HISTORICAL REVIEW OF URANIUM-VANADIUM PRODUCTION IN THE EASTERN CARRIZO MOUNTAINS, SAN JUAN COUNTY, NEW MEXICO, AND APACHE COUNTY, ARIZONA

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with

production statistics

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Introduction

In 1980, a report with the same title was open-filed by the Grand Junction Office of the U.S. Department of Energy (DOE) as Technical Memorandum No. 210. Since this report was released, considerable amount of new information bearing on the early mining history of the Carrizo Mountains has become available.

The principal source of new data is a detailed report prepared by the General Services Administration (GSA), Indian Trust Accounting Division for the Navajo Tribe. This document (GSA, 1981) was admitted as evidence in U.S. Claims Court, Navajo Tribe vs United States, Docket Nos. 69 and 299 (copper, vanadium, uranium, sand, rock and gravel claims) held in Albuquerque, New Mexico, February 24-March 4, 1983. A copy of the vandium and uranium section was obtained for the New Mexico Bureau of Mines and Mineral Resources.

A review of the Vanadium Corporation of America's (VCA) 1947-1953 mill receipts to the Atomic Energy Commission (AEC), located in the DOE archives at Grand Junction, added to our knowledge of the early mining, especially in terms of names of the individuals who operated the VCA mines under contract.

As this report deals only with historical production data, the reader is referred to reports by Blagbrough and Brown (1955), Corey (1958), King (1951, 1952), Masters and others (1955), and Stokes (1951, 1954) for descriptions of the geology and ore

deposits. A report by Albrethsen and McGinley (1982) gives the details of the AEC's uranium procurement program, and a report by Anderson (1981) describes the current condition of the mines. Figure 1 shows the locations of the mines; the production is summarized in Table 1 and Figure 2.

A DOE report (Chenoweth and Learned, 1980) covers the production history of the northern and western Carrizo Mountains, and will be revised in the near future.

Early Prospecting

Outcrops containing uranium/vandium minerals in the Carrizo Mountains were discovered by John Wade of Sweetwater, Arizona, around 1918. At that time the Navajo Reservation was closed to prospecting and mining. A Congressional Act of June 30, 1919, opened the Navajo Reservation to prospecting and locating mining claims in the same manner as prescribed by the United States Mining Law. This act allowed prospectors to enter the Reservation and stake a mining claim if their prospecting located promising mineralization. The locator of the claim then obtained a lease on this land under terms that included escalating advance royalties and rentals, and annual work commitments.

By 1920, Wade, operating as the Carriso Uranium Company, had located 40 claims astride the New Mexico-Arizona state line in the vicinity of Milepost 16.

In April 1921 the area was examined by W. H. Staver, a consulting mining engineer. He noted that the company's holding consisted of the South Butte, Bluebell, North Star, and Hilltop

claim groups. The North Star claims were astride the state line, with five in New Mexico and six in Arizona, and contained the only development. Thirty-seven sacks of high-grade ore from these claims were stored at Beclabito Trading Post (Staver, 1921). He estimated that a total of 2,900 tons of probable ore could be developed on the property.

The GSA (1981) could not locate the details of the Carriso Uranium Company's lease, except for the first year's rental on 177.45 acres paid in May 1922. No production was recorded, and the disposition of the sacked ore at Beclabito is not known.

Two other companies acquired leases in the eastern Carrizos during the early 1920's. The Navajo Mining Company leased 80 acres on April 6, 1921, effective May 10, 1921. The 80 acres included four contiguous claims in sections 29 and 30, T. 13 N., R. 5 W., Navajo Baseline and Meridian, in Apache County, Arizona. The four claims, Navajo Mining Claim, Navajo Mining Claims 1, 2, and 4, were covered by U.S. Mineral Survey Number 3643. It appears that this lease was approximately two miles west of Beclabito Trading Post in the vicinity of Milepost 12. The GSA (1981) report notes that 1,500 pounds of ore was shipped from the lease in April 1921. This is the first recorded shipment of uraniferous material from the eastern Carrizo Mountains. The value of the ore was listed as $68.33 (GSA, 1981).

By 1922 the radium industry in southwestern Colorado was beginning to decline as the carnotite ores were no longer competitive with the newly developed high-grade pitchblende ore in the Belgian Congo. A vanadium market never developed, as there was little demand for domestic vanadium due to imports from Peru.

In spite of the lack of demand for carnotite ores, George O. Williams and Nephi Johnson leased 20.661 acres on June 8, 1923, effective January 22, 1924. This lease covered the Upper Bell Lode Claim of U.S. Mineral Survey Number 1887. The only description of the location is in T. 11 N., R. 5 W., Navajo Baseline and Meridian, San Juan County, New Mexico. Since King Tutt Mesa is located in the north-central part of this township, it is very possible that the lease was located here. No production was located by the GSA (1981), but an Office of Indian Affairs memorandum of December 4, 1936 (in GSA, 1981) noted a 20-ft-deep shaft, or hole, had been dug on the claim, and about one ton of ore had been hauled to Durango, Colorado.

On March 25, 1936, the Secretary of the Interior closed the Navajo Indian Reservation to claim location and prospecting for minerals until further authorization. In July, 1936, an application to prospect was made to the Executive Committee of the Navajo Tribal Council in the form of asking the council to pass a resolution requesting the Secretary of Interior to open the Navajo Reservation for mining to the applicant. The resolution was rejected by the Executive Committee, which evidently did not want prospecting or mining on the Reservation at that time.

Vanadium Mining

By the late 1930's, the mines in the carnotite region of southwestern Colorado and southeastern Utah were being reopened for their vanadium content. At the same time, the Secretary of

the Interior was being asked to open the Navajo Indian Reservation for prospecting and mining.

The Navajo Reservation was opened by a Congressional Act of May 11, 1938, but with new procedures. This act gave the Tribal Council the authority to enter into leases for the Reservation lands with approval of the Secretary of the Interior. Prospectors no longer could enter the Reservation and stake a mining claim under regulations similar to those of the United States Mining Law. The new mining regulations contained escalating annual rentals, a base royalty of 10% (mine-mouth value), bond requirements, acreage limitations, and a term of 10 years which could be extended by production.

Due to the uncertainty of foreign supplies and the need for vanadium for war armaments, the federal government formed the Metals Reserve Company in 1942. The company began an ore-purchasing program and increased the base price paid for vanadium ore. At Monticello, Utah, the Defense Plant Corporation, a government agency, funded the construction of a vanadium plant to be operated by the Vanadium Corporation of America (VCA). Actual construction started in February, and on August 24, 1942, the first vanadium was produced. In April 1942, while construction was under way, the Metals Reserve Company (MRC) established an ore-buying station at Monticello and appointed the United States Vanadium Corporation (USV) as its buying agent. All ore producers, independents and VCA, then sold ore to the MRC. MRC in turn had the ore milled by VCA or other mills.

