

**THE GEOLOGY, LEASING, AND
PRODUCTION HISTORY OF THE
SYRACUSE (R F AND R)
URANIUM-VANADIUM MINE,
APACHE COUNTY, ARIZONA**

by

William n L. Chenoweth
Consulting Geologist, Grand Junction, Colorado

Arizona Geological Survey
Contributed Report 97-D
August 1997

Arizona Geological Survey
416 W. Congress, Suite #100, Tucson, Arizona 85701

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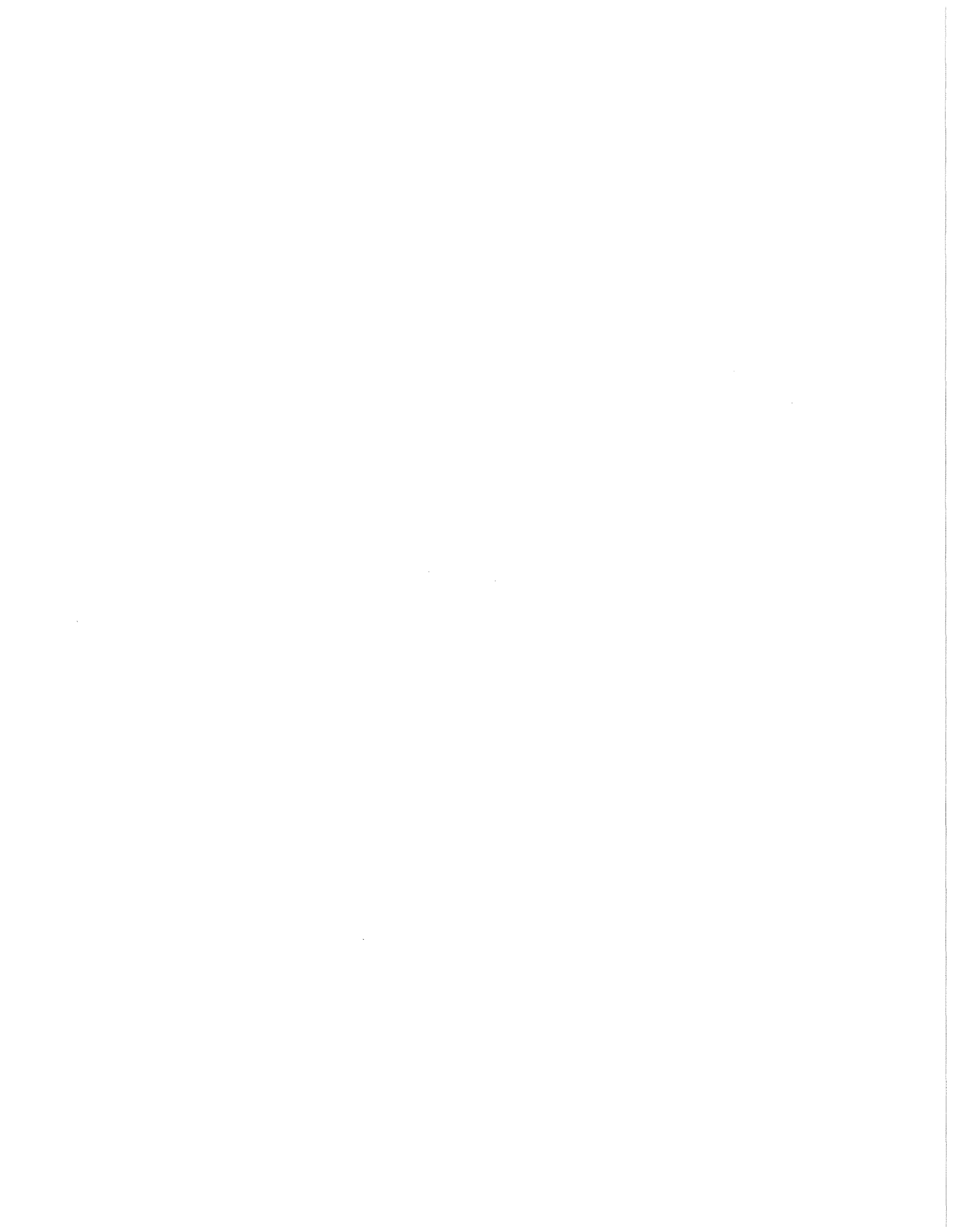
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INTRODUCTION

The Syracuse mine, also known as the R F and R or Sam Harvey Mine, was developed on one of the initial discoveries of uranium-vanadium minerals in the Carrizo Mountains of northeastern Arizona and northwestern New Mexico. The host rock for the ore deposit is the Salt Wash Member of the Morrison Formation of Late Jurassic age. Although the initial mining in the 1920's was for radium, this ore was later sold for its vanadium content.

