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GEOLOGY AND PRODUCTION HISTORY OF THE URANIUM ORE DEPOSITS IN THE CAMERON AREA, COCONINO COUNTY, ARIZONA

by

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ABSTRACT

Uranium ore deposits in the Cameron area have been mined from sandstone lenses in the Shinarump and Petrified Forest Members of the Upper Triassic Chinle Formation and in the Lower Jurassic Kayenta Formation. Uranium was also produced from a breccia pipe in the Lower Triassic Moenkopi Formation. Most of the ore was mined from carbonaceous sandstones in the lower part of the Petrified Forest Member. The deposits were oxidized and mineralogically complex.

Uranium was first reported in the Cameron area in 1950 in the Kayenta Formation on Ward Terrace. As a result of this discovery, the U.S. Atomic Energy Commission (AEC) employed Navajos to prospect the entire area. The first discovery of commercial importance was made in June 1952 by Charles (Charlie) Huskon, an AEC prospector, in the Petrified Forest Member of the Chinle Formation. Surface prospecting supplemented by airborne radiometric surveying led to the discovery of additional orebodies in 1953, including a few in the Shinarump Member. As the area was developed, many deposits having no surface expression were located by shallow exploration drilling.

Production in the Cameron area began in August 1951 from the Kayenta Formation on the Hosteen Nez property. Production reached a peak in 1956 and gradually declined until the latest shipment, which was recorded in January 1963. During that period, a total of 289,247.96 tons of ore, averaging 0.21 percent U_3O_8 and containing 1,211,812.48 pounds of U_3O_8, was produced from 100 separate properties. The ore was mined in open pits, which ranged in size from a small shallow trench containing a single mineralized fossil log to a large pit complex 2,400 feet long and 250 feet wide. Underground mining of the pit walls was commonly practiced to recover additional ore. Four vertical shafts were also mined in the area.

INTRODUCTION

The Cameron uranium-mining area is centered around the settlement of Cameron, Arizona, which is 52 miles north of Flagstaff (Figure 1). This area contains numerous uranium ore deposits in the Upper Triassic Chinle Formation. Cameron is the fourth largest area on the Colorado Plateau that produced uranium from this geologic unit. The largest area is the Lisbon Valley in Utah, followed by the greater White Canyon and San Rafael Swell areas in Utah (Chenoweth and McLemore, 1989). Two other geologic units in the Cameron area also produced ore: the Lower Jurassic Kayenta Formation and a breccia pipe in the Lower Triassic Moenkopi Formation (Table 1).

This report is the result of the author's field work in the Cameron area during the late 1950's and early 1960's for the AEC. The Navajo Tribal Mining Department in Window Rock, Arizona, provided information on the Navajo Tribal Mining Permits (MP's) to the AEC Flagstaff Field Office.

LOCATION

The main mining area forms a curved belt that is approximately 2 miles wide in a 6-mile stretch north of Cameron along U.S. Highway 89 and 5 miles wide in an 18-mile stretch southeast of Cameron along the Little Colorado River (Plate 1). A few small properties, however, are as far north as Bitter Springs, as far south as the Grand Falls of the Little Colorado River, and as far east as Ward Terrace (Figure 1).

Unimproved dirt roads that leave U.S. Highway 89 provided access to the mines. The principal access road follows the east bank of the Little Colorado River south from Cameron. Another access road, which is graded, leaves U.S. Highway 89 6 miles south of Cameron and heads southeast to a large sand and gravel pit, which lies northeast of Black Point (Plate 1).

LAND STATUS

All but nine properties[1] in the Cameron area are on the Navajo Indian Reservation (Plate 1). Within the reservation, mining permits were issued by the Navajo Tribal Council and approved by the Bureau of Indian Affairs (BIA), U.S. Department of the Interior. Permits could be obtained by individual Navajos only. Permit holders, however, could assign the mining rights to another individual or a company; like the permits, these assignments had to be approved by the Tribal Council and the BIA. Mining permits were issued for 2-year terms but could be renewed for an additional 2-year period. The tribe also issued drilling and exploration permits. These permits were good for 120 days and were not renewable.

The BIA encouraged operators to convert their mining assignments to 10-year leases once large amounts of ore had been developed. Many of Charlie Huskon's properties and all of the Ramco properties were converted to leases in the mid-1950's. Leases could be issued directly by the BIA. No more than 960 acres of tribal land could be held by any one company or individual. For companies with a mill on the reservation, the 960-acre limitation was waived.

Both the permittee and the tribe received royalties from ore production. Based on the mine value of the ore, the tribe received between 10-percent and 20-percent royalties and the permittee between 2-percent and 5-percent royalties.

In the Cameron area, the name of a mine on the Navajo Indian Reservation was usually the name of the individual who held the mining permit. Exceptions to this practice are listed in Table 2.

South of the reservation and west of the Little Colorado River, every odd-numbered section was owned by the C O Bar Livestock Company of Flagstaff. With the exception of sections 2, 16, 32, and 36, which are State-owned land, the remaining even-numbered sections are federally owned. Many of the even-numbered sections adjacent to the Little Colorado River were subject to a Federal powersite withdrawal and were closed to claim staking. These lands were restored to the public domain and thus opened to claim staking in April 1957.

PREVIOUS STUDIES

The uranium deposits in the Cameron area were described by Bollin and Kerr (1958), the AEC (1959a), and Chenoweth (in Akers and others, 1962). Hinkley (1957) described the Charles Huskon No. 1 deposits, and Gray (1957) described the deposits on the Liba claims. Chenoweth (1988) described the Riverview breccia pipe, and Scarborough (1981) tabulated information on individual properties. Chenoweth and Magleby (1971) prepared a map showing the location and relative sizes of the deposits, and Austin (1964) described the mineralogy of the deposits.

