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OCCURRENCE OF COPPER AND SILVER AT THE CARRIZO COPPER MINE IN THE CARRIZO MOUNTAINS, APACHE COUNTY, ARIZONA

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Abstract—Copper and silver are present at the Carrizo copper mine in the Carrizo Mountains, approximately 2.5 mi west of Beclabito, NM, in Apache County, AZ. A shipment of 1500 lbs of copper ore worth $68.33 was possibly made to a smelter at Durango, Colorado, from this mine by the Navajo Mining Co. in 1921. The Carrizo Mountains lie along the southern extent of the Colorado lineament, a crustal zone characterized predominantly by Precambrian faults and the Colorado mineral belt. Much of the Carrizo Mountains is formed by a Late Cretaceous to Tertiary diorite-porphyry laccolith, which intrudes older sedimentary rocks. The age of the Carrizo laccolith is uncertain, but it was probably emplaced along northeast-trending fault zones during or soon after the shallow subduction of the Farallon plate beneath the American plate. The Carrizo copper mine is located along a fault zone in the upper sandstone beds of the Salt Wash Member of the Morrison Formation (Jurassic), which trends N65°E with a dip of vertical to 81°S. Malachite, azurite and chalcocite coat fractures and are disseminated within the sandstone, and are associated with organic material. No anomalous radioactivity was noted anywhere at the site. Copper may have been leached from the Carrizo laccolith by meteoric fluids during or after cooling and precipitated in the overlying Salt Wash sandstone in the presence of organic material (supergene processes). Or, copper-rich magmatic-hydrothermal fluids evolved from the Carrizo laccolith, migrated along the fault, and copper precipitated in the sandstone in the presence of reducing organic material or by simple cooling of the fluids (epithermal processes).

INTRODUCTION

The Carrizo copper mine is located in the Carrizo Mountains, approximately 2.5 mi west of Beclabito, New Mexico, in Apache County, Arizona (Fig. 1), in projected SE¼NW¼ sec. 31, T40N, R31W (Gila and Salt River Baseline and Meridian). Gregory (1917) mentioned a gold and copper deposit in the Carrizo Mountains in Apache County, Arizona; subsequent studies of the area located the deposit (Coleman, 1944; Strobell, 1952), but otherwise very little is known about it. On May 24, 1985, and October 30, 1986, the authors examined the deposit as part of a mineral resource assessment of northwestern New Mexico.

HISTORY

In 1891, two groups of prospectors were removed from the Navajo Reservation by the U.S. Army for prospecting without permission by the Navajo Tribe (Gregory, 1917). A protest was filed by the prospectors, and government geologists and engineers examined the area. A commission appointed by the Secretary of the Interior spent two weeks examining the area and found only small outcrops of copper and iron pyrite. The best analyses obtained were 2.95 oz/short ton Ag and 0.015-0.025 oz/short ton Au (Gregory, 1917; Kiersch, 1955, p. 31; Chenoweth, 1989). The Commissioner of Indian Affairs then issued a report stating "that the region was barren of metallic wealth and worthless for mining purposes." In 1901, Tom Leaden led another party into the area and sank a 15-ft shaft, but only encountered copper staining along fractures. The shaft was deepened to 47 ft, but no economic deposits were found. Additional prospecting occurred over the next few years, without much success.

Records of the Bureau of Indian Affairs (BIA), U.S. Department of Interior, indicate that in April 1921, some 1500 lbs of ore worth $68.33 were shipped from the Navajo Mining Co. lease in the Carrizo Mountains, near Milepost 12, Apache County, Arizona (Chenoweth, 1989). The commodity mined was not listed nor was the destination of the ore. It is possible that the ore shipment was for copper to a smelter at Durango, Colorado, from the Carrizo copper mine because the only workings in the vicinity of Milepost 12 in Apache County, Arizona, are the ones described in this report. BIA records also indicate that the Navajo Mining Co. leased 80 acres in sections 29 and 30, T13N, R5W (U.S. Mineral Survey No. 3643); this area may include the Carrizo mine since the entire area is unsurveyed.

