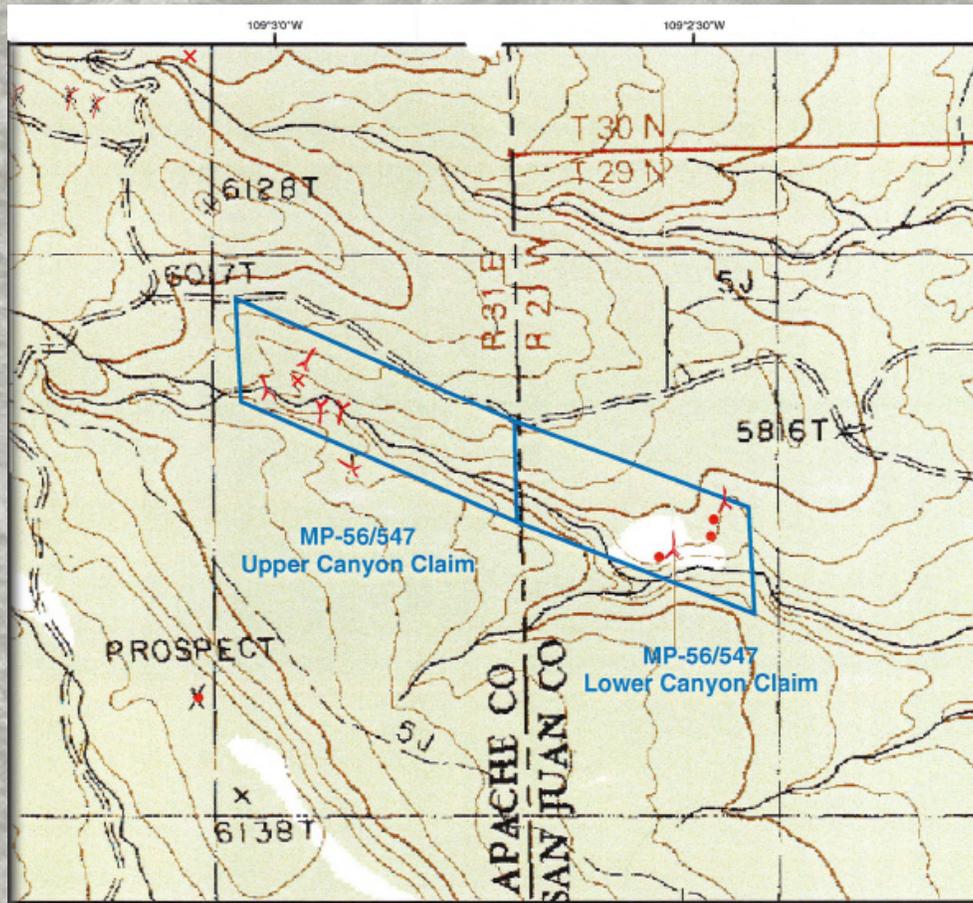


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Upper and Lower Canyon claims mine features.

THE GEOLOGY, EXPLORATION, AND PRODUCTION HISTORY OF THE UPPER AND LOWER CANYON URANIUM-VANADIUM MINES, APACHE COUNTY, ARIZONA AND SAN JUAN COUNTY, NEW MEXICO

September 2011

William L. Chenoweth

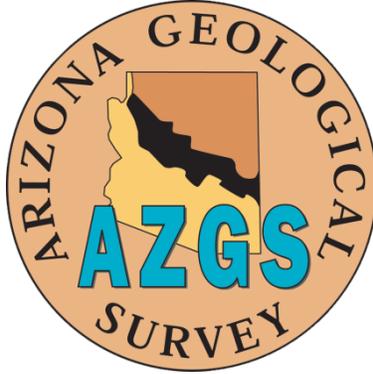
ARIZONA GEOLOGICAL SURVEY

Arizona Geological Survey Contributed Report CR-11-L

The Geology, Exploration, and Production History of
the Upper and Lower Canyon Uranium-Vanadium Mines,
Apache County, Arizona, and San Juan County, New Mexico

September 2011

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INTRODUCTION

The Upper and Lower Canyon mines were developed behind exposures of uranium–vanadium minerals, in the Salt Wash Member of the Morrison Formation, that were first described in 1944. Initial mining was in 1950. Drilling by U.S. Atomic Energy Commission (AEC) in 1953 located an orebody behind the workings of the Upper Canyon mine that was mined in 1955–1956. Mining resumed in late 1961 and continued until late 1964. This report is part of an ongoing study of the history of uranium mining on the Navajo Indian Reservation, Arizona and New Mexico.

Location

The Upper and Lower Canyon mines, also known as the Canyon mines, were located in a canyon north of Oak Springs in the eastern Carrizo Mountains (Figure 1). The Upper Canyon mines are Apache County, Arizona and the smaller Lower Canyon mines are in San Juan County, New Mexico (Figure 2). The canyon where the mines are located is south of a small mesa locally known as North Star Mesa. The uranium–vanadium mines on North Star Mesa have been described by Chenoweth [1999].