During the early 1940s, nearly 500 tons of high-grade vanadium ore was produced. Drilling by the U.S. Atomic Energy Commission (AEC) in 1953 located some additional ore and the mine produced nearly 2,000 tons of uranium-vanadium ore in the 1950s and 1960s.

Scarborough [1981, p.27] mapped the mine workings, but some of the history [ibid., p. 129, 276] of the mine is incorrect. This report, from the author's field notes etc., and documents located after Scarborough's report was finished, summarizes the activities at this historic mine.

LOCATION AND LAND STATUS

The Syracuse Mine is located on a small knoll a mile and a quarter north of the settlement of Oak Springs (Figure 1). The location of the mine is shown on the Beclabito, N. Mexico-Arizona, 1:24,000-scale quadrangle at latitude 36°46'00"N and longitude 100°03'20"W [U.S. Geological Survey, 1982]. The mine was accessible by one and a half miles of an unimproved dirt road that heads north from Oak Springs.

The Syracuse mine is located within the Navajo Indian Reservation. On the Reservation, all prospecting, exploration and mining is controlled by the Navajo Tribal Council and the Bureau of Indian Affairs, U.S. Department of the Interior.

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 early vanadium ore production is contained in 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 vanadium and uranium section was obtained by the Grand Junction Area Office of the U.S. Department of Energy. Details of the mineral leasing regulations, applicable to the Navajo Indian Reservation, were taken from a report prepared by DeVoto and Huber [1982] for the U.S. De-

partment of Justice, which was also admitted as evidence in the above case. Copies of both the GSA report and the DeVoto and Huber report have been donated to the Arizona Geological Survey Library.

GEOLOGIC SETTING

The uranium-vanadium ore bodies at the Syracuse Mine occur in the Salt Wash Member of the Upper Jurassic Morrison Formation. In the Oak Springs-King Tutt Mesa area, the Salt Wash Member is approximately 220 feet thick. It is composed 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. Between 5% and 45% of the total thickness of the member consists of mudstone and siltstone beds. Huffman and others [1980] have subdivided the Salt Wash Member in the Oak Springs-King Tutt Mesa area into three stratigraphic units based on depositional environments. The lowermost unit consists of an average of 30 feet of predominately overbank deposits and alternating thin mudstone and sandstone. It contains few channel sandstones. The middle stratigraphic unit is an average of 70 feet thick and is composed of channel-sandstone deposits, partially and completely abandoned channel-fill deposits, and overbank deposits. Approximately 80% of the sandstone in this unit is active channel fill. The upper unit is 120 feet 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].

The channel sandstones that contains the ore bodies at the Syracuse mine are approximately 40 and 60 feet above the base of the Salt Wash, within the middle unit of the member. Detrital organic plant material, such as leaves, branches, limbs and trunks are common in the ore-bearing channel. Most all of this material is carbonized.

The uranium-vanadium ore bodies were formed by the selective impregnation of the sandstone and adsorption by the mudstone and fossil plant material. Ore bodies were commonly associated with detrital plant fragments in the sandstone. The ore bodies were roughly tabular in cross-section and irregular in plan. They ranged from several feet in width to a few hundred feet in length. Thicknesses at the Syracuse mine ranged from a feather edge to up to eight feet. Small high-grade ($>0.50\%$ U_3O_8) pods of ore were associated with replaced fossil wood.

The deposits were originally called camotite after the bright yellow mineral camotite, a potassium uranium vanadate. Later work by Corey [1958] and S.R. Austin [written communication, 1967] have identified tyuyamunite, a calcium uranium vanadate, and meta-tyuyamunite as the only uranium minerals in the Carrizo deposits. The mineralogy of the nearby Nelson Point mine on King Tutt Mesa was studied by Corey [1958]. In this mine, vanadium clay and montrosite were present. These minerals have been oxidized to form a number of secondary vanadium minerals that include sherwoodite, duttonite(?), hewettite, methahewettite, rossite, metarossite, and hendersonite [Corey, 1958]. Calcite is a common cement in ore. Pyrite, iron oxides, and gypsum may also be present.

The mine is located on the south flank of the east-plunging Syracuse Nose in the eastern Carrizo Mountains. This nose is probably due to an unexposed igneous sill of the Carrizo laccolith. Beds of the Salt Wash member at the mine dip nine degrees to the southeast.

EARLY LEASING AND VANADIUM PRODUCTION

Radium The New Element

The discovery of radium by Marie and Pierre Curie in 1898 led to the realization that all uranium ores contained this new element. Experiments which showed that radium inhibited the growth of certain cancers so astonished the medical profession that an incentive to mine the uranium-bearing ores was created.

