WYOMING STATE GEOLOGICAL SURVEY
Gary B. Glass, State Geologist

ECONOMIC GEOLOGY OF THE SEMINOE MOUNTAINS MINING DISTRICT, CARBON COUNTY, WYOMING

by

W. Dan Hausel

Report of Investigations No. 50
1994

Laramie, Wyoming

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Front Cover: Outcrop of banded iron formation over 2.7 billion years old from the Archean Seminoe formation (Precambrian), Seminoe Mountains, Wyoming. Photograph by W.D. Hausel.

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STATE OF WYOMING
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... a land where the rocks are iron and you can dig copper out of the hills.

Deuteronomy 8:9

Abstract

The Seminoe Mountains form a Precambrian-cored Laramide uplift near the southern margin of the Wyoming craton. The core of the range consists of Archean age crystalline supracrustal rocks greater than 2.7 billion years old (>2.7 Ga) folded into a vertically plunging open fold intruded by granodiorite (>2.6 Ga).

The amphibolite-grade supracrustal rocks are subdivided into three mappable units. The lowermost unit, the Sunday Morning Creek metavolcanics, consists of 11,000 feet of mafic schists with a minor amount of ultramafic schist and metasedimentary rocks. This unit is overlain by a middle unit, the Bradley Peak ultramafics, which consist of 1,000 feet of ultramafic and mafic metavolcanic rocks. These rocks include several mappable ultramafic flows that grade upward from cumulate serpentinite flow bottoms to tremolite-talc-chlorite schist spinifex flow tops. Compositions and textures indicate they are peridotitic and basaltic komatiites. The uppermost unit, informally named the Seminoe formation, consists of 4,000 feet of metasedimentary rocks including metagreywacke, banded iron formation, and pelitic schist, with minor amounts of mafic and ultramafic schist.

Exploration of the district has identified more than 100 million tons of banded iron formation, narrow high-grade gold veins, localized copper-silver-gold veins, gold placers, serpentine, jade, leopard rock, asbestos, kimberlitic indicator minerals, and anomalous zones of zinc and lead. A broad zone of propylitically altered amphibolite with secondary epidote-chlorite-carbonate and quartz-carbonate-sulfide veins may contain a large-tonnage gold deposit.

Introduction

The Seminoe Mountains mining district of south-central Wyoming is restricted to a belt of Archean (>2.5 Ga) metamorphic rocks cropping out along the western flank of the Seminoe Mountains. The core of the Seminoe Mountains is formed by crystalline rocks consisting of an ancient greenstone terrane of metamorphosed volcanic, sedimentary, and plutonic rocks intruded by Late Archean granodiorite. The metamorphic rocks include amphibolite, mica schist, serpentinite, ultramafic schist, metagreywacke, metapelite, and banded iron formation. The flanks of the Precambrian core are unconformably overlain by Phanerozoic [<570 Ma (million years) old] sedimentary rocks that form a spectacular, steeply dipping precipice along the southern flank of the range.

The district is known for its iron ore and gold deposits, but also hosts some copper, silver, serpentine, asbestos, jasper, jade, and leopard rock. During the author's work in this area, some previously unknown zones of anomalous lead and zinc associated with shear zones were detected, and some pyrope garnet and chromian diopside were recovered from a nearby placer. Historic ore production from the district has been minor.

Previous investigations

Iron ore deposits of the Seminoe Mountains were initially investigated by Hendricks (1902) and Dickman (1906), both of whom recognized relatively small reserves of high-grade iron ore in the Pattison Basin area along the southern margin of Bradley Peak. The Bradley Peak area, at the western edge of the Seminoe Mountains, was initially mapped by Lovering (1929), who examined the Precambrian geology emphasizing its iron ore potential. Many years later, Bishop (1964) mapped a large portion of the Seminoe Mountains east of Bradley Peak, and Blackstone (1965) mapped a portion of the Bradley Peak 7 1/2-minute Quadrangle with emphasis on the Bradley Peak thrust fault. Bayley (1968) remapped the Bradley Peak Quadrangle as part of a U.S. Geological Survey field project.

A study on the geology, petrology, and geochemistry of the Bradley Peak area was completed by Klein in 1981. Klein (1981) recognized the Seminoe Mountains as a fragment of an Archean greenstone belt that hosted several metakomatiite flows. Hausel (1989a; 1991a) remapped the supracrustal rocks of the Seminoe Mountains greenstone belt using the earlier work of Klein (1981), Bayley (1968), Blackstone (1965), and Bishop (1964) as a foundation.

The mining district and greenstone belt were toured by the 1982 Archean Geochemistry field conference (Klein, 1982), the 1989 International Geological Congress (Snyder and others, 1989), and the 1991 Wyoming Geological Association field conference (Blackstone and Hausel, 1991). Attendees at all three conferences noted striking similarities to greenstone belts found in Canada, Western Australia, and southern Africa.

Acknowledgments

Without the cooperation and access granted by John France and the Miller Estate Company, this project would not have been possible. I would also like to thank two wonderful people, Donna Kortes and the late Charlie Kortes, for their hospitality, assistance in researching mining claims, and for providing some historical information on the district. I sincerely appreciate their assistance and friendship. I am also indebted to G.G. Kortes and Kim Kortes for their hospitality and for the placer gold specimens they provided to the Wyoming State Geological Survey. I would like to thank Dr. Paul J. Graff for his critical review of the manuscript. The mapping of the Seminoe mining district was greatly enhanced by color aerial photography loaned by Dave Martinez of the U.S. Bureau of Land Management (Rawlins District).

Finally, I would like to dedicate this publication to the late Charlie Kortes. No finer man or prospector ever walked on this planet.

History

The Seminoe Mountains were named in honor of one of General John C. Fremont's guides, Basil Cimineau Lajeunesse. Lajeunesse's middle name, Cimineau, is pronounced "Seminoe" in English. Lajeunesse, a French trapper, was responsible for leading Fremont's expedition out of the Sweetwater Valley through Seminoe Pass, 20 miles west of the Seminoe Mountains near the western edge of the Ferris Mountains (Reed, 1872). Seminoe Pass was renamed Whiskey Gap following the July, 1862, destruction of a load of "bootleg" whiskey by Captain Brown of the 11th Ohio Cavalry at a spring located in the gap (Ferry, 1871).

In June, 1871, troops under the command of General Bradley of Fort Sanders and General Thayer of Nebraska, set out on an expedition to the Seminoe Mountains to search for reported rich deposits of argentiferous galena (Ferry, 1871). An 1869 report by Lieutenant R.H. Young of Fort Steele had described three prospectors returning from the Seminoe Mountains with samples of quartz assaying $2,000 a ton in silver (Morrow, 1871). This is about 1,500 opt (ounces per ton) of silver (Ag).

Instead of finding silver (which probably came from the Ferris Mountains instead of the Seminoe Mountains), gold-quartz veins were discovered by Mr. Ernest, a gold prospector from Laramie who accompanied the 1871 expedition. Ernest's discovery was made along the flank of Bradley Peak (named in honor of General Bradley) about one-half mile west of Deweese Pass. Deweese Pass was named for Captain Deweese who was the first military officer to drive through the pass with wagons (Ferry, 1871).

Shortly after General Bradley's expedition, a second expedition led by General Morrow, along with Captain Dewesse of Fort Steele, was accompanied by E.P. Ferry (surveyor). This expedition reached the southern flank of the Seminoe Mountains where *1,000 feet of Silurian, silver-bearing, limestone near* [the] *Platte* canyon was encountered prior to reaching the crystalline rocks in the core of the range (Ferry, 1871). These "Silurian" limestones were probably part of the Mississippian Madison Limestone, although no known silver-bearing limestones are found in this area.

Several gold prospects were staked following these historic expeditions. Most of the prospects were located on well-defined, gold-quartz veins along the flank of Bradley Peak and included the Ernst, Mammoth, Break of Day, Jesse Murdock, Slattery, and Edward Everett prospects in what was initially known as the Ernst mining district. In several instances, the ore reportedly assayed as high as $100 per ton in gold (5 opt), and in one case ran as high as $250 per ton (12 opt) (Morrow, 1871). In 1873, everything appeared propitious following the erection of a stamp mill by the owners of the Ernst gold mine (Reed, 1873), but in the following year, all prospecting and mining came to an abrupt halt. According to an 1874 Congressional report, many of those living in the mining camp were killed in an

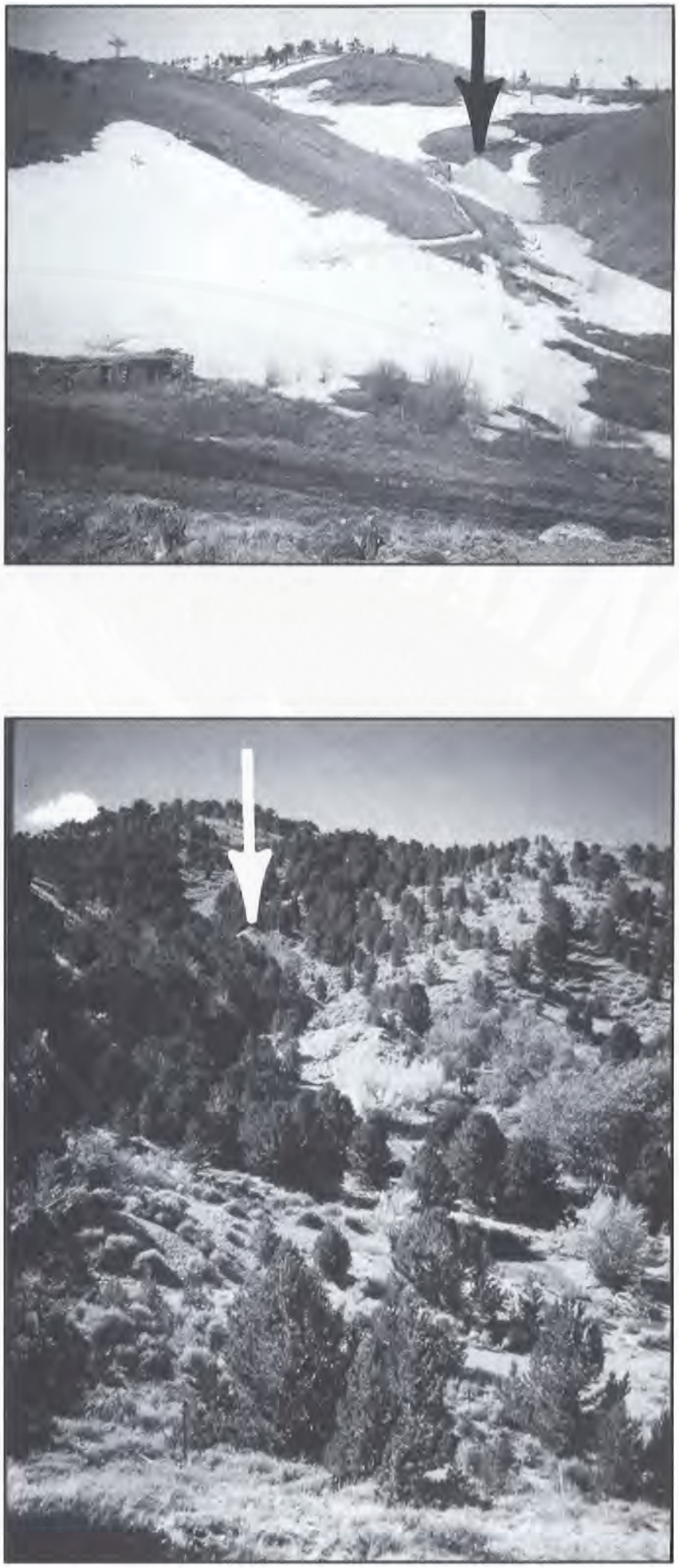
Indian raid, and the few survivors were driven from the district (Reed, 1874). A cavalry expedition to the district reported that all 30 cabins and the stamp mill were vacated (*Rawlins Sentinel*, September 11, 1874).

The Seminoe district was avoided by the miners and prospectors for the next few years. As many as four years after the conflict, an 1878 Congressional report (Reed, 1878) stated: *A visit to the Seminoe Mountains found the mining camp for the most part deserted.* A sample collected from the Ernst tunnel at this time assayed $106.20 in gold per ton (5.14 opt). The report went on to state: *Other prospects in this locality afford quite good indications; and, now that the Indians are no longer to be feared there, I shall expect a revival of interest in it on the return of more prosperous times* (Reed, 1878).

This optimistic report apparently did not hold true, for in an 1881 Congressional report, Corey wrote: *...shafts went down to a little depth and tunnels had been ambitiously started when this camp too was broken up by a band of hostiles...* . It is not clear if this report refers to the earlier 1874 Indian raid or an 1881 raid. In any case, if hostile attacks were not enough, the mining pro-perties were also held in litigation, for it was also stated: *...this property, long in litigation, has just been fully cleared as to its title, and the present undisputed owners are preparing to commence work the next season...* (Corey, 1881).

According to the *Engineering and Mining Journal (EMJ)* (v. 39, April 18, 1885, p. 269), some mines in the district were purchased by the Penn Mining Company in 1885. The Penn Mining Company based out of Wilkes-Barre, Pennsylvania, was incorporated on May 5th, 1885, with a capital stock of $100,000. Five company trustees were named, including Samuel Aughey, the Wyoming Territorial Geologist.

Aughey (1886) reported that the company extended the Deserted Treasure tunnel (possibly the original Ernst mine) to a length of 200 feet (**Figures 1** and **2**). The ore from the mine was described as having free-milling gold in quartz associated with pyrite and chalcopyrite. The vein averaged 4 feet thick. The company constructed a 10-stamp mill with a concentrator which successfully handled about 22 tons of ore per day (Warren, 1885; Aughey, 1886). Plans were made to


a.

b.

Figure 1. (a) Historical photograph (date unknown) of the Deserted Treasure mine dump (arrow). (Photograph courtesy of American Heritage Center, University of Wyoming. Reproduced with permission.) (b) View of the same area taken by the author in 1991. Arrow points to the same mine dump seen in **Figures 2(a)** and **2(b)**. The Deserted Treasure mine is probably the original site of the Ernst mine.

a.

b.

Figure 2. (a) Historical photograph (date unknown) of the Deserted Treasure tunnel and mine dump. (Photograph courtesy of American Heritage Center, University of Wyoming. Reproduced with permission.) (b) View of the same area taken by the author in 1988. Note the thick stand of trees which has invaded the hillside over the years.

construct another stamp mill after the Penn Mining Company struck a 6-foot-thick gold-bearing vein (*EMJ*, v. 42, October 9, 1886, p. 265).

A later document (*EMJ*, v. 59, May 18, 1895, p. 472) disputed the success of the mill and reported that the 10-stamp mill erected by the Penn Mining Company had been a failure due to bad management (and possibly due to the lack of oxidized ore and abundant sulfides in the mine). Three clean-ups from the mill gave \$8, \$12, and \$16 in gold per ton, respectively (*EMJ*, v. 59, May 18, 1895, p. 472).