DESCRIPTION OF WORKINGS

Ruins of a cabin, 500 ft east of the main mine workings, can be reached by a series of dirt roads from NM-504; a trail leads from the cabin ruins to the mine workings (Fig. 2). The workings consist of the lower shaft, which is a minimum of 60 ft deep, a caved adit, and a small prospect pit, approximately 250 ft northeast of the lower shaft. Approximately 500 ft up the canyon lies the upper shaft, now filled with sediment; a concrete slab is nearby. Another small prospect pit is located approximately 800 ft up the canyon from the upper shaft.

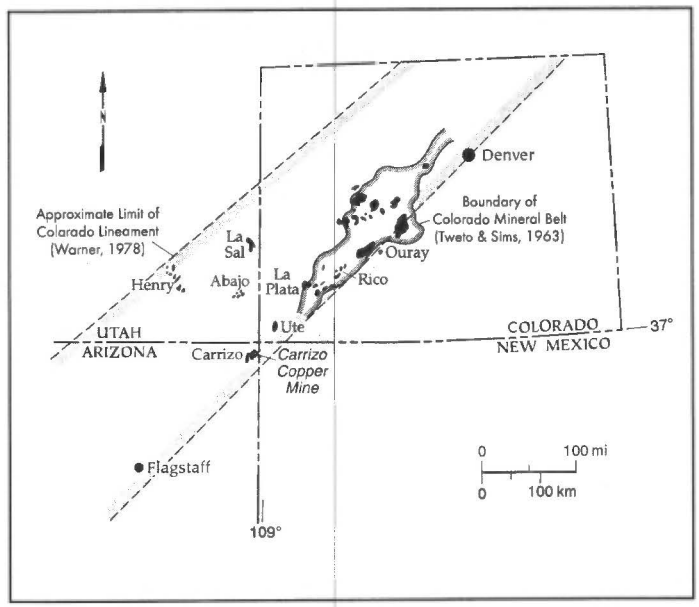


FIGURE 1. Location of the Carrizo copper mine, Apache County, Arizona, and other laccoliths or volcanic centers along the southern Colorado lineament in the Four Corners area of the Colorado Plateau (modified from Warner, 1978, and Cunningham et al., 1994).

REGIONAL GEOLOGIC SETTING

Much of the Carrizo Mountains is formed by a Late Cretaceous to Tertiary diorite-porphyry laccolith, which intrudes Pennsylvanian to Upper Cretaceous sedimentary rocks. Seven major laccoliths in the Four Corners area were emplaced along and at the intersections of basement lineaments (Fig. 1; Kelley, 1955; Witkind, 1975; Cunningham et al., 1994). Carrizo, Ute, La Plata and Rico laccoliths appear to have been emplaced about 51–84 Ma; whereas the Henry, La Sal and Abajo laccoliths appear to range in age from 31 to 20 Ma (Witkind, 1975; Baars and Stevenson, 1981;