At Durango, Colorado, the Reconstruction Finance Corporation, a government agency, contracted with USV to convert

and operate an old lead smelter for vanadium production. The vanadium was supplied to Metals Reserve Company. United States Vanadium operated the plant for the government until early 1944, when the government vanadium purchasing program was terminated because of adequate vanadium stocks. U.S. Vanadium Corporation then purchased the facilities from the Reconstruction Finance Corporation and operated them for the production of vanadium for commercial sales until August 31, 1945, when the plant was closed.

The Metals Reserve's program was the stimulus to revive mining in the Carrizos.

On April 5, 1940, effective May 9, 1940, John F. Wade, Thomas F. V. Curran, and H. R. Redington (d.b.a. Wade, Curran and Co.) leased 42.32 acres in the Carrizo Mountains. Their lease, I-149-IND-4225, covered the Syracuse Lode Claim near MP-16 and the Sunnyside Lode Claim in the western Carrizos. The lease was for a period of five years.

Production from the two claims is not separated, but John Wade (pers. comm., 1955) stated the Syracuse was the first property to be mined. It was also one of the properties prospected by Wade's Carriso Uranium Co. in the 1920's. Shipments from Lease I-149-IND-4225 were recorded from May 1942 through October 1943. Details of the production are given below.

TABLE 2

Vanadium Production 1942-1943,
Lease I-149-IND-4225,
Wade, Curran and Co.

Year	Tons of Ore	Pounds V_2O_5	Percent V_2O_5
1942	246	44,075	8.96
1943	720	40,343	2.80
Totals	966	84,418	4.37

Source: GSA (1981)

Ore mined by Wade, Curran and Company was shipped by truck and rail to the mill at Durango, Colorado. Lease I-149-IND-4225 expired on May 9, 1945.

On April 9, 1941, the Navajo Tribal Council requested the Secretary of the Interior to lease lands for mining purposes to the highest bidder. In order to take care of this situation, the mining leases were written for large areas and subsequently reduced in acreage at the end of a specified time period. The net effect of this type of lease was that a prospecting permit was issued to the highest bidder, who then had the right to lease land within the permit area up to a maximum acreage.

On May 29, 1942, in response to requests by mining companies, the Office of Indian Affairs advertised an exploration lease sale for carnotite and related minerals in the eastern Carrizo Mountains. The area offerred was described as follows: "beginning at a point on the New Mexico-Arizona State Line which is approximately 8 1/3 miles south of the corner common to the states of Colorado, Utah, New Mexico, and Arizona; thence east 6 miles; thence south 12 miles; thence west 6 miles to the Arizona-New Mexico state line; thence west 3 1/2 miles; thence north 2

miles; thence east one mile; thence north 10 miles; thence east 2 1/2 miles to the Arizona-New Mexico state line and in the point of beginning." The area contained approximately 104 square miles. This was the second cavnotite lease sale for Navajo lands held under the bidding procedures. The first was held in November 1941 in the northern and western Carrizo Mountains.

Bids were opened on June 15, 1942, at which time VCA bid $7,600, and John F. Wade and Thomas F. V. Curran, partners, bid $7,550 (GSA, 1981, exhibit 31). As the bids were nearly equal, and since Wade and Curran offered to pay $2,000 over and above the highest bid received, the General Superintendent of the Navajo Service requested that the Commissioner of Indian Affairs make the decision to award the lease. VCA was awarded the lease I-149-IND-5705, which was executed on July 14, 1942, effective July 23, 1942, for a period of 10 years. Mining commenced in August of that year and continued through August 1944. Single shipments were also recorded in February 1945 and in July 1947.

Lease I-149-IND-5705 was commonly referred to as the "East Reservation Lease" by VCA. Details of the vanadium production are tabulated below.

TABLE 3
Vanadium Production 1942-1947,
VCA's East Reservation Lease

Year	Tons of Ore	Pounds V_2O_5	Percent V_2O_5
1942	2,063	100,069	2.43
1943	7,082	346,730	2.45
1944	1,056	56,818	2.69
1945	15	582	1.94
1946	0	0	0
1947	15	623	2.08
Totals	10,231	504,822	2.47

Source: 1942-1945; GSA (1981)
1947; USGS memo dated June 2, 1948 (in DOE files)

On September 2, 1943, the lease was reduced to a permanent operating lease and 12 plots (claims) totalling 436.79 acres were selected to be retained. Details of these plots are given below.

TABLE 4

Location and Size of Plots,
VCA's East Reservation Lease

Number	Name	Acres	Location
1	Red Wash Point	3.53	SE King Tutt Mesa
2	King Tutt Point	9.14	SW King Tutt Mesa
3	Shadyside	145.13	Central King Tutt Mesa
4	Williams Point	8.62	N. Central King Tutt Mesa
5	Fissure	1.57	N. Central King Tutt Mesa
6	Franks Point	6.23	NW King Tutt Mesa
7	Lower Oak Creek	205.39	Oak Creek Canyon
8	Cottonwood Butte	20.66	Cottonwood Butte
9	Lone Star	6.20	E of MP-16
10	Oak Springs	5.53	Oak Springs
11	White Cap	20.66	SW of MP-16
12	Syracuse	4.13	W of MP-16
	Total	436.79 acres	

Three of the plots near Milepost 16 (9, 11, and 12) covered the remainder of the area previously developed by the Carriso Uranium Company on their North Star claims.

The ore from the East Reservation lease was trucked to the

mill at Monticello, Utah, until it closed in February 1944. Later production in 1944 and 1945 was shipped to the Durango plant, and the 1947 production went to VCA's vanadium mill in Naturita, Colorado.

The Metals Reserve's program terminated in March 1944, at which time vanadium mining all but ceased in the Carrizo Mountains.

U.S. Geological Survey Studies

As part of the U.S. Geological Survey's (USGS) investigations of critical war materials, the uranium-vanadium deposits of the Carrizo Mountains were examined during October and November 1942.

The USGS geologists examined and mapped the existing mines, and acquired production history and statistics from the mine operators. Estimates of the vanadium-ore reserves also were made. For the eastern Carrizo Mountains, they are as follows:

	Inferred Ore		Indicated Ore	
Area	Tons	% V_2O_5	Tons	% V_2O_5
Eastside Mines	5,000	2-2.5	25,000	1.5-2.5
Syracuse Mine	600	2-2.5	1,500	2.0-2.5
Horse Mesa	600	2-2.5	9,000	1.5-2.5
Total	6,200	2	35,500	2

The mines on, and in the vicinity of, King Tutt Mesa were referred to as the Eastside Mines, a name still used in recent USGS reports.

The detailed results of the October-November 1942 investigations are in a report by Duncan and Stokes (1942), which

was submitted to the Manhattan Engineer District. The general geology and the description of the ore deposits was later published by Stokes (1951).

Manhattan Engineer District Activities

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 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.

A contract, No. W-7405 Eng-78, effective May 11, 1943, was made with Union Mines Development Corporation (UMDC), a subsidiary of Union Carbide and Carbon Corporation, for carrying out the work. The contract provided that all costs should be reimbursed by the government, with no fixed fee or profit to UMDC.

On the Colorado Plateau, UMDC's investigations were limited to the Salt Wash Member of the Morrison Formation, and the Entrada Sandstone in the area of the roscoelite deposits.

