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METALLIC MINERAL DEPOSITS IN COLFAX AND UNION COUNTIES, NORTHEASTERN NEW MEXICO

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Abstract—The most important metallic mineral deposits in northeastern New Mexico are Great Plains Margin gold-silver deposits in the Elizabethtown-Baldy district. Similar deposits occur in the Cimarroncito district and possibly in the Laughlin Peak area. Thorium, yttrium and rare-earth veins with associated niobium also occur in the Laughlin Peak area and are related to intrusion of phonolite. Development of these deposits depends upon improvement of the markets for thorium, yttrium and rare-earth elements. Clastic plugs containing copper, silver and locally uranium occur in the Cimarron Valley and may be analogous to collapse-breccia pipes in northwestern Arizona. Other deposits occur in northeastern New Mexico, including sedimentary uranium, volcanic-epithermal gold, placer gold and stratabound, sedimentary copper deposits, but these deposits are small and probably uneconomic.

INTRODUCTION

Several different types of metallic mineral deposits are found in Colfax and Union Counties, northeastern New Mexico (Fig. 1, Table 1). As part of evaluating the mineral resources of New Mexico, these areas were examined. The geology, mineralogy, geochemistry and genesis of these deposits are briefly described to aid in evaluating their mineral potential.

DESCRIPTION OF DEPOSITS

Great Plains Margin deposits

Several mining districts in New Mexico lie east of the Rio Grande rift along, or near, the border of the Great Plains and Southern Rocky Mountains or Basin-and-Range physiographic provinces, including the Elizabethtown-Baldy and Cimarroncito districts and possibly in the

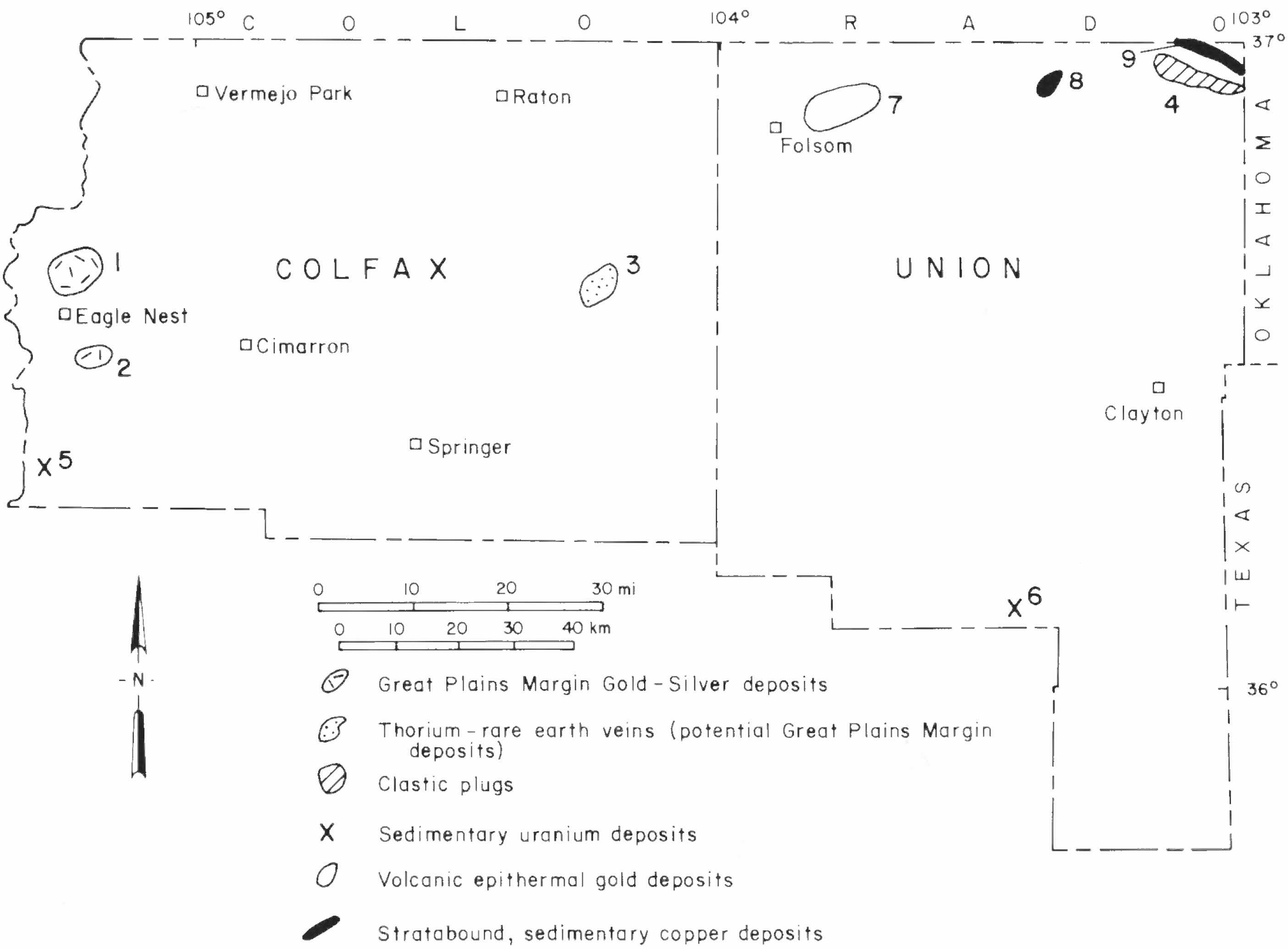

FIGURE 1. Mineral deposits in Colfax and Union Counties, New Mexico. Numbers refer to Table 1.

