The Geological Survey of Wyoming
Gary B. Glass, State Geologist

Field Guide to the Seminoe Mountains

by D. L. Blackstone, Jr. and W. Dan Hausel

Reprint No. 48 • 1992

Laramie, Wyoming

Text printed on 50% recycled fiber paper.

Reprint of 400 copies by Pioneer Printing and Stationery Company, Cheyenne, Wyoming.

This and other publications available from:
The Geological Survey of Wyoming
Box 3008, University Station
Laramie, Wyoming 82071-3008
(307) 766-2286 • FAX (307) 766-2605

This article is reprinted with the generous permission of the Wyoming Geological Association.
Originally published in the Wyoming Geological Association, Forty-Second [Annual] Field Conference Guidebook, 1991.

FIELD GUIDE TO THE SEMINOE MOUNTAINS

D. L. BLACKSTONE, JR.[1] and W. DAN HAUSEL[2]

INTRODUCTION

This field trip will examine the Archean stratigraphy and associated mineral deposits in the Seminoe Mountains, and discuss structures related to the Laramide tectonic event and subsequent adjustments that have affected the uplift. The Seminoe Mountains are considered to be an Archean granite-greenstone belt and have some interesting gold occurrences and extensive iron deposits. The Seminoe Mountains were initially mapped by Bishop (1964), Blackstone (1965), and Bayley (1968) and later re-examined and mapped by Klein (1981) and Hausel (1989a, 1991). Many of the stops in the Archean section were described by Klein (1982) for the 1982 Archean Geochemistry Field Conference and by Snyder and others (1989) for a 1989 International Geological Congress field trip.

The Seminoe Mountains, in central Wyoming along the southeastern margin of the Wyoming Province, form an uplifted Laramide thrust wedge cored by Precambrian metamorphic and igneous rock. The Precambrian rocks consist 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 tectonic event. The uplift is bounded on the southwest by a low-angle reverse fault originally named the Seminoe thrust fault by Lovering (1929) and later described as the Bradley Peak thrust fault by Blackstone (1965) and Bayley (1968). Archean crystalline rocks in the hanging wall of the thrust fault are thrust over sedimentary rocks as young as the Cretaceous Mesaverde Formation in the footwall. The Seminoe Mountains are bounded on the north by the Kortes reverse fault, a Precambrian shear zone that was reactivated during Laramide deformation and again in late Cenozoic time (Klein, 1981; Bohn, 1990).

The crystalline rocks represent a fragment of an Archean greenstone belt dominated by metavolcanic rocks (Klein, 1981). The lower part of this metamorphic belt consists of 11,000 feet of mafic metavolcanic and volcaniclastic rocks (**Figure 1**). These include amphibolite, metabasalt, and metatuff of tholeiitic affinity, with mica schist and minor serpentinite (metaperidotite). The serpentinite is chemically similar to ultramafic komatiite (**Table 1,** no. 2). The lower metavolcanic unit is intruded by metagabbro sills and plugs that occur in greater frequency near the top (north) of the unit.

The lower metavolcanic unit is overlain by nearly 1,000 feet of mafic and ultramafic schists informally named the Bradley Peak ultramafic rocks by Klein (1981, 1982). The Bradley Peak ultramafics consist of massive to highly foliated amphibolite, serpentinite, and tremolite-talc-chlorite schist that have tholeiitic and komatiitic affinity. Rocks in this unit with greater than 8% MgO are classified as komatiites based on their chemistry and texture (**Table 1,** nos. 3-6).

Komatiites are mostly primitive volcanic flows. Typically, they are classified as basaltic (mafic), with MgO contents of 9 to 18%, or peridotitic (ultramafic), with MgO contents greater than 18%. They have relatively high CaO/Al_2O_3 ratios and low TiO_2 and alkali contents. Textures are also diagnostic. Flow tops are chilled and grade downward into spinifex-textured rock overlying equigranular aphyric rock and into cumulate-textured serpentinite at the flow bottom.

Well-preserved individual flows of the Bradley Peak ultramafics are characteristic of komatiites described in other Archean cratons. The basal segment of the individual flow consists of cumulate-textured serpentinite (25-35% MgO), which grades upward into aphyric tremolite-talc-chlorite-serpentine schist, overlain by random spinifex textured, tremolite-rich (15-22% MgO), nematoblastic rock capped by tremolite schist (Klein, 1981, 1982; Snyder and others, 1989). Typically, the MgO content decreases from bottom to top in the flows.