Shortly before 1910, metallurgical processes for relatively large-scale recoveries of radium from carnotite ores were perfected. The improved processes resulted in greatly increased demands for carnotite and in accelerated prospecting in southern Colorado. About one gram of radium is present in every 200 to 300 tons of ore containing 2.0 percent U_3O_8 .

Shortly after 1910, the carnotite deposits in southwestern Colorado and southeastern Utah became one of the principal world sources of radium [Tyler, 1930]. For about 12 years, these deposits were mined for radium and yielded some byproduct uranium and vanadium. This activity led to prospecting and the discovery of similar deposits in the Carrizo Mountains.

Early Prospecting

Outcrops containing uranium and vanadium minerals in the Carrizo Mountains were discovered by John F. Wade in about 1918 with the assistance of local Navajos [personal communication, 1955]. Wade came from Farmington, New Mexico and operated the Sweetwater Trading Post in the western Carrizo Mountains (Figure 1). Through business contacts and field trips, he had determined that the same rocks that contained the carnotite deposits of southwestern Colorado were present in the Carrizo Mountains. The newly discovered deposits could not be mined because the Navajo Indian Reservation was then 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 of 1872. This Act allowed prospectors to enter the Reservation and stake a mining claim if their prospecting located promising mineral deposits. 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.

During the 1920s the Office of Indian Affairs (later changed to Bureau of Indian Affairs), U.S. Department of the Interior, issued four leases for metal mining in the Carrizo Mountains [GSA, 1981]. Three of these were for carnotite mining. A fourth lease, located in the northeastern Carrizo Mountains is believed to have been for copper.

After the Navajo Indian Reservation was opened to prospecting and mining, John F. Wade located 41 claims astride the Arizona - New Mexico state line in the vicinity of Milepost 16 [oral communication, 1955]. The GSA [1981] could not locate the details of the Carriso Uranium Company's lease, except for the first year's rental \$44.36, on 177.45 acres was paid on May 19, 1922, and noted that no production was reported.

In April, 1921 the area was examined by W.H. Staver, a consulting mining engineer. Staver [1921] noted that the company's holding consisted of the South Butte, Bluebell, North Star, and Hilltop claim groups. The North Star Group was located astride the state line, with five claims in New Mexico and six claims in Arizona, and contained the only development. Thirty-seven sacks of high-grade ore from these claims were stored at Beclabito Trading Post (Figure 1). Staver estimated that a total of 2,900 tons of probable ore could be developed on the property. Butler and Allen [1921] mention that 500 feet of benching and 100 feet underground development had been done on the claims. Hess [1924] also visited the area of the Carriso Uranium Company's activities in 1921 and reported that no shipments had been made, and that the ore was richer in vanadium than in uranium.

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 because of imports from Peru. The disposition of the stored ore at Beclabito was never mentioned in any of the early reports. However in 1926, Hess [1929] reported that the Utah Vanadium Company obtained some ore from the Carrizo Mountains and the ore was shipped to Denver for the production of fused vanadium oxide used by eastern ferroalloy manufacturers. Although there are no details on the size of this shipment, it represents the first vanadium production from the Carrizo Mountains. The shipment no doubt included the sacked ore observed by Staver at Beclabito, five year earlier.

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. The application asked the council to pass a resolution requesting the Secretary of the Interior to open the Navajo Indian 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.

Leasing For Vanadium

By the mid-1930s 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 Interior was asked to open the Navajo Indian Reservation for prospecting and mining. The Navajo Indian Reservation was subsequently 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 land with approval of the Secretary of Interior. Prospectors no longer could enter the

Reservation and stake a mining claim under regulation similar to those of the United States Mining Law. The new mining regulation contained escalating annual rentals, a base royalty of 10 percent (mine mouth value), bond requirements, acreage limitations, and a term of 10 years which could be extended by production.

On April 5, 1940, effective May, 1940, John F. Wade, Thomas F. Curran, and H. R. Redington (d.b.a. Wade, Curran and Co.) leased 42.32 acres in the Carrizo Mountains. This lease, I-149-IND-4225, covered the Sunnyside Lode Claim of 20.66 acres on Sunnyside Mesa and the Syracuse Lode Claim of 20.66 acres in the eastern Carrizo Mountains (Figure 1). The claims were described by U.S. Mineral Survey Nos. 3700 and 3857. The lease was for a period of five years. When the United States entered World War II, the demand for vanadium by the steel industry increased significantly. Due to the uncertainty of foreign supplies and the need for vanadium, and other strategic materials, the Federal government had formed Metals Reserve Company in December 1941. This agency was part of the Reconstruction Finance Corporation. The Metals Reserve vanadium program stimulated renewed interest in the carnotite deposits in the Carrizo Mountains with increased ore prices, and the establishment of buying stations. At Monticello, Utah and Durango, Colorado, Metals Reserve had mills to process vanadium ore.

