, Cu, V, and other trace metals (Love, 1961, 1967, 1984; Harris and Hausel, 1984).

Several sedimentary formations in this region, particularly in northwestern Wyoming in Jackson Hole and the Snake River Plain, contain anomalous gold. These gold-bearing quartzite conglomerates, sandstones, and alluvial material have been the subject of research by Antweiler and Love (1967), Lindsey (1972), Love (1973), and Antweiler and others (1977), but according to Antweiler and Love (1967) the average gold content is very low (Table 17).

Table 17. Reported gold content of the gold-bearing conglomerates, northwestern Wyoming (after Antweiler and Love, 1967).

Stratigraphic unit	Average Au content, in ppb	Single-sample maximum, in ppb
Quaternary alluvium	103	2,000
Miocene (?) conglomerate	65	290
Pass Peak Formation (Middle? Eocene)	47	250
Wind River Formation (Early Eocene)	222	2,000
Early (?) Eocene conglomerate	94	400
Pinyon Conglomerate (Paleocene)	86	6,000
Fort Union Formation (Paleocene)	35	300
Harebell Formation (Late Cretaceous)	65	1,000

Alluvial and bench placers along the Snake and Hoback Rivers have been periodically mined during the past on a small scale. These placers generally contain very low grade gold but may have narrow pay streaks with higher values.

Lake Alice district

The Lake Alice district is located about 20 miles north-northeast of Cokeville in the heart of the Overthrust Belt of western Wyoming (Figure 1). This district includes the Ferney Gulch and Griggs mines, with some associated prospects localized along the western flank of Nugget Ridge, a north-south trending anticline in the upper plate of the Tunp Thrust (Figure 28). Mineralization consists of copper, silver, and minor zinc localized along the dip slope of the Gypsum Spring Member of the Twin Creek Limestone (Jurassic)-Nugget Sandstone (Triassic/Jurassic) contact. The mineralization also extends upward into the overlying Gypsum Spring and downward into the Nugget Sandstone from the dip-slope contact (Boberg, 1986; Loose and Boberg, 1987).

In the district, the Nugget Sandstone is a prominent crossbedded redbed unit that is generally bleached near its top. The sandstone is clean and fine grained, with well-rounded frosty grains. The Gypsum Spring sandstones are arkosic and argillaceous with angular quartz grains. In addition, the Gypsum Spring Member of the Twin Creek Limestone contains sedimentary limestone-siltstone breccias, red siltstones, tuffaceous sandstones, petroliferous limestones and dolomites, and mudstones (Boberg, 1984).

Parallel to the crest of Nugget Ridge are numerous joint sets. East-west trending normal faults with displacements of 100 to 200 feet cut the ridge.

Boberg (1986, 1984) recognized some probable controls for the Lake Alice mineralization. Boberg (1984) assumed that the mineralizing fluids were interformational or derived from a similar low-temperature source. Fluid inclusion studies indicate the mineralizing fluids were deposited at temperatures less than 100°C (Loose and Boberg, 1987). During deformation, the fluids migrated to anticlinal traps and along permeable fault and breccia zones. Where the solutions contacted the reactive rocks of the overlying Gypsum Spring Member, sulfides precipitated. Sulfides also precipitated in the underlying Nugget Sandstone (Plate 1A). However, where the Gypsum Spring cap has been removed by erosion, the sulfides in the underlying Nugget have been oxidized and removed (Boberg, 1984). During thrusting and folding in the Overthrust Belt, these deposits were redistributed to structurally prepared sites (Loose and Boberg, 1987). Thus exploration for Lake Alice deposits should focus on anticlinal folds and fractures developed in permeable sandstones capped by reactive rock. The mineralization in the Nugget also appears to be closely associated with bleaching of the redbeds (Love and Antweiler, 1973).

Some ore was shipped from the district between 1914 and 1920 and in 1942 although the actual tonnage is unknown.

Mine and prospect descriptions

Big Park prospect; E½ sec. 12, T.27N., R.117½W. Samples of copper-stained Nugget Sandstone were found at this locality by Love and Antweiler (1973).

Coantag prospect; NE¼ sec. 36, T.28N., R.117½W. (Figure 28). A sample of mineralized Nugget Sandstone from this prospect assayed 0.39 percent Cu, 32 ppm Zn, and 2 ppm Ag (Love and Antweiler, 1973).

<u>Ferney Gulch mines</u>; sec. 1, T.27N., R.117½W. (Figure 28). Some ore was shipped from the Ferney Gulch mines during the early 1900s. The Ferney Gulch mines consisted of a group of short adits driven along the Gypsum Spring-Nugget contact. A selected sample collected by Love and Antweiler (1973) from the mine dump ran 50,000 ppm Cu, 15 ppm Ag, 26,000 pm Zn, 700 ppm Co, 500 ppm Pb, and 70 ppm Mo. Another sample collected by the author in 1982 assayed 1.11 percent Cu, 0.52 oz/ton Ag, 137 ppm Zn, and 63 ppm Co (Hausel and Harris, 1983).

<u>Griggs mine</u>; sec. 7, T.28N., R.117W. (Figure 28). Bleached sandstones of the Nugget Sandstone and gray silty sandstones and petroliferous cherty dolomites of the Gypsum Spring Member contain variable Cu, Ag, Zn, and Pb values. The mineralization occurs at the Gypsum Spring-Nugget contact in a structurally prepared zone on the flank of an anticline (Boberg, 1986) over a vertical thickness of about 300 feet (Love and Antweiler, 1973). In 1919, the Griggs mines consisted of five tunnels and nine shafts with an assortment of exploration shafts, cuts, and pits (Love and Antweiler, 1973). A number of these tunnels were still accessible in 1982 (Plate 1A) (see Hausel, 1982c).

A locally continuous, 2- to 3-foot-thick, gray, silty sandstone of the Gypsum Spring Member contains mineralization averaging 0.2 percent Cu and 0.1 oz/ton Ag wherever it is found in a 2-square-mile area in the vicinity of the mine (Boberg, 1986). Samples of mineralized Nugget Sandstone collected by Love and Antweiler (1973) assayed 180 to 67,000 ppm Cu, a trace to 5,000 ppm Pb, 26 to 32,000 ppm Zn, and a trace to 1,200 ppm (35 oz/ton) Ag. Allen (1942) reported average assays from the mine ran 3.5 percent Cu and 7.4 oz/ton Ag. Ore shipped in 1942 from the Griggs mine also contained significant values (Table 18).

One hole drilled adjacent to the Griggs mine workings by Bear Creek (Kennecott) Exploration in the 1970s contained 2 feet of 0.2 percent Cu and 1.5 oz/ton Ag at 10 feet deep and 5 feet of 0.79 percent Cu and 4.5 oz/ton Ag at 21 feet deep. Both mineralized intervals were in the Gypsum Spring Member (Boberg, 1984).

<u>Landslide Dam occurrence</u>; sec. 20, T.28N., R.117W. (Figure 28). A sample of copper-stained sandstone assayed 860 ppm Cu, 22 ppm Zn, and one ppm Ag (Love and Antweiler, 1973).

<u>Spring Lake Creek occurrence</u>; SE¼ sec. 24, T.28N., R.117½W. (Figure 28). A 110-foot tunnel was driven into bleached Nugget Sandstone. Sparse malachite and pyrite were found in the workings.

Table 18. Assays of ore from the Griggs mine (Allen, 1942).

Sample	Au (oz/ton)	Ag (oz/ton)	Cu (%)	Pb (%)
1	0	62.8	20.95	0
2	0	4.4	7.0	2.6
3	0	2.0	5.6	0
Mark-1	0.01	41.2	5.6	–
Mark-2 (average)	trace	13.7	4.3	–
#2 dump	–	6.3	1.44	–
#3 dump	–	9.4	3.33	–
#4 tunnel #2	–	12.2	4.46	–
#5 tunnel #2	–	6.0	2.94	–
#6 tunnel #2	–	5.3	1.88	–
#7 tunnel #2	–	1.0	0.64	–
#8 tunnel #3	–	0.1	1.11	–
#9 dump	–	11.3	2.87	–
#10 dump	–	10.9	3.39	–

Samples collected from the mine ribs ran 5,000 ppm and 2,100 ppm Cu, 3 ppm and 8 ppm Ag, with traces Zn (Love and Antweiler, 1973). A malachite-stained sample collected from the mine dump yielded 0.25 percent Cu, 46 ppm Zn, and a trace Ag (Hausel and Harris, 1983, p. 56).

Miscellaneous prospects in the Overthrust Belt and adjacent areas

Afton area; N½ T.31N., R.118W. Over a 7-square-mile area, the U.S. Geological Survey collected many hundreds of samples of the Meade Peak Member and adjacent rocks as part of a study of vanadium in the Permian Phosphoria Formation (Love, 1961). However, only a few samples were tested for precious metals. The Meade Peak Member in this area is 90 to 120 feet thick. Of the few samples that were analyzed for silver, values ranged from 2 to 13 ppm (Love, 1984). One bed, 20 miles west of Afton in the Mabie Canyon mine, assayed 145 ppm Ag (4.23 oz/ton) (Desborough, 1977).

Cabin Creek; SE¼ T.34N., R.114W. (unsurveyed), near the headwaters of Cabin Creek. Malachite-stained Nugget Sandstone was found at this locality (Love and Antweiler, 1973).

Cabin Creek Campground; T.38N., R.116W. (43°15′; 110°47′) (unsurveyed). The upper contact of the Nugget Sandstone is locally bleached white. Some malachite and azurite were found staining the bleached sandstone. Samples collected from this locality range from 0.15 to 6.8 percent Cu, 23 to 150 ppm Zn, 5,600 ppm Pb, 30 ppm Co, and a trace to 0.9 ppm Ag (Hausel and Harris, 1983).

Cache Creek; NW¼NE¼ sec. 1, T.40N., R.116W. (unsurveyed). The lower part of the Meade Peak Member on the north side of Cache Creek was trenched and sampled. The Meade Peak is 36 feet thick at this locality. Samples from the basal 1 foot of the member contained 30.07 percent P_2O_5 and 0.02 ppm Au. A weighted average silver content of the overlying 1.4 feet of phosphorite and phosphatic mudstone was 47 ppm (Love, 1984).

Cockscomb; T.19N., R.120W. (unsurveyed), 25 miles north of Evanston and 5 miles from Bear River. Copper carbonates stain the gray sandstone along the axis of an overturned anticline. Copper occurs either in the Beckwith Formation(?) or in the Twin Creek Limestone(?) (Osterwald and others, 1966, p. 56). No samples were analyzed for precious metals.

Davis placer; T.38N., R.116W., on the Snake River. Gravel processed from this placer was reported to run 0.001 to 0.15 oz/yd^3 Au with small pay streaks running 0.1 to 0.15 oz/yd^3 Au. Only one piece of coarse gold was recovered that was about one-half the size of a tenpenny nail (Schultz, 1907).

East Gros Ventre Butte; SW¼NE¼ sec. 15, T.41N., R.116W., 2 miles north of the town of Jackson. The Meade Peak Member of the Phosphoria Formation is 35 feet thick at this locality. The basal 4.5 feet of phosphorite and phosphatic shale averages 25 percent P_2O_5 and 20 ppm Ag. A 1.4-foot-thick phosphorite bed within this unit contains 0.2 percent Cr and 0.05 percent Cu. The uppermost 1 foot of this unit contains 0.1 ppm Au. A 1-foot-thick phosphatic sandstone at the top of the Meade Peak Member averages about 15 percent P_2O_5 with 0.1 ppm Au and traces Ag (Love, 1984).

Game Creek; SW¼ sec. 24, T.40N., R.116W., on the west side of Game Creek in Teton County. The Phosphoria Formation is approximately 220 feet thick at this locality, and only the Meade Peak Member is exposed.

A sample from the 1-foot-thick bed of phosphatic mudstone about 8 feet above the base of this member contained 50 ppm Ag. The underlying 2.7 feet of phosphatic mudstone yielded 30 ppm Ag (Love, 1984).

Green River Lakes; 43°19′, 109°51′ (unsurveyed). Copper-stained Nugget Sandstone is exposed along Mill Creek, which drains into Green River Lakes on the western flank of the Wind River Range (Hausel and Harris, 1983).

Griggs bar; secs. 28 and 29, T.37N., R.111W., a stream terrace that lies 40 feet above the channel of a tributary of North Beaver Creek.

The stream terrace contains very fine gold (about 200 to 300 colors to one cent of value according to Walton, 1940, p. 19).

Halfturn Creek; NE¼ T.37N., R.115W. (unsurveyed), near the headwaters of Halfturn Creek a few miles north of the Cabin Creek occurrence. Copper carbonate stains Nugget Sandstone. A sample of mineralized sandstone from the Halfturn Creek prospect assayed 3.0 percent Cu, 70 ppm Pb, and 150 ppm Ag (Love and Antweiler, 1973).

Horse Creek; T.34N., R.114-115W. A sample of Jurassic sandstone collected from a prospect pit assayed 3.2 oz/ton Au and 27.3 oz/ton Ag (Schultz, 1907).

Hunter Creek; SE¼ sec. 36, T.37N., R.115W. The lower 7 feet of section of the Meade Peak Member yielded a maximum silver content of 15 ppm. Chromium is the most abundant trace element (one percent in a bed 7 feet above the base according to Love, 1984).

Jamb Creek; center sec. 26, T.36N., R.115W. Fourteen samples of the Meade Peak Member contain maximum silver contents of 15 ppm. The highest silver values were from a bed about 8 feet above the base of the member. A fire assay of a 2.7-foot-thick mudstone in the upper part of the member yielded 0.2 ppm Au (Love, 1984).

LaBarge Creek; NW¼ T.27N., R.115W., about 10 miles east-southeast of the Lake Alice district. A west-facing dip slope on the east bank of LaBarge Creek is stained by malachite (Gordon Marlatt, personal communication, 1984).

Pine Bar placer; T.37N., R.116W., in terrace gravels at the mouth of Pine Creek on the south side of the Snake River. In the early 1900s, these gravels were mined hydraulically. Tests showed an average gold content of 0.006 to 0.007 oz/yd^3 with some small pay streaks that contained 0.1 oz/yd^3. The gold was very fine with 1,000 to 1,200 colors to a cent (Schultz, 1907).

Pine Creek Valley; Rock Creek, a tributary of Bear Creek, is located in Pine Creek Valley 15 miles west of Kemmerer and 6 miles north of Nugget Station on the Union Pacific Railroad. Brecciated sandstones below the Permian-Pennsylvanian redbeds contain copper carbonates (Veatch, 1907, p. 163). No precious metal values were reported.

Snow King Mountain; NE¼NE¼ sec. 9, T.40N., R.116W. (unsurveyed). A 7.5-foot-thick phosphatic mudstone 7 feet above the base of the Meade Peak Member yielded a weighted average silver content of 50 ppm. The basal 2 feet of this zone yielded 70 ppm Ag, while the middle 4 feet yielded 0.7 percent Cr. Other portions have maximum concentrations of 0.07 percent La, 0.05 percent Mo, 0.07 percent Ni, 0.3 percent Sr, 0.3 percent V, 0.07 percent Y, and 0.6 ppm Hg (Love, 1984).

Sublette Ridge; in the Sublette Ridge area 20 miles south of Afton. Reported silver concentrations of the Phosphoria Formation are as high as 0.26 percent (75.8 oz/ton Ag!) (Allsman and others, 1949).

Teton Pass. Exposures of Nugget Sandstone cut by State Highway 22 at Teton Pass are stained by malachite (J.D. Love, personal communication, 1982).

E½ sec. 12, T.41N., R.118W. The basal 2 feet of the Meade Peak Member were sampled and assayed for silver. Silver values were as high as 25 ppm. The upper half of this unit yielded 0.2 percent Pb, more than 1.0 percent Zn, more than 0.05 percent Cd, 0.1 percent Cr, 0.1 percent Cu, and 0.2 percent V. A 1-foot bed located 0.4 feet below the top of the basal phosphorite zone yielded 70 ppm Ag (Love, 1984).

Watercress Canyon; NW¼ sec. 4, T.22N., R.118W. The Permo-Pennsylvanian Wells Formation is mineralized along the Rock Creek fault on the west limb of a north trending anticline. Stratigraphically, the Wells Formation is overlain by the Grandeur Limestone (Rubey and others, 1975), which in turn is overlain by black shales of the Phosphoria Formation.

A mineralized sample taken from Wells Formation sandstone assayed 0.1 to 7.5 percent Cu, 70 to 360 ppm Zn, and 0.6 to 2.7 ppm Ag (Rubey and others, 1975).

West Gros Ventre Butte; NW¼NE¼ sec. 17, T.41N., R.116W. The basal phosphorite of the Meade Peak Member was sampled 2 miles west of the East Gros Ventre Butte sample. The basal and top units of this 31-foot-thick phosphorite yielded 20 ppm Ag and the middle unit assayed 0.02 ppm Au and 0.7 percent V. The upper two units of the basal bed have 0.15 percent Cr and 1.0 percent Zn (Love, 1984).

Owl Creek Mountains

The Owl Creek Mountains form a narrow, linear, east-west trending, asymmetrical anticlinal uplift in northcentral Wyoming. The northern flank of the range is unconformably overlain by Paleozoic sedimentary rocks that dip to the north, and the southern flank is onlapped by Tertiary strata. The Tertiary rocks and sediments conceal Paleozoic and Mesozoic rocks that are overthrust by Precambrian rocks.

The Precambrian core of the Owl Creek Mountains has been subdivided into three different rock groups based on age. The oldest are supracrustal metamorphics that are well exposed within the Copper Mountain district. These rocks formed about 2.9 Ga and were metamorphosed approximately 2,750 Ma (Mueller and others, 1985). The metamorphic rocks were intruded by granites that are 2,640 and 2,720 Ma (Giletti and Gast 1961). Later, the supracrustals and the granites were intruded by Proterozoic mafic dikes of tholeiitic affinity 1,190 to 2,100 Ma (Condie and others, 1969). These dikes are the youngest recognized Precambrian rocks in the Owl Creek Mountains.

The Owl Creek Mountains contain scattered cupriferous fissure veins in granites and mafic dikes. However, the fairly extensive supracrustal terrane within the Copper Mountain district along the eastern extent of the range contains an extremely diversified assemblage of mineral deposits including precious metals and a number of strategic minerals (Hausel and Graff, 1983; Hausel and others, 1985).

Copper Mountain district

The Copper Mountain district (Figure 29) lies east of Wind River Canyon near the easternmost extent of the Owl Creek Mountains in a region also known as the Bridger Mountains. The district is southeast of Thermopolis and northeast of Shoshoni (Hausel and Graff, 1983; Hausel and others, 1985).

The Precambrian supracrustal rocks in the district have been separated into three units that form a northeasterly trending homocline(?) (Hausel and others, 1985). The southernmost unit consists of amphibolite with interlayered quartzofeldspathic gneiss. Both orthoamphibolite and para-amphibolite are present. The orthoamphibolites are metamorphosed tholeiitic basalts depleted in light rare-earth elements (LREE) and LREE-enriched basaltic andesites (Mueller and others, 1985). The para-amphibolites are metamorphosed greywackes (Condie, 1967). Quartzofeldspathic gneiss of dacitic affinity (Hausel and others, 1985) represents strongly LREE-enriched dacites (Mueller and others, 1985). This southernmost unit appears to be dominantly metaigneous.

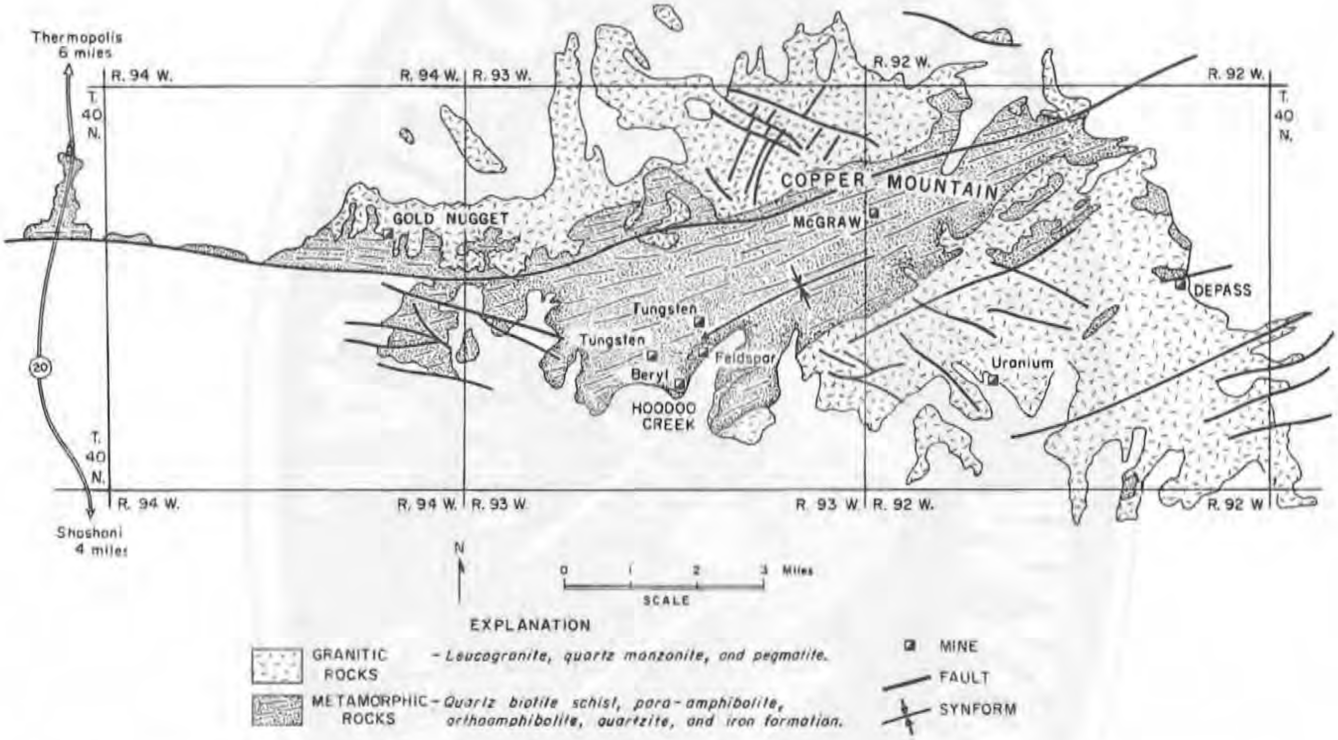


Figure 29. Generalized geologic map of Precambrian rocks in the Copper Mountain district, Fremont County (modified from Hausel and others, 1985).

