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GEOLOGY AND MINERAL RESOURCES OF THE WILD HORSE MESA AREA, BURRO MOUNTAINS, GRANT COUNTY, NEW MEXICO

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Abstract—The alteration, vein textures, metal association, and proximity to the ring-fracture zone of the Schoolhouse Mountain caldera indicate that the mineral deposits at Wild Horse Mesa in the eastern Telegraph district of the northern Burro Mountains are volcanic-epithermal veins. In the Wild Horse Mesa area, there are four types of mineral deposits, including fluorite veins, uranium vein and minor stratabound deposits, base metal veins, and barite veins. Mineral distribution appears to be controlled by the Schoolhouse Mountain fault. Fluorite and uranium veins occur west of the fault, copper with gold and silver occur along the fault, and barite without significant metals occurs east of the fault. The alteration and form of the veins indicate that ascending fluids, not descending fluids, formed the vein deposits. The mineral resource potential for undiscovered volcanic-epithermal vein deposits in the Wild Horse Mesa area is good. The presence of gold concentrations in surface samples and the interpretation of the deposits being at the top of a volcanic-epithermal system suggest that additional deposits are most likely to be deep. The best potential is associated with faults west of, and including, the Schoolhouse Mountain fault.

INTRODUCTION

The Wild Horse Mesa area in the eastern Telegraph district (Fig. 1; North and McLemore, 1986; McLemore, *in press*) lies along the southern ring-fracture zone of the Schoolhouse Mountain caldera in the northern Burro Mountains in Grant County, New Mexico. Fluorite veins, uranium vein and minor strata-bound deposits, base metal veins, and barite veins are found in the Wild Horse Mesa area. The purpose of this paper is to describe the geologic history, types of mineral deposits, relationship between the mineral deposits and the Schoolhouse Mountain caldera, and summarize the mineral resource potential.

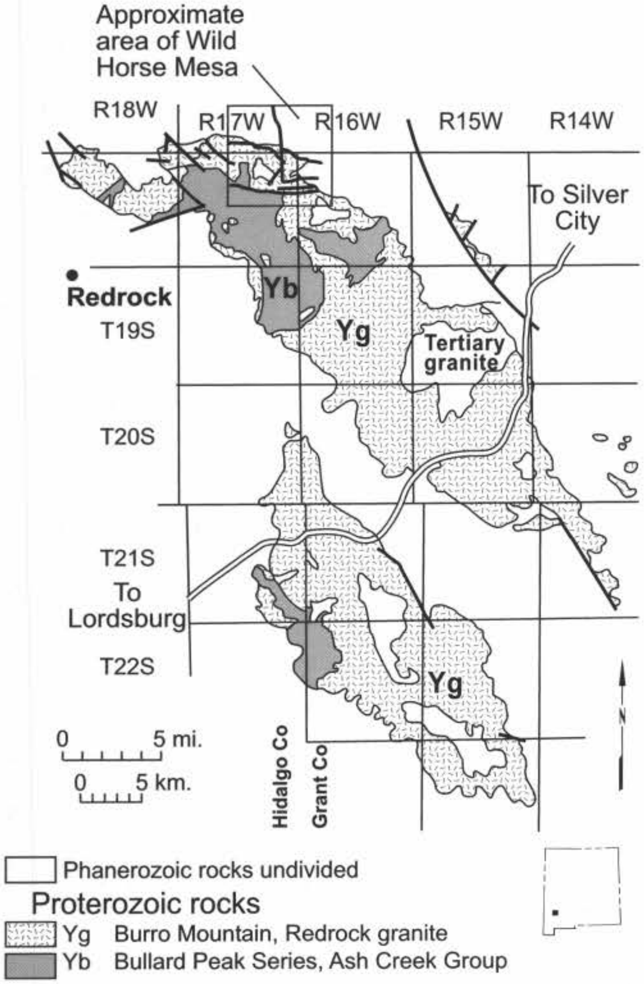

FIGURE 1. Location of the Wild Horse Mesa area, northern Burro Mountains, Grant County, New Mexico.

Numerous reports briefly describe the various mineral deposits (Elston, 1957; Gillerman, 1952, 1964, 1968; Hewitt, 1959; Williams, 1966; McAnulty, 1978; Hedlund, 1980; O'Neill and Thiede, 1982; McLemore, 1983; Richter and Lawrence, 1983; Finnell, 1987; McLemore et al., 1996), but there are no published detailed studies. Regional and local geologic mapping was by Hewitt (1959), Wahl (1980), Hedlund, (1980), Finnell (1987) and unpublished mapping by the author. The author first examined the Wild Horse Mesa area in 1980–1983, as part of a study of uranium resources in the state (McLemore, 1983). In 1993–1994, the area again was examined as part of the evaluation of mineral resources in the Bureau of Land Management's Mimbres Resource Area (McLemore et al., 1996; Bartsch-Winkler, 1997).

The area was remapped at a scale of 1:12,000 and 1:1000 in 1999 as part of a regional study of the Proterozoic rocks in the northern Burro Mountains (Fig. 2; McLemore et al., this volume, p. 117). Mineralized areas were examined and sampled; mines and prospects are listed in Table 1. Mineralized and altered samples were collected and analyzed for trace metals in 1993, 1994, and 1999 to evaluate the economic potential of the area (Table 2).

MINING AND EXPLORATION HISTORY

The Wild Horse Mesa area of the eastern Telegraph district was first prospected for base and precious metal deposits in the late 1800s. The German mine was discovered prior to 1900 and minor production occurred. In 1947, John A. and Bernard Harrison discovered fluorite at the Purple Heart mine. The mine has changed ownership several times. Reported total production from the Purple Heart mine from 1947 to 1978 amounted to 1388 short tons (st) of fluorite ore (McAnulty, 1978). James L. Reed discovered the Reed fluorspar mine in 1951 and shipped 57 st of ore containing approximately 41% CaF_2 (Williams, 1966). In 1953–1954, Reed shipped 150–200 st of 60–75% CaF_2 (Gillerman, 1968). Other fluorite veins were found in the area, but they did not produce any ore.