The two claims comprising Lease I-149-IND-4425 were inactive until the Metals Reserve program was in place. Ore shipments from the lease began in July 1942 and continued through October 1943. Total production from the lease was 966.30 tons of ore containing 84,417.95 pounds V_2O_5 , and averaging 4.37% V_2O_5 (Table 1). Ore mined from the two claims was trucked to Farmington, New Mexico. Here it was transferred to rail cars to be shipped on the narrow gage railroad to the Metals Reserve mill at Durango, Colorado, operated by U.S. Vanadium Corporation.

Shipments from the two claims were not kept separate, but John Wade [oral communication, 1955] stated the Syracuse was the first to be mined as it was more accessible than the Sunnyside. Harshbarger [1946, p. 25] reported that shipments from the Sunnyside mine totaled 475 tons of ore containing 24,395 pounds V_2O_5 with an average grade of 2.57% V_2O_5 . Using these numbers, then the Syracuse mine produced 491 tons containing 60,023 pounds V_2O_5 with an average grade of 6.11% V_2O_5 .

When Duncan and Stokes [1942, p. 25] examined the Syracuse mine in October and November, 1942, they noted that six ore bodies were exposed in open cuts and in several short adits on the south side of the knoll. The ore bodies were 30 to 150 ft in length with an average thickness of 1 ft with some thicknesses up to 4 ft. Duncan and Stokes [1942, p. 25] also reported that between July and October 1942, the Syracuse mine shipped 775 tons of ore. However, this figure does not match with the Metal Reserve numbers in the files of the Bureau of Indian Affairs (Table 1). Based on the relative size of the mine workings on the two claims, the 491 ton figure for the Syracuse, from the Metals Reserve Company records appears to the writer to be more reasonable. Without question, the 1,500 tons reported by Scarborough [1981, p. 129] is too large.

A map of the Oak Springs area prepared by Coleman [1944] shows the Syracuse claim to be a standard 600 by 1,500 ft claim covering the entire knoll. Wade, Curran and Company did not have a Valley View claim as reported by Scarborough [1981, pp. 27, 276]. The Syracuse claim no doubt covered some of the same ground previously held by a few of the North Star claims of Wade's Carrizo Uranium Company.

Lease I-149-IND-4225 was due to expire on May 9, 1945, but was apparently canceled earlier. When Coleman mapped the Syracuse mine workings in the summer of 1944 (Figure 2), he noted the mine was abandoned, but still had low-grade ore showing in many of the walls and headings [Coleman, 1944, p. 20].

New Regulations

On April 9, 1941, the Navajo Tribal Council requested the Secretary of the Interior to approve regulations wherein mining leases would be granted to the highest bidder. These leases were written for large areas and subsequently reduced in acreage at the end of the 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. The maximum acreage a company could lease on the Reservation was 960 acres.

On May 29, 1942, in response to requests by several mining companies, the Office of Indian Affairs advertised an exploration lease sale for carnotite and related minerals in the eastern Carrizo Mountains. The area offered 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 to the point of beginning.”

The area contained approximately 104 square miles. This was the second carnotite lease sale for Navajo lands held under the bidding procedures.

Bids were opened on June 15, 1942, at which time Vanadium Corporation of America (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. Lease I-149-IND-5705 was commonly referred to as the “East Reservation Lease” by VCA. The U.S. Geological Survey (USGS) referred to the mines as the Eastside mines, a name still used in current USGS reports.

On September 2, 1943, the lease was reduced to a permanent operating lease and 12 plots totaling 436.79 acres were selected to be retained. Six of the plots (1-6) were on King Tutt Mesa, two of the plots (7,10) were

southeast of Oak Springs along the north side of Oak Creek Canyon and the remaining four plots (8,9, 11, and 12) were in the vicinity of Milepost 16.

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 its North Star claims. Each of the plots were named by VCA. Unfortunately, Plot 12, immediately west of Milepost 16, was called the Syracuse which lead to some confusion in the old records.

After acquiring six million pounds of V_2O_5 for the nation's strategic stockpile, Metals Reserve terminated its vanadium procurement program in February 1944. This action all but ended vanadium mining in the Carrizo Mountains.

URANIUM PRODUCTION

In 1947, the newly created U.S. Atomic Energy Commission (AEC) began a uranium procurement program. The vanadium mills at Monticello, Utah, and Uravan, Naturita and Durango, Colorado were converted to recover uranium as well as vanadium. With the exception of the Monticello mill, which was owned by the AEC, the other mills had contracts to sell uranium concentrates to the AEC. In the eastern Carrizo Mountains, VCA began mining on their East Reservation Lease in March 1948.