The geology of the main mining area was mapped by Akers and others (1962) and Billingsley (1987). Plate 1 is Chenoweth and Magleby's (1971) map, which Scarborough (1981, Plate 20) modified to show unmined uranium deposits in the main mining area.

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[1] As used in this report, a "property" is an individual mining permit, lease, or group of claims. A mining permit might contain several orebodies and separate open pits, as did Ramco No. 20 (MP-349; Figure 2).

GEOLOGIC SETTING OF THE ORE DEPOSITS

The Cameron area is on the southwest flank of the Black Mesa Basin, where erosion of the Little Colorado River valley has exposed the Chinle Formation in a broad belt approximately parallel to the river. In this area, the Chinle is composed of three members, in ascending order: Shinarump, Petrified Forest, and Owl Rock. The Shinarump Member forms cliffs along the Little Colorado River, and resistant beds of the Owl Rock Member cap Ward Terrace (Plate 1). Between the river and Ward Terrace, the Petrified Forest Member is exposed in an expanse of badlands.

The principal host rocks for the uranium deposits in the Cameron area are fluvial sandstones in the lower part of the Petrified Forest Member. Other deposits have been mined from the upper part of the underlying Shinarump Member. Two deposits in the Kayenta Formation on Ward Terrace have been mined, as was a breccia-pipe deposit in the Moenkopi Formation.

Deposits in the Chinle Formation

The Petrified Forest Member of the Chinle Formation contained most of the uranium deposits in the Cameron area. The member is composed of multicolored claystone and siltstone with some light-gray, fine- to coarse-grained sandstone, especially in the lower part of the member. The Petrified Forest Member erodes into badlands and has brilliant variegated colors typical of the Painted Desert. In the Cameron area, the member is up to 900 feet thick.

Orebodies were present at the surface down to a depth of 130 feet. As many as three ore zones were within 100 feet of section. Orebodies ranged in size from a single mineralized fossil log to the Jack Daniels orebody (Plate 1, No. 24), the largest known in the area. This latter deposit was a nearly continuous body, 450 feet by 300 feet, and contained 178,059 pounds of U_3O_8. By comparison, the second largest deposit was the Charles Huskon No. 4 - Paul Huskie No. 3 (Plate 1, Nos. 97 and 98): 135,616 pounds of U_3O_8 was produced from a cluster of ore pods within an area 1,000 feet by 550 feet. The most productive area lies east of Cameron, where 10 properties within 1 square mile were the source of 264,100 pounds, or 22 percent of the total production from the Cameron area.

The ore consisted of elongated, lenticular deposits within poorly consolidated, cross-stratified, fine- to medium-grained sandstone, clay-pellet sandstone, and clay-pellet conglomerate that contain varying amounts of carbonaceous matter, including carbonaceous fossil logs. The sandstone lenses were deposited in irregular depressions cut into bentonitic claystones and mudstones and are probably ancient fluvial channel fills. The sandstone lenses are up to 6 feet thick and are not continuous, although individual lenses have been traced for more than 1 mile. Secondary uranium minerals fill pore spaces in the sandstone, and uraniferous fossil logs are locally present. The ore was concentrated in abrupt depressions along channels or at changes in channel direction and favored the more carbonaceous layers. The highest grade ore was associated with fossil logs. Most orebodies were elongated parallel to the channel trends, but some were oriented nearly perpendicular to these trends. Each orebody was encased in an alteration halo consisting of bleached sandstone and mudstone. The most visible bleaching effect was a change from gray to locally red to yellowish or buff. Orebodies and haloes abruptly terminated downward against impervious mudstone.

With the exception of the Evans Huskon No. 34 and Charles Huskon No. 20 mines (Plate 1, Nos. 21 and 22), all of the deposits in the Petrified Forest Member were within the lower 150 feet of the member. The other two deposits were associated with uraniferous fossil logs in the upper part of the member.

Seventy properties in the Petrified Forest Member yielded 278,616.46 tons of ore that averaged 0.21 percent U_3O_8 and contained 1,186,889.66 pounds of U_3O_8 (Table 1). This amounts to 98 percent of the total uranium produced in the area.

The Shinarump Member of the Chinle Formation rests unconformably on the Middle Triassic Moenkopi Formation. In the Cameron area, the Shinarump Member is composed of yellowish-gray to pale-red, medium- to coarse-grained, crossbedded, fluvial sandstone and conglomerate with some interbedded, greenish-gray and pale-red mudstone lenses. In the upper part of the member, the sandstones are thin bedded and are mottled pale red to light gray. The Shinarump Member is up to 100 feet thick in the Cameron area. Billingsley (1987) included in the Petrified Forest Member some of the beds that Akers and others (1962) and Haines and Bowles (1976) previously mapped as Shinarump Member. The Shinarump - Petrified Forest contact shown on Plate 1 was based on the earlier mapping.

Twenty-seven properties in the Cameron area were within the Shinarump Member. The host rocks for these deposits were carbonaceous, thin-bedded, cross-stratified, medium- to fine-grained sandstones in the upper 30 feet of the member. Uranium-bearing fossil logs were common in the orebodies. Deposits in the Shinarump Member were similar to those in the Petrified Forest Member, but were smaller.

The largest deposit in the Shinarump Member was the Charles Huskon No. 26 - Charles Huskon No. 11 (Plate 1, Nos. 65 and 66), from which 6,561.41 pounds of U_3O_8 was produced. Total production from the Shinarump Member was 9,941.05 tons of ore, which averaged 0.10 percent U_3O_8 and contained 20,535.00 pounds of U_3O_8.

