URANIUM PROCUREMENT AND GEOLOGIC INVESTIGATIONS OF THE MANHATTAN PROJECT IN ARIZONA

by

William L. Chenoweth*
Consulting Geologist, Grand Junction, Colorado 81506

Arizona Geological Survey
Open-File Report 88-02

January, 1988

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

*Formerly with the
U.S. Atomic Energy Commission
and the U.S. Department of Energy

This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards
TABLE OF CONTENTS

Abstract ................................................................. 1
Introduction ................................................................. 1
Uranium procurement ....................................................... 2
Sources of uranium ......................................................... 2
Monticello, Utah ............................................................. 3
Durango, Colorado .......................................................... 4
Ore production ............................................................... 4
Uranium resource investigations .......................................... 10
Organization of Union Mines Development Corporation ............... 10
Geologic investigations in Arizona ........................................ 14
Colorado Plateau ........................................................... 14
Areas outside the Colorado Plateau ....................................... 17
Land acquisition ............................................................ 18
Summary ................................................................. 19
References ................................................................. 21

ILLUSTRATIONS

Figure 1 Index map of Monument Valley showing the location of the vanadium mines that operated in the 1940s. ................. 8
Figure 2 Index map of the Carrizo Mountains showing the location of vanadium mines that operated in the 1940s. ................. 9
Table 1 Vanadium production, 1942-1946, Navajo Indian Reservation, Arizona - New Mexico. .................. 6
Table 2 Estimated uranium content of vanadium ores, Navajo Indian Reservation, Arizona, 1942-1946 ............. 7
URANIUM PROCUREMENT AND GEOLOGIC INVESTIGATIONS OF THE MANHATTAN PROJECT IN ARIZONA

ABSTRACT

The Manhattan Project was the highly secret project during World War II to develop the atomic bomb, which included the acquisition of raw materials. It was carried out by the Army Corps of Engineers' Manhattan Engineer District. An estimated 64,000 pounds of uranium oxide was recovered from vanadium ores mined in Monument Valley, Apache and Navajo Counties, Arizona, and in the Carrizo Mountains, Apache County. Geologic investigations conducted by a contractor, Union Mines Development Corporation, laid the groundwork for the exploration activities of the Atomic Energy Commission which succeeded the Manhattan Engineer District in 1947.

INTRODUCTION

Forty-three years ago, after the detonation of three atomic bombs in 1945, the public became aware of atomic energy and the Manhattan Project. The Manhattan Project was the code name used by the Army Corps of Engineers for the development of atomic weapons and the procurement of the necessary raw materials, during World War II. The project was carried out under the direction of the Corps' Manhattan Engineer District (MED).

The MED was established in August 1942. The name was taken from District Engineer, Colonel John C. Marshall's office, in New York City (Hewlett and Anderson, 1962, p. 81). In the summer of 1943 the headquarters of MED was transferred to Oak Ridge, Tennessee, and Lieutenant Colonel Kenneth D. Nichols was made District Engineer (Hewlett and Anderson, 1962, p. 117). Brigadier General Leslie R. Groves in Washington, D.C., was responsible for the entire project.
The names of places such as Los Alamos and Mockingbird Gap, New Mexico, that were associated with the project, became well known. The domestic raw materials activities of the project were largely overlooked. This brief historical review summarizes those activities in Arizona.

URANIUM PROCUREMENT

The Madison Square Area office was established for the procurement of raw materials, with Lieutenant Colonel John R. Ruhoff, Area Engineer. He was assisted by Captain Phillip L. Merritt, a graduate geologist.

Raw materials for the project were critical. In 1942 the largest available sources of uranium were the Shinkolobwe Mine in the Belgium Congo (now Zaire), and the Eldorado Mine on Great Bear Lake, Northwest Territories, Canada. In the United States, uranium was known to occur in the carnotite deposits in the Salt Wash Member of the Morrison Formation on the Colorado Plateau.

