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2025, pp. 221-226. https://doi.org/10.56577/FFC-75.221

in:

Geology of the Eastern San Juan Basin - Fall Field Conference 2025, Hobbs, Kevin M.; Mathis, Allyson; Van Der Werff, Brittney;, New Mexico Geological Society 75 th Annual Fall Field Conference Guidebook, 227 p. https://doi.org/10.56577/FFC-75

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New Mexico Geological Society Guidebook, 75th Fall Field Conference, 2025, p. 221–225, https://doi.org/10.56577/FFC-75.221

CRITICAL MINERALS IN THE CUBA MANGANESE DEPOSITS, CUBA MANGANESE MINING DISTRICT, SANDOVAL COUNTY, NEW MEXICO

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Abstract—Reexamination of the mineral resources in the Cuba Manganese district, north of the town of Cuba in Sandoval County, New Mexico, is warranted in light of today's economic importance of critical minerals, which are essential in most of modern electronic devices, including batteries, electric cars, wind turbines, and computer chips. Critical minerals are defined as nonfuel mineral commodities that are essential to the economic and national security of the United States and are from a supply chain that is vulnerable to global and national supply disruptions. Manganese is classified as a critical mineral because there is no current manganese production in the United States and supply chain disruptions are likely. Total production from four small sedimentary manganese deposits in the Cuba Manganese district amounted to 3,786 long tons of manganese ore (grades of 36–41 wt% MnO). The Cuba manganese deposits formed in small, local lacustrine-deltaic environments in the San Jose Formation, where anoxic waters mixed with shallow oxygen-rich waters and created reducing conditions that allowed manganese to precipitate. Although, the deposits in the Cuba Manganese district have manganese concentrations similar to economic deposits elsewhere in the world (>39 wt% MnO), the known Cuba manganese deposits are small in tonnage and have no economic potential at this time. There is potential for finding additional subsurface sedimentary manganese deposits in the area, but they are likely to be small in tonnage and uneconomic because the local stratified, lacustrine-deltaic environments in the San Jose Formation that host the manganese deposits are too small to host the millions of tons of manganese ore needed to form an economic deposit. Arsenic, barium, and cobalt (other critical minerals) concentrations are elevated in the Cuba deposits, but the concentrations are too low to be economic. There are no additional critical minerals known in the Cuba Manganese mining district.

INTRODUCTION

The Cuba Manganese mining district is north of Cuba in Sandoval County, New Mexico (Fig. 1; McLemore et al., 1984; McLemore, 2017). Four small sedimentary manganese deposits have been found and yielded production (Table 1). Manganese is the 12th most abundant element on the surface of the earth (generally in the range of 0.1–0.2 wt% MnO) and is common in many geologic environments (Cannon et al., 2017). The most important economic deposits in the world are marine sedimentary manganese deposits that contain 40–45 wt% MnO and are millions of metric tons in size (Cannon et al., 2017), although manganese also is found in carbonate-hosted replacement, volcanic-epithermal vein, supergene, and seabed deposits (Farnham, 1961; Cannon et al., 2017; McLemore and Austin, 2017).

Economically, manganese is essential to the chemical and manufacturing industries because of important chemical and metallurgical properties, such as desulfurizing, deoxidizing, and alloying. Manganese is classified as a critical mineral by the United States government because there is no current manganese production in the United States and supply chain disruptions are likely (Cannon et al., 2017). In the mining industry, a "mineral" refers to any rock, mineral, or other naturally occurring material of economic value, including metals, industrial minerals, energy minerals, gemstones, aggregates, and synthetic materials sold as commodities. Thus, the term "minerals" as used by the industry includes all inorganic substances as well as hydrocarbons, such as oil and natural gas, and carboniferous deposits, such as coal. "Critical minerals" are mineral resources that are essential to our economy and national defense and whose supply may be disrupted. Many critical minerals are 100% imported into the United States (McLemore and Gysi, 2023). The Department of Defense considers manganese a critical mineral because of potential supply chain disruptions (Cannon et al., 2017). For instance, Ukraine used to produce manganese before the war with Russia and manganese shipments from Gabon were curtailed because of a military coup (U.S. Geological Survey, 2024). Furthermore, there are no substitutions for manganese in most applications. Manganese is used as an alloying addition in the manufacture of steel, essential in refining iron ore to metallic iron before it is used in making steel (an alloy with aluminum and copper), and used in the manufacture of dry cell batteries, fertilizers, other electronics, and chemical applications. Most manganese is imported from Gabon, South Africa, and Australia (U.S. Geological Survey, 2024), where manganese reserves are abundant.

