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GEOLOGY OF THE BENT DOME, OTERO COUNTY, NEW MEXICO

EUGENE E. FOORD and SAMUEL L. MOORE
U.S. Geological Survey, M.S. 905, Box 25046, Denver Federal Center, Lakewood, Colorado 80225

Abstract—The Bent dome, located just south of NM-70 and 8 km (5 mi) west of Mescalero, New Mexico, is composed of a core of Precambrian diorite and granite overlain by Cambro-Ordovician Bliss Sandstone and younger Paleozoic sedimentary strata. The Bliss Sandstone is composed of basal glauconitic sandstone overlain by clean sandstone. Hydrothermal alteration of the diorite has taken place in the area of the Virginia mine and copper mineralization there consists of djurleite and chalcocite in quartz-barite-carbonate veins. Secondary malachite is present in the Precambrian igneous rocks as well as in the overlying Bliss Sandstone. The age of the doming is not known; it could be pre-Permian, eroded in Early Permian and covered by Permian sediments, then exhumed by recent erosion. A Permian or younger age for the doming is also possible.

INTRODUCTION

Recognition of the unusual alkalic rocks and associated Zr-REE mineralization at Pajarito Mountain, in the eastern part of the Mescalero Reservation (Foord and Moore, 1983; Moore et al., 1985; Moore et al., 1991), led to examination and mapping of the igneous rocks at Bent as a possible additional source of REE and Zr. Several brief visits were made to the Bent district to examine the geology and to collect samples for analytical and mineralogical studies.

Copper deposits were discovered near Bent in 1870 and were worked extensively from 1905–1918. The geology of the area and the deposits were described by Lindgren et al. (1910) and Ball (1913). The reader is referred to these two studies for details of the early history of development and description of the underground workings. Bachman (1954, 1960) subsequently mapped the igneous and sedimentary rocks of the Bent dome. The geology of the Mescalero Apache Indian Reservation, immediately to the east of the Bent dome, was studied by Moore et al. (1985, 1988a, b) and Moore and Foord (1986a, b).

LOCATION AND GEOLOGIC SETTING

The town of Bent is located on the south side of NM-70, in Tularosa Canyon, about 8 km (5 mi) west of Mescalero, New Mexico. The Virginia mine (Lindgren et al., 1910), principal site of past mining activity, is 1.25 km (.75 mi) east of Bent, at about 1800 m (6000 ft) elevation. The Bent mining district (Fig. 1) covers an area of about 2.6 km^2 (1 mi^2).

The topographic relief rises fairly rapidly (within about 3.2 km) to the north, east and south, to elevations between 2300 and 2625 m (7000 and 8000 ft). Elevations decrease to the west going down Tularosa Canyon. The highlands adjacent to the mining district are underlain by Lower Permian sedimentary rocks composed chiefly of gypsum and limestone of the Yeso and San Andres Formations. These sedimentary rocks show gentle and undulating shallow dips except near fault structures (Moore et al., 1988a, b). Details of the Pennsylvanian-Permian stratigraphy in the region were given by Otte (1959). Pray (1949, 1959, 1961) showed the existence of a regional unconformity at the base of the Abo Formation. Older Paleozoic sedimentary rocks are not exposed in the immediate region except at Bent, where Precambrian monzodioritic to granitic intrusive igneous rocks occur in the core of a domal structure of Paleozoic sedimentary rocks. In contrast, Pajarito Mountain is an erosional remnant of Precambrian rocks surrounded by onlapping Permian sediments, rather than a domal structure, and is composed of melasyenite, syenite, quartz syenite, alkali granite and pegmatite (Moore et al., 1988b). At Pajarito Mountain, the oldest Paleozoic rocks are of Early Permian age (Yeso Formation). However, lower Paleozoic rocks, of Cambrian and Early Ordovician age, are exposed at Bent as Bliss Sandstone and El Paso Group limestones. Numerous angular blocks of Pennsylvanian reef limestone in the detritus around the dome area indicate that these units also occur on the flanks of the dome but are now covered by alluvium. The closest other Precambrian rocks, in the Sacramento Mountains and vicinity, were discussed by Foster (1959).