Geologic studies for the eastern Carrizo Mountains are contained in a report by Coleman (1944). All of the known outcrops of uranium/vanadium minerals, prospects, and mines were mapped and described by UMDC geologists. The geologists mapped

the Syracuse Mine of Wade, Curran and Co. and described small adits on VCA's Plots 9 and 12, five small open pits and an adit on Plot 7, two open cuts and an adit on Plot 3, and a small adit on Plot 1.

Of the 128 uranium-vanadium-bearing outcrops examined by UMDC, 59 were on ground leased by VCA, and Wade, Curran and Co. The remaining 69 exposures were considered to be "relatively unimportant and have a poor prospective value" (Coleman, 1944, p. 19).

As part of their investigations, UMDC geologists recommended areas that should be acquired by the Federal government for the development of uranium resources. In the Carrizo Mountains, UMDC selected 12 plots from exploration lease I-149-IND-6197 issued to Curran Brothers and Wade, with 2/3 interest assigned to USV. This lease, containing 168 square miles, was 24 miles long, north-south, and 7 miles wide, east-west with the southeast corner located near Cove School (Fig. 1).

Although Coleman (1944, p. 20) considered the Syracuse Mine "to have the best prospective value of anything seen on the Navajo Reservation," it was not acquired since the property was located outside the exploration lease boundary.

Late in 1942 and early in 1943 the Manhattan Engineer District (MED) began a program to obtain uranium from domestic sources. In January 1943, VCA agreed to produce a uranium-vanadium (U-V) sludge at Monticello that was sold by MRC to MED on a unit price basis. The sludge contained 45 to 50% U_3O_8 and about 25% V_2O_5 and was shipped to the Vitro Manufacturing Company at Canonsburg, Pennsylvania, for additional processing. Tailings

from the Monticello mill were considered by the MED to be too low in uranium for additional processing. In February 1944, MRC closed the Monticello mill and ceased production of both fused oxide (V_2O_5) and U-V sludge.

In 1945, VCA leased the Monticello mill from the Defense Plant Corporation and purchased from MRC the remaining ore stockpiles. VCA processed the stockpiled ore plus ore from other sources and sold a U-V sludge to the MED until the mill closed again in 1946.

During the 1943-1944 period, USV constructed and operated a uranium-vandium sludge plant at the Durango site, under a cost-plus-fixed-fee agreement with the MED. Feed for the plant consisted of vanadium tailings from past and current operations. The sludge was shipped to a refinery at Grand Junction, Colorado, also operated for the MED by USV, where the vanadium was removed to make the sludge suitable for further refining to black oxide.

Uranium Mining

The Atomic Energy Commission was established by the Atomic Energy Act of August 1, 1946, in recognition of a need to provide for a civilian government agency which could assure the continued development of atomic energy for military purposes and also promote the research and development necessary to the utilization of atomic energy for peaceful applications.

During World War II, the Manhattan Engineer District (MED), under the Army Corps of Engineers, had been charged with the development of atomic weapons. Its activities included research and development, engineering and design, the operation of

production facilities for weapons materials and components, and the acquisition of uranium for the production of nuclear weapons.

All of these MED functions, and the numerous government-owned facilities in which many of them were being performed, were transferred to the AEC by Executive Order 9816, effective at midnight, December 31, 1946. An Office of New York Directed Operations was established by the AEC on June 9, 1947, and that office supervised the procuring and processing of uranium until the AEC's Division of Raw Materials was formed in October 1947 to direct those activities from the AEC's Headquarters Office in Washington, D.C.

On the Colorado Plateau, the AEC began a procurement program for uranium concentrate. The first domestic contract was signed with VCA on August 28, 1947, effective May 20, 1947, to purchase uranium concentrates from the company's mill in Naturita, Colorado. The AEC also contracted with VCA, effective October 8, 1948, to buy concentrates from the AEC-owned mill at Durango, which VCA had leased with an option to buy.

Since a market had developed, VCA began prospecting and mining on their East Reservation Lease. In March 1948, shipments began from the lease, mainly from Plot 3 (Page Edwards, 1955, pers. comm.). Production in 1948 amounted to 1,303 tons containing 7,614 pounds U_3O_8 (Fig. 2).

The reopening of the Durango mill in March 1949 resulted in a shorter haulage for the mines in the Carrizo Mountains. Production increased in 1949 with mining expansion on the East Reservation Lease, mainly on Plot 3 but also on Plots 1, 2, 4, 6

through 9, 11, and 12. It was not until July 1950 that VCA differentiated the numbers of the individual plots on ore receipts to the AEC. Hence, the exact source of the 6,758 tons containing 29,786 pounds U_3O_8 listed as East Reservation Lease (Table 1) cannot be determined. Also in 1949, Cato Sells made initial shipments from mineralized outcrops near Oak Springs, Arizona.

In the early 1950's, the Navajo Tribal Council adopted a series of resolutions dealing with uranium mining which were approved by the Commissioner of Indian Affairs. These resolutions developed the regulations for prospecting and mining permits, mining leases, and royalty schedules. All prospectors needed to obtain permits for prospecting. Mining permits were granted only to Navajos, who could assign them to non-Navajos. Mining leases were no longer the subject of competitive bidding, but were negotiated with the Tribal Council, subject to approval by the Bureau of Indian Affairs. These actions would greatly increase prospecting and mining in the Carrizo Mountains and throughout the Navajo Reservation.

During 1950, VCA's operations continued to expand on Plot 3 and at the Canyon View Mine on Plot 7. Also, numerous small non-VCA operations commenced throughout the eastern Carrizo Mountains. Among the properties that contributed significantly to the year's production were Cato Sells' Upper Canyon Mine and Nakai Chee Begay's Red Wash Mine. During that year production reached a peak of 5,089 tons of ore containing 27,525 pounds U_3O_8 (Fig. 2). Of the total uranium, 73% came from the East Reservation Lease. The 1950 production represented the all-time

yearly record for uranium produced in the eastern Carrizos.

During May and June 1951, the AEC drilled 12 holes in the vicinity of Nakai Chee Begay's Red Wash Mine, all with negative results (Anderson and others, 1952).

After reaching a peak in 1950, production declined to a low of 1,504 tons of ore containing 8,718 pounds U_3O_8 in 1952 (Fig. 2). This decline was largely due to the fact that all of the exposed ore in outcrops and in the old mines was depleted and no exploration occurred.

On January 7, 1952, the AEC opened an ore-buying station at Shiprock, New Mexico. This station provided a nearby market for independent producers in the Four Corners area. Also, during the first half of 1952 the AEC conducted an extensive exploration drilling project throughout the eastern Carrizos. This drilling project discovered ore on King Tutt Mesa and in the Oak Springs area (Masters and others, 1955).

In 1953, Walter Duncan, Jr. commenced mining at the Begay No. 1 Mine, which was discovered by AEC drilling (Garbrecht, 1954), and mining continued on Plot 3 where AEC and VCA drilling discovered additional ore. Mining resumed at the old Syracuse Mine and was renamed the RF&R Mine. During the spring and summer of 1953, the AEC conducted two more drilling projects in the eastern Carrizos. These drilling projects discovered several small orebodies and the extension of others on Plot 3 and in the Oak Springs and Syracuse Mine areas (Blagbrough and Brown, 1955). On June 30, 1953, VCA exercised their option and purchased the Durango mill from the AEC.