The central unit is a dominantly metasedimentary succession of amphibolite, banded iron formation, and minor metapelite and quartzite. This unit is structurally overlain by the northernmost succession, consisting mostly of amphibolite with lesser quartzofeldspathic gneiss (Hausel and others, 1985). Based on the stratigraphic and structural characteristics of the Copper Mountain supracrustral belt, Hausel and others (1985) interpret it as a high-grade supracrustal succession.

Excluding uranium, the Copper Mountain district has four separate mining areas: (1) DePass, (2) Gold Nugget, (3) Hoodoo Creek, and (4) McGraw (Figure 29). The Hoodoo Creek area was mined principally for tungsten and feldspar-rich pegmatites and will not be discussed further. For information on these pegmatites refer to Hausel and Holden (1978) and Harris and Hausel (1984).

Mine and prospect descriptions

DePass (Williams-Luman) mine; S½ sec. 14, T.40N., R.92W. (Figure 29). The DePass mine was developed in a Proterozoic mafic dike along the northeastern edge of the Copper Mountain supracrustal belt. The mafic dike is 30 to 50 feet wide at the mine site, and is mineralized with copper, gold, and silver. The dike is fractured and several quartz veins fill the fractures. Both the veins and the host dike are mineralized. The veins contain fracture-filling copper sulfides and the dike contains disseminated sulfides.

The mine was developed by more than 11,000 feet of workings, and a shaft was sunk to a depth of at least 810 feet. The haulage tunnel was mapped by the Geological Survey of Wyoming, but the majority of the mine workings were inaccessible (Hausel and others, 1985). Total production from the mine is not known and available reports suggest that at least 568,000 pounds of mill concentrates were shipped from the property. A chip sample taken across a 30-foot width of the dike on the surface assayed 1.79 percent Cu, 74 ppm Ni, and no detectable Au, Ag, or Pt (Hausel and others, 1985). Although precious metals were not detected in these samples, both Beeler (1906b) and Bowdin (1918) reported shipped concentrates to contain as much as 1.45 oz/ton Au and 0.60 oz/ton Ag. Bowdin (1918) reported samples taken in the upper workings of the mine contained 0.08 to 0.14 oz/ton Au. Ore minerals include chalcopyrite, malachite, azurite, cuprite, chalcocite, native copper, and chrysocolla. Gangue minerals include milky quartz, pyrite, earthy and specular hematite, limonite, goethite, and siderite (Hausel and others, 1985). Love (1954) also reported the presence of radioactive minerals on the mine dump.

East Fork Birdseye Creek mines, NE¼NW¼ sec. 13, T.40N., R.94W. Two short adits were mapped by Hausel and others (1985) in the Gold Nugget mining camp east of the Gold Nugget mine (Figure 29). The northernmost mine was driven 300 feet into a thin quartzite and the southernmost adit cut 150 feet of pegmatite and metamorphics. A sample of limonite-stained quartz from the mine dump at the northern adit assayed 0.77 oz/ton Au (Hausel and others, 1985).

Gold Nugget (Hale) mine; SE¼SE¼ sec. 11, T.40N., R.94W. The Gold Nugget mining camp consisted of several small mines and a mill in a tributary of Birdseye Creek near the western edge of the Copper Mountain supracrustal belt (Figure 29). Rocks in this region include para-amphibolite, orthoamphibolite, quartzite, metapelite, and quartzofeldspathic gneiss intruded by and complexly interfingered with granite (see Hausel and others, 1985).

The Gold Nugget mine was developed on a 3-foot wide, 30°SE- to 40°SE-dipping vein in muscovite schist. The schist hosting the vein was extensively invaded by granite and presently is a roof pendant rafted in granite (Hausel and others, 1985).

Bregy (1935) reported the mine was developed to a depth of 400 feet with 1,190 feet of drifts. The vein carries sporadic sulfides (pyrite) and gold values. The vein is traceable on the surface for about 700 feet from the mine portal to where it is cut and assimilated by muscovite granite. Five hundred feet east of this point, another roof pendant is exposed that contains another 200 to 300 feet of the Gold Nugget vein (see Hausel and others, 1985).

Based on the geology of the mine, it appears that the available tonnage is limited (Hausel and others, 1985). Reported production from the mine before 1935 was 1,700 tons of ore. In 1935, the mine was reported to contain reserves of 16,500 tons averaging 0.42 oz/ton Au. An additional 14,000 tons (no grade given) were indicated. Samples taken in the mine drifts ranged from a trace to 2.37 oz/ton Au (Bregy, 1935) and some specimen-grade samples were reported to have assayed 1,450 oz/ton Au (*Wyoming Industrial Journal*, 1906, v. 7, no. 8, p. 4). However such specimen-grade material is extremely rare.

McGraw mining area; in the central metamorphic unit near the center of Copper Mountain. Several mines and prospects are developed in banded iron formation and on strike veins (see Hausel and others, 1985) (Figure 29).

McGraw mine; SW¼SW¼ sec. 7, T.40N., R.92W., in the central portion of the Copper Mountain supracrustal belt in the McGraw mining area (Figure 29). Access is by rough dirt road through private property, either along the West Fork of Dry Creek from the south or along the West Bridger Basin from the north.

The property occurs within "Metamorphic Unit II" (Hausel and others, 1985), which consists of intercalated quartzite, para-amphibolite, orthoamphibolite, metapelite, quartzofeldspathic gneiss, localized strike veins, and iron formation (Figure 30), as well as amphibolite dikes or sills. The McGraw mine dump consists of iron formation and amphibolite with only minor fragments of cupriferous quartz.

Figure 30. Banded iron formation exposed near the McGraw mine in the Copper Mountain district.

The McGraw mine consists of two shafts. The primary shaft is collared into an oxide-facies iron formation. The secondary or ventilation shaft located to the east of the primary shaft was developed into a cupriferous vein that follows the country rock foliation. This vein trends to the southwest from the primary shaft and in all probablility was the primary target for mining.

The McGraw vein is a milky quartz vein that trends parallel to the regional foliation of N.50°E. to N.70°E. and dips 76°SE. Copper occurs as fracture filling and surface coatings. Like the majority of the veins examined on Copper Mountain, this is a strike vein that exhibits no evidence of crosscutting or distinct wallrock alteration. The vein is enclosed by orthoamphibolite and lies adjacent to an iron formation.

Two samples of the McGraw vein were assayed. The first sample, copper-stained milky quartz selected from the mine dump adjacent to the McGraw primary shaft, assayed 0.29 percent Cu and no detectable Au or Ag. The second sample, a grab sample from the McGraw secondary mine dump, ran 0.12 percent Cu with 0.04 oz/ton Au and no detectable Ag.

A sample of typical iron formation collected from the McGraw primary shaft assayed 33.9 percent Fe with no detectable Au. A second sample yielded 0.02 percent Cu with no Au. The iron formation at the McGraw primary shaft contained no visible copper or sulfides, and consisted of banded magnetite, minor hematite, quartz, and amphibole. Harrer (1966) reported that a characteristic iron-formation sample from the McGraw mine contained 33.7 percent Fe, 0.012 percent Mn, 0.20 percent TiO_2, 0.05 percent P, 0.03 percent S, 45.6 percent SiO_2, and 0.25 percent Cu.

West Bridger mine; N½ sec. 8, T.40N., R.92W. Two adits were driven into the central metamorphic unit ("Metamorphic Unit II" of Hausel and others, 1985) and cut amphibolite, pelitic schist, and iron formation. A sample of iron formation from the lower dump assayed 0.06 percent Cu and no detectable Au. A selected sample of quartz from the dump contained 9.0 percent Cu and no Au (Hausel and others, 1985). Ore shipped from the mine in 1907 contained values in copper, gold, and silver (*Wyoming Industrial Journal*, 1907, v. 8, no. 9, p. 3).

8201 Shaft; S½SW¼ sec. 7, T.40N., R.92W., east of the McGraw mine. The shaft was sunk on a 4- to 5-foot-wide cupriferous strike vein hosted by amphibolite. One selected sample of vein material assayed 6.8 percent Cu and no Au (Hausel and others, 1985).

8086 Incline; SE¼ sec. 12, T.40N., R.93W., about 700 feet west of the McGraw mine. The shaft was sunk on copper-stained, banded, magnetite-quartz iron formation. One sample of the iron formation was selected for analysis and assayed 36.9 percent Fe, 0.059 percent Cu, and no detectable Au (Hausel and others, 1985).

NE¼NE¼ sec. 13, T.40N., R.93W. A collapsed adit at this location cut into pelitic schist and amphibolite. A grab sample of quartz-vein material from the mine dump yielded 1.58 percent Cu, 0.26 oz/ton Au, with no detectable Ag (Hausel and others, 1985).

Miscellaneous occurrences

Sec. 34, T.40N., R.92W. Albert's (1986) map shows an anomalous stream-sediment sample at this locality. The sample yielded 3.07 ppm Au. At this location, the East Fork of Dry Creek drains Tertiary sedimentary rocks that onlap Precambrian granite.

Secs. 12, 14, and 24, T.39N., R.93W. Small amounts of mercury were reported in the Wind River Formation. A short distance north, alum and sulfur were also reported (Marzel, 1927; Hagner, 1942d). Cursory gold panning tests conducted by Marzel (1927) and others were discouraging and only produced one color.

J. David Love (personal communication, 1987) reported that a mercury retort had been constructed at the site in the past.

Powder River Basin

Not much information is available concerning gold in the Powder River Basin although some anomalies are reported in Cretaceous sedimentary rocks along the margin of the Black Hills uplift (see Black Hills). There is one interesting description in the *Engineering and Mining Journal* (1896, v. 62, p. 327) on the Powder River placer mines. Unfortunately, the location of these mines is unknown to the author. The reported gold values of 1.5 oz/yd^3 are undoubtedly high-graded or erroneous.

In northern Campbell County and northwestern Crook County, in a nearly 700-square-mile area, Albert (1986) showed 35 gold anomalies with values ranging from 0.20 to 0.44 ppm. He showed an additional ten samples scattered within 25 miles east, southeast, and west of Gillette, which yielded gold concentrations of 0.20 to 0.52 ppm.

Rawlins uplift

The Rawlins uplift contains a poorly exposed core of Precambrian granite flanked by Paleozoic sediments along the east. The western flank is onlapped by Tertiary rocks. The Flathead Formation (Cambrian) forms a prominent, hematitic sandstone and conglomerate outcrop along the southeastern corner of the uplift. Before 1890, about 100,000 tons of this conglomerate were mined and the hematite used as a paint pigment (Osterwald and others, 1966).

The *Engineering and Mining Journal* (1895, v. 59, p. 471) reported the conglomerate also carried gold. The gold content reportedly ranged from 0.04 oz/ton to 0.19 oz/ton.

Seminoe Mountains

The Seminoe Mountains lie in south-central Wyoming about 30 miles north of Sinclair and west of Seminoe Reservoir. The district is accessible by jeep trail from the Seminoe Reservoir road.

Much of the Seminoe Mountains are underlain by Archean supracrustal rocks consisting of a lower group of metavolcanics overlain by metasediments. The lower metavolcanics contain serpentinized, basaltic, peridotitic, and pyroxenitic komatiite flows with thin interlayered banded iron formation. These lower mafic to ultramafic flows (schists) are overlain by a small volume of bimodal calc-alkaline metavolcanics (Klein, 1981). The metasedimentary succession contains metagreywacke, metapelite, graphitic schist, quartzite, metaconglomerate, and thick banded iron formation. The entire supracrustal succession has been intruded by gabbroic sills and dikes, and by granitic stocks and plutons (Klein, 1981).

Mineral deposits in the district occur principally as fracture-fill veins. The veins are gold- and copper-bearing and generally follow regional foliation. In places, banded iron formation also contains sporadic gold values associated with localized sulfide and carbonate alteration (Hausel and Harris, 1983).

Wallrock alteration includes silicification, carbonatization, and chloritization. Silicification is expressed as a distinct bleaching of wallrock adjacent to some veins that extends several feet from the veins into the wallrock. Carbonatization is more widespread in the mineralized area and is expressed as massive carbonate replacements accompanied by chlorite (Klein, 1981). During a brief reconnaissance survey of this area in 1980, several quartz-vein samples containing visible gold were identified. Production from the district is not accurately known although Knight (1893) estimated gold production at about 500 oz. In addition to gold, the Seminoe Mountains contain resources and occurrences of copper, iron, jade, talc, and asbestos (Osterwald and others, 1966).

Bradley Peak area

Mine descriptions

The Bradley Peak area, located at the western edge of the Seminoe Mountains, includes amphibolites overlain by metasediments intruded by metagabbro. Gold-bearing quartz veins and iron formation occur in this area (Hausel and Harris, 1983).

Junk Creek mine; sec. 20, T.26N., R.85W. Malachite, bornite, chrysocolla, and chalcopyrite occur as fracture fillings and coatings in a brecciated N45°E trending quartz vein, aplite dike, and altered amphibolite schist. Both the vein and aplite are approximately 1.5 to 3 feet wide (Bishop, 1964; Klein, 1981). About 650 feet southwest of the Junk Creek shaft is a caved prospect with malachite, bornite, and covellite fracture fillings and coatings in altered granite (Bishop, 1964).

Penn mines; sec. 6, T.25N., R.85W., a group of shafts and adits along the east flank of Bradley Peak (Bayley, 1968). According to Aughey (1886, p. 5) the Penn mines were a group of mines individually named Deserted Treasure, Emeletta, Star, Hope, King, Jennie, Meager, Bennett, and East King. In 1896, it was reported the King mine was developed on a 12- to 50-inch-wide vein that averaged 1.0 oz/ton Au (*Engineering and Mining Journal*, 1896, v. 62, p. 135). Over 700 feet of drifts had been driven at this time. The Penn(?) mine was developed by a 165-foot main tunnel and a 240-foot deep shaft on a 3- to 5-foot vein that also reportedly averaged 1.0 oz/ton Au.

The mines were driven into quartz veins hosted by mafic metavolcanics intruded by a metagabbro sill. The gold-bearing quartz veins were reported to be 4 to 5 feet thick, to carry pyrite and chalcopyrite, and to be free milling. Aughey (1886, p. 5) said the veins were "high grade" and a few of the veins had streaks of "very high grade" gold. For example, 70 tons of ore mined from the King Shaft produced about 35 oz of gold (sulfides were not saved) (Aughey, 1886, p. 5).

More recently, samples of sulfide- and limonite-bearing quartz-vein material collected from mine dumps contained specks and small nuggets of visible gold. One selected vein sample assayed 2.87 oz/ton Au. Nearby, selected altered sulfide-bearing and carbonitized amphibolite and iron formation samples have yielded as much as 1.36

oz/ton Au (Hausel and Harris, 1983). However, no follow-up sampling has been done to verify the assays. Dickman (1906) reported samples of iron formation north of Bradley Peak contained anomalous gold; one sample (sec. 36, T.26N., R.86W.) assayed 0.02 oz/ton Au and 0.5 oz/ton Ag.

Sec. 29, T.26N., R.85W. Several copper prospects occur in a massive quartz vein in a fault zone in amphibolite schist (Bishop, 1964).

Miscellaneous mines and prospects

Charlies Glory Hole; sec. 29, T.26N., R.84W. Bishop (1964) reported free gold was found in a quartz vein enclosed by a small fault hosted by chlorite schist country rock.

Kopper Pit prospect; NW¼ sec. 33, T.26N., R.85W. The Kopper Pit prospect has disseminated chalcopyrite in altered ultramafics (Klein, 1981).

Long Creek area; sec. 26, T.26N., R.85W. Abundant malachite, bornite, chalcopyrite, and chrysocolla occur on a dump adjacent to a shaft sunk on a fault in altered amphibolite schist. X-ray fluorescence analyses of samples indicate anomalous Pb, Au, Ag, U, Fe, and Cu (Bishop, 1964).

Sunday Morning mine; SE¼ sec. 29, T.26N., R.85W. A white to rusty, massive, southeast trending quartz vein crops out in amphibolite schist. The vein bifurcates on the northwest and is locally characterized by boxworks. Free gold, chalcopyrite, malachite, cuprite, and chrysocolla occur on the mine dump (Bishop, 1964; Hausel, 1982c, p. 6).

Sunday Morning prospect; sec. 21, T.26N., R.85W. Gold is reported in felsic metavolcanics and associated metasediments (Gordon Marlatt, personal communication, 1982).

Sec. 32, T.26N., R.85W. Malachite, chrysocolla, bornite, chalcopyrite, and pyrite cubes occur in a quartz vein exposed in three prospect pits dug in amphibolite (Bishop, 1964).

Sec. 29, T.26N., R.85W. Several copper prospects are located on a massive quartz vein in a fault zone in amphibolite schist (Bishop, 1964).

Sierra Madre

The geology of the Sierra Madre is similar to the Medicine Bow Mountains. The entire uplift is essentially one mining district, known as the Encampment district. This district was principally known for its rich copper deposits, but associated gold and silver made it a relatively important source of precious metals. Unfortunately, very little assay information is available for the many copper deposits in the district, thus this chapter is devoted primarily to those deposits with known precious metal values. For a more detailed description of the copper deposits see Hausel (1986a, g).

The Sierra Madre was uplifted during Laramide time. Its Precambrian core consists of rock from two provinces separated by a major east-west trending suture known locally as the Mullen Creek-Nash Fork shear zone (Houston and others, 1968, 1983). North of the shear zone, Archean (>2.5 Ga) granite, gneiss, and infolded metasedimentary and metavolcanic rocks are unconformably overlain by a thick clastic wedge of Early Proterozoic (2.5-1.8 Ga) miogeoclinal and epicontinental metasediments. These Early Proterozoic metasediments include quartzite, metaconglomerate, metalimestone, metadolomite, and phyllite, with lesser metavolcanics. South of the shear zone, late Early Proterozoic eugeoclinal schists and gneisses form a thick suite of metavolcanics and volcaniclastics. These rocks are of calc-alkaline affinity and include metabasalts, meta-andesites, and metarhyolites. At several localities, these units retain relic volcanic textures (Divis, 1976).

Encampment district

Mineral deposits in the Encampment district are dominated by copper. North of the shear zone, the miogeoclinal sequence contains copper-bearing quartzite, pegmatite, quartz veins, and uraniferous metaconglomerate; south of the shear zone, the eugeoclinal rocks host stratiform volcanogenic sulfides and related mineralization. The shear zone itself contains scattered, fracture-controlled, base-metal deposits dominated by copper.

Placer gold deposits were discovered and mined at several locations in the district including Deep Creek, Mill Creek, Nugget Creek, Purgatory Gulch, Sandstone Creek, Spring Creek, and North Spring Creek.

Metals production from the district is not exactly known; however, more than 21 million pounds of copper with some gold and silver were recovered (Table 19).

Table 19. Copper, gold, and silver production from the Encampment district (U.S. Bureau of Mines Minerals Yearbook, 1913).

Year	Cu (pounds)	Ag (oz)	Au (oz)
1898	233,044	314	24
1899	3,104,827	4,183	320
1900	4,203,776	5,663	434
1901	2,698,712	3,636	278
1902	237,892	321	25
1903	773,993	1,043	80
1904	3,527,008	4,483	319
1905	2,385,628	3,549	226
1906	24,000	–	–
1907	2,206,065	2,982	232
1908	2,367,666	3,123	299
1909	33,431	–	–
1910	–	–	–
1911	4,738	21	–
1912	–	–	–
TOTAL	21,800,780	29,318	2,237

Mine and prospect descriptions

Bridger mine; N½NW¼ sec. 2, T.15N., R.87W. This mine may be mislocated on the Divide Peak topographic map because the mine on the map does not fit the description by Spencer (1904) (Paul J. Graff, personal communication, 1984). The Bridger vein is conformable to regional foliation and trends northwest with a dip of 25°SW to 55°SW. The vein is hosted by quartzite and lies near a contact with overlying metagabbro. The vein consists of a 0.5- to 4-foot-wide sulfide- and calcite-bearing quartz vein in quartzite. The sulfides are galena and chalcocite.

The vein has altered zones in both the hanging wall and footwall. The hanging wall consists of altered quartzite averaging 10 inches wide, which is highly mineralized and reported to assay from a trace to 69 oz/ton Au (Spencer, 1904, p. 100). The footwall zone is 4 to 10 inches wide and contains both gold and silver. The altered zones enclose a 6-inch- to 3-foot-wide silicified quartzite.

A 100-pound sample taken from the middle silicified quartzite streak of the Bridger vein assayed 90 oz/ton Ag and 0.26 oz/ton Au; with depth, the gold values decrease and the silver values increase (Spencer, 1904, p. 100).

Broadway mine; S½SW¼ sec. 32, T.13N., R.83W. The Broadway mine consists of an irregular mineralized body lying along a northeast trending contact between granite and a series of gneisses and amphibolites. According to Osterwald (1947), the metals probably replaced amphibolite along a 50- by 1,000-foot zone. The zone dips 50°SE to 50°NW.

Mineralization includes sphalerite, galena, chalcopyrite, chalcocite, and covellite, with some malachite and chrysocolla near the surface. One channel sample assayed 12.5 percent Zn, 1.9 percent Pb, and 0.02 percent Cu with a trace of platinum-group metals (Osterwald, 1947).

Cherokee Creek placer; T.15N., R.90-91W. The U.S. Bureau of Mines Minerals Yearbook, 1938, reported some gold was mined on Cherokee Creek in 1937. The location of this placer was reported as 6 miles south of Encampment; however, Cherokee Creek lies several miles to the west of Encampment along the west flank of the range.

Copper Gem prospect; on Dunkard Creek in Purgatory Gulch, 8 miles south of Encampment. An incline was driven into a 1- to 12-inch-wide gouge zone in granite and mica schist. The gouge zone contained some malachite and a little gold (Beeler, 1901b). Nearby, a 1- to 2-foot-wide quartz vein was developed by a 358-foot-deep shaft. The vein contained specks and streaks of chalcocite and chalcopyrite. Schistose rocks south of the vein also contained scattered sulfides (Beeler, 1903a).

Cox mine; T.13N., R.81W., near Encampment. Assays of ore from the mine ranged from 2.3 percent to 74.5 percent Cu plus some gold and silver (Osterwald and others, 1966, p. 46).

Dexter Peak area; sec. 21, T.15N., R.87W. The basal quartz-pebble conglomerate of the Magnolia Formation contains uranium (3 to 131 ppm) and thorium (16 to 664 ppm). One sample assayed 10.0 ppm Au (Houston and others, 1979; Karlstrom and others, 1981).

Doane-Rambler mine; NE¼ sec. 25, T.14N., R.86W. The host rock is a steeply dipping unit of the Cascade Quartzite. The quartzite trends east-west and dips 65°N to 75°N and is as much as 500 feet thick at the mine site.

