Geological Survey of Wyoming
Mineral Report MR92-6

PRELIMINARY REPORT ON THE GEOLOGY, GEOCHEMISTRY, MINERALIZATION, AND MINING HISTORY OF THE SEMINOE MOUNTAINS MINING DISTRICT, CARBON COUNTY, WYOMING

by

W. Dan Hausel
Senior Economic Geologist
Geological Survey of Wyoming

1992

Contents **Page**

Contents	Page
Introduction	1
Previous investigations	1
Acknowledgements	1
History	2
Geologic Setting	4
Supracrustal rocks	5
Sunday Morning Creek Metavolcanics	5
Bradley Peak ultramafics	7
Seminoe Formation	8
Economic Geology	10
Iron resources	10
Gold-copper-silver-zinc-lead	12
Serpentine-asbestos	14
Jade	15
Chromium-nickel	15
Lapidary	15
Alteration	15
Ore genesis	16
Comparisons to other Wyoming Province Supracrustal Terranes	16
Summary	17
References Cited	18

Figure Captions

Figure 1(a). Historic photos of the Deserted Treasure mine and dump (date unknown). Compare to recent photos (1b) taken by the author in 1991 and 1988. Notable is the thick stand of trees which have invaded the hillside over the years. The Deserted Treasure mine is probably the original site of the Ernst mine.

Figure 2. Historic photograph of the King (?) mine and mill (date unknown).

Figure 3. View northwest towards Bradley Peak from the vicinity of Cheyenne Ridge showing location of the Bradley Peak thrust (arrow).

Figure 4. Jensen AMF ternary diagram showing plots of metaigneous rocks of the Seminoe Mountains greenstone belt (From Klein, 1981).

Figure 5. Generalized geologic map of the Seminoe Mountains greenstone belt.

Figure 6. Jensen AMF ternary diagram showing plots of Sunday Morning Creek Metavolcanics amphibolite and serpentinite analyses, Seminoe Mountains greenstone belt.

Figure 7. Jensen AMF ternary diagram showing compositions of rocks form the Bradley Peak Ultramafics. Whole rock analyses are found in Table 2.

Figure 8. Random spinifex texture in a tremolite schist from the Sunday Morning Creek area of the Seminoe Mountains.

Figure 9. String-beef (?) spinifex texture in a metagabbro at the top of the Bradley Peak ultramafics, Sunday Morning Creek.

Figure 10. 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.

Figure 11. Jensen AMF ternary diagram showing analyses of metavolcanic rock of the Seminoe Formation.

Figure 12. 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 photo.

Figure 13. General sample location map of iron formation reported in Table 4 (from Harrer, 1966).

Figure 14. View of the landslide area in Patterson Basin lying at the southern base of Bradley Peak. Note the characteristic landslide topography of hummocks and sags.

Figure 15. 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.

List of Tables

Table 1. Major and trace element analyses of rocks of the Sunday Morning Creek Formation, Seminoe Mountains.

Table 2. Mjor and trace element analyses of rocks from the Bradley Peak ultramafics.

Table 3. Major and trace element analyses of rocks of the Seminoe Formation (Archean), and of a basaltic dike (Proterozoic ?).

Table 4. Chemical analyses (in percent) of iron formation, from various sources. See Figure 10 for locations.

Table 5. Geochemical analyses of banded iron formation and host veins and veinlets, Seminoe Mountains district, Wyoming (analyses by Bondar Clegg or Wyoming Analytical Labs).

Table 6. Geochemical analyses of mineralized samples and related rocks from the Seminoe Mountains (see Plate 2).

Plates

Plate 1. Geologic map of the Seminoe Mountains greenstone belt (scale 1:24,000).

Plate 2. Sample location map of the Seminoe Mountains (scale 1:24,000).

"... 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 (>2.7 Ga.) rocks 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 (Sunday Morning Creek Metavolcanics) consists of 11,000 feet of mafic schists with minor ultramafic schist and metasedimentary rock. This unit is overlain by the Bradley Peak ultramafics which consists of 1,000 feet of ultramafic and mafic metavolcanic rock. 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 (named the Seminoe Formation), consists of 4,000 feet of metasedimentary rock including metagreywacke, banded iron formation, and pelitic schist with minor amounts of mafic and ultramafic schist.

Modern 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, and anomalous zones of zinc and lead.

PRELIMINARY REPORT ON THE GEOLOGY, GEOCHEMISTRY, MINERALIZATION, AND MINING HISTORY OF THE SEMINOE MOUNTAINS MINING DISTRICT, CARBON COUNTY, WYOMING

by
W. Dan Hausel
Senior Economic Geologist
Geological Survey of Wyoming

Introduction

The Seminoe Mountains mining district near central Wyoming, is restricted to a belt of metamorphic rocks cropping out along the western flank of the Seminoe Mountains. The district is known for its iron ore and gold deposits, but also hosts some copper, silver, serpentine, asbestos, jasper, jade, and leopard rock. Some previously unknown zones of anomalous lead and zinc associated with shears were detected during this project, and some pyrope garnet and chromian diopside were recovered from a nearby gold placer. Historic ore production from the district has been minor.

The core of the Seminoe Mountains is formed of Archean crystalline rock consisting of an ancient greenstone terrane of metamorphosed volcanic, sedimentary, and plutonic rock intruded by granodiorite. These 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 sedimentary rock that form a spectacular steeply dipping precipice along the southern flank of the range.

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 in the Patterson 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 Quadrangle with emphasis on the Seminoe thrust fault. In 1968, Bayley 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 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 Klein's (1981), Bayley's (1968), Blackstone's (1965), and Bishop's (1964) earlier work 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). All three conferences noted striking similarities to greenstone belts found in Canada, Western Australia, and southern Africa.

Acknowledgements

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 appreciated their assistance and friendship. I am also indebted to G.G. Kortes and Kim Kortes for their hospitality and for the placer gold specimens that they provided to the Survey. I would like to thank D.L. Blackstone, Jr., for his review and critical comments on my Bradley Peak Quadrangle, and Dave Martinez and the U.S. Bureau of Land Management (Rawlins district) for loan of color aerial photography of the district.

Finally, I would like to dedicate this paper 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, a French trapper, was responsible for leading Fremont's expedition out of the Sweetwater Valley through Seminoe Pass west of the Seminoe Mountains near the western edge of the Ferris Mountains (Reed, 1872). Lajeunesse's middle name, Cimineau, is pronounced "Seminoe" in English. The name Seminoe Pass was later changed to Whiskey Gap following the destruction of a load of 'bootleg' whiskey by Captain Brown of the 11th Ohio cavalry at a spring in the gap in July of 1862 (Ferry, 1871).

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

Instead of finding silver (which probably came from the Ferris Mountains instead of the Seminoes), 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 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 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 Madison Limestone (Mississippian), 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. In several instances, the ore was reported to assay 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 fatalities resulted from an Indian raid on the mining camp, 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, Sept. 11, 1874).

The Seminoe district was avoided by the miners and prospectors for the next few years. And as many as four years after the conflict, an 1878 congressional report 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 say, "*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 it was written that the "*...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's not clear if this report is referring to the earlier 1874 raid or a later raid in 1881. In any case, if hostile attacks were not enough, the mining properties 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) (1885, v. 39, April 18, 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 to a length of 200 feet (**Figure 1**). The ore from the mine was described as having free milling gold in quartz in association with pyrite and chalcopyrite. The vein averaged 4 feet thick. The company constructed a 10 stamp mill with concentrator which successfully handled about 22 tons of ore per day (Warren, 1885; Aughey, 1886). Plans were made to construct another stamp mill after the Penn Mining Company struck a 6 foot gold-bearing vein (EMJ, 1886, v. 42, Oct. 9, p. 265).

A document published 10 years later in 1895 disagreed as to the success of the mill and reported the 10-stamp mill erected by the Penn Mining Company in 1885 proved to be a failure due to bad management (possibly also due to the lack of oxidized ore and abundant sulfides). Three clean ups from the mill gave $8, $12, and $16 in gold per ton (EMJ, 1895, v. 59, May 18, p. 472).

Some mines active in 1886 included the King and the Deserted Treasure. The King mine ran almost parallel to the Deserted Treasure, but more southwesterly and northeasterly (**Figure 2**). In 1886, the King mine was developed by a 120 foot drift with a 54 foot deep winze. At the bottom of the winze, the ore was 5 feet thick. Seventy tons of the ore reduced by the mill yielded $700 in gold, but the sulfides were not saved. It was also reported that a shaft was sunk near the East King mine (an extension of the King) and a crosscut encountered a streak of very high grade, gold-bearing quartz. Other properties in the district included the Jennie, Meager, and Bennett (Aughey, 1886).

In addition to the lode mines, some placer activity was also reported in the district. The EMJ (1886, v. 42, Oct. 9, p. 265) reported two placer miners (Hanley and Firth) were working a claim yielding $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 (1894, v. 58, Dec. 29, p. 615) reported the Penn Mining Company resumed work on its gold mines in the Seminoe Mountains after a 6 year shut down. The company's stamp mill was also operating again (EMJ, 1896, p. 263).

During this period, the mine workings were extended. The King mine was extended from 120 feet in 1886 to 700 feet in 1896. The vein was reported to vary from 1 to 4 feet wide with an average width of about 30 inches. Assays of the vein quartz averaged $25 in gold per ton (1.2 opt) (EMJ, 1896, Aug. 8, v. 62, 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 was reported to average $20 in gold per ton (1.0 opt) and to carry some copper. The stamp mill, however, recovered only $3 to $4 per ton due to the refractory nature of the ore (EMJ, 1896, Aug. 8, v. 62, p. 135).

In 1902, some interest in iron was expressed when Hendricks (1902) examined the high-grade iron deposits in the Patterson Basin area along the southern flank of Bradley Peak for the Lake Superior iron company. The Patterson Basin deposits were estimated to include 1 million tons of ore averaging 60% iron.

In 1906, claims were staked for gold clear around to the south side of Bradley Peak, where a tunnel was apparently initiated several hundred vertical feet below the old Penn Mining Company's workings for the purpose of cutting 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, 1906, v. 8, no. 3, Aug., p. 14-15). The Wyoming Industrial Journal (1906, v. 8, no. 4, Sept., 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.

In the same year, 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's intentions were to patent all of its holdings (Wyoming Industrial Journal, 1906, v. 8, no. 2, July, 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 of the Patterson Basin area was made by Hendricks (1951) of Wilson Exploration Company for Empire State Oil Company of Thermopolis. 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. And in the following year (1981) a reconnaissance excursion of the Seminoe district by the author resulted in the recovery of 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 this 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 rock. The Precambrian core consists of Archean metasedimentary and metavolcanic rocks (> 2.7 Ga, Snyder and others, 1989, p. 27) 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 rock on a footwall of Phanerozoic sedimentary rock as young as the Cretaceous Mesaverde Formation (Blackstone, 1965) (**Figure 3**). The Seminoe Mountains are bounded on the north by the Kortes reverse fault, a Precambrian shear zone that was reactivated by Laramide deformation and again reactivated in Late Cenozoic time (Klein, 1981; Bohn, 1990).

The crystalline rocks in the Seminoe Mountains represent a fragment of an Archean greenstone belt dominated by metavolcanic rock with compositions ranging from tholeiitic to komatiitic (**Figure 4**) (Klein, 1981). The lower portion of the metamorphic belt consists of 11,000 feet of mafic metavolcanic and volcaniclastic rocks informally named the Sunday Morning Creek Metavolcanics (**Figure 5**), 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.

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 that are dominated by komatiite chemistries. Most rocks in this unit, with MgO contents generally greater than 9%, are classified as komatiites based on their chemistry and texture.

The Bradley Peak Ultramafics are overlain by 2,000 to 4,000 feet of mixed 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 and crystal and lithic metatuffs and felsic schists.

Mineral deposits in the Seminoe Mountains include auriferous quartz veins, cupriferous shears and veins, and iron formation. Harrer (1966) estimated the banded iron formation (BIF) along the north slope of Bradley Peak could potentially include about 100 million tons of taconite. Some other interesting occurrences include serpentinite, leopard rock, minor asbestos and nephrite jade, and zinc and lead anomalies.

Supracrustal Rocks

Sunday Morning Creek Metavolcanics

The lower unit of the Seminoe Mountains greenstone belt consists of 11,000 feet of mafic metavolcanic and volcaniclastic rocks (**Figure 5; Plate 1**). This succession is well exposed along Sunday Morning Creek in section 27, T26N, R85W and includes amphibolite, metabasalt, metatuff, and mica schist with minor BIF and serpentinite. The unit has been intruded by metagabbro sills which occur in greater frequency near the top (north) of the unit.

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.

Table 2. [illegible] analyses of rock samples from the Cooper Hill district. Refer to Plate 1 for sample locations. Analyses by Bondar-Clegg. (Dashes imply not analyzed).