TABLE 1. Mineral deposits in Colfax and Union Counties, New Mexico.

Map No. on Fig. 1	Type of deposit	Area	Host Rock	Probable age of mineralization	Commodities present	Source of data (FN - field notes)
1	Great Plains Margin gold-silver with placer gold	Elizabethtown-Baldy	Oligocene quartz diorite sills, Pierre Shale, Recent gravels	Oligocene to early Miocene, Recent	Au, Ag, Cu, Pb, Co, Ni, W, U	North and McLemore (1986), Clark and Read (1972), Lindgren et al. (1910), Northrop (1959)
2		Cimarroncito	Pennsylvanian limestones adjacent to Oligocene quartz-monzonite porphyry dikes, Recent gravels	Oligocene to early Miocene, Recent	Ag, Au, Cu	Lindgren et al. (1910), Pettit (1946), Johnson (1972)
3		Chico Hills(?)	silica breccia pipes and dikes	Oligocene	Ag, Au	----------
3	Thorium, yttrium, rare-earth veins	Chico Hills	Dakota Sandstone, trachyte, trachy-andesite, intrusive breccia	Oligocene	Th, REE, Y, Nb, U	Staatz (1985, 1986), FN 8/83, 9/86, 1/87
4	Clastic plugs (sedimentary breccia pipes?)	Cimarron Valley (Black Mesa)	clastic plugs in Triassic sedimentary rocks	Triassic to Recent	Cu, Ag, U	Fay (1983), Baldwin and Muehlberger (1959), Parker (1933), FN 8/83, 1/87
5	Sedimentary uranium deposits	Black Lake	Sangre de Cristo Formation (Sandstone)	Pennsylvanian-Permian	U, V	McLemore (1983), McLemore and North (1985), May et al. (1977)
6		Southern Union County	Morrison Formation (sandstone and marls)	Jurassic	U, V	Consulting Professionals Inc. (1982), Abbott (1979)
7	Volcanic-epithermal gold-silver with placer gold	Folsom	Tertiary basalt, Recent gravels	Tertiary, Recent	Au	Harley (1940), Johnson (1972)
8	Stratabound, sedimentary copper	Peacock Canyon	Chinle Formation	Triassic to Recent	Cu, Ag	Soulè (1956)
9		Black Mesa	Sheen Pen Sandstone	Triassic to Recent	Cu, Ag	Soulè (1956)

Laughlin Peak area (Fig. 2, nos. 1, 2 and 3; North and McLemore, 1985, 1986, 1987). These deposits have similar characteristics that, when compared with their tectonic setting, define an interesting class of mineral deposits in New Mexico. The Great Plains Margin deposits contain both base and precious metals, but precious metal values, especially gold, are generally high compared to other deposit types in the state. Alkalic rocks are found in most districts, but mineralization is typically associated with silica-saturated or oversaturated rocks. These deposits are late Eocene to early Miocene in age, part of a mid- to late-Tertiary period of metallogenesis in New Mexico (North and McLemore, 1987). Four distinct deposit types are recognized in these districts: quartz veins, copper and/or lead-zinc skarns, iron skarns and placer deposits. The veins have high gold/base metal ratios and typically low silver/gold ratios, unlike most deposits in New Mexico (North and McLemore, 1986, 1987). A variation of the vein-type deposit includes intrusive breccia pipes containing low-grade, disseminated mineralization and are important producers of gold in a few districts (Old Placers, Santa Fe County, and Nogal, Lincoln County, Fig. 2, nos. 6 and 13).

The origin of the Great Plains Margin deposits is not clear. They coincide with a belt of alkalic igneous rocks and crustal thickening (Bird, 1984) in New Mexico which mimics the margin from Texas to Colorado. This belt of alkalic rocks continues northward into Canada and southward into Mexico (Clark et al., 1982), and some of the ore deposits in other areas are similar. Other commodities found along this general trend are molybdenum, fluorite and tungsten. It is likely that the co-occurrence of these and other elements is the result of several different events and tectonic environments which overlap near the Great Plains Margin, perhaps in a complex zoned system as suggested by Rice et al. (1985) for Mo-Au-fluorite mineralization at Central City, Colorado.

Future exploration along the Great Plains margin will doubtless concentrate on large, low-grade, bulk mineable intrusive breccia-pipe deposits, similar to the Ortiz mine in the Old Placers district. Placer and vein deposits may be exploited on a smaller scale.

Elizabethtown-Baldy district

Gold was discovered in the Elizabethtown-Baldy district during the early 1860's after an Indian found copper-stained float on the upper slope of Mt. Baldy in Poñil Creek. By 1867, a gold rush had begun (Jones, 1904; Lindgren et al., 1910). It is estimated that more than \$2.5 million of placer gold and \$2 million of lode gold were produced prior to 1910 (Lindgren et al., 1910). Total production until 1910 was about \$7 million (Pettit, 1946), and subsequent production through 1952 was \$3 million (Table 2).