Another mine operated by the Penn Mining Company, the King mine, ran almost parallel to the Deserted Treasure mine, but more southwesterly and northeasterly (**Figure 3**). In 1886, improvements in the King mine included a 120-foot drift

Figure 3. Historical photograph of the King (?) mine and mill (date unknown). (Photograph courtesy of American Heritage Center, University of Wyoming. Reproduced with permission.)

with a 54-foot-deep winze. At the bottom of the winze, the ore was 5 feet thick. Seventy tons of the King ore reduced by the mill yielded $700 in gold, but the sulfides were not saved. The East King mine shaft (an extension of the King property) and crosscut encountered a streak of very high grade, gold-bearing quartz. Other properties in the district included the Jennie, Meager, and Bennett properties (Aughey, 1886).

In addition to the lode mines, some placer activity was also reported in the district. The *EMJ* (v. 42, October 9, 1886, p. 265) reported two placer miners named Hanley and Firth worked a claim that yielded $0.30 to the pan. For several years after 1886, not much was reported about the Seminoe district, although Ricketts (1888) noted the occurrence of iron in the district. Then in 1894, the *EMJ* (v. 58, December 29, 1894, p. 615) reported the Penn Mining Company had resumed work on its gold mines in the Seminoe Mountains after a 6-year shut down.

During this period, the mines were enlarged. The King mine was extended from 120 feet in 1886 to 700 feet in 1896. The vein varied from 1 to 4 feet wide with an average width of 30 inches. Assays of the vein quartz averaged $25 in gold per ton (1.2 opt) (*EMJ*, v. 62, August 8, 1896, p. 135). The "Penn mine" tunnel was also extended to 165 feet with a 135-foot-deep winze on a 3- to 5-foot-wide vein. Drifts were driven along the ore body for a distance of 100 feet in each direction. The ore from the mine averaged $20 in gold per ton (1.0 opt) and carried some copper. The stamp mill, however, recovered only $3 to $4 in gold per ton due to the refractory nature of the ore (*EMJ*, v. 62, August 8, 1896, p. 135).

In 1902, some interest in iron was expressed when Hendricks (1902) examined the high-grade iron deposits in the Pattison Basin area along the southern flank of Bradley Peak for the Lake Superior Iron Company. He estimated the Pattison Basin deposits included one million tons of ore averaging 60 percent iron.

In 1906, claims were staked for gold around the south side of Bradley Peak, where a tunnel was apparently initiated several hundred vertical feet below the workings of the old Penn Mining Company. The purpose of this tunnel was to cut the veins on all the claims found on the mountain. It was the intention of these claimants to run drifts along all the veins encountered in the exploratory tunnel (*Wyoming Industrial Journal* (*WIJ*), v. 8, no. 3, August, 1906, p. 14-15). The *WIJ* (v. 8, no. 4, September, 1906, p. 7) later reported the Seminoe Gold Mining Company had driven this tunnel in 100 feet, but there is no present day evidence that this project continued any farther.

Also in 1906, more interest in the extensive iron deposits in the Seminoe Mountains was reported when the Western Iron Ore Company acquired claims in the district. The company intended to patent all of its holdings (*WIJ*, v. 8, no. 2, July, 1906, p. 8). At about the same time, Dickman (1906) reported some of the iron deposits in the district yielded weak precious metal anomalies.

The first detailed description of the iron deposits was made by Lovering (1929). Another detailed investigation was made 37 years later by the U.S. Bureau of Mines (Harrer, 1966). Harrer estimated about 100 million tons of taconite (banded iron formation) occurred in the vicinity of Bradley Peak. In 1951, a geophysical investigation of the iron deposits in the Pattison Basin area was made by Wilson Exploration Company for Empire State Oil Company of Thermopolis, Wyoming. Later, the U.S. Geological Survey completed an aeromagnetic survey of the district (Philbin and McCaslin, 1966).

In 1979 and 1980, gold prices rose to their highest levels in history. In the following year (1981), the author visited the Seminoe district and recovered several quartz vein samples with visible gold that assayed as high as 2.87 opt (the more highly mineralized samples were not assayed). A sample of iron formation recovered at that time assayed more than 1.0 opt Au (Hausel, 1989b). Following this discovery, a gold rush occurred, and Timberline Minerals Company and Kerr-McGee Corporation obtained favorable land positions.

Geologic setting

The Seminoe Mountains lie in central Wyoming along the southeastern margin of the Wyoming Province and form an uplifted Laramide thrust wedge cored by Precambrian metamorphic and plutonic rocks. The Precambrian core consists of Archean metasedimentary and metavolcanic rocks > 2.7 Ga exposed in a broad, vertically plunging fold. The rocks are of lower amphibolite grade and were intruded and folded by syntectonic granodiorite (> 2.6 Ga) (Snyder and others, 1989, p. 27).

The Seminoe Mountains were uplifted during the Laramide orogeny. The uplift is bounded on the southwest by a low-angle reverse fault originally named the Seminoe thrust by Lovering (1929) and later renamed the Bradley Peak thrust by Blackstone (1965). The thrust places Archean crystalline rocks (in the hanging wall) on a footwall of Phanerozoic sedimentary rocks as young as the Late Cretaceous Mesaverde Formation (Blackstone, 1965) (**Figure 4**). To the north, the Seminoe Mountains are bounded by the Kortes reverse fault, a Precambrian shear zone that was reactivated by both Laramide-age deformation and late Cenozoic deformation (Klein, 1981; Bohn, 1990).

The crystalline rocks in the Seminoe Mountains are interpreted to represent a fragment of an Archean greenstone belt dominated by metavolcanic rocks with compositions ranging from tholeiitic to komatiitic (**Figure 5**) (Klein, 1981). The lower portion of the metamorphic belt consists of about 11,000 feet of mafic metavolcanic and volcaniclastic rocks informally named the Sunday Morning Creek metavolcanics (**Figure 6**), which include amphibolite, metabasalt, and metatuff of tholeiitic affinity, mica schist of possible sedimentary origin, and minor serpentinite with peridotitic affinity. This lower metavolcanic unit is intruded by metagabbro sills and plugs that occur in greater frequency near the top (?) (north) of the unit. No definite pillow structures were found; thus, the topping criteria of the entire metamorphic belt is based on flow textures in the Bradley Peak ultramafics.

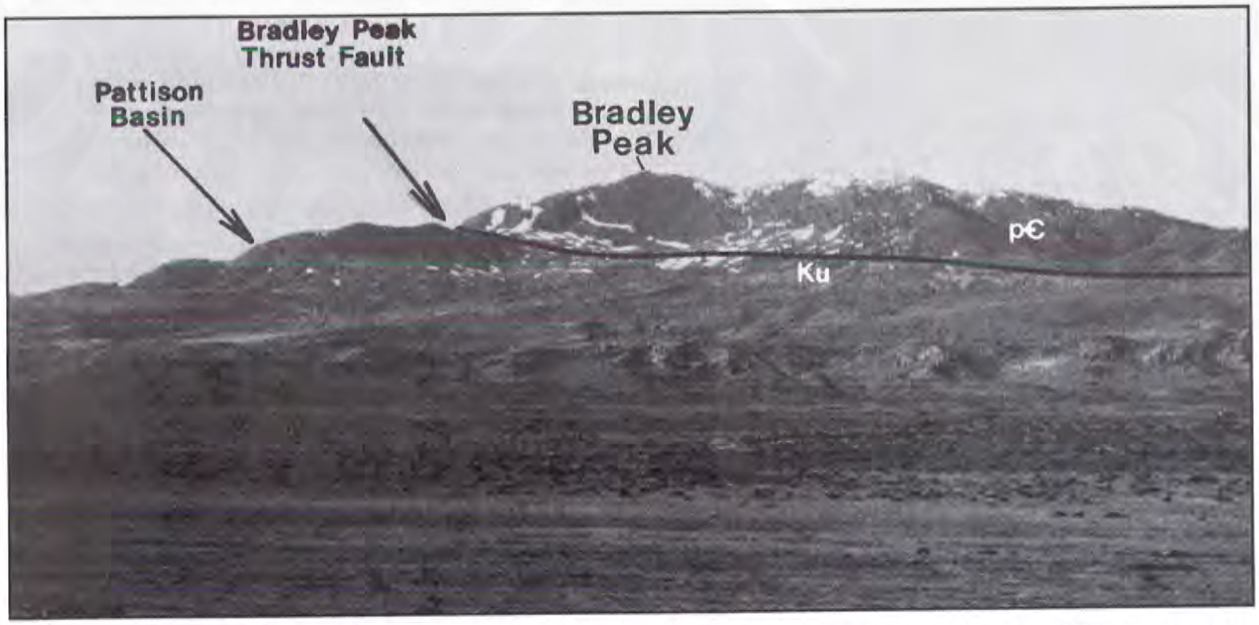


Figure 4. View northwest towards Bradley Peak from the vicinity of Cheyenne Ridge showing location of the Bradley Peak thrust fault (arrow) and Pattison Basin. p€ indicates Precambrian rocks, Ku indicates Upper Cretaceous rocks. (Photograph by W.D. Hausel, 1991; after Blackstone and Hausel, 1991.)

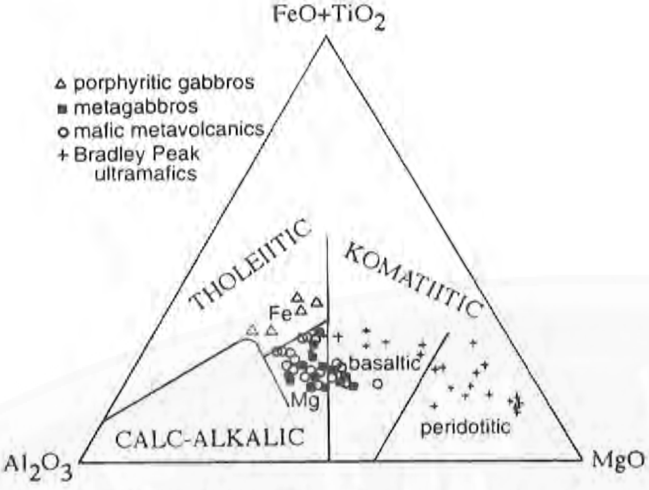


Figure 5. Jensen AMF ternary diagram showing compositions of metaigneous rocks from the Seminoe Mountains greenstone belt (from Klein, 1981).

The Sunday Morning Creek metavolcanics are overlain by nearly 1,000 feet of mafic and ultramafic schists informally named the Bradley Peak ultramafics by Klein (1981, 1982). The Bradley Peak ultramafics consist of massive to highly foliated amphibolites, serpentinites, and tremolite-talc-chlorite schists dominated by komatiite chemistries. Most rocks in this unit, with MgO contents generally greater than 9 percent, are classified as komatiites based on their chemistry and texture.

The Bradley Peak ultramafics are overlain by 2,000 to 4,000 feet of interlayered metasedimentary and metavolcanic rock named the Seminoe formation by Lovering (1929). These include thick bands of quartz-magnetite-grunerite iron formation, some chlorite schist, metagreywacke, and metapelite. Metavolcanics include metabasalt, crystal and lithic metatuffs, and felsic schists.

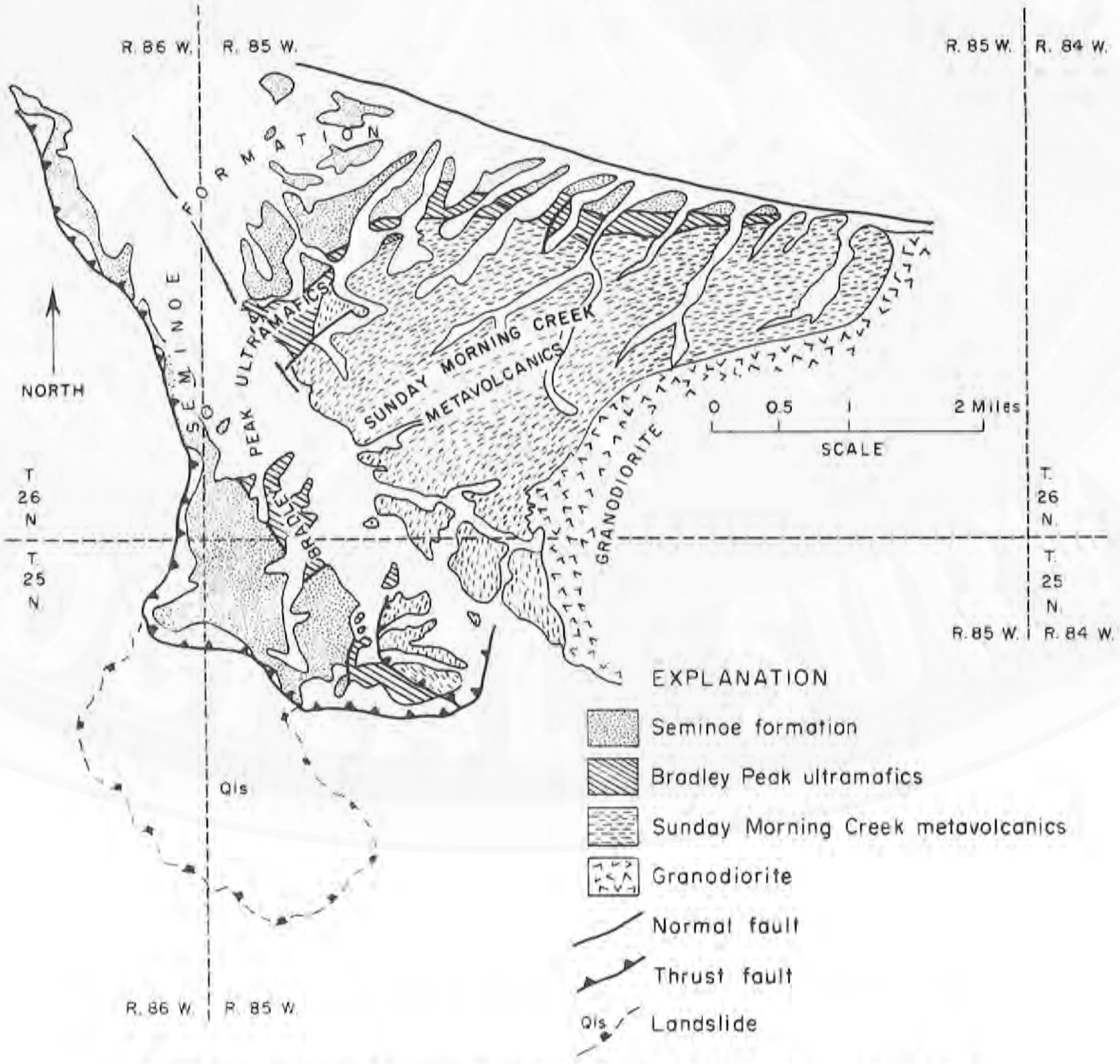


Figure 6. Generalized geologic map of the Seminoe Mountains greenstone belt.

Supracrustal rocks

Sunday Morning Creek metavolcanics

This succession is well exposed along Sunday Morning Creek in section 28, T26N, R85W, and includes amphibolite, metabasalt, metatuff, and mica schist, with minor banded iron formation and serpentinite (**Figure 6** and **Plate 1**). The unit has been intruded by metagabbro sills which occur in greater frequency near the top (north) of the unit.