Floyd Walcop discovered uranium in the Wild Horse Mesa area about 1954 and sold the property to J. H. Winslow and Ernest Nickel (James Reed, personal commun., November 19, 1984). About 1957, Uran Mining Co. was formed to explore and develop the uranium deposits. On May 18, 1958, the New York State Attorney General's Office investigated a potential mail fraud by the company and directed that a 54.9-m adit be driven along the Moneymetal fault to confirm the presence of uranium (Fig. 3). Small pods and clusters of radioactive material were found in the adit (Gillerman, 1968; unpublished data, NMBMMR archives), but there has been no uranium production. Surface sampling, geophysical surveys, and shallow drilling have occurred from the 1950s until today, primarily looking for uranium. Recent exploration has expanded to include precious metals.

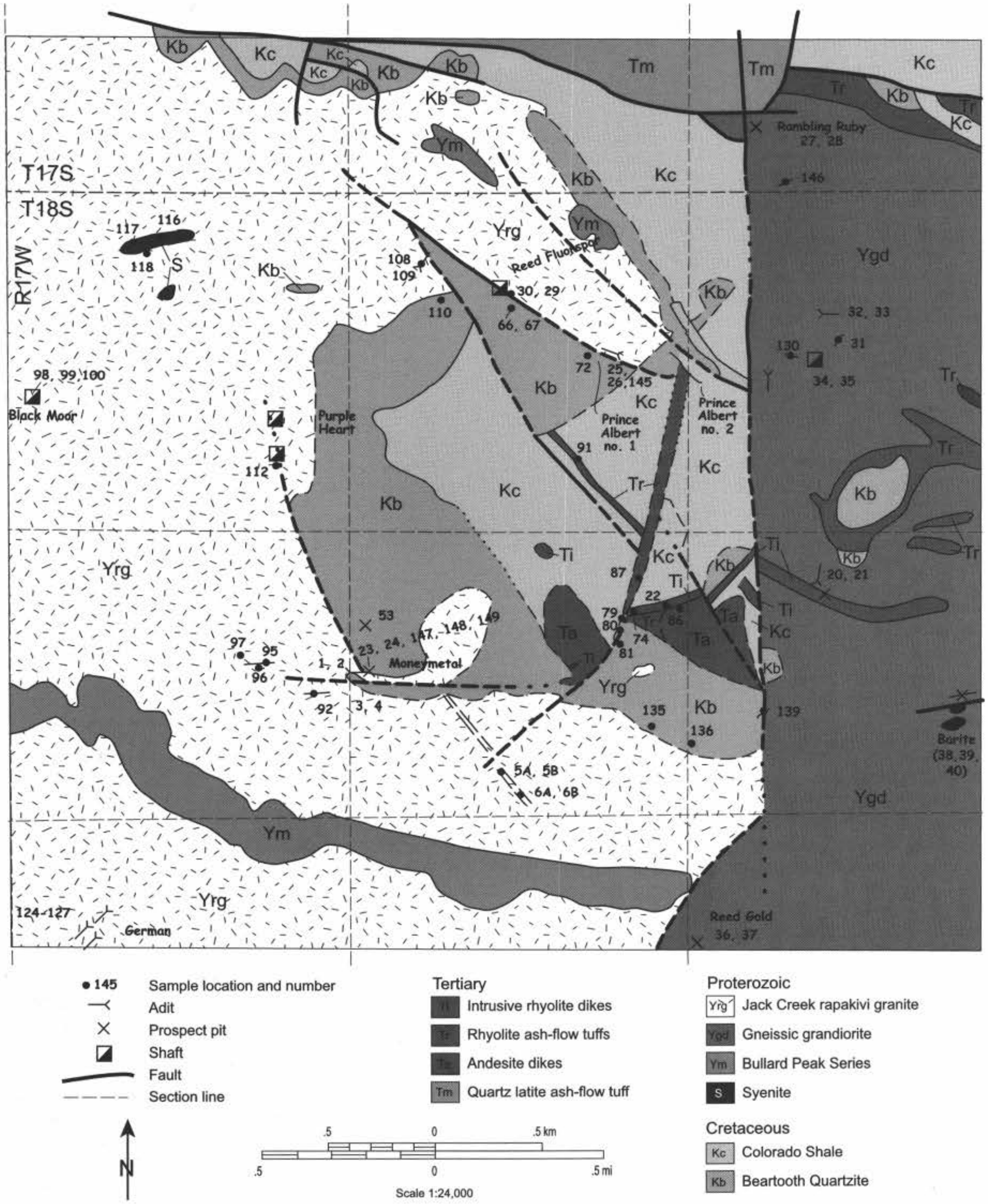

FIGURE 2. Simplified geologic map of the Wild Horse Mesa area, northern Burro Mountains.

REGIONAL GEOLOGIC SETTING

The Burro Mountains lie in the Mexican highland section of the Basin-and-Range physiographic province in southwestern New Mexico. During the latest Proterozoic and Cambrian the Burro Mountains were uplifted and eroded. The Burro Mountains were either a highland during much of Phanerozoic time, or older sedimentary rocks were eroded before deposition of Cretaceous rocks when seas partially covered the mountain range. Laramide compressional tectonics and mid-Tertiary extensional tectonics have since affected the area. Andesites and rhyolites were intruded during the Laramide and mid-Tertiary.

The Schoolhouse Mountain caldera lies north of the Wild Horse Mesa area and is one of approximately 25 calderas that formed in southwestern New Mexico during the mid-Tertiary (McIntosh et al., 1991). The caldera is interpreted to be asymmetrical, as much as 1.5 km deep, and filled with the tuff of Cherokee Canyon and Box Canyon (Schoolhouse Mountain Formation of Wahl, 1980; Finnell, 1987). The Box Canyon Tuff, first recognized by Elston (1957), is the crystal-rich, low-silica outflow unit of the caldera exposed north of the Wild Horse Mesa area and is 33.5 Ma (^{40}Ar/^{39}Ar, McIntosh et al., 1991). Ring-fracture faults occur on the southern side of the caldera, in the Wild Horse Mesa area. Quaternary basalts and sedimentary rocks bury much of the northern caldera. Younger north- and northwest-trending Basin-and-Range faults offset the caldera boundary (Wahl, 1980; Finnell, 1987).