During 1954, sustained production began at Cato Sells' Oak Springs Mine and at VCA's Plot 7. On November 1, 1954, the new Kerr-McGee Oil Industries, Inc. mill at Shiprock, New Mexico, began operating and purchasing ore from independent producers. Operation of the ore buying station was taken over by Kerr-McGee. The ore purchased by the AEC at the buying station was subsequently sold to Kerr-McGee along with ore from other AEC ore-buying stations.

Production from VCA's Plot 10 Mine and Texas Mining Company's Tent Mine and Begay Incline began in 1955. Ore production during that year was 4,481 tons containing 23,502 pounds U_3O_8, the second highest year for the eastern Carrizos (Fig. 2).

After reaching a peak in 1955, production gradually declined to a low in 1961, when only 324 tons of ore containing 1,446 pounds U_3O_8 were produced (Fig. 2). The depletion of the known orebodies was the cause of this decline. The anomaly in the declining trend seen in 1960 (Fig. 2) was due to production from the new Lookout Point Incline on Plot 3.

Production in 1962 increased to 1,933 tons containing 8,124 pounds U_3O_8 (Fig. 2) as Davis Mining Co. commenced mining at the Begay No. 2 Mine that had been developed in the vicinity of earlier AEC ore holes.

On March 1, 1963, VCA acquired the Kerr-McGee mill at Shiprock and closed its Durango mill later that month. In the eastern Carrizos, material which was previously considered uneconomical because of the long haulage to Durango could now be mined.

After reaching a small peak in 1962, production gradually declined to a low of 344 tons containing 1,363 pounds U_3O_8 in 1965 (Fig. 2). This drop occurred because the Begay No. 2 Mine was being depleted and other small operations were running out of ore.

The discovery of some additional ore at the Begay No. 2 boosted the 1966 production to 964 tons containing 4,215 pounds U_3O_8 (Fig. 2). In a final clean-up effort in 1967, VCA produced 740 tons of ore containing 2,089 pounds U_3O_8 (Fig. 2) from the Begay 1, Begay 2, and Nelson Point Mines. The final shipment was made in August 1967.

VCA merged with Foote Mineral Company on August 31, 1967. Foote continued the Shiprock milling operation until May 1968 when the operations ceased.

Summary

Forty-nine properties in the eastern Carrizo Mountains have produced 46,507 tons of ore containing 217,839 pounds U_3O_8 and averaging 0.23% U_3O_8 since 1948. In addition, these ores contained 2,263,758 pounds V_2O_5 averaging 2.43% V_2O_5. It is interesting to note that 115,985 pounds U_3O_8, or 53% of the total uranium produced in the eastern Carrizo Mountains, came from VCA's East Reservation Lease--lands that were acquired in July 1942 for vanadium. Six plots of this lease were located on King Tutt Mesa, an area of 1.4 square miles. Production from these plots plus the other mines on the mesa totaled approximately 127,100 pounds U_3O_8, or 58% of the region's total.

On King Tutt Mesa, Plot 3, containing 145 acres, produced at least 72,400 pounds, or 33% of the total uranium produced in the eastern Carrizos.

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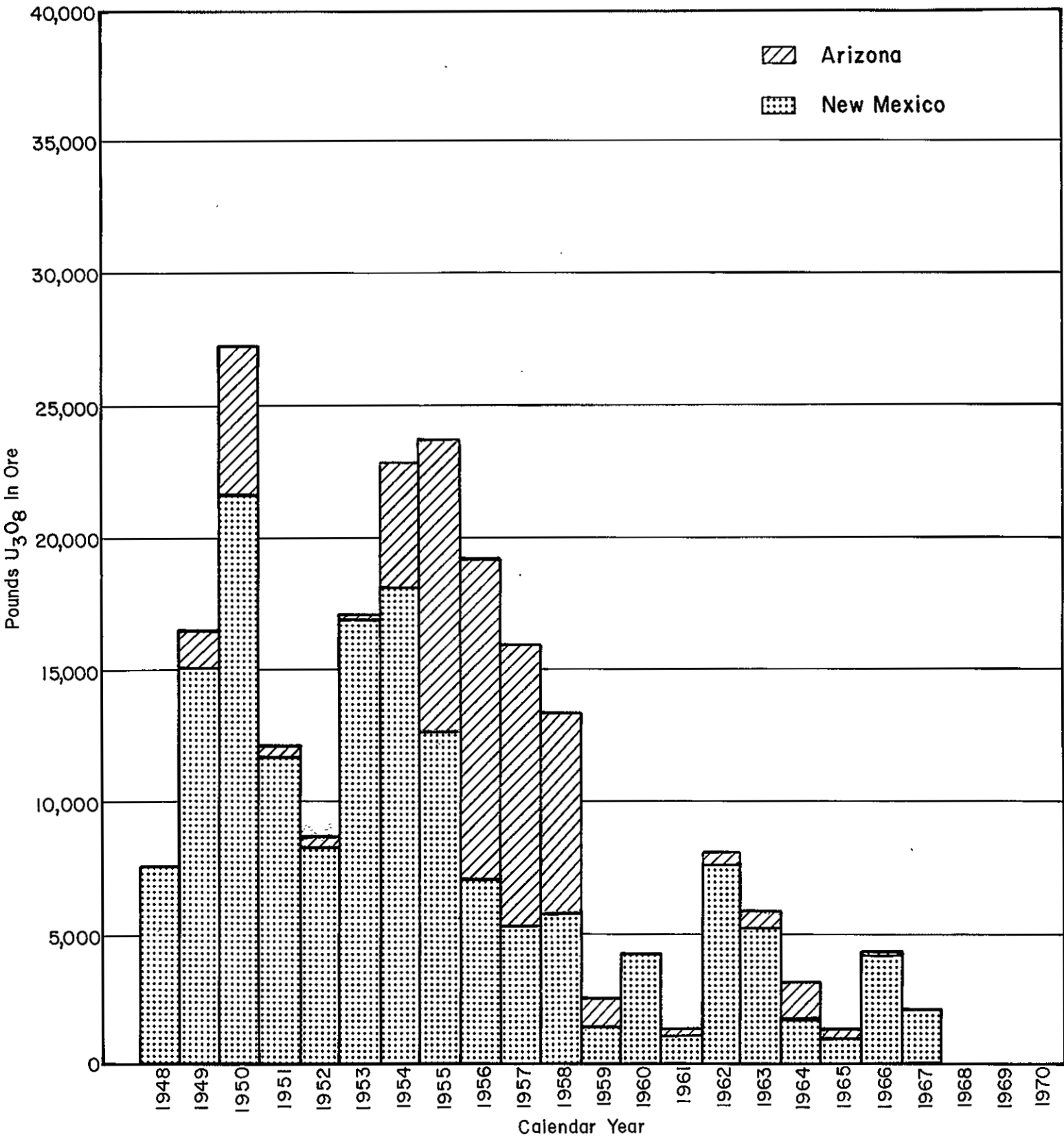


Figure 2

Uranium production, eastern Carrizo Mountains,
San Juan County, New Mexico, and Apache County, Arizona.