Mafic metavolcanics

The bulk of the Sunday Morning Creek metavolcanics consists of foliated mafic metavolcanic rocks. These are slightly to intensely foliated, dark grey to black, orthoamphibolites and chlorite schists. The prominent foliation in these rocks parallels the bedding, as determined by its concordancy with intercalated layers of metasedimentary rocks. Primary textures are typically lacking. Microscopically, the orthoamphibolites have subhedral hornblende in a pronounced nematoblastic texture. Locally, nonfoliated textures dominate where hornblende occurs as equant xenoblastic grains. Plagioclase (An_{40} to An_{35}) is generally granoblastic and largely untwinned. Hornblende and plagioclase typically occur in nearly equal amounts in these rocks with minor magnetite and accessory sphene, epidote, apatite, biotite, and quartz (Klein, 1981).

Whole-rock analyses of the amphibolites range from 4.39 to 10.9 weight percent MgO (Samples 4L-7L, **Table 1**). With the exception of Sample 4L, these analyses fall within the tholeiite field of a

Table 1. Major and trace element analyses of rocks of the Sunday Morning Creek metavolcanics, Seminoe Mountains[1]. LOI=loss on ignition, ppm=parts per million. Dashes indicate not determined. (See **Plate 2** for sample localities.)

	1L	2L	3L	4L	5L	6L	7L	8L	9L
				Whole-rock analyses (weight percent)					
Oxide									
SiO_2	41.70	43.10	50.70	50.10	50.30	47.60	54.00	60.20	81.70
Al_2O_3	2.04	3.90	4.44	11.20	13.10	14.70	12.80	20.50	6.35
Fe_2O_3	9.63	11.00	9.23	11.20	14.00	12.00	13.20	5.50	2.68
MgO	33.80	29.20	21.00	10.90	6.01	7.64	4.39	2.93	1.09
CaO	0.13	2.22	10.00	10.30	8.85	11.90	9.18	0.92	1.81
Na_2O	0.02	0.03	0.27	2.14	2.16	1.82	2.22	1.48	1.98
K_2O	0.06	0.05	0.05	0.46	1.21	0.25	0.50	2.75	0.80
TiO_2	0.13	0.19	0.21	0.59	1.38	0.78	1.33	0.75	0.48
MnO	0.18	0.17	0.18	0.21	0.21	0.20	0.18	0.06	0.04
P_2O_5	0.08	0.18	0.16	0.14	0.23	0.13	0.09	0.14	0.17
LOI	11.05	9.10	3.10	1.10	1.65	0.59	0.60	3.90	0.75
TOTAL	98.82	99.14	99.34	98.34	99.10	97.61	98.49	99.13	97.85
CaO/Al_2O_3	0.06	0.6	2.3	0.9	0.7	0.8	0.7	—	—
				Trace element analyses (ppm)					
Element									
Ag	<1.0	<1.0	<1.0	—	—	<0.1	<1.0	<1.0	<1.0
Au	<0.05	<0.05	<0.05	—	—	0.001	<0.05	<0.05	<0.05
Ba	<100	<100	100	100	200	100	100	300	300
Cr	5,400	7,800	4,600	1,800	300	123	200	1,200	200
Ni	1,632	1,274	873	—	—	30	76	—	—
S	500	200	<200	<200	300	800	<200	<200	400
V	—	—	—	—	—	—	334	—	—
Zr	—	7	—	—	—	—	—	—	—

---

[1] Sample lithologies: (1L) serpentinite; (2L) serpentinite; (3L) chlorite-actinolite schist; (4L) aphanitic amphibolite; (5L) fine-grained mica-plagioclase-amphibole metabasalt; (6L) banded amphibolite schist; (7L) foliated amphibolite; (8L) serpentine pebble conglomerate (?); (9L) dark grey foliated schist to gneiss with plagioclase porphyroblasts.

Jensen diagram (**Figure 7**). Sample 4L lies within the basaltic komatiite field and has relatively high MgO (>9 percent) and chromium (1,800 ppm). The chemical analyses suggest these rocks were originally basalts and basaltic komatiites prior to metamorphism.

Serpentinite

Serpentinite crops out near the base of the Sunday Morning Creek metavolcanics near its contact with the granodiorite pluton east of Deweese Creek, and near the top (?) of the Sunday Morning Creek metavolcanics. This latter serpentinite approximately marks the contact between the foliated amphibolites to the south and the metagabbros to the north.

Near the base of the Sunday Morning Creek metavolcanics, serpentinite crops out in a narrow, sill-like unit traceable for more than three miles along strike. The rock is completely serpentinized and consists of serpentine in a mesh texture with minor magnetite. The magnetite may be responsible for the distinct linear magnetic anomaly detected in the aeromagnetic survey by Philbin and McCaslin (1966).

Whole-rock geochemical analysis of the basal serpentinite (Sample 1L, **Table 1**) gave 33.8 weight percent MgO (38.27 percent MgO on a volatile- free-basis), 5,400 ppm chromium (Cr), 1,632 ppm nickel (Ni), and a very low CaO/Al_2O_3 ratio of 0.06. This anomalously low ratio is possibly due to the loss of CaO with respect to Al_2O_3 during serpentinization. The apparently high Cr content of this rock is not considered anomalous when compared to its high MgO content, in that chromium systematically increases with increasing magnesium.

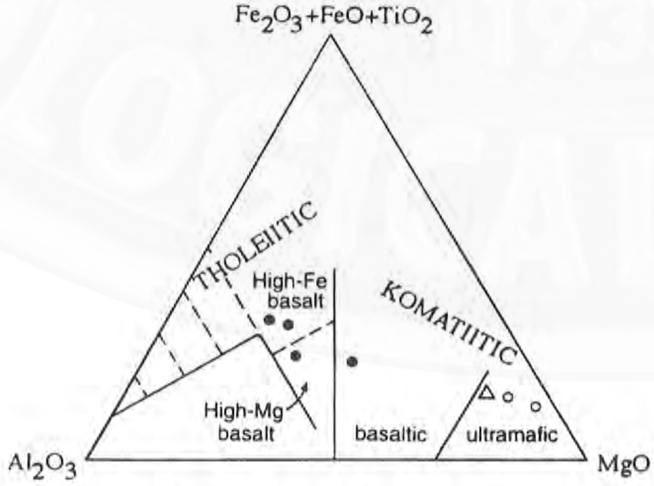


Figure 7. Jensen AMF ternary diagram showing compositions of amphibolite (solid dots), serpentinite (open dots), and chlorite-actinolite schist (triangle) from the Sunday Morning Creek metavolcanics. Whole-rock analyses are found in **Table 1**.

The serpentinite near the top of the Sunday Morning Creek metavolcanics (Sample 2L, **Table 1**) yielded 29.2 weight percent MgO (32.15 percent MgO on a volatile-free-basis), 7,800 ppm Cr, 1,274 ppm Ni, and a CaO/Al_2O_3 ratio of 0.6. The Cr content is weakly anomalous and may be due to the presence of traces of chromite. Both serpentinites plot within the peridotitic komatiite field near the MgO corner of the AMF diagram (**Figure 7**). These rocks are interpreted as metamorphosed peridotite sills or flows.

Chlorite-actinolite schist

An outcrop of strongly folded chlorite-actinolite schist was mapped in the SW section 28, above(?) the lower serpentinite sill. A sample of the schist (Sample 3L, **Table 1**) was analyzed and yielded 21.0 weight percent MgO, 4,600 ppm Cr, 873 ppm Ni, and a very high CaO/Al_2O_3 ratio of 2.3. The analysis plots within the peridotitic komatiite field of the Jensen diagram (**Figure 7**). The high CaO/Al_2O_3 ratio may be due to the introduction of carbonate.

Banded iron formation

Banded iron formation (BIF) is rare in the Sunday Morning Creek metavolcanics. One bed of banded magnetite-quartz-grunerite iron formation mapped in the SE section 28, T26N, R85W, is similar to the BIF mapped in the Seminoe formation. The BIF consists of alternating quartz-rich bands and magnetite-rich bands.

Augen gneiss

Dark gray gneiss with plagioclase porphyroblasts, and quartz and feldspar augen, crops out locally. These intensely deformed rocks are characteristic of augen gneiss found in other supracrustal belts in Wyoming. Their origin is uncertain.

Bradley Peak ultramafics

The Bradley Peak ultramafics were informally named by Klein (1981) for a group of mafic to ultramafic metavolcanic rocks found along the northern flank of the Seminoe Mountains in the vicinity of the Sunday Morning mine, and along the eastern flank of Bradley Peak in the Penn mines area (**Figure 6** and **Plate 1**). Near the mouth of Sunday Morning Creek, Klein (1981, 1982) mapped several differentiated metamorphosed komatiite flows with textures and chemistries similar to komatiites hosted by Archean greenstone terranes elsewhere in the world (Arndt and Nisbet, 1982).

Komatiites for the most part are primitive, high-magnesian, volcanic flows. Typically, they are classified as either basaltic (mafic) komatiites with MgO contents of 9 to 18 percent, or peridotitic (ultramafic) komatiites with MgO contents greater than 18 percent. The CaO/Al_2O_3 ratios are relatively high (~1.0), and the TiO_2 and alkali contents are low. Textures are also diagnostic. Flow tops are chilled and grade downward into spinifex-textured rocks overlying equigranular aphyric rocks and farther downward into cumulate-textured serpentinite at the flow bottom (Arndt and Nisbet, 1982). Cumulate textures are the result of crystal settling in a ultramafic flow, and spinifex textures are quench textures produced by the hot ultramafic magma contacting sea water. The term "spinifex" is derived from a spiney grass known as spinifex, found in the vicinity of the Komati River in southern Africa where komatiite was initially described.

Basaltic komatiite

Basaltic metakomatiite is locally abundant near Bradley Peak. These rocks are chemically and texturally similar to basaltic komatiites reported in other cratons around the world (Klein, 1981, 1982). Texturally, the Bradley Peak basaltic metakomatiites include both aphyric rocks and schists with prominent radiating and parallel spinifex grains of hornblende after pyroxene in a fine-grained chloritic groundmass (Klein, 1981) (**Figure 8**).

Chemically, these are high-magnesian rocks with 9.81 to 18.6 weight percent MgO. Chromium contents range from 559 to 2,400 ppm; nickel contents range from 39 to 190 to ppm. They have relatively low TiO_2 and alkali contents, and CaO/Al_2O_3 ratios average 0.8 (Samples 14B-24B, **Table 2**). Typically, these rocks fall within the basaltic komatiite field of the Jensen AMF ternary diagram (**Figure 9**).

Figure 8. Spinifex-textured basaltic komatiite near Twin Creek along the eastern flank of Bradley Peak. Long-bladed black pseudomorphic amphibole grains after pyroxene are set in a chloritic groundmass. (Photograph by W.D. Hausel, 1991.)

Table 2. Major and trace element analyses of rocks from the Bradley Peak ultramafics[1]. LOI=loss on ignition, ppm=parts per million, ppb=parts per billion. Dashes indicate not determined.

	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	11B	12B	13B	14B
						Whole-rock analyses (weight percent)								
Oxide														
SiO_2	40.80	41.10	41.80	41.70	40.80	36.20	40.00	42.60	41.20	47.10	33.90	47.90	46.60	51.50
Al_2O_3	2.12	3.46	1.54	4.56	4.23	1.32	2.53	2.47	3.69	3.11	1.40	6.35	4.66	6.46
Fe_2O_3	9.28	10.45	10.20	12.50	9.48	11.70	14.00	11.90	14.10	13.77	29.40	10.50	9.42	11.00
MgO	34.40	33.48	32.50	30.80	30.70	30.60	30.00	28.60	28.50	28.26	27.40	22.50	20.70	18.60
CaO	0.51	<0.01	0.52	0.92	1.99	3.63	1.56	0.64	1.16	3.24	0.08	7.48	11.70	5.38
Na_2O	<0.01	<0.01	0.03	0.03	0.03	0.01	0.03	0.04	0.04	<0.01	0.03	0.04	0.26	0.67
K_2O	0.01	<0.01	0.23	0.01	0.04	0.23	0.03	0.24	0.23	<0.01	0.03	<0.01	0.30	0.06
TiO_2	0.08	0.17	0.10	0.21	0.22	0.09	0.11	0.12	0.18	0.13	0.06	0.25	0.33	0.36
MnO	0.08	0.15	0.07	0.12	0.09	0.09	0.13	0.11	0.15	0.14	0.09	0.14	0.15	0.18
P_2O_5	0.35	<0.01	0.42	0.27	0.21	0.42	0.17	0.37	0.43	<0.01	0.23	0.09	0.58	0.18
LOI	11.27	11.06	11.42	9.31	9.43	13.35	9.22	11.09	9.03	3.84	7.89	4.55	3.77	3.50
TOTAL	98.90	99.87	98.83	100.43	97.22	97.64	97.78	98.18	98.71	99.59	100.51	99.80	98.47	97.89
CaO/Al_2O_3	0.2	—	0.3	0.2	0.5	2.8	0.6	0.3	0.3	1.0	0.06	1.2	2.5	0.8
Al_2O_3/TiO_2	26	20	15	22	19	15	23	21	21	24	23	25	14	18
						Trace element analyses (ppm except where noted)								
Element														
Ag	—	<1.0	<5.0	—	<0.1	<5.0	<0.1	<5.0	<5.0	<1.0	—	—	<5.0	<0.1
As	—	—	9	—	—	25	—	19	7	—	—	—	21	—
Au (ppb)	—	6	<5	—	<1	<5	<1	18	<5	<5	<1	21	<5	<1
Ba	—	40	<100	<100	—	<100	<100	<100	<100	30	<100	—	<100	<100
Ce	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Co	—	—	98	—	—	110	—	120	100	—	—	—	86	—
Cr	5,946	7,400	6,680	2,700	6,300	7,330	5,106	2,000	2,400	4,800	3,901	4,541	2,900	2,268
La	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ni	1,081	1,140	1,600	—	1,056	1,700	1,116	940	970	430	775	687	580	96
Pd (ppb)	—	—	—	—	120	—	<1	2	—	—	—	—	—	—
Pt (ppb)	—	—	—	—	<1	—	5	<5	—	—	—	—	—	—
Rb	—	—	<10	—	—	<10	—	<10	<10	—	—	—	<10	—
S	—	<200	<200	<200	700	<200	800	<200	<200	<200	1,200	—	<200	800
Sb	—	—	2.4	—	—	3.2	—	2.9	0.5	—	—	—	0.5	—
Sc	—	—	7.0	—	—	6.1	—	11.0	13.0	—	—	—	32.0	—
Sm	—	—	<0.2	—	—	<0.2	—	0.3	<0.2	—	—	—	0.8	—
Th	—	—	<0.5	—	—	<0.5	—	<0.5	<0.5	—	—	—	<0.5	—
U	—	—	<0.5	—	—	<0.5	—	<0.5	<0.5	—	—	—	<0.5	—
W	—	—	<2.0	—	—	<2.0	—	<2.0	<2.0	—	—	—	<2.0	—
Y	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Zn	—	—	<200	—	—	<200	—	<200	<200	—	—	—	<200	—

See footnote on page 12.