A characteristic feature of the Chinle uranium ores at Cameron was their complex mineralogy. Uraninite was present in the unoxidized zone, as well as the oxidized zone in and near unoxidized logs in association with pyrite and marcasite. Oxidation produced a complex suite of uranium oxides, sulfates, silicates, phosphates, carbonates, molybdates, and rare vanadates (Austin, 1964). The ore was also rich in cobalt. A sample that Karen J. Wenrich (U.S. Geological Survey [USGS]) collected from the Charles Huskon No. 1 (Plate 1, No. 29) dump contained pink, platy, and fibrous crusts of moorhouseite ([Co, Ni, Mn^{+2}] $SO_4 \cdot 6H_2O$) and a cobalt-pickeringite ([Co, Mg, Al_2] $[SO_4]_4 \cdot 22H_2O$). The sample also contained alunogen (Al_2 $[SO_4]_3 \cdot 17H_2O$; Wenrich and others, 1989). The yellowish-gray alteration associated with all deposits at or near the surface was used as a prospecting guide and was chiefly due to oxidation products of sulfides (Austin (1964), although some bleaching (reduction of the ferric iron) of the mudstones and siltstones also occurred.

Deposits in the Kayenta Formation

The Lower Jurassic Kayenta Formation is exposed at the foot of the Adeii Eechii Cliffs, which form the west escarpment of the Moenkopi Plateau (Figure 1). The formation is composed of pale-red fluvial siltstone, fine-grained silty sandstone, and interbedded purplish-red shale and is about 650 feet thick in the Cameron area. A 150-foot-thick zone at the top of the formation contains tongues of the overlying Navajo Sandstone. The Moenave Formation and Wingate Sandstone, in descending order, underlie the Kayenta Formation and separate it from the Chinle Formation.

Two areas in the Kayenta Formation have been mined: the Yellow Jeep claims, 14 miles east-southeast of Cameron, and the Hosteen Nez claim, 18 miles southeast of Cameron. These deposits were in limy, fine-grained sandstone lenses in the middle part of the formation. A yellow uranium mineral, probably tyuyamunite (Ca $[UO_2]_2$ $V_2O_8 \cdot 5\text{-}8H_2O$), was disseminated throughout the sandstone in association with fossil logs. Total production from the two areas was 182.04 tons with an average grade of 0.15 percent U_3O_8 (Table 1).

Deposit in a Collapse-Breccia Pipe

The Riverview mine (Plate 1, No. 93) was developed in a collapse-breccia pipe south of Black Point in T. 26 N., R. 10 E., sec. 8. The pipe is collared in the Wupatki Member of the Moenkopi Formation. The deposit was discovered when prospectors noted the presence of large mineralized blocks

of sandstone, many standing vertically, which seemed to fill a "sinkhole" in the Wupatki Member 45 feet above the base of the member. These blocks appear to be lithologically similar to sandstone in the upper part of the Shinarump Member of the Chinle Formation. The pipe contact at the surface is irregular in shape and measures 135 feet in its maximum north-south dimension and 95 feet in its east-west dimension. Mining at the surface stripped as much as 25 feet of the upper part of the pipe. A shaft was sunk to a depth of 125 feet within the pipe near its south margin on a strong northwest shear.

The blocks of the upper(?) part of the Shinarump Member, which originally capped the pipe, indicate that the pipe was higher than its present elevation of about 4,505 feet. If one assumes a thickness of 365 feet for the Moenkopi Formation and 80 feet for the Shinarump Member, the blocks have been displaced downward about 360 feet from their initial stratigraphic position.

The core of the pipe is irregular in shape and consists of blocks of arkosic, coarse- to very coarse-grained sandstone and conglomerate of the Shinarump Member and sandstone and siltstone of the Moenkopi Formation. A concentric ring of collapsed greenish-gray and reddish-brown siltstone and mudstone of the Moenkopi Formation encircles the core. At the east margin of the pipe, the mudstone is stained with manganese.

Uranium minerals reported from the Riverview mine include uranophane and sporadic grains of carnotite and metatorbernite, as well as minute grains of uraninite in the lower parts of the mine (Chenoweth, 1988). L.E. Evans (in Chenoweth, 1988) reported that the uranophane, carnotite, and malachite were associated with clay, calcite, and iron oxide that cemented a fine-grained quartz sandstone. Some azurite was present in subgrade ore material on the property. More copper was present in this deposit than in other uranium deposits in the Cameron area.

MINING METHODS

Most of the mining was by open pits, which ranged in size from a shallow trench containing a single fossil log to pits as deep as 130 feet. On the Ramco Nos. 20 and 22 and Ryan No. 2 properties (Plate 1, Nos. 74, 73, and 75), a large pit complex was developed that was 2,400 feet long, an average of 250 feet wide, and an average of 70 feet deep (Figure 2). Operators found it uneconomic to exceed a stripping ratio of 13 feet of waste to 1 foot of ore in the Cameron deposits. A contractor stripped away the overburden with bottom scrapers. In 1959 stripping costs were about $0.30 per cubic yard.

Three mines in the Petrified Forest Member (Plate 1, Nos. 32, 45, and 92) and one in the breccia pipe (Plate 1, No. 93) were serviced by vertical shafts. These deposits were too small to be stripped economically. In several pits, ore outside the pit outline was mined underground by modified room-and-pillar methods from adits in the pit walls (Figure 3). Ore grade was controlled by Geiger-counter testing because the ore could not be readily distinguished by eye. By careful blending, most operators tried to maintain their shipping grade at 0.20 percent U_3O_8. Shipman (1957) described the exploration and mining methods used at Cameron, and the AEC (1956b) described the operations at 40 of the active mines.