Several Tertiary intrusives are present immediately to the south and west of Bent. These rocks are hornblende-bearing alkali gabbros and syenogabbros (E. E. Foord and S. L. Moore, unpubl., 1987) similar to rocks of the Black Mountain stock, about 16 km (10 mi) northeast of Bent, on the Mescalero Reservation (Moore et al., 1985, 1988a; Moore and Foord, 1986a, b). The Tertiary intrusives were referred to as hornblende andesite by Ball (1913).

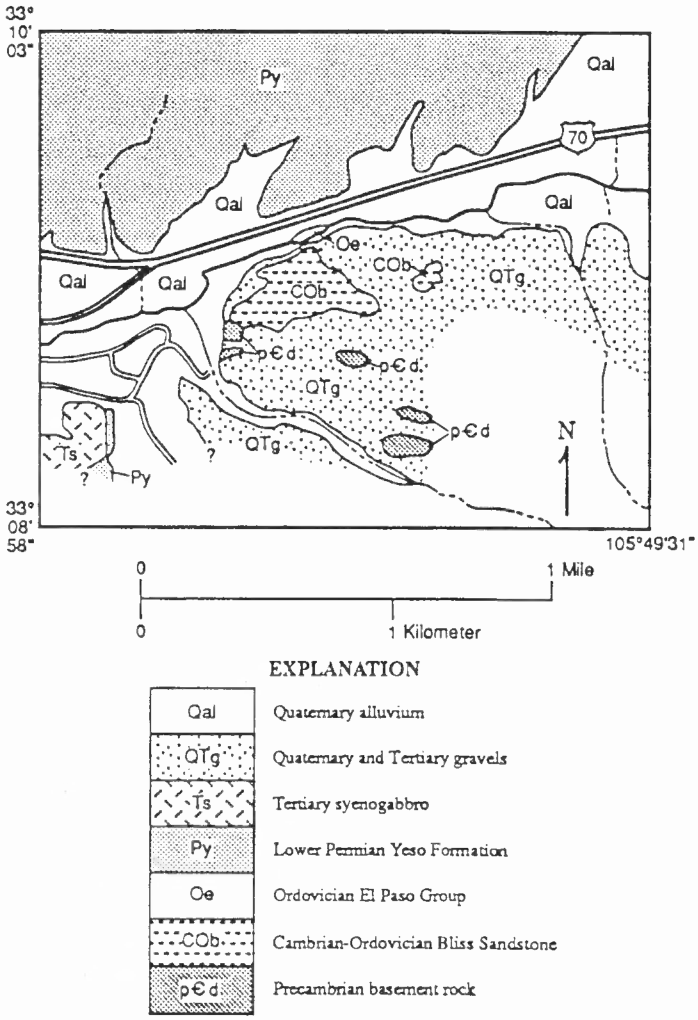

FIGURE 1. Geologic map of the Bent mining district, Bent, NM. Qal = Quaternary alluvium; QTg = Pliocene-Pleistocene terrace and pediment gravels; Ts = Tertiary syenogabbro; Py = Permian Yeso Formation; Oe = Ordovician El Paso Group; COb = Cambrian-Ordovician Bliss Sandstone; PCd = Precambrian diorite-monzodiorite.

ANALYTICAL METHODS

Three plutonic rock samples were collected at the Virginia mine and three were collected 0.8 km (0.5 mi) southeast of the mine, and were analyzed for major, minor and trace element content (Table 1). The major element analyses were done by X-ray fluorescence spectrometry and the trace and minor elements were determined by ICP-AES in the laboratories of the U.S. Geological Survey. FeO was determined by titration. Water was determined by Carl Fisher titration and CO_2 was determined by Leco combustion analysis.