In New Mexico, manganese is found in several types of deposits (Farnham, 1961; McLemore and Austin, 2017; McLemore, 2017): carbonate-hosted silver-manganese (lead) replacement, carbonate-hosted manganese replacement, sedimentary, and volcanic-epithermal vein deposits. From 1883 to 1963, more than 1.9 million long tons of manganese were produced from deposits in New Mexico. Total estimated production from the Cuba Manganese district from 1942 to 1959 amounted to approximately 3,786 long tons (Table 1; McLemore et al., 1984). Previous studies concluded that the Cuba manganese deposits were not economic at the time of their publication (McLemore et al., 1984; McLemore and Austin, 2017).

Reexamination of the mineral resources in the sedimentary manganese deposits in the Cuba Manganese district is warranted in light of today's economic importance of critical minerals.

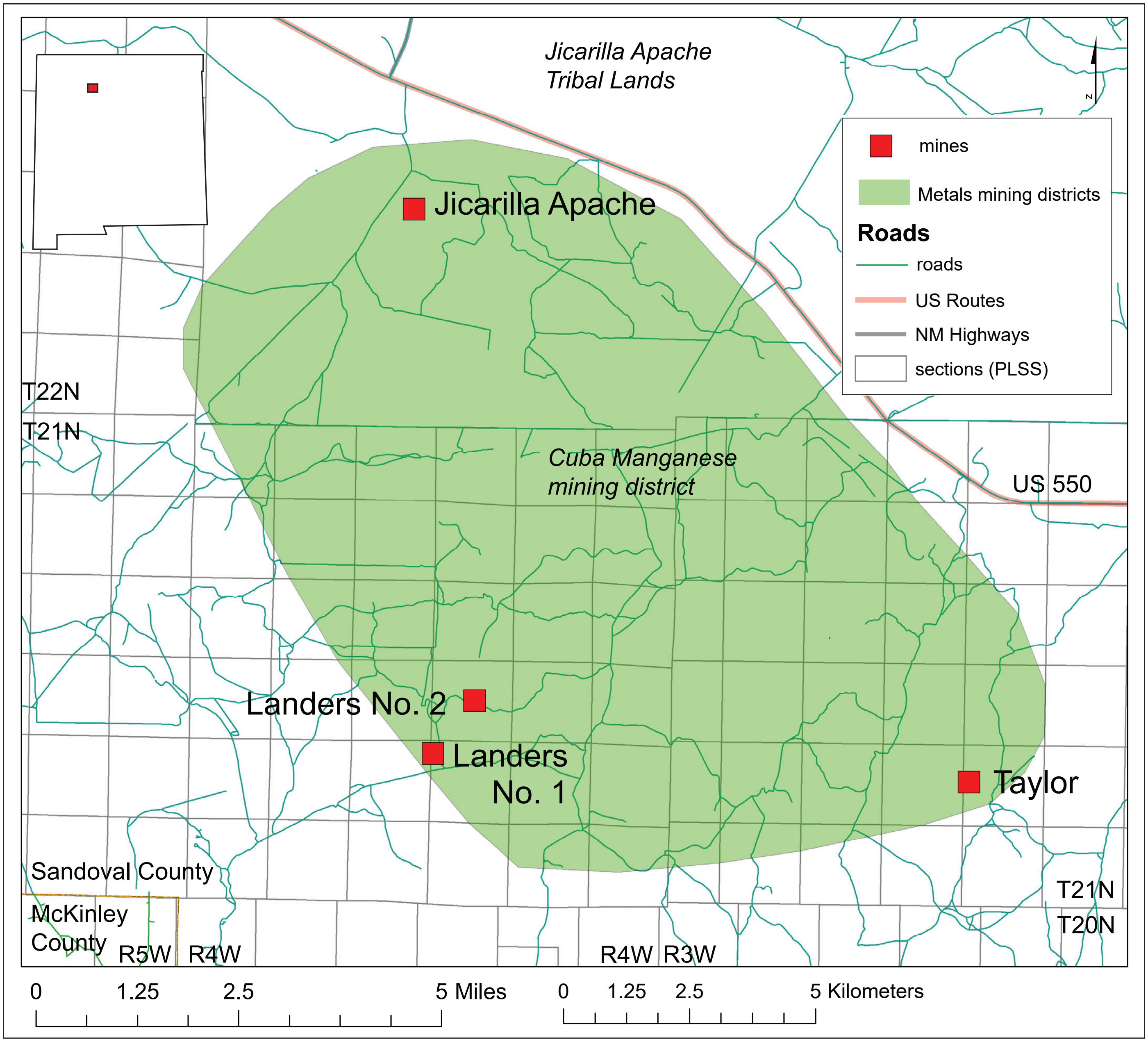

Figure 1. Location of mines (i.e., deposits) in the Cuba Manganese mining district, Sandoval County, New Mexico. District boundaries modified from McLemore (2017).