PRODUCTION HISTORY

Early Activities, 1950-55

In the summer of 1950, Hosteen Nez, a Navajo, found an outcrop containing yellow-colored material on the Ward Terrace at the foot of the Moenkopi Plateau. He took samples to the Lorenzo Hubbell Trading Post in Winslow, Arizona. Roman Hubbell sent a sample to the AEC, which confirmed that it contained uranium and vanadium.

The remote locality where the material was found was examined by Harry C. Granger of the USGS and John W. King of the AEC in March 1951. Hubbell formed the Hosteen Nez Mining Company

and bulldozed a trail from the top of the Moenkopi Plateau down through the Adeii Eechii Cliffs to reach the deposit. The Hosteen Nez Mining Company shipped 1.05 tons of ore to the AEC's ore-buying station at Monticello, Utah, in August 1951. This shipment averaged 0.41 percent U_3O_8, 0.23 percent V_2O_5, and 9.00 percent $CaCO_3$ (Table 3). On January 14, 1952, Philip C. Ellsworth of the AEC examined the prospect and sampled the mineralized exposures (Ellsworth, 1952). He determined the host rock to be a limy siltstone in the Kayenta Formation. The location was determined to be approximately 18 miles southeast of Cameron. The site was later determined to be SW$^1/_4$ sec. 33, T. 27 N., R. 12 E., projected.

On February 11, 1952, an additional 5.35 tons of ore averaging 0.29 percent U_3O_8 and 0.20 percent V_2O_5 was delivered to the Monticello station. On March 24 and 31, 11.52 tons averaging 0.11 percent U_3O_8 and 0.19 percent V_2O_5 was delivered to the AEC's newly opened ore-buying station at Shiprock, New Mexico. Due to the high lime ($CaCO_3$) content of the shipments, no payment was made for the vanadium. (At AEC ore-buying stations, vanadium in carnotite-type ore was purchased for $0.31 per pound, but with some limitations.)

During the early 1950's, the AEC employed Navajos as prospectors. At least 20 men in all parts of the Navajo Indian Reservation were put on the payroll of the Walker-Lybarger Construction Company, the prime contractor to the AEC's Grand Junction office. These prospectors were given Geiger counters and told to look for the "yellow rocks." They were contacted every 2 weeks by AEC field representatives Jack Leonard and Winston Marks. Both of these men had grown up in the Farmington, New Mexico, area and could speak fluent Navajo.

Charlie Huskon was employed to prospect the Cameron area. He was supervised by Leonard, who was known to the Navajos as "Loose Ears" because of the way he could wiggle his ears, to the delight of the Indian children. On June 26, 1952, Charlie Huskon and his son Evans showed AEC geologist Jack Chester and Leonard the uranium-bearing outcrops in the Chinle Formation about 1 mile east of the bridge over the Little Colorado River at Cameron (Chester and Leonard, 1952a). This deposit would later become the Charles Huskon No. 1 mine (Plate 1, No. 29). On that same day, the two Navajos also showed Chester and Leonard another uranium-bearing outcrop in the Chinle Formation 6 miles southeast of Cameron (Chester and Leonard, 1952b). This exposure would later become the Paul Huskie No. 20 mine (Plate 1, No. 52). During this visit to the Cameron area, another Navajo prospector, Chee Paddock, showed Chester and Leonard some uranium-bearing fossil logs in the Chinle Formation, about 17 miles by road southeast of Cameron (Chester and Leonard, 1952c). It is probable that this deposit was later named the Evans Huskon No. 35 mine (Plate 1, No. 60).

Charlie Huskon applied to the Navajo Tribal Mining Department for a mining permit on June 29, 1952, and contacted the Arrowhead Uranium Company of Grand Junction, Colorado, which was exploring for uranium in the Monument Valley area. He quit Walker-Lybarger in July 1952 and began to prospect for Arrowhead. The company also conducted aerial radiometric surveys in the Cameron area using a Piper Cub airplane and a handheld Halross scintillation counter. This ground-air reconnaissance was very successful, and many uranium-bearing outcrops in the Chinle Formation were discovered. Leonard (1952) noted that Charlie Huskon was very successful at finding uranium-bearing outcrops because he recognized the relationship between yellow-colored alteration in the Chinle sediments and uranium minerals.

On August 6, 1952, Charlie Huskon was issued Mining Permit (MP) No. 46 for the Charles Huskon No. 1 deposit. MP-64 covering the No. 2 property was issued to Evans Huskon on September 26, 1952. MP-65 covering the Charles Huskon Nos. 3 through 8 was issued to Charlie on the same day. Charlie and Evans signed operating agreements with Arrowhead on September 29, 1952. Arrowhead commenced mining at the Charles Huskon No. 1 property and delivered 8.21 tons of ore averaging 0.18 percent U_3O_8 and 0.15 percent V_2O_5 to the AEC's ore-buying station at Bluewater, New Mexico, on October 16, 1952.

Between late December 1952 and March 2, 1953, the AEC made a systematic aerial radiometric survey of the Cameron area covering all exposures of the Chinle Formation. A total of 43 radiometric anomalies were detected (Williams and Barrett, 1953).

During 1953, Arrowhead continued to develop ore on the Huskon properties. MP-76 for the Charles Huskon Nos. 9, 10, and 11 properties was issued to Charlie on April 8, 1953, and an operating agreement was signed with Arrowhead on April 24. Shipments to the Bluewater ore-buying station were made from Nos. 1 through 8 and No. 10 (Table 4). The ore was trucked to a railhead at Flagstaff and then shipped by the Atkinson Topeka and Santa Fe Railway to a siding near Bluewater, where the ore was transferred to trucks for the short haul to the buying station. Shipments in 1953 totalled 8,104.54 tons of ore, which averaged 0.26 percent U_3O_8 and 0.08 percent V_2O_5 (Table 3).