Sample #	[illegible]	Au (ppm)	Ag (ppm)	Cu (%)	Pb (ppm)	Zn (ppm)	Ga (ppm)	Cr (ppm)	Ni (ppm)	W (ppm)	Sn (ppm)	Ti (ppm)	Pt (ppb)	Pd (ppb)	V (ppm)	Mo (ppm)	As (ppm)	Sb (ppm)	Hg (ppm)
CH1-91	[illegible] after siderite from Silver Queen mine [illegible]	<0.005	0.6	—	—	—	23	—	—	—	—	—	—	—	—	—	—	—	—
CH2-91	[illegible] after sulfides in chloritized mafic rock, Silver Queen dump.	0.034	0.3	—	—	—	30	500	264	—	—	—	—	—	—	—	—	—	—
CH4-91	Marble from prospect pit (N/2 NE/4 sec. 34).	<0.005	1.6	—	22	5	—	—	—	—	—	—	—	—	—	—	—	—	—
CH5-91	Cupriferous quartz in metalimestone from prospect pit (NW/4 NE/4 sec. 34)	0.187	0.8	0.065	10	—	—	400	—	—	—	—	—	—	—	—	—	—	—
CH7-91	Cupriferous quartz from Silver Queen mine dump	>10.0	<0.2	2.27	<2	12	—	—	—	—	—	—	—	—	—	—	—	—	—
CH8-91	[illegible]-actinolite-epidote-garnet hornfels ([illegible]/2 N/2 NE/4 sec. 34).	<0.005	<0.2	0.014	7	1	—	—	—	—	—	—	—	—	—	—	—	—	—
CH11-91	Milky quartz with limonite boxworks after siderite from Rip Van Winkel mine.	0.006	<0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH13-91	Massive limonite and hematite in quartz vein (E/2 sec. 27)	0.240	<0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH14-91	Boxwork-filled quartz from Richmond mine dump.	0.041	0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH15-91	Limonite boxworks from mine dump along East Fork Dutton Creek (NE/4 NW/4 sec. 27).	0.013	<0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH16-91	Limonite boxworks after siderite in quartz from mine dump.	0.037	0.8	0.08	56	46	—	700	—	—	—	—	—	—	—	—	—	—	—
CH18-91	Limonite- and hematite-stained quartz pebble conglomerate (NW/4 SE/4 sec. 27).	<0.005	<0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH19-91	Milky quartz breccia with massive limonite after siderite (E/2 NE/4 sec. 34).	<0.005	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH20-91	Milky quartz in mafic schist selvage in quartzite, with minor limonite after sulfide.	0.022	<0.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH21-91	Limonite-stained quartz from Emma G mine dump	0.089	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH23-91	Limonite boxworks after sulfides in quartz from Clara B prospect.	>10.0	1.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH25-91	Limonite-stained chalcopyrite-bearing schist from Silver Queen dump	0.046	0.7	0.35	<2	20	—	—	—	—	—	—	—	—	—	—	—	—	—
CH26-91	Milky quartz breccia vein from mine dump (W/2 NW/4 sec. 35).	<0.005	0.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH29-91	Limonite-stained skarn (S/2 SE/4 sec. 27).	0.012	<0.2	0.04	34	21	44	—	—	<2.0	31	—	—	—	—	—	—	—	—
CH30-91	Limonite boxworks from skarn.	0.170	<0.2	0.09	<2	10	—	—	—	—	—	—	—	—	—	9	363	2.4	0.101
CH31-91	Limonite boxworks from skarn (SE/4 SE/4 sec. 27).	<0.05	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH32-91	Limonite-stained, grey-black quartz (SE/4 sec. 27)	0.190	<1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH34-91	Quartz pebble conglomerate with hematite pseudomorphs after magnetite (?) or pyrite (?).	0.040	<0.2	—	—	—	—	—	—	<2.0	<5	<50	—	—	—	—	—	—	—
CH35-91	Select sample of quartz from ore sack at Richmond mine	0.012	<0.1	0.10	25	63	—	—	—	—	—	—	—	—	—	—	—	—	—
CH36-91	Twenty-foot composite chip sample across Richmond breccia vein.	0.080	1.2	0.07	11	50	—	—	—	—	—	—	—	—	—	—	—	—	—
CH38-91	Limonite boxworks in quartz from mine dump (E/2 sec. 27)	0.160	1.8	—	72	46	—	—	—	—	—	—	—	—	—	—	—	—	—
CH39-91	Grab sample of galena-bearing quartz, Albion mine (W/2 sec. 27).	7.5	56.9	0.04	11,242	2.6	—	—	—	—	—	—	—	—	—	—	—	—	—
CH40-91	Boxwork quartz from Albion mine.	<0.05	1.4	0.03	134	45.5	—	—	—	—	—	—	—	—	—	—	—	—	—
CH41-91	Epidote-calcite-actiolite-sulfide-skarn (N/2 NE sec.34).	0.108	0.6	1.88	14	19	-	-	—	5	—	—	4	11	—	—	—	—	—
CH45-91	Weak skarn from prospect pit (NW/4 NE/4 sec. 34).	<0.05	3.5	0.003	60	15.8	—	—	—	—	—	—	—	—	—	—	—	—	—
CH46-91	Skarn from pit	<0.05	2.5	0.004	31	7.3	—	—	—	—	—	—	—	—	—	—	—	—	—
CH50-91	Galena-bearing quartz form Albion mine dump.	1.7	97.2	—	6,193	<0.005	—	—	—	—	—	—	—	—	—	—	—	—	—
CH51-91	Decalcified pyritiferous metalimestone from Albion mine.	0.6	1.0	0.003	93	36.7	—	—	—	—	—	—	—	—	—	—	—	—	—
CH52-91	Boxwork quartz with pyrite from Albion mine	0.2	<0.1	0.003	12	12.7	—	—	—	—	—	—	—	—	—	—	—	—	—
CH1-92	Chip of quartz from rib, Sawmill Creek adit.	<0.005	<0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH2-92	Selected samples of quartz from dump.	<0.005	<0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH4-92	Milky quartz with boxworks.	0.005	<0.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH5-92	Selected sample from rib, Sawmill Creek adit.	0.071	1.9	>2.0	128	55	—	—	—	—	—	—	—	—	—	—	—	—	—

Mafic metavolcanics: The bulk of the Sunday Morning Creek Metavolcanics consists of foliated metavolcanic rock. These are slightly to intensely foliated, dark grey to black, orthoamphibolites and chlorite schists. The prominent foliation in these rocks parallel the primary bedding as determined by concordancy with intercalated layers of metasedimentary rock. 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 10.9 to 4.39 weight percent MgO (samples 4L-7L, **Table 1**). With the exception of sample 4L, these fall within the tholeiite field of a Jensen diagram (**Figure 6**). Sample 4L lies within the basaltic komatiite field and has relatively high MgO (> 9% MgO) and chromium (1,800 ppm Cr). The results suggest these rocks were originally basalts and basaltic komatiites prior to being metamorphosed.

Serpentinite: Serpentinite crops out close to the base of the Sunday Morning Creek Metavolcanics near its contact with the granodiorite pluton east of Deweese Creek. Serpentinite is also found near the top of the unit essentially marking the contact between the foliated amphibolites to the south and the metagabbros to the north.

Near the base of the Sunday Morning Creek Metavolcanics, the serpentinite crops out in a narrow, sill-like unit traceable for more than two miles along strike. The rock is completely serpentinized and formed 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 (**Table 1**, no. 1L) gave 33.8 weight percent MgO (38.27% volatile free basis), 5,400 ppm Cr, 1,632 ppm Ni, and a very low CaO/Al_2O_3 ratio of 0.06. The anomalously low ratio is possibly due to the loss of CaO with respect to Al_2O_3 during serpentinization. In that chromium systematically increases with increasing magnesium, the apparently high Cr content of this rock is not considered anomalous when compared to the high MgO.

The serpentinite near the top of the Sunday Morning Creek Metavolcanics (**Table 1**, no. 2L) yielded 29.2 weight percent MgO (32.15% 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 6**). 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 (**Table 1**, no. 3L) 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 6**). This rock is interpreted as a carbonated schist of komatiite affinity.

Augen gneiss: Dark grey 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. 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 (see Arndt and Nisbet, 1982).

Komatiites for the most part are primitive volcanic flows. Typically, they are classified as either basaltic (mafic) komatiites with MgO contents of 9 to 18%, or peridotitic (ultramafic) komatiites with MgO contents greater than 18%. 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 rock overlying equigranular aphyric rock 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 from 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.

Peridotitic komatiite: Komatiite rocks along Sunday Morning Creek consist of 14 differentiated peridotite flows (20 to <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). These cumulate-textured serpentinites are magnesium-rich and range from 25 to 35 weight percent MgO and plot within the ultramafic komatiite field of the Jensen AMF ternary diagram (**Figure 7**) (Klein, 1981, 1982).

The cumulate-textured serpentinite grades upward into aphyric tremolite-talc-chlorite-serpentine schist and progressively upward 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 8**) (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 7**) and are taken 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.

Rocks with ultramafic (peridotitic) komatiite compositions collected during this study yielded 34.4 to 20.7 weight percent MgO (39.26 to 21.8% MgO volatile free basis), 7,400 ppm to 2,000 ppm Cr, and 1,700 ppm to 430 ppm Ni. The CaO/Al_2O_3 ratios range from 0.06 to 2.5 and average 0.8 (samples 1B-13B, **Table 2**).

The komatiite suite along Sunday Morning Creek has general compositional characteristics of other aluminum-undepleted komatiites found in other Archean cratonic terranes. They have CaO/Al_2O_3 ratios less than unity, 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 have LREE (light rare earth elements) depleted, to flat REE patterns (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 9**). The texture is similar to 'string-beef' spinifex texture reported by Arndt (1976) in the Munro Township in Canada (M. L. Page, personal communication, 1991) and recently identified at the base of metagabbro associated with peridotite of the Diamond Springs Formation of the South Pass greenstone belt. The 'string beef' texture grades upward into gabbro of essentially normal subophitic igneous texture. A geochemical analysis of the 'string beef'-textured rock (sample 29B, **Table 3**) yielded 10.09 weight percent MgO (10.27% volatile free basis), relatively high CaO/Al_2O_3 ratio (0.9), relatively low TiO_2 and alkalies, and 1,100 ppm Cr typical of basaltic komatiite.

<u>Basaltic komatiite:</u> A less MgO-rich 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 (**Figure 10**).

Chemically, these rocks are high magnesian basalts with 18.56 to 9.81 weight percent MgO (19.61 to 10.1 MgO on a volatile free basis). Chromium and nickel contents range from 2,400 ppm to 559 ppm Cr, and 190 to 39 ppm Ni. They have relatively low TiO_2 and alkali contents, and CaO/Al_2O_3 ratios average 0.84 and range from 1.6 to 0.6 (**Table 2**, samples 14B-24B).

<u>Metatholeiites:</u> A small number of amphibolites from this region fall within the tholeiite field of the Jensen plot (**Figure 7**). Some of these also have spinifex textures. Geochemical analyses for the amphibolites give 9.22 to 4.29 weight percent MgO (9.57 to 4.38 volatile free), 440 ppm to <100 ppm Cr, and 110 ppm to 35 ppm Ni. The CaO/Al_2O_3 ratios average 0.6 and vary from 0.7 to 0.4 (**Table 2**, samples 25B-28B).

Spinifex texture in tholeiites is apparently uncommon. Thus the spinifex-textured rocks either represent metasomatically altered basaltic komatiites in which magnesium, chromium, and nickel were removed during alteration, or they represent high-magnesian tholeiitic basalts with spinifex texture, or possibly the spinifex textures in these rocks are metamorphic rather than igneous.

<u>Iron formation:</u> Interflow iron formation occurs as narrow beds (typically less than 4 feet) of magnetite-rich rock between komatiite flows. These interflow iron formations generally lack the distinct banding seen in the more extensive Seminoe Formation BIF and appears to be more magnetite-rich and silica poor.

Seminoe Formation

The Bradley Peak ultramafics are overlain by 2,000 to 4,000 feet of mixed metasedimentary and metavolcanic rocks named the Seminoe Formation by 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, with 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 dominately tholeiitic (**Figure 11**). The formation has been extensively invaded by metagabbro sills.

<u>Banded iron formation:</u> BIF of the Seminoe Formation attracted attention as early as 1888. The iron formation is prominent where it crops out over relatively large areas around Bradley Peak, on Junk Hill, and east of Junk Hill as far as Wood Creek (**Plate 1**). The type section for this

supracrustal unit was described by Lovering (1929) along Twin Creek on the northern flank of Bradley Peak.

In the vicinity of the type section immediately north of Bradley Peak, the BIF was mapped over an 800 foot width with nearly 3,500 feet of strike length. 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 taconite, 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 (**Figure 12**) (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, & 14U), and additional iron analyses are listed in **Table 4** in the *Economic Geology* section. 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% Fe_2O_3 and 47.80% SiO_2. The high CaO content (15.50%) suggests the presence of appreciable amounts of the calcium-rich tremolite/actinolite amphibole. Samples 13U and 14U are typical banded magnetite iron formation samples. These yielded 39.00 and 40.10 weight percent Fe_2O_3 and 53.20 and 54.90 weight percent SiO_2. The high silica content is reflective of the quartz-rich bands. Notable trace elements associated with BIF in the district include gold, silver, zinc, and lead (see *Economic Geology* section).