PETROLOGIC AND MINERALOGICAL DATA

Outcrops of the diorite-monzodiorite are exposed in the area of the Virginia mine and as scattered small outcrops south and east of the mine. In addition, a dark, mafic, fine-grained diabasic dike of probable Precambrian age is present at the Virginia mine and cuts across the other Precambrian rocks.

The monzodiorite porphyry exposed in a small gulch just southeast of the Virginia mine was described by Lindgren et al. (1910) as consisting of "plagioclase feldspar, with green and brown hornblende and numerous grains of magnetite." As stated by Lindgren et al. (1910), hydrothermal alteration near the ore-bearing veins at the Virginia mine has caused the porphyry to become brownish gray to reddish buff due to the formation of calcite, dolomite, sericite (from feldspar) and chlorite (from hornblende). Biotite is also present in the porphyry adjacent to the areas of alteration and is believed by us to be partially hydrothermal in origin. Primary flakes of biotite show reaction rims of secondary biotite. Three analyses (1A, 1B and 2; Table 1) of the monzodiorite at the Virginia mine are of variably altered and mineralized rock (viz. e.g., CO_2 content and Cu content). Even the freshest material (sample 2) is appreciably altered and mineralized. We hope that Ar-Ar isotopic apparent ages will be obtained on primary hornblende and biotite to ascertain a minimum age of the monzodiorite porphyry and possibly of the mineralization.

The chemical classifications, according to the method of De la Roche et al. (1980), of the six analyzed rocks from the Bent dome are shown in Fig. 2. The two extremely altered samples (1a, 1b) from the Virginia mine dump plot distinctly removed, largely due to a decrease in CaO and increases in K_2O and Na_2O, from the fresher sample (2) of diorite and the two samples (84-4, 84-5) collected southeast of the mine. The one granite sample (84-3), from southeast of the Virginia mine, is representative of a dike cutting the diorite porphyry.

Trace and minor element data for two extremely hydrothermally altered diorite samples and one partially altered sample are given in

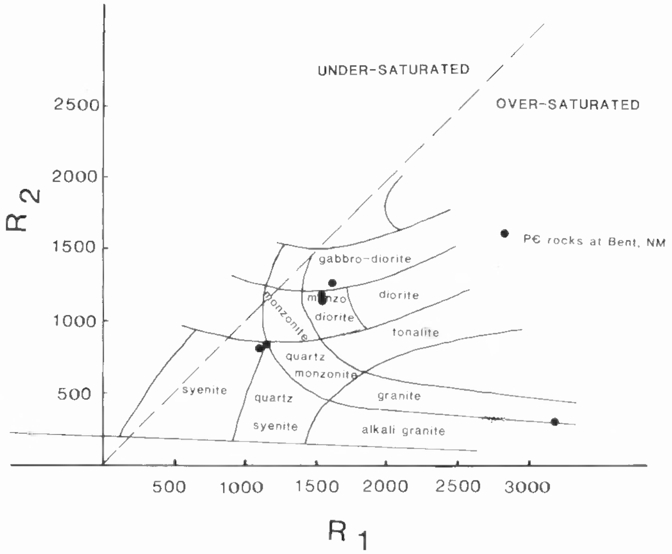

FIGURE 2. R_1-R_2 plot of compositions of igneous rocks from Bent, NM. Diagram is after De la Roche et al. (1980). $R_1 = 4Si - 11(Na + K) - 2(Fe + Ti)$; $R_2 = 6Ca + 2Mg + Al$. Values in millications.

Table 1. Between 0.5–0.6 wt% Cu is present in the two most altered samples. Only 0.035 wt% is present in the one partially altered sample. The contents of V and Zn are elevated in all three samples (0.05–0.06% V and 0.06% Zn).