Arrowhead's activities created much interest in the Cameron area. Other Navajos who found uranium deposits and applied for mining permits were Paul Huskie (another son of Charlie), Harry Walker, Earl Huskon, Ancil Thomas, and Taylor Reid.

The AEC rim stripped and trenched 15 deposits in the Cameron area between January 19 and February 3, 1954 (Hinkley, 1955). This was done to expose the dimensions of the orebodies for ore-reserve estimates and geologic studies. A total of 45,000 lineal feet of trenching and stripping was done, exposing 1,500 tons of ore (Hinkley, 1955).

During 1954, six operators besides Arrowhead began shipping ore from the Cameron area (Table 4). Arrowhead developed enough ore on its holdings to get a commitment from the AEC for a contract to sell concentrates from a proposed processing mill. After Arrowhead received this commitment, the Navajo Tribe lifted its 960-acre limit on property held by one company or individual. Arrowhead increased its holdings to several thousand acres, including the Charles Huskon Nos. 12 through 17 properties. Production in 1954 from the Cameron area totalled 11,366.50 tons of ore, which averaged 0.23 percent U_3O_8 and 0.08 percent V_2O_5 (Table 3). Of this amount, 8,133.97 tons was produced by Arrowhead from the Charles Huskon Nos. 1 through 4, 9 through 11, and 17 properties.[2]

Arrowhead's increasing activities caused many companies and individuals to prospect in the Cameron area. Dozens of drilling permits were issued. The resulting discoveries meant that mining permits were issued to Navajos, who assigned them to operators. Navajos with important discoveries included William Robbins, Max Johnson, Max Huskon, and Lemuel Littleman. Claims were also staked on Federal land south of the reservation, on the west side of the Little Colorado River. The odd-numbered sections in that area were leased from the C O Bar Livestock Company.

Arrowhead's holdings were acquired by the Rare Metals Corporation of America of Salt Lake City, Utah, in December 1954 (G.E. Morehouse, oral commun., 1991). The BIA approved this transaction in February 1955.

Exploration and development drilling in the Cameron area increased during 1955 as operators were waiting for the AEC to establish an ore-buying station in the area. Foley Brothers drilled in the area between Tohachi and Nahakaad Washes and located the orebodies known as the Yazzie Nos. 1 and 2, covered by Maxwell Yazzie's MP-261 (Plate 1, Nos. 79 and 80). Foley Brothers also made a discovery near the Evans Huskon No. 2 mine, on Maxwell Yazzie's MP-312. This deposit was originally named the Foley No. 5 mine but was later changed to the Yazzie No. 312 mine (Table 5; Plate 1, No. 37). Chesser and Company also made a discovery near Evans Huskon No. 2, which was called Yazzie No. 101 (Plate 1, No. 36) and was covered by George D. Yazzie's MP-302. Chesser made another discovery north of the Charles Huskon No. 10 mine. This discovery was named Yazzie No. 102 (Plate 1, No. 54) and was covered by George D. Yazzie's MP-311.

Early in 1955, Rare Metals dropped the assignment of the Charles Huskon No. 5 property (a portion of MP-63). The assignment was picked up by B C Associates of Phoenix, Arizona, which shipped 162.72 tons averaging 0.17 percent U_3O_8 early in 1956.

MP-360 was issued to Denetso on April 10, 1955, for the Jack Daniels No. 1 ore deposit (Table 2; Plate 1, No. 24). This discovery was named for a bourbon bottle found near the surface anomaly, which led to the discovery of the orebody. The anomaly, which lay in cuttings from a powerline pole at Milepost 469 on U.S. Highway 89 north of Cameron, was discovered by two prospectors who were slowly driving down the highway. The assignment of MP-360 to the Marcy Exploration and Mining Company of Durango, Colorado, was approved on November 15, 1955. Drilling and mining showed that the Jack Daniels No. 1 property contained the largest orebody in the Cameron area (Table 5).

On July 15, 1955, Rare Metals signed a contract with the AEC to produce uranium concentrates (yellowcake) from a mill to be built 5 miles northeast of Tuba City, Arizona (Albrethsen and McGinley, 1982). The site was selected because of the availability of ground water from the Navajo Sandstone. Construction of the mill began in August 1955. Exploration by Rare Metals located significant orebodies near the Yazzie Nos. 1 and 2. These deposits would be named the Ramco Nos. 20, 21, and 22 on MP-349, 350, and 351, which were issued to Calvin Semallie, Dan McClellan, and Elvin Gordy, respectively (Table 2; Plate 1, Nos. 74, 72, and 73).

During the summer of 1955, Rare Metals cancelled its assignments to the Charles Huskon Nos. 4 and 9 mines (portions of MP-65 and 76). These assignments were picked up by Utco Uranium Corporation on August 1955. Utco also acquired the assignments of the Charles Huskon Nos. 18, 19, and 20 properties (MP-388, 461, and 465). Exploration by Utco determined that the orebodies on the Charles Huskon No. 4 permit extended off the permit area. The ground surrounding Charles Huskon No. 4 was claimed by Paul Huskie as MP-377 (Paul Huskie No. 3; Plate 1, No. 98), which was issued on November 16, 1955.

Ryan Oil Company located an east extension of the orebody on Ramco No. 22. This ground was claimed by Clay Bigman as MP-410. The orebody, known as Ryan No. 2 (Table 2), was mined by a single large open pit covering the Ramco Nos. 20 and 22 and Ryan No. 2 orebodies (Figure 2). Total production during 1955 was only 1,606.53 tons of ore, which averaged 0.21 percent U_3O_8 (Table 3). Seven companies besides Rare Metals made shipments during the year (Table 4). Several of these operators shipped their ore to the ore-buying station at Monticello.