Table 2 continues on page 12.

Table 2 continued.

	15B	16B	17B	18B	19B	20B	21B	22B	23B	24B	25B	26B	27B	28B	29B
Whole-rock analyses (weight percent)															
Oxide															
SiO_2	45.40	49.40	51.92	50.60	48.90	48.30	50.00	49.90	52.70	48.30	48.50	50.50	48.70	52.60	47.66
Al_2O_3	5.61	9.58	10.84	11.10	10.70	10.40	11.50	11.80	11.70	11.70	12.80	12.60	12.50	12.80	14.14
Fe_2O_3	15.70	12.90	12.50	11.50	11.90	11.00	12.00	11.30	11.10	9.18	13.20	12.00	11.80	16.80	11.76
MgO	17.40	13.40	13.36	12.90	12.40	11.90	11.50	10.80	10.60	9.81	9.22	8.87	8.54	4.29	10.09
CaO	9.18	6.43	8.11	8.21	7.94	6.60	8.02	7.60	6.81	16.00	9.50	7.48	7.37	5.21	12.03
Na_2O	0.03	1.56	1.17	2.02	1.65	1.38	2.42	2.11	3.27	0.28	1.63	2.41	2.68	4.14	1.39
K_2O	0.03	0.16	<0.01	0.06	0.33	0.23	0.08	0.38	0.06	0.37	0.28	0.69	0.46	0.23	0.17
TiO_2	0.22	0.49	0.43	0.41	0.44	0.40	0.47	0.39	0.43	0.49	0.57	0.58	0.57	1.45	0.79
MnO	0.17	0.16	0.18	0.17	0.18	0.17	0.18	0.17	0.16	0.19	0.20	0.17	0.17	0.21	0.21
P_2O_5	0.33	0.30	<0.01	0.17	0.54	0.47	0.39	0.52	0.10	0.63	0.34	0.52	0.51	0.20	0.02
LOI	3.77	3.85	1.09	2.62	2.25	7.54	2.47	2.60	2.47	0.87	2.86	3.52	5.32	1.15	1.17
TOTAL	97.84	98.23	99.60	99.76	97.23	98.39	99.03	97.57	99.40	97.82	99.10	99.34	98.62	99.08	99.43
CaO/Al_2O_3	1.6	0.7	0.8	0.7	0.7	0.6	0.7	0.6	0.6	1.4	0.7	0.6	0.6	0.4	0.9
Al_2O_3/TiO_2	26	20	24	27	24	26	24	30	27	34	22	22	22	9	18
Trace element analyses (ppm except where noted)															
Ag	—	<1.0	<1.0	<0.1	<5.0	<5.0	—	<5.0	—	<5.0	—	<5.0	<5.0	<1.0	<1.0
As	—	—	—	—	1.0	<1.0	—	<1.0	—	1.0	—	10.0	9.0	—	—
Au (ppb)	—	<50	<5	3	<5	5	<1	<5	<1	<5	—	47	1	<50	6
Ba	<100	100	30	<100	<100	<100	—	<100	<100	<100	<100	<100	110	<100	110
Ce	—	92	—	—	—	—	—	—	—	—	—	—	—	—	—
Co	—	—	—	—	58	58	—	60	—	53	—	51	50	—	—
Cr	2,400	1,700	1,500	1,340	930	1,100	559	940	672	1,000	400	440	370	<100	1,100
La	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—
Ni	—	166	39	108	140	160	78	130	70	190	—	110	73	35	49
Pd (ppb)	—	—	—	—	—	2	—	—	—	—	—	5	6	—	—
Pt (ppb)	—	—	—	—	—	<5	—	—	—	—	—	7	9	—	—
Rb	—	—	—	—	<10	<10	—	<10	—	<10	—	21	12	—	—
S	<200	300	<200	700	<200	<200	—	200	600	<200	300	300	300	<200	<200
Sb	—	—	—	—	0.7	0.5	—	0.5	—	0.3	—	1.7	1.0	—	—
Sc	—	—	—	—	30.0	28.0	—	32.0	—	32.0	—	35.0	35.0	—	—
Sm	—	—	—	—	0.9	0.9	—	0.8	—	1.3	—	1.2	1.3	—	—
Th	—	—	—	—	0.7	<0.5	—	<0.5	—	<0.5	—	<0.5	0.5	—	—
U	—	—	—	—	<0.5	<0.5	—	<0.5	—	<0.5	—	<0.5	<0.5	—	—
W	—	—	—	—	<2.0	<2.0	—	<2.0	—	<2.0	—	<2.0	<2.0	—	—
Y	—	20	—	—	—	—	—	—	—	—	—	—	—	—	—
Zn	—	—	—	—	230	<200	—	<200	—	<200	—	210	<200	—	—

[1] Samples 1B-13B are rocks with ultramafic (peridotitic) komatiite compositions, with the following lithologies: (1B) cumulate-textured serpentinite; (2B) highly magnetic serpentinite; (3b) massive serpentinite; (4B) cumulate-textured serpentinite; (5B) cumulate-textured serpentinite; (6B) serpentinized dunite (?) cumulate; (7B) highly magnetic serpentinite; (8B) ultramafic schist; (9B) serpentinized pyroxenite (?); (10B) cumulate-textured serpentinite; (11B) cumulate-textured serpentinite; (12B) talc-chlorite-tremolite schist; and (13B) chlorite-serpentine schist. Samples 14B-24B and 29B are rocks with basaltic (high magnesian) komatiite compositions, with the following lithologies: (14B) banded talc-chlorite schist; (15B) banded talc-chlorite schist; (16B)spinifex-textured tremolite chlorite schist; (17B) spinifex-textured tremolite-talc-chlorite schist flow top; (18B) spinifex-textured tremolite-talc-chlorite schist; (19B) chlorite-serpentine schist; (20B) tremolite-talc hornfels; (21B)spinifex-textured basaltic metakomatiite; (22B) basaltic metakomatiite; (23B) spinifex-textured tremolite-talc-chlorite schist; (24B) fine-grained amphibolite; and Sample 29B is string-beef spinifex-textured metagabbro. Samples 25B-28B are rocks with metatholeiite compositions, with the following sample lithologies: (25B) spinifex-textured basaltic metakomatiite; (26B) spinifex-textured basaltic metakomatiite; (27B) spinifex-textured basaltic metakomatiite; and (28B) amphibolite.

Peridotitic komatiite

Komatiitic rocks along Sunday Morning Creek consist of 14 differentiated peridotite flows (each from 20 to less than 100 feet thick) (Klein, 1981). The flows have basal cumulates that are relatively fine-grained, equigranular, and partially to completely serpentinized. Relict olivine (Fo_{90}) has been identified in several samples from the area (Klein, 1981). According to Klein (1981, 1982), these cumulate-textured serpentinites are magnesium-rich, range from 25 to 35 weight percent MgO, and plot within the ultramafic komatiite field of the Jensen AMF ternary diagram (**Figure 9**).

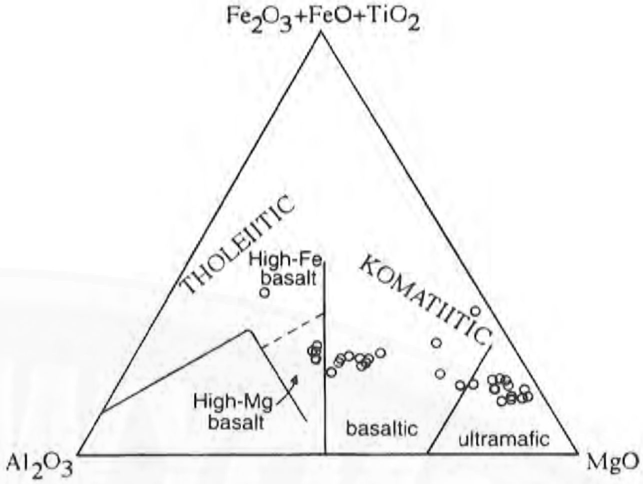


Figure 9. Jensen AMF ternary diagram showing compositions of rocks from the Bradley Peak ultramafics. Whole-rock analyses are found in **Table 2**.

The cumulate-textured serpentinite grades upward into aphyric tremolite-talc-chlorite-serpentine schist and then into tremolite-rich nematoblastic schist. Random spinifex textures are preserved locally by pseudomorphic tremolite or serpentine replacements of elongate pyroxene or olivine grains in a groundmass of fine-grained granular chlorite, talc, or fine-grained amphibole (**Figure 10**) (Klein, 1981, 1982; Snyder and others, 1989). These tremolite-rich rocks plot within the ultramafic komatiite field, or near the extreme magnesium-rich end of the basaltic komatiite field of the Jensen AMF ternary diagram (**Figure 9**) and are inferred to represent the original magma compositions. The MgO content typically ranges from 15 to 22 weight percent (Klein, 1981; Snyder and others, 1989). Individual flows are commonly separated by a thin interflow magnetite-rich iron formation.

Figure 10. Random spinifex texture in a tremolite schist from the Sunday Morning Creek area of the Seminoe Mountains. (Photograph by W.D. Hausel, 1989.)

Rocks with ultramafic (peridotitic) komatiite compositions collected during this study yielded from 20.7 to 34.4 weight percent MgO (21.8 to 39.26 percent MgO on a volatile-free-basis), 2,000 to 7,400 ppm Cr, and 430 to 1,700 ppm Ni. The CaO/Al_2O_3 ratios average 0.8 (Samples 1B-13B, **Table 2**).

The komatiite suite along Sunday Morning Creek has the general compositional characteristics of aluminum-undepleted komatiites found in other Archean cratonic terranes. They have CaO/Al_2O_3 ratios less than 1.0, Al_2O_3/TiO_2 ratios near 20, high MgO (8 to 35 weight percent), high Cr (>300 ppm), high Ni (generally >100 ppm), and depleted LREE (light rare earth elements). They also have flat REE (rare earth elements) patterns when each REE is plotted according to concentration (Snyder and others, 1989).

Spinifex-textured metagabbro

The peridotite flows are overlain by massive, thick, gabbroic rock near the mouth of Sunday Morning Creek. The base of the gabbro is marked by a thin melanocratic layer consisting of plagioclase laths enclosed by amphibole perpendicular to the base of the gabbro (**Figure 11**). The texture is similar to "string-beef" spinifex texture reported by Arndt (1976) in the Munro Township in Canada (M.L. Page, verbal communication, 1991) and to a metagabbro recently identified overlying (?) peridotite of the Diamond Springs Formation in the South Pass greenstone belt (W.D. Hausel, personal field notes, 1991). The "string beef" texture grades upward into gabbro with subophitic igneous texture. A geochemical analysis of the "string beef"-textured rock (Sample 29B, **Table 2**) yielded 10.09 weight percent MgO (10.27 percent MgO on a volatile-free-basis), relatively high CaO/Al_2O_3 ratio (0.9), relatively low TiO_2 and alkalies, and 1,100 ppm Cr, which is typical of basaltic komatiite.

Figure 11. String-beef spinifex (?) texture in a metagabbro at the top of the Bradley Peak ultramafics, Sunday Morning Creek. (Photograph by W.D. Hausel, 1991.)

Metatholeiites

A small number of amphibolites from this region fall within the tholeiite field of the Jensen plot (**Figure 9**). Some of these also have spinifex textures. Geochemical analyses of the amphibolites give 4.29 to 9.22 weight percent MgO (4.38 to 9.57 percent MgO on a volatile-free-basis), <100 to 440 ppm Cr, and 35 to 110 ppm Ni. The CaO/Al_2O_3 ratios average 0.6 and vary from 0.4 to 0.7 (Samples 25B-28B, **Table 2**).

Spinifex texture in tholeiites is apparently uncommon. Thus, the spinifex-textured tholeiites represent either metasomatically altered basaltic komatiites in which magnesium, chromium, and nickel were removed during alteration, or they represent high-magnesian tholeiitic basalts with spinifex texture. Another possibility is that the spinifex textures in these rocks are metamorphic rather than igneous. Similar textures, assumed to be metamorphic, have been reported in amphibolites of the North Park Range of Colorado (P.J. Graff, verbal communication, 1993).

Iron formation

Interflow iron formation occurs as narrow (typically less than 4 feet thick) beds of magnetite-rich rock between komatiite flows. These interflow iron formations generally lack the distinct banding seen in the more extensive banded iron formations in the Seminoe formation, and they appear to be more magnetite-rich and silica-poor.

Seminoe formation

The Bradley Peak ultramafics are overlain by 2,000 to 4,000 feet of interlayered metasedimentary and metavolcanic rocks named the Seminoe formation (**Figure 6** and **Plate 1**) (Lovering, 1929). These include fine-grained clastic rocks (quartz-biotite-garnet schist, quartz-plagioclase-muscovite schist, metagreywacke, and quartzite), thick beds of quartz-magnetite-grunerite iron formation, some chlorite schist, metabasalt, crystal and lithic metatuffs, and intercalated felsic metavolcanic and volcaniclastic rocks, including a quartz phyric rhyodacite flow dated at 2.7 Ga (Snyder and others, 1989, p. 34). The metavolcanics are dominantly tholeiitic (**Figure 12**). The formation has been extensively invaded by gabbro.

Banded iron formation

Banded iron formation (BIF) is the dominant rock type in the formation. BIF is prominent where it crops out over relatively large areas around Bradley Peak, on Junk Hill (sections 23 and 24, T26N, R86W), and east of Junk Hill as far as Wood Creek (**Plate 1**). The type section for this supra-crustal unit was described by Lovering (1929) along Twin Creek on the northern flank of Bradley Peak.

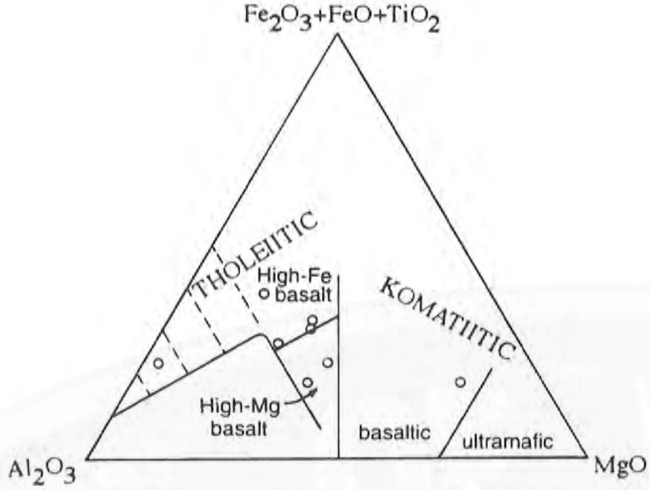


Figure 12. Jensen AMF ternary diagram showing compositions of metavolcanic rocks from the Seminoe formation. Whole-rock analyses are found in **Table 3.**

In the vicinity of the type section immediately north of Bradley Peak, the BIF was mapped over an 800-foot-wide outcrop for nearly 3,500 feet of strike length (**Plate 1**). Other BIF outcrops occur in this area but are not as extensive. The BIF is a black to tawny, jaspery, iron formation with bands of magnetite, quartz, and amphibole. Magnetite is generally the dominant iron-bearing phase of the BIF, although grunerite dominates locally.