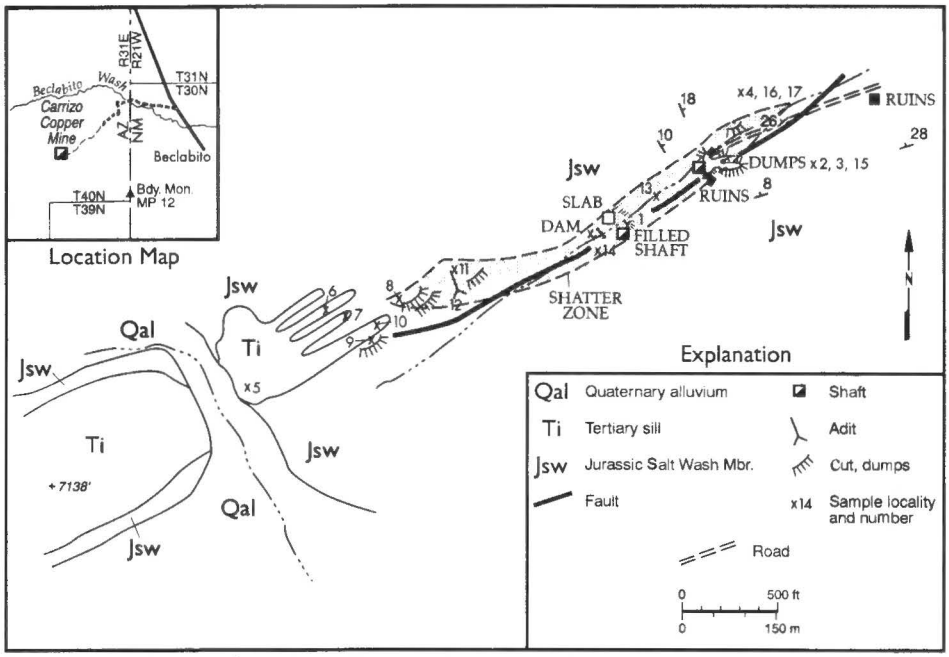


FIGURE 2. Brunton and pace geologic map of the Carrizo copper mine workings (V. T. McLemore and W. L. Chenoweth, May 24, 1985).

Nelson et al., 1992; Cunningham et al., 1994). Recent $^{40}Ar/^{39}Ar$ dates from the Henry, La Sal and Abajo laccoliths have shown that excess argon and the presence of xenocrysts may have altered K-Ar systematics such that previous K-Ar ages may be older than the actual age as determined by newer $^{40}Ar/^{39}Ar$ (Nelson et al., 1992). Therefore, it is possible that the "older plutons" (Carrizo, Ute, La Plata and Rico) may also be mid-Cenozoic in age. $^{40}Ar/^{39}Ar$ age dating of the Carrizo, Ute, La Plata and Rico laccoliths is required to address this issue. Work is currently underway on some of these laccoliths.

The Carrizo Mountains lie along the Colorado lineament (Fig. 1), a broad northeast-trending zone characterized by northeast-trending Precambrian faults (Tweto and Sims, 1963; Warner, 1978). The Colorado lineament also separates an older Precambrian terrain in Wyoming (>2400 Ma) from a younger Precambrian terrain in Colorado (<1750 Ma; Warner, 1978). All seven major laccoliths in the Four Corners area lie along this zone. The Colorado mineral belt also lies along this major crustal lineament and the Carrizo copper deposit is the southernmost mineral deposit along this zone.

Mineral deposits are associated with several of these laccoliths. Copper deposits in the Ute Mountains are similar to those of the Carrizo Mountains; copper at Battle Rock and Little Maud mines occur along shear zones in locally baked sandstone near the intrusive sill or laccoliths (Ekren and Houser, 1965). The La Plata district probably has had the most base- and precious-metals production in the Four Corners area where veins of chalcocite, silver, telluride and gold-bearing pyrite occur together with contact-metamorphic replacement and placer gold deposits (Eckel et al., 1949). The La Plata deposits are associated with the latest stage of intrusions, Laramide syenites and rhyolites (Cunningham et al., 1994). A stockwork Mo deposit and shallow replacement and vein deposits in calcareous sedimentary rocks are found in the Rico district, Colorado (Larson et al., 1994). This deposit was formed about 4 Ma and may be related to the Rio Grande rift (Cunningham et al., 1994). Four types of deposits are found in the Henry Mountains: fissure veins of gold, silver and copper; placer gold deposits; sandstone vanadium deposits; and zones of disseminated pyrite in the laccoliths and shatter zones (Hunt, 1953). In the La Sal Mountains in Utah, three types of mineral deposits occur: gold placers, hydrothermal polymetallic veins, and sandstone uranium-vanadium and manganese deposits (Hunt, 1958). The bedded uranium-vanadium and manganese deposits are most likely older than the laccolith (Chenoweth, 1990). Three types of deposits are found in the Abajo Mountains; sandstone uranium-vanadium deposits, placer gold deposits, veins of gold and silver, and sedimentary copper deposits (Witkind, 1964, 1975).