Samples of high-grade Cu ore from quartz-barite-dolomite-sulfide veins at the Virginia mine were collected and studied. X-ray diffraction results indicate that both djurleite ($Cu_{31}S_{16}$) and chalcocite (Cu_2S) are present, with djurleite being more abundant. A six-step emission spectrographic analysis (N. M. Conklin, USGS, analyst) of djurleite with very minor malachite, collected in 1982 from the 35-ft level of the Virginia mine, gave: Fe 0.7%, Mg 0.03%, Ca 0.5%, Mn 700 ppm, Ag 200 ppm (5.85 oz/ton), Ba 15 ppm, Co$<$10 ppm, Cr 3 ppm, Cu—major, Ni 7 ppm, Pb 500 ppm, V 7 ppm. Other elements were not detected at respective limits of detection. The determination for Ag agrees well with that reported by Lindgren et al. (1910) for high-grade Cu ore coming from stringers within diorite (25–45% Cu, 3–4 oz/ton Ag) in the 35-ft level of the Virginia mine. Veins and veinlets of calcite containing variable minor amounts of Mg-Fe-Mn and associated sulfide mineralization are also present. Additional minerals reported by Ball (1913) are chalcopyrite, sphalerite, pyrite and molybdenite.

The body of low-grade copper ore 45 ft (14.8 m) thick reported in the press (Lindgren et al., 1910) is probably the glauconitic Bliss Sandstone exposed about 0.8 km (0.5 mi) east of the Virginia mine. The dark green (resembling malachite, but darker green) mineral present between the grains of detrital quartz is glauconite, often in pelletal form. As much as 35% of some samples is made up of glauconite. X-ray diffraction studies and scanning electron microscope studies confirmed the identification as this mineral. Locally, the Bliss Sandstone is characterized by containing appreciable glauconite and/or iron oxides (Pray, 1961). It is possible that this sandstone is of Precambrian age, but the exposed stratigraphy at Bent matches that reported in the Sacramento Mountains (Pray, 1961), namely, glauconitic sandstone overlying clean, laminated sandstone and conglomeratic sandstone.

Mineralization within the sandstone where it unconformably overlies the "diorite" at the Virginia mine was reported by Lindgren et al. (1910) and Ball (1913). Ore minerals include chalcocite, malachite and azurite. Lindgren et al. (1910) thought that the igneous and sedimentary rocks had been mineralized at the same time. As stated by Ball (1913), we think that the mineralization in the basal sandstone of the Bliss Formation immediately overlying vein deposits in the monzodiorite porphyry is secondary in origin, a product of weathering and supergene enrichment of material eroded from the veins. The chalcocite present in the sandstone is sooty, fine-grained, secondary chalcocite rather than primary vein-type chalcocite. Minor malachite and azurite are typical secondary copper minerals developed upon weathering of primary ores, and coat fractures and grains of quartz and glauconite in the sandstone.

GEOLOGY OF THE BENT DOME

A new preliminary geologic map of the Bent dome (Fig. 1) requires additional mapping to fill in peripheral information and additional details in the immediate area of the Virginia mine. Our interpretation of the geology differs substantially from that of Bachman (1960). The predominant structure is a dome with a core of Precambrian basement flanked by lower Paleozoic rocks. The Bent dome has evolved through repeated episodes of uplift from as early as Cambrian time to early Tertiary time (Moore et al., 1988a). These repeated episodes of uplift in the area of the Bent dome cannot clearly be demonstrated because of limited outcrops within the surficial Quaternary and Tertiary cover and extensive late Tertiary and Quaternary erosion along the Tularosa Valley. Uplift in the dome area can be mapped in the early Paleozoic strata that crop out along the north and northeast parts of the dome, where dips range from 10° to 25° to the north and northeast. The Lower Permian Yeso and San Andres strata north of Tularosa Canyon and east of the Bent dome have dips of 3° to 8° to the north and east respectively. These diminishing dips in older to younger strata are interpreted to reflect diminishing uplift in each successive period of uplift. Elsewhere in the Ruidoso region, Cretaceous and early Tertiary uplift has occurred in the Black Mountain and Pajarito Mountain areas (Moore et al., 1988a,

TABLE 1. Chemical analyses of igneous rocks from the Bent dome, Bent, New Mexico.