The lode deposits in the district include vein, copper-skarn and iron-skarn deposits. Placer deposits derived from the lodes are found on the flanks of Baldy Mountain. Most of the mines of the district are caved, so the following description is summarized from published and unpublished accounts of the district and from observations of material on the mine dumps.

The most important lode deposits in the Elizabethtown-Baldy district were veins which formed in fissures in the Cretaceous Pierre Shale and intervening Tertiary quartz-diorite porphyry sills and along the contact between shale and sandstone of the overlying Cretaceous-Tertiary Raton Formation. The shale and sandstone are locally in fault contact, and elsewhere in unconformable sedimentary contact. Mineralization may occur in either shale or sandstone, but the shale invariably shows higher gold values (Lee, 1916; Chase and Muir, 1923). Veins cutting the shale and sills contain quartz, pyrite, calcite, chalcopyrite, pyrrhotite and minor magnetite and molybdenite (Clark and Read, 1972). Early high-grade ores at the shale-sandstone contact in the Aztec mine contained native gold, calcite and possibly some contact-metamorphic minerals such as epidote and garnet (Chase and Muir, 1923). Calcite-rich samples from dumps of the Poñil #1 and #2 adits also contain arsenopyrite and galucodot ([Co,Fe]AsS). Electron microprobe analyses show the

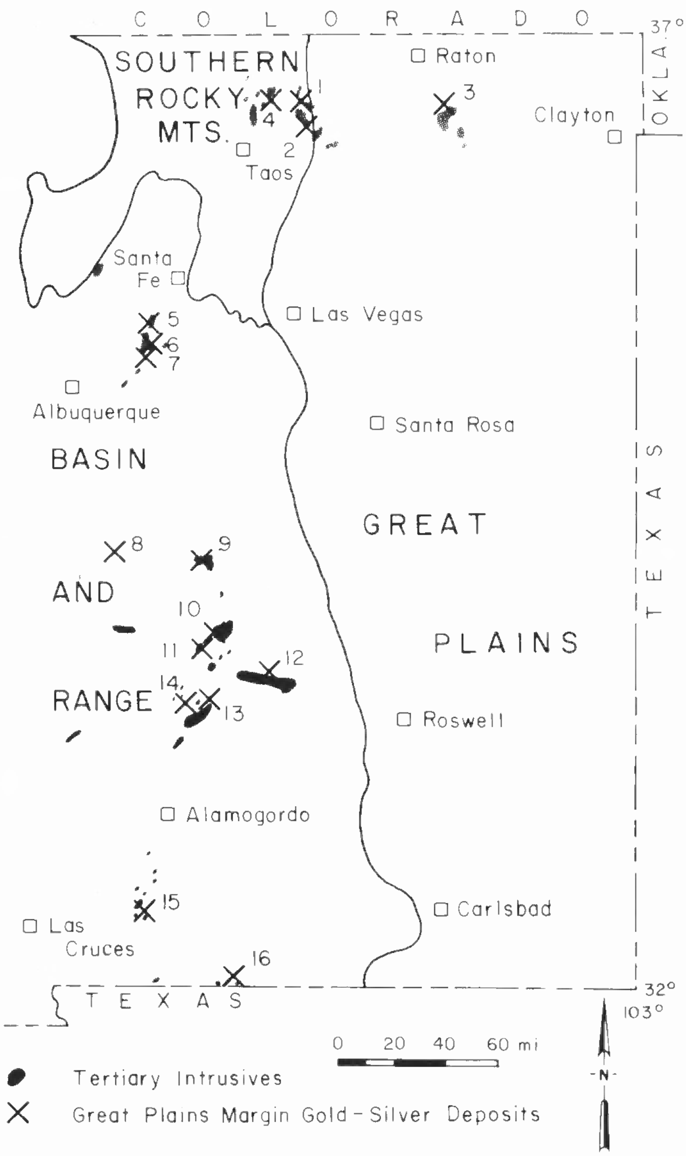

FIGURE 2. Great Plains Margin gold-silver deposits in New Mexico (North and McLemore, 1985, 1986). Physiographic provinces and Tertiary igneous intrusives from New Mexico Geological Society (1981). 1 – Elizabethtown-Baldy, 2 – Cimarroncito, 3 – Laughlin Peak area, 4 – Red River, 5 – Cerrillos, 6 – Old Placers, 7 – New Placers, 8 – Chupadera, 9 – Gallinas, 10 – Jicarilla, 11 – White Oaks, 12 – Capitan, 13 – Nogal, 14 – Schelerville, 15 – Orogrande, 16 – Cornudas Mountains.

material to be zoned, alternating between iron-rich areas (arsenopyrite) and cobalt-rich areas (cobaltian arsenopyrite and glaucodot). Probe analyses also indicate small areas in the arsenopyrite/glaucodot which contain as much as 1.5 wt% nickel (Paul Hlava, written commun., 1986). Samples of calcite and arsenopyrite/glaucodot from the dump assay as high as 1% cobalt. Erythrite was also noted in several samples.