Mineralization at the Doane-Rambler mine is localized where fracture planes intersect bedding planes within three distinct horizons. The ore follows stratification within the quartzite (Spencer, 1904; Houston and others, 1975). Ore minerals include chalcopyrite, bornite, chalcocite, covellite, malachite, azurite, and chrysocolla; the ore carried some gold and cobalt was detected (Armstrong, 1970, p. 2; *Wyoming Industrial Journal*, 1899, v. 1, no. 2, p. 19). By 1904, at least 2,800 feet of drifts and tunnels were developed in the mine (*Wyoming Industrial Journal*, 1904, no. 10, p. 271).

Dreamland King group; secs. 1 and 2, T.14N., R.86W., on South Spring Creek. Interlayered quartzite and schist with occasional gabbro dikes strike east-west and dip south. Limonite, malachite, and azurite stain a 20-foot-wide quartz vein in schist and gabbro. The vein also contains some pyrite and a little gold (Beeler, 1905b).

Eureka mine; SW¼ sec. 22, T.14N., R.84W. The host rock is diorite. A shallow shaft was sunk on a hematite-limonite-malachite-stained milky quartz vein that contained disseminated and fracture-filling chalcopyrite. The wallrock adjacent to the vein shows narrow biotite selvages. Reported assays are 11 to 46 percent Cu and 0.15 to 0.38 oz/ton Au (Armstrong 1970, p. 3).

Evening Star mine; location unknown. The Evening Star Company shipped a carload of ore to Denver from its mine on Beaver Creek that averaged 26 percent Cu with nearly 3.0 oz/ton Au (*Mining Reporter*, 1900, v. 42, p. 267).

Ferris-Haggarty mine; center sec. 16, T.14N., R.86W. The mine is in a thick quartzite of the Deep Lake Group (Proterozoic) north of the Mullen Creek-Nash Fork shear zone. Mineralization occurs in a steeply dipping (35°S to 50°S) quartzite, which flattens out in the lower mine workings (Ralph E. Platt, personal communication, 1988) and is capped by impermeable hanging-wall schist. The ore is massive chalcocite with lesser chalcopyrite filling an irregular breccia zone along the contact with the hanging-wall schist. Ore shoots in the quartzite range from a few feet to more than 20 feet thick and average 6 to 8 percent copper. However, from 1902 to 1908, mostly high-grade ore was mined. These high-grade ores varied from 30 to 40 percent copper (Spencer, 1904; Beeler, 1905a). The ore was followed down dip along a dip length of 400 feet. Spencer (1904) reported the extent of mineralization at depth had not been determined by 1903.

In addition to copper, the Ferris-Haggarty ore carries precious metal values. For example, Beeler (1905a) reported the ore contained some silver and 0.1 to 0.44 oz/ton Au. Assays of grab samples from the mine dump yielded 3.23 to 4.6 percent Cu and a trace to 0.61 oz/ton Ag (Hausel, 1986a).

Gertrude mine; E½ sec. 29, T.14N., R.85W. The Gertrude mine was developed on a stratiform, massive, earthy hematite body containing some specularite and minor copper stains. The host quartzite trends east-west and dips 40°S. The hematite varied from 2.5 feet thick near the surface to 9 feet thick at 80 feet deep. The extent of the hematite along strike was not investigated.

Assays of hematite samples showed 0.37 oz/ton Au (Spencer, 1904, p. 92-93). Spencer suggested that the Gertrude deposit was probably a gossan cap over a copper deposit. Beeler (1901c) noted that lime (probably calcite) occasionally substituted for quartz in the hematite.

Gold Coin prospect; E½SW¼ sec. 11, T.15N., R.87W., south of the Bridger mine on the Continental Divide. A 1-foot-wide calcite-quartz vein contains galena, pyrite, and chalcopyrite, with some gold and silver. The minerals fill a N75°E trending fissure that dips steeply south. The vein cuts regional schistosity in the host diorite (Spencer, 1904, p. 100-101). Southwest of the Gold Coin are some historic gold placers on Jim Creek and Strawberry Creek (Paul J. Graff, personal communication, 1982).

Great Lakes claims; S½ sec. 30, T.14N., R.84W., east of Willow Creek and immediately west of the Kurtze-Chatterton mine. A 4- to 5-foot-wide vein in gabbro(?) contained as much as 30 percent Cu and 0.13 oz/ton Au (Armstrong, 1970, p. 7).

Hidden Treasure mine; sec. 28, T.14N., R.85W., 1 mile east of the historic town of Battle and 0.5 mile from the Gertrude claim. A N70°E trending vein dips steeply to the south. The country rock also strikes northeasterly and dips to the south; it is brecciated and mylonitized schist, quartzite, and altered diorite. The vein occurs near the center of the intrusive diorite and contains chalcopyrite, chalcocite, malachite, and some gold. The average of nine assays from samples in the Hidden Treasure workings was 0.3 oz/ton Au. One sample reportedly produced 11 oz/ton Au. Gangue minerals include a small amount of specular hematite with quartz, calcite, siderite, and lesser feldspar (Spencer, 1904, p. 93-94).

Hub mine; E½NE¼ sec. 6, T.15N., R.87W. The prospect was developed on a 1.5-foot-wide, steeply dipping quartz vein in sheared amphibolite. A selected vein sample assayed 0.41 percent Cu, no detectable Au, and 4.4 oz/ton Ag. Paul J. Graff (personal communication, 1985) observed visible gold in a quartz vein sample from the mine.

Independence group; a group of lode and placer claims originally staked in secs. 11, 12, 13 and 14, T.12N., R.86W., near the Colorado-Wyoming State Line. A quartz vein at the contact between diorite and schist strikes N60°W. The vein is stained with limonite and contains a little gold and silver. The diorite footwall contains pyrite and chalcopyrite (Beeler, 1905c).

Itmay mine; E½NE¼ sec. 14, T.13N., R.86W. A sample collected by Spencer (1904, p. 51) from the Itmay mine assayed 17.92 percent

Cu and 0.05 oz/ton Au. Based on recent work in the area, mineralization at the Itmay Mine is interpreted to be associated with pyritiferous actinolite-epidote-magnetite exhalites in a metarhyolite sequence (Hausel, 1986a). This deposit and similar prospects in the area appear to have high potential for large tonnage Cu-Zn-Ag massive sulfides.

King of the Camp prospect; sec. 36, T.14N., R.83W., about 5 miles south of Encampment on the South Fork of Encampment River. At the surface, a 5-foot-thick quartz vein in mica schist trends northeast and dips 45°NW. However, in the shaft, the dip of the quartz vein is 20°NW. The quartz is stained with iron oxides and contains pyrite and chalcopyrite with gold below an oxidized zone. Traces of azurite and malachite are scattered throughout the vein (Beeler, 1903b). A tunnel developed to intersect the vein cut numerous faults and six veins from 2 to 4 feet wide. In addition to these veins, a 15-foot vein was cut by the shaft at a depth of 100 feet. This vein assayed 0.2 to 0.3 oz/ton Au (Beeler, 1904e).

Kurtze-Chatterton mine; S½S½ sec. 29, T.14N., R.84W., along Copper Creek, 5 miles southwest of Encampment. By 1901, more than 1,700 feet of tunnel and several hundred feet of drifts had been driven on several N55°W trending, northerly dipping, cupriferous veins in altered diabase (Hausel, 1986a). The ore was reported to run from 10 to 20 percent copper with some gold and silver (*Wyoming Industrial Journal*, 1901, v. 3, no. 2, p. 46).

Meta mine; sec. 24 or 25, T.15N., R.86W. The Meta mine was developed by a 100-foot shaft on a 6-inch to 6-foot wide vein. The vein strikes roughly east-west and dips nearly vertical at the surface, but at depth it dips about 60°S. The foliation of the quartz-biotite gneiss country rock strikes parallel to the Meta vein, but dips only 20-25°N.

Samples of vein material contain a variety of minerals. The ore consists of massive galena that is probably argentiferous (Spencer, 1904, p. 99, reported that silver was produced from the mine), anglesite(?), cerussite(?), some sphalerite, chalcopyrite, pyrite, azurite, malachite, chrysocolla(?), hematite, limonite, hemimorphite(?), and smithsonite(?), in a gangue of mostly quartz and lesser barite (Haff, 1944c).

Spencer (1904, p. 99) reported one carload of silver ore was shipped from the property. Haff (1944c) estimated six or seven carloads of ore were shipped to Salt Lake City sometime after 1930. From these accounts, it appears that a least 200 to 300 tons of ore were shipped from this mine. Ore mined after 1930 was reported to run 27 to 54 percent lead, about 8 percent zinc, and \$20 to \$22/ton combined gold and silver (prices prior to 1944) (Haff, 1944c).

North Fork group; sec. 13, T.12N., R.86W., 14 miles south of Battle. Granitic and dioritic dikes strike northwesterly and dip northeasterly and are cut by a N45°W trending, 70°NE dipping quartz vein. The vein is 6 to 26 inches wide at a depth of 160 feet. Near the surface, limonite, malachite, and azurite were found in the vein, and at depth the vein carried pyrite and chalcopyrite with some lead and zinc. A second vein trending N88°E cuts the first vein. This vein is 23 feet wide and is mineralized throughout much of its width with pyrite and chalcopyrite. According to Beeler (1905d), some galena ore from the property assayed as high as 600 oz/ton Ag. Assays of the oxidized ore produced as much as 33 to 73 oz/ton Au! The average workable ore ran \$36.39/ton gold, silver, and lead (1905 prices).

North Spring Creek placers; along the northeastern flank of the Sierra Madre. Placers on North Spring Creek and Spring Creek were mined in the 1930s (U.S. Bureau of Mines Minerals Yearbooks, 1936-1940). The Saratoga Mining Company operated a dragline (1-yd^3 bucket) and a screening and sluicing plant in 1939 in these placers.

Prospect 9,999; W½ sec. 15, E½ sec. 16, T.13N., R.86W. The geology of this prospect is similar to the massive sulfide located at the Itmay mine to the southeast.

Garnet-epidote-rich tuffaceous metasediments and metatuffs contain anomalous copper, zinc, and silver. One hole drilled by Conoco Minerals in 1979 and 1980 intersected a 67-foot-thick mineralized zone that averaged 0.9 percent Zn, 0.16 percent Cu, and 0.32 oz/ton Ag (Hausel, 1986a).

Purgatory Gulch mines; NE¼ sec. 1, T.13N., R.84W. (includes the Golden Eagle claim and the El Rey mine). A group of short adits were driven into limonite-stained shears in gneiss (see also Copper Gem prospect). On the west side of the gulch, two abandoned mines were examined in 1984. The southernmost adit was driven into granodiorite gneiss along a narrow shear. Four narrow copper- and limonite-stained veins were intersected in the mine workings. A short distance north, an adit extended less than 100 feet into the country rock. Across the gulch are more extensive workings, but when visited by the author in 1984, the adit was caved. In 1988, the author collected quartz vein samples from an adit on a hill in the

NE¼SE¼ sec. 36, T.14N., R.84W. which contained visible gold. One sample of boxwork-filled quartz without visible gold assayed 19.0 ppm Au, 4.2 ppm Ag, and 0.013 percent Cu.

Some remarkably rich gold specimens were found here (Beeler, 1905a, p. 20). According to Armstrong (1970, p. 2), a 10-foot-wide, free-milling gold vein was struck on Purgatory Gulch. Samples assayed as high as 6.0 oz/ton Au. In 1911 and 1912, some placer gold was also recovered from Purgatory Gulch (U.S. Bureau of Mines Minerals Yearbooks, 1912 and 1913).

Savory Creek placers; on the northwestern flank of the Sierra Madre. Several small placers were mined along Savory Creek in the 1930s and early 1940s according to U.S. Bureau of Mines Minerals Yearbooks (1935-1942). One sluicing operation in 1941 extracted only 2.5 oz of gold from 700 yds^3 of gravel (see also Working Boy placer). In 1897, it was reported that 24 oz of gold were recovered from a 20-day clean-up operation (*Engineering and Mining Journal*, July 3, 1897, v. 64, p.19).

Saw Mill Creek placer; along the northwestern flank of the Sierra Madre(?). In 1934 and 1935, a dragline with a 50 yds^3/hour capacity was installed on Saw Mill Creek. The recovered gold averaged 0.905 in fineness (U.S. Bureau of Mines Minerals Yearbooks, 1935, 1936).

Tennant property; in secs. 21 and 22, T.14N., R.84W. A 6-foot-wide fissure vein in section 22 contains copper and minor gold. Six tons of ore mined from the claim netted $400.00 in copper (at $0.20 per pound) (Osterwald and others, 1966, p. 49). In section 21, three strike veins containing gold, silver, and lead assayed from $15 to $112/ton (1927 prices). Some of the country rock schist is also mineralized and assayed 0.12 to 0.18 oz/ton Au (Osterwald and others, 1966, p. 84).

Three Forks group; in secs. 11, 12, 13, and 14, T.12N., R.86W. Smoky quartz veins along a contact between granite and schist contain a small amount of copper with some lead and zinc. The veins are stained by hematite near the surface and carry some gold. The galena is argentiferous. Some cerargyrite is present (Osterwald and others, 1966, p. 49).

Verde-Hinton mine; in NE¼NW¼ sec. 32, T.13N., R.85W. An average ore sample collected from the mine dump by Spencer (1904) assayed 8.18 percent Cu and 0.02 oz/ton Au. Spencer described the ore as stratabound. Samples collected by Swift (1982) contained flecks of chalcopyrite, pyrite, and magnetite in a fine-grained hedenbergite matrix.

The Verde-Hinton mine was examined by Conoco Minerals, Incorporated, in 1981. Weak to moderate Cu-Zn sulfide mineralization (2 percent Cu, 0.04 percent Zn, 0.15 oz/ton Au, and 0.35 oz/ton Ag) was found in a ferruginous chert and in a felsic tuff breccia on the mine dump. Outcrops of chert, actinolite-epidote-garnet exhalite, pods of marble (possibly metamorphosed travertine), and a tuff breccia containing rhyolite clasts up to 18 inches long are in the immediate vicinity. The breccia is interpreted to be a vent breccia (mill rock). The entire horizon of felsic volcanic exhalite varies from 100 to 400 feet thick and can be traced 5,000 to 7,000 feet along strike (Lawrence, 1982).

Working Boy placer; sec. 23, T.15N., R.87W., in Strawberry Gulch, a tributary of Savory Creek. According to the U.S. Bureau of Mines Minerals Yearbooks, production was reported in 1934, 1937, and 1940. The actual production is unknown, but the Bureau of Mines did report 1933 production at only 6.24 oz gold. The fineness of the gold from the gulch was 0.936. Placers were also mined in nearby Jim Creek (secs. 10 and 15, T.15N., R.87W.) (Paul J. Graff, personal communication, 1982).

Wind River Basin

The Wind River Basin is a broad structural and topographic basin covered by Tertiary sedimentary rocks. The northern flank of the Wind River Basin is bordered by the Owl Creek Mountains, the western flank by the Wind River Range, the southern flank by the Granite Mountains, and the eastern flank by the Casper arch. A major portion of the basin is covered by Tertiary sediments.

Wind River Basin placers

Alluvial deposits along the Wind River, Little Wind River, and Popo Agie River contain gold. In places, gold-bearing terrace gravels cap benches and buttes and blanket the plains, mesas, and uplands for several miles from the present streams. The deposits vary considerably in lateral and vertical extent. In the principal drainages, the deposits may average 12 to 14 feet thick over widths of 3 to 4 miles.

The gold commonly occurs as very fine tablet-like particles smaller than a pinhead. In 1913, some of these alluvial deposits were tested in the Wind River Indian Reservation, and the gravel ranged from 0 to 0.016 oz/yd^3, averaging less than 0.0025 oz/yd^3 Au. The best results were obtained on the Wind River, 7 to 8 miles downstream from Riverton in Ts.1 and 2N., R.5E, where the gold content of the gravels ranged from 0.007 to 0.016 oz/yd³. The gravels in this area are 22 feet thick and averaged 0.014 oz/yd³ Au (Schrader, 1913).

During 1910, this area was the site of a gold boom and claim-staking rush. In addition to the many individual prospectors, two gold dredges operated 7 miles northeast and 7 miles west of the town of Riverton on the Wind River. The Neble dredge (of the Shoshoni Gold Dredging Company), located northeast of Riverton in T.2N., R.5E., was described as a 40-foot-wide by 85-foot-long dredge with 64 buckets weighing 800 pounds each (*The Mining World*, June 17, 1911, v. 34, p. 1250). The dredge had a designed capacity of 2,000 yds³/day. It operated six weeks and processed a large volume of gravel that averaged 0.014 oz/yd³ Au. However, the gold could not be recovered in economic quantities. The Riverton Mining and Dredging Company's Clark portable dredge periodically operated west of Riverton for several years and treated gravel averaging 0.037 to 0.039 oz/yd³ Au (Schrader, 1913; U.S. Bureau of Mines Minerals Yearbook, 1911, p. 781).

Placer deposits near Shoshoni extend northward from the mouth of Poison Creek to beyond Badwater Creek. Gold in these placers averaged 0.036 oz/yd³ (Bolmer and Biggs, 1965, p. 95-96). Presently, these placers are mostly submerged beneath the Boysen Reservoir.

The source of the placer gold was believed by Schrader (1913) to have been weathered quartz veins from mountain ranges adjacent to the Wind River Basin. Seeland (1986) however, suggested the gold source was more likely auriferous conglomerates in the Eocene Wind River Formation.

Wind River Range

The Wind River Range, in western Wyoming, forms an asymmetrical arch. Along the east flank, Paleozoic and Mesozoic strata dip into the Wind River Basin. Along the northern and northeastern flanks, the strata are folded and faulted against the Precambrian basement complex. Major boundary faults along the southern flank of the range continue along the western margin and place Precambrian igneous and metamorphic rocks over younger sedimentary rocks in the Green River Basin (fault traces and the folded Phanerozoic strata are covered by Tertiary rocks).

The Archean basement complex, which forms the core of the Wind River Range, is a high-grade metamorphic and igneous complex of migmatite, amphibolite- to granulite-facies felsic orthogneiss, and paragneiss intruded by quartz diorite to granite plutons. Amphibolite-grade orthogneisses have produced Rb-Sr ages of 2.8 to 3.0 Ga, and in the northern part of the range, these gneisses are intruded by granite pegmatites that yielded Rb-Sr mineral ages of 2,000 to 2,795 Ma (Stuckless and others, 1985).

Near the south end of the range, the Louis Lake batholith cuts the early crystalline core complex and the South Pass greenstone belt. The Louis Lake batholith is approximately 2.6 Ga (Stuckless and others, 1985). The youngest of the Archean metamorphic units in the South Pass greenstone belt is the Miners Delight Formation, which produced a Rb-Sr whole-rock age of 2.8 Ga (Z.E. Peterman in personal communication to Stuckless and others, 1985). Granites, which lie in fault contact and in places intrude the greenstone belt at the extreme southern tip of the range, are believed to be part of the Granite Mountains batholith dated at about 2.6 Ga (Stuckless and Peterman, 1977) or they may be related to the Louis Lake batholith. Proterozoic diabase dikes that date between 1,270 to 2,010 Ma (Condie and others, 1969) intrude the Archean high-grade metamorphic complex, granitic plutons, and greenstone belt in the Wind River Range.

Gold-bearing placers have been reported in the Clarks Camp-Union Pass area near the northern tip of the Wind River Range. But by far the greatest potential for significant economic gold deposits in the Wind River Range, as well as Wyoming, is in the South Pass area. The South Pass granite-greenstone terrane has significant gold anomalies throughout the supracrustal terrane and in adjacent placers. South Pass has been the State's most important source of gold and iron ore.

Clarks Camp-Union Pass gold placers

Warm Spring Creek is located in the northern Wind River Range (Ts.41 and 42N., R.108W.) (**Figure 1**). Placer gold and monazite were discovered in gravels along Warm Spring Creek. The gold was reported to be finely divided and difficult to recover at Clarks Camp (sec. 33, T.42N., R.108W.). The monazite-bearing gravels extend along Warm Spring Creek above Union Pass Road and along South Fork at least as far upstream as its junction with Crow Creek (Bolmer and Biggs, 1965; Osterwald and others, 1966).

The monazite-bearing sands occur in terrace deposits and gravels in and along Warm Spring Creek. The alluvial deposits are 0.25 to 0.6

mile wide and 1.7 miles long, and the highest terraces rise more than 100 feet above the stream bottom. The alluvial material along the South Fork is several hundred feet wide and more than 3 miles long (Dunnewald, 1958). South of Warm Spring Creek, placer gold has been found in stream gravels of Dinwoody, Dry, Meadow, Jakeys, and St. Lawrence Creeks (Bolmer and Biggs, 1965). Gold was also recovered from the Riviere du Nord (DuNoir Creek) (*Wyoming Industrial Journal*, 1900, v. 2, no. 1, p. 14).

South Pass greenstone belt

The South Pass greenstone belt has been Wyoming's most prolific source of gold and iron ore. The supracrustal rocks of the greenstone belt occur as a tightly folded synform that has been subjected to at least three separate episodes of deformation, producing complexly folded rocks (Figure 31). Along the eastern flank of the greenstone

Figure 31. Chevron folds in metagreywacke of the Miners Delight Formation.

belt, the metamorphic rocks lie in fault contact with granodiorite and granite, and the northwestern flank is in both fault and intrusive contact with granodiorite and granite of the Louis Lake batholith. Near the western margin of the belt, the supracrustals have been intruded by the South Pass and Sweetwater granites. There is a narrow belt of augen gneiss exposed along much of the northwestern flank of the greenstone belt between the Louis Lake batholith and the rocks of the South Pass greenstone belt. In places, the gneiss is intercalated with supracrustal rocks and Louis Lake granodiorite and may represent the remnants of a tectonically interleaved basement.

The supracrustal rocks have been subdivided into four mappable units by Bayley and others (1973) and Hausel (1986f, 1987b). The lowermost unit, the Diamond Springs Formation, consists of ultramafic and mafic schist and amphibolite. Chemically, these rocks are similar to ultramafic and basaltic komatiites and high magnesian tholeiites and are interpreted to represent the primitive volcanic to subvolcanic ultramafic to mafic base of the South Pass synform.