Quartzite: The Seminoe Formation includes quartzite. The quartzite consists of granoblastic quartz, minor plagioclase, chlorite, and fuchsite with accessory sphene, apatite, epidote, and magnetite. Fine-grained arkosic quartzite consists of granoblastic plagioclase and quartz. No samples of quartzite were chemically analyzed for this study.

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 51.4 to 58.4 weight percent SiO_2, and 13.4 to 14.8 weight percent Al_2O_3. The silica content of the greywackes are relatively low but lie within the range of the metagreywackes reported for the South Pass greenstone belt in the Wind River Mountains to the west of the Seminoe Mountains (see Hausel, 1991b).

Pelitic schist: Pelitic metasediments are highly foliated with common kink bands. These rocks include 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 in NE section 19 and the NW section 20, T26N, R85W during this study are similar to the 'peanut schists' in the South Pass greenstone belt of the southern Wind River Mountains. The Seminoe Mountains porphyroblastic schists contain centimeter and smaller size, rounded, dark-grey to white, peanut-shaped porphyroblasts of cordierite (confirmed by x-ray diffraction by R. W. Gregory, 1991). Much of the cordierite has been replaced by quartz and sericite.

Volcaniclastics: Intermediate to felsic volcaniclastics were mapped in the northern portion of the Seminoe Mountains greenstone belt near the Sunday Morning Mine at the mouth of Sunday Morning Creek (5U and 6U, **Table 3**). These exhibit moderate to intense shearing with quartz augen and have a relatively fine-grained groundmass with lithic fragments of plagioclase and plagioclase and quartz (Klein, 1981). The volcaniclastics are interbedded with pelitic and clastic metasediments.

Metakomatiite: Minor outcrops of metakomatiite also occur in the Seminoe Formation. These are spinifex textured tremolite-talc-chlorite schists similar to those mapped in the Bradley Peak ultramafics. Spinifex-textured rocks were mapped in the Seminoe Formation in the SE section 25, T26N, R86W, and in NW section 30, T26N, R85W (samples 1U and 2U, **Table 3**). These rocks have CaO/Al_2O_3 ratios of 1.0 and 0.7 and have basaltic komatiite affinities (**Figure 11**).

Metatholeiite: Rocks of metatholeiitic composition in the Seminoe Formation include metabasalts, metagabbros, metadiabases chlorite schist, and amphibolite. Sample analyses 3U, 4U, 7U (**Table 3**) are typical metatholeiites.

Economic Geology

Prospecting and exploration in past years in the Seminoe Mountains mining district concentrated on iron, gold, copper, and jade. According to Knight (1893), early gold production from the district amounted to only about 500 ounces. However, historic reports indicate much of the development work on the Penn mines occurred after 1893. The tunnels were extended to as much as 6 times their 1893 length in 1896. Although, there are many variables that should be taken into account (ore grade, mill efficientcy, waste rock mined, etc.) for which I have no information, this leds me to suggest total gold production for the district was probably less than 3,000 ounces. Production of other minerals and metals has also been minimal.

Iron resources

Banded iron formation is widespread in the Seminoe Formation, and forms only a very minor part of the Bradley Peak Ultramafics and the Sunday Morning Creek Metavolcanics. No attempt was made during this study to determine the amount of BIF resources in the district.

Some early studies attempted to assess the potential of developing the iron deposits for Bessemer steel. For example, Dickman (1906) noted that the BIF contained only minor phosphorous 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 and similar low-grade iron deposits more attractive.

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

The U.S. Bureau of Mines reviewed the data on Patterson Basin and specifically looked at one small block of high grade ore along the section line between the NW section 18 and the SW section 7, T25N, R85W (Harrer, 1966). This block reported to have an aerial extent of 75 to 100 feet by 800 feet long (mapping indicates the block to be at least 1,800 feet long), was estimated to have a potential for about 200,000 tons of ore to a depth of 50 feet. Twenty samples of the BIF assayed 31.4 to 68.72% iron, 0.015 to 0.223% phosphorous, and 1.37 to 54.28% SiO_2 (**Table 4, Figure 13**) (Harrer, 1966).

Much of the early work on the iron deposits in the Seminoe district concentrated efforts in Patterson Basin. Although the iron deposits in the basin are oxidized and generally 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 Patterson 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 14**). 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 in the BIF (Dickman, 1906) apparently did not cut into the underlying Cretaceous sedimentary rock.

Harrer (1966) expanded the study of the iron resources of the district to the much larger, low-grade, iron deposits to the south on Bradley Peak. In particular, Harrer (1966) noted that the Twin Creek BIF on the north slope of Bradley Peak contained a considerably larger iron resource than Patterson Basin. The Twin Creek BIF forms a substantial block of low-grade iron formation with an maximum width of 800 feet traceable down the northern slope for 3,500 feet (**Plate 1**). The block is faulted along its southern flank by the Twin Creek fault, but still continues another 2,000 feet south of the fault prior to terminating against the Bradley Peak thrust. This latter outcrop is disseminated with interlayers of amphibolite. The Twin Creek taconite was estimated to have potential for about 100 million tons of low grade ore (Harrer, 1966).

In addition to BIF in Patterson 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 greatest potential for open pitable ore on the Twin Creek BIF.

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

Reports of precious metals in the BIF were apparently common knowledge to prospectors in the district. For Lovering (1929) writes, *"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."*

The author conducted a brief reconnaissance of the district in 1981 and collected select samples of quartz and BIF in the Penn mines area for assay. The BIF samples were collected because of physical evidence of epigenetic alteration (crosscutting carbonate veins with pyrite). One sample was highly anomalous yielding 1.36 opt Au (sample 21A, **Table 5**). Later samples (samples 35A-39A, **Table 5**) collected in the same area were not anomalous.

Two possibilities are envisioned to explain the results. The most obvious is that the initial BIF assay was contaminated at the lab by quartz vein samples during sample preparation. The second possibility is that of the 'nugget effect' which would make sample analysis repeatability difficult. The nugget effect is due to gold being concentrated in small pods or nuggets. Thus, a sample with a nugget would yield high gold analyses, however, another sample collected adjacent to the nugget may not contain detectable gold. Exploration of this area after 1981 by Timberline

Minerals Company encountered many difficulties in the repetition of assay results which was attributed to the nugget effect. Additionally, a sample of BIF collected by Timberline Minerals Company in the Penn Mines area was reported to contain visible gold (John Wells, personal communication, 1984).

Numerous other BIF samples were collected throughout the district. The results of these samples (**Table 5**) show clear evidence of trace amounts of precious metals in the BIF and host veins. Anomalous gold is rare; silver is more common. In every sample but one which yielded anomalous precious metals, clear evidence of epigenesis was present. It is also notable that another sample (20A) produced a zinc anomaly (0.28% Zn). These results suggest any exploration for iron resources should also consider potential by-product recovery of gold, silver, and other trace metals.

Gold-copper-silver-zinc-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 partly due 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 deterrence may have been the rock conditions. Exploration of the Penn Mines by Timberline Minerals in the early 1980s included the reopening of the Deserted Treasure adits. The backs of these mines were very unstable due to intersecting joints and fractures.

Vein samples in the area around Bradley Peak generally yield anomalous gold. These veins are 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 oz/ton) Au, <1.0 to 55.0 ppm (1.6 oz/ton) Ag, 0.03 to 3.75% Cu, 3.0 ppm to 0.39% Pb, and 22 ppm to 4.3% Zn (samples 51A-68A, **Table 6**).

Widespread propylitic alteration in the Penn mines area suggests more detailed sampling of the wallrocks is warranted. 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**), 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 % Cu. Another sample of chloritized metatholeiite yielded 0.12 ppm Au, <1.0 ppm Ag, and 0.09% Cu (sample 56A, **Table 6**). These two samples collected within the altered zone indicate mineralization in the Penn Mines area is not only confined to the quartz veins.

Quartz veins exhibit three orientations in the Penn mines area (N70°E, N50°W, and N-S) (**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 was sampled at two locations yielding anomalous gold and silver (4.6 ppm and 6.8 ppm Au, 5.2 ppm and 4.2 ppm Ag) (samples 52A and 66A, **Table 6**), suggesting possible enrichment in fold closures. Vein-vein and vein-shear intersections could not be assessed during this study because of 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 individual mines and prospects were examined:

<u>Sunday Morning prospect</u> (SE section 29, T26N, R85W). This prospect lies on a shear hosting cupriferous milky quartz (**Figure 15**). Both chrysocolla and cuprite are common. Bishop (1964) reported finding some visible gold at this prospect, although none was found during this investigation.

Two samples collected from the prospect were assayed. Sample 46A (**Table 6**), a channel cut across the copper-stained shear, yielded 1.8% Cu, 45.4 ppm Ag, and 0.07 ppm Au. Sample 47A (**Table 6**), a grab sample of cupriferous quartz from the dump, assayed 5.8% Cu, 26.9 ppm Ag, 2.1 ppm Au, and 0.2% Pb. This shear (the Apex shear) was traced along a northeasterly trend for 2 miles and is marked by well-developed penetrative foliation in schists of the Sunday Morning Creek Metavolcanics. Copper mineralization (and probably precious metals) is confined to small, localized pods, in the shear zone.

<u>Apex adit</u> (N/2 N/2 section 32, T26N, R85W). The Apex shear continues southwesterly from the Sunday Morning prospect to where it is cut by the Apex adit. At the adit, the shear grades into a quartz breccia vein containing angular clasts of country rock and more than one generation of quartz. Some visible gold was collected near the portal in the past (Charlie Kortes, personal communication, 1989), although no visible gold was found during this investigation. Samples collected from the property assayed 0.14% to 3.81% Cu, 0.3 ppm to 63.8 ppm Ag, 0.001 ppm to 0.013 ppm Au, 61 ppm to 0.95% Pb, and 68 ppm to 0.23% Zn (69A-72A, **Table 6**).

<u>Deserted Treasure #1 adit</u> (S/2 NE section 6, T25N, R85W). According to the 1880 patent, the Deserted Treasure tunnel was 216 feet in length with two drifts. The west drift was 50 feet long and stoped upward 20 feet and the east drift was 15 feet long and stoped upward 9 feet. The tunnel was driven S15°W across foliation in order to intersect a N67°E trending, 46°N dipping vein cropping out about 300 to 400 feet to the south (see **Plate 1**). Samples of sulfide-bearing quartz and boxwork quartz from the mine dump yield anomalous precious metal contents. One sample of limonite-stained quartz from the mine dump assayed 1.2 ppm Au, and 3.6 ppm Ag (sample 65A, **Table 6**). During 1981, samples of quartz were collected from the dump with visible gold.

<u>Deserted Treasure #2 adit</u> (SE NE section 6, T25N, R85W). This adit was apparently developed sometime after the Deserted Treasure went to patent. The crosscut tunnel was driven across foliation to intersect the same vein as the Deserted Treasure #1. Select samples from the mine dump (samples 62A-64A and 68A, **Table 6**) were highly anomalous and yielded 0.87 ppm to 89.3 ppm Au, <2.0 to 18.0 ppm Ag, and 0.06 to 0.39% Cu. Samples with visible gold were also collected from the dump in 1981.

<u>King mine</u> (E/2 SE NE section 6, T25N, R85W). Improvements made for the King patent in 1880 included a 100 foot tunnel with a 60 foot deep shaft. A later report (EMJ, 1896, Aug. 8, v. 62, p. 135) stated the mine had been extended to 700 feet in length. A select sample from the King property (66A, **Table 6**) yielded 6.8 ppm Au and 4.2 ppm Ag.

<u>Junk Creek area</u> (SW section 20, T26N, R85W). 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 unnamed shaft. According to Bishop (1964), copper occurs as fracture fillings and coatings on the quartz, in the altered metagabbro, and in fault gouge surrounding the vein at the shaft. The principal copper mineral on the surface is malachite, although some bornite and chalcopyrite occur on some fracture surfaces. Small ramifying quartz veins crosscut the older quartz vein (Bishop, 1964). Samples of sheared tawny to russet BIF contained no detectable precious metals (sample 14A, 15A, **Table 5**). Copper-stained quartz (48A, 49A, **Table 6**) contained trace silver and 0.78 and 1.2% Cu.

Sunday Morning mine (E/2 E/2 section 21, T26N, R85W). The U.S. Geological Survey topographic map of Bradley Peak 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 a 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 conglomerates containing BIF pebbles and cobbles along the northern flank of the greenstone belt contain colors and flakes of gold (Charlie and Donna Kortes, personal 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 also yielded four grains of chromian diopside and eight rounded yellow-orange to purple pyrope garnets. The source of these mantle minerals is unknown. Possibly, they were 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 to locate diamondiferous and barren kimberlite in the Laramie Mountains (see Hausel and others, 1979). Future studies in this area should consider geochemical testing of pyrope garnets to assess if there is any potential for diamonds in this region.

