THE ZONA NO. 1 URANIUM-VANADIUM MINE, NORTHEASTERN CARRIZO MOUNTAINS, APACHE COUNTY, ARIZONA

by

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Introduction

The Zona No. 1 uranium-vanadium deposit is similar to other ore deposits in the Salt Wash Member of the Morrison Formation along the perimeter of the Carrizo Mountains. What makes this deposit unusual is that it shows evidence of deformation and metamorphism due to the emplacement of the Carrizo laccolith.

The information presented in this report was obtained in the 1950's when the author was employed by the U.S. Atomic Energy Commission (AEC). The interpretation of the geology of the mine area was greatly aided by geologic maps published by the U.S. Geological Survey (Strobell, 1952,a,b).

Location

The Zona No.1 uranium-vanadium mine is about 5 mi west of Beclabito Trading Post in Apache County, Arizona. The mine is at an elevation of 8,080 ft on the north side of Black Rock Canyon in the northeastern Carrizo Mountains (Figure 1). During the time the mine was active, a camp was established at Black Rock Canyon Spring on the floor of the canyon. The spring may be reached by a 5-mi-long unimproved road, which joins New Mexico State Highway 504 just east of the Arizona State line (Figure 2). A 1-mi-long access road containing 21 switchbacks was built from the spring up the canyon wall to the mine.

The mine is in NE$^1/_4$ sec. 34, T. 40 N., R. 30 E., Gila and Salt River Baseline and Meridian (projected). The spring, mine adit, and mine road are shown on the 1982 provisional, 7$^1/_2$' topographic map of the Beclabito quadrangle. In 1985 the author found that the road to the spring was completely washed out where it enters Black Rock Canyon about $^1/_2$ mi northeast of the spring.

The area is within the Navajo Indian Reservation. All mining leases and permits are issued by the Navajo Tribal Council and are approved by the Bureau of Indian Affairs, U.S. Department of the Interior.

Geologic Setting

Uranium and vanadium have been mined from the Salt Wash Member of the Upper Jurassic Morrison Formation along the perimeter of the Carrizo Mountains. The principal mining areas are the eastern (Oak Springs), northwestern (Rattlesnake), and southern (Cove Mesa) parts of the range (Figure 1).

The Carrizo Mountains consist of an irregularly shaped, 68 Ma (Armstrong, 1969) intrusive mass composed of a central stock and several sills of light-gray diorite porphyry that have been injected laterally into the surrounding sedimentary rocks. The mountains are about 13 mi in diameter and rise 2,000 to 3,000 ft above the surrounding plain. Pastora Peak, at elevation 9,420 ft, is the highest point in the range. On the eastern side of the mountains, the Salt Wash Member outcrops in a belt from Red Rock to Beclabito, roughly paralleling the Arizona-New Mexico State line; south of Beclabito it rims Beclabito dome. West of the dome, a narrow band of the Salt Wash Member is exposed on the margin of the intrusion. On the northern side of the mountains, the upper

Salt Wash Member is exposed in a large outcrop southwest of the Four Corners area. The lower Salt Wash Member outcrops in a small area at the foot of the mountains, and in the northeastern part of the intrusive, it is interlayered with igneous sills. The Zona No. 1 mine is in this area (Figure 2).

The Toh Atin anticline exposes the lower Salt Wash Member in the northwestern Carrizo Mountains. It is also exposed near the Utah line, but is largely covered with dune sand north of the anticline. West and south of the mountains, the Salt Wash Member caps numerous mesas. Discontinuous outcrops within the intrusive sills are present in the central portion of the range.

In the Carrizo Mountains, the Salt Wash Member is composed of pale-gray to tan, fine-grained, well-sorted, quartzose, continental fluvial sandstone. Beds are locally as thick as 20 ft. Interbedded with the sandstone are thin beds of gray, greenish-gray, and reddish-brown mudstone and siltstone. The mudstone and siltstone compose only 5% to 30% of the Salt Wash Member. Near the Zona No. 1 mine, the Salt Wash Member is approximately 200 ft thick.