LOCAL GEOLOGIC SETTING

The Carrizo Mountain diorite porphyry covers over 100 mi^2 and consists of small phenocrysts of orthoclase and plagioclase in a matrix of quartz, orthoclase, biotite, diopside and hornblende (Emery, 1916; Williams, 1936; V. T. McLemore, unpublished field notes). Apatite, titanite and iron oxides are present in trace amounts. A sample of the hornblende-diorite porphyry from Teec Nos Pos Canyon in the Carrizo Mountains has a K-Ar age date of 69.6±1.4 Ma (Strobell, 1956; Armstrong, 1969; recalculated using decay constants by Steiger and Jager, 1977). The sandstone and siltstone adjacent to the diorite porphyry is bleached and altered to quartzite and hornsfels; the altered zone is less than a foot wide. Diorite sills and dikes radiating from the laccolith are common (Emory, 1916). Younger lamprophyre dikes also locally intrude the laccolith and have been dated as 23 Ma (Laughlin et al., 1986).

The Carrizo copper mine is located along a fault zone in the upper sandstone and siltstone beds of the Salt Wash Member of the Morrison Formation (Jurassic). The fault zone trends N65°E, dips vertically to 81°S, and is at least 2500 ft long (Fig. 2). Actual displacement along the fault could not be determined, but the south side is downdropped, suggesting a normal fault. The sandstones and siltstones are highly fractured and silicified (Fig. 3). The Salt Wash beds dip 18°NE in the vicinity of the lower shaft, but at the upper shaft the beds dip 26°NE as a result of deformation by underlying sills of the Carrizo laccolith. West of the mine workings, the Salt Wash Member is intruded by at least five separate sills from the laccolith. The sills have intruded along bedding planes and are up to 20 ft thick. The upper prospect pit is within one of the sandstone units between two sills (Fig. 2).

Malachite and azurite coat fractures and are disseminated within the sandstone at the mine workings. Dark gray chalcocite is also locally disseminated within the sandstone. Copper mineralization is spatially associated with the fault zone (Fig. 2). Organic material is common within the sandstone and locally, copper minerals appear to be associated with it. Chemical analyses are in Table 1. No anomalous radioactivity was noted anywhere at the site.

ORIGIN AND SIGNIFICANCE OF MINERALIZATION

The Carrizo copper deposit lies along the southern extension of the Colorado lineament, which includes the Colorado mineral belt. Proximity to the laccolith and the spatial association between mineralization, the fault, and the sills suggests that the mineralization at the Carrizo copper mine is



FIGURE 3. Collar of lower shaft. Note the fractured sandstone at and above the collar.

probably related to intrusion of the diorite laccolith, but the age of this laccolith is questionable in view of recent studies (Nelson et al., 1992). During the Laramide, the Farallon plate was being subducted at a shallow angle beneath the American plate, producing Laramide compressional folding and faulting and subsequent crustal thickening. Cunningham et al. (1994) suggested that several parallel northeast-trending transform faults developed in the Four Corners region during the Laramide, and allowed intrusion of isolated igneous centers, including the Carrizo laccolith. Nelson et al. (1992) suggested that the laccoliths in the Four Corners region may all be Oligocene–Miocene in age and part of the widespread Oligocene–Miocene magmatism that occurred throughout southwestern United States. If so, the Carrizo laccolith formed as a result of cessation of subduction of the Farallon plate. Regardless of the age and tectonic origin of the laccolith, these igneous centers were associated with base- and precious-metal deposits, such as the Carrizo copper deposit.

Copper may have been leached from the Carrizo laccolith by meteoric fluids during or after cooling and precipitated in the overlying Salt Wash sandstone in the presence of organic material (supergene processes). It is

TABLE 1. Chemical analyses from the Carrizo copper mine (New Mexico Bureau of Mines and Mineral Resources Chemical Laboratory; Cu, Pb, Zn, V by flame atomic adsorption after *aqua regia* digestion; Au, Ag by fire assay; U by wet chemical methods). Samples 7975 and 7974 have a trace of gold; the remainder of the samples contain <0.02 oz/ton Au.