TABLE 1—Mines and prospects in the Wild Horse Mesa area, eastern Telegraph mining district, Grant County, New Mexico (Fig. 2). Location includes section, township, and range. FN—V. T. McLemore, unpublished field notes. * not shown on Figure 2.

MINE NAME (ALIAS)	LOCATION	LATITUDE, LONGITUDE	COMMODITIES	DEVELOPMENT	TYPE OF DEPOSIT	REFERENCES
Barite prospect	NW7 18S 16W	32° 45' 5", 108° 32' 32"	Ba, Ag, Cu	pit	Vein	FN 8/21/94
*Barite No. 2	NE18 18S 16W	32° 44' 58", 108° 32' 25"	Ba	pits	Vein	Hedlund (1980), FN 9/8/99
Blackmoor (Cloverleaf, Blackamoor, Blackmore)	SW3 18S 17W	32° 46' 06", 108° 35' 38"	F	10 ft deep prospect pit, 50 ft shaft	Fluorite veins	Gillerman (1964), Williams (1966), Hewitt (1959), Gillerman (1952), FN 9/2, 4/99
German (Hard Pan)	NW 15 18S 17W	32° 44' 44", 108° 35' 27"	Pb, Zn, Cu	shaft and three adits	Base-metal vein	Hewitt (1959), Gillerman (1964), Hedlund (1980), NMBMMR file data, FN 9/5/99
*May Day 1 and 2 (Yukon Group)	N2 18S 17W	32° 46' 31", 108° 34' 16"	U	no workings-outcrop only	Uranium vein	Gillerman (1964), O'Neill and Thiede (1982)
Moneymetal	NE 11 18S 17W	32° 45' 20", 108° 34' 58"	U	180 ft adit	Uranium vein	Gillerman (1968), FN 8/20/94, 9/1/99
Prince Albert No. 1	1 18S 17W	32° 45' 55", 108° 33' 05"	U	15 ft adit, cut, pit	Uranium vein	Gillerman (1964), O'Neill and Thiede (1982), FN 8/20/94
Prince Albert No. 2	E 2 18S 17W	32° 46' 11", 108° 33' 46"	U	bulldozer stripping, outcrop, shallow pit	Uranium vein	O'Neill and Thiede (1982), Gillerman (1964), FN 8/20/94
Purple Heart	SE 3 18S 17W	32° 45' 56", 108° 34' 54"	F, U	65 ft inclined shaft, 108 ft vertical shaft, adit	Fluorite vein	Gillerman (1952), Hewitt (1959), Gillerman (1964), Williams (1966), FN 8/19/94, 9/3/99
Rambling Ruby	E 2 18S 17W	32° 46' 11", 108° 33' 45"	F, U, Cu	pits, shaft, trenches	Fluorite vein	Gillerman (1964), FN 8/20/94, 9/9/99
Reed Fluorspar (Fluorspar No. 1)	C of N2 18S 17W	32° 46' 22", 108° 34' 13"	F, U, Au	3 shafts (30-50 ft deep), 2 open cuts, a few prospect pits	Fluorite vein	Gillerman (1964), Williams (1966), FN 8/20/94, 8/31/99
Reed gold deposit	13, 14 18S 17W	32° 44' 40", 108° 33' 50"	Au	Prospect pits	Gold vein	FN 8/21/94
*Sandy	12, 22 18S 18W	32° 44' 00", 108° 41' 25"	U, fluorite	80 ft shaft, pits	Fluorite vein	Hewitt (1959), McLemore (1983)
*Springfield	9 18S 17W	32° 45' 15", 108° 36' 00"	U, Cu	2 shallow pits, one cut		O'Neill and Thiede (1982)
*Union Hill Claims	NE 10 18S 17W	32° 45' 25", 108° 34' 45"	Mo, Pb, Sb, W, Zn, U	cuts, drilling	Uranium vein	O'Neill and Thiede (1982), Gillerman (1964)
*WF Claims	NW 12 18S 17W	32° 45' 40", 108° 33' 30"	U, Au	no workings-outcrop only	Uranium vein	FN 8/5/82
Unknown (Butterfly Seep area)	C 1 18S 17W	32° 45' 55", 108° 33' 45"	Cu	20 ft shaft, 15 ft pit	Base-metal vein	FN 8/21/94
Unknown	12 18S 17W	32° 45' 30", 108° 33' 20"	Cu	Pit, shaft	Base-metal vein	FN 8/21/94

LOCAL GEOLOGY

Proterozoic rocks

Bullard Peak Series metamorphic rocks

The oldest rocks in the Wild Horse Mesa area are metamorphic rocks that Hewitt (1959) called the Bullard Peak Series. These units of light-colored, fine- to medium-grained, quartz-feldspathic gneiss and schist, dark-colored biotite and hornblende schists, black amphibolite, gray–greenish-gray phyllite, and gray–white quartzite (Hewitt, 1959). Individual units are irregular in shape, discontinuous, and difficult to map. Therefore, they are typically grouped as undifferentiated metamorphic rocks (Hedlund, 1980; Finnell, 1987; unpublished mapping by the author). Foliation is well to poorly developed and variable in orientation. The metamorphic rocks consist of interlayered units of igneous and sedimentary protolith that are cross-cut by granitic gneiss, pegmatites, and fine-grained biotite granite dikes. Migmatites are common along some contacts with the younger granitic intrusions; other contacts with the granite are sharp. A sample of the metamorphic gneiss was dated as 1560 Ma by U/Pb methods on zircon (Hedlund, 1980).

Gneissic granite/granodiorite

This unit is gray, medium- to coarse-grained, hypidiomorphic-granular to porphyritic granite to granodiorite that consists of microcline, oligoclase, quartz, biotite, hornblende, and trace amounts of sphene, zircon, apatite, epidote, pyrite, and magnetite. The granite/granodiorite is typically foliated and contains xenoliths of metamorphic rocks. Hedlund (1980) reports a K/Ar biotite age of 1380 ± 45 Ma.