Most of the mines in the Carrizo Mountains are on the rims of canyons or mesas or on benches near a rim. The Zona No. 1 mine is on a canyon wall high in the mountains, nearly midway between the eastern and northwestern Carrizo mining areas (Figure 2). The ore deposits in these two areas were described by Masters and others (1955) and Chenoweth (1955), respectively. The ore deposit at the Zona No. 1 mine is in a block of the Salt Wash Member that is both overlain and underlain by gray, diorite porphyry sills (Figure 2). The total area of this isolated block is approximately 40 acres. The underlying sill is part of the large 200- to 300-ft-thick Teec Nos Pos (Tisnasbas) sill described by Emery (1916). A small remnant of the overlying sill is exposed on the top of the ridge above the mine. South of the mine and below the Teec Nos Pos sill, rocks of the basal Salt Wash Member and underlying Wanakah, Entrada, and Wingate Formations are poorly exposed in a wooded slope. Southeast of the mine, a lower sill is exposed along the mine-access road and intrudes the sedimentary rocks at the Salt Wash-Wanakah contact (Figure 2).

Emery (1916) noted that the Teec Nos Pos sill dipped away from the central core of the Carrizo Mountains at an angle of 15°, whereas the sill that forms the North Mesa (Figure 2) was nearly horizontal. The beds of the Salt Wash Member near the Zona No. 1 mine portal strike N33°W and dip 16° to the northeast (Figure 3). Only 50 ft of the Salt Wash Member is present between the two sills. It is impossible to determine the stratigraphic position of these beds in relationship to the entire member, but they are believed to belong to its lower half because that is the location of ore bodies in this area.

The ore at the Zona No. 1 mine consists of sandstone beds impregnated with uranium and vanadium minerals. Some detrital organic materials, such as fossil leaves and small twigs and limbs, are contained in the ore, but much of the ore is unassociated with these materials. The dark color of the ore makes recognition of the plant fossils difficult.

Three ore-bearing sandstone beds, each about 1 ft thick, are exposed in the outcrop at the mine yard. The upper and middle sandstones are underlain by a 2-ft-thick bed of gray mudstone. The upper sandstone is overlain by a 3-ft-thick bed of reddish-brown mudstone; a similar bed underlies the lower ore-bearing sandstone.

Within the mine, the mudstones separating the ore-bearing sandstones are thinner or missing because of scouring by the overlying sandstone. Ore thickness averages 4 ft, but reaches 8 ft in the northwestern part of the mine. The base of the ore at the Zona No. 1 mine is approximately 30 ft above the top of the sill.

No uranium minerals have been identified from the Zona No. 1 mine. The ore has a dark bluish-black color because of the high vanadium content. Small flakes of a yellow uranium mineral, probably tyuyamunite, are present in the ore and as thin coatings on

fractures in the mine. Although this yellow mineral was originally called carnotite (a potassium-uranium vanadate), later work identified the only uranium minerals in the Carrizo deposits as tyuyamunite (a calcium-uranium vanadate) and metatyuyamunite (Corey, 1956; S.R. Austin, written commun., 1967).

A grab sample (No. 31356) collected from the original mineralized outcrop of the Salt Wash Member in September 1953 was analyzed by the AEC's petrology laboratory in Grand Junction, Colorado. This sample assayed 0.57% eU_3O_8, 0.63% cU_3O_8, and 10.99% V_2O_5. Another sample (No. 1180) of high-grade vanadium ore was submitted to the AEC's lab in the summer of 1954. Gross (1954) was able to identify only pascolite, a calcium vanadate. Two other minerals in the sample, suspected to be montroseite, a vanadium oxide, and corvusite, an oxidation product of montroseite, were submitted for X-ray identification. The results of the X-ray work could not be found in 1982.

Compared to host sandstones at other uranium-vanadium deposits in the northwestern Carrizo Mountains, the host rocks at the Zona No. 1 mine are so well cemented that they resemble a metaquartzite. (Navajo workers at the Zona No. 1 mine noted that the ore was much harder to break than at the Rattlesnake mine in the northwestern part of the range.) The interbedded mudstones are also more indurated than most Salt Wash Member mudstones.

The AEC's petrology laboratory determined that the sand grains were cemented by quartz overgrowths. The overgrowths were actually on uranium-vanadium minerals coating the quartz grains, which suggests that they resulted from the intrusion of nearby sills (E.B. Gross, written commun., 1957). This laboratory evidence and the field relationships suggest that the uranium-vanadium deposit was already in place in the Salt Wash Member when the Carrizo laccolith was intruded 68 m.y. ago (Armstrong, 1969).