In 1949, the Interior Department and the Navajo Tribal Council developed new regulations that allowed individual Navajos to prospect. If a discovery was made, the ground would be held by a tribal mining permit. In 1951, additional regulations allowed non-Navajos to prospect on the Reservation, but only Navajos could obtain a mining permit. Permits could be assigned to an individual or company to explore and mine. Permits were issued for 2 years and could be renewed. Both the Tribe and the permittee received royalties. Since VCA held 960 acres of Reservation land, including their other Carrizo Mountains and Monument Valley leases, the company could not expand their holdings past this acreage limit.

In order to encourage mining in northwestern New Mexico and northeastern Arizona, the AEC established an ore-buying station at Shiprock, New Mexico on January 7, 1952. The VCA controlled mines continued to ship to the company's mill at Durango, Colorado, but the non-VCA mines now had a market at nearby Shiprock.

Beginning in 1952, the AEC conducted drilling programs in the eastern Carrizo Mountain in order to locate additional ore bodies. During the summer of 1953, the area of the Syracuse mine was drilled with both diamond and wagon drill holes. This drilling located two ore bodies behind the abandoned Syracuse mine [Blagbrough and Brown, 1955]. At the time of the drilling, the AEC believed the mine was controlled by VCA as part of their East Reservation Lease [Blagbrough and Brown, 1955]. Local Navajo prospectors held the same view [Leroy Pettigrew, oral communication, 1955].

Sam Harvey, a local Navajo who had done contract mining for VCA, apparently discovered the Syracuse mine was on open ground. On April 25, 1954, he was issued Navajo Tribal Mining No. 176 covering 43.85 acres of the old mine.

Harvey signed an operating agreement with Randol, Fry and Randol in the summer of 1954. In December 1954 Andrew A. Fry began shipments to the newly opened mill at Shiprock, operated by Kerr-McGee Oil Industries, Inc. Fry continued shipments through June 1955 (Table 2). Ore was mined on the south side of the knoll near the old mine workings and was shipped as the R F and R mine (Figure 3).

On October 21, 1955, the mining rights to Mining Permit No. 176 were assigned to Titan Uranium Corporation of Albuquerque, New Mexico. Titan began shipments to the Shiprock mill in January 1956. Monthly ore production at the beginning of 1956 was about 100 tons, but decreased to less than 50 tons per month by summer. At the beginning of 1957, monthly production rates were about 80 tons per month, but by the end of 1957 had decreased to about 20 tons per month. Most of Titan's mining was done on the north side of the knoll (Figure 3).

When the writer visited the mine on February 11, 1958, a contractor, Jess Fay, had started a new entry into the knoll on the east side (Figure 3). Fay hoped to produce between 50 and 60 tons per month for the next few months. Fay completed mining in May 1958, and when the writer examined the mine on June 9, 1958 it appeared abandoned.

After Titan ceased mining, the mine was considered depleted, and Mining Permit No. 176 was canceled by the Navajo Tribal Mining Department on April 27, 1961.

On October 17, 1961, Sam Harvey was issued Mining Permit No. 560 for the same 43.85 acres as No. 176. Since there was no mining at this time on the permit, it expired on October 17, 1963.

Early in 1964, Sam Harvey was issued Mining Permit No. 610 to replace No. 560. During April through June of 1964 he shipped a total of 180.40 tons to the mill at Shiprock, now operated by VCA. Small, lower-grade shipments were made in 1965 and 1966 (Table 2). All of these shipments were identified as the "Sam Harvey Mine, MP-610" at the mill. Harvey's shipments of 259.61 tons averaging 0.22 percent U_3O_8 and 22.6 percent V_2O_5 came from clean up mining in the existing workings of the R F and R mine.

SUMMARY

Although originally leased for radium, the Syracuse mine produced vanadium ore in 1926 and the early 1940s for the steel industry. In the 1940s, the Durango vanadium mill secretly recovered uranium from the mill tailings for the Manhattan Project [Chenoweth, 1997].

During the AEC program, in the 1950s and 1960s, a total of 1,966.77 tons of ore averaging 0.28% U_3O_8 and 2.61% V_2O_5 were produced from the R F and R or Sam Harvey mine, originally known as the Syracuse mine.

All of the uranium recovered at the Shiprock mill was sold to the AEC. At this mill, vanadium was paid for, but not all of it was recovered [Albrethren and McGinley, 1982].

Acknowledgments. Stephen M. Richard of the Arizona Geological Survey reviewed the initial version of this report. Originals of Coleman's 1944 maps were located in the AEC Research Collection at the Museum of Western Colorado in Grand Junction.