A less MgO-rich (8-10% MgO) metakomatiite is locally abundant near Bradley Peak. These rocks are chemically similar to basaltic komatiites (Klein, 1981, 1982). Texturally, they have random and par-

[1]Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming 82071

[2]Geological Survey of Wyoming
P.O. Box 3008 University Station
Laramie, Wyoming 82071

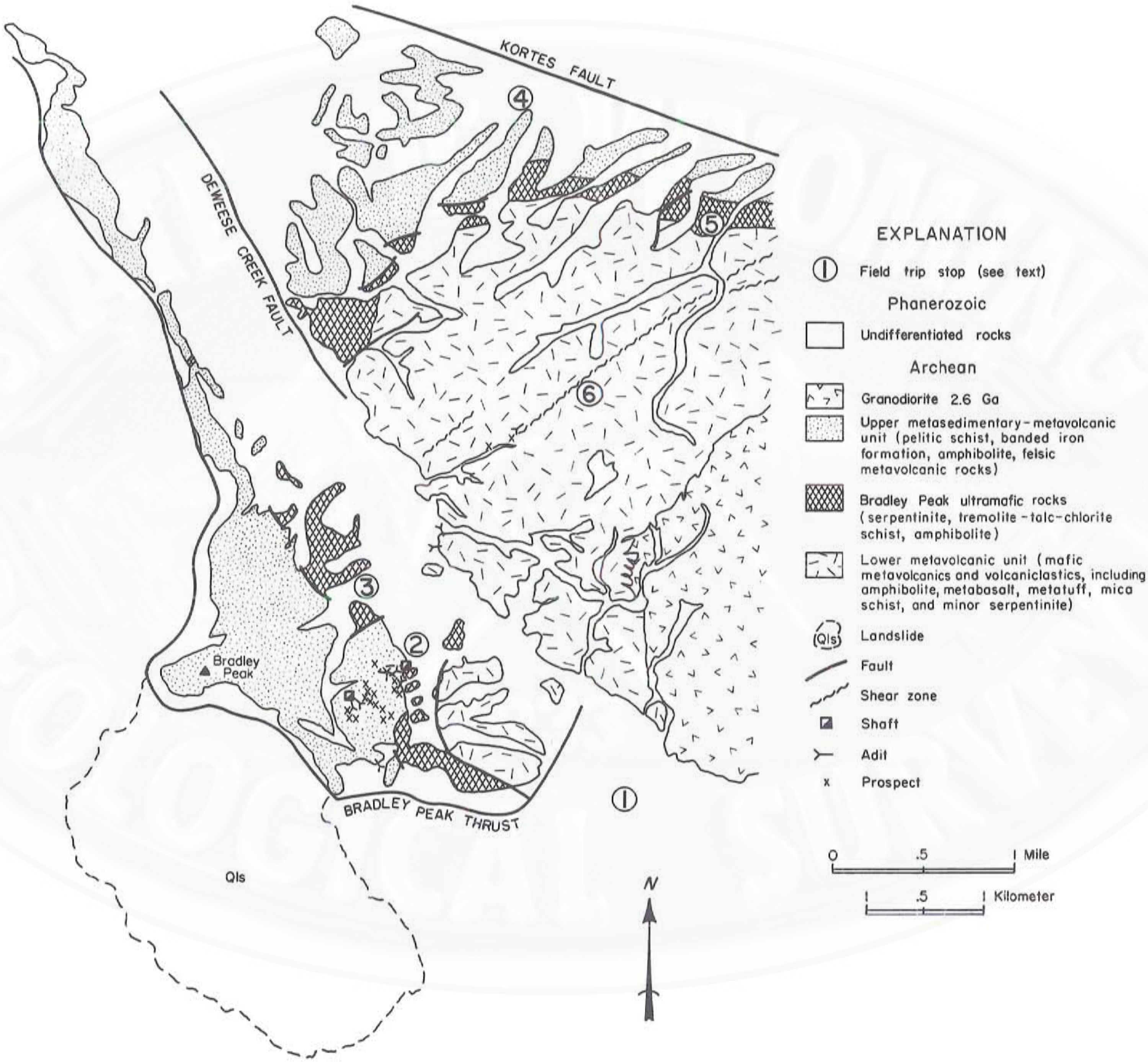

Figure 1. Generalized geologic map of the Seminoe Mountains greenstone belt (modified from Hausel, 1991).