These deposits, principally in southwestern Colorado and southeastern Utah, had been mined for radium from about 1910 to 1924, with some uranium and vanadium recovered as by-products. Since 1936 the same deposits had been mined for vanadium. At the Naturita and Uravan, Colorado vanadium mills, large tonnages of tailings containing low concentrations of uranium had been stockpiled.

Due to the uncertainty of foreign supplies and the need for vanadium for war armaments, the Federal government formed Metals Reserve Company in 1942. This agency, which was part of the Reconstruction Finance Corporation, began an ore-purchasing program and increased the base price paid for vanadium ore.

Sources of Uranium

A survey of the vanadium activities on the Colorado Plateau by MED in December 1942, led to contracts with the two largest vanadium
producers, United States Vanadium Corporation and Vanadium Corporation of America, and with the Metals Reserve Company. Uranium in vanadium ores from Arizona were recovered at plants in Monticello, Utah, and Durango, Colorado.

Monticello, Utah.

In late 1940, Vanadium Corporation of America (VCA) opened a vanadium ore buying station at Monticello, Utah, in order to stimulate mining in the area. Within a short time, ore production increased sufficiently to justify construction of a vanadium mill. In September 1941, the War Production Board approved VCA's proposal to build a mill. Funding was provided through the government's Defense Plant Corporation. The plant was to be operated by VCA for Metals Reserve. Actual construction started in February, and on August 24, 1942, the first vanadium was produced (Albrethsen and McGinley, 1982, p. 92).

In January, 1943, Metals Reserve Company (MRC) agreed to produce a uranium-vanadium (U-V) sludge at Monticello that was sold to MED on a unit price basis. The sludge contained 45 to 50% U₃O₈ and about 25% V₂O₅ and was shipped to the Vitro Manufacturing Co. at Canonsburg, Pennsylvania, for additional processing (Hewlett and Anderson, 1962, p. 292). Tailings from the Monticello mill were considered by the MED to be too low in uranium for additional processing (Merritt, 1945, p. 2). In February, 1944, MRC closed the Monticello mill and ceased production of both fused vanadium oxide (V₂O₅) and the 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 (Albrethsen and McGinley, 1982, p. 92).
Durango, Colorado.

In 1942, the Reconstruction Finance Corporation, a government agency, contracted with United States Vanadium Corporation (USV) to convert and operate an old lead smelter for vanadium production. The vanadium was supplied to Metals Reserve Company. USV operated the plant for the government until early 1944, when the government vanadium purchasing program was terminated because of adequate vanadium stocks. USV 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 (Albrethsen and McGinley, 1982, p. A-11).

During the 1943-1944 period, USV constructed and operated a uranium-vanadium 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 the MED refinery at Grand Junction, Colorado (U.S. Department of Energy, 1982, p. 3). The purpose of the refinery was to further concentrate the uranium and to remove the vanadium from the green sludge which was received from tailings treatment plants at Durango and Uravan. The product from the refinery was shipped to Tonawanda for further processing into black oxide (Hewlett and Anderson, 1962, p. 292). The Grand Junction refinery was in operation from 1943 through 1945.

Ore Production

During the 1940s, the Interior Department's Office of Indian Affairs issued eight leases to mine carnotite ore on the Navajo Indian Reservation in Arizona. Two of the leases were in the Monument Valley area of Navajo and Apache Counties, and five were in the Carrizo Mountains of Apache County. Another lease (I-149-IND-5705), in the Carrizo Mountains was largely in San Juan County, New Mexico, but three plots, or tracts, of the lease were in Arizona. The locations of the mines which produced vanadium ore from these leases are shown in Figures 1 and 2. The host rock
for the carnnotite deposits in Monument Valley was the Shinarump Member of the Chinle Formation, and in the Carrizo Mountains it was the Salt Wash Member of the Morrison Formation.

A summary of the vanadium production from these leases is given in Table 1. Details of the production history of these leases and individual mines are given by Chenoweth (1985a,b).