The Canyon mines are not shown on the Beclabito 7-1/2 minute topographic quadrangle [U.S. Geological, Survey, 1982]. The rim stripped area on the Upper Canyon tract (Figure 2) is located at latitude 36° 45' 33" N and longitude 109° 02' 50" W. When the mines were being operated they could be reached by a narrow mine road that turned off the Red Rock–Beclabito on the north side of the canyon and descended to the canyon floor.

Land Status

The Oak Springs area is located within the Navajo Indian Reservation. Mining permits and leases were issued by the Navajo Tribal Council and approved by the Bureau of Indian Affairs (BIA), U.S. Department of the Interior. Navajos individuals could obtain mining permits only. Permit holders could assign the mining rights to another individual or a company, like the permits, these assignments had to be approved by the Tribal Council and the BIA. Leases could be issued directly by the BIA. Permits were issued for periods up to 10 years. Any one company or individual could hold no more than 960 acres of tribal land. The permittee and the tribal received royalties from ore production. Based on the mine value of the ore, the tribe received between 10 and 20 percent royalties and the permittee between 2 and 5 percent royalties.

In addition to mining permits, the tribe issued drilling exploration permits. These permits were good for 120 days and were not renewable.

Previous Studies

The Lower Canyon mines in San Juan County, New Mexico have been overlooked in previous studies. Both Scarborough [1981] and Anderson [1980] did not look for the Lower Canyon workings, as they were lead to believe that all of the production was from the Upper Canyon tract in Apache County, Arizona. Chenoweth [1984] was unable to separate the ore production of the two canyon tracts in his summary of the uranium–vanadium mining in the eastern Carrizo Mountains.

Sources of Information

Most of the information presented in this report was obtained while the author was employed by the U.S. Atomic Energy Commission (AEC) and succeeding agencies: the U.S. Energy Research and Development Administration and the U.S. Department of Energy.

Information on the Mining Permits was obtained from the Navajo Tribal Mining Department, Window Rock, Arizona. Information on the mining activities, in 1963 and 1964, was obtained from AEC records in the National Archives, Rocky Mountain Region, Denver, Colorado. The author last examined the Upper Canyon mines in June 1980.

GEOLOGIC SETTING

The uranium–vanadium orebodies at the Upper and Lower Canyon mines located in the Salt Wash Member of the Upper Jurassic Morrison Formation. In the Oak Springs area, the Salt Wash Member is approximately 220 ft thick and consists of gray, fine-to very fine-grained, well rounded, quartz sandstone with interbedded lenses in beds of reddish–brown and greenish-gray mudstone and siltstone. The mudstone and siltstone beds comprise between 5 to 45 percent of the total thickness.

Huffman and others [1980] have subdivided the Salt Wash Member in the Carrizo Mountains into three stratigraphic units based on depositional environments. The lowermost unit is an average of 30 ft thick and was considered to be predominantly over bank deposits of alternating thin mudstone. It reportedly contains a few channel sandstones, however, the present author notes that this is lithologically distinct from the overlying ore–bearing unit. It, also, does not host any uranium–vanadium ore deposits. Investigations of the Morrison Formation by Anderson and Lucas [1998] have determined that this lower unit would be included with the underlying Bluff Sandstone and not with the Morrison Formation.

The middle stratigraphic unit is an average of 70 ft thick and is composed of channel-sandstone deposits, partially and completely abandoned channel-fill deposits, and overbank deposits. It resists with sharp erosional contact on the lower unit. Approximately 80 percent of the sandstone this unit is active channel fill in a generally eastward flowing fluvial system [Craig and others, 1955].

The upper unit is 120 ft thick. Most of the unit is composed of braided-stream deposits, and thin overbank deposits. Active channel-fill sandstone and conglomerates are also present. The sequence of stratigraphic units probably represent a prograding wet, alluvial fan [Huffman and others, 1980].

Drilling by the AEC in the area north of Oak Springs recognized a prominent channel sandstone which was informally named the C unit. The channel had east-southeast depositional trend based on drill hole information [Masters and others, 1955, p.43]. The Upper and Lower Canyon mines were located along the south edge of the C unit (Masters and others, 1955, p.43). The C unit had a maximum thickness of 28 ft and was within the middle unit of Huffman and others [1980].

The uranium-vanadium deposits were formed by the selected impregnation of the sandstone and absorption by the mudstone and fossil plant material. Detrital organic plant material, such as leaves, branches, limbs, and small trunks are common in the mineralized sandstone. Most of this material is carbonized. The larger deposits were commonly associated with plant material. Ore thickness at the Canyon mines ranged from featheredge to a maximum to 3 ft, with an average 1.5 ft.

The bright yellow uranium mineral in the Carrizo deposits was originally misidentified as carnotite, a potassium uranium vanadate. Later work by Corey [1958] and S.R. Austin [written

communication, 1967] identified tyuyamunite, a calcium uranium vanadate, and metatyuyamunite as the only uranium minerals in the Carrizo deposits. The mineralogy of the Nelson Point mine on King Tutt Mesa was studied by Corey [1956]. In this mine, vanadium clay and monrosite were present. These minerals oxidized to form a number of secondary vanadium minerals that include sherwoodite, duttonite, hewettite, metahewettite, rossite, metarossite, and hendersonite [Corey, 1958]. Calcite is common cement in ore. Pyrite, iron oxides, and gypsum also may be present.