Table 1. Whole-rock analyses of selected samples from the Seminoe Mountains greenstone belt.

	Sample number[1]					
	1	2	3	4	5	6
SiO_2	53.20	41.70	41.80	41.20	48.70	48.90
Al_2O_3	0.98	2.04	1.54	3.69	12.50	10.70
TiO_2	0.08	0.13	0.10	0.18	0.57	0.44
Fe_2O_3	39.00	9.63	10.20	14.10	11.80	11.90
FeO						
MnO	0.13	0.18	0.07	0.15	0.17	0.18
Mgo	1.84	33.80	32.50	28.50	8.54	12.40
CaO	0.49	0.13	0.52	1.16	7.37	7.94
Na_2O	0.04	0.02	0.03	0.04	2.68	1.65
K_2O	0.59	0.06	0.23	0.23	0.46	0.33
P_2O_5	0.59		0.42	0.43	0.51	0.54
CO_2						
LOI	0.97	11.15	11.42	9.03	5.32	2.25
TOTAL	97.91	98.84	98.83	98.71	98.62	97.23
CaO/Al_2O_3		0.06	0.3	0.3	0.6	0.7
Al_2O_3/TiO_2		16	15	20	22	24
Ag (ppm)	<5		<5	<5	<5	<5
Au(ppb)	51		<5	5	1	<5
As(ppm)	32		9	7	9	1
Cr(ppm)		2,700	6,680	2,400	370	930
Ni(ppm)		1,632	1,600	970	73	140
Pt (ppb)					9	
Pd (ppb)					6	

[1]Sample descriptions: (1) BIF near Penn mines, (2) serpentinite from lower metavolcanic group, (3) serpentinite from Bradley Peak ultramafic rocks, (4) metaperidotite, Bradley Peak ultramafics, (5) spinifex-textured arnphibole-chlorite schist, Bradley Peak ultramafics, (6) spinifex-textured tremolite-chlorite schist, Bradley Peak ultramafics.

allel spinifex grains of hornblende after pyroxene in a fine-grained chloritic groundmass.

The Bradley Peak ultramafic rocks are overlain by 2,000 to 4,000 feet of mixed metasedimentary and metavolcanic rocks. These include thick bands of quartz-magnetite-grunerite iron formation, with some chlorite schist, metagreywacke, and metapelite. Metavolcanics include metabasalt and crystal and lithic metatuffs.

Mineral deposits in the Seminoe Mountains include auriferous quartz veins, cupriferous shears and veins, iron formation deposits, and nephrite jade. Harrer (1966) estimated the banded iron formation (BIF) along the north slope of Bradley Peak could include about 100 million tons of taconite.

The route (**Figure 2**) will traverse Paleocene and Cretaceous rocks, and pass east of the Haystack Hills structure, which has been drilled for oil and gas. We