Rocks of the Diamond Springs Formation are overlain by metasediments of the Goldman Meadows Formation. The Goldman Meadows Formation consists of quartzite, fuchsitic quartzite, metapelite, amphibolite, and banded iron formation. Near the northern edge of the belt, the banded iron formation has been structurally thickened, making it amenable to mining. From 1962 to 1983, U.S. Steel Corporation operated a large open pit and recovered more than 90 million tons of iron ore from this area. The iron ore consists of alternating quartz-rich and magnetite-rich layers containing abundant amphibole and chlorite schist selvages. In places, the iron formation is sulfide-bearing and may host as much as 5 percent pyrite with accessory chalcopyrite. The sulfide grains exhibit both syngenetic and epigenetic characteristics (Hausel, 1986b).

The Goldman Meadows Formation is overlain by greenstone, greenschist, amphibolite, and minor actinolite schist of the Roundtop Mountain Greenstone. Chemically, these rocks are similar to high-magnesian and high-iron tholeiitic basalts (Hausel, 1987b).

The Roundtop Mountain Greenstone is unconformably overlain by rocks of the Miners Delight Formation. This formation is dominated by metagreywackes with lesser mica schist, graphitic schist, metaconglomerate, agglomerate, metachert, actinolite schist, metabasalt, meta-andesite porphyry, and orthoamphibolite. These metamorphics have been intruded by mafic sills and dikes and tonalite stocks and dikes (Bayley and others, 1973).

Gold in the South Pass greenstone belt occurs chiefly in strike-trending shear zones hosted by metagreywacke and hornblendic orthoamphibolites (Hausel, 1987c, 1987d). Significant placer deposits occur throughout much of the greenstone belt, but information on the size of the gold nuggets recovered from this terrane is noticeably scarce. The largest nuggets recorded in the literature include a nearly 5-oz nugget found in Yankee Gulch along the northeastern edge of the greenstone belt (*American Mining Journal*, 1868, v. 6, p. 180); a 3-oz nugget and a 4.5-oz nugget found in Two Johns Gulch near Lewiston in 1905 (*Wyoming Industrial Journal*, 1905, v. 6, no. 12, p. 18); and a 3.4-oz nugget recovered during the dredging of Rock Creek in the early 1930s (Ross and Gardner, 1935). Specimens of placer gravel have also been found with abundant gold enclosed by quartz and gangue. For example, the *Wyoming Industrial Journal* (1905, v. 6, no. 12, p. 18) described one piece of fist-size gravel discovered in Rock Creek that was covered with gold and filled with 1/8-inch-thick veinlets of gold. The sample had an estimated 24 oz of the precious metal. Another similar specimen reported in the *Wyoming Industrial Journal*, which was discovered earlier in Rock Creek, contained 630 oz of gold!

According to the *Wyoming Industrial Journal* (1905, v. 6, no. 12, p. 18), gold has been mined from many placers in the greenstone belt including Meadow Gulch, Yankee Gulch, Spring Gulch, Poormans Gulch, Promise Gulch, Smith Gulch, Atlantic Gulch, Beaver Creek, Goddard Gulch, Burr Gulch, Breastpin Gulch, Nugget Gulch, Strawberry Creek, Two Johns Gulch, Wilson Bar, Deep Creek, and others. Some other well-known gold-bearing creeks include Rock Creek and Willow Creek.

In addition to these Recent placers, Tertiary paleoplacers are abundant and have been identified along the southern and northeastern flanks of the greenstone belt. These paleoplacers are interesting and may be much more widespread throughout the greenstone belt. In many areas, the Precambrian rocks in the greenstone belt are overlain by large volumes of Tertiary sedimentary rocks that have been mapped by various authors as South Pass Formation, White River Formation, and Miocene rocks undivided. At some localities, these units also contain paleoplacers marked by rounded boulders, pebbles, and cobbles eroded from the Precambrian greenstone terrane.

Anderson Ridge

Anderson Ridge lies west of the South Pass-Atlantic City district. The Anderson Ridge area, in the western portion of the greenstone belt, contains some scattered gold occurrences. This area consists principally of metagreywackes of the Miners Delight Formation intruded by pegmatitic granite of the South Pass granite (Hausel, 1986c).

Anderson Ridge fault; sec. 21, T.29N., R.101W. Between the Louis Lake batholith and the South Pass metamorphic terrane, the Anderson Ridge fault swells to several hundred feet wide. One copper-stained sample collected from a trench assayed 1.86 percent Cu and 175 ppb Au. A second sample, coated with a thin film of manganese, yielded 2.27 ppm Au. Later, eight samples were collected (spaced every 10 feet) running north from the second sample. These samples did not contain anomalous gold. James E. Bond, II (personal communication, 1986) collected a sample of manganese-stained cataclastic rock in the trench that assayed 0.02 oz/ton Au.

Burnt Meadow prospect; NW¼ sec. 17, T.29N., R.101W. Sheared Louis Lake granodiorite adjacent to a Proterozoic diabase dike is stained by copper carbonates. A short adit was driven through the unmineralized mafic dike into the granodiorite. A sample of the granodiorite collected from a prospect pit assayed 2.75 percent Cu, 3.03 oz/ton Ag, and 4.03 ppm Au.

Mill Creek boulder conglomerate; secs. 25, 26, and 34, T.29N., R.102W. In 1986, a boulder conglomerate lying along the southern margin of the Anderson Ridge fault was sampled at two sites, but the panned concentrates contained no detectable gold. The conglomerate probably represents an alluvial fan eroded from a paleo-uplift immediately north of the Anderson Ridge fault. This conglomerate has not been adequately sampled.

NW¼ sec. 32, T.29N., R.101W. A shallow incline shaft sunk in sheared metagreywacke of the Miners Delight Formation (see Hausel, 1986c) contains some copper-stained quartz. An assay of one selected sample of copper-hematite-stained quartz from the mine dump yielded 1.54 percent Cu, 4.4 ppm Ag, and 3.4 ppm Au.

Dickie Springs-Oregon Gulch

The Dickie Springs-Oregon Gulch area lies along the southern margin of the South Pass greenstone belt near the Fremont-Sweetwater County border. The district is accessible from State Highway 28, which connects Farson with Lander. From Lander, the district is reached by 41 miles of paved road and 6 miles of graded light-duty road.

Gold placers in the Dickie Springs-Oregon Gulch region were discovered along the historic Overland Trail in 1863. In that same year, the discoverers were killed by Indians. Between 1864 and 1882, the Overland Trail was abandoned because of hostilities between the whites and Indians and was later reopened with the signing of the Treaty of Five Nations in 1882 (Greene, 1896). Following the reopening of the trail, several prospectors and miners began mining gold from alluvial placer deposits. The total amount of gold extracted from the district is not known, but the total resource contained in the alluvial gravels may be significant. Greene (1896) reported that the placer gravels contained a total gold resource of about 2.2 million oz.

Reports by both Greene (1896) and Love and others (1978) suggested that the district contains significant amounts of gold. However, two major factors have restricted development: (1) much of the gold in this region is finely disseminated throughout a boulder conglomerate facies of the Wasatch Formation, and (2) the district is barren of water except during the spring. The closest source of surface water is the Sweetwater River, which lies nearly 6 miles to the north (Love and others, 1978). The following description is abstracted from Love and others (1978) and the original paper should be consulted for details.

The Dickie Springs-Oregon Gulch district contains rocks of Tertiary age unconformably overlying Precambrian units. Boulder conglomerates of the Wasatch Formation and Recent alluvium eroded from the Wasatch Formation are significant gold-bearing units. The conglomerate facies of the Wasatch Formation is separated into a western and an eastern lobe by nearly 2 miles of sandstone and siltstone also of the Wasatch Formation.

The conglomerate facies contains giant boulders (some as large as 25 feet in diameter) in a brown arkosic matrix. The boulder conglomerate is interpreted to represent a large alluvial fan eroded from uplifted Precambrian rocks north of the Continental fault (a boundary fault at the south end of the Wind River Range). The boulders, cobbles, and pebbles found in the conglomerate are typical of the rock types that would be found along the edge of the granite-greenstone belt in a dominantly granitic terrane. Compositions of igneous rocks vary from granitic to ultramafic (mafic and ultramafic rocks are uncommon). Fragments of gneiss and schist are also common. Pebbles and cobbles of metagreywacke typical of the Miners Delight Formation also occur in the conglomerate, but not in great abundance. Some boulders in the conglomerate are as large as pickup trucks and many gold flakes are relatively coarse (averaging about

0.1 inch in diameter), suggesting minimal transport distances. The minimum stratigraphic thickness of the conglomerates is 1,300 feet, and they have a combined areal extent of 8 square miles.

The paleo-uplift north of the Continental fault has long since readjusted and downfaulted, and is now partially buried under the extensive Tertiary cover overlying much of the southern portion of the South Pass granite-greenstone belt. The source area may lie under this blanket of Tertiary sediment. Love and others (1978) reported that gold-bearing drill cuttings were recovered 6,500 to 7,000 feet deep from an oil well drilled about 0.5 mile north of the fault.

Some of the richest gold concentrations in the Dickie Springs-Oregon Gulch district are found in alluvial deposits north of the Continental fault. These deposits were derived from the erosion of the Wasatch boulder conglomerate facies and were worked by the early prospectors. Gold concentrations in the alluvial deposits average about 0.00105 oz/yd^3 (Love and others, 1978). Green (1896) estimated that 5,843 acres of the placer deposits average 0.039 oz/yd^3 Au, with some local areas of gravel running from as high as 0.73 oz/yd^3 to as low as 0.003 oz/yd^3 Au. The gold is relatively coarse, and many flakes average 0.2 inch in diameter (Love and others, 1978).

Geochemical and trace element studies of the Dickie Springs-Oregon Gulch gold suggest it originated from hydrothermal veins in a predominantly granitic terrane (Love and others, 1978). This conclusion suggests that the gold was primarily derived from a region other than the South Pass-Atlantic City district, where the gold is principally associated with metagreywacke and metagabbro rather than granite.

Radically different gold concentrations suggest that the conglomerate to the west in the Pacific Butte area was derived from a different source region than the facies to the east of Dickie Springs. The conglomerate facies on the western end of the district has a very low gold content, with values ranging from <0.00003 to 0.0019 oz/yd^3 Au, whereas the eastern facies averages 0.0026 oz/yd^3 Au and ranges from 0.00002 to 0.1038 oz/yd^3 Au (Love and others, 1978). The total gold content estimated in these conglomerates is significant and may exceed 28.5 million oz (Love and others, 1978).

The Big Placer claims were staked on the basal conglomerate of the Arikaree Formation (Miocene), immediately north of the Continental fault and east of Dickie Springs, running through the southern parts of secs. 21, 22, 23, and 24, T.27N., R100W. This conglomerate is believed to be a gold-bearing paleoplacer (Zeller and Stephens, 1969; and unpublished Anaconda Minerals Company report, document 56105.28, American Heritage Center, University of Wyoming).

Lewiston district

Gold-bearing shear zones in the Lewiston district (Figure 32) occur in chloritized hematitic metagreywacke of the Miners Delight Formation (Hausel, 1988d). These shears follow regional foliation and were developed near the apex of a regional fold in the metasediments. A few mines occur at the point of intersection of strike shears with crosscutting shears on the northern limb of the regional fold (Hausel, 1986d). The strike shears are mineralized in gold, but the crosscutting shears are barren to poorly mineralized.

The strike shears are traceable on the surface hundreds of feet to a few thousand feet. Most of the mines in the district are presently inaccessible, and the deepest mine is probably not much more than 100 feet deep. Thus the continuation of the gold-bearing shears downdip has not been tested. The shears are relatively narrow (commonly less than 5 feet wide) although the Hidden Hand shear zone swells to as much as 30 feet wide or more. The Lewiston shears contain sheared and brecciated quartz, and the wallrocks exhibit limited sericitic alteration and tourmalization. Chloritic and hematitic alteration, however, are distinct and stain shear-zone cataclastics and as much as 5 to 10 feet of the adjacent wallrock.

Scattered historic reports show that the gold tenor of the Lewiston shears ranged from a trace to as much as 3,100 oz/ton (Pfaff, 1978). However, these rich specimen-grade samples were quite rare. Although samples commonly produce anomalous gold assays, average grades are not known because the district is essentially unexplored and poorly sampled. The gold occurs as fracture fillings in quartz and is also associated with sulfides. Both iron sulfides and arsenopyrite occur, and scheelite has also been identified in some shear zones (Hausel, 1986b).

Anaconda mine; W½SW¼ sec. 34, T.29N., R.98W., at the junction of the Oregon Trail with a north-south jeep trail. The mine was developed on a N31°E trending vertical shear that cuts foliation of the country rock at an acute angle.

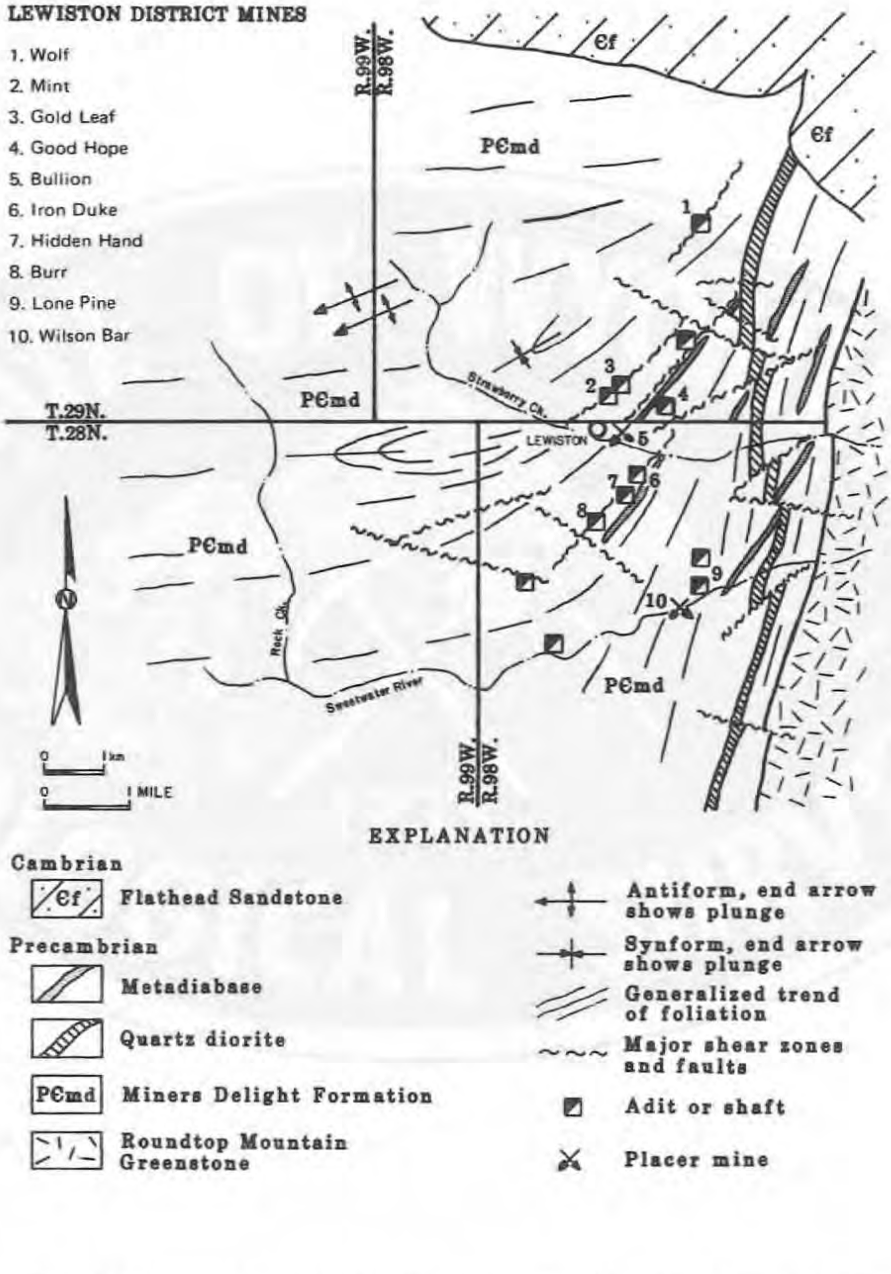


Figure 32. Geologic map of the Lewiston district (modified from Hausel, 1986d).

Big Nugget placer; secs. 31, 32, and 33, T.29N., R.98W. and sec. 6, T.28N., R.98W. Five "good-size" nuggets were recovered from Strawberry Creek and the Big Nugget ditch (Haff, 1944a). Unfortunately Haff (1944a) does not give any sizes or weights.

Bullion mine; N½ sec. 5, T.28N., R.98W. The Bullion was developed by a series of open cuts on the north bank of Strawberry Creek adjacent to the Lewiston (originally Lewis Town) ghost town. A N46°E trending silicified shear zone runs north from the Bullion mine for nearly 2 miles. A single sample of milky quartz with limonite pseudomorphs collected from the mine dump contained no detectable precious metals. Pfaff (1978) reported that at least 21,000 oz of gold were recovered from the mine during its early operations.

Burr mine; N½ sec. 8, T.28N., R.98W. The Burr lode was the first major mineralized deposit found in this area, and its discovery led to the development of the district in 1879. Sporadic rich pockets found in the mine contained from 25 to 250 oz/ton Au (*The Lewiston Gold Miner*, 1894) and some rare specimen-grade samples assayed 1,690 oz/ton Au (*Wyoming Industrial Journal*, 1901, v. 2, no. 11, p. 320). Many years later, scheelite stringers, veinlets, pods, and disseminations were found on the 25-foot level in the mine. Assays varied from 2.5 to 70 percent WO_3 (Wilson, 1951b). Scheelite has also been reported elsewhere in the district (Day and others, 1988).

The mine is located at the coalescing shear zones and foliation in the metagreywacke country rock. The shear at the Burr adit trends N49°E and dips 78°NW. At the Amanda shaft about 100 feet to the west, the shear trends N56°E and dips 51°NW. One 16-foot-wide mineralized zone encountered at the mine was reported to average 0.5 oz/ton Au (*The Lewiston Gold Miner*, 1894). In 1893, one pocket of gold in the Burr mine reportedly produced about 2,900 oz of gold (*Engineering and Mining Journal*, 1893, v. 56, p. 406).

Crows Nest and Dutch Tom Flat placers; T.29N., R.99W. Gold from these placers was typically coarse and rough; 2-ounce nuggets were occasionally recovered (Spencer, 1916). Scheelite has also been recovered from the Crows Nest placers (Jim Rutter, personal communication, 1984).

Gold Leaf mine (see Mint mine).

Goodhope mine; SW¼ sec. 34, T.29N., R.98W. The shaft was developed in a 2-foot-wide, N45°E trending, vertical, chloritized shear zone. The shear zone contains sheared quartz and is in metagreywacke adjacent to a narrow mafic dike. The shear is traceable for nearly a mile on the surface (Hausel, 1986d).

Samples of the quartz vein contain visible gold, and one grab sample assayed 1.18 oz/ton Au (Plate 1B). Two 2-foot channel samples taken across the shear assayed 0.11 oz/ton Au and 0.35 oz/ton Au, respectively. Another channel sample collected by James E. Bond II (personal communication, 1986) assayed 0.63 oz/ton Au.

Hidden Hand mine; SE¼ sec. 5, T.28N., R.98W. The Hidden Hand mine was developed in a 10- to 30-foot-wide, N40°E trending, 62°NW dipping shear. The shaft was sunk to a 110-foot depth with 640 feet of crosscuts and drifts (Henderson, 1926). The wallrock is stained red to green by secondary hematite and chlorite.

Two samples of altered metagreywacke collected from the mine dump were analyzed for gold and silver. One sample contained no Au and 0.01 oz/ton Ag, and the other sample yielded 0.05 oz/ton Au with no Ag.

Ore from the 30-foot level was reported to assay as high as 75 oz/ton Au. In 1916, nearly 1,000 tons of ore stockpiled on the dump averaged 4.0 oz/ton Au (Anonymous, 1916). One rich ore shoot intersected in the mine produced some specimen-grade rock that assayed as high as 3,100 oz/ton Au (Pfaff, 1978).

Iron Duke mine; SE¼ sec. 5, T.28N., R.98W., north of the Hidden Hand mine on the same shear. Wallrocks are stained red and contain various quantities of secondary sericite, quartz, chlorite, hematite, and epidote. A sample of silicified metagreywacke collected from the shear zone assayed 0.21 oz/ton Au. A 6-foot channel sample taken across the shear zone yielded 0.036 oz/ton Au (Hausel, 1987b).

Lewiston Lakes iron formation; SW¼ sec. 19, T.29N., R.97W. Banded oxide-facies iron formation occurs south of Diamond Springs in the Lewiston Lakes Quadrangle (Hausel, 1988a). The iron formation is banded magnetite and silica with minor amphibole. To the west, the iron formation is oxidized to hematite. Fuchsitic quartzite occurs in limited amounts adjacent to the iron formation.

Samples of iron formation assayed <0.01 to 0.04 oz/ton Au, and <0.01 to 0.10 oz/ton Ag. A sample of the hematite iron formation to the west in the N½NE¼ sec. 25, T.29N., R.98W. assayed 0.02 oz/ton Au, 0.05 oz/ton Ag, and 0.55 percent Cu.

Lone Pine mine; SE¼ sec. 9, T.28N., R.98W., along the Sweetwater River near Wilson Bar. A 470-foot tunnel was driven in metagreywacke on a N67°W trend perpendicular to regional foliation. The adit may have been developed to intersect a N45°E trending vein located northwest of the portal, but fell short by at least 700 feet. A buried shear zone that intersects this vein 700 feet northwest of the mine face is as much as 17 feet wide. This shear was exposed by trenching during 1987. A channel sample taken across the 17-foot width of the shear zone yielded 1.6 ppm Au and 2.9 ppm Ag. The shear zone contains quartz stringers and chloritized metagreywacke.

The Lone Pine tunnel cut through several small shears, a 10-foot-wide breccia zone, and a narrow 1-inch-wide arsenopyrite-bearing quartz vein. A sample collected from the arsenopyrite-bearing vein yielded 0.61 oz/ton Ag with no detectable Au. The adit was mapped at a 1:240 scale (Hausel, 1983c).

Maxwell prospect; (location not given). Scheelite is found erratically distributed in specks, seams, and small pockets in the country rock. A drift driven from a 40-foot-deep shaft on the property exposed scheelite in the mine ribs (Hagner, 1942a). No precious metals were reported.

Metterling prospect; near the Maxwell prospect. A 30-foot shaft was sunk on a scheelite-bearing vein. The vein is hosted by diorite(?). The tungsten-bearing zone ranges from a few inches to a few feet wide, but averages 1.5 feet wide. The scheelite is fairly uniform throughout the deposit (Hagner, 1942b). No precious metal values were reported.