Copper-rich skarn deposits occur on the south side of Copper Park, northeast of Baldy Mountain. The skarns are in calcareous sandstone (Raton Formation?) near the contact with quartz-diorite porphyry. Ore mineralization found on the dump is oxidized and includes cuprite, malachite and chrysocolla with minor azurite. Garnet, quartz and limonite are the chief gangue.

The principle iron deposits in the district are skarns in limy shale at Iron Mountain, southwest of Baldy Mountain (Clark and Read, 1972). The deposits consist of specular hematite and magnetite with epidote, diopside, hornblende, garnet and scapolite gangue (Lindgren et al., 1910), with small amounts of pyrite and gold (Clark and Read, 1972). Kelley (1949) estimated the ore contained between 50 and 55% iron. Four assays of material reported to Colorado Fuel and Iron Company by W. S. Ward (written commun., 1907) ranged from 35.5 to 60.4% iron and averaged 51.5%. The tonnage is too low to sustain mining. Pettit (1966) reported that oxidized ("soft") iron ore from the area averaged about 0.77 oz/ton (26 ppm) gold and that the "hard" or unoxidized ore averaged about 0.14 oz/ton (5 ppm) gold. No subsequent work is known which has confirmed or refuted these averages.

It is estimated that 250,000 oz (7,087,000 g) of gold were produced from placer deposits in the district, more than any other placer district in the state (Johnson, 1972). Placer deposits in the district occur on both the western and eastern flanks of Baldy Mountain. Gold-bearing drainages on the west flank, which were the most productive, included Willow Creek, Humbug Gulch, Grouse Gulch, Big Nigger Gulch, Pine Creek and the Moreno River, whereas gold was produced from the east flank at Ute and South Poñil Creeks. The gold occurs as flour, flakes and nuggets in Quaternary gravel deposits. Some nuggets were quite coarse. Bismuth is mixed with gold in one nugget from the district, according to a label in the mineral collection of the U.S. National Museum.

TABLE 2. Mineral production from mining districts in Colfax and Union Counties, New Mexico.

Map No. on Fig. 1	District	Cu (lbs)	Pb (lbs)	Au (oz)	Ag (oz)	Total Value (dollars)	Years of production	Source of data[1]
1	Elizabethtown-Baldy	unknown	unknown	390,800[2]	unknown	7 million[2]	1867-1909	Lindgren (1910), Pettit (1946)
		329,239	5,287	80,600[2]	25,547	3 million[2]	1910-1952	Pettit (1946)
2	Cimarroncito	unknown	---	100[2]	1,000[2]	unknown	early 1900's	U.S. Bureau of Mines files
4	Cimarron Valley (clastic plugs)	800	---	---	10	349	1956	U.S. Bureau of Mines mineral yearbooks
	TOTAL (excluding unknown)	330,039	5,287	471,500[2]	26,557	10 million[2]	1867-1956	--------

1 supplemented by U.S. Bureau of Mines mineral yearbooks.
2 estimated values
--- no production reported.

Cimarroncito district

The Cimarroncito district has some similarities to the Elizabethtown-Baldy district, but has enjoyed very little production. Little is known of the district. Mineralization is nearly always found as skarns in calcareous beds of the Pennsylvanian-Permian Sangre de Cristo Formation adjacent to quartz-monzonite porphyry sills (Robinson et al., 1964) and are classed as Great Plains Margin deposits based on their similarity in age, form and metal content (North and McLemore, 1986). The intrusive rocks, which have been dated at 33.8 m.y. (Armstrong, 1969; K-Ar on biotite), are similar to some of the intrusives in the Elizabethtown-Baldy district. Quartz veins cutting the intrusive are known, but are very minor (Anderson, 1957). Small, high-grade pockets of ore reportedly assayed as much as 0.5 oz/ton (17 ppm) gold, 4 oz/ton (137 ppm) silver and 8–10% copper (Lindgren et al., 1910). Total production, however, is small, estimated at about 100 oz (3,110 g) gold, 1,000 oz (31,100 g) silver and some copper. Some placer gold deposits have been reported (Johnson, 1972).

Laughlin Peak area

The intrusive breccias in the Laughlin Peak area are similar in age and tectonic setting to mineralized intrusive breccias found in the Old Placers district (Fig. 2, no. 6; Wright, 1983), Nogal district (Fig. 2, no. 13; Thompson, 1973) and Cripple Creek district in Colorado (Thompson et al., 1985). Production from the Ortiz breccia in the Old Placers district is estimated to have been 231,900 oz (7,212,000 g) from 1981 to 1984 (North and McLemore, 1987). The total production from the Cripple Creek district has been about 21 million oz (653 million g) of gold since 1891. Recognition of similar deposits in the Laughlin Peak area could have important economic implications.

The intrusive breccias in the Laughlin Peak area occur as dikes and pipes. The dikes are as much as 170 m long and range in thickness from 0.5 to 6 m. The pipes are elliptical to circular, ranging from 60 to 300 m in length. These breccias occur along faults and fractures, and thorium veins cut a few of them. The breccias consist of fine- to cobble-size fragments of sedimentary and igneous country rocks as well as granite which does not crop out in the area (Staatz, 1985). The matrix is a fine-grained mixture of quartz, feldspars, clay and limonite. Pyrite and marcasite occur in several zones at depth. Silver contents range as high as 0.7 oz/ton (24 ppm) with gold assays up to 82 ppb. Gold assays of the breccias, although low, have been verified by repeated analyses. Drilling and geochemical sampling are still underway.