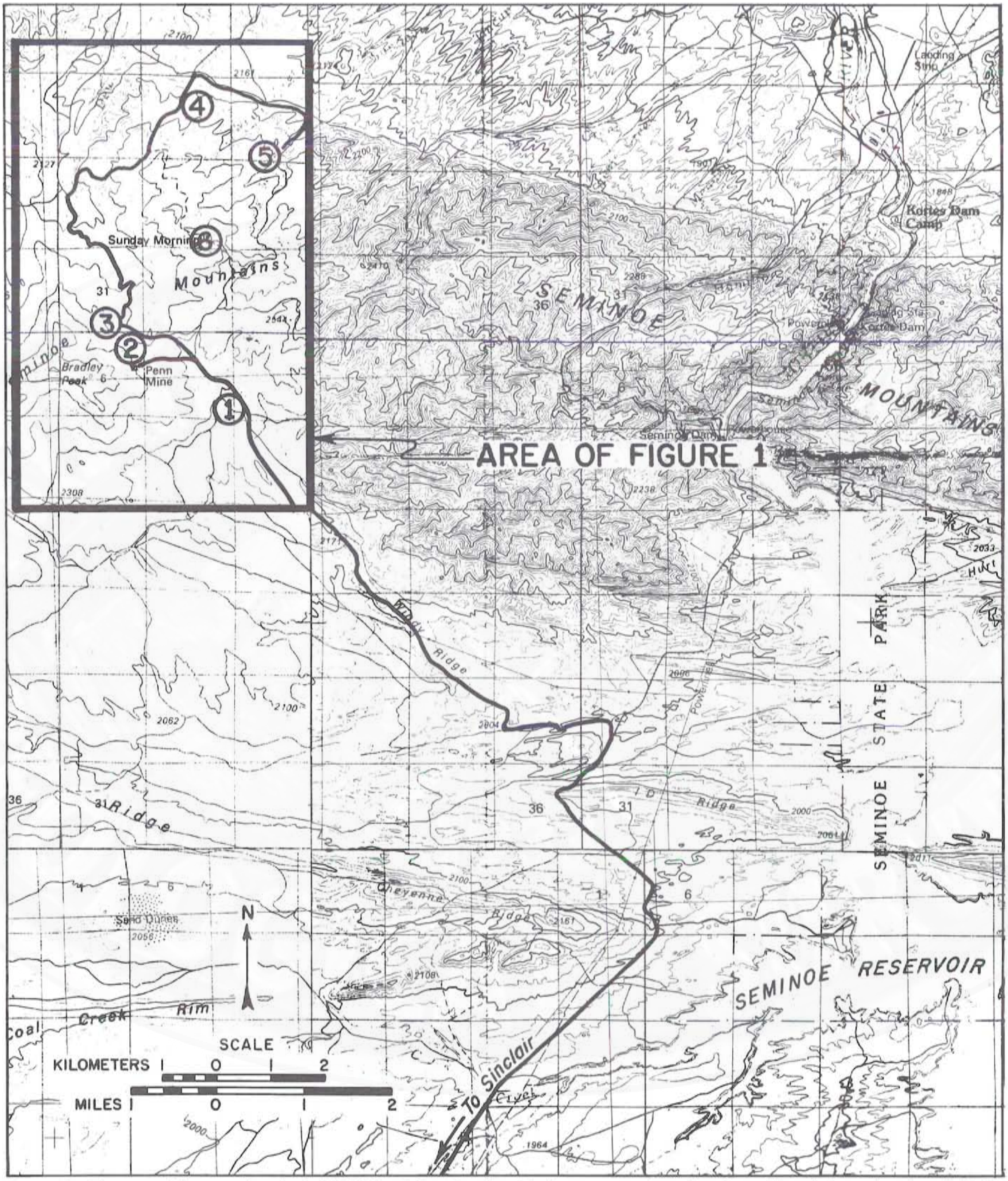

Figure 2. Topographic map (scale 1:100,000) of the Bradley Peak area, western Seminoe Mountains, showing field trip route and scheduled stops. Field trip stops are in T 25 and 26 N, R 85 W.

will then leave the paved road near ID ridge, along the southern edge of the Seminoe uplift, and continue west along Windy Ridge to Bradley Peak.

Acknowledgments

We thank John France and the Miller Estate Company for granting the Wyoming Geological Association access to the Bradley Peak area. We sincerely appreciate Charlie and Donna Kortes' contributions to the geologic study and mining history of the area, and appreciate the support by Alex Semryck.

ROAD LOG AND STOP DESCRIPTIONS

Cumulative
mileage from Sinclair (approximate).

0.0 Leave I-80 at Sinclair and travel north on the Seminoe State Park Road to the Seminoe Reservoir Recreation area.

28 ID Ridge; the route crosses the Pine Ridge Sandstone Member of the Mesaverde Formation on the north flank of the Obrien Springs anticline.

29 Road forks; take a sharp left after the large sand dune (see **Figure 2**).

33 The route has traversed Steele Shale (overturned with northeast dip). At this point, we are on the Niobrara Formation. Road runs parallel to and southwest of Hurt Creek. Cross low ridge of Wall Creek Sandstone Member of the Frontier Formation.

33.5 Cross ridge of Cloverly Formation.

34 Cross Alcova limestone dipping 60° or more south.

36 **Stop 1. Overview.** Come up to pediment surface. From here you can see the Bradley Peak-Seminoe-Emigrant Trail thrust fault (**Figure 3**), allochtonous masses of Mesozoic rocks, and a slide mass with iron formation (**Figure 4**). Continue north into Archean crystalline terrane and turn left into the Penn mines area.

38 **Stop 2. Penn mines.** The Penn mines are a group of mines and prospects and the remains of a mill that were operated by the historic Penn Mining Company. Mining operations began sometime before 1886, but were relatively short lived. Operations resumed during the Great Depression, but again, only a minor amount of ore was mined.