The beds of Salt Wash at the Canyon mines dip six degrees to the southeast. This is due to the east-plunging Syracuse nose that is north of the mines. This nose is probably due to an unexposed igneous sill of the Carrizo laccolith.

EXPLORATION AND PRODUCTION HISTORY

During World War II the Army Corps of Engineers formed the Manhattan Engineer District (MED) for the development of atomic weapons and acquisition of raw materials for the production of weapons. The Murray Hill Area of MED was established on June 15, 1943 for the major purpose of the exploration and development of raw materials on which the entire Manhattan Project was dependent. Determination and evaluation of the uranium resources of the world was first undertaken, and the program was later expanded to include thorium ores.

Union Mines Development Corporation (UMDC), a subsidiary of Union Carbide and Carbon Corporation was contracted to carry out the work (Contract, No. W-7405, effective May 11, 1943). On the Colorado Plateau, UMDC's geologic investigations were limited to the Salt Wash Member of the Morrison Formation, and the Entrada Sandstone in the areas of the Colorado roscoelite deposits.

Geologic studies in the eastern Carrizo Mountains were done by Coleman [1944]. All the known exposures of uranium–vanadium minerals were described and their location plotted on base maps. In the canyon north of Oak Springs, Coleman [1944 p. 10,11] described five mineralized outcrops in the Salt Wash Member of the Morrison Formation (Table 1, Figure 3). The highest grade sample Coleman collected was from exposure E–SE–31 in New Mexico which was 2.3 feet thick and assayed 0.23 percent U_3O_8 and 4.53 percent V_2O_5 . This sample was taken in the area where the Lower Canyon mines would be developed.

On August 15, 1949, Cato Sells of Farmington New Mexico was granted unnumbered Navajo Tribal Mining Permit covering 647.2 acres. Besides the Upper and the Lower Canyon tracts, this permit covered a tract each on Mesa 5 and Mesa 6 in the Lukachukai Mountains, two tracts in the Saytah Wash area in the northwest Carrizo Mountains, two tracts near Oak Springs and a single tract covering the northern one third of Cove Mesa (Figure 1).

Between February and November 1950, Cato Sells produced 970.24 tons of ore averaging 0.14 percent U_3O_8 and 4.53 percent V_2O_5 from properties he identified to the ore buyer at Durango mill as Canyon, Canyon 1, Canyon 2, and Canyon 3 (Table 2). In correspondence with the AEC, Mr. Sells stated that all of these shipments came from his Upper Canyon and Lower Canyon tracts [Hill and Taylor, 1956].

In order to locate additional ore reserves in the King Tutt Mesa–Oak Springs area, the AEC conducted a diamond drill project in this area between February and August 1952. Known as the East Carrizo No. 1 Project, a total of 948 holes with a total footage of 100,030 feet were drilled (Masters and others, 1955). Only the middle and lower units of the Salt Wash were cored.

Using a cutoff of 1 ft of 0.10 percent U_3O_8 material, the AEC geologists calculated on orebody of 1,150 tons averaging 0.20 percent U_3O_8 and V_2O_5 with an average thickness of 1.5 ft behind the mine workings of the Canyon No. 1 mine. No ore was found behind the workings of the Canyon No. 2 mine [Masters and others, 1955]. The locations of these mines on a map of the drill holes [Masters and others, 1955, p.44] confirms that the No. 1 mine is on the Upper Canyon tract and the No. 2 mine is the Lower Canyon mine.

On August 6, 1952, Cato Sells renewed his unnumbered mining permit as Navajo Tribal Mining Permit No. 56. Although there was no mining in 1952, 1953 or 1954, Sells renewed this permit for another two years on August 6, 1954.

Using his own company miners, Cato Sells began mining the ore the AEC had discovered. Shipments commenced during August 1955 and continued until October 1956. Production during this period totaled 1,275.09 tons of ore that averaged 0.21 percent U_3O_8 and 2.22 percent V_2O_5 (Table 2).

On June 29, 1956, Albert Taylor, AEC engineer, mapped the mine workings on the Upper Canyon claim (Figure 4). The working consisted of two short adits, one large underground mine and two small rim stripped areas [Hill and Taylor, 1956].

After the mining ceased in late 1956, the Upper Canyon mine appeared abandoned when the author and other AEC geologists visited the property in 1957. On October 24, 1958, Cato Sells informed an AEC geologist that he may do some drilling near the Lower Canyon mine. Sells cancelled Mining Permit No. 56 on August 24, 1959. When an AEC geologist examined the property on June 10, 1960, he noted two adits and an inclined shaft on the Upper Canyon claim and a 50 ft long inclined shaft on the Lower Canyon claim.

On September 26, 1960, Cato Sells was issued a Navajo Tribal Mining Permit No. 547. This permit covered 135.27 acres that included 73.80 acres on the northern part of Cove Mesa, 41.81 acres of the Upper and Lower Canyon tracts and 20.66 acres of the Gravel Top tract near Oak Springs. The Cove Mesa tract was assigned to VCA on March 16, 1961.