A second type of gold mineralization may be present in this area. A pyrite-rich veinlet altering to jarosite was found in a piece of trachyte float in Tinaja Creek, downstream from its confluence with Jimmy Spring Canyon. This veinlet was found to contain 165 ppb gold using a fire assay with atomic absorption finish. The same value was verified by a second assay, indicating rocks other than the breccias may have weak gold mineralization.

Thorium, yttrium and rare-earth element veins, Laughlin Peak area

Thorium, yttrium and rare-earth element veins with associated niobium were first discovered in the Laughlin Peak area during the 1950's. Although there has not been any production, these veins have been examined sporadically since the 1950's, because of their anomalous radioactivity which is due mainly to their thorium content.

Economic demand for thorium, yttrium, rare-earth elements and niobium is relatively small, but critical to our high technological industries. Thorium is used as a nuclear-fuel in a commercial generating plant. Nonenergy uses of thorium include incandescent lamp mantles, refactories, welding electrodes and alloys, among others. Yttrium (typically associated with the rare-earth elements) and rare-earth elements are used as phosphors in televisions and lamps and in producing synthetic garnets (U.S. Bureau of Mines, 1986). Rare-earth elements also are used for petroleum catalysts, metallurgical products (alloys), ceramics and glass and other specialized uses (U.S. Bureau of Mines, 1986).

The thorium, yttrium and rare-earth veins in the Laughlin Peak area are steeply-dipping, lenticular, fracture-filling deposits. More than 30 veins have been located (Staatz, 1985, 1986), and several areas remain unmapped. The veins range in size from 0.5 to 550 m long and 0.2 to 70 cm thick. Most of the veins strike N30°W and N85°W and parallel the strike of early faults (Staatz, 1985).

An extensive suite of minerals has been found in these veins (Staatz, 1985). Potassium-feldspar, quartz and calcite are found in most veins. Other minerals found in most veins are goethite, magnetite, barite, brockite, crandallite, xenotime, zircon and rutile. Small amounts of fluorite, thorite, apatite, spinel, thorianite-uraninite and several other minerals are found in a few veins.

Thorium content ranges from 30 to 24,200 ppm (Tschanz, 1958; Staatz, 1985) miscellaneous analyses by the authors). Yttrium contents as high as 10,000 ppm are reported (Staatz, 1985). Total rare-earth elements content ranges from 100 to 30,000 ppm (Staatz, 1985; Tschanz, 1958). Niobium concentrations as high as 1,200 ppm are reported (Staatz, 1985). Uranium analyses range as high as 510 ppm U_3O_8 (McLemore, 1983), but are mostly less than 50 ppm.

The Oligocene to Pliocene alkalic igneous rocks in the Laughlin Peak area are near the younger Raton-Clayton volcanic field which consists of widespread basalt flows of several ages. Most veins cut Oligocene trachyte and Romeroville Sandstone (Cretaceous); however, a few veins cut intrusive breccia and trachyandesite, also of Oligocene age, but younger than the trachyte. Other rocks in the area include lamprophyre dikes, a carbonatite dike, phonolite, rhyodacite and basalt (Staatz, 1985, 1986).

Thorium, yttrium and rare-earth element veins are typically associated with alkalic rocks and carbonatites in many districts in the world. The veins most likely represent late-stage, volatile phases of alkalic magmas (Staatz, 1974). In the Laughlin Peak area, the veins are emplaced prior to or during intrusion of the phonolite, which is enriched in thorium, yttrium, rare-earth elements, niobium and uranium. Most likely the phonolite is the source for these veins (Staatz, 1985).

Clastic plugs, Cimarron Valley

More than 120 clastic plugs have been located in the Cimarron Valley (Black Mesa) area in northeastern Union County and adjacent parts of southeastern Colorado and western Oklahoma (Fig. 1, no. 4; Parker, 1933; Baldwin and Muehlberger, 1959; Reynolds, 1979; Fay, 1983), but only a few are mineralized at the surface. Copper, silver and locally uranium occur in a few plugs. The plugs are in Triassic rocks and overlain by undisturbed Entrada (Exeter) Sandstone (Jurassic), suggesting they are pre-Jurassic. The age of mineralization is unknown. The plugs are apparently not associated with any igneous activity and are similar in form, structure, mineralization and alteration to collapse-breccia pipes in northwestern Arizona which contain economic concentrations of copper, some silver, and typically, uranium; only uranium is recovered presently. The Arizona collapse-breccia pipes occur in Triassic, Permian, Pennsylvanian and Mississippian rocks.

The clastic plugs in Cimarron Valley are vertical or steeply-dipping cylindrical features bounded by ring fractures and filled with a heterogeneous mixture of brecciated wall rocks. They range in size from 3 to 91 m in diameter and are as much as 116 m or more in length (Parker, 1933). The San Miguel mine in sec. 12, T31N, R35E is 116 m deep, but other workings in the area are shallow, less than 12 m deep (Fay, 1983). In contrast, the Orphan Lode breccia pipe in Arizona is 45 to 153 m in diameter and extends at least 506 m in depth (Gornitz and Kerr, 1970; Chenoweth, 1986). Irregular, sheet-like unmineralized clastic dikes radiate from a few plugs, but are not found in northwestern Arizona. The dikes are less than a meter thick and as much as 30 m long.