Production History

The mineralized outcrop in which the Zona No. 1 mine was developed was reportedly found by Navajo sheepherders. Joe Eppich from Farmington, New Mexico was shown the exposures in 1950. Eppich was the stepson of John F. Wade, the discoverer of the uranium-vanadium deposits in the Carrizo Mountains, and had been associated with vanadium mining. Because Eppich was no longer involved in mining, he showed the outcrop to James B. Ashcroft, also from Farmington. Ashcroft was then mining uranium-vanadium ore in Monument Valley.

On March 10, 1953, the Bureau of Indian Affairs issued mining lease No. 14-20-603-20 to Ashcroft. The lease covered 71.1 acres and was valid for 10 years. An access road was constructed during the summer of 1953 at a reported cost of $10,000 and mining commenced in September of that year. The ore was shipped to the AEC's ore-buying station in Shiprock, New Mexico.

Production during 1953 totaled 207.74 tons of ore, which averaged 0.22% U_3O_8 and 3.92% V_2O_5 (Table 1). During 1954 production averaged approximately 150 tons per month and seven men were employed at the mine. The deposit was developed through the use of two parallel declines (16°) and mined through the use of a modified room-and-pillar system. A diesel-powered shuttlebuggy was originally used to move ore and waste from the working faces to the mine yard. At the request of the Federal mine inspector, the diesel equipment was replaced by a horse-drawn cart. In the mine yard, two miners visually sorted waste from ore, which reduced ore volume by about 10%. The ore was loaded into a modified jeep and shuttled down the access road to a stockpile near the mine camp, where it was transferred to a conventional dump truck for the trip to Shiprock. (See Figure 3 for map of mine workings.)

By September 1954, approximately 1,300 tons of ore averaging 0.22% U_3O_8 and 3.43%

V_2O_5 had been mined. Ore production continued until the summer of 1955, when the deposit was mined out and the mine closed. During its 2-year operation, the mine produced 2,116.14 tons of ore averaging 0.19% U_3O_8 and 2.91% V_2O_5 and containing 8,224.30 lb and 123,091.52 lb of uranium and vanadium oxides, respectively (Table 1). This production ranks the Zona No.1 mine among the top three mines developed in the Carrizo Mountains during the 1950's (Chenoweth, 1985). An attempt to visit the mine in August 1956 was hindered by numerous rock slides, which blocked the switchbacks from the camp to the mine; the road to the camp in Black Rock Canyon was also in need of repairs. Bureau of Indian Affairs records show that the lease was cancelled on March 10, 1959.

All of the uranium and vanadium produced by the Zona No. 1 mine was purchased by the AEC. Ashcroft received a $35,000 bonus from the AEC for producing 10,000 lb of U_3O_8 from a new discovery. This bonus was paid under the AEC's Domestic Uranium Program (Circular 6).

Mining at the Zona property spurred interest in the Black Rock Canyon area. Several other mineralized outcrops were found in 1954 by Navajos, especially northeast of the mine. These exposures never developed into significant mines; only 247 tons of ore were shipped from four properties during 1955 (Table 2).

The Bettie No. 1 mine is $1^1/_2$ mi northwest of the Zona No. 1 mine (Figure 2). This deposit is in an exposure of the Salt Wash Member below the Teec Nos Pos sill. The mineralized outcrop was discovered in 1955. During 1955 and 1956, the mine produced 52.59 tons of ore averaging 0.18% U_3O_8 and 0.90% V_2O_5 and containing 192.45 lb of U_3O_8 and 955.04 lb of V_2O_5. The property was operated by Hamilton and Wilhite (Chenoweth, 1985); the ore was brought out of the mountains on pack horses.

The Rattlesnake No. 1 mine, located approximately 2 mi north of the Bettie No. 1 mine (Figure 2), is an old Vanadium Corporation of America lease, first operated in 1944 (Chenoweth, 1985).