Mint-Gold Leaf mine; SE¼ sec. 33, T.29N., R.98W. Two shafts 500 feet apart lie on the same N53°E trending, vertical, silicified shear. This mineralized shear has been traced for 2 miles on the surface between Strawberry Creek and Deep Creek (Hausel, 1986d).

A 2.5-foot channel sample collected across the shear zone adjacent to the Mint shaft assayed 1.29 oz/ton Au (Hausel, 1987b). Another 2.5-foot channel sample assayed 3.05 oz/ton Au (James E. Bond II, personal communication, 1986). The exposed shear zone varies from 2.5 to 5.0 feet wide. Quartz samples from this mine sometimes contain visible gold. An ore sample collected from the Mint mine for metallurgical testing by Knight (1901) assayed 0.61 oz/ton Au. Cyanide extraction proved to be inefficient and only 77 percent of the gold was recovered (Knight, 1901).

Knight (1901) indicated one of the reasons for the demise of the mine, as well as the entire region, was that the gold was free milling in quartz and was difficult to concentrate. Ordinary stamp-mill crushing and amalgamation had even poorer recovery results than cyanide treatment or chlorination, (Knight, 1901).

Wilson Bar adit; SW¼ sec. 9, T.28N., R.98W. The Wilson Bar adit was driven 180 feet to the northwest to intersect a 2- to 3-foot-wide vein in metagreywacke. Instead, the vein pinched out to a narrow breccia zone, which was cut by the mine workings. The mine was mapped at 1:240 scale by personnel of the Geological Survey of Wyoming.

Wilson Bar placer; SW¼ sec. 9, NW¼ sec. 16, T.28N., R.98W. Runoff from the Burr and Hidden Hand mines drains down through Burr Gulch into Wilson Bar along the Sweetwater River. The Wilson Bar placer was discovered following several pannings that averaged 1 oz/ton Au (*The Lewiston Gold Miner*, 1894). In one successful day, it was reported that three persons using a long tom extracted 21 oz of gold. Production from one 500-foot strip of gravel amounted to 370 ounces (*The Lewiston Gold Miner*, 1894). Total production from this placer is unknown. The area was also dredged immediately before World War II.

Wolf mine; SE¼ sec. 22, T.29N., R.98W. The Wolf mine was developed by three shafts sunk into a 0.75-mile-long shear. The shafts were sunk to a depth of 80 to 100 feet. Shear-zone cataclastics and wallrocks are stained red and green by secondary hematite and chlorite. The footwall is silicified and contains gray quartz. One sample of gray quartz with altered metagreywacke assayed 0.68 oz/ton Au.

7605 Incline; S½ sec. 7, T.28N., R.98W. This incline was sunk approximately 100 feet on a N36°E trending, 42°NW dipping shear in metagreywacke. The iron-stained shear is approximately 10 feet wide and contains scattered quartz boudins and pods. A grab sample of quartz from the mine dump assayed 0.05 oz/ton Ag and no Au.

Other mines. Other mines, such as the Ruby and Jumbo (locations unknown), were located in the Lewiston district. The Jumbo had a 76-foot-deep shaft with 400 feet of drifts. Reported assays from the mine ranged from 0.3 to 3 oz/ton Au (Bartlett and Runner, 1926).

SE¼ sec. 9, T.28N., R.98W., on the north bank of the Sweetwater River and a few hundred feet east of the Lone Pine mine. Two parallel veins carry considerable arsenopyrite. Samples collected from the vein assayed no Au and 0.13 oz/ton Ag (Hausel, 1982d). Two more samples recently collected from the vein assayed 0.85 ppm Au, 130 ppm Ag, and 0.16 percent Cu; and 1.73 ppm Au, 24 ppm Ag, and 0.28 percent Cu.

South Pass-Atlantic City district

The South Pass-Atlantic City district (Figure 33) lies along the northwestern flank of the South Pass greenstone belt and has been

Figure 33. Generalized geologic map of the South Pass-Atlantic City district, Wind River Range (modified from Bayley and others, 1973).

Wyoming's most prolific source of gold and iron ore. Total iron ore production from this district is more than 90 million tons.

Gold production estimates for the South Pass-Atlantic City district range from a low of 70,000 oz (Koschmann and Bergendahl, 1968) to a high of 334,000 oz (Hausel, 1987b). The lower figure by Koschmann and Bergendahl (1968) does not include production from some mines in the district and is based on a turn-of-the-century estimate that does not include at least 16,700 oz of production recorded after 1911. The higher figure by Hausel (1987b) is considered to be optimistic and is based on reported production and historic estimates made by Jamison (1911a, b).

Mineralized fractures in the South Pass-Atlantic City district commonly follow orthoamphibolite-metagreywacke contacts and less commonly penetrate the hornblendic orthoamphibolite (metagabbro) (Bayley and others, 1973; Hausel, 1987c) (Figure 33). The spatial association of auriferous shears with an east-northeast trending belt of orthoamphibolite is structural. The auriferous shears occur along contacts of high competency contrast, between the less competent metagreywacke and the structurally more competent amphibolite (Bayley and others, 1973). A thin graphitic schist member located adjacent to the belt of orthoamphibolites has also been sheared at many localities, but is generally poorly mineralized. Along the southern margin of the orthoamphibolite belt is a sheared actinolite schist, actinolite-carbonate schist, and chlorite schist belt interpreted to represent metamorphosed and sheared basaltic komatiites and basalts (Hausel, 1987e, 1988b, 1988c). These rocks may have been the original source of the gold in the district (Bow, 1986) although the orthoamphibolites and metagreywackes are also potential source rocks.

Many of the gold-bearing shears are strike shears that follow regional foliation. Some are continuous over distances up to a mile, but pinch and swell along trend. The continuation of the lodes downdip has not been tested to any extent since the deepest gold mine in the district (the Carissa) was sunk only 400 feet. At that depth, the lower workings of the Carissa are still in sheared metagreywacke. The mineralized zone in the Carissa mine is 3 to 15 feet wide throughout much of the mine (Armstrong, 1948), but near the surface and in the third mine level, the mineralized zone swells to greater widths (Curran, 1926).

Nearly all of the principal mines in the district are epigenetic shear-zone deposits (Hausel, 1987c, d). One exception appears to be the Snowbird deposit, located northwest of Atlantic City, which has the appearance of a carbonate-quartz-massive-sulfide in a metatholeiite.

Megascopically, the shears are permeable zones of cataclastics with discontinuous quartz boudins and sheared and brecciated quartz lenses and pods. Continuous veins are rare and have been mapped at only a few mines (Alpine, Carrie Shields, Diana, and Mary Ellen) (Figure 33). The quartz in the mineralized zones may be milky quartz or dark gray translucent quartz. The darker varieties of quartz are generally blackened by abundant microscopic tourmaline. Compared to the average igneous rock, the gold ore is enriched in Au, As, Ag, B, Bi, Co, Cr, Cu, Mo, Ni, Sc, and V (Bayley and others, 1973).

Wallrock alteration associated with the mineralized shear is seldom megascopically distinct. In the field, the wallrocks may have narrow, indistinct, slightly bleached zones. Whole-rock analyses show the altered wallrock to be enriched in silica and potassium as well as several transition metals. Petrographically, this enrichment is manifested as weak phyllic alteration where secondary sericite and quartz disappear short distances from the shear zone. Some chlorite, microcline, calcite, and tourmaline may also replace portions of the wallrock.

Sulfides in the strike shears include pyrite, pyrrhotite, and arsenopyrite. These oxidize and stain the cataclastics with limonite, hematite, and scorodite. Studies on gold paragenesis have not been undertaken. Most samples containing visible gold show that the precious metal fills fractures in quartz. One specimen from the Mary Ellen mine contained visible gold enclosed by hematite. Several samples collected from the Carissa mine showed visible gold enclosed by arsenopyrite (Tony Salazar, personal communication, 1986).

A hematitic gold-bearing breccia exposed in the Outpost mine workings is unique in the district. This shear is characterized by massive hematite that fills open spaces in the breccia. The breccia cuts both foliation and narrow strike shears at an acute angle.

Ratios of Au/Ag and Au/Cu in native gold samples from the South Pass-Atlantic City district are characteristic of hypothermal veins (Antweiler and Campbell, 1977).

Historic reports indicate that the gold tenor of the South Pass lodes ranged from a trace to as high as 260 oz/ton for some rich ore from the Carissa mine. Average grades are not well established and are available for only a few mine properties. The Carissa mine was reported to average 0.3 oz/ton (Beeler, 1908a); the Mary Ellen mine was reported to average 0.4 oz/ton (Jamison, 1911a); and the Diana vein averaged 0.13 oz/ton (Hausel and Gyorvary, 1984a).

Banded iron formation along the northwestern and eastern flanks of the greenstone belt is probably exhalative in origin. In the South Pass-Atlantic City district along the northwestern flank of the greenstone belt, the iron formation was mined by open pit. However, during the little more than two decades of mining, no gold was ever reported in the iron ore.

Throughout the South Pass-Atlantic City district, modern stream placers have been relatively productive. In the vicinity of Miners Delight along the northeast flank of the belt, as much as 75,000 oz of gold may have been mined before 1911. Modern placers along Rock Creek south of Atlantic City averaged 0.012 to 0.016 oz/yd^3 Au. Some spots were reported to run as high as 1.17 oz/yd^3 Au (Wilson, 1953).

Alpine mine; W½NE¼ sec. 20, T.29N., R.100W., a short distance north of South Pass City. The 30° to 35° Alpine incline was driven along three quartz veins in metagreywacke of the Miners Delight Formation, and was sunk to a vertical depth of at least 50 feet. Below 50 feet, the workings were flooded and inaccessible in 1985; however, the accessible portions were mapped at 1:240 scale (Hausel and Gyorvary, 1985a) and sampled by the author in 1987 (Figure 34 and Table 20).

At about 50 feet deep, some drifting occurred both east and west of the incline. To the east, the drift continued 40 feet before it intersected the uppermost vein.

Atlantic City iron mine; sec. 26, T.30N., R.100W. U.S. Steel Corporation developed the mine as an open pit in banded iron formation (taconite). The mine was operated from 1962 to 1983 and produced more than 90 million tons of ore. The taconite was pelletized at the Atlantic City mill and shipped by rail to the Geneva Steel Works near Provo, Utah.

At the mine site, the banded iron formation was structurally thickened. The iron formation is a dense, hard, laminated rock composed of quartz, magnetite, and amphibole. Magnetite-rich layers alterate with quartz-rich layers and the average iron content of the rock is about 30 percent (Bayley, 1963). When U.S. Steel terminated operations in 1983, it was reported that ten years of ore reserves remained in place (about 50 million tons). Recent mapping indicates a large iron resource is present (Hausel, 1987e).

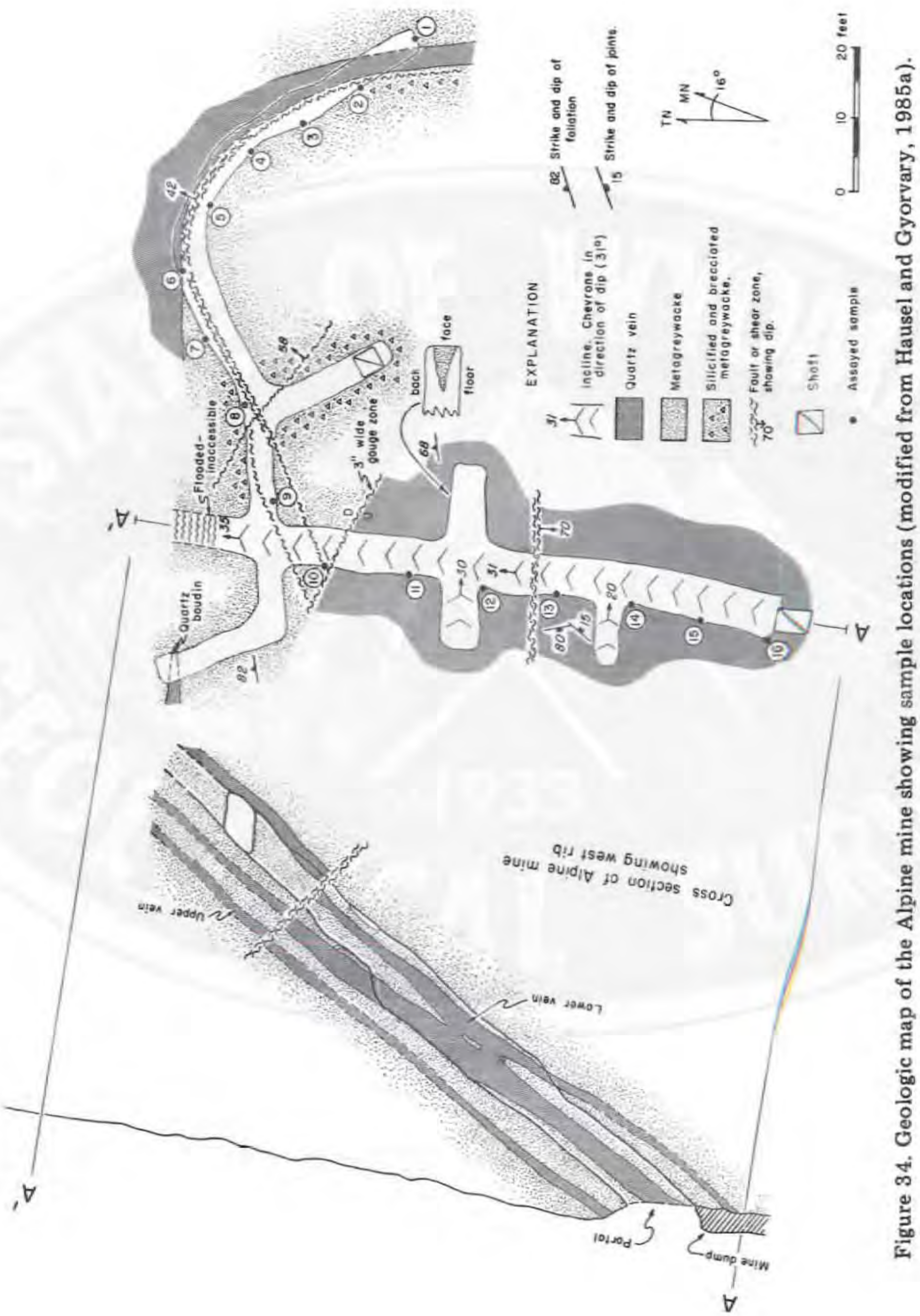


Figure 34. Geologic map of the Alpine mine showing sample locations (modified from Hausel and Gyorvary, 1985a).

Table 20. Preliminary assays of the Alpine gold mine, South Pass-Atlantic City district (mapped at waist level). Locality numbers refer to Figure 34.

		Assay values (ppm)				Assay values (ppm)	
Locality number	Sample number	Au	Ag	Locality number	Sample number	Au	Ag
1	AP1-87	0.08	0	9	AP 9-87	2.3	1.0
2	AP2-87	0.17	0	10	AP10-87	0.58	0
3	AP3-87	0.41	0	11	AP11-87	0.85	0
4	AP4-87	101.0	2.7	12	AP12-87	0.18	0
5	AP5-87	9.8	0	13	AP13-87	0.29	0
6	AP6-87	0.22	0	14	AP14-87	0.61	0
7	AP7-87	0.10	0	15	AP15-87	0.34	0
8	AP8-87	1.3	0	16	AP16-87	0.36	0

At several sites, the iron formation is sulfide-bearing and contains small amounts of pyrite and chalcopyrite. In places, the sulfides parallel bedding in the iron formation, indicating that some are probably syngenetic. At many sites the sulfides cross cut foliation, indicating that some are remobilized (Hausel, 1986b). There is no record of any gold being produced from the mine.

B&H (Empire State) mine; sec. 22, T.29N., R.100W., 1.5 to 2.0 miles east of South Pass City. The mine was developed at the intersection of two shear zones in metagreywacke of the Miners Delight Formation (Hausel, 1988b). The shears vary from a few inches to 8 feet wide, are near vertical, and trend N80°E and N5°E.

The shears host some sheared and brecciated quartz containing pyrite, arsenopyrite, tourmaline, and gold. Bane (1929) reported the following assays:

1. A composite of twelve samples from a 3-foot vein collected from the 100-foot level assayed 1.09 oz/ton Au.

2. Four samples from a 4-foot vein at the surface on the Ellen M.C. no. 1 claim assayed 0.33 oz/ton Au.

3. A composite of three samples from a 6-foot-wide vein on the surface of the Ellen M.C. no. 3 claim yielded 0.34 oz/ton Au.

4. A composite of five samples from an 8-foot vein on the surface of the Caroline no. 1 claim assayed 0.28 oz/ton Au.

5. A composite sample collected from a 3-foot vein exposed in shallow 30-foot shafts near the center of the Emma claim gave 0.76 oz/ton Au.

6. A composite of two samples from a 6-foot vein collected from the discovery shaft on the Gold Nugget claim yielded 0.81 oz/ton Au.

A composite sample of a scorodite-stained quartz vein containing some sulfides was collected from the B&H mine dump in 1983. This material assayed no Au and only 0.16 oz/ton Ag. Armstrong (1948) reported the B&H ore typically had a low Au/Ag ratio, and may have been as low as 0.5. Love and others, (1978) reported the Au/Ag ratio to average 2.5.

The B&H shaft was developed to a 105-foot depth with 255 feet of drifts on three different levels. The mine produced at least 600 tons of ore, which averaged 0.75 oz/ton Au (Armstrong, 1948 p. 51-53). Jamison (1911a) estimated production at 240 oz of gold.

<u>Big Atlantic Gulch mine</u>; NW¼ sec. 6, T.29N., R.99W., a short distance north of the Snowbird mine. The adit was driven 30 feet to the east and one drift continued N60°E and cut a thin graphitic schist bed in metagreywacke country rock. The other drift ran N25°W in metagreywacke (Hausel and King, 1985a).

<u>Big Chief mine</u>; SE¼ sec. 11, T.29N., R.100W., on the west bank of Rock Creek a short distance northwest of Atlantic City. The mine was driven on a southwest trending shear in metagreywacke. More than 650 feet of drifts and crosscuts were developed (Hausel, Gyorvary, and Albert, 1984). According to Jamison (1911b) at least 1,000 feet of drifts were dug, and a 100-foot shaft was sunk on the property. At 280 feet into the mine, the primary southwest shear pinched out, but a crosscut to the south intersected coalescing shears. The northernmost shear was followed only a short distance, but the south shear was followed 150 feet.

A sample of gray to clear quartz containing disseminated pyrite and arsenopyrite collected from the mine dump in 1984 assayed no Au and only 0.02 oz/ton Ag. Historic newspaper accounts reported the Big Chief ore to run as high as 25 oz/ton Au(*The Lewiston Gold Miner*, 1984). Jamison (1911a) reported the ore from the mine averaged about 2.0 oz/ton Au. Hausel (1987b) estimated maximum gold production from the mine to be 2,000 oz.

<u>Caribou mine</u>; S½ sec. 1, T.29N., R.100W. The Caribou may have produced as much as 24,000 oz of gold from the northeast trending shear zone (Jamison, 1911a). One sample of limonite-stained quartz collected from the mine dump in 1983 assayed 0.33 oz/ton Au, and a specimen of limonite-stained metagreywacke ran only 0.03 oz/ton Ag with no Au.

Carissa mine; NW¼ sec. 21, T.29N., R.100W. According to Jamison (1911a) and Hausel (1980a), early gold production from the Carissa mine may have amounted to about 50,000 oz. However, production figures from the *Wyoming Industrial Journal* suggest the amount recovered from this mine may have been greater than 180,000 oz. Unfortunately, production figures were reported for only five years (Table 21), and although the workings in the Carissa mine are extensive, the estimated volume of rock removed from the mine is probably not enough to account for the production figures reported by the *Wyoming Industrial Journal.*

Table 21. Reported gold production for the Carissa mine.

Year	Au (oz)	Reference
1867-1899	unknown	
1899	43,541	*Wyoming Industrial Journal,* 1900, v. 1, no. 8, p. 186.
1900	38,703	*Wyoming Industrial Journal,* 1901, v. 2, no. 8, p. 221.
1901	48,400	*Wyoming Industrial Journal,* 1902, v. 3, no. 8, p. 202.
1902	48,380	*Wyoming Industrial Journal,* 1902, v. 3, no. 8, p. 173.
1903-1946	unknown	
1947	1,455	U.S. Bureau of Mines Minerals Yearbook, 1948, p. 1536.
TOTAL	180,479	

The mine was developed on a N70°E trending shear in metagreywacke adjacent to hornblendic orthoamphibolite and a thin actinolite-tremolite carbonate schist (Hausel, 1988b). The shear is conformable to regional foliation; it averages 6.33 feet wide and in a few places is as much as 50 feet wide.

The primary shaft was sunk to 350 feet and a winze was sunk another 50 feet. More than 2,300 feet of drifts were driven on five levels and several stopes were opened up. Gold was identified in quartz associated with arsenopyrite (Armstrong, 1948). Spencer (1916) reported small amounts of pyrrhotite, realgar(?), orpiment(?), and scorodite on the property. The Carissa ore was reported to average 0.3 oz/ton Au with values ranging from a trace to 2.6 oz/ton Au (Beeler, 1908a). Some rich specimens contained as much as 260 oz/ton Au.

Wallrock adjacent to the shear zone is also fractured and silicified over a 200-foot width. A 30-foot-long composite chip sample collected north of the shear in the wallrock assayed 2.4 ppm Au (Hausel, 1987b). Later samples collected in the wallrock adjacent to the shear also suggest the possibility of a large, low-grade gold deposit (Table 22). This possibility is supported by descriptions by Beeler (1908a)

Table 22. Assays of composite chip samples taken in wallrock at the Carissa mine in 1987.

Sample description	Au (ppm)	Average Au (ppm)	Average Au (ppm) 97-ft-width
0 to 10 feet north of Carissa shear	0.4		
10 to 20 feet north of Carissa shear	1.05	1.425	
20 to 37 feet north of Carissa shear	2.5		0.80
0 to 10 feet south of Carissa shear	0.65		
10 to 20 feet south of Carissa shear	0.25	0.375	
20 to 30 feet south of Carissa shear	0.30		
30 to 60 feet south of Carissa shear	0.35		

and Curran (1926). For example, Beeler (1908a), reported samples taken across a 180-foot crosscut in the fractured wallrock on the 140-foot level yielded from a trace to 2.6 oz/ton Au. Curran (1926) reported the wallrock was exposed by crosscuts in the mine in an aggregate width of 300 feet. Samples taken across this width assayed 0.02 to 0.05 oz/ton Au.

During 1973 and 1974, Anaconda Minerals Company drilled a group of holes that intersected the Carissa shear about 150 to 200 feet below the lowermost level of the mine.