Some bleaching and deformation of the country rock adjacent to the clastic plugs has occurred. The surrounding sedimentary rocks are flat-lying or dip inward toward the plug. Clay alteration along the ring fracture and within the breccia zone occurs locally. Bleaching of sediments in the Arizona collapse-breccia pipes and the surrounding sedimentary red beds is the most recognizable feature there. Wall rocks in Arizona also show little deformation.

Mineralized clastic plugs and collapse-breccia pipes consist predominantly of copper mineralization, but some are slightly radioactive. Mineralization consists of chalcocite, malachite, azurite and traces of barite. Most plugs are capped by limonite and hematite. Organic material is common. Mineralized plugs in the Cimarron Valley area contain minor amounts of silver (20–200 ppm), molybdenum (20–66 ppm) and titanium (666–2,000 ppm; Fay, 1983). A sample from the Ft. Pitt copper mine in sec. 7, T31N, R36E assayed 0.004% U_3O_8 (Finch, 1972). Additional samples collected by the authors from the same mine contain as much as 4.13% copper and 0.7 oz/ton (24 ppm) silver. Supergene copper minerals, anomalous radioactivity, silica and calcite are common at the surface of mineralized breccia pipes in Arizona. A 160-kg sample from the Orphan Lode adit contained 0.217% U_3O_8, 0.81% Cu, 3.6 oz/ton (120 ppm) Ag and 1.51% V_2O_5 (Chenoweth, 1986).

In 1956, four tons of ore containing 800 lbs (360 kg) of copper and 10 oz (311 g) of silver worth $349 were produced from the San Miguel mine (Table 2; U.S. Bureau of Mines, mineral yearbooks). Production from clastic plugs in Baca County, Colorado from 1900 to 1902 and 1915 to 1917 amounted to 8 oz (248 g) of gold, 356 oz (11,072 g) of silver, and 21,511 lbs (9,757 kg) of copper worth $4,959 (Fay, 1983). Additional grade/tonnage of these deposits is not available. Most of these deposits have not been explored at depth. At depth, the mineralized breccia pipes in Arizona average 0.3 to 0.6% U_3O_8 and 0.3 to 3 oz/ton (10 to 100 ppm) of silver, with a lot of copper (Wenrich, 1985; Chenoweth, 1986). Production from the Orphan Lode pipe during 1962–1969 was 2,645,674 lbs (1,200,058 kg) U_3O_8, 6,680,000 lbs (3,029,997 kg) Cu and 170,000 oz (4,819,419 g) Ag (Chenoweth, 1986).

Similarities between the clastic plugs in the Cimarron Valley area and the collapse-breccia pipes in northwestern Arizona suggest a similar origin. Solution collapse of underlying Redwall Limestone formed the Grand Canyon, Arizona breccia pipes (Weinrich, 1985). Many features described of the clastic plugs in the Cimarron Valley support solution collapse of underlying Paleozoic limestones, most likely the San Andres Formation. The San Andres Formation consists of 500–1,000 m of limestone and minor anhydrite in northeastern Union County (Baldwin and Muehlberger, 1959) and is related to similar, but more extensive, solution-collapse features in the Santa Rosa area (Sweeting, 1972). Upward-turning, small-scale drag folds adjacent to ring fractures of some clastic plugs in the Cimarron Valley convinced many geologists (Parker, 1933) that these plugs were formed by intrusion of sand and rock fragments from underlying strata into the Triassic beds. However, recent small-scale fluidization, spouting and channeling experiments by McCallum (1985) suggest that compressional folds, similar in appearance to drag folds, may develop adjacent to the ring fractures during solution collapse. Therefore, these features are not necessarily drag folds and may not be indicative of direction of vertical movement as previously suggested (Parker, 1933). After formation of the collapse feature, wallrocks are downdropped into the pipe. Material from below and above the pipes also filled the void. Copper, iron and other associated metals were probably transported in low-temperature solutions through the permeable collapse fractures. Precipitation occurred at favorable oxidation-reduction interfaces in the presence of organic material, H_2S-rich waters or clays, especially along the ring-fracture zone, but also within the breccia-zone and perhaps even in adjacent permeable sandstones. Similar mineralized collapse-features occur in the San Rafael Swell in Emery County, Utah (near Harksville). These contain copper and silver and were probably formed by solution of the Sinbad Limestone Member of the Moenkopi Formation (W. L. Chenoweth, written commun., 1987).

The potential for copper, silver and uranium in these deposits in New Mexico, Oklahoma and Colorado is uncertain. The depth of the clastic plugs and the extent of mineralization are unknown. The low radioactivity of most plugs suggests that uranium concentrations are low. Although mineralogical and geochemical studies may provide clues to the mineral potential, drilling of these plugs is required to evaluate fully their potential.