Jack Creek rapakivi granite

The Jack Creek rapakivi granite is pink–gray to red-orange and is medium–coarse grained. It is characterized by large K-feldspar phenocrysts, some of which are mantled by plagioclase to form the rapakivi texture. This granite consists of plagioclase, K-feldspar, quartz, biotite, and accessory apatite and magnetite. The rapakivi granite is locally foliated at the contact with the older gneissic granite/granodiorite in Wild Horse Canyon, east of the Schoolhouse Mountain fault (Fig. 2). The granite extends from north of Redrock, eastward to the Schoolhouse Mountain fault, east of Wild Horse Mesa. McLemore et al. (this volume, p. 117) named this unit after Jack Creek, which cuts through the granite in the Redrock area.

Numerous xenoliths of older metamorphic rocks and comagmatic enclaves and synplutonic dikes of lamprophyre (minette) characterize the Jack Creek rapakivi granite (McLemore et al., this volume, p. 117). Xenoliths are extraneous pieces of older country rock introduced into the magma, whereas enclaves are residues of melting or coeval magma (Didier and Barbarin, 1991). Xenoliths range in size from a few centimeters in diameter to lenses tens of meters across. Typically the metamorphic xenoliths are similar to the metamorphic rocks found in the

TABLE 2—Chemical analyses of samples from Wild Horse Mesa area, Telegraph district. All analyses are in ppm (parts per million) except for gold, which is in ppb (parts per billion). Samples WH1-WH40 and Purple Heart were analyzed by Bondar-Clegg and Co. Ltd. (Au by fire assay; Ag, Cu, Pb, Zn, Mo by FAAS; As, Sb by INAA; Hg by cold vapor AA). Samples WH71, 98, 124-125, 127, 148, 149 were analyzed by FAAS at the NMBMMR using four-acid digestion. Remaining samples were analyzed by XRF spectrometry at the NMBMMR. Au and Ag were by fire assay at NMBMMR. — not analyzed for.

SAMPLE	As	Zn	Cu	Mo	Pb	Th	U	Au	Ag	Sb	LITHOLOGY
Moneymetal vein											
WH 1	20	1683	504	15	429	12	<100	8	0.6	4.5	Dump, Moneymetal vein
WH 2 (Hot Hole)	58	758	28	75	1367	6	190	7	0.4	12	Dump, Moneymetal vein
WH 3	0.5	67	40	4	46	<4	<100	<5	<0.1	0.5	1.1 m chip of Moneymetal vein
WH 4	39	1095	9	12	1256	<4	<100	<5	0.6	1.7	1.1 m chip of Moneymetal vein
WH 23	4.7	233	7	4	53	—	—	<5	1	2.9	1.2 m chip across vein, Moneymetal adit
WH 24 (Hot Hole)	4.6	84	130	4	38	—	—	<5	0.2	1.1	Moneymetal pit
WH 92	2	147	8	<1	27	<1	16	—	—	—	Fault in granite
WH 95	5	42	4	<1	20	8	2	—	—	—	Andesite porphyry dike
WH 96	<1	13	65	<1	17	<1	2	—	—	—	Quartz
WH 97	<1	5	7	<1	5	<1	2	—	—	—	Quartz
WH 147 (Hot Hole)	21	102	15	12	118	2	75	—	—	—	Vein select
WH 148 (Hot Hole)	6	42	12	32	786	<1	181	<10	0.3	—	Vein
WH 149	5.3	31	<40	27	740	—	—	<10	<0.3	—	Grab of fault zone
Veins east of Schoolhouse Mountain fault											
WH 20	5.3	366	5	5	10	—	—	<5	0.3	1.4	1.1 m chip, N20 18S 17W
WH 21	4.3	412	4	4	14	—	—	<5	0.3	1.1	Select dump, N20 18S 17W
WH 31	1.8	12	6	2	60	—	—	<5	<0.2	0.4	0.2 m chip, C1 18S 17W
WH 32	2.5	84	15,968	4	261	—	—	38	18.8	0.3	Select dump, C1 18S 17W
WH 33	4.9	185	122	5	41	—	—	<5	0.5	1.3	Dump, C1 18S 17W
WH 34	2.4	37	8438	3	108	—	—	122	5.5	0.9	select dump, C1 18S 17W
WH 35	2.1	19	9343	4	204	—	—	109	6.4	1	0.2 m chip, C1 18S 17W
WH 130	<1	16	9	<1	17	<1	2	—	—	—	Quartz vein
Beartooth Quartzite											
WH 53	28	28	10	3	8	<1	6	—	—	—	Altered Beartooth
WH 110	2	6	14	4	10	<1	3	—	—	—	12 cm quartz vein
WH 135	6	28	9	8	44	3	41	—	—	—	Beartooth
WH 136	19	2194	22	4	118	<1	7	—	—	—	Beartooth
WH 139	3	17	7	<1	45	<1	2	—	—	—	Beartooth
Rhyolite dikes											
WH 22	2.3	17	3	<1	12	—	—	<5	<0.2	0.6	Altered rhyolite, 11 18S 17W
WH 74	16	300	<40	<5	32	—	—	<10	<0.3	—	Altered rhyolite dike
WH 79	2	35	6	<1	20	12	4	—	—	—	1.1 m chip rhyolite
WH 80	2	33	5	<1	21	11	4	—	—	—	Porphyry dike
WH 81	14	49	11	<1	32	9	5	—	—	—	Rhyolite
WH 86	<1	47	5	<1	24	11	3	—	—	—	Rhyolite
WH 87	2	43	6	<1	18	11	4	—	—	—	Fresh rhyolite
WH 91	<1	24	5	<1	22	9	2	—	—	—	Rhyolite
Reed-Prince Albert fault											
WH 29	36	65	101	9	130	—	—	25	0.8	1.7	Grab, NE2 18S 17W
WH 30	1.4	15	39	1	26	—	—	<5	<0.2	1	0.1 m chip
WH 66	8	22	10	5	68	2	9	—	—	—	2 m chip silicified body
WH 67	4	19	7	4	59	<1	9	—	—	—	Select breccia vein
WH 72	3	38	5	<1	23	12	3	—	—	—	Beartooth
WH 108	2	33	6	<1	11	9	9	—	—	—	Quartz vein at adit
WH 109	2	8	10	<1	<1	<1	2	—	—	—	Dump of fluorite
WH 25	63	134	9	16	50	—	—	40	3.2	1.9	1 m chip , Prince Albert
WH 26	12	30	3	6	78	—	—	11	1.9	1.5	1 m chip, Prince Albert
Precambrian, Ramsey saddle											
WH 116	7	132	19	<1	57	43	10	—	—	—	Metasomatized granite
WH 117	1	27	4	<1	19	23	4	—	—	—	Metasomatized granite
WH 118	2	19	5	<1	17	31	8	—	—	—	Coarse grained granite
Precambrian quartz vein											
WH 5A	1.6	79	105	<1	42	—	—	<5	<0.1	1.6	1.1 m chip of vein, 11 18S 17W
WH 5B	3.3	32	49	2	79	—	—	<5	0.3	3.3	2.2 m chip of vein, 11 18S 17W
WH 6A	0.6	32	21	3	27	—	—	<5	<0.1	0.6	3.1 m chip, 11 18S 17W
WH 6B	0.5	11	20	2	5	—	—	<5	<0.1	0.5	Chip of vein, 11 18S 17W
WH 145	13	225	10	4	115	28	141	—	—	—	vein in granite
Rambling Ruby											
WH 27	3	30	9138	3	114	—	—	<5	20.7	2.2	outcrop, SE36 17S 17W
WH 28	4	113	>20,000	31	106	—	—	195	>50.0	5.8	select dump, Rambling Ruby
WH 146	4	104	12	<1	37	5	3	—	—	—	breccia vein
Reed gold deposit											
WH 36	<0.1	299	161	5	351	—	—	245	2.7	<0.2	dump, NE13 18S 17W
WH 37	1.9	42	169	3	8	—	—	<5	0.7	0.7	quartz pod, NE13 18S 17W
Barite deposit											
WH 38	2.9	47	59	<1	40	—	—	<5	0.3	6.2	10 ft chip of vein
WH 39	7.2	248	151	2	80	—	—	<5	3.4	4.9	6 ft chip of vein
WH 40	4.6	101	67	2	68	—	—	<5	0.8	7	6 ft chip, Barite prospect
Purple Heart mine											
Purple Heart	523	26	8	1265	13	—	—	1043	0.5	12	grab of dump at adit
WH 112	<1	19	11	<1	21	<1	2	—	—	—	vein
Blackmore mine											
WH 98	110	210	155	<5	20,680	—	—	<10	0.3	—	12 cm vein
WH 99	3	12	26	<1	24	<1	3	—	—	—	fluorite
WH 100	2	29	7	<1	36	15	4	—	—	—	dike
German mine											
WH 124	<1	5390	60	<5	4190	—	—	<10	<0.3	—	1 m chip across vein
WH 125	10	25,160	60	<5	27,540	—	—	<10	0.3	—	Upper dump select
WH 126	2	537	25	<1	47	38	4	—	—	—	white granite
WH 127	4.7	260,580	1640	5.4	150,650	—	—	41	405	—	Lower dump select