The Boom Years, 1956-58

The AEC opened an ore-buying station at the mill site on February 1, 1956. Rare Metals built the station and leased it to the AEC (Albrethsen and McGinley, 1982). AEC ore-purchasing schedules provided for payment of uranium and vanadium in carnotite-type ore down to 0.10 percent each of U_3O_8 and V_2O_5. Because the Cameron ores contained very little vanadium, no payment was received for the vanadium. The ore-buying station, which provided a market for the Cameron ores, greatly stimulated production in the area. Ores that had been stockpiled during 1955 were shipped in 1956. During 1956, uranium ore production from the Cameron area reached an all-time annual high point: 84,799.13 tons of ore averaging 0.21 percent U_3O_8 was produced by 19 companies from 55 properties (Tables 3 and 4).

During February 1956, Rare Metals commenced shipments from the Ramco Nos. 20, 21, and 22 open-pit mines, which had been discovered the previous year. Shipments from the Ryan No. 2 orebody, an east extension of the Ramco No. 22, commenced in the spring of 1956. The east-trending pit on the Ramco Nos. 20 and 22 and Ryan No. 2 was the deepest deposit to be mined to date in the Cameron area. Ore depths ranged from 60 feet on Ramco No. 20 to 97 feet on Ryan No. 2 (Figure 2). Exploration drilling continued throughout the mining area, and many additional discoveries were made. Mining permits were issued to Alyce Tolino, Julius Chee, Elwood Canyon, and Emmett Lee.

The Tuba City mill, owned by Rare Metals, began operating in June 1956. The plant used an acid-leaching process; uranium was recovered through a resin-in-pulp ion-exchange process. The plant had an initial processing capacity of 260 tons of ore per day, which was increased to 300 tons per day

(Albrethsen and McGinley, 1982). No attempt was made to recover vanadium from the ore. With the mill operating, the AEC turned over the ore buying and sampling to Rare Metals in the fall of 1956. Rare Metals would not accept ores containing less than 0.20 percent U_3O_8, computed on a monthly average basis per property. Monthly quotas were established to give each independent producer an equal share of the available milling capacity.

During 1956, uranium production commenced at the Black Point-Murphy group of claims northeast of Black Point in T. 27 N., R. 10 E., sec. 22 (Plate 1, No. 88). Terrace gravels of the Little Colorado River overlying the ore deposit proved to be more valuable than the uranium. The property became one of the largest sand and gravel operations in Coconino County, Arizona.

An orebody in the south part of the area under the corner common to Julius Chee No. 2 (MP-315), Emmett Lee No. 1 (MP-445), Julius Chee No. 4 (MP-446), and Julius Chee No. 3, (MP-444) was mined by a single, shallow open pit (Plate 1, No. 94). During 1956, shipments commenced from the Jeepster No. 1 mine on William Robbins MP-347 (Table 2; Plate 1, No. 13).

Two companies made shipments in 1956 from non-Chinle properties. United Exploration Syndicate made a "no-pay" shipment (42.89 tons averaging 0.09 percent U_3O_8) from the inactive Hosteen Nez property in the Kayenta Formation. Utco commenced production from the Riverview breccia pipe in December 1956. Production from this pipe lasted less than a year. Of the total uranium shipped in 1956 (363,508.40 pounds U_3O_8), 35 percent was produced by Rare Metals, 27 percent by Utco, 20 percent by Marcy Exploration and Mining Company (from the Jack Daniels No. 1 mine), and 8 percent by Chesser (Table 4).

Uranium ore production in 1957 declined slightly from the previous year: 78,219.55 tons of ore averaging 0.21 percent U_3O_8 was produced (Table 3). Exploration and development drilling continued to increase to the average rate of 7,500 feet per month (Table 7). Woodson Exploration Company discovered a deep (130-foot) orebody, which it planned to mine as an open pit. The orebody was covered by the Jack Huskon's No. 3 permit (MP-493).

During the year, Utah Southern Oil Company took over the assignments of the Foley Brothers and continued mining at the Yazzie No. 312 mine. Diamond Uranium Company commenced mining at the Lemuel Littleman No. 2 orebody (MP-225), which had been discovered in previous years. Skiles Oil Company sank an 80-foot-deep shaft on the Elwood Canyon No. 2 (MP-421) property and commenced shipments. An orebody in the south part of the area was located on two adjacent permits, Emmett Lee No. 3 (MP-466) and Julia Semallie (MP-479). The ore was mined by a single, shallow open pit (Plate 1, No. 100). Other significant mines commencing shipments in 1957 were the Alyce Tolino Nos. 1 and 3 (MP-412) and Kachina No. 6 (MP-457).

Rare Metals commenced shipments from the Ramco No. 24 open pits on Daniel Webster's MP-464. The ore in the south pit extended to the adjacent Harry Walker No. 16 (MP-443), which was controlled by Utco. In April 1956, Rare Metals made an initial shipment from Charles Huskon No. 11 (MP-76) in the upper part of the Shinarump Member. This was the last of Charlie Huskon's original Arrowhead properties to obtain production. A northeast extension of the ore off the old permit area was acquired by Rare Metals as Charles Huskon No. 26 (MP-427; Plate 1, No. 65). On the same Shinarump channel, 1 mile to the south, Rare Metals leased the $E^1/_2$ sec. 9, T. 27 N., R. 10 E. from the C O Bar Livestock Company and made a small, low-grade shipment (17.95 tons averaging 0.09 percent U_3O_8).