Drill hole DDH-1 intersected 16.1 feet of mineralized shear which averaged 0.13 oz/ton Au. A 2.3-foot zone of mineralization averaging 0.36 oz/ton Au was intersected in drill hole DDH-1A. Drill hole DDH-4 intersected two zones of mineralized rock. One was 7.4 feet wide and the second was 3.0 feet wide and both averaged 0.14 oz/ton Au. In DDH-5, an 11.9-foot-wide zone was intersected that averaged 0.12 oz/ton Au, and in DDH-6, two zones were cut — one was 7.4 feet wide and averaged 0.11 oz/ton Au and the other was 8.3 feet wide and averaged 0.18 oz/ton Au.

Drill holes DDH-7 and DDH-8 were drilled several hundred feet west of the shaft to test the western extension of the Carissa lode. Only trace amounts of gold were detected in the core from these drill holes.

Seventeen samples taken over a length of 100.5 feet on the second mine level averaged 0.65 oz/ton Au. The average sample width was 5.9 feet. On the third level, 78 samples with an average width of 4.37 feet were collected over a total sample length of 340.5 feet. Excluding some samples, these averaged 0.26 oz/ton Au. On the fourth level of the mine, 91 samples with an average width of 5.89 feet collected over a total sample length of 536.5 feet averaged 0.31 oz/ton Au. On the fifth level of the Carissa mine, another group of samples were collected with an average 5.7–foot width over a sample length of 547.15 feet. These averaged 0.36 oz/ton Au (Anaconda Minerals Company collection, document 56102.07, American Heritage Center, University of Wyoming). It is not clear from the Anaconda report whether these samples were collected by Anaconda personnel or whether the assays were a summary from earlier sampling.

Carrie Shields mine; SE¼ sec. 21, T.29N., R.100W., 1 mile east of South Pass City along the east bank of Willow Creek. The adit was developed on a 52°SE dipping, N60°E trending shear zone, which is as much as 3 feet thick and hosts a 1- to 2-foot-thick quartz vein (Hausel, 1983d). From this drift, the shear was stoped to the surface and a short distance downdip. At the surface, a portal was opened and a log cabin constructed that was equipped with a mule-powered hoist. A grab sample of quartz from the mine dump near the cabin assayed no Au and 0.04 oz/ton Ag.

Jamison (1911a) estimated early gold production from the Carrie Shields mine was 1,750 oz. According to Armstrong (1948, p. 61-62), the average ore grade of the mine was approximately 1.0 oz/ton Au.

Dexter Tunnel; S½ sec. 2, T.29N., R.100W., on the east bank of Rock Creek and a little more than a mile northwest of Atlantic City. The Dexter Tunnel was driven through metagreywacke of the Miners Delight Formation. The mine intersected at least three blind leads with subeconomic gold while being lengthened to 1,400 feet before work was suspended (Beeler, 1908a, p. 11). However, the *Wyoming Industrial Journal* (1905, v. 6, no. 12, p. 5) indicated the mine owners planned to drive 2,800 feet through the hill and that in 1905, the tunnel was 1,500 feet long and had cut six blind leads. One grab sample of arsenopyrite-bearing silicified metagreywacke collected from the mine dump by the author in 1986 assayed 0.01 oz/ton Au and 0.02 oz/ton Ag.

Diamond Development Company; W½W½ sec. 29, T.30N., R.99W. A 100-foot-long adit was driven into crossbedded Flathead Sandstone (Cambrian) along the northeastern edge of the South Pass greenstone belt. A winze sunk from the middle of the tunnel intersected the unconformable contact between the overlying Cambrian sandstone and underlying Precambrian Roundtop Mountain Greenstone. The contact is marked by a pyrite- and chalcopyrite-bearing milky quartz vein. Some specimens of milky quartz with visible gold were found on the mine dump (Steve Gyorvary, personal communication, 1987).

Diana (Tom McGrath) mine; NW¼ sec. 12, and SW¼ sec. 1, T.29N., R.100W. Geologically, the Diana is one of the more complex mines in the district. It was developed by a minimum of 700 feet of crosscuts and drifts (Figure 35 and Table 23). A winze sunk below the main level was flooded and inaccessible in 1984.

The mine workings cut metagreywacke, graphitic schist, orthoamphibolite, grunerite schist, and tremolite-actinolite schist. The principal mineralized zone in the mine is a steeply dipping quartz vein with associated quartz breccia. The vein trends northwesterly (perpendicular to regional foliation), rolls over, and makes a nearly right-angle bend near the winze.

Using gold geochemical data, Antweiler and Campbell (1977) concluded that the Diana vein was a typical hypothermal vein formed at high temperatures and pressures. A chemical analysis of native gold produced 92.5 percent Au, 7.4 percent Ag, 0.05 percent Cu, and traces of As, Bi, Ni, and Pb. The Au/Ag ratio is relatively high (12.5), and the Au/Cu ratio is relatively low (1,850) compared to gold samples collected from other mines in the Rocky Mountains (Antweiler and Campbell, 1977).

Production from the mine is estimated at about 500 ounces of gold (Jamison, 1911a). Gold in the Diana ore was reported to average about 0.7 oz/ton and to run as high as 2.85 oz/ton (Wilson, 1951b). Recent sampling shows the vein to average about 0.13 oz/ton Au and range from a trace to 0.71 oz/ton Au and a trace to 0.26 oz/ton Ag.

During the early 1980s, a small heap leach pad was constructed adjacent to the Diana mine to leach some tailings from various mines in the area with cyanide, but this heap-leaching effort was a complete failure. Apparently, the operators failed to crush the ore and they also compacted the pile, destroying its permeability. Although the tailings averaged 0.28 oz/ton Au, no gold was recovered from the operation (Hank Hudspeth, Jr., personal communication, 1986).

Doc Barr mine; sec. 22, T.29N., R.100W. The mine was developed by a 150-foot-long tunnel, a 65-foot-deep shaft, and a drift driven 200 feet west from the bottom of the shaft. The vein is 30 inches wide, averages 1.7 oz/ton Au, and is offset at the bottom of the shaft. The vein was lost beyond the offset. The ore was stoped to the surface from the bottom of the shaft, along the full length of the drift (Jamison, 1911b). Jamison (1911a) estimated 820 oz of gold were recovered from the mine.

Duncan mine; W½W½ sec. 14, T.29N., R.100W., 1 mile southwest of Atlantic City (Plate 2). At the northwestern edge of the property,

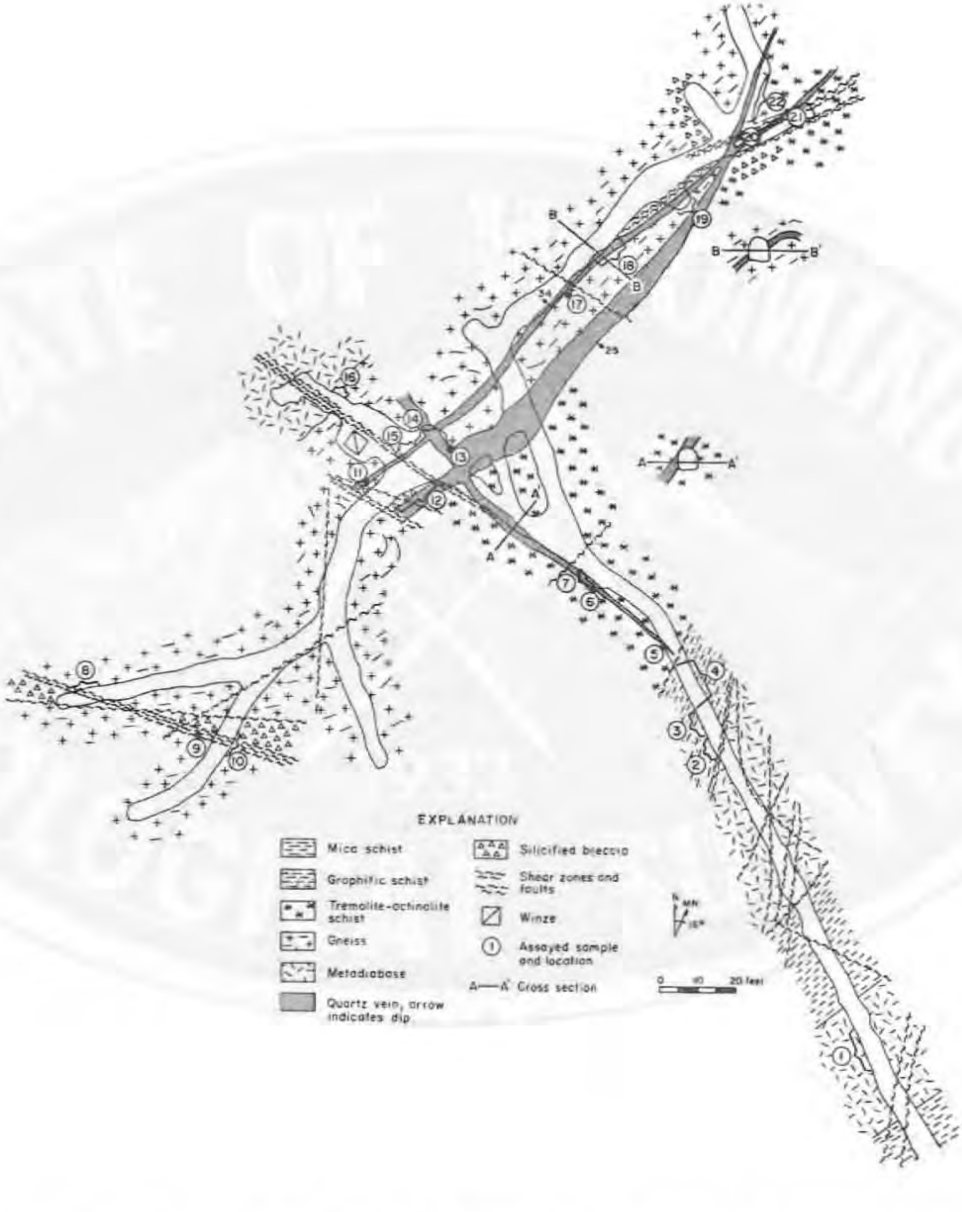


Figure 35. Geology at the Diana mine, showing sample locations (modified from Hausel and Gyorvary, 1984a).

Table 23. Preliminary assays of the Diana mine, South Pass-Atlantic City district. Locality numbers refer to Figure 35.

Locality number	Sample number	Description	Assay values (ppm) Au	Ag	W	As	Cu
1	DM2678	Chip sample	0.09	1.2	7.0	195.0	41.0
2	DM2679	Chip sample	0.08	2.5	4.0	651.0	269.0
3	DM2680	Chip sample	<0.02	2.2	5.0	1,290.0	113.0
4	DM2681	Chip sample	0.06	1.9	12.0	1,930.0	91.0
5	DM2682	5 feet of vein footwall	0.14	1.7	6.0	917.0	112.0
6	DM2683	Vein	<0.02	1.2	8.0	190.0	147.0
7	DM2684	Hanging-wall sample	<0.02	0.7	3.0	171.0	44.0
8	DM2693	6-foot chip sample	0.89	0.5	4.0	779.0	107.0
9	DM2694	2-foot sample of silicified breccia	0.74	0.7	5.0	488.0	58.0
10	DM2695	5-foot sample of shear zone	0.27	1.0	6.0	836.0	142.0
11	DM2692	2-foot chip sample of quartz vein	23.7	0.5	8.0	326.0	13.0
12	DM2691	Composite chip sample	10.5	1.2	7.0	1,030.0	65.0
13	DM2686	Chip sample across 18 inches of quartz vein	0.93	0.5	4.0	180.0	13.0
	DM2687	5-foot sample of footwall below vein	0.92	0.5	3.0	133.0	38.0
14	DM2689	7-foot channel in northeast portion of muck pile	24.0	8.9	25.0	1,640.0	77.0
	DM2685	3-foot hanging wall sample	13.2	4.1	20.0	1,320.0	70.0
15	DM2688	7-foot channel in southwest part of muck pile	3.11	1.4	11.0	444.0	59.0
16	DM2690	3-foot channel along contact	4.41	1.0	32.0	2,830.0	84.0
17	DM2696	2-foot chip sample of vein	1.37	0.2	4.0	2,490.0	31.0
	DM2697	5-foot sample of footwall	0.06	0.5	4.0	498.0	83.0
18	DM2698	Sample along strike of 1-foot-wide vein	1.71	<0.2	2.0	178.0	15.0
19	DM2699	Sample across 18-inch quartz vein	5.66	2.2	5.0	362.0	16.0
	DM2700	4-foot footwall sample below vein	0.84	1.4	6.0	1,150.0	50.0
20	DM2702	5-foot oblique sample across quartz vein	1.62	0.7	5.0	134.0	22.0
21	DM2701	3-foot sample in sheared actinolite schist in back	0.05	1.0	3.0	388.0	152.0
22	DM2703	2-foot sample across swell in quartz vein	0.31	1.2	3.0	467.0	30.0
	DM2704	2-foot sample across footwall breccia	0.03	1.0	7.0	714.0	66.0

the main lode (strike N65°W) is intersected by a vertical cross shear trending N80°E. At the point of intersection of these two shears, the Duncan shaft was sunk to a depth of 250 feet and a glory hole was dug on rich oxidized ore. Several hundred feet of drifts, crosscuts, and open stopes were developed (Armstrong, 1948). Jamison (1911b) reported that the mine contained 1,255 feet of drifts. But because the mine was operated after 1911, the workings are undoubtedly more extensive. Recently, channel samples collected across the width of the Duncan shear yielded anomalous gold(Table 24).

Table 24. Assays of channel samples collected in the Duncan mine glory hole by the author in 1987.

Sample number	Sample description	Au (ppm)	Ag (ppm)
DUN1-87	2-foot channel, west end of shear	3.0	2.2
DUN2-87	2-foot channel across quartz boudin in shear	33.0	6.0
DUN3-87	5-foot channel, east of boudin	1.8	1.8
DUN4-87	10-foot channel, east of DUN 3	6.6	2.7
DUN5-87	10-foot channel, east of DUN 4	0.71	7.4
DUN6-87	10-foot channel, east of DUN 5	0.53	1.0
Average		2.66	2.27

The ore was reported to range from 0.25 to 5.25 oz/ton Au. Estimated and actual production records show that about 3,800 oz of gold were mined from the property (Jamison, 1911a; Hausel, 1980a). Mill tailings below the Duncan mine still host anomalous gold, which attest to the poor metallurgical extractive methods used at the mill (Elmer C. Winters, personal communication, 1982).

Anaconda Minerals Company drilled four holes at the Duncan mine in 1974. One of the holes was not completed. Drill hole DDH-9 intersected two mineralized zones. Zone 1 averaged 7 feet wide at 0.18 oz/ton Au and zone 2 averaged 2.1 feet wide at 0.11 oz/ton Au. Drill hole DDH-10A was drilled 375 feet west of DDH-9. Here zone 1 contained only a trace of gold and zone 2 was 0.7 feet wide and averaged 0.17 oz/ton Au. Drill hole DDH-11 was collared 550 feet west of DDH-10A. A trace of gold was detected in zone 1 and an average of 0.025 oz/ton Au over 5.7 feet was found in zone 2 (unpublished Anaconda Minerals Company report, document 56102.07, American Heritage Center, University of Wyoming).

<u>Exchange prospect</u>; E½E½ sec. 15 and W½W½ sec. 14, T.29N., R.100W., adjacent to, and west of the Duncan mine. The Exchange

prospect is located on a narrow N63°E trending shear at the contact between orthoamphibolite and metagreywacke. Samples collected for wallrock alteration studies showed weak phyllic alteration adjacent to the shear zone. Whole-rock analyses of the samples showed silica and potassium enrichment which decreased a short distance from the shear. A 2-foot channel sample dug across the Exchange shear yielded 2.1 ppm Au and 1.2 ppm Ag. A sample of milky quartz collected west of the channel sample in the Exchange lode assayed 18.1 percent Cu, 0.73 ppm Au, and 27 ppm Ag. Jamison (1911a) estimated gold production from the Exchange mine at about 1,000 oz. This estimate is undoubtedly much too high.

Franklin mine; W½SW¼ sec. 20, T.29N., R.100W., 0.5 mile west of South Pass City. The Franklin was developed by a shaft sunk to intersect veins in shear zones in Miners Delight metagreywacke. The metagreywacke at this locality has been extensively invaded by pegmatite.

Production from the mine was estimated at about 15,000 oz of gold (Jamison, 1911a). A grab sample of quartz vein material collected by the author from the mine dump assayed 0.50 oz/ton Au.

Garfield (Buckeye) mine; NE¼NE¼ sec. 11, T.29N., R.100W. The Buckeye shaft of the Garfield mine reached a depth of 140 feet in 1870. At that time, the mine was producing about 2,500 oz of gold annually. One clean up of 105 tons of ore in 1895 yielded 96 oz of gold (*Engineering and Mining Journal*, 1895, v. 60, p. 208). Estimated total gold production from the mine is 20,000 oz (*Engineering and Mining Journal*, 1895, v. 60, p. 208; Jamison, 1911a). According to Spencer (1916), 250 oz of gold were extracted from about 1,000 tons of rock in 1905.

Gold Dollar mine; SW¼ sec. 32, T.30N., R.99W. The Gold Dollar mine is a 1,300-foot-long tunnel driven across regional foliation for the purpose of intersecting the western extent of the Miners Delight lode. The tunnel cut through metagreywacke, metachert, and hornblendic orthoamphibolite of the Miners Delight Formation (Hausel, 1983e). At 1,210 feet from the portal, three N40°W to N50°W trending quartz veins were intersected and a raise was driven to the surface. The veins are 0.5 to 2.0 feet thick and are sulfide bearing. A short distance to the north, the workings cut banded metachert and metagreywacke and terminated.

The foundation and other structures associated with the Gold Dollar mill lie west of the adit. Examination of the mine workings suggest only a minor amount of gold could have been milled since the quartz veins were not intersected until 1,210 feet from the adit. Drifts on these veins are short.

Samples collected from the mine dump at the Gold Dollar adit contained no detectable gold, but one sample collected by Prinz (1974) along the Gold Dollar trend to the east assayed 17.5 ppm (0.51 oz/ton) Au and 60 ppm As.

Ground Hog mine; SW¼ sec. 11, T.29N., R.100W. Two shafts 40 to 100 feet deep with at least 200 feet of drifts were developed on several small quartz veins in hornblendic orthoamphibolite. The average ore grade of the property was reported to range between 0.25 and 0.4 oz/ton Au, and production was estimated at 1,450 oz of gold (Jamison, 1911a).

A 2-foot channel sample of mixed quartz and orthoamphibolite taken by Prinz (1974) from the surface workings yielded 47.3 ppm (1.38 oz/ton) Au and 250 ppm As.

Homestake mine; NW¼ sec. 21, T.29N., R.100W., on the northeastern edge of Hermit Gulch reservoir, east of the Carissa mine. An adit was driven north in Miners Delight metagreywacke. Mine dump samples contain sporadic actinolite schist mixed with abundant silicified metagreywacke. Some samples on the dump contain as much as 5 percent arsenopyrite.

Knight (1901) collected a 10-pound sample from the mine that assayed 0.92 oz/ton Au.

King Solomon prospect; SW¼ sec. 15, T.29N., R.100W. Prospect pits and a short adit were dug into graphitic schist at the contact between the schist and orthoamphibolite. One sample collected from the prospect assayed 0.16 oz/ton Au (Knight, 1901, p. 28).

Lander Belle; (location unknown). A 200-foot-wide, silicified, quartz porphyry dike between schist and granite assayed 0.13 to 0.25 oz/ton Au (Jamison, 1911a).

Lone Star mine; W½ sec. 35, T.30N., R.100W. The Lone Star mine occurs within schists of the Goldman Meadows Formation. Approximately 2,000 oz of gold were produced from the property (Jamison, 1911a). Bayley (1963) reported that the Lone Star shaft was sunk on a quartz vein adjacent to banded iron formation. The vein averaged 0.06 oz/ton Au.

Lucky Boy; NE¼ sec. 11, T.29N., R.100W., adjacent to the Garfield mine. An estimated 150 oz of gold were recovered from this property (Jamison, 1911a).

Mary Ellen mine; NE¼ sec. 14, T.29N., R.100W. The Mary Ellen was developed by a 240-foot incline with five levels. The actual depth at the bottom of the incline to the surface is only about 100 feet (Hausel, Gyorvary, and Roberts, 1984). The incline was developed along a 6-inch to 3-foot-wide milky quartz vein hosted by metatonalite porphyry. Several samples of quartz containing visible gold have been found in recent years. Samples collected for assay in the upper two levels of the mine in 1983 ranged from no detectable gold to as high as 20.25 ppm (0.59 oz/ton) Au (Steve Gyorvary, personal communication, 1984).

Native gold samples collected from the Mary Ellen mine by Love and others (1978) contained an average of 89.1 percent Au, 10.7 percent Ag, and 0.2 percent Cu with Au/Ag=8.3, Au/Cu=445, and Ag/Cu=50. Characteristic trace elements included Bi, Pb, As, Sb, Sn, V, Mo, W, B, Nb, and Zn.

The average ore tenor of the mine, reported by Jamison (1911a), was 0.4 oz/ton Au. Mined ore was reported to range from 0.25 oz/ton to 5.25 oz/ton with some high-grade zones yielding as much as 50 oz/ton (Anonymous, 1916). Early gold production was estimated at 6,050 oz (Jamison, 1911a). In 1895, the tailings from the Mary Ellen mine were purchased and treated with cyanide. The cyanide yielded 340 oz of gold (*Engineering and Mining Journal*, 1895, v. 60, p. 452).

Midas (1914, McGrath, Sullivan) mine; S½SW¼ sec. 1, T.29N., R.100W. The Midas was developed along a thin graphitic schist member of the Miners Delight Formation. Four samples collected by the author from the graphitic schist contained only 95 to 405 ppb Au. A sample of limonite-stained sheared schist collected by Prinz (1974) assayed 2.8 ppm (0.08 oz/ton) Au and 1,200 ppm As. The Midas shaft was sunk to a depth of 300 feet with 1,500 feet of drifts on the 100- and 200-foot levels (Bartlett and Runner, 1926).

According to Henderson (1926), the mine was retimbered in 1926. The vein was developed by an inclined shaft and intersected by an adit on the 100-foot level. The shaft follows the vein downdip at 74°NW from the surface to the 100-foot level. From the 100-foot level to 83 feet below the 200-foot level, the shaft dips 69°.