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, personal communication, 1990). This sample was collected on the Sunrise Placer and Dredging Company's placer claims patented 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, personal 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 encountered asbestos veinlets in serpentinite along Sunday Morning Creek (SE section 21, T26N, R85W) east of Deweese Creek, and also near the toe of the extreme southeastern flank of Bradley Peak (N/2 N/2 section 8, T25N, R85W). On Sunday Morning Creek, some prospect pits were dug on the asbestos, but the mineralization was very minor. The asbestos is in narrow (less than 1/4 inch) cross-fiber veinlets in the serpentinite. The veinlets are very restricted.

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 (sections 23, 26, and 28, T26N, R85W) and in a granite outlier to the north (section 12, T26N, R83W (?) reported as 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 Bishop's nephrite-like dikes as actinoliferous amphibolite dikes. These rocks are probably some of the tremolite-talc-chlorite-serpentine schists (metakomatiites) of the Bradley Peak ultramafics. The rocks, according to Sherer (1969) have been cut locally by quartz veins. One vein hosted small mafic inclusions (up to 2 cm) with small patches of nephrite (Sherer, 1969).

Another jade occurrence reported by Bishop (1964) was the Sage Creek nephrite deposit. The Sage Creek deposit found in the granite outlier to the north (NE SE section 12, T26N, R84W), 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 this study.

Chromium-nickel

Because of the presence of ultramafic komatiites in the greenstone succession, serpentinite samples collected during this study were regularly tested for chromium and nickel, and gossans developed at the base of cumulate zones were prime sample sites. The results of the samples were discouraging. Some very weak chromium anomalies were detected, but no nickel anomalies were identified.

The geochemistry of these rocks indicate further testing for nickel may still be warranted. The geochemistry of some of the Seminoe Mountains rocks are similar to nickeliferous komatiites from Western Australia. Future studies should include rare earth analyses to assist in the isolation of the most favorable host rocks.

Lapidary

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

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 after for use in paperweights, bookends, and other decorative stone.

Alteration

Widespread epidote alteration occurs along the contact between the Seminoe Mountains granodiorite batholith with rocks of the Sunday Morning Creek Metavolcanics, and in association with the Sunday Morning-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 to have produced relative decreases in Al_2O_3, MgO, Cr, and Sb, and 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 seen in the Zimbabwe gold fields.

Ore Genesis

Klein (1981) noted that 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 mine areas, fine-grained chlorite and carbonate form dense intergrowths which obliterate most relict igneous and metamorphic textures. In this case, Klein (1981) suggests the alteration to be epigenetic and later than the prograde metamorphic event.

The country rock in the Penn mines area is prevasively 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 the depletion of As, Au and Te in the spinifex schists suggests these rocks may be the source for the metals found in the gold veins of the Penn mines and Junk Creek areas and the zinc in sheared rock 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 suggests that these two elements may have had their source in the ultramafics alone and may have been introduced into the altered amphibolites during cabonatization (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; (3) derivation from the alteration of iron formations. The gold-copper deposits in the Seminoe Mountains bare resemblance to those deposits derived from the second process in which the 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 and he and 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 older 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 studied to date.

By contrast, the South Pass greenstone belt in the Wind River Mountains to the west is dominated by a thick succession of metasedimentary rock with only a minor component of metatholeiites and very minor component of ultramafic schists (Hausel, 1991b). To the north, the Copper Mountain supracrustal belt in the Owl Creek Mountains is dominated by high-grade metasedimentary rock and orthoamphibolite with practically no ultramafic component. Primary textures in these rocks have all, for the most part, been obliterated (Hausel and others, 1985). Copper Mountain is typical of a high-grade supracrustal terrane rather than a greenstone belt.

Recent mapping in the Rattlesnake Hills greenstone belt south of Copper Mountain and north of the Seminoe Mountains by the author, show the Rattlesnakes to consist of nearly equal volumes of well-preserved pillow metabasalts with orthoamphibolites of tholeiitic affinity, and metasedimentary rock with practically no ultramafic component and only minor BIF. This belt was later disrupted by dozens of Tertiary alkalic intrusives, and exhibits both Archean and Tertiary gold mineralization.

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 and metagreywacke and only minor BIF.

Rocks in the Casper Mountain greenstone terrane east of the Rattlesnake Hills, contain a thick section of ultramafic schists similar to the Seminoe Mountains (Burford and others, 1979), and may represent the closest analogy 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 non-preservation, or more likely, the BIF-rich portion of the terrane still lies at depth and was not raised during the Laramide orogeny. Many of the supracrustal terranes in Province in Montana, are metasedimentary-dominated supracrustal belts and lack the thick volcanic component seen in the Seminoe Mountains.

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. The mineral resources have not been explored in any great detail and indications are some deposits could be economic under favorable conditions. Low-grade iron deposits are widespread and include a minimum resource of 100,000,000 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) milky quartz. Copper mineralization is localized and does not represent a significant resource, as may be the same for zinc and lead.

In my opinion, 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 rock have been neglected. The altered zone in the vicinity of the Penn mines should been considered as a target for widespread low-grade gold mineralization with potential credits in silver, copper, lead, and zinc.

References Cited

Arndt, N.T., 1976, Ultramafic rocks of Munro Township: economic and tectonic implications: Geological Association of Canada Special Paper 14, p. 617- 657.

Arndt, N.T., and Nisbet, E.G. (editors), 1982, Komatiites: George Allen & Unwin Ltd., London, 526 p.

Aughey, S., 1886, Annual report of the Territorial Geologist to the Governor of Wyoming, 61 p.

Bayley, R.W., 1968, Geological map of the Bradley Peak Quadrangle, Carbon County, Wyoming: U.S. Geological Survey Geological Quadrangle Map GQ-773, scale 1:24,000.

Bishop, D.T., 1964, Retrogressive metamorphism in the Seminoe Mountains, Carbon County, Wyoming: M.S. thesis, University of Wyoming, Laramie, 49 p.

Blackstone, D.L., 1965, Gravity thrusting in the Bradley Peak-Seminoe Dam Quadrangles, Carbon County, Wyoming and relationships to the Seminoe iron deposits: Geological Survey of Wyoming, Preliminary Report 6, 13 p.

Blackstone, D.L., and Hausel, W.D., 1991, Field guide to the Seminoe Mountains in Frost, B.R., and Roberts, S. editors, Mineral Resources of Wyoming: Wyoming Geological Association 42nd annual field conference guidebook, p. 201-210.

Bohn, Debre, 1990, Laramide shortening and Neogene extension superposed on a Precambrian structural grain near Little Basin, Seminoe and Shirley Mountains, Carbon County, Wyoming: M.S. thesis, University of Wyoming, Laramie.

Boyle, R.W., 1979, The geochemistry of gold and its deposits: Geological Survey of Canada Bulletin 280, 584 p.

Burford, A.E., Corbett, R.G., Franks, P.C., Friberg, L.M., Lorson, R.C., Marsek, F.A., Nanna, R.F., Schumacher, J.C., and Wymer, R.E., 1979, Precambrian complex of Casper Mountain, Wyoming-A preliminary paper: Wyoming Geological Association Earth Science Bulletin, v. 12, no. 2, p. 58-69.

Corey, G.W., 1881, Report of the Secretary of Interior to the 1st Session of the 47th Congress, Ex. Doc. 1, Part 5, v. 11, Government Printing Office, Washington D.C., p. 1021-1022.

Dickman, R.H., 1906, Report on iron ore development of the Seminoe mining district, north from Rawlins, Wyoming: Geological Survey of Wyoming Mineral Report 06-69, 7 p.

Ferry, E.P., 1871, Report of the Secretary of Interior to the 2nd session of the 42nd congress, Ex Doc 1, Part 5, Sept 27, p. 305-309.

Graff, P.J., Sears, J.W., Holden, G.S., and Hausel, W.D., 1982, Geology of the Elmers Rock greenstone belt, Laramie Range, Wyoming: Geological Survey of Wyoming, Report of Investigations 14, 23 p.

Harrer, C.M., 1966, Wyoming iron-ore deposits: U.S. Bureau of Mines, Information Circular 8315, 112 p.

Hausel, W.D., 1989a, Precambrian geology of the Seminoe gold district, Bradley Peak Quadrangle, Carbon County, Wyoming: Geological Survey of Wyoming, Open File Report 89-10, scale 1:24,000.

Hausel, W.D., 1989b, The geology of Wyoming's precious metal lode and placer deposits: Geological Survey of Wyoming, Bulletin 68, 248 p.

Hausel, W.D., 1991a, Precambrian geology of the Seminoe Mountains (Fe-Au) mining district, Bradley Peak Quadrangle, Carbon County, Wyoming: Geological Survey of Wyoming Open File Report 91-3, scale 1:24,000.

Hausel, W.D., 1991b, Economic geology of the South Pass granite-greenstone belt, southern Wind River Range, western Wyoming: Geological Survey of Wyoming Report of Investigations 44, 129 p.

Hausel, W.D., Graff, P.J., and Albert, K.G.,1985, Economic geology of the Copper Mountain supracrustal belt, Owl Creek Mountains, Fremont County, Wyoming: Geological Survey of Wyoming, Report of Investigations 28, 33 p..

Hausel, W.D., Edwards, B.E., and Graff, P.J., 1991, Geology and mineralization of the Wyoming Province: Society for Mining, Metallurgy, and Exploration of AIME Preprint 91-72, 12 p.

Hendricks, C.E., 1902, Seminoe iron deposits: Geological Survey of Wyoming unpublished mineral report MR02-1, 5 p.

Houston, R.S., 1983, Wyoming Precambrian Province-example of the evolution of mineral deposits through time?, *in* Sheila Roberts, (ed), Metallic and Nonmetallic deposits of Wyoming and Adjacent Areas, 1983 Conference Proceedings: Geological Survey of Wyoming, Public Information Circular 25, p.1-12.

Klein, T.L., 1981, The geology and geochemistry of the sulfide deposits of the Seminoe district, Carbon County, Wyoming: PhD thesis, Colorado School of Mines, Golden, 232 p.

Klein, T.L., 1982, Archean metavolcanic rocks of the Bradley Peak area, Seminoe Mountains, Wyoming: 1982 Archean Geochemistry Field Conference guidebook, August 15-19, p. 24-49.

Knight, W.C., 1893, Notes on the mineral resources of the State: University of Wyoming Experiment Station Bulletin 14, p. 103-212.

Lovering, T.S., 1929, The Rawlins, Shirley and Seminoe iron-ore deposits of Carbon County, Wyoming: U.S. Geological Survey Bulletin 811-D, p. 203-235.

Morrow, H.A., 1871, Report of the Secretary of Interior to the 2nd session of the 42nd congress, Ex Doc 1, Part 5, p. 305-309.

Philbin, P.W., and McCaslin, W.E., 1966, Aeromagnetic map of the Seminoe Mountains and vicinity, Carbon County, Wyoming: U.S. Geological Survey Geophysical Investigations map GP-558, scale 1:48.000.

Reed, S., 1872, Annual report of the Secretary of Interior on the operations of the Department for the year 1872: Government Printing Office, Washington, Sept. 30, p. 253-254.

Reed, S., 1873, Report of the Secretary of Interior to the 1st Session of the 43rd Congress, Ex Doc 1, Part 5, v. 1, Sept 25, p. 250.

Reed, S., 1874, Report of the Secretary of Interior to the 2nd Session of the 43rd Congress, Ex Doc 1, Part 5, v. 1, Government Printing Office, Washington D.C., Sept 1, p. 258.

Reed, S., 1878, Report of the Secretary of Interior to the 3rd Session of the 45th Congress, Ex Doc 1, Part 5, v. 1, Government Printing Office, Washington D.C., p. 1141.

Ricketts, L.D., 1888, Annual report of the Territorial Geologist to the Governor of Wyoming: Cheyenne, 87 p.

Sherer, R.L., 1969, Nephrite deposits of the Granite, the Seminoe, and the Laramie Mountains, Wyoming: PhD dissertation, University of Wyoming, 194 p.

Snyder, G.L., Hausel, W.D., Klein, T.L., Houston, R.S., and Graff, P.J., 1989, Precambrian rocks and mineralization, southern Wyoming Province: 28th International Geological Congress Field Trip Guidebook T332: American Geophysical Union, Washington D.C., 48 p.

Warren, F.E., 1885, Report of the Secretary of Interior to the 1st Session of the 49th Congress, v. 2.