Late in 1961, Cato Sells made his final shipments from the property. A 13.06 ton shipment identified as Upper and Lower Canyon averaged 0.14 percent U_3O_8 and 1.19 percent V_2O_5 (Table 1). Total production from the property by Cato Sells was 2,258.39 tons of ore that averaged 0.18 percent U_3O_8 and 2.25 percent V_2O_5 (Table 2). All of these shipments were made to the mill at Durango, Colorado operated by Vanadium Corporation of America.

On April 3, 1962, W.D. Tripp, Cortez Colorado, was issued the assignment of the mining rights to the Upper and Lower tracts of Tribal Mining Permit No. 547. Operating as Tripp Mining Company, Mr. Tripp did some drilling on the property in late 1962 and began shipments from the Lower Canyon mine. Shipments continued through March 1963 when a small shipment was made from a Upper Canyon mine.

On July 1963, Tripp made his final shipment from a Lower Canyon mine. In January through April 1964, Tripp made shipments from the Upper Canyon mines (Table 2). When Tripp completed mining in April 1964 he had produced a total of 536.27 tons of ore averaging 0.13 percent U_3O_8 and 1.24 percent V_2O_5 from the Upper and Lower Canyon mines. All his shipments were to the mill at Shiprock, New Mexico which was operated by Kerr- McGee Oil Industries, Inc. until March 1963 when it was purchased by VCA.

A map of the Canyon claims (Figure 2) prepared by the Navajo Abandoned Mine Lands Reclamation Program in 2003 shows four underground mines and rim stripped area on the Upper Canyon claim, two underground mines, and three prospects on the Lower Canyon claim. An

underground mine southeast of the Upper Canyon mines (Figure 2) is the Leroy incline on Leroy Pettigrew's Navajo Tribal Mining Permit No. 552. This mine, operated by the Davis Mining Company, Dove Creek, Colorado, shipped 25.32 tons of ore averaging 0.19 percent U_3O_8 and 2.43 percent V_2O_5 during last quarter of 1961.

Two prospects are shown on the topographic base map south of the Upper Canyon claim (Figure 2). These are gravel pits used in road construction of the Oaks Springs–Red Rock road.

SUMMARY

Based on available information, it appears that the mines on the Upper Canyon tract produced 2,440.37 tons of ore averaging 0.17 percent U_3O_8 and 2.12 percent V_2O_5 , while the mine on the Lower Canyon tract shipped 354.29 tons averaging 0.15 percent U_3O_8 and 1.67 percent V_2O_5 (Table 3). This compilation assumes that the 1953 shipment marked Canyon No. 3 came from the Upper Canyon tract and the 1961 shipment had equal amounts of ore from both tracts.

All of the uranium recovered from the Canyon mines ore at the Durango, Colorado and Shiprock, New Mexico mills was sold to the AEC. At the Durango mill, the vanadium that was produced was sold to the steel industry. Excess vanadium concentrate was sold to the AEC. At Shiprock, vanadium was paid for but not all of it was recovered [Albethsen and McGinley, 1982].

Acknowledgments

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Madeline Roanhorse, Manager of the Navajo Abandoned Mine Lands Department, Window Rock, Arizona, graciously allowed the departments contractors, the U.S. Corps of Engineers and TerraSpectra Geomatics, to provide a copy of Figure 2 to the author for this report.

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APPENDIX

Legal Description Upper and Lower Canyon Claims Navajo Tribal Mining Permit No. 56

“Upper Canyon Claim: Beginning at corner No. 1 which bears N.0° 08'E, 1222 ft, north of the Arizona-New Mexico State line Mile post No. 17. The said corner No. 1 also being 121 ft. south along the said State line from a point where State line intersects the Red Rock and Beclabito Road. From corner No. 1 by metes and bounds, N65° 00'W., 1800 ft. to corner No. 2; S.0° 08' W., 600 ft. to corner No. 3; S65° 00'E., 1800 ft. to corner No. 4; N.0° 08'E., 600 ft. to corner No. 1, the place of beginning. This tract as described being in Apache County, Arizona and contains 22.5 acres.

Lower Canyon Claim: Beginning at corner No. 2 which bears N.0° 08'E., 1222 ft. north of the Arizona-New Mexico State line Mile post No. 17. The said corner No. 1 also being 121 ft. south along the said State line from a point where State line intersects the Red Rock and Beclabito Road. From corner No. 1 by metes and bounds, S69° 00'E., 1500 ft to corner No. 2; S.0° 08'W, 600 ft to corner No. 3; N69° 00'W., 1500 ft. to corner No. 4; N.0° 08'E., 600 ft. to corner No. 1, the place of beginning. The tract as described being in San Juan County, New Mexico and contains 19.31 acres.”

From Navajo Tribal Mining Department

Table 1. Samples from the area where the Canyon mines would be developed [Coleman, 1944].