Discussion

After many years of investigation, the source of uranium and vanadium in the Salt Wash Member is unconfirmed. Two principal sources, however, have been proposed (Thamm and others, 1981):

(1) **The tuffaceous material of the Salt Wash Member and/or the overlying Brushy basin siltstones and mudstones.** This source, proposed by most investigators, has also been suggested for all principal sandstone uranium deposits in the United States. In each case, this hypothesis is based more on the presence of such volcaniclastic sediments in the area than on any convincing documentation. Although these relationships provide a strong circumstantial argument that these sediments were the source of the uranium, chemical studies are required to test this hypothesis.

(2) **Source rocks with anomalous uranium concentrations.** Most uranium districts are within regions that contain such rocks. These anomalous concentrations may be present as high background values in granites, volcanic sequences, or metasediments. Both uraniferous granites and volcanic rocks are within the Wyoming basins and Grants uranium region. Similarly, the Colorado Plateau, including the areas of mineralization in the Salt Wash Member, is within a province of uraniferous Precambrian basement. The importance of a uraniferous province to the formation of uranium deposits is clear. It is uncertain, however, whether normal uranium concentrations in source rocks are adequate to form the deposits or whether the concentrations must be truly anomalous (Thamm and others, 1981).

The Salt Wash Member deposits are essentially vanadium deposits, but as yet no convincing case has been made for the source of that vanadium. Hypotheses suggest that

it was (a) derived from altered ilmenite and magnetite, (b) introduced diagenetically from the overlying Cretaceous sediments, or (c) derived from the leaching and erosion of Paleozoic sediments west of the Colorado Plateau. All of these hypotheses are plausible, but unsubstantiated (Thamm and others, 1981).

Hershey (1958), in his reconnaissance of the uranium-vanadium deposits along the perimeter of the Carrizo Mountains, noted that the mines nearest the intrusives had the highest vanadium to uranium ratios. The Zona No. 1 mine, with a 15:1 vanadium to uranium ratio, is higher that the 7:1 ratios at the Rattlesnake mines in the northwestern part of the range and the mines on Cove Mesa (Chenoweth, 1985). The increase in vanadium content near the intrusives lead Hershey (1958) to speculate that hydrothermal solutions associated with the intrusives were the source of the vanadium. This is a theory the author cannot accept. Most investigators suggest that the ore deposits in the Salt Wash Member were formed before regional (Laramide) deformation (Thamm and others, 1981). It is not surprising, therefore, to find a uranium-vanadium deposit in the Carrizo Mountains that has been disturbed and metamorphosed by the intrusion of the 68 Ma laccolith and related sills.

Summary

The Zona No. 1 mine is a unique uranium-vanadium deposit. Field relationships at this mine and adjacent prospects indicate that the intrusion of the Carrizo Mountain sills faulted and fractured the existing ore deposits in the Salt Wash Member of the Upper Jurassic Morrison Formation. Paragenetic studies on ore samples indicate that the Salt Wash Member was silicified after the uranium and vanadium minerals were deposited. Both field and laboratory evidence indicate that intrusion of the Carrizo laccolith (68 Ma) occurred after deposition of the ore minerals.

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Evelyn VandenDolder and Jon Spencer of the Arizona Geological Survey reviewed this report and greatly improved it.

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Table 1. Ore production, by year, Zona No. 1 mine, Apache County, Arizona.

YEAR	QUARTER	TONS OF ORE	LB U_3O_8	% U_3O_8	LB V_2O_5	% V_2O_5
1953	4th	207.74	909.77	0.22	16,274.40	3.92
1954	1st	446.12	2,021.96	0.23	32,038.12	3.59
1954	2nd	344.38	1,606.87	0.23	24,981.00	3.63
1954	3rd	461.01	1,768.51	0.19	24,275.00	2.63
1954	4th	590.60	1,685.55	0.14	21,358.00	1.81
1955	1st	30.88	127.85	0.21	2,303.00	3.73
1955	2nd	23.54	87.18	0.19	1,724.00	3.66
1955	3rd	11.87	16.61	0.07	138.00	0.58
TOTAL		2,116.14	8,224.30	0.19	123,091.52	2.91

Source: Unpublished data, U.S. Atomic Energy Commission files, Grand Junction, Colorado.

Table 2. Ore production from properties in Black Rock Canyon adjacent to the Zona No. 1 mine (see Figure 2 for location).