Deserted Treasure #1

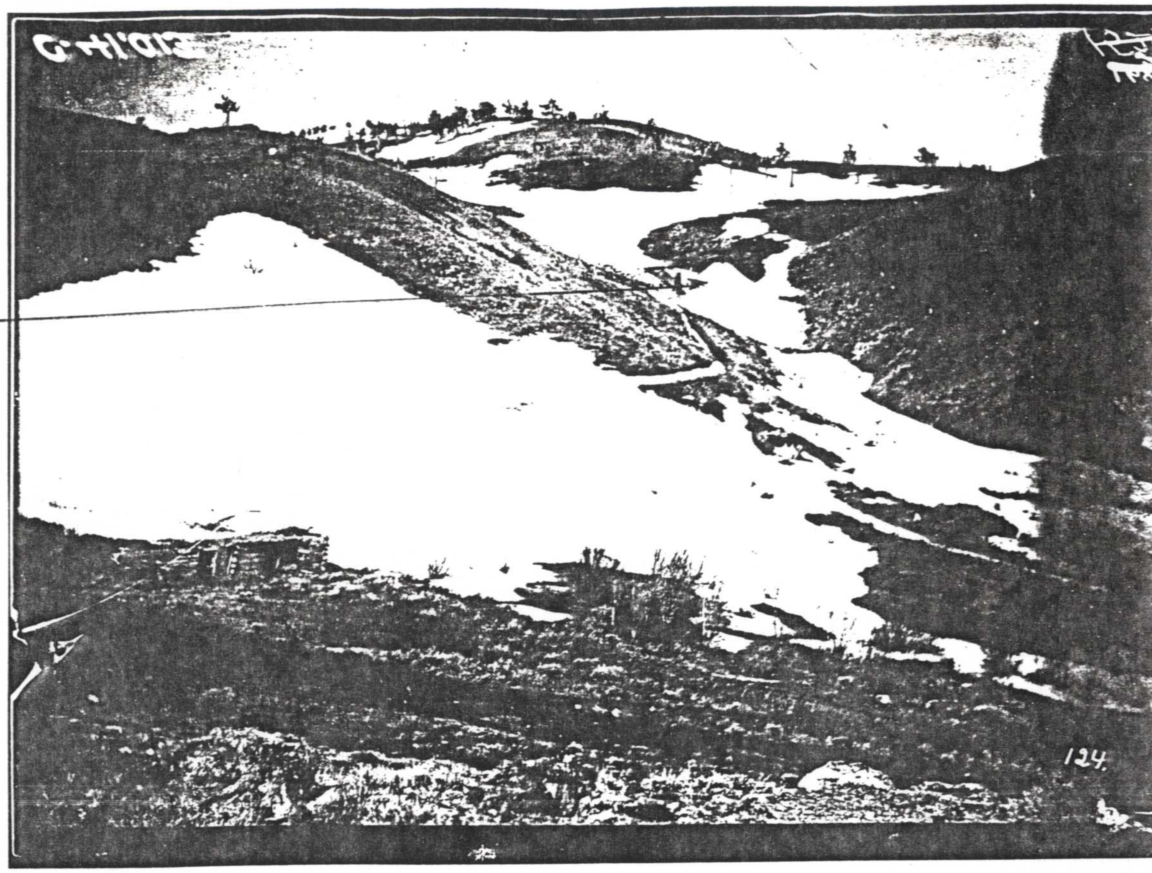


Figure (1a)

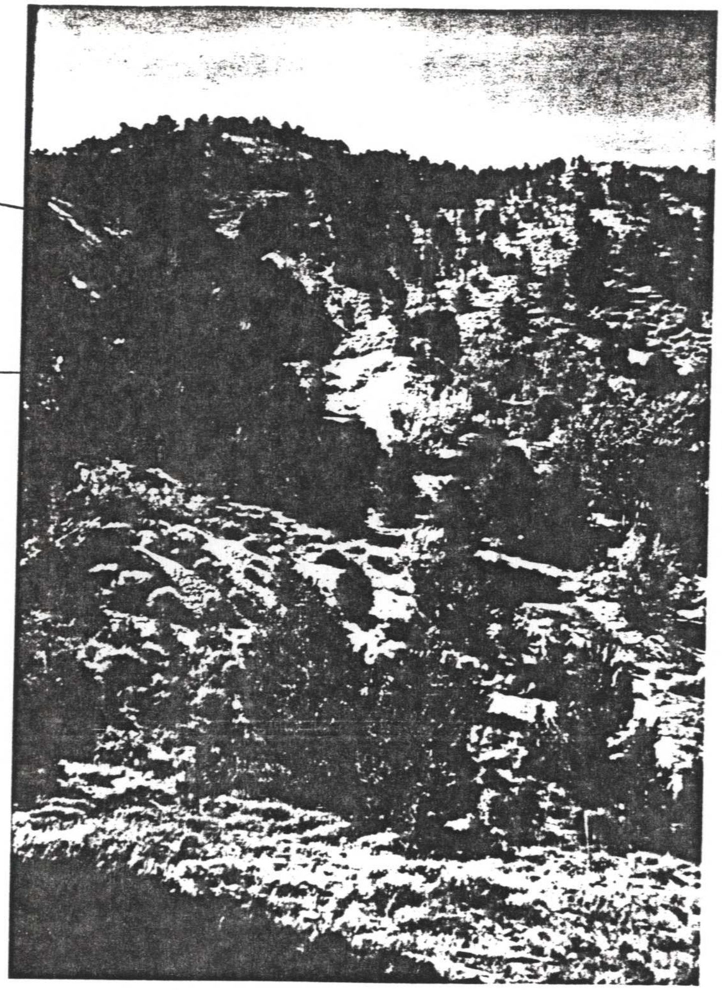


Figure (1b).

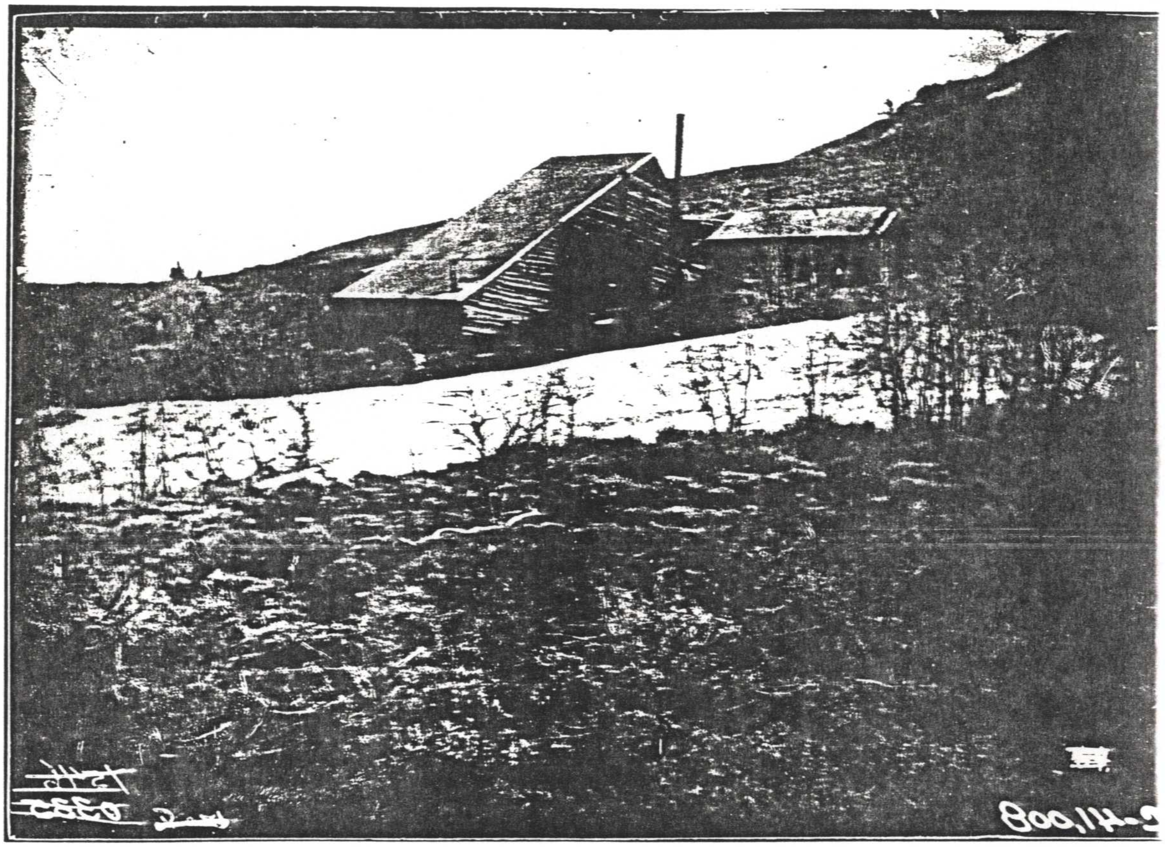


Figure 2

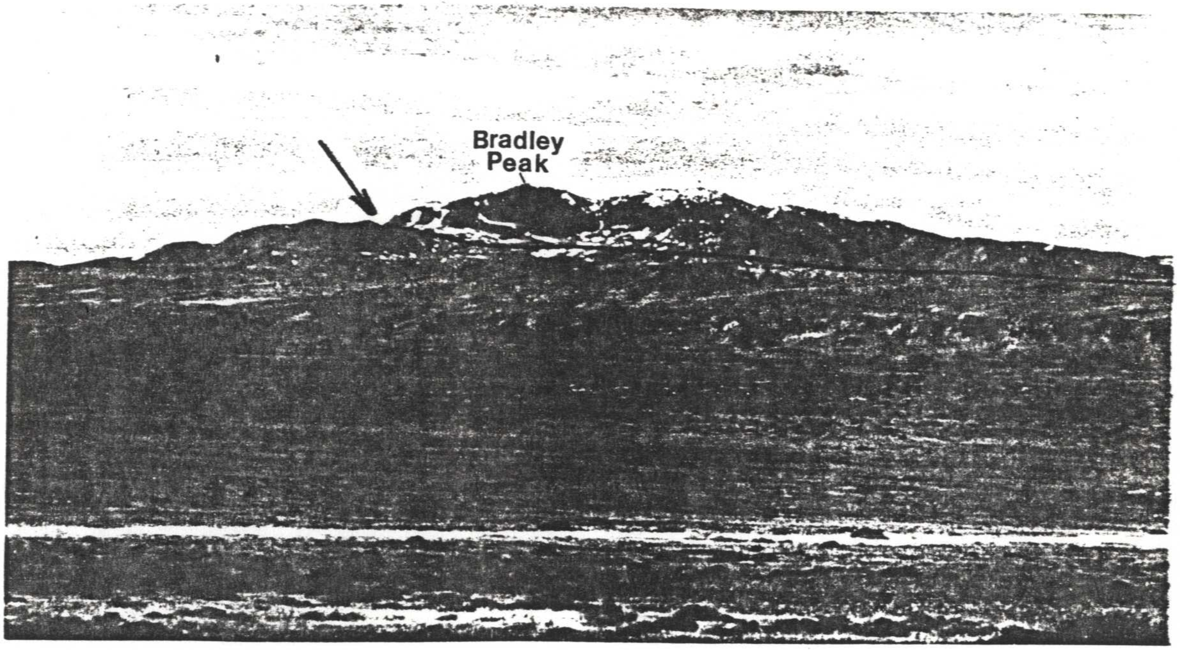
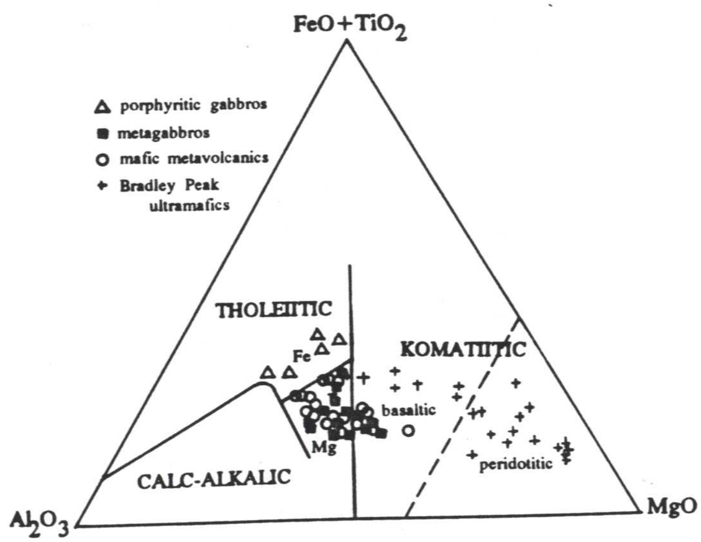


Fig. 3



FeO+TiO2
porphyritic gabbros
metagabbros
mafic metavolcanics
Bradley Peak ultramafics
THOLEIITIC
Fe
KOMATIITIC
basaltic
Mg
peridotitic
CALC-ALKALIC
Al2O3
MgO

Figure 4.