The operators of the vanadium mines were the Vanadium Corporation of America (VCA), and John F. Wade and his associates, Thomas F.V. Curran and Charles F. Curran. VCA trucked their ores to the plant at Monticello, Utah, and Wade and the Curran brothers sent their ore to Farmington, New Mexico where it was loaded on railroad cars for shipment to Durango, Colorado.

Nearly all the ore mined by VCA on Lease I-149-IND-5705 came from New Mexico and is not considered in this report. The ore from the Rattlesnake No. 1 Mine (Lease I-149-IND-6342), near Teec Nos Pas Trading Post was so low grade it was not considered to contain significant uranium.

In order to estimate the amount of uranium oxide in the vanadium ores, I used the $\text{U}_3\text{O}_8$ to $\text{V}_2\text{O}_5$ ratios for these same mines from the U.S. Atomic Energy Commission records of the early production in the late 1940s and early 1950s. This procedure suggests that the 15,070 tons of vanadium ore produced in Arizona during 1942 through 1946 contained 91,216 pounds of uranium oxide ($\text{U}_3\text{O}_8$). Details of this calculation are given in Table 2.

Using a recovery factor of 70 percent at the mills, an estimated 64,000 pounds of $\text{U}_3\text{O}_8$ from Arizona went into the manufacture of the first atomic weapons. Although this represents only a small fraction of the total domestic production of 2,698,000 pounds of $\text{U}_3\text{O}_8$ (U.S. Department of Energy, 1982), Arizona is usually overlooked as contributing to the Manhattan Project.
## Table 1

**Vanadium Production, 1942-1946, Navajo Indian Reservation**  
Arizona-New Mexico

<table>
<thead>
<tr>
<th>Lease No.</th>
<th>Mines¹/</th>
<th>Tons of Ore</th>
<th>%V₂O₅</th>
<th>Pounds V₂O₅</th>
<th>Operator</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-149-IND</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MONUMENT VALLEY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5869</td>
<td>Monument No. 1</td>
<td>3,525</td>
<td>1.94</td>
<td>136,797</td>
<td>VCA</td>
<td>1942-46</td>
</tr>
<tr>
<td>6204</td>
<td>Monument No. 2</td>
<td>489</td>
<td>1.40</td>
<td>13,737</td>
<td>VCA</td>
<td>1943-46</td>
</tr>
<tr>
<td>CARRIZO MOUNTAINS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3798</td>
<td>Martin, Saytah, Eurida</td>
<td>2,198</td>
<td>2.91</td>
<td>127,909</td>
<td>Wade, Curran &amp; Co.</td>
<td>1942-43</td>
</tr>
<tr>
<td>4225</td>
<td>Sunnyside, Syracuse</td>
<td>966</td>
<td>4.37</td>
<td>84,418</td>
<td>Wade, Curran &amp; Co.</td>
<td>1942-43</td>
</tr>
<tr>
<td>5465</td>
<td>Rattlesnake Mines</td>
<td>7,504</td>
<td>1.83</td>
<td>274,411</td>
<td>VCA</td>
<td>1942-44</td>
</tr>
<tr>
<td>5705</td>
<td>Eastside Mines</td>
<td>10,216</td>
<td>2.46</td>
<td>504,195</td>
<td>VCA</td>
<td>1942-45</td>
</tr>
<tr>
<td>6197</td>
<td>Saytah Canyon Mines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cove Mesa</td>
<td>388</td>
<td>1.94</td>
<td>15,060</td>
<td>Curran Bros. &amp; Wade</td>
<td>1943-44</td>
</tr>
<tr>
<td>6342</td>
<td>Rattlesnake No.1</td>
<td>146</td>
<td>.12</td>
<td>361</td>
<td>VCA</td>
<td>1944</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>25,432</td>
<td>2.27</td>
<td>1,156,888</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹/ See Figures 1 and 2 for location of mines.