NAME	TONS OF ORE	LB U_3O_8	% U_3O_8	LB V_2O_5	% V_2O_5	YEAR OF PRODUCTION & OPERATOR
Ruben No.1	64.17	283.18	0.23	2,700.00	2.10	1955 De Greer and Isbell 1955 Edwards and Mallery
Jim Lee No. 1	120.49	286.76	0.12	4,218.12	1.75	1955 Mexona Corp.
Richard King No. 1	56.84	209.20	0.18	3,170.43	2.79	1955 G.B. Cree Drilling Co.
Todakonzie No. 1	5.54	23.28	0.21	200.69	1.81	1955 Haskell Uranium Co.
TOTAL	247.04	802.42	0.16	10,289.24	2.08	

Source: Unpublished data, U.S. Atomic Energy Commission files, Grand Junction, Colorado; Chenoweth (1985).

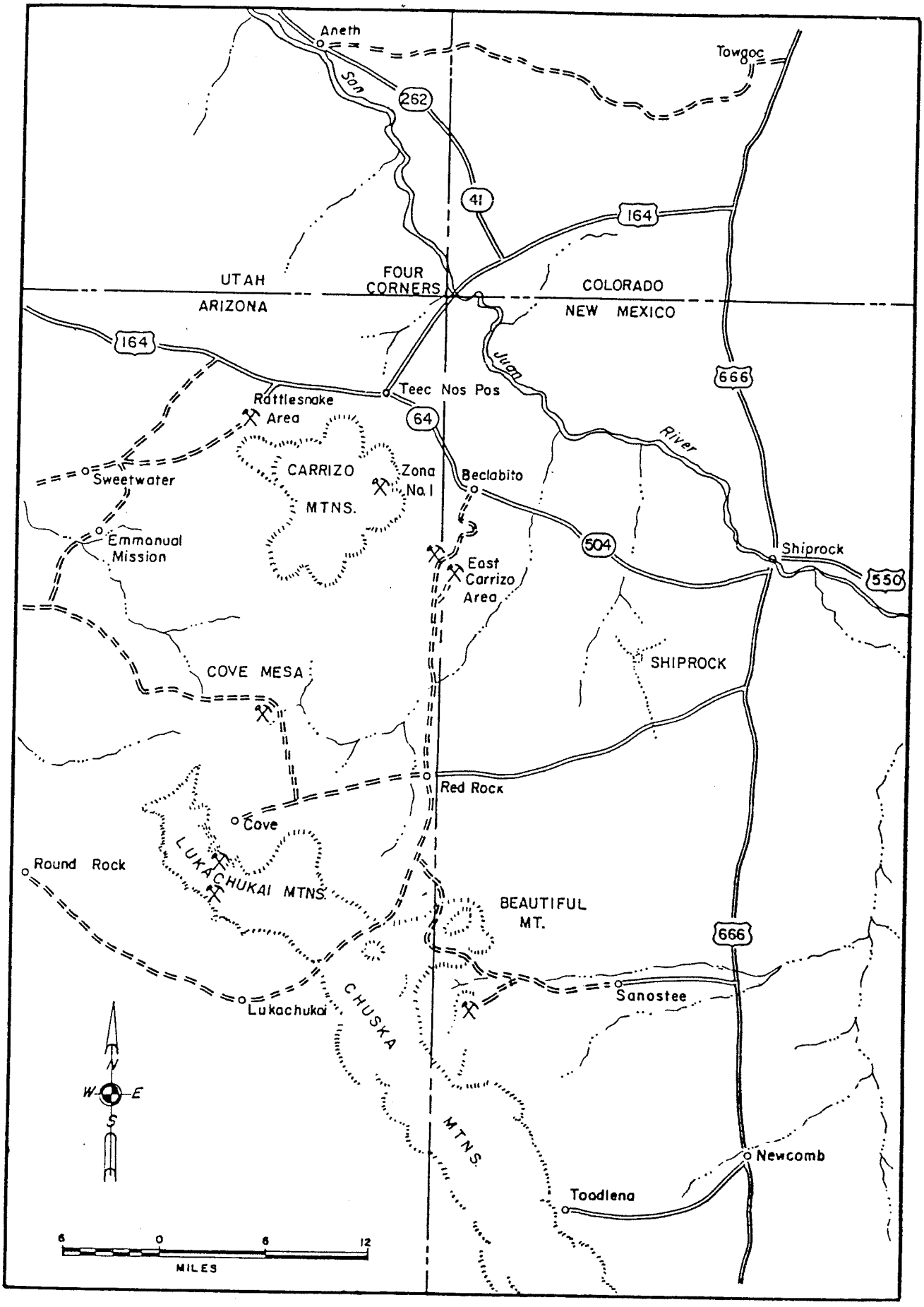

Figure 1. Index map of the Four Corners area showing the location of the principal uranium mines