Timberline Minerals and Kerr McGee Corporation obtained large land holdings in the area in the early 1980s, following

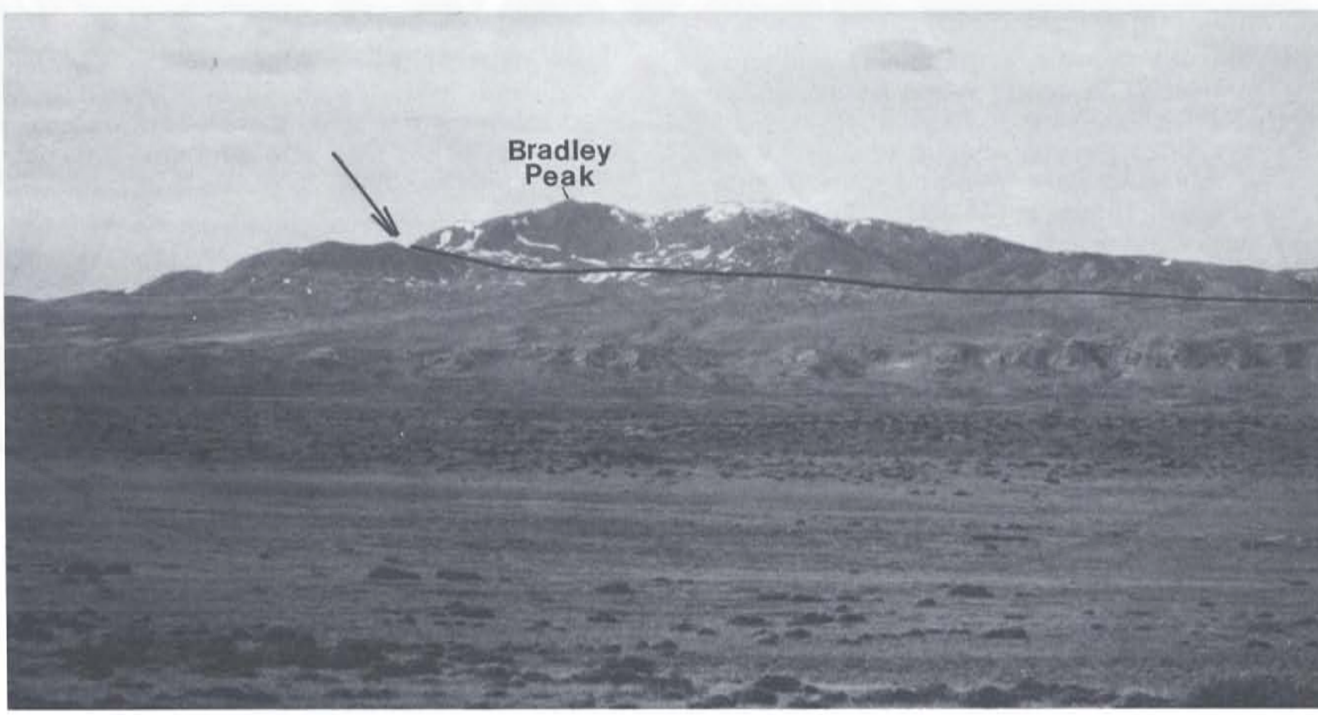

Figure 3. View northwest toward Bradley Peak (center skyline) from Seminoe State Park Road near Cheyenne Ridge. Thrust fault at arrow. Low ridge across center is Medicine Bow Formation. (Photo by W.D. Hausel.)

Figure 4. Close view of the major landslide area, showing characteristic topography. Hummocks and sag ponds are common. Banded iron formation is abundant in the slide. (Photo by W.D. Hausel.)

the 1981 discovery of significant gold mineralization in quartz veins, metatholeiite, and BIF by the Geological Survey of Wyoming. Several samples of quartz with visible gold were found on mine dumps (Hausel, 1989b, p.149-150). Samples of quartz and metatholeiite assayed a trace to 98.4 ppm (2.87 opt) Au. One sample of altered BIF assayed 46.8 ppm (1.36 opt) (**Table 2**). The Geological Survey has not been able to duplicate the BIF analysis done by Wyoming Analytical Labs in 1981, but Timberline Minerals reported finding BIF with visible gold (John Wells, personal communication, 1984).