TABLE 1
Details of Uranium/Vanadium Production in the Eastern Carrizo Mountains,
San Juan County, New Mexico and Apache County, Arizona
(Revised 9/1/83)

Index No.	Mine	Tons Ore	Pounds U_3O_8	% U_3O_8	Pounds V_2O_5	% V_2O_5	Periods of Production/ Operator(s)
59.	Harvey Begay 3	21	49	0.12	860	2.05	1956- Troy Rose Mining Co.
60.	Tony Tuc	407	1,379	0.17	26,074	3.20	1953- Charles Ashcroft 1956-57- Titan Uranium Corp. 1962- W.D. Tripp 1966- Sam Harvey
61.	Upper Red Canyon	26	134	0.26	1,695	3.26	1950-1951- Tony Garnonez
62.	King 6	54	114	0.11	773	0.72	1955,1957- Troy Rose Mining Co.
63.	Barton & Begay (Beclabito Lease)	254	740	0.15	11,311	2.23	1950- Barton, Begay & Beyale 1950- Barton & Begay 1951- Lewis Barton 1953- Caylor & Neeley
64.	Rocky Flats 1, 2 (Rocky 1, 2)	698	2,214	0.16	34,154	2.45	1950-52- Barton & Lee 1953,55- Barrett Smith Mng.Co.
65.	Canyon 1	111	237	0.11	4,639	2.09	1950-51,1953- Pete Atcitty
66.	John John 1	25	97	0.19	1,392	2.78	1955- John John
67.	King 2	557	1,761	0.16	31,424	2.82	1950-54- Jimmie King
68.	Cottonwood Butte (Plot 8)	- - - - - - - - See Footnote 1 - - - - - - - -					1949- VCA 1950-51- Alfred Nelson
		250	1,245	0.25	15,013	3.00	1954- VCA
69.	Lone Star (Plot 9)	- - - - - See Footnotes 1 and 2 - - - - - -					1943, 1949- VCA
		276	1,814	0.33	16,852	3.05	1950- Raymond Marshall 1950-51- Harry Russell 1952- Leroy Pettigrew 1962- VCA

Table 1 (continued)

Index No.	Mine	Tons Ore	Pounds U_3O_8	% U_3O_8	Pounds V_2O_5	% V_2O_5	Periods of Production/ Operator(s)
70.	Syracuse (Plot 12)	- - - - - - See Footnotes 1 and 2 - - - - - - -					1943, 1949- VCA
		225	1,203	0.27	13,321	2.96	1950-52- Leroy Pettigrew
71.	Hazel	36	112	0.16	1,357	1.88	1955,1957- Leroy Pettigrew
72.	White Cap (Plot 11)	- - - - - - - See Footnote 1 - - - - - - - -					1949- VCA
73.	Syracuse (R, F, & R, Sam Harvey)	- - - - - - - See Footnote 3 - - - - - - - -					1942-43- Wade, Curran & Co.
		1,967	11,051	0.28	102,491	2.60	1954-56- Andrew A. Fry 1956-58- Titan Uranium Co. 1964-66- Sam Harvey
74.	Valley View	73	135	0.09	3,338	2.29	1950- Cato Sells
75.	Upper & Lower Canyon	2,795	9,496	0.17	115,252	2.06	1950,1955-56,1961- Cato Sells 1962-63- Tripp Mining Co. 1963-64- W.D. Tripp
76.	Leroy (MP-552)	25	96	0.19	1,230	2.46	1961- Davis Mining Co.
77.	Oak Springs (Gravel Top)	5,112	23,289	0.23	233,362	2.28	1950,1954-59- Cato Sells 1962,1966- W.D.Tripp
78.	Oak Springs (Plot 10)	1,979	9,389	0.24	111,458	2.82	1949,50- Cato Sells 1955-57- VCA 1957-58- Tanner & Thomas
79.	Lower Oak Creek (Plot 7)	- - - - - - See Footnotes 1 and 2 - - - - - - -					1943-44,1948-50- VCA
		3,870	21,014	0.27	171,268	2.21	1950-52- Hosteen S.Begay 1950- Eugene Tapahanso 1951- Tom Jones, Jr. 1954-57,1961-64- VCA 1955-59- Kennedy & McGee 1960- C.H. Corey, Jr. 1961- William George

Table 1 (continued)

Index No.	Mine	Tons Ore	Pounds U_3O_8	% U_3O_8	Pounds V_2O_5	% V_2O_5	Periods of Production/ Operator(s)
80.	Salt Canyon	93	331	0.18	4,473	2.41	1950- Cato Sells 1953- Shorty & Tutt 1954- Hosteen S. Begay 1955- Kennedy & McGee
81.	Franks Point (Plot 6)	- - - - - - - - See Footnote 1 - - - - - - - - -					1949- VCA
82.	Upper & Lower Salt Rock	107	358	0.17	4,122	1.93	1950-51- Eugene Tapahonso 1961-62- Davis Mining Co.
83.	Williams Point (Plot 4)	- - - - - - - - See Footnote 1 - - - - - - - - -					1949- VCA
84.	Sunnyside & Lookout Point	- - - - - - See Footnotes 1 and 2 - - - - - - - -					1942, 1948-50- VCA
		2,556	16,327	0.32	144,337	2.82	1950- Billy, Peterson,& Shorty 1950- Billy & Shorty 1950-54- Paul Shorty 1956,1959- VCA
85.	Lookout Point Incline	506	2,713	0.27	28,485	2.81	1960- C.H. Corey, Jr. 1960-61- William George
86.	Shadyside 2	- - - - - - See Footnotes 1 and 2 - - - - - - - -					1942,1498-50- VCA
		809	6,183	0.35	66,842	3.76	1951,1953-54- Harry Russell 1954-55,1966- VCA
87.	Shadyside, Shadyside Incline	- - - - - - See Footnotes 1 and 2 - - - - - - - -					1942,1948-50- VCA
		1,728	8,841	0.26	108,589	3.14	1950- Tutt & Thomas 1950-51- Tutt & Tanner 1951- Harry Russell 1951,'53,'56,1964-65- VCA 1952-King Tutt
88.	Nelson Point	- - - - - - See Footnotes 1 and 2 - - - - - - - -					1942-43, 1948-50- VCA
		2,684	13,364	0.25	211,347	3.94	1950-58,1961- Paul Shorty 1965-67- VCA
89.	Tent	1,198	5,303	0.22	54,156	2.26	1955- Texas Mining Co. 1956-57- Eugene Tapahonso 1963- Hazel Bryant

Table 1 (continued)