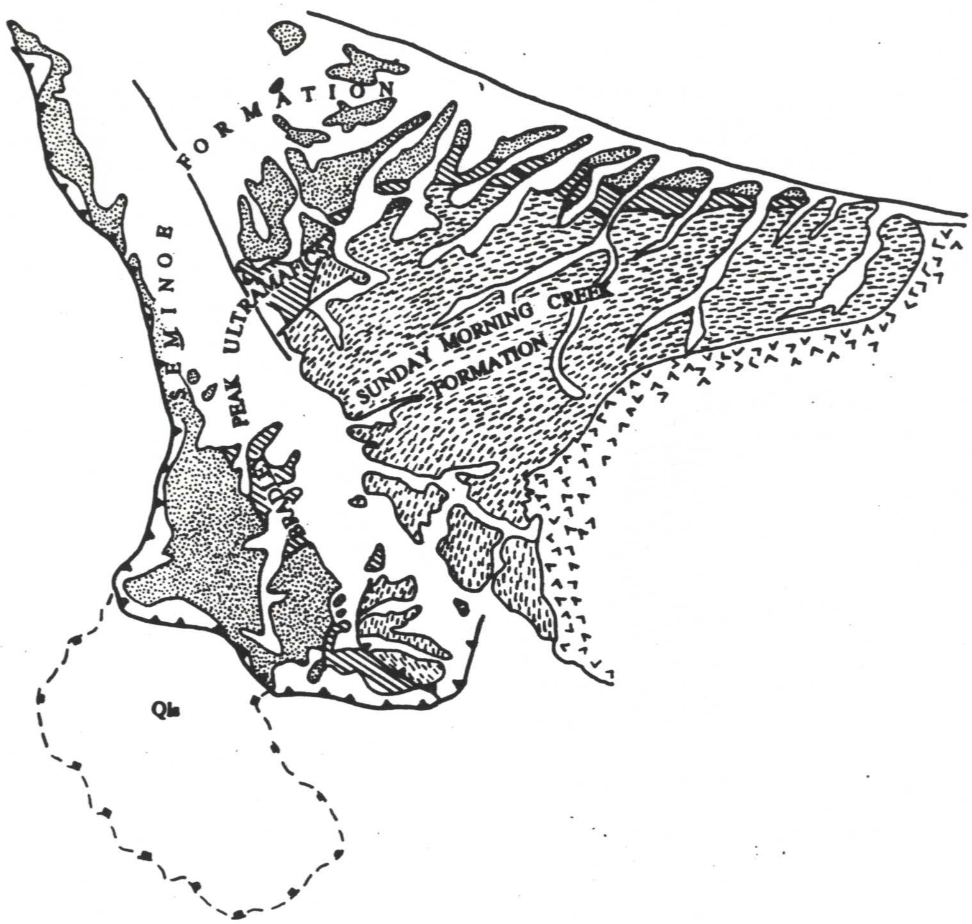
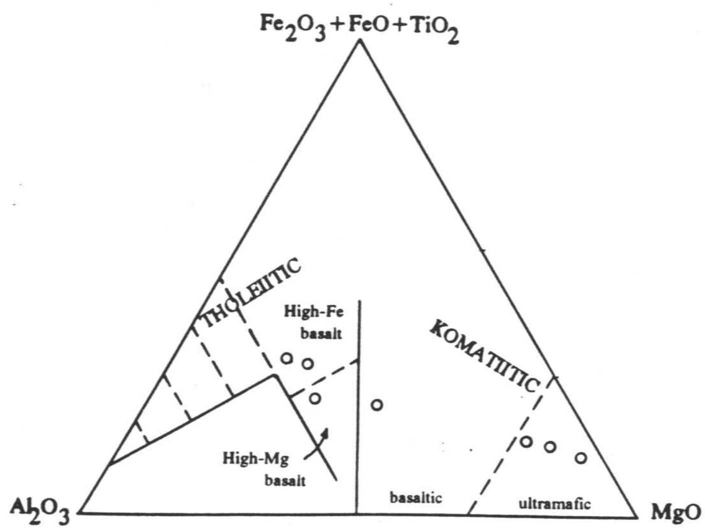
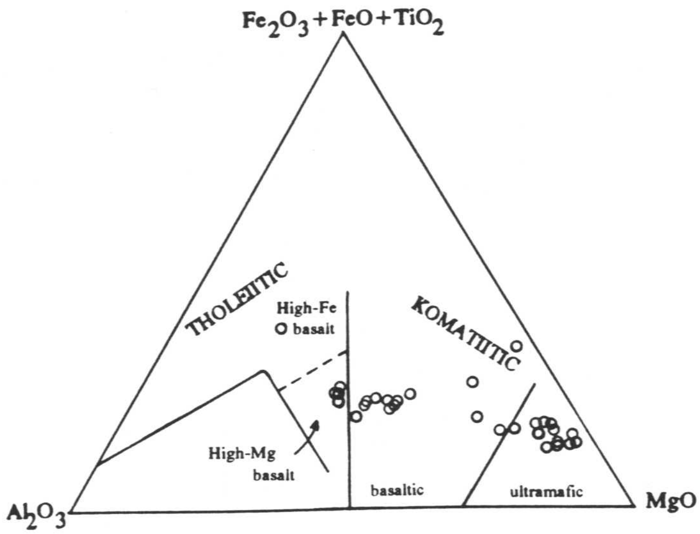


Figure 5.



$Fe_2O_3 + FeO + TiO_2$
THOLEIITIC
High-Fe basalt
KOMATIITIC
High-Mg basalt
basaltic
ultramafic
Al_2O_3
MgO

Figure 6.



Fe$_2$O$_3$+FeO+TiO$_2$
THOLEIITIC
High-Fe
basalt
KOMATIITIC
High-Mg
basalt
basaltic
ultramafic
Al$_2$O$_3$
MgO

Figure 7

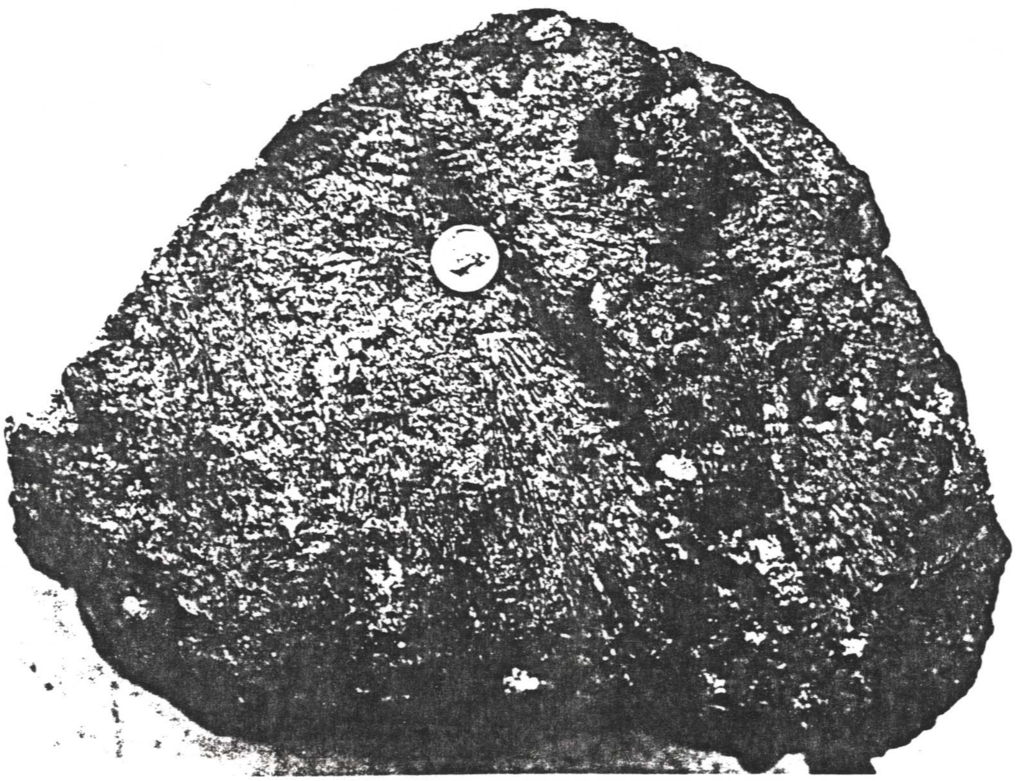


Figure 8.

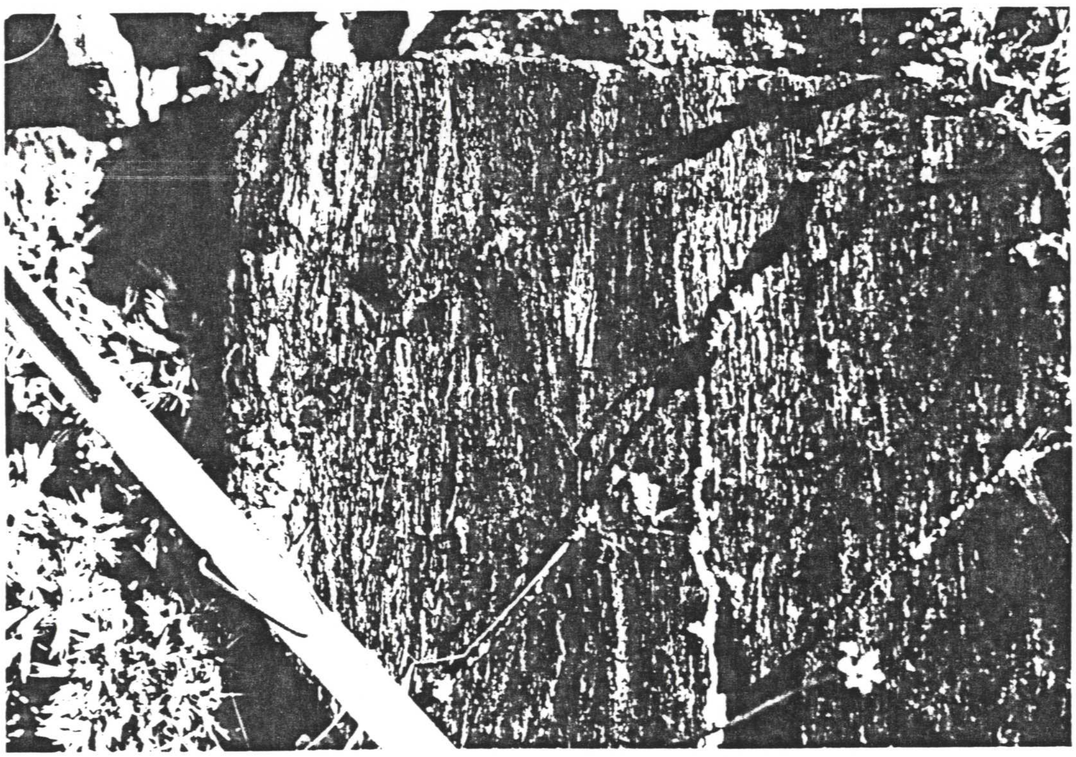
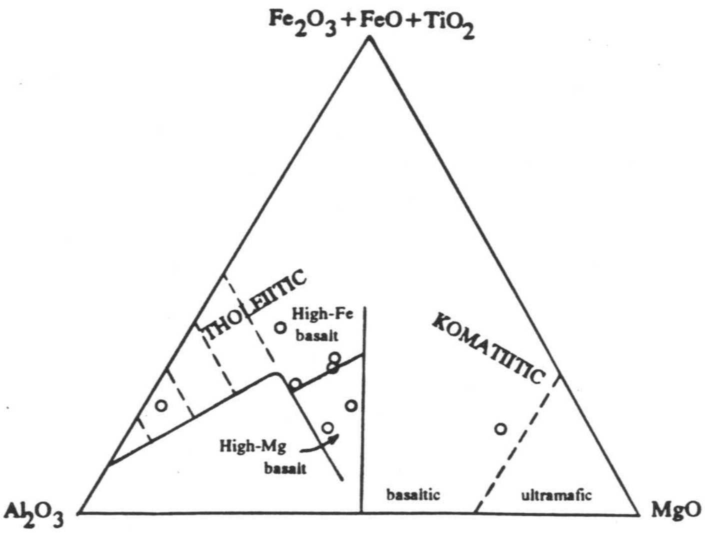


Figure 9.

Figure 10



Fe2O3+FeO+TiO2
THOLEIITIC
High-Fe
basalt
KOMATIITIC
High-Mg
basalt
Al2O3
basaltic
ultramafic
MgO

Figure 11.

Figure 12.