**TABLE 2**

ESTIMATED URANIUM CONTENT OF VANADIUM ORES, NAVAJO INDIAN RESERVATION, ARIZONA 1942-1946

<table>
<thead>
<tr>
<th>Mines</th>
<th>Ton of Ore</th>
<th>Pounds $V_2O_5$</th>
<th>$U_3O_8$ to $V_2O_5$ Ratio*</th>
<th>Estimated Pounds $U_3O_8$</th>
<th>Milling Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monument No. 1</td>
<td>3,525</td>
<td>136,797</td>
<td>1:4.6</td>
<td>29,738</td>
<td>Monticello</td>
</tr>
<tr>
<td>Monument No. 2</td>
<td>489</td>
<td>13,737</td>
<td>1:4.2</td>
<td>3,271</td>
<td>Monticello</td>
</tr>
<tr>
<td>Rattlesnake</td>
<td>7,504</td>
<td>274,411</td>
<td>1:9.0</td>
<td>30,490</td>
<td>Monticello</td>
</tr>
<tr>
<td><strong>Subtotal Monticello</strong></td>
<td><strong>11,518</strong></td>
<td><strong>424,945</strong></td>
<td></td>
<td><strong>63,499</strong></td>
<td></td>
</tr>
<tr>
<td>Martin, Saytah, Eurida</td>
<td>2,198</td>
<td>127,909</td>
<td>1:7.5</td>
<td>17,055</td>
<td>Durango</td>
</tr>
<tr>
<td>Sunnyside, Syracuse</td>
<td>966</td>
<td>84,418</td>
<td>1:9.3</td>
<td>9,077</td>
<td>Durango</td>
</tr>
<tr>
<td>Saytah Canyon, Cove Mesa</td>
<td>388</td>
<td>15,060</td>
<td>1:9.5</td>
<td>1,585</td>
<td>Durango</td>
</tr>
<tr>
<td><strong>Subtotal Durango</strong></td>
<td><strong>3,552</strong></td>
<td><strong>227,387</strong></td>
<td></td>
<td><strong>27,717</strong></td>
<td></td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>15,070</strong></td>
<td><strong>652,332</strong></td>
<td></td>
<td><strong>91,216</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Based on 1948-1953 production purchased by the U.S. Atomic Energy Commission.
Figure 1. Index map of Monument Valley showing the location of the vanadium mines that operated in the 1940's
Figure 2. Index map of the Carrizo Mountains showing the location of the vanadium mines that operated in the 1940's.
URANIUM RESOURCE INVESTIGATIONS

Early in 1943, MED decided it needed to learn as much as possible about the uranium and thorium resources of the world. Rather than establish a new agency, MED decided to use the services of an existing organization (Groves, 1962, p. 180). Union Carbide and Carbon Corporation was a prime contractor to MED at Oak Ridge, Tennessee. A subsidiary, United States Vanadium Corporation was a supplier of uranium to the project. With such a background, Union Carbide agreed to undertake the resource evaluation assignment (Groves, 1962, p. 180), and Union Mines Development Corporation (UMDC) was created. A contract No. W-7405 Eng-78, effected May 11, 1943, provided that all costs should be reimbursed by the government, with no fixed fee or profit to UMDC (Manhattan District Engineers, 1947, p. 1.1).

To oversee the resource appraisal activities of UMDC, the MED created the Murray Hill Area Office in New York City on June 15, 1943. Lieutenant Colonel Paul L. Guarin served as Area Engineer from June 1943 until March 1946. He was succeeded by Lieutenant Colonel A.W. Oberbeck who served as Area Engineer for about one month, until the Murray Hill Area was absorbed by the Madison Square Area in April 1946 (Manhattan District Engineers, 1947, p. 5.5-5.6). Lieutenant Colonel Guarin was assisted by civilian geologists George C. Selfridge and George W. Bain, and a mining engineer Frank J. Belina.

Organization of Union Mines Development Corporation

Union Mines set up offices in June 1943 on the 18th floor at 50 East 42nd Street in New York City and immediately began the recruitment of personnel. Due to the extreme secrecy of the project, UMDC operated under the pretense of a large international mining company, interested in tungsten, molybdenum, and vanadium (Manhattan District Engineers, 1947, p. 1.6).
Operations of UMDC were performed by four divisions: bibliographic search, field exploration, exploration research, and metallurgical research.