Index No.	Mine	Tons Ore	Pounds U_3O_8	% U_3O_8	Pounds V_2O_5	% V_2O_5	Periods of Production/ Operator(s)
90.	Begay 2	4,515	18,450	0.20	190,638	2.11	1962- Davis Mining Co. 1963-64- Hazel I. Davis 1965-66- Fritz-Ericson Co. 1967- VCA
91.	Begay Incline	655	3,475	0.27	38,215	2.92	1955-56- Texas Mining Co.
92.	Carrizo 1	828	3,426	0.21	21,917	1.32	1956-58- Spafford & Sons
93.	Begay 1	3,921	16,491	0.21	127,499	1.63	1953-54- Walter Duncan, Jr. 1966-67- VCA
94.	King Tuff Point (Plot 2)	- - - - - - See Footnotes 1 and 2 - - - - - - - -					1942, 1948-50- VCA
		294	1,900	0.32	15,222	2.59	1950- John Joe 1950- Ray Marshall 1950- Leroy Pettigrew 1951- Carl Thomas 1953, 1956- VCA
95.	King Tuff 1	290	1,060	0.18	8,257	1.42	1951,1953- Shorty & Tuff 1956- Sylvania Mining Co. 1958- Charles N. Pickens
96.	Red Wash Point (Plot 1)	- - - - - - See Footnotes 1 and 2 - - - - - - - -					1942,1948-50- VCA
		300	2,206	0.37	17,786	2.97	1951-52- Sam Harvey 1952- Harry Russell
97.	Junction	18	38	0.11	153	0.43	1953- Walter Duncan
98.	Alongo	27	76	0.14	76	0.14	1956- E.J. Alongo
99.	Red Wash	61	127	0.10	636	0.53	1952- Hosteen S. Begay
100.	Red Rock	22	65	0.15	1,001	2.25	1950-51- Leroy Pettigrew
101.	Red Wash	27	137	0.26	1,176	2.19	1950- Leroy Pettigrew

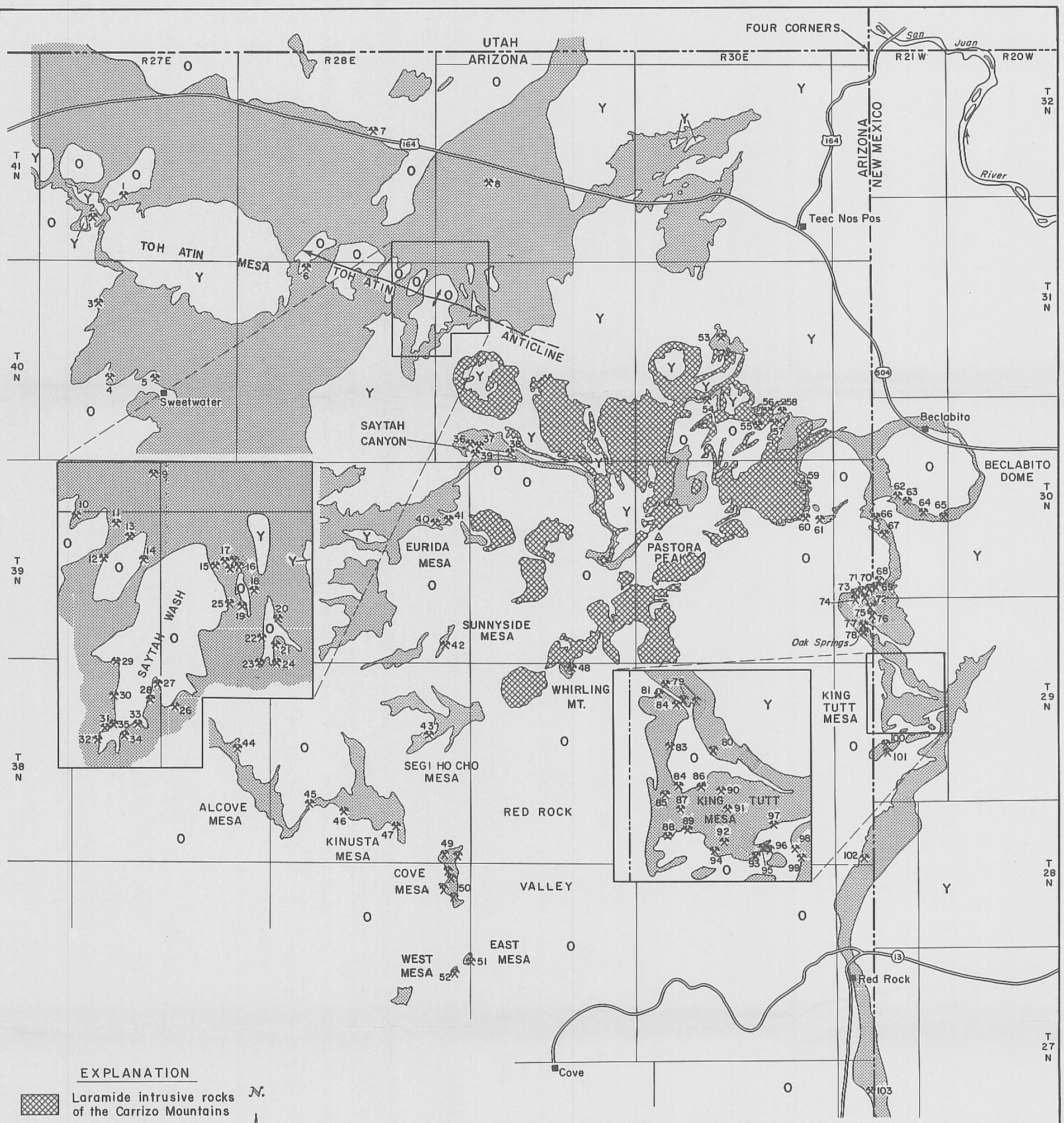
Index No.	Mine	Tons Ore	Pounds U_3O_8	% U_3O_8	Pounds V_2O_5	% V_2O_5	Periods of Production/ Operation(s)
102.	Upper Red Wash	4/ 338	1,610	0.24	10,002	1.48	1950-51- Nakai Chee Begay 1953- Pershing Mining Co.
103.	Rocky Spring	11	3	0.01	62	0.28	1951- Jerome Chee
	East Reservation Lease 5/	6,758	29,786	0.22	311,503	2.30	1948-50- VCA

1/ Early production shipped as East Reservation Lease, see Footnote 5.
2/ During the period August 1942 through February 1945, shipments from the East Reservation Lease totaled 10,216 tons of ore averaging 2.47% V_2O_5. Mining was on Plot 3 with some production from Plots 1, 2, 7, 9, and 12.
3/ During the period July 1942 through August 1943, a total of 966 tons of ore, averaging 4.37% V_2O_5 was shipped from the Syracuse and Sunnyside Mines (Sunnyside is in the western Carrizos).
4/ An additional 410 tons of material was shipped from this property for which no payment was received for either uranium or vanadium.
5/ Early, 1948-50, production from Plot 3, also includes minor production from Plots 1, 2, 4, 6, 7, 9, 11, and 12.

Source: AEC production records, GSA report, AEC field notes, VCA mill receipts, and Bureau of Indian Affairs records.