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Table 1. Vanadium ore production, Lease I-149-IND-4225, Syracuse and Sunnyside claims, Apache County, Arizona

YEAR	QUARTER	TONS OF ORE	POUNDS V_2O_5	% V_2O_5	VALUE (U.S. dollars)
1942	3rd	94.14	26,332.68	13.99	8,273.85
1942	4th	151.64	17,741.89	5.85	8,541.73
1943	1st	194.85	12,542.07	3.22	5,676.56
1943	2nd	211.29	13,639.32	3.23	6,429.46
1943	3rd	291.82	12,930.49	2.22	6,175.99
1943	4th	22.56	1,231.50	2.73	565.49
TOTAL		966.30	84,417.95	4.37	\$35,663.08

Royalty paid to the Navajo Tribe - \$5,442.55

Source: GSA [1981]

Table 2. Uranium-vanadium ore production, R F and R Mine, Apache County, Arizona

YEAR	OPERATOR	TONS OF ORE	POUNDS U_3O_8	% U_3O_8	POUNDS V_2O_5	% V_2O_5
1954	Andrew A. Fry	55.01	231.99	0.21	2,923.90	2.66
1955	Andrew A. Fry	140.66	854.53	0.30	8,840.61	3.14
1956	Titan Uranium	547.34	3,571.42	0.33	32,075.39	2.93
1957	Titan Uranium	584.02	3,272.80	0.28	30,130.61	2.58
1958	Titan Uranium	380.07	1,985.89	0.26	16,774.00	2.21
1964	San Harvey ¹	180.48	830.16	0.23	8,029.00	2.22
1965	Sam Harvey ¹	66.27	267.42	0.20	3,177.00	2.40
1966	Sam Harvey ¹	12.86	37.05	0.14	540.00	2.10
TOTAL		1,966.77	11,051.26	0.28	102,490.51	2.61