The Bibliographic Search Division did the examination of all available literature and the preparation of reports on all recorded occurrences of uranium ores. About 67,000 volumes were examined, more than half were in foreign languages.

The Field Exploration Division sent out field parties of geologists and mining engineers who made examinations in more than 20 foreign countries and in 36 states in this country.

The Exploration Research Division dealt with the development of information and methods for field exploration, in two principal fields: research as to the applicability of geophysical methods of prospecting, and mineralogical research.

The geophysical research was concerned with the development of improved portable models of Geiger-Muller counters for field use, procedures for the use of these counters for quantitative or semiquantitative assaying, laboratory counters for accurate quantitative assays, and radioactive methods of locating and measuring ore reserves.

The mineralogical research was carried out first in the laboratories of the Union Carbide and Carbon Corporation at Niagara Falls, New York, and later, in a laboratory established at the New York offices. This work resulted in the development of a device for measuring the maximum sensitivity of the bead test, which was the standard chemical method of testing for the presence of uranium. Research determined that lithium fluoride be used instead of sodium fluoride as a flux in the bead test.

The Metallurgical Research Division devoted its first efforts to the development of suitable processes for concentrating carnotite.
ores from the Colorado Plateau region, but before their work was finished they had done work on nearly every type of uranium ore occurring throughout the world. The Division made a working agreement with the Denver Equipment Co., Denver, Colorado, whereby, the research investigations were carried on in that company's laboratories, with the use of the company's facilities and many of its personnel. The results of work done on samples from the Carrizo Mountains are contained in a report by Handley (1946).

The majority of the work of the Field Exploration Division was on the Colorado Plateau. A field office was established in Grand Junction, Colorado, in July 1943, with Benjamin N. Webber, as Chief Field Geologist (Van Fleet, 1944, p. 4).

After a brief geological training period by geologists of USV, field work by UMDC geologists began on July 28, 1943, in the southern Carrizo Mountains in Apache County. By February 1, 1944, the Grand Junction Field Office had a staff of 48 geologists and engineers, divided into 11 field parties, plus a small administrative force (Van Fleet, 1944, p. 4).

Geologic work on the Colorado Plateau was limited to the Salt Wash Member of the Morrison Formation, and the Entrada Sandstone in the areas where it contained uraniferous vanadium deposits, such as at Rifle, Placerville, and Rico, Colorado. The Chinle Formation was studied only in the Temple Mountain, Utah area, since it was the sole area of radium production in the 1910s and 1920s from the Chinle (Murphy, 1944). It has been suggested that the uranium potential of the Chinle Formation was overlooked by UMDC due to the fact that the U.S. Vanadium Corporation, who trained the UMDC geologists, had no interest in the vanadium resources of that formation (R.P. Fischer, personal communication, 1987).
All known exposures of the Salt Wash Member were prospected and mapped. Exposures of carnotite-bearing minerals, prospects, and mines were mapped and described. Ore reserves were calculated from samples collected on outcrops and in mines. Areas where reserves could be developed by additional drilling were especially noted. Stratigraphic sections of the Morrison and adjacent formations were measured throughout the Colorado Plateau. All of this work was done under the disguise of looking for vanadium.

Although the reports of the UMDC geologists were classified as SECRET by the MED, they could not contain the word uranium. Hence, special codes were used: S-37 were uranium minerals; SOM was uranium; and SOQ was uranium oxide (U₃O₈). A typical description of an occurrence was, "...31 ft. long outcrop, avg. thickness 3.2 ft. of vanadium with some weakly disseminated S-37. Avg. grade estimated to be better than 1% V₂O₅ and 0.25% SOQ. Horizon about 42 ft. above base of Salt Wash. Sample 3513 cut."

UMDC geologists also collected historical production information on the mines which had been active during the radium and vanadium eras.