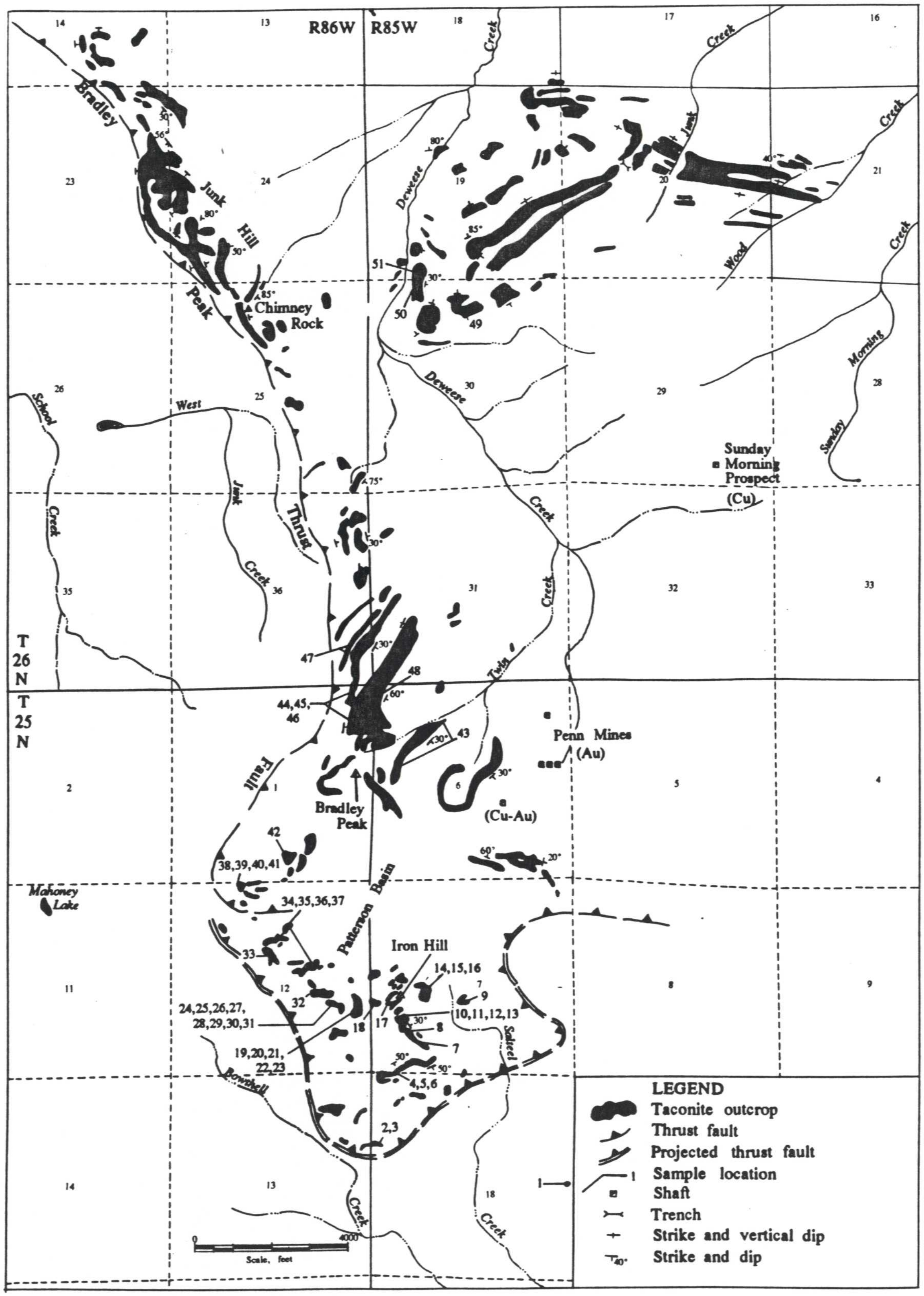

R86W
R85W
T 26 N
T 25 N
Bradley
Junk
Hill
Peak
Chimney Rock
Thrust
Fault
Bradley Peak
Patterson Basin
Iron Hill
Penn Mines (Au)
(Cu-Au)
Sunday Morning Prospect (Cu)
Mahoney Lake
Deweese
Deweese
Creek
Junk
Creek
Wood
Creek
Morning
Sunday
School
Creek
West
Junk
Creek
Creek
Twin
Creek
Sodseel
Bowthell
Creek
Creek
LEGEND
Taconite outcrop
Thrust fault
Projected thrust fault
Sample location
Shaft
Trench
Strike and vertical dip
Strike and dip
Scale, feet
0
4000

Figure 13.

Table 1. Major and trace element analyses of rocks of the Sunday Morning Creek Metavolcanics, Seminoe Mountains.

	1L	2L	3L	4L	5L	6L	7L	8L	9L
SiO_2(%)	41.70	43.10	50.70	50.10	50.30	47.60	54.00	60.20	81.70
TiO_2	0.13	0.19	0.21	0.59	1.38	0.78	1.33	0.75	0.48
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
MnO	0.18	0.17	0.18	0.21	0.21	0.20	0.18	0.06	0.04
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
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	99.36	99.92	99.80	98.52	99.13	97.75	98.51	99.25	97.87
CaO/Al_2O_3	0.06	0.6	2.3	0.9	0.7	0.8	0.7	--	--
Ag (ppm)	<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	--	--	--	--	--	--	--

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.

Table 2. Mjor and trace element analyses of rocks from the Bradley Peak Ultramafics.

	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	11B	12B	13B	14B
SiO_2 (%)	40.80	41.10	41.80	41.70	40.80	36.20	40.00	42.60	41.20	47.10	33.90	41.90	46.60	51.50
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
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
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
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	18.56
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
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	99.82	99.87	99.46	100.70	97.85	98.32	98.56	98.39	98.93	99.59	100.51	100.34	98.72	98.15
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
Ag (ppm)	--	<1.0	<5.0	--	<0.1	<5.0	<0.1	<5.0	<5.0	<1.0	--	--	<5.0	<0.1
As (ppm)	--	--	9	--	--	25	--	19	7	--	--	--	21	--
Au (ppb)	--	6	<5	--	<1	<5	<1	18	<5	<5	<1	21	<5	<1
Ba (ppm)	--	40	<100	<100	--	<100	<100	<100	<100	30	<100	--	<100	<100
Ce (ppm)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Co (ppm)	--	--	98	--	--	110	--	120	100	--	--	--	86	--
Cr (ppm)	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 (ppm)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ni (ppm)	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 (ppm)	--	--	<10	--	--	<10	--	<10	<10	--	--	--	<10	--
S (ppm)	--	<200	<200	<200	700	<200	800	<200	<200	<200	1,200	--	<200	800
Sb (ppm)	--	--	2.4	--	--	3.2	--	2.9	0.5	--	--	--	0.5	--
Sc (ppm)	--	--	7.0	--	--	6.1	--	11.0	13.0	--	--	--	32.0	--
Sm (ppm)	--	--	<0.2	--	--	<0.2	--	0.3	<0.2	--	--	--	0.8	--
Th (ppm)	--	--	<0.5	--	--	<0.5	--	<0.5	<0.5	--	--	--	<0.5	--
U (ppm)	--	--	<0.5	--	--	<0.5	--	<0.5	<0.5	--	--	--	<0.5	--
W (ppm)	--	--	<2.0	--	--	<2.0	--	<2.0	<2.0	--	--	--	<2.0	--
Y (ppm)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zn (ppm)	--	--	<200	--	--	<200	--	<200	<200	--	--	--	<200	--

15B	16B	17B	18B	19B	20B	21B	22B	23B	24B	25B	26B	27B	28B	29B
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
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
5.61	9.58	10.48	11.10	10.70	10.40	11.50	11.80	11.70	11.70	12.80	12.60	12.50	12.80	14.14
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
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
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
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
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
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
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
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
98.08	98.40	99.60	99.92	97.32	98.50	99.17	97.66	99.51	97.91	99.14	99.39	98.67	99.08	99.43
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
26	20	24	27	24	26	24	30	27	34	22	22	22	9	18
--	<1.0	<1.0	<0.1	<5.0	<5.0	--	<5.0	--	<5.0	--	<5.0	<5.0	<1.0	<1.0
--	--	--	--	1.0	<1.0	--	<1.0	--	1.0	--	10.0	9.0	--	--
--	<50	<5	3	<5	5	<1	<5	<1	<5	--	47	1	<50	6
<100	100	30	<100	<100	<100	--	<100	<100	<100	<100	<100	110	<100	110
--	92	--	--	--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	58	58	--	60	--	53	--	51	50	--	--
2,400	1,700	1,500	1,340	930	1,100	559	940	672	1,000	400	440	370	<100	1,100
--	24	--	--	--	--	--	--	--	--	--	--	--	--	--
--	166	39	108	140	160	78	130	70	190	--	110	73	35	49
--	--	--	--	--	2	--	--	--	--	--	5	6	--	--
--	--	--	--	--	<5	--	--	--	--	--	7	9	--	--
--	--	--	--	<10	<10	--	<10	--	<10	--	21	12	--	--
<200	300	<200	700	<200	<200	--	200	600	<200	300	300	300	<200	<200
--	--	--	--	0.7	0.5	--	0.5	--	0.3	--	1.7	1.0	--	--
--	--	--	--	30.0	28.0	--	32.0	--	32.0	--	35.0	35.0	--	--
--	--	--	--	0.9	0.9	--	0.8	--	1.3	--	1.2	1.3	--	--
--	--	--	--	0.7	<0.5	--	<0.5	--	<0.5	--	<0.5	0.5	--	--
--	--	--	--	<0.5	<0.5	--	<0.5	--	<0.5	--	<0.5	<0.5	--	--
--	--	--	--	<2.0	<2.0	--	<2.0	--	<2.0	--	<2.0	<2.0	--	--
--	20	--	--	--	--	--	--	--	--	--	--	--	--	--
--	--	--	--	230	<200	--	<200	--	<200	--	210	<200	--	--

Table 2, sample 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; (13B) chlorite-serpentine schist; (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; (25B) spinifex-textured basaltic metakomatiite; (26B) spinifex-textured basaltic metakomatiite; (27B) spinifex-textured basaltic metakomatiite; (28B) amphibolite; (29B) string-beef spinifex textured metagabbro.

Table 3. Major and trace element analyses of rocks of the Seminoe Formation (Archean), and of a basaltic dike (Proterozoic ?).

	1U	2U	3U	4U	5U	6U	7U	8U	9U	10U	11U	12U	13U	14U
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
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
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
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
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
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
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
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
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
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
TOTAL	98.77	99.39	98.72	98.59	100.06	99.83	99.70	99.66	98.51	98.58	98.65	99.95	97.91	99.66
CaO/Al_2O_3	1.0	0.7	0.4	0.8	--	--	--	--	--	--	--	--	--	--
Ag (ppm)	<1.0	<0.1	<5.0	<1.0	--	--	--	<1.0	<1.0	<1.0	--	--	<5.0	0.2
As	--	--	<1.0	--	--	--	--	--	--	--	--	--	--	32
Au (ppb)	<50	1	12	<50	--	--	--	<50	<50	<50	--	--	51	3
Ba (ppm)	<100	<100	100	<100	<100	90	200	200	400	<100	<100	<100	<100	<100
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
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	--	--	--	--	--	--	--	--

	1P
SiO_2 (%)	50.00
TiO_2	1.63
Al_2O_3	12.60
Fe_2O_3	14.20
MnO	0.25
MgO	6.15
CaO	8.89
Na_2O	3.18
K_2O	0.82
P_2O_5	0.42
TOTAL	99.53
CaO/Al_2O_3	--
Ag (ppm)	--
As	--
Au (ppb)	--
Ba (ppm)	200
Ce	--
Co	--
Cr	--
La	--
Ni	--
Rb	--
S	900
Sb	--
Sc	--
Sm	--
Sr	--
Th	--
U	--
W	--
Y	--
Zn	--
Zr	--

Table 3, sample lithologies: (1U) spinifex-textured tremolite-talc-chlorite schist; (2U) spinifex-textured basaltic komatiite; (3U) metadiab chlorite schist; (5U) meta-andesite porphyry (phenocrysts of An65-confirmed by XRD); (6U) metafelsite; (7U) amphibolite; (8U) metagrey (9U) metagreywacke; (10U) metagreywacke; (11U) quartz-chlorite schist; (12U) cummingtonite schist; (13U) banded iron formation; (14L iron formation; (1P) basaltic dike (Proterozic ?).

Table 4. Chemical analyses (in percent) of iron formation, from various sources. See Figure 13 for locations.