TABLE 1. Production from mines in the Cuba Manganese mining district (U.S. Bureau of Mines, 1942–1959; Farnham, 1961; Dorr, 1965). W = withheld production. Mine ID is from the New Mexico Mines database.

Year	Mine ID	Mine	Latitude, longitude	Production (long tons)	Grade MnO%
1942	NMSA0302, NMSA0303	Landers No. 1 and 2	36.025199, −107.25302; 36.0348139, −107.2439777	2242	41
1944–1945	NMSA0366	Taylor	36.021371, −107.134455	896	38
1952–1955	NMSA0302, NMSA0303	Landers No. 1 and 2	36.025199, −107.25302; 36.0348139, −107.2439777	68	38
1957–1958	NMSA0302, NMSA0303	Landers No. 1 and 2	36.025199, −107.25302; 36.0348139, −107.2439777	271	41
1957–1958	NMSA0056	Jicarilla Apache	36.1229321, −107.2588777	309	36
1958–1959	NMSA0302, NMSA0303	Landers No. 1 and 2	36.025199, −107.25302; 36.0348139, −107.2439777	w	w
Total				3786	

This study reexamines sedimentary manganese deposits in the Cuba Manganese district as part of statewide studies of critical minerals. Furthermore, very little research on the geochemistry of these deposits is available to determine if additional critical minerals can be found in sedimentary manganese deposits (Cannon et al., 2017). This paper is one of the first to examine the geochemistry of the deposits and potential for additional critical minerals.

METHODS

Published and unpublished data on existing mines and mills within Cuba Manganese district were identified, plotted on base maps, and compiled in the New Mexico Mines Database (McLemore, 2017). Locations of mines were obtained from published and unpublished reports and patented mining claims files.

Mineralized areas were sampled and analyzed in this study for geochemical composition. Both composite and select samples were collected in 2024 (McLemore and Owen, 2024). Composite samples include collection along the width and thickness of the sedimentary layer or along a mine dump in order to obtain a representative sample (samples COAL370 and COAL372). Select samples included manganese nodules and petrified wood found in the area (samples COAL371 and COAL373). Samples were stored in plastic bags. Coordinates of sample locations and brief descriptions are presented in Table 2. Sample locations are shown in Figure 1.

Geochemical data are an important part of locating and evaluating critical mineral resources. Whole-rock major and trace element geochemical analyses of samples collected for this study were determined by the ALS Laboratory. Sample preparation occurred at the laboratory. Duplicate samples and internal standards were analyzed, and the uncertainty of the results was generally <5%. Specific analytical methods for each element are indicated in Table 3 and Appendix 1, and associated quality assurance and quality control are available on request. Chemical plots were created using ioGAS-64. Chemical analyses are presented in Table 3 and Appendix 1.

The mineralogy of selected samples was determined by visual, petrographic, and X-ray diffraction (XRD). Powder XRD analysis was conducted on either whole rock or mineral separates with a Panalytical X'Pert Pro® diffractometer at the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) XRD Laboratory using Cu Kα radiation and a tube power of 45 kV x 40 mA. Phase identification from XRD data was done using the HighScore Plus® software and the ICDD Powder Diffraction File database. An example diffractogram is shown in Figure 2.

HISTORY AND DESCRIPTION OF DEPOSITS

Four mine sites (i.e., deposits) are found in the Cuba Manganese district (Fig. 1): Landers No. 1, Landers No. 2, Taylor, and Jicarilla Apache (locations are in Table 1). In 1926, W. Crook staked the first claims, but production did not occur until 1942 (Farnham, 1961). Only the Landers No. 1 and Taylor deposits were examined and sampled in 2024; the roads were washed out leading to Landers No. 2 and the Jicarilla Apache deposit is in the Jicarilla Apache Nation.

The Landers No. 1 and No. 2 mines (also known as Crook No. 1 and Crook No. 2) were first mined in 1942 by R.E. Anderson of the Good Luck Mining Co. Ore was shipped to the Deming manganese stockpile. Between 1952 and 1955, Sterling C. Landers operated the mines until the Deming manganese stockpile closed in 1955. J.F. McRee then operated the mines. The mines consisted of open pits and trenches.