INDEX OF MINES

NO.	MINE NAME
1.	Barton 3
2.	Tom Morgan 1
3.	John Lee Benally
4.	Phillip Dee 1
5.	Johnny McCoy 1
6.	Brodie 1
7.	John Kee 4
8.	Capitan Benally 4A
9.	Block K
10.	Silentman 1
11.	McKenzie 3
12.	Plot 1 (Hogan Mine)
13.	Plot 2
14.	Plot 4 (Gila Mine)
15.	Pope 1
16.	Hoskie Henry
17.	Plot 6 (Rattlesnake Mines)
18.	Black Rock Point Mines
19.	Plot 8
20.	Sandy K
21.	Jimmie Bileen 1
22.	Plot 9
23.	Plot 10 (Horse Mine)
24.	Plot 11 (Two Level Mine)
25.	Plot 7 (Rattlesnake No. 5 Mine)
26.	Tsosie 1
27.	Grover Cleveland 1
28.	Plot 12 (Rattlesnake No. 8 Mine)
29.	North Martin (AEC Plot 2)
30.	Martin (AEC Plot 1); Geo. Simpson 1
31.	George Simpson 1 Incline
32.	Last Chance
33.	Carson
34.	Plot 13
35.	Saytah
36.	Melvin Benally 1
37.	Saytah Canyon (AEC Plot 4)
38.	School Boy
39.	CBW-MC (AEC Plot 5)
40.	Eurida Mines (AEC Plot 6)
41.	Eurida Mesa (Plots 14, 15, 16)
42.	Sunnyside
43.	Mildred 1
44.	Chester Mud 1
45.	Sheepskin Mesa (Hanley)
46.	Tree Mesa (Clani)
47.	Kinusta Mesa (AEC Plot E)
48.	Tohe Thlany Begay
49.	Cove Mesa Mines (Sells)
50.	Cove Mesa Mines (AEC Plot 7)
51.	East Mesa Mines
52.	West Mesa
53.	Rattlesnake 1 (Shorty)
54.	Bettie 1
55.	Zona 1
56.	Ruben 1
57.	Jim Lee 1; Richard King 1
58.	Todakonzie 1
59.	Harvey Begay 3
60.	Tony Tuc
61.	Upper Red Canyon
62.	King 6
63.	Beclabito Lease (BB)
64.	Rocky Flats 1, 2 (Rocky 1, 2)
65.	Canyon 1
66.	John John 1
67.	King 2
68.	Cottonwood Butte (Plot 8)
69.	Lone Star (Plot 9)
70.	Syracuse (Plot 12)
71.	Hazel
72.	White Cap (Plot 11)
73.	Syracuse (R, F & R)
74.	Valley View
75.	Upper; and Lower Canyon Mines
76.	Leroy (MP-552)
77.	Oak Springs (Gravel Cap)
78.	Oak Springs (Plot 10)
79.	Lower Oak Creek Mines (Plot 7)
80.	Salt Canyon
81.	Franks Point (Plot 6)
82.	Upper and Lower Salt Rock
83.	Williams Point (Plot 4)
84.	Sunnyside and Lookout Point (Plot 3)
85.	Lookout Point Incline (Plot 3)
86.	Shadyside 2 (Plot 3)
87.	Shadyside (Plot 3)
88.	Nelson Point
89.	Tent
90.	Begay 2
91.	Begay Incline
92.	Carrizo 1
93.	Begay 1
94.	King Tutt Point (Plot 2)
95.	King Tutt 1
96.	Red Wash Point (Plot 1)
97.	Junction
98.	Alongo
99.	Red Wash (Hosteen S. Begay)
100.	Red Rock
101.	Red Wash (Leroy Pettigrew)
102.	Upper Red Wash (Nakai Chee Begay)
103.	Rocky Spring



EXPLANATION

- Laramide intrusive rocks of the Carrizo Mountains
- Y — Post-Salt Wash sedimentary rocks
- Salt Wash Member of Morrison Formation
- O — Pre-Morrison sedimentary rocks
- Uranium mine

N.

0 1 2 3 MILES

Compiled by W.L. Chenoweth, 1973, modified 1984
Geology after Cooley and others, 1969

Figure 1. Mine Location Map, Carrizo Mountains Uranium Area, Apache County, Arizona, and San Juan County, New Mexico.

Open-file 193

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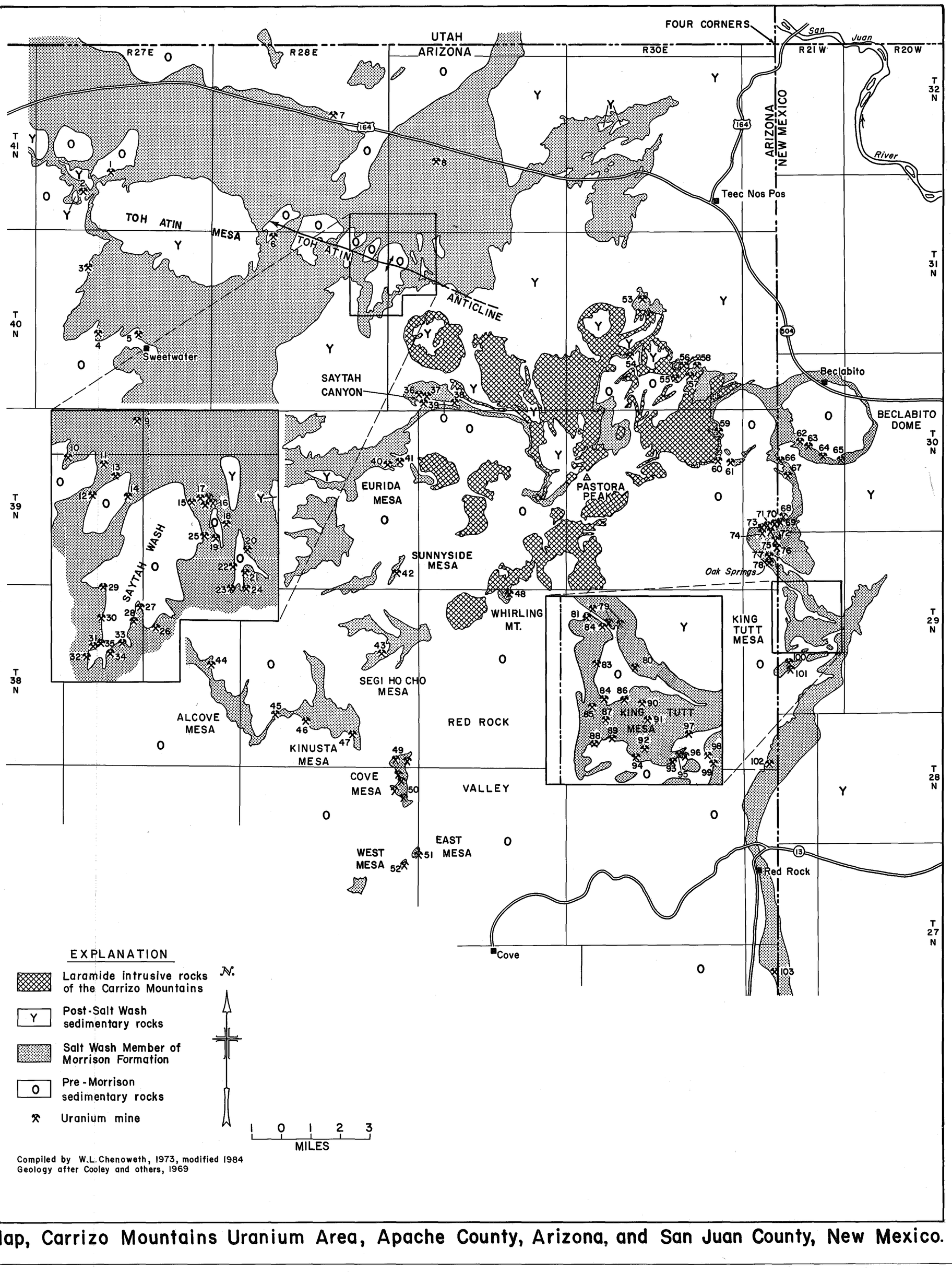