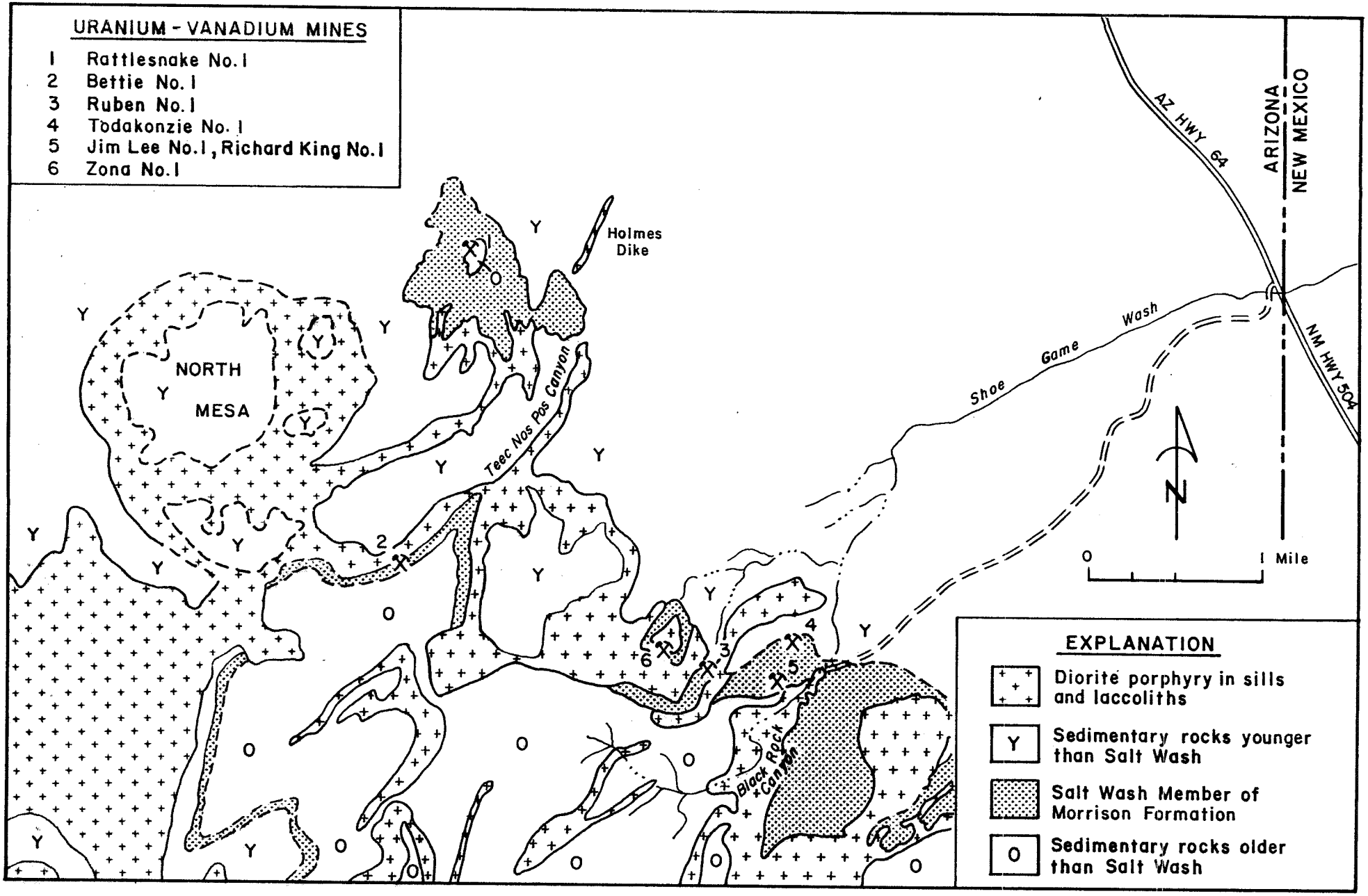

Figure 2. Geologic map of a portion of the northeastern Carrizo Mountains, Apache County, Arizona. Modified from Strobell (1952, a, b).