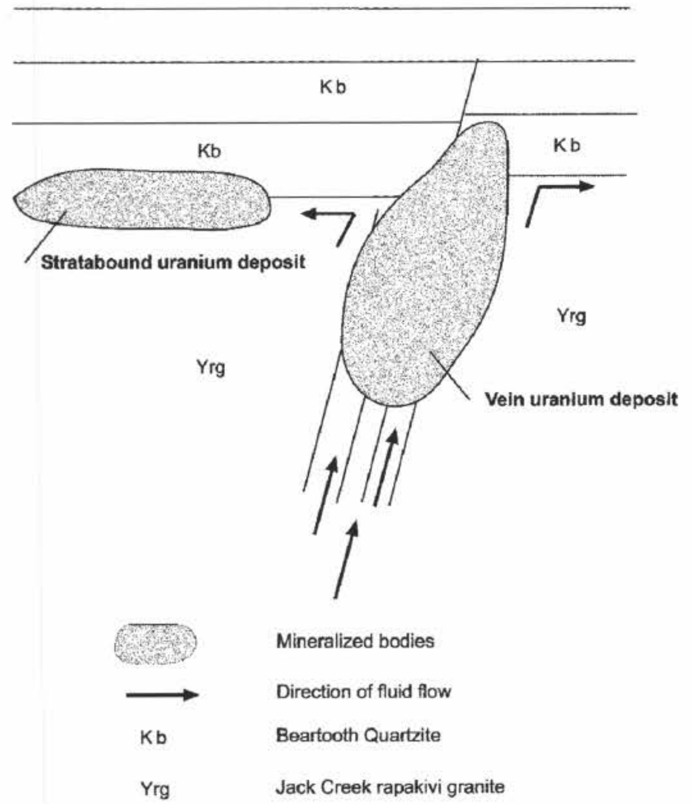

FIGURE 3. Schematic sketch of formation of uranium deposits in the Wild Horse Mesa area.

Bullard Peak Series and consist predominantly of light-colored, fine-grained quartz-feldspathic gneisses and schists, although locally dark-colored biotite schists and amphibolites are common. Foliation of the larger individual xenoliths in most areas is randomly oriented, suggesting rotation of the blocks during granitic intrusion. The lamprophyre enclaves range in size from a few centimeters to several meters in diameter and occur as isolated pods or pillows, swarms of pods or pillows, and synplutonic dikes.

Two outcrops of brick red, metasomatic syenite plugs occur in rapakivi granite at Ramsey Saddle (Fig. 2). The metasomatic syenite consists of K-feldspar, biotite, and plagioclase; quartz is absent. The syenite exhibits similar coarse-grained texture as the enclosing rapakivi granite. The syenites contain 10.7–10.4% K_2O and 0.15–0.19% Na_2O (unpublished chemical analyses), two to three times background radioactivity, and are grossly similar in composition and occurrence to metasomatic and intrusive syenites that are characteristic of Cambro–Ordovician alkaline magmatism in New Mexico (McLemore and McKee, 1988; McLemore et al., 1999; McMillan et al., this volume).