Sample #	Description	Fe	Mn	TiO_2	P	S	SiO_2
1	15 ft wide BIF, Greeley claim (Dickman, 1906).	28.80	--	--	0.35	--	35.80
2	BIF, Frozen Finger claim, Patterson Basin (Hendricks, 1902).	31.40	--	--	0.08	--	48.77
3	See no. 2.	32.70	--	--	0.107	--	48.95
4	Patterson Basin (Dickman, 1902).	65.80	--	--	0.181	--	1.00
5	BIF from 50 ft deep shaft (Dickman, 1906).	62.00	--	--	0.090	--	7.60
6	Hematite jasper outcrop 75-100 ft & 800 ft, Patterson Basin (Harrer, 1966).	52.40	0.044	0.21	0.16	0.03	22.0
7	Hematite, Barton claim, Patterson Basin (Hendricks, 1902).	40.35	--	--	0.055	--	40.46
8	Hematite-magnetite BIF, New Year claim, Patterson Basin (Hendricks, 1902).	44.10	--	--	0.188	--	13.51
9	Magnetite jasper BIF, Patterson Basin (Harrer, 1966).	33.70	0.005	0.10	0.04	0.05	47.2
10	Iron Hill BIF, Patterson Basin (Harrer, 1966).	34.9	0.2	<0.1	0.14	0.10	47.2
11	Iron Hill hematite, Patterson Basin (Harrer, 1966).	30.3	0.4	0.2	0.14	0.10	57.4
12	Iron Hill hematite-jasper (Harrer, 1966).	37.3	0.03	0.2	0.07	0.04	46.0
13	Iron Hill hematite-jasper (Harrer, 1966).	40.4	0.008	0.14	0.08	0.05	40.0
14	Haynes claim, Patterson 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, Patterson Basin (Hendricks, 1902).	28.70	--	--	0.087	--	53.91
18	Greeley claim BIF, Patterson 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, Patterson Basin (Lovering, 1929).	62.51	--	--	0.040	0.026	10.2
21	Hematite jasper (Lovering, 1929).	32.65	--	--	--	--	54.28
22	Hematite jasper (Lovering, 1929).	33.80	--	--	--	--	51.98
23	Hematite jasper (Lovering, 1929).	35.37	--	--	--	--	50.06
24	Calcator claim BIF, Patterson 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	--	--	0.190	--	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, Patterson Basin (Dickman, 1906).	45.00	--	--	0.080	--	33.60
33	Hematite jasper, Patterson 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, Patterson 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, Patterson Basin (Dickman, 1906).	40.00	--	--	0.31	--	40.80
43	BIF, south of Twin Creek fault (Harrer, 1966).	32.30	0.016	0.16	0.07	0.04	49.00
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	0.16	0.055	0.03	46.80
49	BIF float above Deweese Creek (Harrer, 1966).	34.70	0.007	0.16	0.06	0.04	43.3
50	BIF, Deweese Creek (Harrer, 1966).	34.00	0.027	0.16	0.09	0.03	47.3
51	BIF, Deweese Creek (Harrer, 1966).	34.00	0.1	0.1	0.13	0.12	50.2
52	Hematite (Ricketts, 1880).	55.3	--	--	--	--	20.10
53	Magnetite (Ricketts, 1880).	29.5	--	--	--	--	15.00
54	Hematite (Ricketts, 1880).	63.56	--	--	--	--	2.63
55	hematite (Ricketts, 1880).	68.60	--	--	--	--	4.30
56	Hematite (0.076% Zn, 0.013% Cu, & 0.006% As) (Ricketts, 1880).	61.35	0.042	0.075	0.046	0.005	--
57	Carroll Bros tunnel, SE sec. 1, T25N, R86W., 150-164 ft (Dickman, 1906).	19.50	--	--	0.060	--	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	--	--	0.070	--	40.80
64	Cut above Carroll Bros tunnel (Dickman, 1906).	38.20	--	--	0.067	--	43.65
65	Cut in wash (sec.18, T25N, R85W) (Dickman, 1906).	37.50	--	--	0.119	--	36.15
66	Cut in wash (sec.18, T25N, R85W) (Dickman, 1906).	64.60	--	--	0.096	--	1.75
67	Ore in place (sec.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

Table 5. Geochemical analyses of banded iron formation and host veins and veinlets, Seminoe Mountains district, Wyoming (analyses by Bondar Clegg or Wyoming Analytical Labs) (see Plate 2 for sample locations).

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

Table 6. Geochemical analyses of mineralized samples and related rocks from the Seminoe Mountains (see Plate 2 for locations).

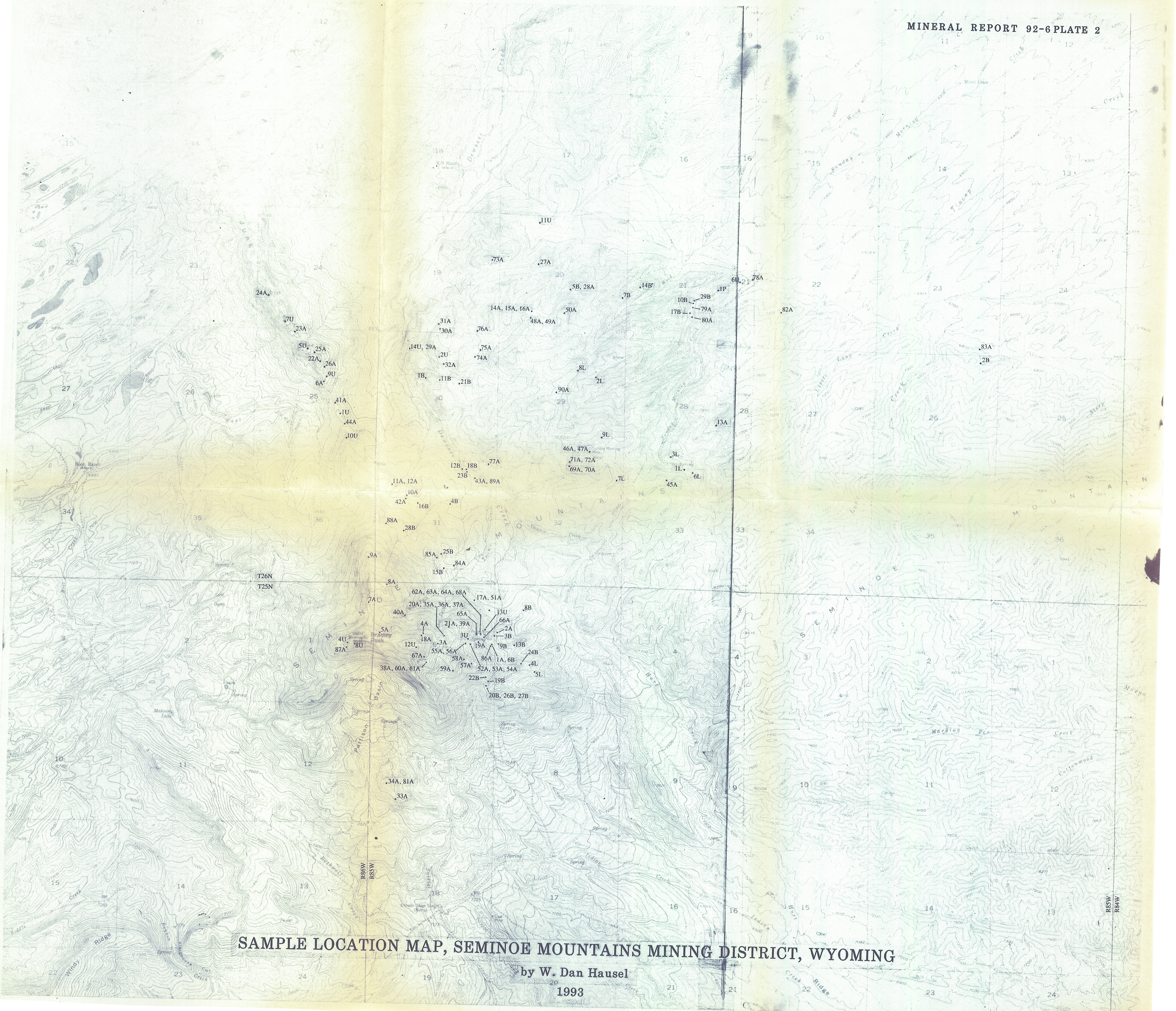
Sample No.	Description	Au (ppm)	Ag (ppm)	Cu (%)	Pb (ppm)	Zn (ppm)	Co (ppm)	Cr (ppm)	Ni (ppm)	Pt (ppb)	Pd (ppb)
42A	Milky quartz stockworks in chlorite schist	1.3	4.0	0.14	14	43	--	--	--	--	--
43A	Weakly iron-stained schist	<0.05	2.1	--	--	--	--	--	--	--	--
44A	Limonite-cemented fault breccia w/ goethite	<0.06	1.1	--	--	--	--	--	--	--	--
45A	Cupriferous felsite from prospect pit	<0.05	<1.0	4.4	16	39	62	--	--	--	--
46A	1 ft channel, across Cu-stained shear	0.07	45.4	1.8	220	47	--	--	--	--	--
47A	Grab, Cu-stained quartz, Sunday Morning prospect	2.1	26.9	5.8	1,970	140	--	--	--	--	--
48A	10 ft composite, Cu-mafic wallrock, Junk Creek	<0.05	1.7	0.78	--	--	--	--	--	--	--
49A	Grab, azurite-malachite-tenorite-limonite-quartz	0.05	1.4	1.2	--	--	6	--	--	--	--
50A	Cu-stained quartz	0.15	2.7	3.7	66	2,920	--	--	--	--	--
51A	Quartz from mine dump	<0.05	<1.0	--	--	--	--	--	--	--	--
52A	Quartz in fold closure from prospect pit	4.6	5.2	0.12	54	22	--	--	--	--	--
53A	Cu- Fe-stained fracture in metatholeiite	12.0	55.0	3.75	25	250	--	--	--	--	--
54A	Limonite-stained metatholeiite	9.8	12.0	0.81	10	85	--	--	--	--	--
55A	Vein quartz, south of Emeletta mine	2.2	3.5	0.11	5.4	28	--	--	--	--	--
56A	Wallrock adjacent to stockwork	0.12	<1.0	0.09	3.0	120	--	--	--	--	--
57A	Cu-stained quartz with minor pyrite	8.8	6.8	0.37	23	120	--	--	--	--	--
58A	Cu-stained quartz with minor pyrite	11.0	9.3	0.94	75	480	--	--	--	--	--
59A	Quartz with chalcopyrite, covellite, and pyrite	2.2	26.0	1.61	11	110	--	--	--	--	--
60A	Banded metachert	<0.05	3.3	0.03	3,890	43,000	--	--	--	--	--
61A	Cu-stained boxworks	0.05	8.1	0.28	2,180	25,000	--	--	--	--	--
62A	Boxwork quartz, Deserted Treasure #2 mine dump.	28.0	18.0	0.39	--	--	--	--	--	--	--
63A	Boxwork quartz, Deserted Treasure #2 mine dump.	20.0	18.0	0.38	--	--	--	--	--	--	--
64A	Quartz w/ chalcopyrite & bornite.	0.87	<2.0	0.06	--	--	--	--	--	--	--
65A	Selected quartz, Deserted Treasure #1 dump.	1.2	3.6	--	--	--	--	--	--	--	--
66A	Limonite-stained quartz in fold closure, King mine.	6.8	4.2	--	--	--	--	--	--	--	--
67A	Sulfide-bearing amphibolite.	35.4	--	--	--	--	--	--	--	--	--
68A	Selected sample quartz, Deserted Treasure #2 dump.	89.3	--	--	--	--	--	--	--	--	--
69A	Selected boxwork quartz breccia, Apex mine.	0.004	4.0	0.53	9,530	2,330	--	--	--	--	--
70A	3 ft composite, quartz breccia, Apex mine dump.	0.003	0.5	0.14	175	108	<10	--	--	--	--
71A	Grab, Cu-stained mafic schist, Apex mine.	0.013	63.8	3.81	92	68	--	--	--	--	--
72A	Cu-stained schist, Apex mine dump.	0.001	0.3	0.49	61	131	--	--	--	--	--
73A	Cupiferous, amphibolite-hosted, quartz vein.	0.038	3.6	3.43	3	11	--	--	--	--	--
74A	Stockwork in magnetite-bearing ultramafic schist.	0.010	<0.1	--	--	--	--	2,771	1,379	--	--
75A	Metagabbro	--	--	--	--	--	--	27	65	--	--
76A	Cu-stained schist from prospect pit.	0.14	0.2	4.7	10	622	19	--	--	--	--
77A	Milky quartz with boxworks.	0.027	1.7	--	--	--	--	206	15	<5	1
78A	Grab, quartz w/ limonite boxworks.	<0.010	<0.5	--	--	--	--	--	--	--	--
79A	Serpentinite w/ asbestos & minor chromite.	<0.010	<0.5	--	--	--	--	6,000	1,700	--	--
80A	Talc serpentine schist, common limonite pits.	<0.010	<0.5	--	--	--	--	1,900	2,400	--	--
81A	Limonite-stained milky quartz.	<0.010	0.8	--	--	--	--	--	--	--	--
82A	Limonite-stained serpentinite (27.8% MgO).	--	--	--	--	--	--	7,600	627	--	--
83A	Cu-stained quartz, Charlie's glory hole.	<0.05	0.33	0.52	30.1	106	--	--	--	--	--
84A	Gossan adjacent to spinifex metakomatiite.	<0.05	<1.0	--	--	--	--	66	43	--	--
85A	Iron-stained schist.	<0.05	<1.0	--	--	--	--	--	46	--	--
86A	Banded amphibolite.	<0.05	<1.0	--	--	--	--	--	--	--	--
87A	Massive gossan with boxworks.	<0.05	<1.0	--	--	--	--	--	--	--	--
88A	Gossan cut by quartz & carbonate vein stockwork.	<0.05	<1.0	--	--	--	<5	--	--	--	--
89A	Iron-rich gossan at serpentinite base.	<0.05	<1.0	--	--	--	--	202	23	--	--
90A	Limonite-cemented milky quartz breccia.	<0.05	<1.0	--	--	--	<5	--	--	--	--

MINERAL REPORT 92-6PLATE I

GEOLOGIC MAP OF THE SEMINOE MOUNTAINS GREENSTONE BELT, WYOMING

by W. Dan Hausel

1992



SAMPLE LOCATION MAP, SEMINOE MOUNTAINS MINING DISTRICT, WYOMING

by W. Dan Hausel

1993