On the 100-foot level, the vein was followed by 100 feet of drifts southwest of the shaft and 77 feet northeast of the shaft with 87 feet of crosscuts. On the 200-foot level, drifts continue 180 feet northeast and 25 feet southwest of the shaft with 25 feet of crosscuts.

Bane's (1929) microscopic research led to the conclusion that both gold and arsenopyrite entered along fractures in the quartz. Armstrong (1948) reported the mine produced 1,380 oz of gold in 1934.

Miners Delight mine; center sec. 32, T.30N., R.99W. The Miners Delight mine was one of the largest gold producers in the State of Wyoming. Production was estimated at about 60,000 oz (Jamison, 1911a). Geochemically, the Miners Delight gold has an average of 87.2 percent Au, 12.7 percent Ag, and 0.02 percent Cu, with metal ratios of Au/Ag=6.9, Au/Cu=4,360, and Ag/Cu=640. Characteristic trace elements include Bi, Pb, Sn, V, and B (Love and others, 1978).

The Miners Delight lode lies in a predominantly metavolcanic succession of meta-andesite porphyry, metabasalt, and metachert. Native gold occurs throughout the host rock matrix and in cavities of a 3- to 16-foot-wide shear zone (Figure 36). The mineralized shear

Figure 36. The Miners Delight shear zone, showing the steep dip of the shear.

zone was traced on the surface for 2,000 feet (Kyner, 1907) and ranged from $7 to $3,800/ton (prospectus of Miners Delight Mining Company, undated). (Because the actual date for these dollar values is unknown, they were not converted to oz/ton for this report.)

The ore deposit was developed by a 175-foot-deep shaft (Bartlett and Runner, 1926). Three levels were driven from the shaft with more than 2,400 feet of drifts. A manway (chute) was constructed from the 150-foot level to the surface. North of the manway on the 90-foot level, the gold-bearing zone assayed from $7.83/ton to $10.76/ton Au with a trace Ag. On the 115-foot level, northeast and southwest of the manway, the vein assayed $15.28/ton Au. Two intersecting veins exposed in the 150-foot level contained a pocket of ore that assayed $300.00/ton Au. On the same level, 94 feet north of the manway, the ore consistently assayed $19.00/ton Au (Prospectus of the Miners Delight Mining Company, undated).

Monarch (Mars) mine; NE¼ sec. 21, T.29N., R.100W. Two adits were developed along a N50°E trending shear zone in metagreywacke (Figure 37). The lower adit, at 60 feet from the portal, contains a 20-foot crosscut that intersects actinolite schist. One sample of limonite-stained quartz along the contact between actinolite schist and metagreywacke assayed 8.76 ppm Au with 0.2 ppm Ag (Table 25). The lower adit has approximately 280 feet of workings and was recently sampled (Hausel and King, 1985b). The upper adit, which is about 100 feet long, was not sampled.

Old Hermit mine; NW¼ sec. 13, T.29N., R.100W. The mine consists of about 340 feet of workings in brecciated and sheared metagreywacke and orthoamphibolite. The mine was driven on a S10°E trend and cut several small N60°E trending shears and veinlets (Hausel and King, 1985c).

A channel sample of carbonate-cemented metagreywacke taken 150 feet from the portal contained no detectable gold or silver. A chip sample of limonite-stained metagreywacke at 170 feet from the portal yielded only 80 ppb Au and no Ag.

Oswego prospect; NE¼ sec. 31, T.30N., R.99W. In 1916, this prospect was developed by two shafts, 40 feet and 70 feet deep. Visible gold was discovered in a quartz vein (Anonymous, 1916).

Outpost mine; W½NW¼ sec. 18, T.29N., R.99W. Two adits were driven to the south to intersect a N50°W to N60°W cross-cutting, hematite-cemented breccia (Hausel, 1988c). Approximately 1,500 feet of drifts and crosscuts were driven to develop the breccia (Hausel and Albert, 1985; Hausel and King, 1985d).

Figure 37. Geologic map of the Monarch mine with sample locations (modified from Hausel and King, 1985b).

Table 25. Assays of samples collected in the lower portal of the Monarch (Mars) tunnel, South Pass-Atlantic City district. Locality numbers refer to Figure 37.

Locality number	Sample number	Description	Assay values (ppm) Au	Ag
1	MON 1-87	6-inch channel at face	0.13	0.0
2	MON 2-87	1-foot channel	0.14	0.0
3	MON 3-87	1-foot channel at face	0.19	0.0
4	MON 4-87	Chip sample from back	0.17	0.0
5	MON 5-87	Chip sample from back	0.17	0.0
6	MON 6-87	8-inch channel from back	0.16	0.0
7	MON 7-87	2-foot channel from back	0.16	0.0
8	MON 8-87	1-foot channel from back	0.13	0.0
9	MON 9-87	1-foot channel from back	0.14	0.0
10	MON 10-87	1-foot channel from back	0.19	0.0
11	MON 11-87	6-inch channel from back	0.16	0.0
12	MON 12-87	8-inch channel from back	0.24	0.0
13	MON 13-87	6-inch channel from back	0.21	0.0
14	MON 14-87	Chip sample from back	0.13	0.0
15	MON 15-87	1-foot channel from back	0.15	0.0
16	MON 16-87	Chip sample from back	0.19	0.0
17	MON 17-87	10-inch channel from back	0.15	0.0
18	MON 18-87	Chip sample from back	0.15	0.0
19	MON 19-87	Chip sample from back	0.36	0.0
20	MON 20-87	Chip sample from back	0.22	0.0
21	MON 21-87	2-foot channel from back	0.18	0.0
22	MON 22-87	3-foot channel from back	0.22	0.0
23	MON 23-87	4-foot channel from back	0.24	0.0
24	MON 24-87	14-inch channel from back	0.26	0.0
25	MON 25-87	18-inch composite chip from back	0.36	0.0
26	MON 26-87	3-foot channel from back	0.74	0.0
27	MON 27-87	3-foot channel from back	2.29	0.0
28	MON 28-87	1-foot channel from back	2.19	0.0
29	MON 29-87	1.5-foot channel from back	3.14	0.0
30	MON 30-87	Chip from shear intersection	1.09	0.0
31	DBW-2-85	Limonite-stained metagreywacke	8.76	0.2

Samples of limonitic metagreywacke collected from the mine dump contained only traces of gold. A chip sample of limonitic quartz from the back of the Outpost no. 1 adit assayed 870 ppb Au with 8.2 ppm Ag. Another sample of hematitic breccia from the Outpost no. 2 adit yielded 1.33 ppm Au.

Peacock mine; SE¼ sec. 25, T.30N., R.100W., in the Roundtop Mountain Greenstone. As much as 240 oz of gold may have been produced from this property (Jamison, 1911a).

Placer mines; Placer deposits were worked throughout much of the history of mining in the South Pass greenstone belt and may have yielded as much as 90,000 to 100,000 oz of gold before the Second World War. Since World War II, placer mining has been sporadic and no records have been kept on production.

More than one dredge operated in the district during the early 1900s and some hydraulic mining was also reported. Hydraulic mining along Mill Hill south of Atlantic City from 1890 to 1892 recovered 10,000 to 11,000 oz of gold (Spencer, 1916, p. 25).

One of the more enterprising operations was that of the Granier Mining Company. Emil Granier's company constructed a network of flumes and ditches from the headwaters of the Popo Agie River, which was used for hydraulicing. His first clean up in 1891 yielded 6,720 oz of gold from what was known as the Christina Lake placer (*Engineering and Mining Journal*, 1891, v. 52, p. 436).

Rock Creek placers; along Rock Creek (Figure 33). Between 1933 and 1941, 3,000,000 yd^3 of gravel that averaged 0.012 oz/yd^3 were mined by the E.T. Fisher Company. Seventy-five percent of the gold was found in 1 to 3 feet of bedrock. According to production records, a minimum of 11,500 oz of gold were mined by the E.T. Fisher Company, but the average reported grade of the gravels indicates this figure is probably somewhat under the actual amount recovered.

In places, the Rock Creek channel is 100 to 250 feet wide with an average depth of 10 feet. The recovered gold was generally rounded and occurred as flakes with rare nuggets (Plate 3B). One nugget recovered in 1934 weighed 3.4 oz; larger nuggets were recovered after 1934 (Gerald Stout, personal communication, 1987). The gold fineness ranged from 0.840 to 0.900 (Ross and Gardner, 1935).

Some of the richest gravel was discovered 1 mile below Atlantic City near a place where a large fault crosses Rock Creek. In 1987, this same general area was mined again by the Stout Mining Company. Previously unmined gravels averaged about 0.01 oz/yd^3 Au with a large percentage of nuggets (Plate 3A). Sample concentrates examined by the Geological Survey of Wyoming showed anomalous amounts of scheelite and traces of cassiterite. In S½ secs. 20, 21, 22, and N½ secs. 27, 28, 29, T.30N., R.100W., three claims averaged 0.016 oz/yd^3 Au with some spots that contained as much as 1.17 oz/yd^3. In 1953, this area was mined by Wyoming Mica and Metals Corporation (Wilson, 1953).

Rocky Barr mine; S½S½ sec. 15, T.29N., R.100W., on Hermit Gulch. The mine has 400 feet of workings in Miners Delight Formation metagreywacke. The adit was driven from Hermit Gulch and intersected several shears, breccia zones, and narrow quartz veins and boudins to the south (Hausel and Albert, 1984). Some of the quartz contains varying amounts of sulfides (principally pyrite).

In 1987, 29 samples collected in the mine yielded poor assay results. The values ranged from no detectable Au to 1.1 ppm Au. One sample of limonite-stained metagreywacke from a prospect pit on the surface south of the Rocky Barr adit contained 32.8 ppm Au and 250 ppm As (Prinz, 1974).

Rose (W.J. Bryan) mine; SE¼ sec. 2, T.29N., R.100W. The Rose shaft was sunk on a 2- to 3-foot-wide, N60°E trending, 80°SE dipping shear zone in metagreywacke and porphyroblastic "peanut" schist. Assays of samples collected from the mine in 1987 are shown in Table 26. Approximately 250 oz of gold were recovered from mine operations before 1911 (Jamison, 1911a).

Table 26. Assay results of some recent samples from the Rose mine.

Sample number	Sample description	Au (ppm)	Ag (ppm)
MD 1-87	1-foot channel across Rose shear	0.35	—
MD 17-87	2-foot channel in sheared footwall	0.65	—
MD 18-87	Grab sample of quartz from dump	0.29	1.0

St. Louis (Jim Dyer) mine; W½NW¼ sec. 13, T.29N., R.100W., south of Atlantic City on Mill Hill. The mine was developed by a 160-foot-deep, 65° incline. At 60 feet deep, the incline intersected 300 feet of tunnel developed from an adit west of the shaft.

The workings intersected several shears, and the tunnel followed a 2-foot-wide shear in orthoamphibolite (Figure 38) (Hausel and King, 1985e). At approximately 180 feet into the adit, the workings intersected fractures filled with gold, but the gold quickly played out (Dave Haddenham, personal communication, 1985). Jamison (1911a) estimated about 360 oz of gold were produced from this mine.

Silent Friend prospect; S½ sec. 14, T.29N., R.100W. The vein on this property was reported to be 10 to 50(?) feet wide and to contain copper and gold values. Some tonnage ran 0.1 oz/ton Au (Anonymous, 1916).

<u>Snowbird (Rosella) mine</u>; center sec. 6, T.29N., R.99W., on Big Atlantic Gulch just south of the U.S. Bureau of Land Management's Placerita Gulch campground. The mine was developed by 800 feet of workings on the main level which cut metagreywacke, metadacite, and orthoamphibolite. At 290 feet from the portal, a 50° incline connected the drifts to the surface, but it was inaccessible in 1985 (Hausel and King, 1985f).

Figure 38. The exposed shear in the back of the St. Louis mine, which cuts through orthoamphibolite (metagabbro).

The incline was sunk on a mineralized shear in metagreywacke. Prinz (1974) collected a grab sample of a calcite-quartz vein from the mine dump that assayed 4.5 ppm Au (0.13 oz/ton) with 30 ppm As. Bayley and others (1973) reported galena from this mine produced a model lead date of 2.8 Ga. However, it is not known whether the sample came from the shear zone in metagreywacke or the massive carbonate-quartz-sulfide zone in orthoamphibolite.

From the incline, the tunnel continued north across regional foliation and intersected a 30- to 50-foot-wide calcite-pyrite-quartz mineralized zone hosted by orthoamphibolite. The metadacite occurring along the southern contact with the amphibolite has calc-alkaline affinity, whereas the hornblendic orthoamphibolite has tholeiitic affinity (Hausel, 1986b). Pyrite is the dominant sulfide, with minor chalcopyrite.

Assays of samples collected from the pyritized zone gave the following results:

1. A sample of a metadacite-hosted calcite pod from the rib of the mine contained no detectable Au or Ag.

2. A sample of sheared orthoamphibolite in the mineralized zone contained no detectable Au and 0.3 ppm Ag.

3. A chip sample of quartz from the mine face in the mineralized zone contained no detectable Au or Ag.

4. A sample of sulfide-bearing orthoamphibolite assayed no Au or Ag with 33 ppm Cu.

5. A calcite-pyrite pod from the orthoamphibolite yielded 320 ppb Au, 415 ppm Cu, and 0.8 ppm Ag.

6. A pyrite-rich sample from the orthoamphibolite contained 370 ppb Au, 197 ppm Cu, and 0.5 ppm Ag (Hausel, 1986b).

Smith Gulch mine; SE¼ sec. 6, T.29N., R.99W., on the east bank of Smith Gulch. A 200-foot tunnel driven into sheared and brecciated graphitic schist cut actinolite schist and terminated in metagreywacke (Hausel and King, 1985g).

Samples collected from the mine included a chip of a sulfide-bearing quartz vein that assayed 2.28 ppm Au with 6.31 oz/ton Ag and a sample of limonite-stained actinolite schist that yielded 80 ppb Au, 0.4 ppm Ag, and 346 ppm Ni.

Smith Gulch placer; along Smith Gulch south of the Smith Gulch adit. Gravels mined in 1987 were rich, averaging 0.1 oz/yd^3 Au (Figure 39 and Plate 4) (Hank Hudspeth, Jr., personal communication, 1987). Much of the gold occurred as flattened flakes with lesser flattened nuggets.

Figure 39. (A) Smith Gulch placer in 1987. The gold was localized in specific horizons above bedrock. (B) Some of the gold recovered from Smith Gulch in 1987 by Hank Hudspeth, Jr. and Buddy Presgrove (approximately 20 oz).

Soules and Perkins (Bucks Tunnel, Britanna, Victoria Regina) mine; E½ NE¼ sec. 11, T.29N., R.100W. The Soules and Perkins mine was developed by more than 500 feet of tunnel driven through quartzofeldspathic gneiss, orthoamphibolite, and metagreywacke. At 210 feet from the portal, the tunnel intersected a 2-foot-wide quartz vein (Hausel and Gyorvary, 1984b). This vein was reported to have an average gold tenor of 0.58 oz/ton (*Engineering and Mining Journal*, 1883, v. 35, p. 228). Within 20 feet of the mine face of the primary drift, a 10- to 15-foot-thick stretched-pebble conglomerate was cut by the workings.

Production from the mine was estimated to be about 25,000 oz by *The Lewiston Miner* (1890), and about 17,000 to 18,000 oz by Jamison (1911a). The extent of the mine workings suggests production was probably considerably lower.

Tabor Grand mine; NE¼ sec. 14, T.29N., R.100W.; named after the historic Tabor Grand Hotel in Leadville, Colorado (see Voynick, 1978). The Tabor Grand mine was driven along a 3- to 10-foot-wide shear zone in hornblendic amphibolite (Figure 40). Approximately 500 feet of drifts were developed on the 120-foot level with some crosscuts. In places, the sheared rock was stoped to the surface and a three-compartment shaft was sunk to a depth below the 120-foot level. This level was inaccessible in 1984. Samples collected in the mine ranged from a trace to 58 ppm Au (Table 27). It appears the Tabor Grand shear continues several hundred feet to the east before it is offset (Hausel, 1988c).

The principal sulfide in the shear zone was arsenopyrite (Bane, 1929). According to Armstrong (1948), two shafts were sunk in the mine to 180 and 160 feet, respectively. The average ore grade was approximately 0.5 oz/ton Au (Armstrong, 1948).

Tornado mine; S½SE¼ sec. 30, T.30N., R.99W. The Tornado mine was developed into metatholeiite of the Roundtop Mountain Greenstone. A narrow, sheared, cupriferous vein with calcite and siderite gangue was followed downdip for 180 feet. The vein strikes N20°W and dips 12°SW (Hausel and Gyorvary, 1985b). One sample of copper-bearing milky quartz collected from the mine rib in 1985 assayed 1.68 percent Cu, 10 ppm Ag, and 0.45 oz/ton Au. Thirteen samples collected by the author in 1987 yielded 0.0 to 37.0 ppm Au, 0.0 to 19.0 ppm Ag, 0.01 to 3.5 percent Cu, and traces Pb, Ni, and Zn.

Wyoming Copper Mining Company; sec. 18, T. 29N., R.100W(?) (Hausel, 1988b). It was reported that a quartz vein in schist con-

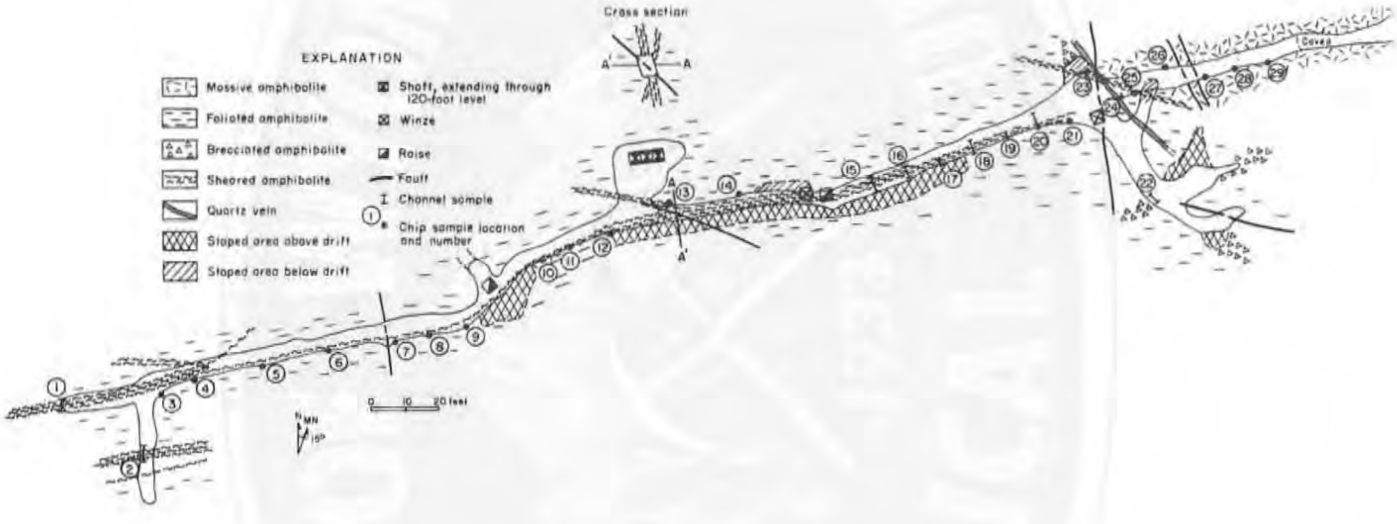


Figure 40. Geologic map of the Tabor Grand mine showing sample locations (plan view) (modified from Gyorvary and Hausel, 1984).

Table 27. Assays from the 120-foot level of the Tabor Grand gold mine, South Pass, Wyoming. Locality numbers refer to Figure 40.

Locality number	Sample number	Sample description	Assay values (ppm) Au	Ag
1	TG 25-87	3-foot channel across face	0.06	0
2	TG 24-87	4-foot channel across shear	1.7	0
3	TG 29-87	Chip sample of gouge from south rib	0.07	0
4	TG 28-87	Chip from south rib	0.05	0
5	TG 27-87	Chip from south rib	2.2	0
6	TG 26-87	Chip from south rib	0.81	0
7	TG 23-87	Mylonite from south rib	8.6	2.5
8	TG 22-87	Mylonite from south rib	58.0	4.7
9	TG 21-87	Massive amphibolite	0.10	0
10	TG 20-87	Chip of massive amphibolite with milky quartz veinlets	0.12	0
11	TG 19-87	Chip, contains milky quartz in massive amphibolite	0.74	0
12	TG 18-87	Chip from south rib, contains some quartz	3.0	0
13	TG 17-87	Chip from north rib, contains some quartz	4.6	0
14	TG 16-87	Chip sample from north rib	2.3	0
15	TG 15-87	4-foot channel across mine back	9.1	0
16	TG 14-87	3.5-foot channel sample across mine back, includes 2-inch-wide quartz vein	14.0	0
17	TG 13-87	3-foot channel in back	4.4	0
18	TG 12-87	4-foot channel in back	8.7	0
19	TG 11-87	1-foot channel from back	1.9	0
20	TG 10-87	5-foot channel across back includes both blocky massive and sheared amphibolite	2.1	0
21	TG 9-87	Chip sample across narrow gouge zone in back	5.2	0
22	TG 7-87	3-foot channel sample	7.0	0
23	TG 6-87	Chip sample across shear in north rib	5.3	0
24	TG 8-87	2-foot channel across 2-foot-wide gray quartz vein	22.0	0
25	TG 5-87	1-foot-wide channel across limonite-stained shear in foliated orthoamphibolite	3.6	0
26	TG 4-87	Chip sample from north rib	0.15	0
27	TG 3-87	Channel sample in south rib	0.09	0
28	TG 2-87	Chip sample from south rib	0.68	0
29	TG 1-87	Chip sample from south rib	0.09	0

tained 4 to 16 percent Cu, 0.10 to 0.52 oz/ton Au, and 1.5 to 40 oz/ton Ag. The mineralized zone was reported as being 40 feet wide (Spencer, 1916). Some lead also occurred in the mine (Anonymous, 1916). A shaft was sunk to a depth of 500 feet (Spencer, 1916).

Other gold mines. A number of mines and prospects for which no locations are available are briefly discussed in the literature. For example the Young American, Independence, Gold Dust, McKinley, Rustler, Harrison, Little Bee, Big Copper, Midget, Prixley, Charles Dickens, Klondike, Payrock, Clipper, and Poiree Estate are mentioned with no other information (see Knight, 1901; Spencer, 1916).