Vein samples in this area generally yield anomalous gold (**Table 2**). They are narrow quartz-carbonate veins in a broad zone of propylitized amphibolites. The altered zone is approximately 0.5 mile in diameter (Klein, 1981). The amphibolites are moderately to pervasively altered to chlorite and carbonate assemblages with quartz-calcite-sulfide veins, veinlets, and stockworks. 39

Historic reports indicate the ore bodies were vein deposits (4 to 5 feet wide) containing free milling gold, pyrite, and chalcopyrite. One vein averaged 1.0 opt Au (Aughey, 1886).

Total gold production from the Penn mine area is unknown. Knight (1893) estimated 500 ounces were recovered, and production records and estimates after 1893 are nonexistent. Mine development was relatively minor, although one shaft was sunk to a depth of 240 feet (Aughey, 1886).

The district has not been extensively developed for gold principally because the veins are relatively narrow (generally less than 2 feet wide). Therefore, research is currently being directed toward the search for widespread, low-grade, gold mineralization in altered wallrock, stockworks, placers, and BIF.

Stop 3. Basaltic komatiites along Twin Creek. Basaltic komatiites along Twin Creek, have well preserved coarse radiating amphibole (after pyroxene)

Table 2. Assay results of samples from the Seminoe Mountains. Analyses by J.T. Roberts, Geological Survey of Wyoming, Bondar-Clegg, and Wyoming Analytical Labs.

Location	Description	Au (ppm)	Ag (ppm)	Fe (%)	Cu (%)	Pb (ppm)	Zn (ppm)	Ga (ppm)
W5-25-85	Weekly magnetic BIF	nd	nd	23.2				
W5-25-85	Float BIF	nd	nd	26.4				
6-25-85	BIF with minor cross cut quartz veinlets	nd	1.1	20.4				
6-25-85	Retake of sheared BIF-amphibolite contact (location BP24-84)	nd	2.9		0.05	12.0	90.0	
W6-25-85	BIF	nd	nd	33.4				
25-26-86	Brecciated BIF. Clasts cemented with carbonate and hematite	nd	1.8					
NE1-75-86	Stratabound veinlet in BIF	nd	nd	9.5				
NW6-26-85	Quartz vein in BIF, limonite staining	nd	1.5					
SE36-26-86	BIF	nd	nd	30.4				
NW31-26-85	Carbonated BIF	nd	1.2					
NW31-26-85	Milky quartz stockworks in chlorite schist (20-30 ft wide) minor sulfide	1.3	4.0		0.14	14.0	43.0	
NW31-26-85	BIF from E=CM2 prospect. Minor disseminated pyrite?	nd	nd	23.5				
NE31-26-85	Weakly iron-stained, milky quartz	nd	2.1					
SE25-26-86	Limonite cemented fault breccia with goethite rosettes	nd	1.1					
NW33-26-85	Cupriferous felsite from prospect pit	nd	nd		4.4	16.0	39.0	62.0
SE29-26-85	One foot wide channel cut across copper-stained shear	0.07	45.4		1.8	220.0	47.0	
SE29-26-85	Grab sample of cupriferous quartz float (Sunday morning)	2.1	26.9		5.8	1,970.0	140.0	
SE28-26-85	BIF, massive, thinly bedded	nd	nd	31.6				
SW20-26-85	10 foot composite of copper-stained mafic wallrock (Junk Creek)	nd	1.7		0.78			
SW20-26-85	Grab sample of azurite-malachite-tennorite-limonite quartz	0.05	1.4		1.2			6.0
SW20-26-85	BIF near Junk Creek prospect	nd	nd	16.2				
S20-26-85	Copper-stained quartz	0.15	2.7		3.7	66.0	2,920.0	
NE6-25-85	BIF from landslide mine dump	nd	5.4	26.1				
NE6-25-85	Quartz from landslide mine dump	nd	1.0					
6-25-85	Carbonated quartz from BIF	0.06	8.1					
E6-25-85	Quartz from fold closure	4.6	5.2		0.12	54.0	22.0	
E6-25-85	Copper-and-limonite-stained fracture in metatholeiite	12.0	55.0		3.75	25.0	250.0	
E6-25-85	Limonite-stained metatholeiite wallrock	9.8	12.0		0.81	10.0	85.0	
E6-25-85	Vein quartz from weak stockwork south of Emeletta mine	2.2	3.5		0.11	5.4	28.0	
E6-25-85	Wallrock of weak stockwork	0.12	nd		0.09	3.0	120	
E6-25-85	Crosscut vein in BIF	0.34	nd		0.02	7.2		
NE6-25-85	BIF with quartz-carbonate breccia vein	nd	nd		0.04	170.0	2,820.0	
SE6-25-85	Quartz vein, copper stained, minor pyrite	8.8	6.8		0.37	23.0	120.0	
SE6-25-85	Quartz vein, copper stained, minor pyrite	11.0	9.3		0.94	75.0	480.0	
SE6-25-85	Quartz with chalcopyrite, covellite, and pyrite	2.2	26.0		1.61	11.0	110.0	
NW6-25-85	Banded chert	nd	3.3		0.03	3,890.0	43,000	
NW6-25-85	Boxworks and copper-stained rock chips	0.05	8.1		0.28	2,180.0	25,000	
6-25-85	Vein with boxworks, Hidden Treasure mine dump	28.0	18.0		0.39			
6-25-85	Vein with boxworks, Hidden Treasure mine dump	20.0	18.0		0.38			
6-25-85	Quartz with bornite and chalcopyrite	0.87			0.06			
6-25-85	Selected sample of limonitic quartz form Emeletta mine	1.2	3.6					
6-25-85	Sample of limonitic quartz vein in fold closure	6.8	4.2					
6-25-85	Altered metagabbro	39.0						
6-25-85	Carbonated iron formation (minor sulfides)	46.8						
6-25-85	Quartz vein from Deserted Treasure mine dump	98.4						