Pegmatites

Pegmatites are relatively rare in the Wild Horse Mesa area as compared to other Proterozoic terrains in New Mexico. They are simple pegmatites, consisting of quartz, plagioclase, and K-feldspar with rare biotite. They are pink-red and typically small, from a few centimeters to <1 m wide and only several tens of meters long. Locally, quartz forms an irregular core that is surrounded by intergrown plagioclase and K-feldspar.

Cretaceous rocks

Beartooth Quartzite

The Beartooth Quartzite, the oldest Cretaceous unit exposed in the area, lies unconformably on or in fault contact with the Proterozoic rocks and is conformably overlain by the Colorado Shale. It typically forms ridges and caps mountaintops (Fig. 2). The Beartooth Quartzite consists of 27.4–38.1 m of white to light gray–tan, fine- to medium-grained orthoquartzite and arkosic to lithic sandstone, with minor interbeds of conglomerate, shale, and siltstone. Thin beds of black-chert-pebble conglomerate with chert pebbles several centimeters in diameter are common at the base of the unit, but thin conglomerate beds occur throughout the unit. Fragments of the underlying Proterozoic rocks are absent in the conglomerate. Most of the unit consists of light gray–brown-gray, thick-bedded, well-sorted, fine- to medium-grained orthoquartzite, with quartz cement and rounded grains of quartz and trace amounts of magnetite, hematite, and lithic fragments. Locally, the sandstones contain trace amounts of pyrite cubes and black organic material disseminated throughout the sandstone. Small-scale cross-beds are present in many sandstone beds. The upper part of the unit contains thin beds of black shale. The unit was most likely deposited within a transgressive, epicontinental sea.

Colorado Shale

The Colorado Shale lies conformably on the Beartooth Quartzite and typically crops out in valleys and saddles of ridges. It consists of thin-bedded, fissile, silty, carbonaceous, brown–black shale. Locally, nodules of dark-gray limestone occur in the upper beds.

Tertiary rocks

Andesite

Andesite occurs as dark-gray to black to dark-olive-green, porphyritic dikes and consists of feldspar, biotite, and hornblende altered to chlorite, iron oxides, and sericite. The green color is a result of chloritization. Rhyolite dikes intruded the andesites locally. The andesites are offset by faults (Fig. 2) and may be as old as Late Cretaceous or as young as mid-Tertiary. Both Cretaceous and mid-Tertiary andesites are common in the northern Burro Mountains (Hedlund, 1980; Finnell, 1988).

Ash-flow tuffs

Rhyolite ash-flow tuffs lie unconformably on Cretaceous sedimentary rocks on Wild Horse Mesa (Fig. 2). The ash-flow tuffs are gray to tan to light-brown, fine-grained to porphyritic, crystal-poor, moderately to poorly welded and consist of altered pumice and <5% quartz, feldspar, and biotite phenocrysts. They are offset by faults (Fig. 2). The similarity in composition and spatial relationship to the intrusive rhyolite plugs, domes, and dikes suggest that the ash-flow tuffs may be extrusive equivalents to the rhyolite intrusions. The ash-flow tuffs may have been erupted from the Schoolhouse Mountain caldera. However, the ash-flow tuffs related to the caldera are lithic and crystal-rich (Finnell, 1987), unlike the lithic- and crystal-poor ash-flow tuffs on Wild Horse Mesa.

Intrusive rhyolite

Rhyolite dikes are white–gray, fine grained, foliated, and consist of <5% quartz, feldspar, and biotite phenocrysts. They intruded Proterozoic granite, Cretaceous sedimentary rocks, and andesite dikes, and occur along and are offset by faults on Wild Horse Mesa (Fig. 2). Similar rhyolite plugs, domes, and dikes intruded the Proterozoic gneissic granite/granodiorite east of Schoolhouse Mountain fault and form many of the mountaintops (Finnell, 1987). These rhyolites are probably related to the Schoolhouse Mountain caldera.

STRUCTURAL GEOLOGY

Faults in the Wild Horse Mesa area trend north, east–west, northwest, and northeast (Fig. 2). The youngest and most prominent fault is the Schoolhouse Mountain fault, which trends N10°W to due north and dips steeply. The fault is radial to the Schoolhouse Mountain caldera and cuts the ring fractures and ash-flow tuffs associated with the caldera (Finnell, 1987). It forms the eastern edge of Wild Horse Mesa and places Cretaceous sedimentary and mid-Tertiary igneous rocks against Proterozoic gneissic granite/granodiorite (Fig. 2). However, the fault cannot be traced in the Proterozoic gneissic granite/granodiorite south of Bear Canyon (Hedlund, 1980). The main fault is typically unmineralized, but mineralized veins and shear zones parallel the fault locally. A north-trending fault is also present at the Blackmoor mine, but this fault does not cut the ring fracture zone (Finnell, 1987).

Three east–west-trending faults are found in the Wild Horse Mesa area. Two normal faults form the southern edge of Wild Horse Mesa and strike N75°W and dip 60–80°N. The northern fault, called the Moneymetal fault, is separated from the southern fault by approximately 50 m of Proterozoic rapakivi granite (unpublished mapping at 1:1000 scale by the author). The Moneymetal adit lies along the Moneymetal fault. At the Barite prospect, east of the Schoolhouse Mountain fault, a rhyolite dike and barite vein intruded a third east–west fault, which may be a continuation of the Moneymetal fault (Fig. 2).

Four steeply-dipping normal faults trend northwest; the Purple Heart, Reed, a fault south of the Reed, and a fault north of the Reed (Fig. 2). Slickensides along the Purple Heart and Reed faults indicate that the last movement was dip-slip. These faults are perhaps the oldest of the faults in the area, because they are offset by the Schoolhouse Mountain fault, Moneymetal fault, and northeast-trending faults. Fluorite, uranium, and quartz veins occur along the Purple Heart and Reed faults. Rhyolite and andesite dikes intruded along the other two northwest-trending faults.

The curvilinear northeast-trending faults cut the northwest-trending faults. A rhyolite dike intruded two of the faults (Fig. 2). These faults are unmineralized.