¹ Ore was shipped as the Sam Harvey mine, MP-610

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

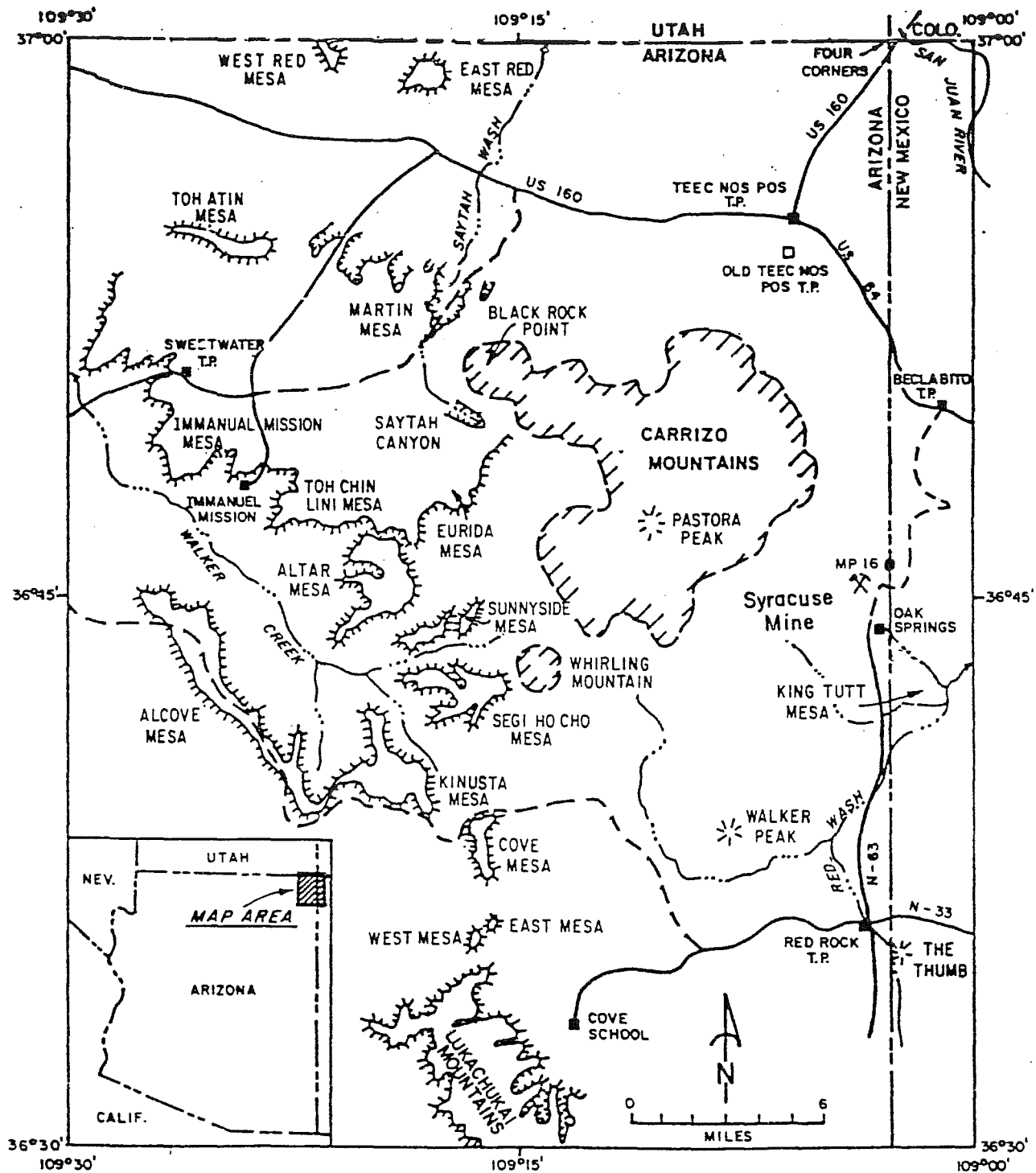


Figure 1. Index map of the Carrizo Mountains, Arizona-New Mexico, Showing the location of the Syracuse (R F and R) mine.



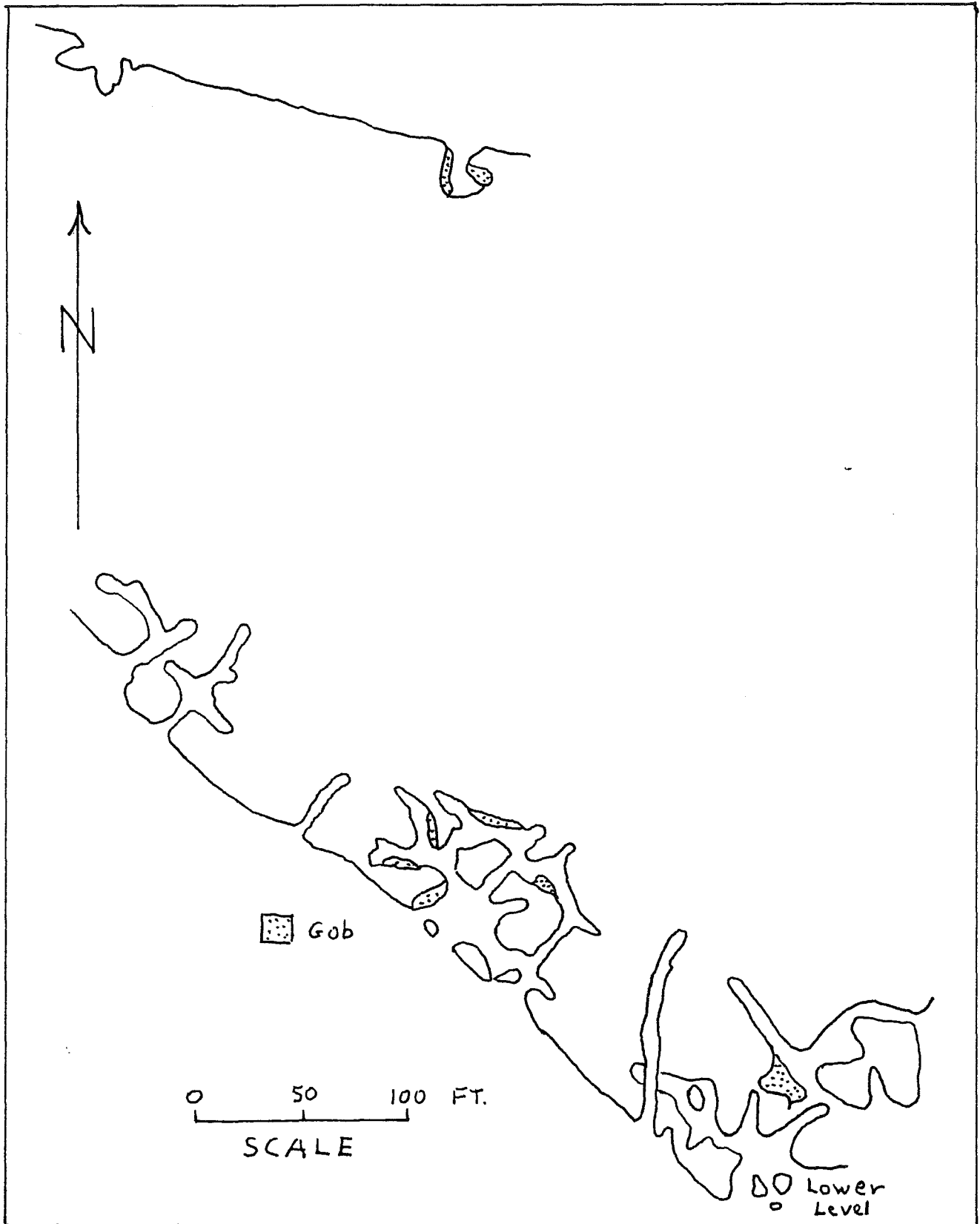


Figure 2. Map of the Syracuse mine, August 1944. From Coleman (1944).