Lovering (1929) reported paragasite (amphibole) and hyperstene (pyroxene) in the BIF, although no pyroxene was observed in BIF samples during this study. Locally, grunerite shows signs of retrograde metamorphism and is altered to a blue-green amphibole. Accessory minerals include garnet, apatite, chlorite, biotite, hematite, and tremolite. Folding is well-displayed in the BIF and consists of small scale disharmonic folds and crenulations superimposed on larger scale isoclinal and box folds (**cover** photograph and **Figure 13**) (Snyder and others, 1989). The BIF has been intruded by gabbro at several localities and has also been disrupted by folding and faulting.

Whole-rock analyses of the BIF are presented in **Table 3** (Samples 12U, 13U and 14U), and additional iron formation analyses are listed in **Table 4**. Sample 12U, a cummingtonite-tremolite schist or silicate-facies iron formation, consists principally of the iron-rich amphibole. Geochemical analysis of this rock yielded 20.40 percent Fe_2O_3 and 47.80 percent SiO_2. The high CaO content (15.50 percent) of Sample 12U suggests the presence of appreciable amounts of the calcium-rich tremolite/actinolite amphibole. Samples 13U and 14U are typical banded magnetite iron formation. These samples yielded 39.00 and 40.10 weight percent Fe_2O_3 and 53.20 and 54.90 weight percent SiO_2, respectively. The high silica content reflects the presence of the quartz-rich bands. Notable trace elements associated with BIF in the district include gold, silver, zinc, and lead (see **Economic geology** section).

Figure 13. Isoclinally folded banded iron formation along the West Fork of Junk Creek, northern flank of the Seminoe Mountains. Note the characteristic small scale disharmonic folds and the prominent box fold in the upper left hand portion of the photograph. (Photograph by W.D. Hausel, 1989.)

Metatholeiite

Metatholeiite (orthoamphibolite) is less common in the Seminoe Formation than BIF. These rocks typically have tholeiitic compositions and include metabasalt, metadiabase, chlorite schist, and amphibolite of speculative origin. Sample analyses 3U, 4U, 7U (**Table 3**) are representative metatholeiites.

Quartzite

The Seminoe formation includes minor beds of quartzite. The quartzite consists of recrystallized

Table 3. Major and trace element analyses of rocks of the Seminoe formation (Archean), and of a basaltic dike (Proterozoic?)[1]. LOI = loss on ignition, Ppm = parts per million, ppb = parts per billion. Dashes indicate not determined. (See **Plate 2** for sample locations.)

	1U	2U	3U	4U	5U	6U	7U	8U	9U	10U	11U	12U	13U	14U	1P
							Whole-rock analyses (weight percent)								
Oxide															
SiO_2	45.80	51.20	44.60	48.20	47.30	81.40	49.80	56.20	58.40	51.40	55.60	47.80	53.20	54.90	50.00
Al_2O_3	6.86	12.60	16.00	10.50	16.40	7.17	14.50	14.80	14.40	13.40	15.40	1.39	0.98	0.36	12.60
Fe_2O_3	11.40	14.00	9.00	12.70	13.30	2.70	18.60	10.60	7.46	10.80	9.67	20.40	39.00	40.10	14.20
MgO	21.20	7.48	9.50	6.11	6.56	0.19	3.92	5.33	3.83	9.42	5.64	9.19	1.84	0.94	6.15
CaO	6.63	9.02	5.95	7.98	10.30	6.87	7.10	2.75	5.49	7.57	3.69	15.50	0.49	0.78	8.89
Na_2O	0.01	2.57	3.29	1.55	2.51	0.12	0.50	2.48	2.02	1.57	5.57	0.19	0.04	0.03	3.18
K_2O	0.05	0.12	0.32	0.15	0.30	0.20	1.43	1.18	2.13	0.16	0.14	0.13	0.59	0.09	0.82
TiO_2	0.37	0.60	0.74	1.21	1.30	0.39	1.27	1.18	0.70	0.64	1.12	0.07	0.08	0.03	1.63
MnO	0.15	0.14	0.14	0.16	0.16	0.06	0.14	0.11	0.08	0.17	0.15	0.19	0.13	0.12	0.25
P_2O_5	0.21	0.34	0.49	0.21	0.30	0.11	0.27	0.26	0.39	0.10	0.35	0.29	0.59	0.44	0.42
LOI	5.75	1.28	8.61	9.75	1.62	0.54	2.15	4.75	3.60	3.52	1.29	4.80	0.97	2.27	1.35
TOTAL	98.43	99.35	98.64	98.52	100.05	99.75	99.68	99.64	98.5	98.75	98.62	99.95	97.91	100.06	99.49
CaO/Al_2O_3	1.0	0.7	0.4	0.8	—	—	—	—	—	—	—	—	—	—	—
							Trace element analyses (ppm except where noted)								
Element															
Ag	<1.0	<0.1	<5.0	<1.0	—	—	—	<1.0	<1.0	<1.0	—	—	<5.0	0.2	—
As	—	—	<1.0	—	—	—	—	—	—	—	—	—	32	32	—
Au (ppb)	<50	1	12	<50	—	—	—	<50	<50	<50	—	—	51	3	—
Ba	<100	<100	<100	<100	<100	90	200	200	400	<100	<100	<100	<100	<100	200
Ce	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Co	—	—	47	—	—	—	—	—	—	—	—	—	<10	—	—
Cr	3,800	400	560	700	—	—	—	200	—	100	—	<100	<50	<100	—
La	<10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ni	813	43	240	—	—	—	—	—	—	—	—	—	<50	—	—
Rb	—	—	14	—	—	20	—	—	—	—	—	—	15	—	—
S	300	800	<200	<200	700	—	700	<200	<200	300	700	<200	200	700	900
Sb	—	—	0.5	—	—	—	—	—	—	—	—	—	3.5	—	—
Sc	—	—	28	—	—	—	—	—	—	—	—	—	1.3	—	—
Sm	—	—	2.1	—	—	—	—	—	—	—	—	—	1.2	—	—
Sr	—	—	14	—	—	340	—	—	—	—	—	—	—	—	—
Th	—	—	<0.5	—	—	—	—	—	—	—	—	—	0.8	—	—
U	—	—	<0.5	—	—	—	—	—	—	—	—	—	1.3	—	—
W	—	—	<2	—	—	—	—	—	—	—	—	—	<2	—	—
Y	—	—	—	—	—	<10	—	—	—	—	—	—	—	—	—
Zn	—	—	<200	—	—	—	—	—	—	—	—	—	430	—	—
Zr	—	—	—	—	—	80	—	—	—	—	—	—	—	—	—

[1] Sample lithologies are as follows: (1U) spinifex-textured tremolite-talc-chlorite schist; (2U) spinifex-textured basaltic komatiite; (3U) metadiabase; (4U) chlorite schist; (5U) meta-andesite porphyry (phenocrysts of An_{65}-confirmed by XRD); (6U) metafelsite; (7U) amphibolite; (8U) metagreywacke; (9U) metagreywacke; (10U) metagreywacke; (11U) quartz-chlorite schist; (12U) cummingtonite schist; (13U) banded iron formation; (14U) banded iron formation; (1P) basaltic dike (Proterozoic?).

Table 4. Chemical analyses (in weight percent) of banded iron formation (BIF), from various sources. Dashes indicate not determined, ft=feet. (See **Figure 14** for locations of Samples 1-51.)

Sample Number	Description	Fe	Mn	P	S	SiO_2	TiO_2
1	15-foot-wide BIF, Greeley claim (Dickman, 1906).	28.80	—	—	0.35	35.80	—
2	BIF, Frozen Finger claim, Pattison Basin (Hendricks, 1902).	31.40	—	—	0.08	48.77	—
3	See No. 2.	32.70	—	0.107	—	48.95	—
4	Pattison Basin (Dickman, 1906).	65.80	—	0.181	—	1.00	—
5	BIF from 50-foot-deep shaft (Dickman, 1906).	62.00	—	0.09	—	7.60	—
6	Hematite jasper outcrop 75-100 feet & 800 feet, Pattison Basin (Harrer, 1966).	52.4	0.044	0.16	0.03	22.0	0.21
7	Hematite, Barton claim, Pattison Basin (Hendricks, 1902).	40.35	—	0.055	—	40.46	—
8	Hematite-magnetite BIF, New Year claim, Pattison Basin (Hendricks, 1902).	44.10	—	0.188	—	13.51	—
9	Magnetite jasper BIF, Pattison Basin (Harrer, 1966).	33.70	0.005	0.04	0.05	47.2	0.10
10	Iron Hill BIF, Pattison Basin (Harrer, 1966).	34.9	0.2	0.14	0.1	47.2	<0.1
11	Iron Hill hematite, Pattison Basin (Harrer, 1966).	30.3	0.4	0.14	0.1	57.4	0.2
12	Iron Hill hematite-jasper (Harrer, 1966).	37.3	0.03	0.07	0.04	46.0	0.2
13	Iron Hill hematite-jasper (Harrer, 1966).	40.4	0.008	0.08	0.05	40.0	0.14
14	Haynes claim, Pattison Basin (Hendricks, 1902).	33.45	—	0.137	—	49.66	—
16	Haynes claim hematite-magnetite (Hendricks, 1902).	31.40	—	0.057	—	53.26	—
17	Domingo claim BIF, Pattison Basin (Hendricks, 1902).	28.70	—	0.087	—	53.91	—
18	Greeley claim BIF, Pattison Basin (Hendricks, 1902).	66.30	—	0.223	—	1.37	—
19	Hard hematite, west of Iron Hill (Lovering, 1929).	68.72	—	0.015	—	3.32	—
20	Hard hematite, Pattison Basin (Lovering, 1929).	62.51	—	0.04	0.026	10.2	—
21	Hematite jasper (Lovering, 1929).	32.65	—	—	—	54.28	—
22	Hematite jasper (Lovering, 1929).	33.8	—	—	—	51.98	—
23	Hematite jasper (Lovering, 1929).	35.37	—	—	—	50.06	—
24	Calcator claim BIF, Pattison Basin (Hendricks, 1902).	61.80	—	0.168	—	6.38	—
25	Hematite (Hendricks, 1902).	68.55	—	0.074	—	0.91	—
26	BIF (Hendricks, 1902).	37.85	—	0.154	—	37.18	—
27	Hematite (Hendricks, 1902).	58.65	—	0.19	—	13.71	—
28	BIF (Hendricks, 1902).	45.00	—	0.143	—	33.41	—
29	Hematite (Hendricks, 1902).	60.05	—	0.149	—	8.25	—
30	Hematite (Hendricks, 1902).	56.30	—	0.036	—	15.25	—
31	Hematite, St. Louis claim (Hendricks, 1902).	56.45	—	0.144	—	15.98	—
32	Dump sample, Pattison Basin (Dickman, 1906).	45.00	—	0.08	—	33.60	—
33	Hematite jasper, Pattison Basin (Lovering, 1929).	36.40	—	—	—	47.80	—
34	BIF, Midnight claim (Hendricks, 1902).	38.75	—	0.067	—	42.09	—
35	Hematite (Hendricks, 1902).	56.05	—	0.249	—	16.50	—
36	BIF (Hendricks, 1902).	33.90	—	0.094	—	49.75	—
37	Hematite (Hendricks, 1902).	63.30	—	0.129	—	3.81	—
38	BIF, Pattison Basin (Dickman, 1906).	34.00	—	0.091	—	48.00	—
39	BIF (Dickman, 1906).	41.00	—	0.061	—	39.70	—
40	Hematite (Dickman, 1906).	53.00	—	0.064	—	20.50	—
41	Hematite (Dickman, 1906).	64.60	—	0.179	—	1.80	—
42	BIF, Pattison Basin (Dickman, 1906).	40.00	—	0.31	—	40.80	—
43	BIF, south of Twin Creek fault (Harrer, 1966).	32.30	0.016	0.07	0.04	49.00	0.16
44	BIF (CaO=2.24%), Bradley Peak (Lovering, 1929).	32.42	—	0.014	—	50.42	—
45	BIF, Bradley Peak (Lovering, 1929).	35.84	—	—	—	47.70	—
46	Lean magnetite jasper (Lovering, 1929).	27.97	—	—	—	59.90	—
47	Bradley Peak BIF (Dickman, 1906).	35.50	—	0.055	—	5.50	—
48	BIF, north of Twin Creek fault (Harrer, 1966).	34.70	0.016	0.055	0.03	46.80	0.16
49	BIF float above Deweese Creek (Harrer, 1966).	34.70	0.007	0.06	0.04	43.3	0.16
50	BIF, Deweese Creek (Harrer, 1966).	34.00	0.027	0.09	0.03	47.3	0.16
51	BIF, Deweese Creek (Harrer, 1966).	34.00	0.1	0.13	0.12	50.2	0.1
52	Hematite (Ricketts, 1888).	55.30	—	—	—	20.10	—
53	Magnetite (Ricketts, 1888).	29.50	—	—	—	15.00	—
54	Hematite (Ricketts, 1888).	63.56	—	—	—	2.63	—
55	Hematite (Ricketts, 1888).	68.60	—	—	—	4.3	—

Table 4 continued.

Sample Number	Description	Fe	Mn	P	S	SiO2	TiO2
56	Hematite (0.076% Zn, 0.013% Cu, & 0.006% As) (Ricketts, 1888).	61.35	0.042	0.046	0.005	—	0.075
57	Carroll Bros tunnel, SE section 1, T25N, R86W., 150-164 ft (Dickman, 1906).	19.50	—	0.06	—	48.02	—
58	150-140 ft, Carroll Bros tunnel (Dickman,1906).	31.50	—	0.094	—	53.50	—
59	140-130 ft, Carroll Bros tunnel (Dickman,1906).	44.50	—	0.116	—	35.00	—
60	130-120 ft, Carroll Bros tunnel (Dickman,1906).	34.50	—	0.071	—	51.50	—
61	120-110 ft, Carroll Bros tunnel (Dickman,1906).	37.50	—	0.079	—	45.80	—
62	110-100 ft, Carroll Bros tunnel (Dickman,1906).	34.50	—	0.089	—	27.50	—
63	Selected ore from dump (Dickman, 1906).	40.00	—	0.07	—	40.80	—
64	Cut above Carroll Bros tunnel (Dickman, 1906).	38.20	—	0.067	—	43.65	—
65	Cut in wash (section 18, T25N, R85W) (Dickman, 1906).	37.50	—	0.119	—	36.15	—
66	Cut in wash (section 18, T25N, R85W) (Dickman, 1906).	64.60	—	0.096	—	1.75	—
67	Ore in place (section 18, T25N, R85W) (Dickman, 1906).	33.00	—	0.082	—	53.20	—
68	Ore from Patterson shaft, 104 ft deep (NW sec.7, T25N, R85W) (Dickman, 1906).	37.00	—	0.058	—	28.00	—

quartz, minor plagioclase, chlorite, and fuchsite, with accessory sphene, apatite, epidote, and magnetite. Fine-grained arkosic quartzite consists of granoblastic plagioclase and quartz.