Sedimentary uranium deposits

Black Lake

Tyuyamunite and metatyuyamunite are distributed along bedding planes and fractures in a 3-m-thick, coarse-grained sandstone in the Sangre de Cristo Formation (Pennsylvanian-Permian) at Black Lake, western Colfax County (Fig. 1, no. 5). A sample from a roadcut contained 0.002% U_3O_8 with no detectable gold or silver (McLemore, 1983; McLemore and North, 1985). As much as 1.1% V_2O_5 and 0.13% U_3O_8 are reported from the area (May et al., 1977; Bendix Field Engineering Corp., written commun., 1978).

Similar occurrences are found in the Sangre de Cristo Formation throughout east-central New Mexico (McLemore and North, 1985; Reid et al., 1980, 1982) and southern Colorado (Nelson-Moore et al., 1978). Reid et al. (1980, 1982) and the U.S. Department of Energy (1980) suggested that sandstone uranium deposits may occur in the Sangre de Cristo Formation in the subsurface of the area. However, these deposits are probably small, low grade, discontinuous and uneconomic at present. Extensive drilling is required to delineate such deposits.

Southern Union County

Uranium mineralization occurs in marls and sandstones in the upper two-thirds of the Morrison Formation in southern Union (Fig. 1), southern Harding and northern San Miguel Counties (McLemore and North, 1985) and in western Oklahoma (Consulting Professionals, Inc., 1982). Numerous ground-water samples from the NURE (National Uranium Resource Evaluation) HSSR (Hydrogeochemical and Stream Sediment Reconnaissance) data are anomalously high in uranium (Morgan and Broxton, 1978; Morgan, 1980; Union Carbide Corp., 1981; McLemore and North, 1985). These anomalies occur north of the Morrison outcrop and suggest additional mineralization may be present. Only one mine in the area produced ore; the Polita #2 mine in Harding County yielded 1 ton (0.9 tonne) of ore from the Morrison Formation that contained 1 lb (.5 kg) of U_3O_8 (0.15%) and 5 lbs (2 kg) of V_2O_5 in 1955.

At the Polita #2 mine, uranium occurs with fossil logs and bones in medium-grained sandstone. Elsewhere, uranium occurs in one or two thin (1- to 2-m-thick) marls within the Morrison Formation (Abbott, 1979; Consulting Professionals, Inc., 1982). The known occurrences of uranium mineralization are found above the distinctive "agate bed," consisting of one or two layers of red-brown chalcedony nodules (Mankin, 1958; Abbott, 1979). The "agate bed" may be correlative with the lower disconformity in the Morrison Formation of the Colorado Plateau described by Green (1980). All known uranium deposits in the Morrison Formation in the Colorado Plateau occur above this disconformity.

Most of the uranium produced from New Mexico has come from sandstones of the Morrison Formation in the Colorado Plateau, northwestern New Mexico (McLemore, 1983). The Morrison in northeastern New Mexico may have potential for uranium deposits; however, evidence suggests that they are probably small, low grade (less than 0.10% U_3O_8) and uneconomic at present.

Volcanic-epithermal(?) and placer gold deposits at Folsom

Reports of gold in the Folsom area date back to the late 1800's, but there has not been any reported production. Thin veins and stringers of quartz containing minor quantities of gold have been found sporadically in basaltic lavas near Folsom. Assays as high as 1 oz/ton (34 ppm) gold are reported, but probably represent selected high-grade material (Harley, 1940). These deposits are similar to many volcanic-epithermal deposits in New Mexico and probably are formed at low to moderate temperatures and low pressures (North and McLemore, 1986).

Gravels and sediments derived from erosion of the basaltic lavas reportedly contained small amounts of placer gold, but these placers are sporadic, small and economically insignificant (Harley, 1940; Johnson, 1972).

Stratabound, sedimentary copper deposits

Small, low-grade stratabound, sedimentary copper deposits occur in sandstones of the Sloan Canyon and Chinle Formations and Sheep Pen Sandstone (Triassic) in the Peacock Canyon and Cimarron Valley (Black Mesa) areas of northern Union County (Fig. 1, nos. 8, 9; Soulé, 1956; North and McLemore, 1986). These deposits occur within red-bed sequences deposited in intracratonic basins that lack both volcanic and magmatic activity.

Stratabound, sedimentary copper deposits typically occur within fluvial to marginal-marine sedimentary deposits. Concordant or penecon-cordant stratabound zones of disseminated copper mineralization with local concentrations of lead, silver, zinc, uranium and vanadium occur. Dump samples from northeastern New Mexico contained less than 2% copper and traces of silver and gold (Soulé, 1956), but mineralization is typically sporadic and discontinuous.

The deposits in Union County have not produced any ore. However, production from similar deposits in the Pastura district of Guadalupe County amounted to more than 13 million lbs (5.9 million kg) of copper, 42,000 oz (1.3 million g) of silver, 58,000 lbs (26,000 kg) of lead and 2 oz (62 g) of gold (McLemore and North, 1985).

Copper and associated metals were probably transported in low-temperature solutions through permeable sediments and along faults shortly after burial, similar to other stratabound, sedimentary copper deposits elsewhere in New Mexico (North and McLemore, 1986). Oxidizing water could leach the metals from (1) Precambrian base-metal deposits, (2) Precambrian rocks enriched in these metals and (3) clay minerals and detrital grains within the host rocks. Sources for carbonates to form soluble cuprous-carbonate complexes occur in older Paleozoic carbonate sequences. Precipitation occurred at favorable oxidation-reduction interfaces in the presence of organic material or H_2S-rich waters.