spinifex megacrysts in a chloritic matrix (**Figure 5**). These rocks are hornblende-plagioclase metakomatiites locally overprinted by chlorite-carbonate and talc-carbonate alteration assemblages (Klein, 1982) (**Table 1, nos. 5** and **6**). The rocks have 8 to 12% MgO, CaO/Al_2O_3 ratios of 0.6 to 0.7, and Al_2O_3/TiO_2 ratios near 20.

Figure 5. Spinifex textured basaltic komatiite along Twin Creek at stop 3. (Photo by W.D. Hausel.)

Nearby, weak gossans in the Bradley Peak ultramafic rocks were sampled for gold and nickel. No anomalies were detected.

42 to 43 **Stop 4. Banded iron formation near Junk Creek.** The BIF at this stop is quartz-magnetite-grunerite iron formation (**Table 1**) initially named the Seminoe Formation by Lovering (1929). Magnetite is generally the dominant iron-bearing phase of the BIF, although grunerite dominates locally.

Small-scale isoclinal and box folds within the iron formation are generally disharmonic with many attenuated fold limbs (**Figure 6**). The large scale folds are probably related to deformation that accompanied the development of a regional shear system marked by the Kortes fault (Klein, 1982; Snyder and others, 1989). Metagabbro and metabasalt dikes, possibly of Late Archean or Early Proterozoic age, cut the BIF.

The BIF is locally mineralized in precious metals (Dickman, 1926; Hausel, 1989). Recent investigations have isolated only weak silver anomalies (**Table 2**).

44.5 **Stop 5. Sunday Morning Creek komatiites and tholeiites** *(CAUTION-This area includes a well-stocked rattlesnake den).*

Several well-developed komatiite flows along the west ridge adjacent to Sunday Morning Creek were mapped and described by Klein (1981, 1982). The ridge contains mafic metatholeiites (hornblende schists) interlayered with several komatiite flows that have fine-grained random spinifex texture. The section is comprised of at least 14 flows (20 to <100 feet thick) with hypabyssal ultramafic sills. Many of the flows are capped by spinifex-textured komatiite that grades downward into aphyric komatiite. The aphyric komatiite grades downward into a basal cumulate-textured serpentinite. Interflow magnetite iron formation is common. The morphology of the flows can be used as topping criteria (i.e., the top of the section lies to the north).

Figure 6. Intensely folded banded iron formation at stop 4. (Photo by W.D. Hausel.)

The komatiite suite along Sunday Morning Creek has the general compositional characteristics of other aluminum-depleted komatiites from other Archean cratons. They have CaO/Al_2O_3 ratios less than unity, Al_2O_3/TiO_2 ratios near 20, high MgO contents (8 to 35%), high Cr contents (>300 ppm), high Ni contents (generally >100 ppm), and depleted light rare earth element to flat rare earth element patterns (Snyder and others, 1989).

Metasedimentary rocks north of the komatiite flows include fine-grained clastic rocks (quartz-biotite-garnet schist, quartz-plagioclase-muscovite schist, and quartzite) and thin iron formation members, with intercalated felsic metavolcanic rocks including a quartz phyric rhyodacite flow dated at 2.7 Ga (Snyder and others, 1989, p. 34).