Sample Locality	Description
S-E-29	Outcrop 110 ft in length, thickness averages 0.25 ft except as below. Area a, outcrop 40 ft, in length, 0.2 to 2.5 ft in thickness. Sample No. 1371, 1.1 ft, 0.09 % U ₃ O ₈ , 1.59 % V ₂ O ₅ . Area f, outcrop poorly exposed for 20 ft, 0.6 to 4.0 ft in thickness. Sample No. 1392, 1.0 ft, 0.07 % U ₃ O ₈ , 1.68 % V ₂ O ₅ .
S-E-30	Outcrop 90 ft in length, maximum thickness 0.1 ft. Not sampled, estimated grade 2.00 % V ₂ O ₅ .
S-E-31	Outcrop 20 ft in length, 1.0-4.0 ft in thickness. Sample No. 1376, 2.3 ft, 0.23 % U ₃ O ₈ , 4.53 % V ₂ O ₅ .
S-E-32	Area a, outcrop 20 ft in length, 0.4 to 1.4 ft in thickness. Sample No. 1381, 1.4 ft, 0.21 % U ₃ O ₈ , 1.25 % V ₂ O ₅ . Area b, outcrop 50 ft in length, 0.4 to 1.7 ft in thickness. Sample No. 1383, 1.3 ft, 0.06 % U ₃ O ₈ , 1.37 % V ₂ O ₅ .
S-E-33	Outcrop 20 ft in length, 0.5 to 1.5 ft in thickness. Sample No. 1372, 1.5 ft, 0.04 % U ₃ O ₈ , 1.16 % V ₂ O ₅ .
See Figure 3 for sample locations. Chemical assays by Linde Air Products Company, Tonawanda, New York. Uranium oxide originally reported as % SOQ.	

**Table 2. Uranium-Vanadium production, Upper and Lower Canyon Mines
Apache County, Arizona and San Juan County, New Mexico**

Year	Qtr	Mine	Operator	Tons of ore	Pounds U₃O₈	% U₃O₈	Pounds V₂O₅	% V₂O₅
1950	1	Canyon	Cato Sells	116.17	181.61	0.08	4,969.00	2.14
1950	1,2	Canyon 1	Cato Sells	779.02	2,203.00	0.14	35,851.00	2.30
1950	3	Canyon 2	Cato Sells	54.68	264.84	0.24	3,393.00	3.10
1950	3	Canyon 3	Cato Sells	20.37	121.49	0.30	871.00	2.14
1955	3	Upper	Cato Sells	7.99	28.75	0.18	349.83	2.19
1955	4	Upper	Cato Sells	78.15	273.20	0.17	3,307.89	2.12
1956	1	Upper	Cato Sells	414.18	1,459.00	0.18	15,389.66	1.86
1956	2	Upper	Cato Sells	495.17	2,248.12	0.24	23,095.52	2.33
1956	3	Upper	Cato Sells	262.58	1,129.64	0.22	13,827.79	2.63
1956	4	Upper	Cato Sells	17.02	53.46	0.16	579.02	1.70
1961	4	Upper & Lower	Cato Sells	13.06	35.27	0.14	311.00	1.19
1962	4	Lower	Tripp Mng Co.	75.67	164.44	0.11	2,182.00	1.44
1963	1	Lower	Tripp Mng Co.	111.32	250.64	0.11	3,413.00	1.53
1963	2	Lower	Tripp Mng. Co.	90.43	329.44	0.18	2,064.00	1.14
1963	2	Upper	W.D. Tripp	17.59	52.76	0.15	584.00	1.66
1963	3	Lower	Tripp Mng. Co.	15.66	64.50	0.21	611.00	1.95
1964	1	Upper	W.D. Tripp	202.61	455.41	0.11	3,841.00	0.95
1964	2	Upper	W.D. Tripp	22.99	80.00	0.17	602.00	1.31
Total				2,794.66	9,495.57	0.17	115,251.71	2.06

Source: Unpublished ore production records, U.S. Atomic Energy Commission, Grand Junction office

Table 3. Estimated Ore Production by Claim, Upper and Lower Canyon Mines Apache County, Arizona and San Juan County, New Mexico

Claim	Tons of Ore	Pounds U₃O₈	% U₃O₈	Pounds V₂O₅	% V₂O₅	Years of Shipments
Upper Canyon	2,440.37	8,404.07	0.17	103,433.71	2.12	1950, 1955-56 1961, 1963-64
Lower Canyon	354.29	1,091.50	0.15	11,818.00	1.67	1950, 1961-63
Total	2,794.66	9,495.57	0.17	115,251.71	2.06	