The Taylor mine (also known as Miller) was located in 1941 by Joel Taylor and leased to T.B. Everhart and D.B. Miller in 1943. Everhart and Miller mined the deposit in 1944 and 1945 by surface pits and trenches and shipped the ore to a mill near the paved highway. J.F. McRee then operated the mine again in 1957.

The Jicarilla Apache mine was operated by J.F. McRee in 1957 under a lease from the tribe. The ore was shipped to Socorro (Farnham, 1961).

The four manganese deposits are hosted in the Paleogene San Jose Formation, which is predominantly sandstone with interbedded shales mostly deposited by streams and on floodplains (Smith and Lucas, 1991). Manganese ore is generally found in 1–2-m-thick stratiform or blankets of rounded to subrounded nodules in shale or fine-grained sandstone, generally in pods less than 100 m long, few meters wide, and only thousands of metric tons in size. Farnham (1961) reported the manganese mineralization as psilomelane (a general term for a group of hard black manganese oxide minerals). Analyses by XRD indicated the primary manganese mineral is pyrolusite (Fig. 2). Other major minerals in the deposits include quartz, hematite/goethite, a spinel group mineral, clay, and albite.

The Cuba manganese deposits formed in reducing conditions where anoxic waters mixed with shallow oxygen-rich waters, which allowed the manganese to precipitate (Force and Cannon, 1988; Cannon et al., 2017). Stratigraphic studies by Smith and Lucas (1991) indicated that similar anoxic

TABLE 2. Location and brief description of samples collected from the Cuba Manganese district, Sandoval County, New Mexico. Latitude and longitude are in WGS83.

Sample ID	Date Collected	Date Analyzed	Chem Lab File No.	Latitude	Longitude	Method Collected	Sample Source	Sample Description
Coal370	10/9/2024	11/14/2024	RE24294640	36.021371	−107.134455	composite	outcrop	Mn from dump, Taylor
Coal371	10/9/2024	11/14/2024	RE24294640	36.025199	−107.25302	select	outcrop	Mn nodules, Landers No. 1
Coal372	10/9/2024	11/14/2024	RE24294640	36.025199	−107.25302	composite	outcrop	Mn sandstone bed, Landers No. 1
Coal373	10/9/2024	11/14/2024	RE24294640	36.025199	−107.25302	select	outcrop	fossil log, Landers No. 1

conditions were found in local stratified, lacustrine-deltaic environments in the San Jose Formation. These environments are rare in the San Jose Formation and not expected to contain large resources of manganese.

CRITICAL MINERALS POTENTIAL

Manganese concentrations of samples collected from two of the deposits range from 5 to >39 wt% MnO. Arsenic ranges from 3.5 to 206 ppm (Table 3; Appendix 1). Barium (6,190 to >10,000 ppm) and cobalt (32 to 354 ppm) are elevated in these deposits (Fig. 3; Appendix 1), but these concentrations are too low to be economic. Rare earth elements and other critical minerals are at normal concentrations for sedimentary deposits and are not economic (Fig. 4; Appendix 1). The Cuba manganese deposits are small in tonnage and have no economic potential at this time. There are no additional critical minerals known in the Cuba Manganese mining district as indicated by the chemical analyses (Table 3; Appendix 1). There is potential for finding additional subsurface sedimentary manganese deposits in the area, but they are likely to be small in tonnage and uneconomic because the local stratified, lacustrine-deltaic environments in the San Jose Formation hosting the manganese deposits are too small (Smith and Lucas, 1991) for the millions of tons of manganese ore needed to form an economic manganese deposit.

TABLE 3. Chemical analyses of major elements (in wt%) of samples collected from the Cuba Manganese district. Locations and brief descriptions of samples are in Table 1. Fe_2O_3T = total iron reported as Fe_2O_3. Major oxides were determined by XRF (X-ray fluorescence), S and C by combustion analysis by induction furnace, and LOI (loss on ignition) by furnace at 500ºC after sample was predried at 105ºC.

Sample ID/ Element	Coal370	Coal371	Coal372	Coal373
SiO_2	16.57	10.78	75.31	94.85
TiO_2	0.15	0.17	0.36	0.01
Al_2O_3	4.53	2.91	7.89	0.23
Fe_2O_3T	26.85	13.40	1.82	3.05
MnO	33.80	>39	5.29	0.12
MgO	0.16	0.13	0.36	0.03
CaO	1.22	1.00	0.59	0.06
Na_2O	0.09	0.08	1.43	0.09
K_2O	0.46	0.41	2.61	0.07
P_2O_5	0.72	0.66	0.06	0.03
LOI	10.65	10.69	2.46	0.77
S	0.40	0.50	0.04	0.22
C	0.10	0.05	0.04	0.14
Total oxides	95.7	79.78	98.26	99.67

CONCLUSIONS

The Cuba manganese deposits form in small, local lacustrine-deltaic environments where anoxic waters mixed with shallow oxygen-rich waters, creating reducing conditions that allowed the manganese to precipitate. Although the Cuba Manganese district has manganese concentrations similar to economic deposits (>39 wt% MnO), the deposits are small in tonnage and have no economic potential at this time. Barium and cobalt are elevated in these deposits, but the concentrations are too low to be economic. There are no additional critical minerals known in the Cuba Manganese mining district.