Twin Creek paleoplacers

These paleoplacers are located in T.31N., R.98-99W. and T.30N., R.98-100W. Antweiler and others (1980) reported Oligocene gold-bearing conglomerates of the White River Formation lie immediately northeast of the South Pass greenstone belt. The White River conglomerate samples collected by Antweiler and others (1980) averaged 0.0047 oz/yd^3 Au. Some recent placers derived from the conglomerates contain greater gold concentrations.

The conglomerate is interpreted as part of a giant alluvial fan eroded from the greenstone belt. The conglomerate hosts boulders and pebbles of granite and banded iron formation in considerable amounts with lesser slate, mafic dike rocks, and Paleozoic rocks (Antweiler and others, 1980). Prospectors generally use banded iron formation boulders and pebbles in this area as a guide to the richer portions of the conglomerate (Hank Hudspeth, Jr., personal communication, 1986).

Antweiler and others (1980) consider the source region to be the ancestral headwaters area of Twin Creek, which was captured by Beaver Creek. The headwaters area is underlain by Louis Lake granodiorite, banded iron formation and other metasediments of the Goldman Meadows Formation, and metatholeiites of the Roundtop Mountain Greenstone. A 2-square-mile area in the headwaters region is also concealed by White River Formation (see Bayley, 1965; Hausel, 1987e).

The important implication of this gold-bearing conglomerate is that it may have been derived from a small but very rich undiscovered lode (Antweiler and others, 1980):

The probability that the source area is still there but is now buried by the White River strata rather than having been completely eroded away during Oligocene time is suggested by

(1) the calculated less-than-100-feet of erosion within the drainage basin necessary to provide the volume of debris from the fan, and (2) the decrease in gold content in the White River Formation above the basal conglomerate.

These conglomerates were mined in the early 1900s by hydraulic methods (J. David Love, personal communication, 1986) and probably during the late 1800s. Gold production may have totaled several thousand oz. The amount of gold remaining in the conglomerate far exceeds the amount mined (Antweiler and others, 1980).

Red Canyon placers; sec. 36, T.31N., R.99W., and sec. 31, T.31N., R.98W. Historical reports suggest that the Red Canyon placers may have been salted and their value greatly exaggerated. However, the Red Canyon placers are small isolated areas consisting of White River Formation conglomerates that are part of the Twin Creek paleoplacers (see Antweiler and others, 1980, p. 228). The gravel was reported to average about 0.05 oz/yd^3 (*Mining Reporter*, 1907, v. 56, p. 227) and Jamison (1911a) estimated that about 1,000 oz were recovered from these placers by hydraulic mining.

St. Lawrence Creek

St. Lawrence Creek drains Precambrian granite and schist along the eastern flank of the Wind River Mountains west of Riverton, Wyoming. Bolmer and Biggs (1965) reported auriferous quartz lenses and stringers as much as 4 feet wide occurred in T.1N., Rs.3 and 4W.

Yellowstone National Park

Much of Yellowstone National Park, in the northwestern corner of Wyoming, is underlain by Pliocene and Quaternary rhyolitic tuffs and flows erupted from the Yellowstone caldera. The Bighorn Basin east of Yellowstone must have been inundated by ash falls originating from the park area and the Absaroka Mountains. This volcanic ash might be responsible for the numerous weak gold anomalies reported by Albert (1986) in the Bighorn Basin.

The study of gold occurrences in Yellowstone National Park has been restricted because of the national park designation. It is illegal to collect samples in the park without a permit. However, one authorized study by Gottfried and others (1972) reported randomly collected specimens of rhyolite tuffs and flows contained gold values of only 0.1 to 1.3 ppb, and basalt samples yielded an average of only

0.2 ppb Au. These values are very low indeed, especially when it is considered that the average crustal abundance is 4 ppb Au.

However, the thermal springs sampled by Gottfried and others (1972) produced some interesting results. The waters yielded only traces of gold, but the sinters deposited by the thermal waters tend to concentrate the gold in amounts that could be considered economic if they occurred outside the Park. The thermal waters contained only trace amounts of gold ranging from 0.004 to 0.1 ppb. Sinters associated with the springs yielded values ranging from 0.5 ppb to 5.0 ppm (Gottfried and others, 1972). It is also interesting to note that veinlets of auriferous pyrite were discovered in sinters deposited by the Monarch Geyser in the Norris Basin (Weed, 1905).

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APPENDICES

Appendix A. Ore minerals associated with Wyoming precious metal deposits

Appendix B. Historic metal prices

Appendix A

Ore minerals associated with Wyoming precious metal deposits

Arsenopyrite — FeAsS

Arsenopyrite is a silver-gray metallic mineral with high heft. It commonly produces a garlic odor when hammered. The mineral streak is black, it has prismatic cleavage, and in Wyoming it most commonly occurs as masses in quartz veins (Hausel, 1986e). Boyle (1979), reports gold solubility in arsenopyrite may be as high as 0.1 percent. Some deposits in the South Pass-Atlantic City district show a direct correlation of gold content and arsenic values, and some specimens from the Carissa mine have enclosed visible gold.

Azurite — $Cu_3(CO_3)_2(OH)_2$

This copper carbonate has a striking blue color that often forms crusts or stains on rocks and is associated with malachite and chalcopyrite. The mineral will effervesce in cold dilute hydrochloric acid. Specimens of malachite from Bisbee, Arizona, have been reported to contain as much as 29 ppm Ag and 0.210 ppm Au (Boyle, 1979).

Berthierite — $FeSb_2S_4$

This dark gray metallic mineral usually occurs in masses although some crystals have vertical striations. In Wyoming, it has only been reported in the Garrett (Sellers Mountain) area associated with arsenopyrite in a stratiform, low-grade gold deposit (Hausel, 1986e).

Bornite — Cu_5FeS_4

This metallic reddish bronze mineral has a characteristic iridescent blue and purple tarnish. It commonly occurs in masses with high heft intermixed with chalcopyrite and chalcocite. One sample from Mansfield, Germany, was reported to yield 8 ppm gold and >1,000 ppm silver (Boyle, 1979).

Cassiterite — SnO_2

Because of its high specific gravity, this brown to brownish black mineral often occurs in stream placers with gold. In the Black Hills region of Wyoming, many gold placers contain irregular to rare twinned, tetragonal, grains of cassiterite. Cassiterite has been reported to host as much as 100 ppm silver (Boyle, 1979).

Cerussite — $PbCO_3$

This is a colorless to white to gray mineral that has high heft and brilliant luster. The most characteristic habit is intergrown slender twinned crystals forming a grid-like pattern.

Chalcanthite — $CuSO_4 \cdot 5H_2O$

This is a soft, light weight, deep azure blue mineral that readily alters to a pale greenish white powder. Crystals are commonly thick, tabular, and triclinic.

Chalcocite — Cu_2S

This mineral is found associated with chalcopyrite, malachite, and tenorite. Chalcocite forms soft, sectile, black-gray masses often coated with a thin film of malachite. Specimens of chalcocite have been reported to contain a maximum of 12 ppm Au and 500 ppm Ag (Boyle, 1979).

Chalcopyrite — $CuFeS_2$

This deep bronze colored, metallic mineral is an important copper ore mineral. Chalcopyrite has been found in many of Wyoming's historic copper mines (Hausel, 1986a, 1986e). Boyle (1979) reported specimens of chalcopyrite have contained traces to 22 ppm Au and traces to 1,300 ppm Ag. Although chalcopyrite as well as bornite and chalcocite carry anomalous gold, Boyle stressed that free gold has not been observed in the minerals.

Chrysocolla — $CuSiO_3 \cdot 2H_2O$

Chrysocolla is a vitreous to earthy blue-green mineral occurring in compact masses, frequently associated with other secondary copper minerals such as malachite and azurite. It often has a glassy sheen.

Cobaltite — CoAsS

A hard, brittle, silver-white metallic sulfide, this mineral often occurs in masses, cubes, and pyritohedrons. Its appearance is similar to pyrite but cobaltite is silver in color compared to pyrite's brassy color. Boyle (1979) reports specimens containing from 0.3 to 10 ppm Au and from 1 to 50,000 ppm Ag.

Copper — Cu

Native copper forms soft, sectile, malleable, copper-red metallic crystals, plates, irregular masses, and dendrites. Copper has a distinct hackly fracture, metallic luster, and commonly is associated with malachite. Boyle (1979) reports native copper can have significant gold and silver contents. For example, some copper from Kviteseid, Norway, contained as much as 200 ppm Au and >1,000 ppm Ag.

Covellite — CuS

Covellite forms distinctive, dark indigo blue, platy masses that split into thin flexible cleavage plates. It has a perfect basal, micaceous cleavage and is associated with other copper minerals typical of secondary sulfide enrichment such as bornite and chalcocite. Some covellite from the New Rambler mine has been platinum bearing.

Cuprite — Cu_2O

Cuprite forms earthy to submetallic red masses typically associated with malachite and similar secondary cupriferous minerals. Cuprite has been found in several copper deposits in the Sierra Madre (Hausel, 1986e).

Electrum — Au, Ag

This is a variety of gold that contains more than 20 percent silver.

Galena — PbS

Galena is a soft, massive to cubic, lead-gray mineral with very high heft (specific gravity). The mineral is soft enough that it can easily be scratched with a knife. According to Boyle (1979), galena has been known to carry from a trace to 30 ppm Au, but galena is more often associated with silver. Silver-rich cubic specimens may have slightly bowed or rounded surfaces and may contain as much as 6,300 ppm Ag.

Gold — Au

Gold forms soft, sectile, malleable, metallic, golden yellow masses and flakes with very high heft. It frequently occurs in veins associated with limonite, pyrite, arsenopyrite, or copper minerals, and as nuggets in stream placers. Gold forms an alloy with silver. Gold purity is reported as fineness, such that 0.900 fine means the specimen is 90 percent Au and 10 percent other metals (principally silver although gold can alloy with other metals such as Cu, Fe, Pt, Pb, Zn, Sn, and Bi).

Hematite — Fe_2O_3

Hematite's habits include soft, dull, earthy red material to hard steel gray masses that produce characteristic reddish brown streaks. Hematite was mined for nearly 100 years in the Hartville uplift of eastern Wyoming (Hausel, 1986e) and occurs in association with some gold deposits at South Pass and with massive sulfides in the Tin Cup district. According to Boyle (1979), the few specimens of hematite tested for gold and silver have not generally yielded anomalous amounts. Gold is generally not detectable in hematite and, in three of four samples from Canada reported by Boyle (1979, p. 34), silver was not detected. The fourth specimen contained 7.5 ppm Ag. However, a sample of hematite collected by the author from the Outpost mine in South Pass contained 1.33 ppm Au.

Limonite — $FeO(OH) \cdot nH_2O$

Limonite closely resembles goethite [$FeO(OH)$] and is commonly a vitreous to dull-earthy porous mass often found as replacement of sulfides in quartz veins. Native gold is sometimes observed in limonitic boxworks in some of Wyoming's quartz veins such as in the Bradley Peak area of the Seminoe Mountains district or Gold Hill in the Medicine Bow Mountains. Boyle (1979) reported various limonite specimens to have 1 to 35 ppm Au and 1 to more than 1,000 ppm Ag.

Lorandite — $TlAsS_2$

Lorandite has been identifed as carmine red to ocher yellow encrustations on fine-grained massive pyrite at the New Rambler mine, Wyoming. The mineral occurs in association with realgar and orpiment.

Magnetite — Fe_3O_4

Magnetite is a highly magnetic, steel gray to black oxide commonly occurring as octahedrons to rounded equant grains in stream placers (black sands) or as magnetic masses in banded iron formation (Hausel, 1986e). Boyle (1979) suggested a small amount of gold may substitute for iron in the magnetite lattice, but reported values range only up to 0.05 ppm Au.

Malachite — $Cu_2CO_3(OH)_2$

Malachite occurs as bright to dull green masses and as coatings or encrustations found in association with other secondary copper minerals such as cuprite, azurite, and chrysocolla. Malachite may contain traces of gold as well as anomalous silver. According to Boyle (1979), one specimen from Bisbee, Arizona, yielded 106 ppm Ag.

Marcasite — FeS_2

Marcasite occurs as hard, brittle, pale brassy colored masses or as tabular cockscomb crystals with a greenish cast.

Olivenite — $CuAsO_4$

Olivenite occurs in the oxidized zone of some ore deposits with malachite, scorodite, limonite, and azurite. The mineral's habit is generally opaque to translucent, vitreous olive green to greenish brown, massive, earthy to fibrous crystals.

Orpiment — As_2S_3

Orpiment occurs as soft, sectile, lemon yellow, foliated masses with resinous to pearly luster found in association with realgar. Its perfect micaceous cleavage and association with realgar are used to distinguish it from sulfur.

Polybasite — $(Ag,Cu)_{16}Sb_2S_{11}$

Polybasite often forms soft, iron-black masses and pseudohexagonal tabular crystals with trigons on the basal surfaces. It is usually found in hydrothermal veins.

Pyrite — FeS_2

Pyrite, frequently called "fool's gold", often occurs in association with gold. The pyrite itself may host significant gold. It occurs as a brass colored, hard, brittle, metallic mineral in cubes, pyritohedrons, and masses. The mineral has a greenish black streak. Boyle (1979) reports that gold will occur in solid solution with pyrite, and that up to 2,000 ppm gold may substitute in the crystal lattice. Gold also forms crystalline crusts on pyrite.

Pyrrhotite — $Fe_{1-X}S$

Pyrrhotite has been identified in several of the gold deposits at South Pass and is also found in the Esterbrook district. It usually occurs in granular masses as a brittle, bronze colored, metallic mineral that is weakly to moderately magnetic. Pyrrhotite has been reported to contain traces to 22 ppm Au and up to 100 ppm Ag (Boyle, 1979).

Platinum — Pt

Platinum is a precious metal that occurs as a silver-gray malleable metal that does not tarnish. The metal has a very high heft similar to native gold. Platinum may be weakly magnetic depending upon its iron content. Platinum has been found occurring as nuggets in some of the Douglas Creek district placers, and also has been recovered from covellite ore at the New Rambler mine in the Medicine Bow Mountains. The platinoids invariably contain some gold. Boyle (1979) reports some specimens have contained up to 3 percent Au and >1,000 ppm Ag. Some osmiridium (Os, Ir), an alloy of platinoids, has been reported to carry as much as 19.3 percent Au. The platinum group includes Ir, Os, Pd, Pt, Rb, Rh, and Ru.

Realgar — AsS

This is a soft, sectile, orange-red mineral that alters to orpiment. It is rare in Wyoming.

Scorodite — $FeAsO_4 \cdot 2H_2O$

Scorodite occurs as a pale grayish to yellowish green and yellowish brown, porous to earthy crust on quartz veins associated with arsenopyrite. It is relatively common in the South Pass region. Because it forms from the replacement of arsenopyrite, it often contains gold values up to 10 ppm and silver values as high as 50 ppm (Boyle, 1979).

Siderite — $FeCO_3$

Siderite is a brittle, pale yellow to yellowish brown, rhombohedral to massive mineral with moderate heft. Typically, siderite, like all of the common carbonates, carries very low gold contents (Boyle, 1979).

Silver — Ag

Silver has a high specific gravity, and in the native form it is a soft, sectile, malleable, gray to black tarnished mineral that produces a shining silver streak. It commonly occurs in wires and dendritic shapes. Gold may or may not occur in significant amounts with silver, however, gold substitutes for silver and a complete series extends through native silver to native gold (Boyle, 1979).

Sperrylite — $PtAs_2$

Sperrylite is a rare, tin-white, cubic metallic mineral found associated with covellite at the New Rambler mine in the Medicine Bow Mountains. Specimens from Sudbury, Ontario, have contained as much as 700 ppm Au and 2,300 ppm Ag (Boyle, 1979).

Sphalerite — ZnS

Sphalerite occurs as resinous, brown, isometric crystals associated with galena, pyrite, or chalcopyrite. Gold values in sphalerite range from 0.0012 to 4.08 ppm and the gold, when present, occurs as very finely dispersed inclusions in the sphalerite (Boyle, 1979).

Stromeyerite — AgCuS

Stromeyerite usually occurs in compact brittle masses with a dark blue tarnish on the steel-gray mineral. It is rare in Wyoming.

Sylvanite — $(Au,Ag)Te_2$

Sylvanite is a soft, brittle, massive, and silver-white metallic mineral with high heft. The mineral often exhibits a yellowish cast. Sometimes sylvanite occurs in distinctive skeletal crystals that resemble writing (graphic habit).

Tennanite — $(Cu,Fe)_{12}As_4S_{13}$

Tennanite is a massive, granular to compact, steel-gray to black metallic mineral, which sometimes forms modified tetrahedral crystals. Boyle (1979) reported that tennanite often carries significant silver (up to 785 ppm).

Tenorite — CuO

Tenorite occurs as a shining to earthy black stain associated with other oxidation-zone copper minerals such as malachite and cuprite.

Tetrahedrite – $Cu_{12}Sb_4S_{13}$

This mineral occurs as tetrahedral crystals and as massive to granular grains in veins and fractures. It is steel gray to black metallic. Tetrahedrite often contains significant silver (as much as 25 percent Ag) and anomalous gold (as much as 100 ppm Au) according to Boyle (1979).

Wad (manganese oxides)

Manganese oxides including pyrolusite (MnO_2) and psilomelane [$BaMnMn_8O_{16}(OH)_4$] generally have minor to anomalous gold ($<$100 ppm) although some specimens are rich in silver (1,000 ppm or more) (Boyle, 1979). However manganiferous ores are refractory and only yield their silver values.

Appendix B

Historic metal prices

Year	Au ($/oz)	Ag ($/oz)	Cu ($/lb)	Year	Au ($/oz)	Ag ($/oz)	Cu ($/lb)
1867	20.67	1.33	0.25	1910	20.67	0.54	0.13
1868	20.67	1.33	0.23	1911	20.67	0.53	0.13
1869	20.67	1.33	0.23	1912	20.67	0.62	0.17
1870	20.67	1.33	0.20	1913	20.67	0.60	0.16
1871	20.67	1.33	0.22	1914	20.67	0.55	0.13
1872	20.67	1.32	0.32	1915	20.67	0.51	0.18
1873	20.67	1.30	0.29	1916	20.67	0.66	0.25
1874	20.67	1.28	0.23	1917	20.67	0.82	0.27
1875	20.67	1.25	0.23	1918	20.67	1.00	0.25
1876	20.67	1.16	0.21	1919	20.67	1.12	0.19
1877	20.67	1.20	0.18	1920	20.67	1.09	0.18
1878	20.67	1.15	0.16	1921	20.67	1.00	0.13
1879	20.67	1.12	0.18	1922	20.67	1.00	0.14
1880	20.67	1.15	0.19	1923	20.67	0.82	0.15
1881	20.67	1.14	0.17	1924	20.67	0.67	0.13
1882	20.67	1.14	0.18	1925	20.67	0.69	0.14
1883	20.67	1.11	0.15	1926	20.67	0.62	0.14
1884	20.67	1.11	0.12	1927	20.67	0.57	0.13
1885	20.67	1.06	0.11	1928	20.67	0.59	0.14
1886	20.67	1.00	0.10	1929	20.67	0.53	0.18
1887	20.67	0.98	0.11	1930	20.67	0.39	0.13
1888	20.67	0.94	0.15	1931	20.67	0.29	0.09
1889	20.67	0.94	0.12	1932	20.67	0.28	0.06
1890	20.67	1.05	0.12	1933	25.56	0.35	0.06
1891	20.67	0.99	0.13	1934	34.95	0.65	0.08
1892	20.67	0.88	0.11	1935	35.00	0.72	0.08
1893	20.67	0.78	0.09	1936	35.00	0.77	0.09
1894	20.67	0.64	0.09	1937	35.00	0.77	0.12
1895	20.67	0.65	0.10	1938	35.00	0.65	0.10
1896	20.67	0.67	0.11	1939	35.00	0.68	0.10
1897	20.67	0.60	0.11	1940	35.00	0.71	0.11
1898	20.67	0.59	0.12	1941	35.00	0.71	0.12
1899	20.67	0.60	0.18	1942	35.00	0.71	0.12
1900	20.67	0.62	0.16	1943	35.00	0.71	0.13
1901	20.67	0.60	0.16	1944	35.00	0.71	0.14
1902	20.67	0.53	0.12	1945	35.00	0.71	0.14
1903	20.67	0.54	0.13	1946	35.00	0.81	0.16
1904	20.67	0.57	0.13	1947	35.00	0.91	0.21
1905	20.67	0.60	0.16	1948	35.00	0.91	0.22
1906	20.67	0.67	0.19	1949	35.00	0.91	0.20
1907	20.67	0.66	0.20	1950	35.00	0.91	0.21
1908	20.67	0.53	0.13	1951	35.00	0.91	0.24
1909	20.67	0.52	0.13	1952-68	35.00	—	—
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ABBREVIATIONS AND CONVERSION FACTORS USED IN THIS TEXT

Chemical symbols

Symbol	Element	Symbol	Element
Ag	Silver	Mo	Molybdenum
Al	Aluminum	Na	Sodium
Ar	Argon	Nb	Niobium
As	Arsenic	Ni	Nickel
Au	Gold	O	Oxygen
B	Boron	Os	Osmium
Ba	Barium	P	Phosphorus
Be	Beryllium	Pb	Lead
Bi	Bismuth	Pd	Palladium
C	Carbon	Pt	Platinum
Cd	Cadmium	Rb	Rubidium
Ce	Cerium	Rh	Rhodium
Co	Cobalt	Ru	Ruthenium
Cr	Chromium	S	Sulfur
Cu	Copper	Sb	Antimony
F	Fluorine	Sc	Scandium
Fe	Iron	Si	Silicon
Ga	Gallium	Sn	Tin
Ge	Germanium	Sr	Strontium
Hg	Mercury	Te	Tellurium
Ir	Iridium	Th	Thorium
K	Potassium	Ti	Titanium
La	Lanthanum	Tl	Thallium
Mg	Magnesium	W	Tungsten
Mn	Manganese	Y	Yttrium
		Zn	Zinc

Conversion factors

1 ounce (oz)	=	31.1 grams
1 ounce (oz)	=	20 pennyweights
1 metric ton (tonne)	=	1,000 kilograms
1 short ton	=	0.907 metric ton or 2,000 pounds
1 ounce per ton (oz/ton)	=	34.3 grams per tonne
1 ounce per ton (oz/ton)	=	34.3 parts per million (ppm)
1 part per million (ppm)	=	1,000 parts per billion (ppb)
1 percent	=	10,000 ppm
1 ounce per cubic yard	=	40.7 grams per cubic meter

Miscellaneous

$<$ = less than
$>$ = greater than
lbs = pounds
yd^3 = cubic yard

Age

Ga = billions of years (old)
Ma = millions of years (old)

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