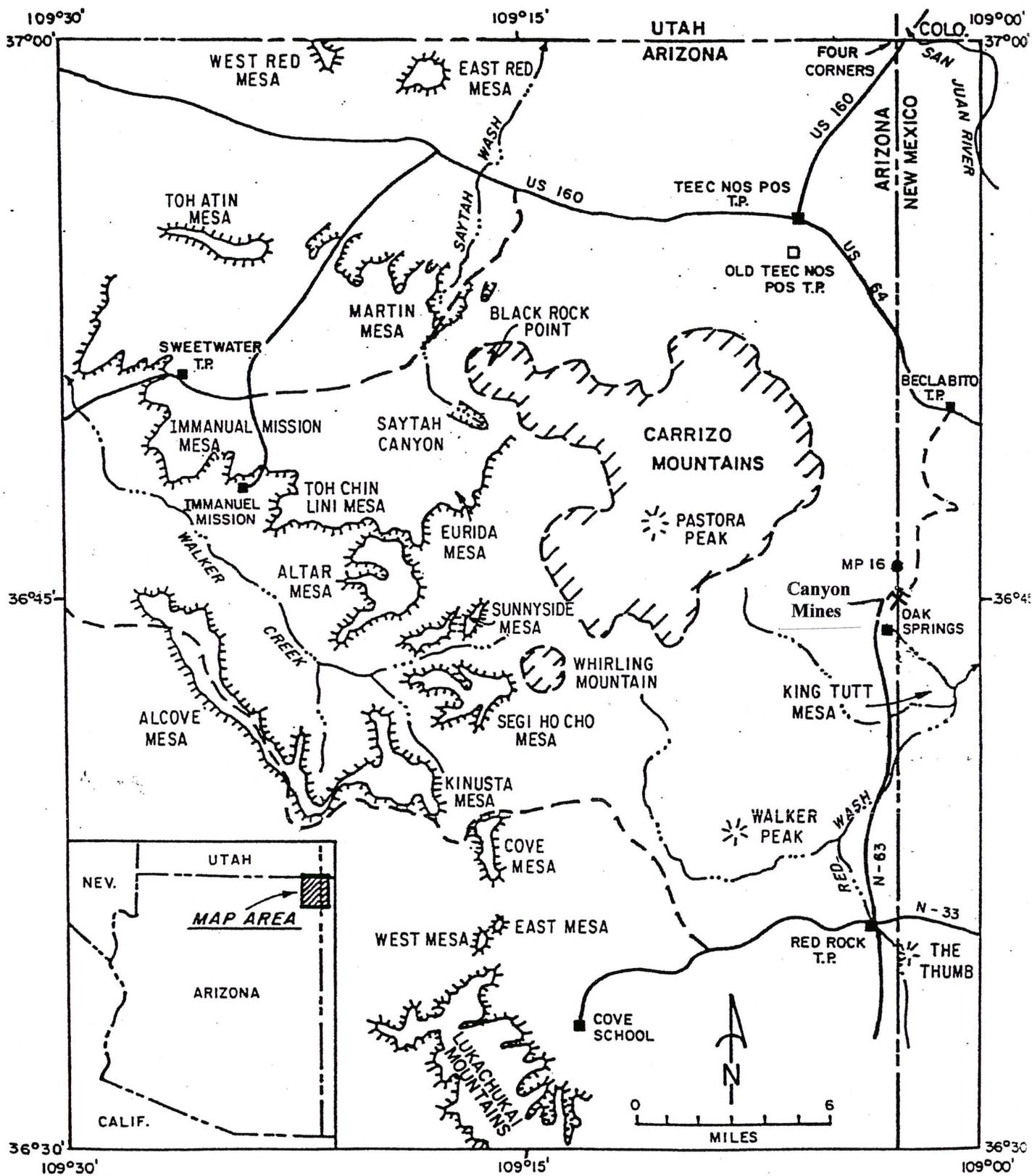


Figure 1. Index Map of the Carrizo Mountains, Arizona – New Mexico Showing the Location of the Upper and Lower Canyon Mines