ACKNOWLEDGMENTS

This work is part of ongoing research on the economic geology of mineral resources in New Mexico at NMBGMR, Dr. Mike Timmons, Director and State Geologist. This study was

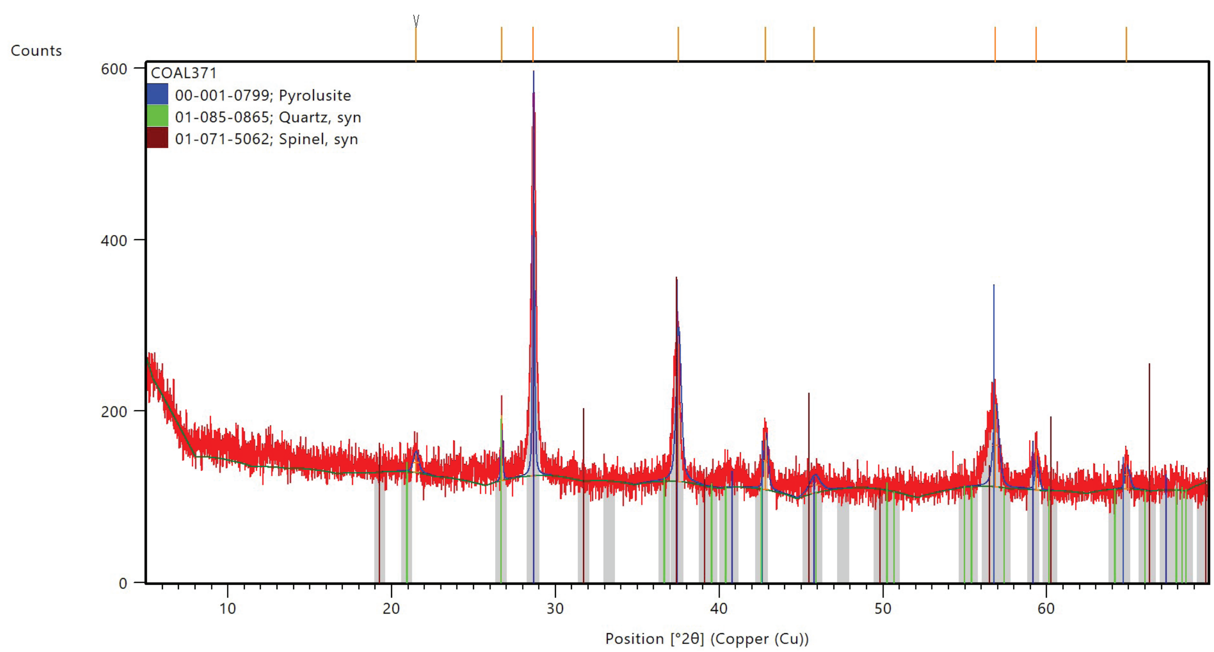

Figure 2. XRD (X-ray diffraction) diffractogram of sample COAL371.

partially funded by a Department of Energy contract—Carbon Ore, Rare Earth Elements, and Critical Minerals (CORE-CM) Assessment of San Juan River-Raton Coal Basin, New Mexico (DE-FE0032051). Thanks to Mark Leo-Russell for database support. Evan Owen assisted with field examination and sampling, and Rebecca Boakeye analysed samples for XRD. Students of the Bureau's Economic Geology Group inventoried, photographed, prepped, and shipped the samples. Thanks to John Rakovan, Kevin Hobbs, and Floyd Gray for reviewing an earlier version of this manuscript. The views and conclusions contained in this document are those of the author and should not be interpreted as representing the opinions or polices of the U.S. Department of Energy. Mention of trade names or commercial products does not constitute their endorsement by the Department of Energy or the New Mexico Bureau of Geology and Mineral Resources.

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Appendix can be found at
https://nmgs.nmt.edu/repository/index.cfml?rid=2025005

Yellow wild-indigo (*Baptisia sphaerocarpa*) above a meadow along Clear Creek in the Sierra Nacimiento above Cuba.