Sample no. and descr.	1A hydrothermally altered diorite	1B	2 Partially altered diorite	84-4 diorite	84-5 monzodiorite	84-3 mafic granite
Location	Virginia Mine dump			Southeast of Virginia mine		
SiO_2	47.0	47.8	46.2	48.8	48.8	68.2
Al_2O_3	13.6	13.5	12.5	13.4	13.4	5.29
FeTO3	12.9	12.6	15.1	14.3	15.6	15.7
Fe_2O_3	4.5	4.45	5.04	7.34	5.02	14.74
FeO	7.56	7.33	9.05	6.26	9.52	0.86
MgO	4.60	4.48	5.42	3.14	4.24	1.26
CaO	3.32	3.52	6.40	8.06	6.09	1.00
Na_2O	3.70	3.69	2.36	2.30	2.48	<0.15
K_2O	1.47	1.52	1.08	1.80	1.68	4.00
TiO_2	2.00	1.92	1.80	1.72	1.91	0.58
P_2O_5	0.21	0.20	0.21	0.24	0.24	0.64
MnO	0.48	0.46	0.70	0.50	0.36	<0.02
LOI (920°C)	9.38	8.98	8.02	5.83	4.77	3.12
H_2O^+	2.47	2.47	3.29	n.d.	n.d.	n.d.
H_2O^-	0.28	0.26	0.25	n.d.	n.d.	n.d.
CO_2	7.65	7.43	5.83	n.d.	n.d.	n.d.
Total*	98.84	99.03	100.13	99.39	98.51	99.69
FeO/Fe_2O_3	1.69	1.65	1.80	0.85	1.90	0.06

* Total calculated using waters and CO_2 rather than LOI for samples nos. 1A, 1B, and 2; FeO and Fe_TO_3 determined, with Fe_2O_3 calculated by difference.

Classif. according to De La Roche et al. (1980)	syenite	syenite	monzodiorite	gabbro-diorite	monzodiorite	alkali granite

Trace element data (ppm)

	1A	1B	2
Ba	180	410	270
Be	1	1	1
Ce	31	29	32
Co	70	69	75
Cr	5	5	6
Cu	5200	5700	350
Ga	24	23	26
La	17	17	18
Li	65	67	54
Nb	8	8	6
Nd	22	21	21
Ni	52	53	42
Pb	5	11	10
Sc	41	40	38
Sr	95	100	140
Th	6	7	8
V	570	560	490
Y	26	25	28
Zn	610	610	620

Other elements were looked for and not detected at respective limits of detection.

b). Additional mapping should determine the actual relationship. The sedimentary rocks on three sides of the dome dip away from it at shallow to moderate angles. Extensive cover by Pliocene-Pleistocene terrace and pediment gravels is present to the south and east of the Virginia mine. The terrace gravels are well cemented and indurated, whereas the Quaternary pediment and outwash gravels are unconsolidated. Either one or both may be present at any given spot. Quartzite, reported by Ball (1913) and Bachman (1960), 1.6 km (1 mi) east of the Virginia mine, on the border of the Mescalero Reservation, was not found by us. Ball (1913) also reported that quartzite was intersected at the bottom of several drill holes in the area of the Virginia mine.

RECOMMENDATIONS FOR FUTURE WORK

The geology of the Bent dome should be examined in greater detail. The Precambrian quartzite reported by Ball (1913) and Bachman (1960) requires verification and restudy (see Bauer and Lozinsky, 1991, this volume). Radiometric age determinations on the igneous rocks at Bent and of the mineralization will be necessary to confirm a Precambrian age. Additional analyses of both fresh and altered igneous rocks would establish limits on the compositions of the igneous rocks and clarify the types of hydrothermal alteration that occurred at the time of mineralization. Aspects of the mineralization at Bent are also worthy of further studies.

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REFERENCES

Bachman, G. O., 1954, Reconnaissance map of an area southeast of Sierra Blanca in Lincoln, Otero, and Chaves Counties, New Mexico: New Mexico Geological Society, Guidebook 5, p. 94b.