LAB NO.	SAMPLE NO.	Ag oz/ton (ppm)	Cu%	Pb% ppm	Zn ppm	U_3O_8	V_2O_5%	DESCRIPTION
242	7	<0.30 (<10)	0.011	<0.02	260	<10	0.007	baked siltstone, Jms
244	9	<0.30 (<10)	<0.006	<0.02	140	<10	0.007	south pit, west wall
240	8	98.00 (3,360)	1.87	<0.02	39	<10	0.050	grab of dump
243	11	0.80 (27)	0.09	0.220	170	80	0.240	adit zone
241	12	4.18 (143)	0.37	<0.02	31	<10	0.040	grab of dump
245	14	17.54 (601)	0.64	<0.02	90	80	0.110	sandstone outcrop
7975	1	13.32 (467)	0.95	<0.02	100	10	0.070	grab sample at upper shaft
248	13	9.84 (337)	0.59	<0.02	110	80	0.070	sandstone outcrop
8846	2	6.50 (223)	0.52	<0.01	30	2	0.280	grab of dump at east shaft
8845	3	4.20 (144)	0.43	<0.01	2	<2	0.080	grab of dump at east shaft
252	15	0.76 (26)	0.16	0.048	47	20	0.130	grab of dump at east shaft
7974	4	89.18 (3,058)	1.84	<0.02	8	2	0.170	grab of dump in east pit
247	16	17.30 (593)	0.40	<0.02	78	20	0.180	grab of dump in east pit
246	17	101.62 (3,484)	3.39	<0.02	190	<10	0.230	grab of dump in east pit

also possible that copper-rich magmatic-hydrothermal fluids evolved from the Carrizo laccolith, migrated along the fault, and copper precipitated in the sandstone in the presence of reducing organic material or by simple cooling of the fluids (epithermal processes). It is unlikely that the Carrizo copper deposit is related to the widespread uranium deposits hosted by the Salt Wash sandstone elsewhere in the Four Corners area, because the Carrizo deposit is not tabular or bedded, but is controlled by a fault formed as a result of intrusion of the laccolith. In addition, the mineral assemblage at the Carrizo copper mine is much different than typical uranium deposits hosted by the Salt Wash sandstone (Chenoweth and Malan, 1973; McLemore and Chenoweth, 1989, this volume). The Carrizo Mountains should be examined in more detail for additional potential supergene or epithermal-vein deposits.

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REFERENCES

Armstrong, R. L., 1969, K-Ar dating of laccolith centers of the Colorado Plateau and vicinity: Geological Society of America Bulletin, v. 83, p. 273–288.

Baars, D. L. and Stevenson, G. M., 1981, Tectonic evolution of western Colorado and eastern Utah: New Mexico Geological Society, Guidebook 32, p. 105–112.

Chenoweth, W. L., 1989, The Carrizo "gold" mine: Arizona Geological Survey, Contributed Report CR-89-B, 26 p.

Chenoweth, W. L., 1990, The Zena #1 uranium-vanadium mine, northeastern Carrizo Mountains, Apache County, Arizona: Arizona Geological Survey, Contributed Report CR-90-C, 9 p.

Chenoweth, W. L. and Malan, R. C., 1973, The uranium deposits of northeastern Arizona: New Mexico Geological Society, Guidebook 24, p. 139–149.

Coleman, A. H., 1944, A report on the geology and ore deposits of the B'Cla B'Toh (Beclabito) district, Carrizo uplift area, New Mexico-Arizona: U.S. Army, Manhattan Engineer District, Report RMO-469, 28 p.

Cunningham, C. G., Naeser, C. W., Marvin, R. F., Luedke, R. G. and Wallace, A. R., 1994, Ages of selected intrusive rocks and associated ore deposits in the Colorado mineral belt: U.S. Geological Survey, Bulletin 2109, 31 p.

Eckel, E. B., Williams, J. S. and Galbraith, F. W., 1949, Geology and ore deposits of the La Plata district, Colorado: U.S. Geological Survey, Professional Paper 219, 179 p.