Metagreywacke

Fine-grained metagreywacke consists of quartz and feldspar, with matrix chlorite, biotite, and minor amounts of epidote. Locally, cordierite porphyroblasts may be present. Accessory minerals include calcite, sericite, apatite, zircon, and opaques. Chlorite is a common retrograde product derived from the alteration of biotite. Cordierite typically is altered to sericite and quartz.

Samples of metagreywacke analyzed for whole-rock geochemistry (Samples 8U-10U, **Table 3**) yielded from 51.4 to 58.4 weight percent SiO_2, and 13.4 to 14.8 weight percent Al_2O_3. The silica contents of the greywackes are relatively low but lie within the range of the metagreywackes reported to the west of the Seminoe Mountains in both the South Pass greenstone belt in the Wind River Range (see Hausel, 1991b) and the Rattlesnake Hills greenstone belt in the Granite Mountains (Hausel, 1993a,1994).

Pelitic schist

Pelitic metasediments are highly foliated with common kink bands. These rocks are relatively uncommon and include thin units of quartz-mica schists and porphyroblastic mica schists. Metapelites mapped by Klein (1981) consisted of andalusite-quartz-mica schists. Locally, some of these schists contain garnet replaced by chlorite and magnetite.

Porphyroblastic mica schists mapped during this study in NE section 19 and NW section 20, T26N, R85W, are similar to the "peanut schists" in the South Pass greenstone belt of the southern Wind River Range and the Rattlesnake Hills in the Granite Mountains. The Seminoe Mountains porphyroblastic schists contain one centimeter and smaller-sized, rounded, dark-gray to white, peanut-shaped porphyroblasts of cordierite (confirmed by x-ray diffraction by R.W. Gregory, Wyoming State Geological Survey, written communication, 1991). Much of the cordierite has been replaced by quartz and sericite.

Volcaniclastics

Intermediate to felsic volcaniclastics were found only along the northern flank of the Seminoe Mountains near the Sunday Morning mine at the mouth of Sunday Morning Creek (Samples 5U and 6U, **Table 3** and **Plate 2**). These rocks are moderately to intensely sheared with quartz augen in a relatively fine-grained groundmass with crystal and lithic fragments of plagioclase and plagioclase and quartz (Klein, 1981). The volcaniclastics are interbedded with pelitic and clastic metasediments.

Metakomatiite

Rare, thin, outcrops of metakomatiite occur in the Seminoe formation. These are spinifex-textured tremolite-talc-chlorite schists similar to those in the Bradley Peak ultramafics. These spinifex-textured rocks were mapped in SE section 25, T26N, R86W, and in NW section 30, T26N, R85W (Samples 1U and 2U, **Table 3** and **Plate 2**). These rocks have CaO/Al_2O_3 ratios of 1.0 and 0.7, respectively, and have basaltic komatiite affinities.

Economic geology

Prospecting and exploration in the Seminoe Mountains has concentrated on iron, gold, copper, and jade. Production has been minimal.

Iron resources

Banded iron formation (BIF) is widespread in the Seminoe formation, but forms only a very minor part of the Bradley Peak ultramafics and the Sunday Morning Creek metavolcanics. Although no attempt was made during this study to determine the amount of BIF resources in the district, previous work (discussed below) has assessed those resources.

Some early studies attempted to assess the potential of developing the iron deposits for production of Bessemer steel. For example, Dickman (1906) noted that the BIF contained only minor phosphorous, which is favorable for the production of the steel, but the iron content was generally considered too low. Since these early studies were made, advances in ore dressing and blast furnace technologies have made these low-grade iron deposits more attractive.

Attempts to determine the extent of the iron resources began with a study by Hendricks (1902). Hendricks estimated that the Pattison Basin landslide area south of Bradley Peak (**Plate 1**) hosted a resource of one million tons of ore averaging 60 percent iron. In 1951, the Wilson Exploration Company estimated that the Pattison Basin area had several million tons of iron ore (Harrer, 1966).

The U.S. Bureau of Mines reviewed the data on Pattison Basin and specifically looked at one small block of high-grade ore along the section line between SW section 7 and NW section 18, T25N, R85W (Harrer, 1966). This block reportedly had an areal extent of 75 to 100 feet wide by 800 feet long, but recent mapping by the author indicates the block is at least 1,800 feet long. Harrer (1966) estimated this block had as much as 200,000 tons of ore to a depth of 50 feet. Twenty samples of the BIF assayed from 31.4 to 68.72 percent iron, 0.015 to 0.223 percent phosphorous, and 1.37 to 54.28 percent SiO_2 (**Table 4** and **Figure 14**) (Harrer, 1966).

Much of the early work on the iron deposits in the Seminoe district concentrated on Pattison Basin. Although the iron deposits in the basin are oxidized and generally of higher grade than the BIF to the north on Bradley Peak, Junk Hill, and the region east of Junk Hill, they represent only a minor amount of the total resource available in the district. The Pattison Basin iron deposits crop out over a small surface area and lie within a highly fractured, hummocky, broken landslide block which originated from the south slope of Bradley Peak (Blackstone, 1965) (**Figure 15**). The depth of these deposits is limited by the thickness of the landslide block. The thickness is unknown, but shafts sunk 50 and 104 feet deep into the BIF (Dickman, 1906) apparently did not reach the underlying Cretaceous sedimentary rocks.

Harrer (1966) expanded the study of the iron resources of the district to the much larger, low-grade, iron deposits of the Bradley Peak area north of Pattison Basin. In particular, Harrer (1966) noted the Twin Creek BIF on the north slope of Bradley Peak contained a considerably larger iron resource than Pattison Basin. The Twin Creek BIF forms a substantial block of low-grade iron formation with a maximum outcrop width of 800 feet traceable down the northern slope of Bradley Peak for 3,500 feet (**Plate 1**). The block is faulted along its southern flank by the Twin Creek fault, but additional, thinner, offset outcrops of BIF continue another 2,000 feet south of this fault prior to terminating against the Bradley Peak thrust fault. The offset outcrops of BIF are interlayered with thick amphibolite. The Twin Creek deposit was estimated to have as much as 100 million tons of low-grade iron ore (Harrer, 1966).

In addition to BIF in Pattison Basin and on Bradley Peak, abundant BIF crops out along Junk Hill north of Bradley Peak, and in a fault block east of Junk Hill bounded by the Deweese Creek and Kortes faults. In total, the iron resource is large (in the range of a few hundred million tons), with the Twin Creek BIF having the greatest potential for iron ore amenable to open pit mining.

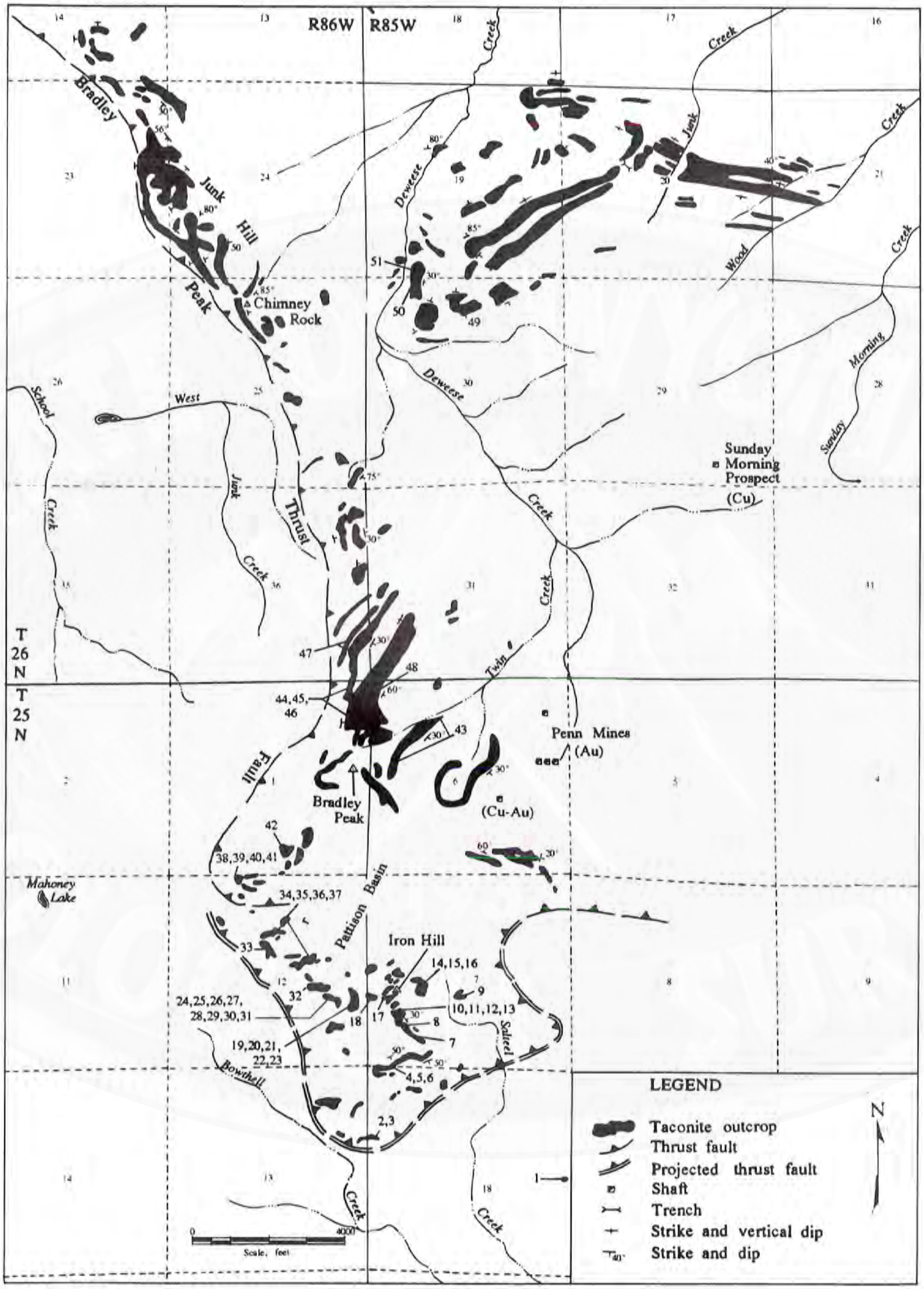


Figure 14. Generalized sample location map of iron formation reported in **Table 4** (modified from Harrer, 1966). Sample locations are numbered.

Figure 15. View of the landslide area in Pattison Basin lying at the southern base of Bradley Peak. Note the characteristic landslide topography of hummocks and sags. (Photograph by W.D. Hausel, 1990.)

The BIF is also notable for trace amounts of precious metals. Dickman (1906) reported a sample of BIF along the section line between section 31, T26N, R85W, and section 36, T26N, R86W, yielded anomalous gold and silver. A sample of an 8-foot-wide iron formation at this location was reported by Dickman (1906) to have yielded 33.5 percent Fe, 0.5 opt Ag, and 0.02 opt Au (**Table 5**).

Reports of precious metals in the BIF were apparently common knowledge to prospectors in the district. Lovering (1929) wrote:

> *High gold assays are said to have been obtained from the banded jasper of the iron formation, but the writer was unable to verify this statement, as the samples of the iron formation that he gathered carried only traces of gold, with one exception, which ran 0.01 ounce in gold to the ton.*

During a brief reconnaissance of the district in 1981, the author collected some select samples of quartz and BIF in the Penn mines area for assay. The BIF samples were collected because of evidence of epigenetic alteration in the form of crosscutting carbonate veins with pyrite (Hausel, 1993b). One sample was highly anomalous, yielding 1.36 opt Au (Sample 21A, **Table 5** and **Plate 2**). Samples 35A-39A, (**Table 5**) of BIF collected later from this same area were not anomalous.

There are two possible explanations for these differing results. The most obvious explanation is that the initial BIF assay was contaminated by gold-bearing quartz vein samples during sample preparation in the laboratory. The second possibility is the "nugget effect." The nugget effect occurs when gold is concentrated in small pods or nuggets, which makes repeatability of analyses difficult. Thus, a sample containing a nugget would yield a high gold analysis; however, another sample collected adjacent to the nugget may not contain detectable gold. Timberline Minerals Company explored this area after 1981 and encountered many difficulties repeating assays; the company attributed these difficulties to the nugget effect. Incidentally, a sample of BIF collected by Timberline Minerals Company in the Penn mines area reportedly contained visible gold (John Wells, verbal communication, 1984).

The author collected numerous other BIF samples throughout the district. Chemical analyses of these samples (**Table 5**) show the presence of

Table 5. Geochemical analyses of banded iron formation (BIF) and host veins and veinlets, Seminoe Mountains mining district, Wyoming. Dashes indicate not determined; ppm=parts per million. (See **Plate 2** for sample locations.) Analyses by Bondar Clegg or Wyoming Analytical Laboratories.