Field work on the Colorado Plateau was curtailed in early 1946. When the work was completed later that year, some 44 separate geological reports had been written for the Colorado Plateau localities. These included 3 reports for Arizona, 18 for Colorado, 1 for New Mexico, and 22 for Utah. The geologic investigations of UMDC were summarized in a report by Webber (1947).
Colorado Plateau.

**Carrizo Mountains Studies** - During the summer and fall of 1943, UMDC sent three field parties into the western and southern Carrizo Mountains in Apache County to begin a reconnaissance of the Salt Wash Member of the Morrison Formation. The work was concentrated in the area of a 168 square mile prospecting lease (I-149-IND-6197) which was being acquired by the Curran brothers and John Wade in partnership with U.S. Vanadium Corporation. This lease was 7 miles wide east-west and 24 miles long north-south, with the southeast corner near Cove School (Figure 2). Excluded were all lands of prior approved leases.

Party No. 1 under Alfred H. Coleman worked on Cove Mesa, East Mesa, and West Mesa in the southern Carrizo Mountains and on Mexican Cry Mesa on the northwest tip of the Lukachukai Mountains (Figure 2). Bad weather in December ended the field work in the Lukachukai Mountains. Coleman planned no further work in the Lukachukais, as the uranium-vanadium occurrences on Mexican Cry Mesa were small and scattered, and he believed that the pre-Chuska unconformity had cut out the Salt Wash beds to the southeast (J.W. Harshbarger, personal communication, 1983). Had mapping continued the next field season, UMDC geologists would have no doubt discovered the large outcrops of uranium-vanadium minerals in the central and southeastern part of the mountains. These were not discovered until 1949 at the beginning of the uranium boom.

Party No. 2, with Francis X. Corbett in charge, examined the Salt Wash on Emmanuel Mission, Toh Chin Lini, Segi Ho Cho, and Altar Mesas, and in the vicinity of the Sunnyside and Eurida Mines (Figure 2). Party No. 3 with Edward H. Eakland Jr. as Party Chief mapped on Kinusta and Alcove Mesas in the southwestern Carrizo Mountains and in the Saytah Canyon and Martin Mesa areas of the northwestern Carrizos (Figure 2).
The results of these three reconnaissance parties are included in a report by Webber (1943) in which he recommended 9,810 feet of drilling behind mineralized outcrops on Cove, Kinusta, Segi Ho Cho Mesas in Saytah Canyon. Webber also stated that the most promising outcrops of uranium-vanadium minerals within the Curran Brothers and Wade - U.S. Vanadium prospecting lease had been located, mapped, and sampled.

During the 1944 field season, Coleman's Party No. 1 made a reconnaissance of the Salt Wash between Red Rock and Beclabito Trading Posts in the eastern Carrizos (Figure 2). Although most of the area was in New Mexico, the Syracuse Mine in Apache County (Figure 2) was mapped and sampled. Coleman (1944, p. 20) considered the Syracuse Mine "to have the best prospective value of anything seen on the Navajo Reservation". However, it could not be acquired as UMDC already held their maximum 960 acres on the Reservation, due to the acquisition of the Curran Brothers and Wade-U.S. Vanadium lease.

The results of the 1944 reconnaissance (Coleman, 1944) were considered preliminary, and UMDC planned additional mapping and sampling in order to make detailed ore reserve estimates. Unfortunately, no follow-up work was done in the eastern Carrizos, due to Coleman's untimely death in 1945. Hence, the eastern Carrizo project is not as complete as other UMDC district studies (J.W. Harshbarger, personal communication, 1983).