Ekren, E. B. and Houser, F. N., 1965, Geology and petrology of the Ute Mountains area, Colorado: U.S. Geological Survey, Professional Paper 481, 74 p.

Emery, W. B., 1916, The igneous geology of Carrizo Mountain: American Journal of Science, 4th series, v. 42, p. 356–357.

Gregory, H. E., 1917, Geology of the Navajo country, a reconnaissance of parts of Arizona, New Mexico, and Utah: U.S. Geological Survey, Professional Paper 93, 161 p.

Hunt, C. B., 1953, Geology and geography of the Henry Mountains region, Utah: U.S. Geological Survey, Professional Paper 228, 234 p.

Hunt, C. B., 1958, Structural and igneous geology of the La Sal Mountains, Utah: U.S. Geological Survey, Professional Paper 294-I, p. 305–364.

Kelley, V. C., 1955, Regional tectonics of the Colorado Plateau and relationships to the origin and distribution of uranium: University of New Mexico Publications in Geology, no. 5, 120 p.

Kiersch, G. A., 1955, Mineral resources, Navajo-Hopi Indian Reservations, Arizona-Utah, vol. 1 metalliferous minerals and mineral fuels: Indian Services-Geologic Project, University of Arizona, 75 p.

Larson, P. B., Cunningham, C. G. and Naeser, C. W., 1994, Large-scale effects in the Rico paleothermal anomaly, southwest Colorado: Economic Geology, v. 89, p. 1769–1779.

Laughlin, A. W., Aldrich, M. J., Jr., Shafiqulllah, M. and Hulser, J., 1986, Tectonic implications of the age, composition, and orientation of lamprophyre dikes, Navajo volcanic field, Arizona: Earth and Planetary Science Letters, v. 76, p. 361–374.

McLemore, V. T. and Chenoweth, W. L., 1989, Uranium resources in New Mexico: New Mexico Bureau of Mines and Minerals Resources, Resource Map 18, 36 p.

McLemore, V. T. and Chenoweth, W. L., 1997, Geology and uranium-vanadium deposits in the Salt Wash Member, Morrison Formation, King Tutt Mesa area, San Juan County, New Mexico: New Mexico Geological Society, Guidebook 48.

Nelson, S. T., Davidson, J. P. and Sullivan, K. R., 1992, New age determinations of central Colorado Plateau laccoliths, Utah: recognizing disturbed K-Ar systematics and re-evaluating tectonomagmatic relationships: Geological Society of America, Bulletin, v. 104, p. 1547–1560.

Steiger, R. H. and Jager, E., 1977, Subcommission on geochronology; convention and use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359–362.

Strobell, J. D., Jr., 1952, Pastora Peak NE, preliminary geologic map of part of the Carrizo Mountains area, northeastern Arizona, northwestern New Mexico: U.S. Geological Survey, Trace Elements Memorandum Report TEM-425, 1 sheet, scale 1:24,000.

Strobell, J. D., Jr., 1956, Geology of the Carrizo Mountains area in northeastern Arizona and New Mexico: U.S. Geological Survey, Oil and Gas Investigations Map OM-160, 2 sheets, scale 1:48,000.

Tweto, O. and Sims, P. K., 1963, Precambrian ancestry of the Colorado mineral belt: Geological Society of America Bulletin, v. 74, p. 991–1014.

Warner, L. A., 1978, The Colorado lineament: a middle Precambrian wrench fault system: Geological Society of America Bulletin, v. 89, p. 161–171.

Williams, H., 1936, Pliocene volcanoes of the Navajo-Hopi country: Geological Society of America Bulletin, v. 47, p. 111–172.

Witkind, I. J., 1964, Geology of the Abajo Mountains area, San Juan County, Utah: U.S. Geological Survey, Professional Paper 453, 110 p.

Witkind, I. J., 1975, The Abajo Mountains: an example of the laccolithic groups on the Colorado Plateau: Four Corners Geological Society, 8th field conference, p. 245–252.