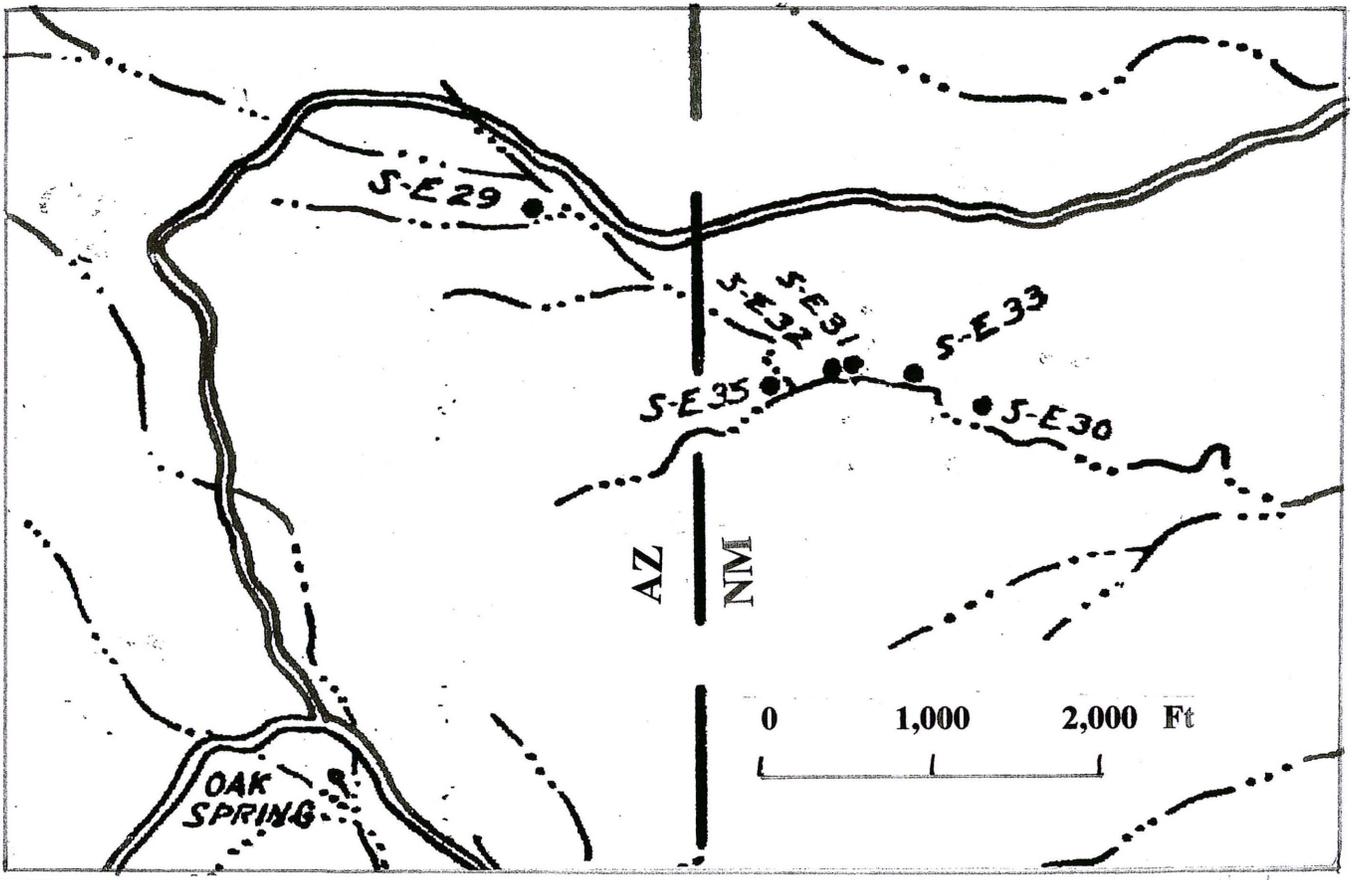
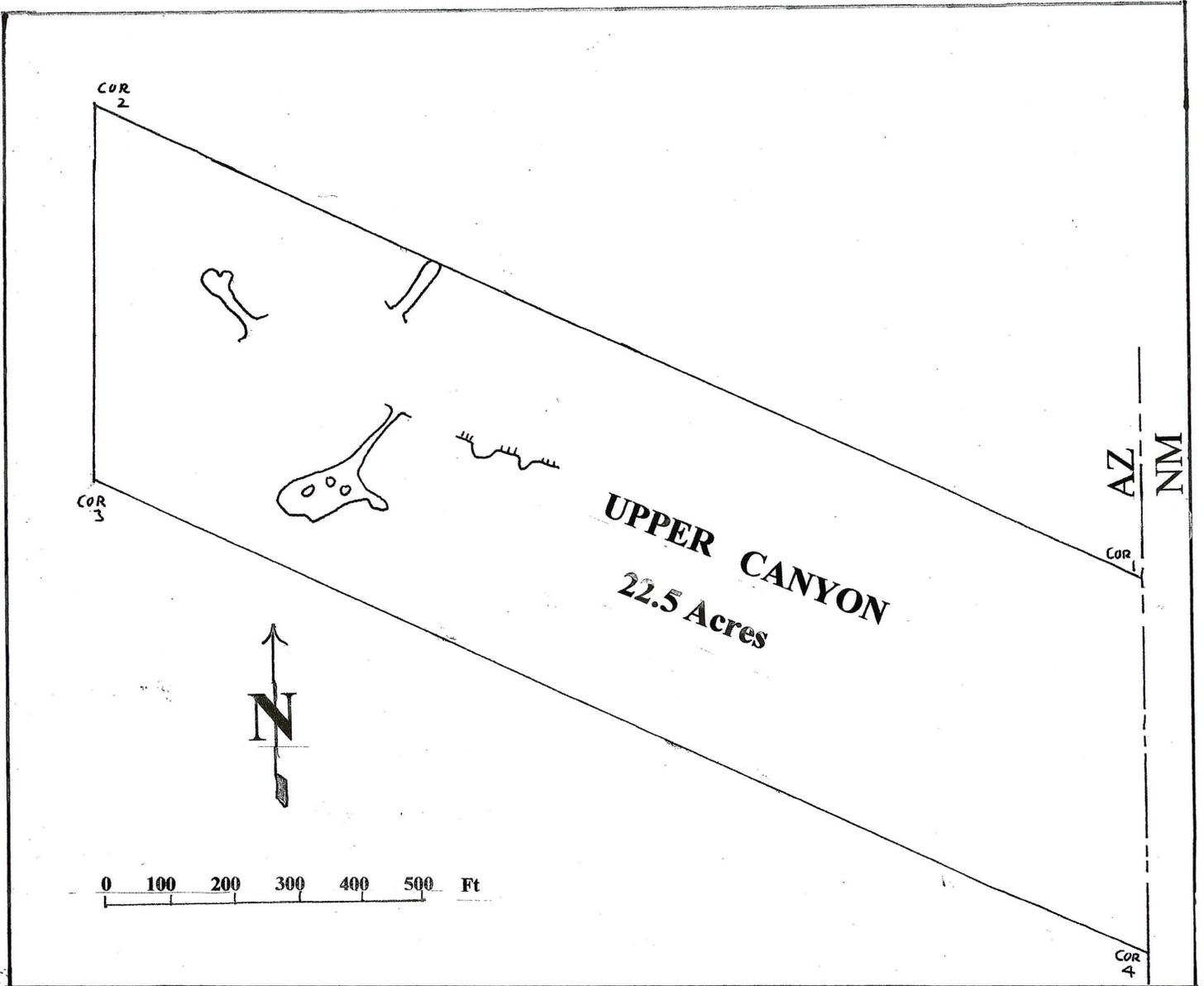
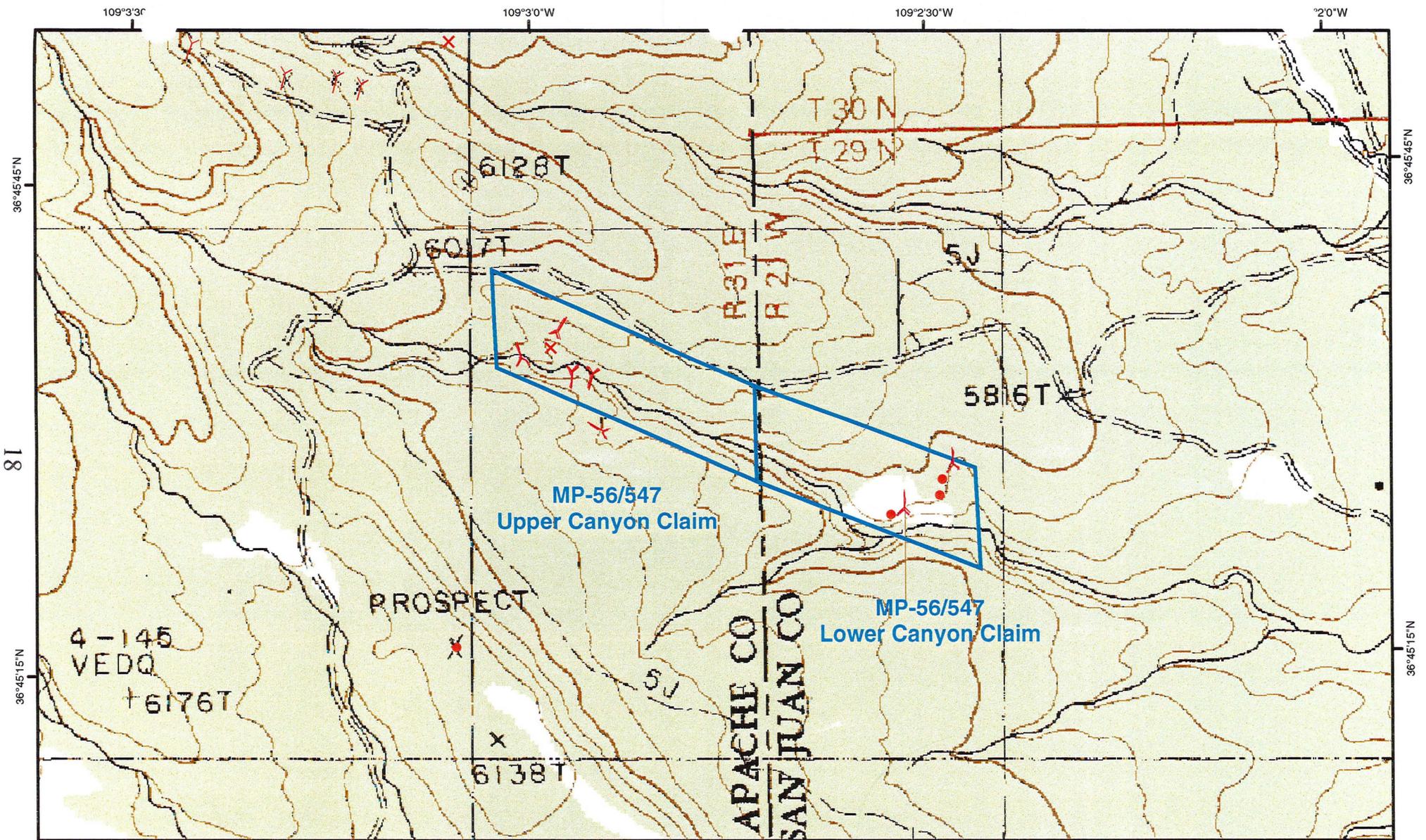


Figure 3. Map showing the location of samples taken in 1944,
(From Coleman, 1944, map NMex-CU-9)



**Figure 4. Map Showing the working of mines on the Upper Canyon Claim,
(From Hill and Taylor, 1956)**



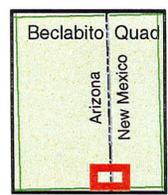
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UPPER AND LOWER CANYON CLAIMS MINE FEATURES

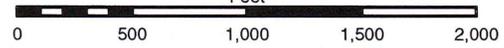
Figure 2

Mine feature information from the Navajo Abandoned Mine Lands Reclamation Program (2003). Mining Permit boundary from McLemore (1983), Hill & Taylor (1956), and Masters & others (1955). The map background is a 1:24,000 scale USGS topographic map (Beclabito, AZ-UT, 1997).

Transverse Mercator Projection, UTM Zone 12, NAD83 Datum. Map produced by TerraSpectra Geomatics, January 28, 2004.



Map Location



Scale 1:10,000

Navajo AML Mines Features

-  Adit / Incline
-  Prospect
-  Rim Strip / Pit
-  Mining Permit Boundary