Party No. 3 of Eakland returned to the northwest Carrizos in February and March 1944 and completed a reconnaissance of the Salt Wash in the vicinity of Sweetwater Trading Post, and on the northside of Toh Atin Mesa including the Salt Wash on East and West Red Mesas (Figure 2). The area studied was completely outside the boundaries of the prospecting lease of Curran Brothers and Wade-U.S. Vanadium. Eakland was subsequently drafted into the military service, and his report (Eakland, 1946) was completed by the UMDC staff.
Party No. 3 now under the leadership of John W. Harshbarger, returned to the southern and western Carrizo Mountains in July and August of 1945, to obtain data for the calculation of ore reserves. Many of the mineralized occurrences which had been located and mapped in 1943 were re-examined and re-sampled. Several new discoveries were mapped and described. The Rattlesnake Mines on Vanadium Corporation of America's lease (I-149-IND-5465) were mapped and sampled.

Harshbarger's report (1946) was a summary of UMDC's mapping and examinations in the western and southern Carrizo Mountains, including the 1943 preliminary reconnaissance work of Parties 1, 2 and 3. Using a cutoff grade of 0.05 percent U₃O₈, a total positive, indicated, and inferred ore reserve of 399,950 tons averaging 0.091 percent U₃O₈ and 1.308 percent V₂O₅ was calculated for the area. When a cutoff of 0.15 percent U₃O₈ was used, a reserve of 48,780 tons averaging 0.21 percent U₃O₈ and 2.08 percent V₂O₅ was calculated. This was a very realistic figure as the area produced 73,118 tons averaging 0.21 percent U₃O₈ and 1.64 percent U₃O₈ between 1948 and 1966 (Chenoweth, 1985a).

Harshbarger (1946) also recommended a drilling program of some 115,000 feet, plus a small amount of underground drifting to develop the uranium resources on the lease plots UMDC had acquired. A total of 24 stratigraphic sections of the Salt Wash and adjacent units were measured in the western and southern Carrizo Mountains.

Morrison Formation Reconnaissance - After completing reconnaissance investigations in the western Carrizo Mountains, Party No. 2 under Francis X. Corbett made a regional reconnaissance study of the Morrison Formation on the perimeter of the Black Mesa Basin. A total of 67 stratigraphic sections of the Morrison and adjacent formations were measured Corbett (1943) and Zebal (1943a,b). The information from these sections was incorporated into a regional synthesis of the Morrison Formation that was prepared by the UMDC staff in Grand Junction (Webber, 1947).
Areas Outside the Colorado Plateau.

With the exception of the Huerfano Park area in south central Colorado, areas outside the Colorado Plateau were examined by UMDC geologists reporting to the New York office. In October and November of 1943, John W. Hill made a reconnaissance survey of nine mountain ranges near Tucson. The ranges examined included Tortollita, Santa Catalina, Tanque Verde, Rincon, Sierrita, Quinlan-Coyote, Santa Rita, Baboquivari, and Comobabi. Pegmatite veins in the ranges were found to be small and scarce, and quartz veins were also found to be barren of uranium (Hill, 1944).

Following the reconnaissance in the Tucson area, Hill would spend two years examining pegmatites, metallic lode deposits and placers in central and southeastern Arizona. At times he was assisted by J.H. Skidmore and A. F. Carper.

Uranium was detected in concentrates from the Model Creek placers in the Peeples Valley of Yavapai County, and in the Black Mountain Wash southwest of Tucson. Overall, Hill (1946) gave a negative report for the uranium potential for southern Arizona.

In a review of Hill's report for MED, George C. Selfridge, the civilian geologist, noted that UMDC made no mention of uranium at the Hillside Mine in Yavapai County (in Hill, 1946, p. 1-4). Torbernite had been reported at this mine and a U.S. Geological Survey's examination had indicated that the tailings pile at the mill, and the mine dump might contain 250,000 tons of material averaging 0.013 to 0.023 percent $U_3O_8$ (Harder and Wyant, 1944). This examination was part of a reconnaissance of 27 mines and prospects in the western U.S. which the USGS made for MED, independently of UMDC. The uranium occurrence of the Hillside Mine was the only property in Arizona the USGS found of interest.
Land Acquisition

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 northern and western Carrizo Mountains, UMDC took action to acquire the lease of Curran Brothers and Wade-U.S. Vanadium.