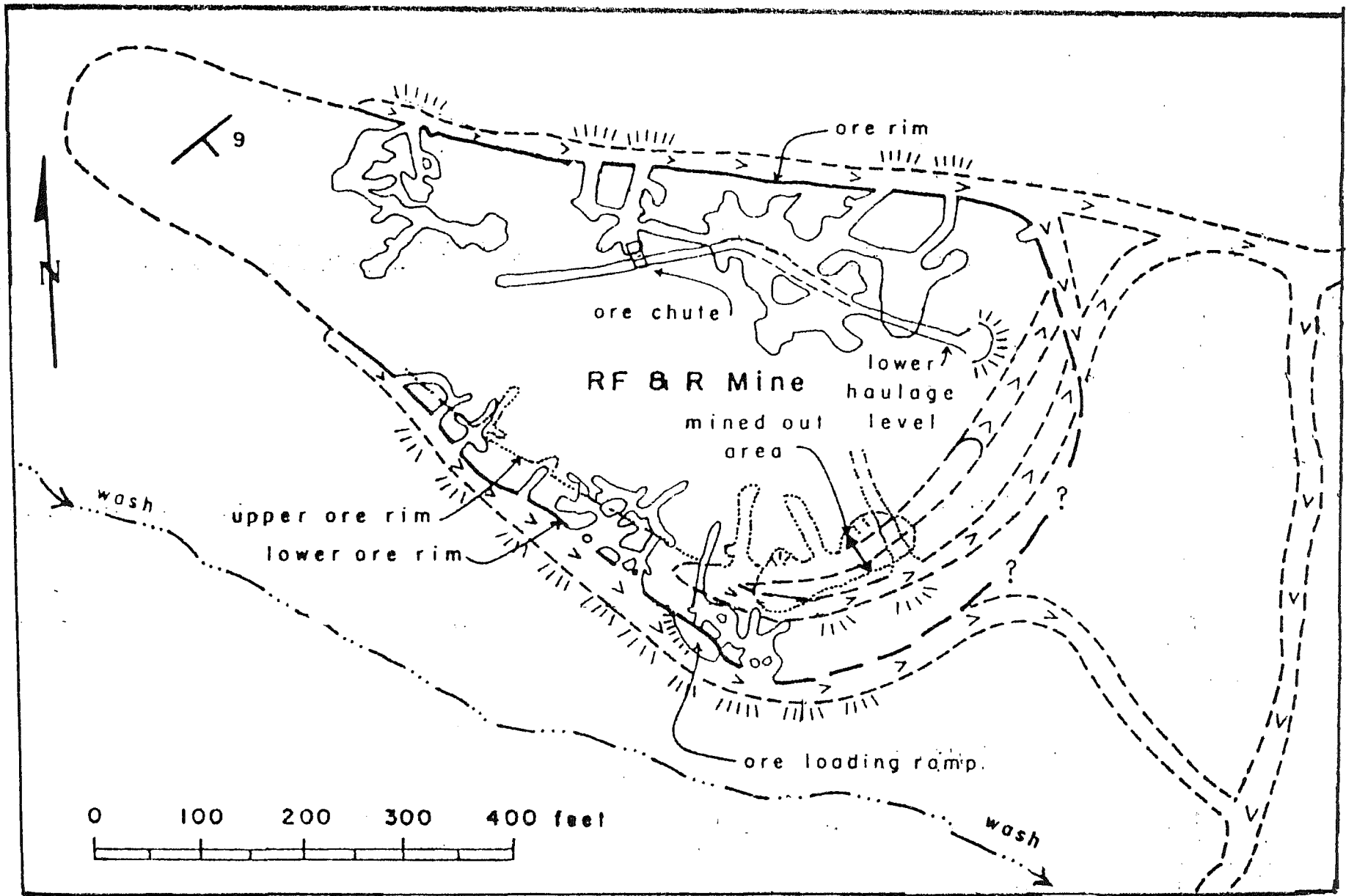


Figure 3. Map of the R F and R (Syracuse) mine, June 26, 1980. From Scarborough (1981, p. 27).