DESCRIPTION OF MINERAL DEPOSITS

Four types of deposits are present in the Wild Horse Mesa area. These include fluorite veins, uranium veins and minor stratabound deposits, base-metal veins, and barite veins. Fluorite veins are the most significant in size and past production. Assays from some of these veins are in Table 2. Alteration is variable. The mineralized granite is typically altered to kaolinite, chlorite, and sericite and exhibits iron staining. Silicification of the granite is locally intense, especially along faults, and in other areas minor. The mineralized Beartooth Quartzite is typically fractured, silicified, and exhibits iron staining.

Fluorite veins

Five fluorite deposits have been developed in the Wild Horse Mesa area (Table 1). All of the fluorite deposits, except the Rambling Ruby, are hosted by faults in rapakivi granite west of the Schoolhouse Mountain fault. The Purple Heart mine consists of two back-filled shafts (19.8 and 30.5 m deep) and an adit. Fluorite occurs in two slightly radioactive veins striking N20–47°W and dipping 65°NE as fracture filling and crustiform masses cementing granite fragments in a fault-breccia zone (Rothrock et al., 1946; Gillerman, 1952; Williams, 1966). The veins are only two to three times background radioactivity (McLemore, 1983). The veins are <1–2 m wide and 200 m long, and consist of fluorite, quartz, calcite, and a trace of pyrite and barite. A selected dump sample contained the highest gold and molybdenum concentrations in the area, 10.4 ppm Au and 1265 ppm Mo (Table 2, sample #Purple Heart). The adjacent granite is altered to chlorite and sericite; silicification occurs within the breccia zone. The paragenetic sequence is (1) early green-gray–black jasperoid breccia with pyrite, (2) brecciation, (3) blue-gray–black jasperoid with pyrite, (4) white–clear fluorite, (5) milky quartz and banded, crustiform quartz, (6) green, purple, and clear fluorite with quartz, (7) milky quartz, and (8) late white calcite with clear–white quartz crystals.

The Blackmoor (Clover Leaf, Blackmar) mine consists of green and purple fluorite with quartz and clay in Proterozoic rapakivi granite that is exposed by a 12.2-m shaft (Gillerman, 1952; Williams, 1966). The vertical vein strikes N10°W and is 1.2–1.8 m wide and 130 m long. There is no reported production. The paragenetic sequence is (1) early quartz with trace pyrite, (2) green and purple fluorite (locally banded), and (3) late drusy quartz. Thin veins (8–15 cm) of galena, quartz, pyrite, and fluorite striking N90°E cut the granite near the main vein. A sample contained 20,680 ppm Cu and 0.3 ppm Ag (Table 2, sample #WH 98).

The Reed fluorspar deposit consists of green, purple, and clear fluorite, quartz, calcite, and trace of barite along a fault in Proterozoic granite. The mine consists of three shafts, 9–15 m deep that are now caved and backfilled (Williams, 1966). The vein is less than 1.5 m wide and is traceable along strike for approximately 300 m. The paragenetic sequence is (1) early quartz with trace pyrite, (2) green and purple fluorite (locally banded), (3) late drusy quartz. A sample from the Mayday claims along the Reed fault contained 0.009% U_3O_8 (McLemore, 1983).

The Rambling Ruby prospect is along a shear zone near the intersection of the east–west ring fracture of the Schoolhouse Mountain caldera and a N15°W-trending fault subparallel to the Schoolhouse Mountain fault. The deposit consists of clay, quartz, fluorite, malachite, and chrysocolla in altered granite and rhyolite. A selected dump sample contained >20,000 ppm Cu (Table 2, sample #WH 28). Shallow pits expose the deposit. The altered shear zone is several meters long and <2 m wide.

Uranium deposits

Two types of uranium deposits, minor stratabound deposits and veins along faults and shear zones occur in the Wild Horse Mesa area (Fig. 3). The vein deposits are the higher-grade uranium deposits and occur as thin veins and stringers along shear zones cutting the Proterozoic rapakivi granite and Beartooth Quartzite. Minor uranium also occurs within fluorite veins cutting the Proterozoic rapakivi granite. In most areas, the veins occur as thin fracture fillings within a breccia-fault or shear zone; discrete megascopic veins are rare and typically found only as fluorite veins. In many faulted areas, mineralized stratabound zones continue laterally from the mineralized faults into the adjacent beds of the Beartooth Quartzite and along the unconformity, typically within 15 m of the faults (Fig. 3; O'Neill and Thiede, 1982). The mineralized fault zones are typically <1 m wide, although locally small occurrences may be as much as 1.5 m wide, especially where hosted by the granite. The veins are typically thinner where located in the quartzite. The highest-grade deposits are found along the Moneymetal fault, where uraninite and metatorbernite with pyrite has been found in veinlets and as disseminations within the fault zone. Assays range from 0.009% to 0.59% U_3O_8 (McLemore, 1983). A sample from Hot Hole #1 pit on the Moneymetal fault contained 7 ppb gold and 190 ppm U_3O_8, a second sample contained 181 ppm U_3O_8 (Table 2, #WH2, 148). Samples along the Moneymetal fault also contained elevated concentrations of zinc (Table 2). A sample from the pit from the Prince Albert #1 claim near Wild Horse Mesa assayed 0.09% U_3O_8 and trace gold (<0.7 ppm; McLemore, 1983).

Stratabound uranium deposits occur as small lenses or pods in quartzite and rapakivi granite at the unconformity between the Proterozoic granite and Beartooth Quartzite (Fig. 3). Other minor stratabound uranium occurrences are found in permeable zones in the basal 10 m of the Beartooth Quartzite. Typically, dark-red to reddish-brown, iron-stained, poorly sorted arkosic or lithic sandstones host the stratabound uranium deposits. Oxidized pyrite and carbonaceous material are present in some deposits. Most stratabound deposits in the Wild Horse Mesa area are found laterally within a few tens of meters from mineralized faults or shear zones. A sample from the pit on the Prince Albert #2 claim assayed 0.09% U_3O_8 (McLemore, 1983). Most samples contained low concentrations of other metals (Table 2).