On July 23, 1943, in response to requests from mining companies, the Office of Indian Affairs advertised an exploration mining lease sale for carnotite and related minerals in the northern and western Carrizo Mountains. The area offered consisted of 168 square miles in a tract 7 miles wide east-west, and 24 miles long, north-south, with the southeast corner located near Cove School (Figure 2). Excluded were all lands subject to prior approved mineral leases.

Bids were opened on August 23, 1943 at which time the only bid received was $5,085.00 from Thomas F. V. Curran, Charles F. Curran, and John F. Wade, d.b.a. Curran Brothers and Wade (GSA, 1981, exhibit 38). Lease I-149-IND-6197 was executed on August 6, 1943, effective October 27, 1943 for a period of ten years. On the date the lease became effective, a two thirds interest was assigned to U.S. Vanadium Corp. (USV). The assignment was made due to the fact that USV had advanced the Curran brothers and John Wade $4,068.00 needed to meet the terms of the lease (Manhattan District Engineers, 1947, p. 2.5).

With the assistance of UMDC geologists, the exploration lease was reduced to an operating lease, consisting of 12 plots or tracts, totalling 960 acres on March 22, 1944. These 12 plots covered the most promising ore-bearing outcrops as well as some mines that UMDC had examined and mapped in 1943. Party No. 4, under Anthony M. Mastrovich, surveyed the location of these plots during December 1943 and January 1944.

On April 17, 1944, the one third interest in Lease I-149-IND-6197 held by Curran Brothers and Wade, was reassigned to Union Mines.
The two thirds interest held by USV was reassigned to UMDC on April 24, 1944. Both reassignments were approved by the Office of Indian Affairs on October 31, 1944 (GSA, 1981).

The cost of acquiring the lease was reported at $16,000 or about $16.50 an acre (Manhattan District Engineers, 1947, p. 2.6). Union Mines did no physical exploration or mining on the lease, a proposal drilling project was never approved by MED.

SUMMARY

During World War II, the Manhattan Engineer District, under the direction of 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 Atomic Energy Commission (AEC) by Executive Order 9816, effective at midnight, December 31, 1946. The creation of the AEC transformed the development of atomic energy from a secret military organization to a civilian agency, whose general activities were a matter of public record.

Uranium procurement which was done secretly by the MED was continued by the AEC, but that agency's need for uranium was made public. The price schedules, bonuses, and other incentives of the AEC, created a prospecting effort unsurpassed in any other metal. The Monument No. 2 Mine in Monument Valley and the Rattlesnake Mine in the northwestern Carrizo Mountains were the first properties in Arizona to produce uranium for the AEC program.
The geologic reports and maps of UMDC provided the foundations of the exploration activities of the newly created AEC. These documents were found to be extremely thorough by AEC geologists. With the exception of the interior of the Carrizos, which was not investigated by UMDC, only a few mineralized outcrops in the Salt Wash were missed by the UMDC reconnaissance. Many of the outcrops they described later became small mines.

Recommendations by UMDC geologists were the basis of planning many AEC drilling projects in the Carrizo Mountains.

Unfortunately, the maps and reports were not declassified and made available to the public until the late 1950s and early 1960s. By that time, the uranium boom had peaked, and it was too late for the prospector or company geologist to benefit from this massive compilation of geological data.

The 960 acre Navajo lease in the Carrizo Mountains was leased to the Vanadium Corporation of America for mining by the AEC in 1948. Ore production from the plots totalled 38,344 tons averaging 0.22 percent U₃O₈ and 1.63 percent V₂O₅, or 56 percent of the total uranium that was purchased in the northern and western Carrizo Mountains (Chenoweth, 1985a). The AEC cancelled the lease on June 30, 1961 and the ground was returned to the Navajo Tribe.
REFERENCES


Groves, L. R., 1962, Now it can be told, the story of the Manhattan Project: Harper and Row, New York, New York, 484 p.


Present Address
William L. Chenoweth
Consulting Geologist
707 Brassie Drive
Grand Junction, Colorado 81506-3911