During 1957, Yellow Jeep Mining Company made a shipment from Ben and Pete Semallie's MP-437, which was called Yellow Jeep Nos. 7A and 7B. This property was in the Kayenta Formation, 14 miles southeast of Cameron (Table 6). The location of the small rim-stripped area is approximately $SW^1/_4$ sec. 10, T. 28 N., R. 11 E., projected. The property was accessed via a road bulldozed up Landmark Wash to the top of Ward Terrace. Utco commenced production from Charles Huskon No. 19 (MP-461), Charles Huskon No. 20 (MP-465), and Evans Huskon No. 34 (MP-489). The latter two properties (Plate 1, Nos. 22 and 21) were in the upper part of the Petrified Forest Member near the foot of Ward Terrace.

The uranium content of the ore produced in 1957 was 326,236.75 pounds U_3O_8 (Table 3). Of this amount, Rare Metals produced 52 percent, the Jack Daniels No. 1 mine, 19 percent, and Utco, 14 percent. Rare Metals and Utco operated 16 and 8 separate properties, respectively (Table 4).

Uranium ore production continued to decline in 1958 as the larger orebodies, such as those on Jack Daniels No. 1, Yazzie No. 312, Yazzie No. 101, and Ramco Nos. 20, 21, 22, and 24, were depleted. Production in 1958 was 57,347.84 tons of ore with an average grade of 0.20 percent U_3O_8 (Table 3). Rare Metals stopped analyzing the ore for vanadium on July 1, 1958 (Table 3). Rare Metals produced 53 percent of the uranium that was shipped, Utah Southern Oil Company produced 9 percent, and Steinberger Drilling Company produced 6 percent (Table 4).

During the summer of 1958, production commenced at the Juan Horse No. 3 (MP-502), the Juan Horse No. 4 (MP-497), and the Evans Huskon No. 35 (MP-489) mines. The latter deposit was located in the upper part of the Petrified Forest Member of the Chinle Formation northeast of the Ramco Nos. 20, 21, and 22, and Ryan No. 2 mines (Plate 1). At about the same time, shipments commenced from the Max Johnson No. 9 (MP-498) mine. This orebody was discovered in the area between the Elwood Canyon and Alyce Tolino mines (Plate 1, No. 31). In August, shipments began from the deep Jack Huskon No. 3 pit. Errors in calculating ore grades and thicknesses from the gamma-ray logs greatly overestimated the size and grade of this orebody. The mine closed in slightly more than a year.

C.L. Rankin acquired the former Rare Metals lease on T. 27 N., R. 10 E., sec. 9 from the C O Bar Livestock Company. In the fall of 1958, Rankin shipped 87.21 tons of ore averaging 0.12 percent U_3O_8 from a short decline in the northeast quarter of the section (Plate 1, No. 71). Rankin and W.W. Stevenson, Rankin's attorney, made small shipments from the Navajo No. 26 claim in T. 27 N., R. 10 E., sec. 18 (Plate 1, No. 81). Pleistocene cinder dunes overlie the ore-bearing sandstone in the Petrified Forest Member on the terrace surface of the Little Colorado River at the Navajo No. 26 mine (Chenoweth and Cooley, 1960).

Larger mines from which final shipments were made during 1958 included Jack Daniels No. 1, Charles Huskon No. 7, Ryan No. 2, Julius Chee Nos. 2 and 4, Julia Semallie, Paul Huskie No. 3, and Ramco No. 24. Exploration and development drilling increased to between 12,000 and 13,000 feet per month in 1958 (Table 7). Operators looked for the extensions of known orebodies as well as new orebodies missed by previous drilling.

On November 24, 1958, the AEC announced that after April 1, 1962, it would only purchase uranium concentrate (yellowcake) derived from ores that had been discovered before November 24. The procurement program was curtailed because more uranium had been discovered in the United States, especially in New Mexico and Wyoming, than the agency could buy. Beginning in April 1962, all independent producers would be given an annual allocation (market quota) based on ore reserves discovered before November 24, 1958. Because many operators did not develop large ore reserves before mining them, allocations were also based on historical ore production during the period from July 1, 1956, through June 30, 1960.

As controller of the mineral rights on the Navajo Indian Reservation, the Navajo Tribe applied to the AEC for a blanket allocation for all reservation properties in the Cameron area. The AEC gave the tribe an annual allocation (A-249) to produce up to 177,252 pounds U_3O_8 in ore. It was hoped that this large allocation would prolong mining near Cameron after 1961.

The Final Years, 1959-63

Uranium production from the Cameron area in 1959 declined by nearly 50 percent from the previous year. In 1959, 27,705.79 tons of ore averaging 0.20 percent U_3O_8 was shipped (Table 3). Seventy-three percent of the uranium in the shipments came from the properties controlled by Rare

Metals. An additional 6 percent was shipped by Utah Southern Oil Company and Wells Cargo, Inc. (Table 4).

In April 1959, Rare Metals stopped all mining and turned over its properties to the Cameron Mining Company for cleanup mining on a contract basis. When Rare Metals terminated operations, the firm had produced a total of 116,448.58 tons of ore averaging 0.215 percent U_3O_8 from its Cameron mines (AEC, unpublished records).

On November 25, 1958, Page Blakemore (president of Cameron Mining Company) obtained the assignment of Elwood Canyon's MP-421. In early 1959, he resumed underground mining on the property. Wells Cargo, Inc. sank a 50-foot-deep shaft on the Manuel Denetsone No. 2 property (MP-508) and mined out a small orebody during 1959 (Table 5).

The AEC investigated the Liba claims in T. 27 N., R. 10 E., sec. 4 and determined that the claims were invalid because that section had been withdrawn from mineral entry by the First Form Reclamation Withdrawal Act of June 17, 1902. Hence, shipments made in 1955 and 1956 were trespassing (Tables 4 and 5). On April 22, 1957, the land was restored to mineral entry and claim location (*Federal Register,* March 26, 1957, p. 1,991). On that date, the New Liba Nos. 1 through 22 claims were located. Sustained mining commenced in section 4 in the fall of 1959. Cameron Mining Company operated the mine for the claim owners, L.L. Travis and others. Initial shipments were made from the No. 17 claim.