Bachman, G. O., 1960, Southwestern edge of late Paleozoic landmass in New Mexico: U.S. Geological Survey, Professional Paper 400-B, p. 239–241.

Ball, S. H., 1913, Sandstone copper deposits at Bent, New Mexico: Mining and Scientific Press, v. 107, p. 132–135.

De la Roche, H., Leterrier, J., Grandclaude, P. and Marchal, M., 1980, A classification of volcanic and plutonic rocks using R_1R_2—diagram and major-element analyses—Its relationship with current nomenclature: Chemical Geology, v. 29, p. 183–210.

Foord, E. E., Moore, S. L., Marvin, R. F. and Taggart, J. E., Jr., 1983, Petrology of the Proterozoic syenites at Pajarito Mountain and the Tertiary igneous complex of the Sierra Blanca region, Otero County, New Mexico: 1983 MSA symposium on alkaline complexes, Wausau, Wisconsin, Sept. 16–18, 1983.

Foster, R. W., 1959, Precambrian rocks of the Sacramento Mountains and vicinity: Permian Basin Section of the Society of Economic Paleontologists and Mineralogists and Roswell Geological Society Guidebook, Sacramento Mountains, p. 137–153.

Lindgren, W., Graton, L. C. and Gordon, C. H., 1910, The ore deposits of New Mexico: U.S. Geological Survey, Professional Paper 68, 361 p.

Moore, S. L., Foord, E. E., Myer, G. A. and Smith, G. W., 1985, Mineral resources of the Mescalero Apache Indian Reservation, Otero County, New Mexico: Administrative Report for Bureau of Indian Affairs, 133 p.

Moore, S. L. and Foord, E. E., 1986a, Structure and petrology of the Tertiary igneous complex of the Sierra Blanca region, Otero County, New Mexico: Southwestern section, American Association of Petroleum Geologists meeting, Ruidoso, NM, April 25–28, 1986, p. 347.

Moore, S. L. and Foord, E. E., 1986b, Field Trip 4—The Sierra Blanca igneous complex. Road log from Inn of the Mountain Gods to the Ruidoso Ski Area on Sierra Blanca Peak; *in* Ahlen, J. L. and Hanson, M. E., eds., Southwest section of American Association of Petroleum Geologists, Transactions and Guidebook of 1986 convention, Ruidoso, NM, New Mexico Bureau of Mines and Mineral Resources, p. 29–36.

Moore, S. L., Foord, E. E., Meyer, G. A. and Smith, G. W., 1988a, Geologic map of the northwestern part of the Mescalero Apache Indian Reservation, Otero County, New Mexico: U.S. Geological Survey, Miscellaneous Investigations Map-1895, scale 1:24,000.

Moore, S. L., Foord, E. E. and Meyer, G. A., 1988b, Geologic map of a part of the Mescalero Apache Indian Reservation, Otero County, New Mexico: U.S. Geological Survey, Miscellaneous Investigations Map-1775, scale 1:50,000.

Moore, S. L., Thompson, T. B. and Foord, E. E., 1991, Geology, structure, and igneous rocks of the Ruidoso region, New Mexico: New Mexico Geological Society, Guidebook 42.

Otte, C., Jr., 1959, Late Pennsylvanian and Early Permian stratigraphy of the northern Sacramento Mountains, Otero County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 50, 111 p.

Pray, L. C., 1949, Pre-Abo deformation in the Sacramento Mountains, New Mexico: Geological Society of America Bulletin, v. 60, p. 1914–1915.

Pray, L. C., 1959, Stratigraphy and structure of the Sacramento Mountains: Permian Basin Section of the Society of Economic Paleontologists and Mineralogists and Roswell Geological Society Guidebook, Sacramento Mountains, p. 86–130.

Pray, L. C., 1961, Geology of the Sacramento Mountains escarpment, Otero County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 35, 144 p.