Sample Number	Description	Ag (ppm)	Au (ppm)	Cr (ppm)	Cu (%)	Fe (%)	Ga (ppm)	Ni (ppm)	Pb (ppm)	Zn (ppm)
1A	Weakly magnetic BIF.	<1.0	<0.05	—	—	23.2	—	—	—	—
2A	Float BIF.	<1.0	<0.05	—	—	26.4	—	—	—	—
3A	BIF with crosscutting quartz veinlets.	1.1	<0.05	—	—	20.4	—	—	—	—
4A	Sheared BIF in contact with amphibolite.	2.9	<0.05	—	0.045	—	—	—	12	90
5A	BIF.	<1.0	<0.05	—	—	33.4	—	—	—	—
6A	Brecciated BIF cemented with carbonate and hematite.	1.8	<0.05	—	—	—	—	—	—	—
7A	Stratabound quartz veinlet in BIF.	<1.0	<0.05	—	—	9.5	—	—	—	—
8A	Limonite stained quartz in BIF.	1.5	<0.05	—	—	—	—	—	—	—
9A	BIF.	<1.0	<0.05	—	—	30.4	—	—	—	—
10A	Carbonated BIF.	1.2	<0.05	—	—	—	—	—	—	—
11A	BIF from E=CM2 prospect.	<1.0	<0.05	—	—	23.5	—	—	—	—
12A	Milky quartz from BIF at E=CM2 prospect	<1.0	<0.05	—	—	—	—	—	—	—
13A	Massive, thinly bedded BIF.	<1.0	<0.05	—	—	31.6	—	—	—	—
14A	BIF near Junk Creek prospect.	<1.0	<0.05	—	—	16.2	—	—	—	—
15A	Lemon-yellow stained sheared BIF at Junk Creek.	<1.0	<0.05	60	—	—	<5	25	—	—
16A	Lemon-yellow stained sheared BIF at Junk Creek prospect.	<1.0	<0.05	22	—	—	<5	20	—	—
17A	BIF from landslide mine dump	5.4	<0.05	98	—	26.1	—	—	—	—
18A	Carbonated quartz from BIF.	8.1	0.06	—	—	—	—	—	—	—
19A	Crosscutting vein in BIF.	<1.0	0.34	—	0.02	—	—	—	7.2	—
20A	Quartz-carbonate breccia vein in BIF.	<1.0	<0.05	—	0.04	—	—	—	170	2,820
21A	Carbonated BIF with minor pyrite.	—	42.3	—	—	—	—	—	—	—
22A	Junk Hill BIF with 4mm wide quartz veinlet.	0.2	0.001	—	—	—	—	—	—	—
23A	Carbonated BIF.	<0.1	<0.001	—	—	—	—	—	—	—
24A	Junk Hill silicate BIF with quartz vein.	<0.1	<0.001	—	—	—	—	—	—	—
25A	Crosscutting quartz vein in Junk Hill BIF.	<0.1	<0.001	—	—	—	—	—	—	—
26A	Carbonate facies BIF.	<0.1	0.002	—	—	—	—	—	—	—
27A	Quartz vein in BIF.	<0.1	0.008	—	—	—	—	—	—	—
28A	Gossaniferous contact between serpentinite and BIF.	<0.1	0.003	—	—	—	—	18	—	—
29A	Silicified shear in BIF.	<0.1	0.041	—	—	—	—	—	—	—
30A	BIF with boxworks in fold closure.	<0.1	0.004	—	—	—	—	—	—	—
31A	Brecciated BIF rehealed by quartz.	<0.1	0.01	—	—	—	—	—	—	—
32A	Limonite-stained BIF.	<0.1	0.002	—	—	—	—	—	—	—
33A	Limonite-stained BIF with cross-cutting quartz veinlets.	0.6	<0.010	—	—	11.9	—	—	—	—
34A	Isoclinally folded BIF.	<0.5	<0.010	—	—	—	—	—	—	—
35A	BIF with crosscutting carbonate veins and prismatic quartz-filled vug.	<1.0	<0.05	—	0.009	—	—	—	220	—
36A	BIF with limonite-stained carbonate.	<1.0	<0.05	—	0.003	—	—	—	30	—
37A	Pyritiferous carbonate fracture-filling in BIF.	<1.0	<0.05	—	0.005	—	—	—	11	—
38A	BIF.	<1.0	<0.05	66	—	—	—	43	—	—
39A	Quartz-carbonate breccia vein in BIF.	<1.0	<0.05	—	—	—	—	—	—	—
40A	Fault gouge in BIF in West Twin Creek adit.	<1.0	<0.05	—	—	—	—	—	—	—
41A	Gossaniferous BIF from prospect pit.	<1.0	<0.005	—	—	—	—	—	—	—
—	Sample of 8 ft wide BIF in sections 31 and 36, T26N, R86W (0.125% P, no detectable Pt) (Dickman, 1906).	15.55	0.622	—	—	33.5	—	—	—	—

trace amounts of precious metals in the BIF and host veins. Anomalous gold is rare; silver is more common. In samples that yielded anomalous precious metals, clear evidence of epigenesis was present in all but one sample (Hausel, 1993b) It is also notable that BIF Sample 20A produced a zinc anomaly (0.28 percent Zn). All these results suggest that any exploration for iron resources in the district should also consider potential by-product recovery of gold, silver, and other trace metals.

Gold, copper, silver, zinc, and lead

The Seminoe Mountains district was initially explored for gold following the discovery of the precious metal during General Bradley's 1871 expedition. However, no major developments occurred, due in part to the constant threat of Indian attacks, the properties being held in litigation, the general lack of serious exploration ventures, and because of the narrow width and limited strike length of the known veins. Another possible deterrent may have been the rock conditions in the area. For example, exploration of the Penn mines by Timberline Minerals in the early 1980s included reopening the Deserted Treasure adits. The backs of these mines were very unstable due to intersecting joints and fractures.

According to Knight (1893), early gold production from the district amounted to only about 500 ounces. However, historical reports indicate much of the development work on the Penn mines occurred after 1893. The tunnels at the Penn mines were extended to as much as six times their 1893 length in 1896. Although there are many variables (e.g., ore grade, mill efficiency, waste rock mined, etc.) that should be considered in calculating production, the values for these variables are not known. Nevertheless, total gold production for the district was probably less than 3,000 ounces.

Vein samples in the area around Bradley Peak generally yield anomalous gold (Hausel, 1993b). These veins are typically narrow (generally less than 3 feet wide), sulfide-bearing (pyrite and chalcopyrite), quartz-carbonate veins in a broad zone of propylitized amphibolites (metabasalt and metagabbro). The altered zone is approximately 0.5 mile in diameter and confined principally to the eastern half of section 6, T25N, R85W (Klein, 1981). The amphibolites are moderately to pervasively altered to chlorite, carbonate, actinolite, and epidote. Samples collected from the altered zone ranged from <0.05 ppm to 89.3 ppm (2.6 opt) Au, <1.0 to 55.0 ppm (1.6 opt) Ag, 0.03 to 3.75 percent Cu, 3.0 ppm to 0.39 percent Pb, and 22 ppm to 4.3 percent Zn (Samples 51A-68A, **Table 6**).

Widespread propylitic alteration in the Penn mines area warrants more detailed sampling of the wallrocks. At a few localities where the wallrock exhibited distinct limonitic alteration, or was cut by quartz-carbonate veinlets, it was sampled and assayed. Sample 54A (**Table 6** and **Plate 2**), a limonite-stained metatholeiite with some secondary quartz, was highly anomalous in precious metals yielding 9.8 ppm Au, 12.0 ppm Ag, and 0.81 percent Cu. Another sample of chloritized metatholeiite yielded 0.12 ppm Au, <1.0 ppm Ag, and 0.09 percent Cu (Sample 56A, **Table 6** and **Plate 2**). These two samples, collected from the altered zone, indicate mineralization in the Penn mines area is not confined only to the quartz veins.

Quartz veins exhibit orientations of N70°E, N50°W, and N-S in the Penn mines area (**Plate 1**). No information is available on the possibility of ore shoots in the veins, and the lack of surface exposure makes this difficult to assess. Isoclinally folded quartz sampled at two locations yielded anomalous gold and silver (4.6 ppm and 6.8 ppm Au and 5.2 ppm and 4.2 ppm Ag, respectively) (Samples 52A and 66A, **Table 6** and **Plate 2**), suggesting possible enrichment in fold closures. Vein-vein and vein-shear intersections were not assessed during this study because of the lack of exposure, and there is no evidence that any such intersections were tested historically. Copper prospects examined during this project were of limited extent.

The following mines and prospects were examined:

Deserted Treasure #1 adit

This mine is located in S/2 NE section 6, T25N, R85W. The tunnel was driven S15°W across foliation to intersect a N67°E-trending, 46°N-dipping vein cropping out 300 to 400 feet to the south on the east flank of Bradley Peak (see **Plate 1**). Samples of sulfide-bearing quartz and boxwork quartz from the mine dump yielded anomalous precious metal contents. One sample of limonite-stained quartz from the dump assayed 1.2 ppm Au and 3.6 ppm Ag (Sample 65A, **Table 6**). During 1981, several quartz samples with visible gold were collected from the mine dump.

Deserted Treasure #2 adit

This mine is located in SE NE section 6, T25N, R85W, a short distance downslope from the #1 adit.

Table 6. Geochemical analyses of mineralized samples and related rocks from the Seminoe Mountains. Dashes indicate not determined; ppm=parts per million, ppb=parts per billion. (See **Plate 2** for locations.)

Sample Number	Description	Ag (ppm)	Au (ppm)	Cr (ppm)	Cu (%)	Ga (ppm)	Ni (ppm)	Pb (ppm)	Pd (ppb)	Pt (ppb)	Zn (ppm)
42A	Milky quartz stockworks in chlorite schist	4.0	1.3	—	0.14	—	—	14	—	—	43
43A	Weakly iron-stained schist	<0.05	2.1	—	—	—	—	—	—	—	—
42A	Milky quartz stockworks in chlorite schist	4	1.3	—	0.14	—	—	14	—	—	43
43A	Weakly iron-stained schist	2.1	<0.05	—	—	—	—	—	—	—	—
44A	Limonite-cemented fault breccia w/ goethite	1.1	<0.05	—	—	—	—	—	—		
45A	Cupriferous felsite from prospect pit	<1.0	<0.05	—	4.4	62	—	16	—	—	39
46A	1 ft channel, across Cu-stained shear	45.4	0.07	—	1.8	—	—	220	—	—	47
47A	Grab, Cu-stained quartz, Sunday Morning prospect	26.9	2.1	—	5.8	—	—	1,970	—	—	140
48A	10 ft composite, Cu-mafic wallrock, Junk Creek	1.7	<0.05	—	0.78	—	—	—	—	—	—
49A	Grab, azurite-malachite-tenorite-limonite-quartz	1.4	0.05	—	1.2	6	—	—	—	—	—
50A	Cu-stained quartz	2.7	0.15	—	3.7	—	—	66	—	—	2,920
51A	Quartz from mine dump	<1.0	<0.05	—	—	—	—	—	—	—	—
52A	Quartz in fold closure from prospect pit	5.2	4.6	—	0.12	—	—	54	—	—	22
53A	Cu-Fe-stained fracture in metatholeiite	55.0	12.0	—	3.75	—	—	25	—	—	250
54A	Limonite-stained metatholeiite	12.0	9.8	—	0.81	—	—	10	—	—	85
55A	Vein quartz, south of Emeletta mine	3.5	2.2	—	0.11	—	—	5.4	—	—	28
56A	Wallrock adjacent to stockwork	<1.0	0.12	—	0.09	—	—	3.0	—	—	120
57A	Cu-stained quartz with minor pyrite	6.8	8.8	—	0.37	—	—	23	—	—	120
58A	Cu-stained quartz with minor pyrite	9.3	11.0	—	0.94	—	—	75	—	—	480
59A	Quartz with chalcopyrite, covellite, and pyrite	26.0	2.2	—	1.61	—	—	11	—	—	110
60A	Banded metachert	3.3	<0.05	—	0.03	—	—	3,890	—	—	43,000
61A	Cu-stained boxworks	8.1	0.05	—	0.28	—	—	2,180	—	—	25,000
62A	Boxwork quartz, Deserted Treasure #2 mine dump	18.0	28.0	—	0.39	—	—	—	—	—	—
63A	Boxwork quartz, Deserted Treasure #2 mine dump	18.0	20.0	—	0.38	—	—	—	—	—	—
64A	Quartz w/ chalcopyrite & bornite	<2.0	0.87	—	0.06	—	—	—	—	—	—
65A	Selected quartz, Deserted Treasure #1 mine dump	3.6	1.2	—	—	—	—	—	—	—	—
66A	Limonite-stained quartz in fold closure, King mine	4.2	6.8	—	—	—	—	—	—	—	—
67A	Sulfide-bearing amphibolite	—	35.4	—	—	—	—	—	—	—	—
68A	Selected sample quartz, Deserted Treasure #2 mine dump	—	89.3	—	—	—	—	—	—	—	—
69A	Selected boxwork quartz breccia, Apex mine	4.0	0.004	—	0.53	—	—	9,530	—	—	2,330
70A	3 ft composite, quartz breccia, Apex mine dump	0.5	0.003	—	0.14	<10	—	175	—	—	108
71A	Grab, Cu-stained mafic schist, Apex mine	63.8	0.013	—	3.81	—	—	92	—	—	68
72A	Cu-stained schist, Apex mine dump	0.3	0.001	—	0.49	—	—	61	—	—	131
73A	Cupiferous, amphibolite-hosted, quartz vein	3.6	0.038	—	3.43	—	—	3	—	—	11
74A	Stockwork in magnetite-bearing ultramafic schist	<0.1	0.01	2,771	—	—	1,379	—	—	—	—
75A	Metagabbro	—	—	27	—	—	65	—	—	—	—
76A	Cu-stained schist from prospect pit	0.2	0.14	—	4.7	19	—	10	—	—	622
77A	Milky quartz with boxworks	1.7	0.027	206	—	—	15	—	1	<5	—
78A	Grab, quartz w/ limonite boxworks	<0.5	<0.010	—	—	—	—	—	—	—	—
79A	Serpentinite w/ asbestos & minor chromite	<0.5	<0.010	6,000	—		1,700	—	—	—	—
80A	Talc serpentine schist, common limonite pits	<0.5	<0.010	1,900	—	—	2,400	—	—	—	—
81A	Limonite-stained milky quartz	0.8	<0.010	—	—	—	—	—	—	—	—
82A	Limonite-stained serpentinite (27.8% MgO)	—	—	7,600	—	—	627	—	—	—	—
83A	Cu-stained quartz, Charlie's glory hole	0.33	<0.05	—	0.52	—	—	30.1	—	—	106
84A	Gossan adjacent to spinifex metakomatiite	<1.0	<0.05	66	—	—	43	—	—	—	—
85A	Iron-stained schist	<1.0	<0.05	—	—	—	46	—	—	—	—
86A	Banded amphibolite	<1.0	<0.05	—	—	—	—	—	—	—	—
87A	Massive gossan with boxworks	<1.0	<0.05	—	—	—	—	—	—	—	—
88A	Gossan cut by quartz & carbonate vein stockwork	<1.0	<0.05	—	—	<5	—	—	—	—	—
89A	Iron-rich gossan at serpentinite base	<1.0	<0.05	202	—	—	23	—	—	—	—
90A	Limonite-cemented milky quartz breccia	<1.0	<0.05	—	—	<5	—	—	—	—	—

The crosscut tunnel was driven across foliation to intersect the same vein cut by the Deserted Treasure #1 adit. Select samples from the mine dump (Samples 62A-64A and 68A, **Table 6**) were highly anomalous and yielded from 0.87 ppm to 89.3 ppm Au, <2.0 to 18.0 ppm Ag, and 0.06 to 0.39 percent Cu. In 1981, the author collected a few samples with visible gold from this mine dump.

King mine

Located in E/2 SE NE section 6, T25N, R85W. This mine is farther downslope from the Deserted Treasure adits. Improvements listed on the 1880 King patent included a 100-foot tunnel with a 60-foot-deep shaft. A later report (*EMJ*, v. 62, August 8, 1896, p. 135) stated that the mine had been extended to 700 feet in length. A select sample from the King property (Sample 66A, **Table 6**) yielded 6.8 ppm Au and 4.2 ppm Ag.

Sunday Morning prospect

Located in SE section 29, T26N, R85W, the Sunday Morning prospect east of Bradley Peak was developed on a copper-stained shear in metavolcanics (**Figure 16**). An assay of Sample 46A (**Table 6** and **Plate 2**), a channel cut across the shear, yielded 1.8 percent Cu, 45.4 ppm Ag, and 0.07 ppm Au. Sample 47A (**Table 6**), a grab sample of cupriferous quartz from the mine dump, assayed 5.8 percent Cu, 26.9 ppm Ag, 2.1 ppm Au, and 0.2 percent Pb. This shear (the Apex shear) is traceable along a northeasterly trend for 2 miles and is marked by well-developed penetrative foliation. Copper mineralization is confined to small, localized pods in the shear zone. Both chrysocolla and cuprite are common, and Bishop (1964) reported some visible gold, although none was found during the present investigation.