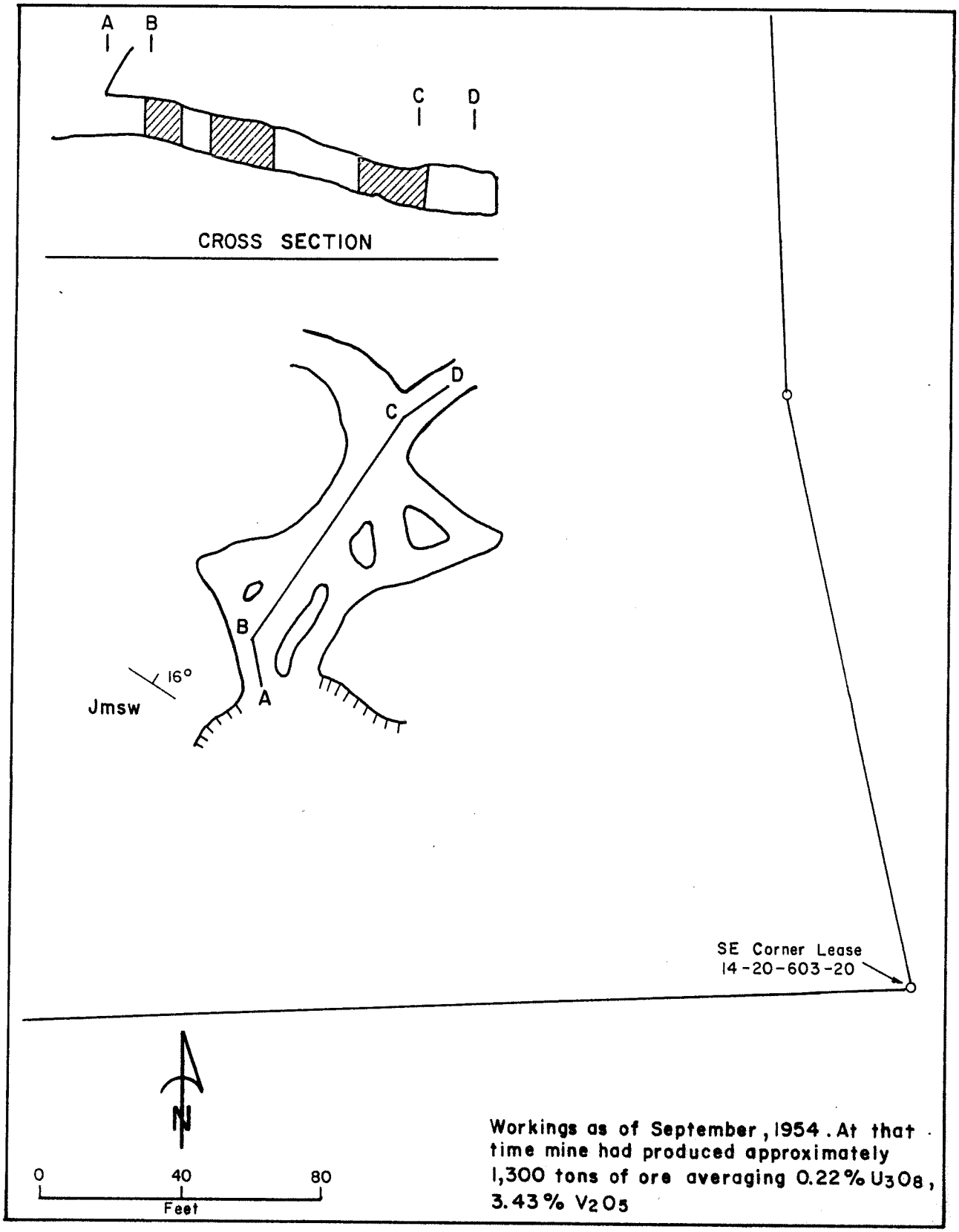

Figure 3. Plan map of the Zona No. I mine, Apache County, Arizona (from AEC files)