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Geology after Cooley and others, 1969

Figure 1. Mine Location Map, Carrizo Mountains Uranium Area, Apache County, Arizona, and San Juan County, New Mexico.

S.W. 1/4 FENCE LAKE 1:100,000 SHEET

SCALE 1:50,000

CONTOUR INTERVAL = 20 METERS

NMBMMR: OPEN FILE 207

PLATE I

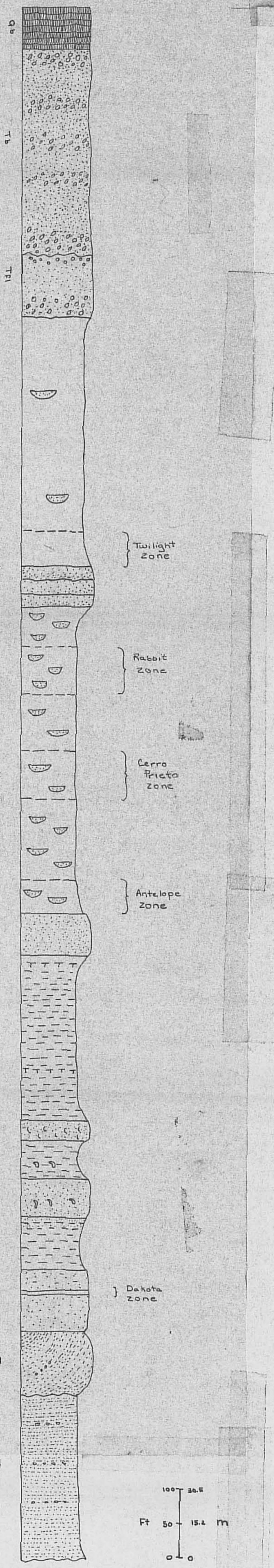
LEGEND

Qal – QUATERNARY ALLUVIUM	Kdt – DAKOTA SANDSTONE twowells tongue
Qb – QUATERNARY BASALT	Kmwa MANCOS SHALE whitewater arroyo tongue
Tb – BIDAHOCHI	Kdp – DAKOTA SANDSTONE paguate tongue
Tfl – FENCE LAKE	Kmi – MANCOS SHALE lower part
Ti – TERTIARY INTRUSIVE	Kdm – DAKOTA SANDSTONE main body
KMhu – MORENO HILL upper member	Jz – ZUNI SANDSTONE
Kmhm – MORENO HILL middle member	Trc CHINLE
Kmhl – MORENO HILL lower member	Trcp CHINLE petrified forest member
Ka – ATARQUE SANDSTONE	
Kmrs – MANCOS SHALE rio salado tongue	

SYMBOLS

DIP & STRIKE	FAULT	INFERRED FAULT
Y		

Generalized Geologic Column - Fence Lake 1:50,000 Geologic Map



Quaternary basalt

Bidahochi Formation - Light gray, coarse to fine-grained sandstones, highly variable light brown sands, and pebbly conglomerates. Fair to poor cementation with calcareous cemented lenses and volcanic clasts. Conglomerates consist of basaltic and rhyolitic pebbles and minor amounts of quartzite pebbles.

Fence Lake Formation -

Upper unit- Poorly-sorted, very fine to coarse-grained, grayish-pink, calcareous sandstones containing quartz, feldspar and mafic mineral fragments.

Lower unit - Coarse conglomerate in a calcareous sandstone matrix. Pebbles, cobbles, and boulders are subrounded to subangular basalts, rhyolites, cherts, quartzites and petrified wood fragments.

Moreno Hill Formation -

Upper Member - Green to yellow-gray to light-gray fluvial mudstones, claystones and siltstones, with a few thin silty, fine-grained sandstones, and a single zone of thin coals.

Middle Member- Laterally continuous, pinkish-yellow, subangular, medium- to coarse-grained fluvial quartz sandstones, with subangular feldspar fragments. Sandstones are planar to trough crossbedded.

Lower Member - Non-marine Series of yellow-gray, medium to fine-grained Sandstones, interbedded dark-gray to black mudstones and claystones, carbonaceous mudstones and three predominant coal zones.

Atarque Formation-

Upper unit - Marine, yellow fine-grained, intensely burrowed sandstones.

Middle unit - Highly crossbedded sandstones.

Lower unit - Yellow, flat-bedded, burrowed sandstone, coarsening upward to fine to very fine-grained fossiliferous sandstones.

Mancos Shale -

→Rio Salado Tongue - Offshore marine, olive-gray to yellow-brown shales with thin fossiliferous limestone concretions, calcarenites, and glauconite beds.

Dakota Sandstone -

→Twowells Tongue - Yellow-brown to dark-gray, fine to medium-grained sandstone, planar crossbedded at top. Middle: very fine to fine-grained, massive, burrowed sandstone. Bottom: fine-grained, poorly bedded, sandstones.

Mancos Shale

→White water Arroyo Tongue- Medium dark gray fossiliferous shales and siltstones, thin bentonite beds and cone-in-cone limestone concretions.

Dakota Sandstone-

→Paguate Tongue- Yellow to grayish-yellow, fine-grained sandstone. Sandstone is poorly-sorted, poorly cemented, with massive to irregular bedding. Fossiliferous.

→Lower Member

Mancos Shale-

Lower Part - Marine dark gray to dusky yellow shales with interbedded siltstones, and limestone concretions.

→Dakota Sandstone-

Main body - Marine to non-marine. Upper 2/3 yellow-gray to gray claystones and siltstones with a few resistant very fine to fine-grained calcareous sandstones. Claystones are fossiliferous. Lower 1/3: fine to coarse-grained sandstones. In both upper and lower portions. Carbonaceous siltstones, claystones, and coals occur locally.

Zuni Sandstone - Eolian, white to pink, fine to medium-grained sandstone. High angle crossbedding and a few pebble conglomerates concentrated along bedding planes within the unit.

Chinle Formation- Non-marine grayish-red to reddish-brown, light green to grayish green and purple mudstones, siltstones and claystones. Scattered lenses of sandstones and conglomerates.

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PLATE 2