Figure 16. Exposure of the Apex shear at the Sunday Morning prospect. Milky quartz pods parallel to the penetrative shear foliation are sometimes cupriferous, whereas, the isoclinally folded oblique veins are typically post-mineralization. (Photograph by W.D. Hausel, 1981.)

Apex adit

This adit is located in N/2 N/2 section 32, T26N, R85W. At the Apex adit, a short distance west and downslope from the Sunday Morning prospect, the shear grades into a quartz breccia vein containing angular clasts of country rock and more than one generation of quartz. Visible gold was collected near the portal in the past (Charlie Kortes, verbal communication, 1989), although no gold was found during this investigation. Samples collected from the property assayed from 0.14 to 3.81 percent Cu, 0.3 to 63.8 ppm Ag, 0.001 to 0.013 ppm Au, 61 ppm to 0.95 percent Pb, and 68 ppm to 0.23 percent Zn (Samples 69A-72A, **Table 6** and **Plate 2**).

Junk Creek area

This area is located in SW section 20, T26N, R85W, a few miles northeast of Bradley Peak. An unnamed shaft was sunk on brecciated quartz in metagabbro, and prospect pits were dug in sheared BIF about 1,500 feet west of the shaft. According to Bishop (1964), copper is found as fracture fillings and as coatings on the quartz, in the altered metagabbro, and in fault gouge surrounding the vein. Copper-stained quartz (Samples 48A and 49A, **Table 6** and **Plate 2**) contained traces of silver and 0.78 and 1.2 percent Cu, respectively. Samples of sheared tawny to russet BIF west of the shaft contained no detectable precious metals (Samples 14A and 15A, **Table 5** and **Plate 2**).

Sunday Morning mine

This mine is located in E/2 E/2 section 21, T26N, R85W. The U.S. Geological Survey 7 1/2-minute topographic quadrangle map of Bradley Peak incorrectly identifies a prospect in section 29 as the Sunday Morning mine. According to the original patent, the Sunday Morning mine was instead located at the mouth of Sunday Morning Creek.

This property was staked as early as 1882, and improvements at the time of the later patent (1919) included a 60-foot-deep shaft and a 146-foot tunnel driven from an adit at Sunday Morning Creek. The tunnel included three crosscuts of 15 feet, 40 feet, and 27 feet in length. A grab sample of quartz from the mine dump contained no detectable precious metals (Sample 78A, **Table 6**).

Placers

Streams draining the Seminoe district are immature, intermittent, and generally not conducive to development of significant placer gold resources. However, some gold placers do occur. Samples panned from unconsolidated paleoplacer conglomerates containing BIF pebbles and cobbles along the northern flank of the greenstone belt (located in T26N, R84W) east of the North Platte River contained colors and flakes of gold (Charlie and Donna Kortes, verbal communication, 1989). Panned samples collected from this placer by the author also yielded some gold colors and assayed 5.2 ppm Au.

The sample concentrates from the panned samples described above also yielded four grains of chromian diopside and eight rounded yellow-orange to purple pyrope garnets. The source of these mantle minerals is unknown. They were either derived from ultramafic schists in the greenstone belt (although no similar mantle material was identified in any of the peridotites), or they represent material transported to the earth's surface by some undiscovered ultramafic or ultrabasic intrusive. Similar minerals have been used worldwide as a guide to both diamondiferous and barren kimberlite. Future studies should consider geochemical testing of the pyrope garnets to determine if they are similar to diamond-inclusion garnets.

At another location, sand panned from the junction of Little Long Creek and Long Creek (E/2 E/2 section 23, T26N, R85W) produced several flakes of gold (Charlie Kortes, verbal communication, 1990). This sample was collected on the placer claims patented by Sunrise Placer and Dredging Company in 1913. These claims included portions of sections 23 and 24, T26N, R85W, and portions of sections 19 and 30, T26N, R84W (Charlie and Donna Kortes, verbal communication, 1990).

Serpentine-asbestos

The LaPlatte Lode and the Asbestos Lode Vein claims were staked for asbestos in 1882 on the north slope of Chlorite Mountain (location unknown) somewhere near Deweese Creek. During this study, the author located some asbestos veinlets in serpentinite along Sunday Morning Creek (SE section 21, T26N, R85W) east of Deweese Creek, and near the toe of the extreme southeastern flank of Bradley Peak (N/2 N/2 section 8, T25N, R85W). On Sunday Morning Creek, some old prospect pits can be found on the asbestos, but the mineralization is very restricted. The asbestos is in narrow (less than 1/4-inch-wide) cross-fiber veinlets in the serpentinite.

Serpentinite crops out at several locations in the Bradley Peak ultramafics. The serpentinite on the southeastern flank of Bradley Peak includes some localized pods of yellow-green material that may produce an attractive lapidary stone.

Jade

Nephrite jade was reported by Bishop (1964) along the northern flank of the Seminoe Mountains in sections 23, 26, and 28, T26N, R85W, and in a granite outlier to the north in section 12, T26N, R83W(?). The granite outlier was reported in T26N, R84W, by Sherer (1969). Bishop's jade locality in section 23 was briefly examined during this study. The host rock is a serpentinized peridotite, but no jade was found.

Sherer (1969) described the nephrite-like dikes of Bishop (1964) on the northern flank of the Seminoe Mountains as actinoliferous amphibolite dikes. These rocks are probably some of the tremolite-talc-chlorite-serpentine schists (metakomatiites) of the Bradley Peak ultramafics. According to Sherer (1969), the rocks have been cut locally by quartz veins. One vein hosted small mafic inclusions (up to 2 cm) with small patches of nephrite (Sherer, 1969).

The Sage Creek nephrite deposit, the jade occurrence in a granite outlier, was mistakenly located by Bishop (1964) in T26N, R83W. It now appears that the Sage Creek deposit is located, instead, in NE SE section 12, T26N, R84W. The deposit consists of a pod-like mass of olive-green nephrite in association with quartz in a quartz diorite dike (Sherer, 1969). This locality was not investigated during the present study.

Chromium-nickel

Because ultramafic komatiites occur in the greenstone succession, serpentinite samples were regularly tested for chromium and nickel. Gossans developed at the base of cumulate zones were prime sample sites.

The analyses were discouraging. Some very weak chromium anomalies were detected, but no nickel anomalies were identified. However, the geochemistry of these rocks warrants further testing and exploration for nickel. The geochemistry of some of the Seminoe Mountains rocks is similar to nickeliferous komatiites from Western Australia (Hausel, 1993c). Future studies should include analyses for rare earth elements to assist in isolating the most favorable host rocks.

Lapidary and decorative stone

Lapidary materials, in addition to jade, include the very attractive banded tawny and brown jasperized BIF found principally as float along Deweese Creek. These rocks give a general appearance of petrified wood, but instead are jasperized iron formation. Similar material has been found as far away as the northern edge of the Hanna Basin southeast of the Seminoe Mountains (Alan J. Ver Ploeg, Wyoming State Geological Survey, verbal communication, 1990).

Fractured milky quartz filled with cuprite and chrysocolla from the Sunday Morning prospect has also been exploited by collectors as a decorative stone. Much of this attractive rock has been depleted during the past 20 to 30 years.

Leopard rock, a porphyritic metagabbro to metabasalt containing large, rounded, white feldspar crystals in a black aphanitic groundmass, was found at a few localities in the Seminoe formation (**Plate 1**). The most extensive and better-quality material occurs in the SE section 20, T26N, R85W, on a ridge between Wood Creek and an unnamed creek. This material is generally sought for use in paperweights, bookends, and as other decorative stone.

Alteration

Widespread epidote alteration occurs along the contact between the Seminoe Mountains granodiorite batholith and rocks of the Sunday Morning Creek metavolcanics, and in association with the Apex shear zone. Mineralization is associated with the shear, but does not appear to be associated with the batholith contact. The epidote alteration consists primarily of extensive replacement of Ca-plagioclase by epidote. Amphiboles within the epidotized mafic metavolcanics may also be partly altered to actinolite (Klein, 1981). The alteration was interpreted by Klein (1981) to have produced relative decreases in Al_2O_3, MgO, Cr, and antimony (Sb), and relative increases in Na_2O, TiO_2, H_2O^+, Ba, Cu, and Sr in the affected rocks.

Zones of chlorite-carbonate-epidote alteration occur in the Junk Creek and Penn mines areas. Chalcopyrite-pyrite-gold deposits in these areas are found in quartz veins and lenses associated with a chlorite-carbonate-epidote alteration zone (Klein, 1981). The alteration is similar to that in the Zimbabwe gold fields.

Ore genesis

The Seminoe gold deposits are spatially associated with mafic and ultramafic metaigneous rocks. Chlorite-carbonate-epidote alteration occurs in the mafic metaigneous rocks in the Penn mines area, and sporadically within the Bradley Peak ultramafics. Chlorite in the Bradley Peak ultramafics may be the result of the stability of chlorite during amphibolite-grade metamorphism. However, in the Junk Creek and Penn mines areas, fine-grained chlorite and carbonate form dense intergrowths which obliterate most relict igneous and metamorphic textures. In this case, Klein (1981) suggested that the alteration was epigenetic and occurred later than the prograde metamorphic event.

The country rock in the Penn mines area is pervasively altered to calcite, chlorite, and epidote assemblages. Actinolite after hornblende after pyroxene is also common in this area. The intensity of alteration increases adjacent to quartz veins and decreases away from the veins. Klein (1981, p. 140) noted an apparent enrichment of Au, Cu, and Te in intensely altered samples. A sample of altered spinifex rock near the Penn mines also showed depletions in As, Au, Cr, Ni, and Te (Klein, 1981).

Apparent depletion of As, Cu, Sb, and Zn in the severely altered amphibolites and depletion of As, Au, and Te in the spinifex schists suggest these rocks may be the source for the metals found in the gold veins of the Penn mines and Junk Creek areas and the source for zinc in sheared rocks west of the Penn mines. The lack of apparent depletion of leachable Te and leachable Au found in the altered amphibolites and their depletion within the spinifex-textured tremolite schist suggest that these two elements may have had their source in the ultramafics alone and may have been introduced into the altered amphibolites during carbonatization (Klein, 1981).

Processes for the formation of Archean gold deposits as suggested by Boyle (1979) and summarized by Klein (1981) are: (1) thermal mobilization and lateral secretion of volatiles and metals during metamorphism of volcanic-sedimentary piles; (2) derivation of metals from carbonated zones in volcanics and sediments; and (3) derivation from the alteration of iron formations. The gold-copper deposits in the Seminoe Mountains bear resemblance to those deposits derived from the second process: the Seminoe Mountains deposits occur in elongate carbonate zones within metavolcanic rocks. The suggested mechanism of formation is that the metals (As, Au, Cu, Sb, Te, and Zn) are mobilized during the breakdown of silicate minerals and deposited in dilation zones in structurally favorable rocks. During alteration, large amounts of silica are liberated to form the associated quartz veins (Klein, 1981).

Comparisons to other Wyoming Province supracrustal terranes

Houston (1983) noted two general ages of Archean greenstone belts in the Wyoming Archean Province. Hausel and others (1991) separated the Archean supracrustal terranes of the province into more than one type of terrane. In comparison, the Seminoe Mountains greenstone terrane is geologically younger than the other greenstone terranes (i.e., South Pass), and contains a greater volume of metavolcanic rocks relative to metasedimentary rocks.

There are no perfect analogs to the Seminoe Mountains greenstone terrane in the Wyoming Province. The Seminoe Mountains belt is dominated by lower amphibolite-grade metavolcanic (tholeiitic) rock with a relatively thick section of well-preserved ultramafic komatiites, unlike the other greenstone belts in the Wyoming Province.

In contrast to the Seminoe Mountains greenstone belt, the South Pass greenstone belt in the Wind River Range to the west (see Location map, **Plate 2**) is dominated by a thick succession of metasedi-mentary rocks with only a minor component of ultramafic schists (Hausel, 1991b). North of the Seminoe Mountains, the Copper Mountain supracrustal belt in the Owl Creek Mountains is dominated by high-grade, metasedimentary rock and orthoamphibolite with practically no ultramafic component. All primary textures in these rocks, for the most part, have been obliterated (Hausel and others, 1985). Copper Mountain is typical of a high-grade supracrustal terrane rather than a greenstone belt.

Recent mapping by the author in the Rattlesnake Hills greenstone belt south of Copper Mountain and north of the Seminoe Mountains (see Location map, **Plate 2**) shows the Rattlesnake Hills to consist of a relatively thick succession of metasedimentary rocks with a smaller, well-preserved pillow metabasalt (tholeiitic) unit, practically no ultramafic component, and only minor BIF (Hausel, 1993a). Additionally, this belt was later disrupted by dozens of Tertiary alkalic intrusives, and exhibits both Archean and Tertiary gold mineralization (Hausel, 1994).

The Elmers Rock greenstone belt in the Laramie Mountains to the east (Graff and others, 1982) is somewhat similar to the Rattlesnake Hills. Elmers Rock also has common amphibolite of tholeiitic affinity, metagreywacke, and only minor BIF and ultramafic schist.

The Casper Mountain greenstone terrane east of the Rattlesnake Hills contains a thick section of ultramafic schists similar to the Seminoe Mountains (Burford and others, 1979), and may represent the closest analog to the Seminoe Mountains in the Wyoming Province. Cumulate textures are preserved in some of the Casper Mountain ultramafics, although no spinifex textures have been reported. Casper Mountain also has no known BIF. The lack of BIF may be the result of nonpreservation, or more likely, the BIF-rich portion of this terrane still lies at depth and was not raised during the Laramide orogeny. Many of the supracrustal terranes of the Wyoming Province in Montana are metasedimentary-dominated supracrustal belts and lack the thick volcanic component seen in the Seminoe Mountains (Hausel and others, 1991).

Summary

The Seminoe Mountains greenstone belt represents a fragment of an Archean greenstone terrane. Mineral resources in the belt are varied, as is typical of most greenstone terranes, although historic production has been minor. However, the mineral resources have not been explored in any great detail, and indications are that some deposits could be mined under favorable economic conditions. Low-grade iron deposits are widespread and include a minimum resource of 100 million tons. The actual resource is probably three to four times this estimate. Lapidary and decorative stone is varied and includes several types of attractive rock including serpentinite, leopard rock, jade, jasperized BIF, and copper-coated (malachite, chrysocolla, cuprite) and fracture-filled milky quartz. Copper mineralization is localized and does not represent a significant resource, as may be the same for the zinc and lead mineralization discovered during this project, although the extent of the zinc and lead mineralization deserves a closer look. The author's discovery of pyrope garnet and chromian diopside in a paleoplacer along the north flank of the Seminoe Mountains suggests that the Seminoe Mountains should be appraised for possible diamond deposits.

It is the author's opinion that the gold and silver resource has not been adequately assessed. In past years, exploration efforts have been geared to the testing of narrow quartz veins and unfortunately, the possibility of broader auriferous pods enclosed in altered rocks has been neglected. The altered zone in the vicinity of the Penn mines should be considered as a target for widespread, low-grade gold mineralization with potential credits in silver, copper, lead, and zinc.

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