52.5 **Stop 6 (optional). Sunday Morning prospect**. Time permitting, you may want to visit the Sunday Morning prospect northeast of the Apex mine. The Apex mine and the Sunday Morning prospect lie 1.25 and 1.5 miles northeast of the Penn mines. Confusion has arisen because the Bradley Peak 1:24,000-scale topographic map identifies this prospect as the Sunday Morning mine, whereas mine records identify the mine at the mouth of Sunday Morning Creek (stop 5) as the Sunday Morning mine. For our purposes, we will refer to this prospect at stop 6 as the Sunday Morning prospect instead of mine.

The Sunday Morning prosect is located on cupriferous milky quartz in a shear zone. Samples of milky quartz commonly contain chrysocolla and cuprite. The shear zone has been mapped along a northeast trend for 2 miles and is marked by well developed penetrative foliation in schists of the lower metavolcanic unit. Crosscutting veins oblique to foliation are folded and offset along the penetrative foliation demonstrating brittle-ductile deformation (**Figure 7**).

To the southwest at the Apex mine, the shear grades into a quartz breccia vein. Some visible gold was found at the adit (Charlie Kortes, personal communication, 1989). One sample of cupriferous breccia collected from the mine dump assayed 3.81% Cu, 1.86 opt Ag, and a trace gold.

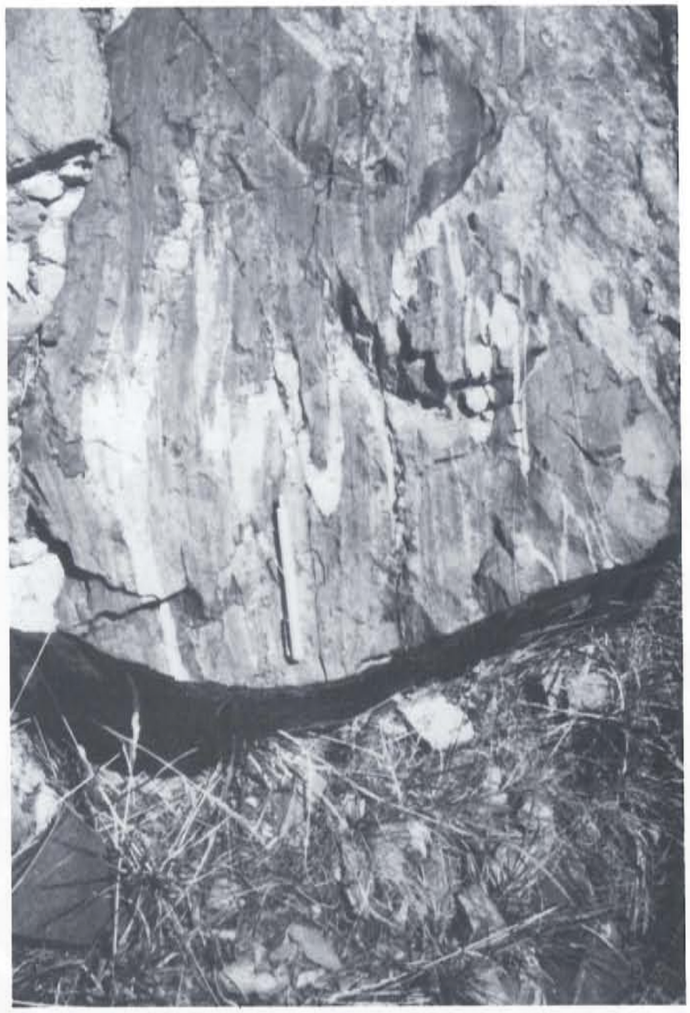

Figure 7. Oblique vein in shear zone at the Sunday Morning prospect, stop 6. (Photo by W.D. Hausel.)

REFERENCES CITED

Aughey, Samuel, 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.

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, 83 p.

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.

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

Klein, T.L., 1981, The geology and geochemistry of the sulfide deposits of the Seminoe district, Carbon County, Wyoming: Ph.D. dissertation, 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 , Geological Survey of Wyoming files (unpublished), 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.

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.

STATE OF WYOMING GEOLOGICAL SURVEY

1933

STATE OF WYOMING
GEOLOGICAL SURVEY
1933

Geology -- Interpreting the past to provide for the future

Field Guide to the Seminoe Mountains

R 48