Base-metal veins

Only a few base-metal veins are found in the Wild Horse Mesa area. The patented German mine (Hard Pan) in Little Bear Canyon consists of three adits and one shaft; all are now caved. The adits are reported to have been 9.7–53.6 m long (Gillerman, 1964). The mine was worked prior to 1900 and again during the late 1930s through early 1950s (Gillerman, 1964); production is undocumented and presumed small. Sulfide minerals (pyrite, chalcopyrite, sphalerite, and galena) occur as thin veins and stringers (<15 cm wide), nodules, and disseminations within amphibolite schist xenoliths in Proterozoic granite. The vein is covered at the surface; Hewitt (1959) reported it strikes east–west. Within the schist, fractures striking N40–50°E also are mineralized. The adjacent granite is unmineralized but it is altered to sericite and chlorite veins occur along the fractures. A sample from the lower dump assayed 41 ppm Au, 405 ppm Ag, 150,650 ppm Pb and 260,580 ppm Zn (Table 2, sample #WH 127). The paragenetic sequence is (1) early pyrite and quartz, (2) sphalerite, galena, chalcopyrite, quartz, and pyrite, (3) quartz, pyrite, calcite, and (4) late calcite. The vein is subparallel to an east–west-trending andesite porphyry dike (Hewitt, 1959; Hedlund, 1980).

In the Butterfly Seep area, east of the Schoolhouse Mountain fault, several small veins of secondary copper minerals occur in Proterozoic gneissic granite/granodiorite, amphibolite schist, and quartz-feldspar gneiss. A 6-m adit and shallow pit expose a vein that strikes N25°E and consists of quartz, calcite, and trace amounts of pyrite and malachite. The veins are only a few meters long and <1 m wide. Samples collected along the veins contain variable amounts of copper (9–15,968 ppm), gold (<5–122 ppb), and other metals (Table 2).

Barite veins

Two barite and quartz veins occur east of the Schoolhouse Mountain fault. The Barite prospect consists of quartz, barite, and trace amounts of pyrite in a fault zone in gneissic granite/granodiorite. A rhyolite dike intruded the fault that strikes N80°E. Samples of the vein contain low concentrations of metals (Table 2, samples #WH 38, 39, 40). The Barite No. 2 prospect, south of the mapped area in Figure 2 (Hedlund, 1980), consists of quartz and barite in a silicified fault zone that strikes N60°W in gneissic granite/granodiorite. A rhyolite dike intruded this fault also. Background levels of radioactivity characterize both deposits.

MINERAL DISTRIBUTION

Fluorite veins are prominent in the northwestern part of the Wild Horse Mesa area, west of the Schoolhouse Mountain fault and may form the center of the mineralization. The highest gold and silver concentrations are associated with the Purple Heart and Reed fluorite veins and east of the Schoolhouse Mountain fault (Table 2). Uranium forms the intermediate zone and occurs west of the Schoolhouse Mountain fault. The highest-grade uranium deposit is along the Moneymetal fault in the southwest part of the area. Low-grade copper and barite deposits with minor gold form the outer zone and typically occur east of the Schoolhouse Mountain fault.

The relationship of the German deposit to the other deposits in the Wild Horse Mesa area is unknown. The German deposit is associated with a metamorphic xenolith and may be Proterozoic in age. The deposits may also represent a separate volcanic-epithermal system that formed copper and fluorite deposits in the Redrock area in the western part of the Telegraph district. It is also possible that the Wild Horse Mesa area is part of a much larger volcanic-epithermal system in the Telegraph district. Future studies will further address the relationship of the deposits in the entire Telegraph district.

DISCUSSION

Alteration style, vein textures, metal association, and proximity to the Schoolhouse Mountain caldera indicate that the mineral deposits in the Wild Horse Mesa area are classified as volcanic-epithermal veins. The morphology, paragenesis, district zoning, and composition of the veins suggest they may represent the upper parts of a volcanic-epithermal system, most likely related to the Schoolhouse Mountain caldera. The age of mineralization is constrained by the age of the mineralized faults, which occurred after formation of the caldera; mineralization may be related to intrusion of the rhyolite plugs, domes, and dikes. The fluorite and uranium deposits also appear to be restricted to the outcrop of the Jack Creek rapakivi granite and the copper and barite deposits are restricted to the gneissic granite/granodiorite or metamorphic rocks, although this may be a coincidence.

Previous studies have suggested that the fluorite and uranium deposits are related to the same mineralizing event (Hewitt, 1959; O'Neill and Thiede, 1982). The fluorite veins are associated with minor amounts of uranium, but most of them are not significantly radioactive at the surface. The common metal association and similar alteration of the host rocks between the various types of veins in the Wild Horse Mesa area are supportive of a single mineralizing event (Table 2; O'Neill and Thiede, 1982).

The distribution of the alteration and form of the veins indicate that ascending fluids, not descending fluids (O'Neill and Thiede, 1982), formed the vein deposits. The highest-grade uranium deposits occur along faults at the base of the quartzite (Fig. 3). The upper beds of the Beartooth Quartzite along the mineralized faults are not mineralized. Uraniferous fluids probably moved upward along faults and precipitated uranium and other minerals where the fault zone intersected the Beartooth Quartzite. Fault and shear zones in the granite are wider and more permeable than in the harder, more resistant and less permeable quartzite. Locally, rhyolite dikes have intruded the quartzite. Where the fluids reached the quartzite, permeability decreased and the fluids ponded, forming the mineralized fault zones. Locally, the fluids migrated along the permeable unconformity and permeable sandstone beds in the Beartooth quartzite, forming the stratabound deposits. The presence of pyrite, organic material, and clay provided a reducing environment that allowed deposition of the uranium, forming localized stratabound uranium deposits.

The mineral resource potential for undiscovered volcanic-epithermal vein deposits in the Wild Horse Mesa area is good. The presence of gold concentrations in surface samples and the interpretation of the deposits as representing the top of a volcanic-epithermal system suggest that additional deposits are likely to lie at depth. The best potential is associated with faults west of, and including the Schoolhouse Mountain fault. Geophysical techniques may aid in delineating potential drill targets.

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