The mineral potential for copper, silver and other associated metals in these deposits in Union County is low because of low grade, small tonnage and poor access to existing mills. Economic conditions are unfavorable for these metals at the present time. If in situ leaching of copper deposits becomes feasible and economic, perhaps deposits in Union County will be examined in more detail.

ECONOMIC POTENTIAL

The most important mineral deposits in northeastern New Mexico are Great Plains Margin gold-silver and gold placer deposits in the Elizabethtown-Baldy district. However, most of the favorable land is not open to mineral entry. Significant Great Plains Margin gold-silver deposits similar to those in the Elizabethtown-Baldy and New Placers (Santa Fe County) districts, may occur in the Cimarroncito district and possibly in the Laughlin Peak area, but detailed geologic mapping and exploration of these areas are required. Thorium, yttrium and rare-earth veins in the Chico Hills may be economically important in the future as markets for thorium, yttrium and/or rare-earth elements develop. Additional geochemical studies are required to evaluate the potential for niobium. Clastic plugs in the Cimarron Valley area consist of copper, silver and locally uranium and may be analogous to copper-uranium-silver collapse-breccia pipes in northwestern Arizona. Exploration drilling of these clastic plugs is required to evaluate fully their potential. Other deposits in Colfax and Union Counties are small, low grade and probably uneconomic at the present.

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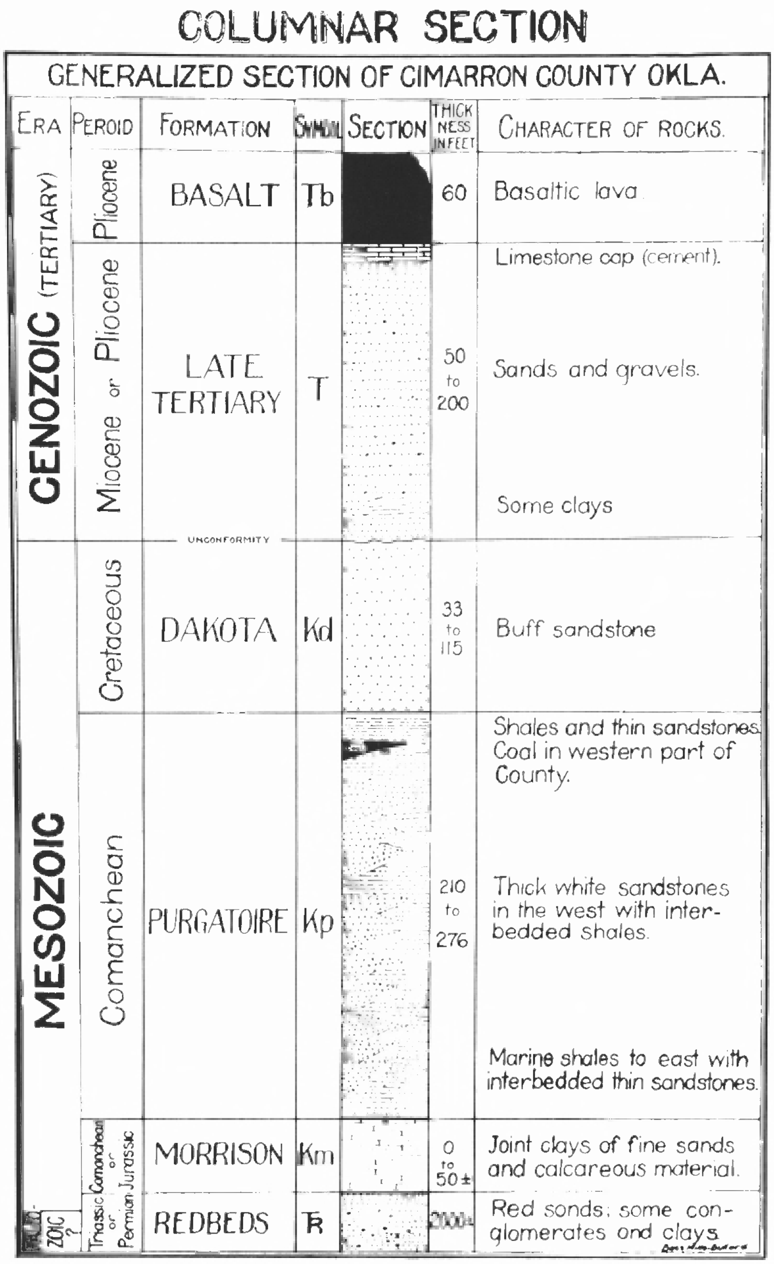

Composite stratigraphic section of rocks exposed in the Dry Cimarron Valley, Cimarron County, Oklahoma. From an Oklahoma Geological Survey Bulletin by Rothrock (1925). Note that the strata identified as Purgatoire actually encompass the Entrada, Bell Ranch, Morrison, Lytle and Glencairn formations. Also note that strata termed Morrison are actually Upper Triassic Sloan Canyon Formation.