During 1959, production ceased at the Jack Huskon No. 3 pit, Ramco No. 22 pit, and Juan Horse Nos. 3 and 4 pits. Underground mining in the adit off the wall of the Ramco No. 21 pit also ceased (Figure 3).

In September 1959, C.L. Rankin's lease in T. 27 N., R. 10 E., sec. 9 was acquired by Murchison Ventures, Inc. of Denver, Colorado. The firm built a "Benson Upgrader" on the property near the old Rare Metals open pit. This plant, designed by Ross L. Benson of Boulder, Colorado, used a wet, mechanical, sand-slime separation to concentrate the uranium minerals in the slime fraction. The sand fraction, or tailings, was deposited on the bank of the Little Colorado River. According to Benson (oral commun., 1959), the plant could treat 1,000 to 1,500 tons per day of material averaging 0.01 to 0.03 percent U_3O_8 and produce 200 to 300 tons per day of material containing 0.25 to 0.30 percent U_3O_8. John Milton Addison, a Texas promotor, was in charge of the operation. After processing some low-grade ore from section 9, Murchison Ventures made a shipment of concentrate to the Tuba City mill in December 1959. This 10.76-ton shipment, made under the name of the C O Bar Livestock Company lease, averaged 0.16 percent U_3O_8.

The plant was modified. In April 1960, another shipment was made to the mill. This shipment consisted of 11.31 tons of material, which averaged 0.16 percent U_3O_8. After much legal action by the investors, the company was reorganized in June 1960 into Milestone Hawaii, Inc. In February 1961, Addison and six associates were convicted in a Texas court of mail fraud, conspiracy, and Federal security-law violations (*Arizona Daily Sun,* February 17, 1961).

Production in 1960 continued to decline by about 50 percent from 1959. In 1960 a total of 13,029.03 tons of ore averaging 0.19 percent U_3O_8 was produced (Table 3). For the first time since shipments began in 1951, the average grade of the ore dropped below 0.20 percent U_3O_8 (Table 3). During the year, final shipments were made from the Alyce Tolino No. 1, Lemuel Littleman No. 2, Max Johnson No. 9, Kachina No. 6, Charles Huskon No. 8, and New Liba open-pit mines. Final shipments were also made from the Elwood Canyon shaft and from the underground workings off the pit wall of the Ramco No. 20 (Figure 3).

The assignment of the mining rights to MP-360 (Jack Daniels No. 1) to Page P. Blakemore were approved on December 3, 1959. Marcy Exploration and Mining Company had cancelled its assignment on September 17, 1959. During 1960, Blakemore shipped 993.73 tons of ore averaging 0.18 percent U_3O_8 before closing the mine late in the year.

A new permit, MP-542, was issued to George D. Yazzie on February 15, 1960. This permit covered the same ground as the former MP-311, which was held by Chesser and Company. The assignment of the mining rights to Harold F. Rodgers was approved on March 1, 1960. Rodgers mined 123.10 tons averaging 0.24 percent U_3O_8 during 1960, and then abandoned the mine.

The Twilight Company acquired the mining rights to Elwood Thompson's MP-462 (formerly Ramco No. 23) on December 22, 1959. The company sank a 90-foot-deep shaft and began shipments in March 1960. The orebody on MP-462 had been discovered by Rare Metals in 1957 but had never been mined. During 1960, as the operators sought to locate additional ore, drilling averaged approximately 16,300 feet per month, the greatest amount of drilling in the Cameron area during any year (Table 7).

Annual production again declined by 50 percent in 1961. A total of 6,397.62 tons of ore, containing 24,186.29 pounds of U_3O_8 and averaging 0.19 percent U_3O_8, were shipped (Table 3). Final shipments were made from the Charles Huskon Nos. 1, 2, 3, 6, 10, 11, and 12, Yazzie No. 2, Max Johnson No. 1, and Yazzie Nos. 101 and 312 open pits. Final shipments were also made from the Elwood Thompson No. 1 shaft (Table 4).

On December 14, 1960, Charlie Huskon was issued MP-550 to cover the Charles Huskon No. 4 property, which Utco had abandoned in early 1960. Harold F. Rodgers was assigned the mining rights on February 8, 1961. Rodgers produced 1,245.64 tons of ore averaging 0.13 percent U_3O_8 in 1961 before cancelling his assignment in early 1962.

In January 1962, the final shipment of 167.69 tons averaging 0.25 percent U_3O_8 was made from Charles Huskon No. 17. This was the last of the Huskon mines to close. During March 1962, Milestone Hawaii, Inc. made a 23.93-ton shipment from its remodeled upgrader in section 9. This shipment averaged 0.10 percent U_3O_8. Material that was processed for this shipment came from shallow pits in T. 27 N., R. 10 E., secs. 9 and 16 and was labeled Milestone No. 1.

Because production at Cameron had steadily declined since 1957, the Orphan Lode mine in Grand Canyon National Park became the principal source of mill feed for the Tuba City mill (Chenoweth, 1986). A collapsed ore bin and resulting shaft damage forced the Orphan Lode mine to close on December 22, 1961, causing the mill to run out of ore. Rare Metals' ore-buying station at the mill would not accept any ore after March 31, 1962. The mill closed in May 1962.

In July 1962, Rare Metals was merged into the El Paso Natural Gas Company. On November 19, 1962 (effective September 10, 1962), El Paso signed a new contract with the AEC to produce concentrates from the Orphan Lode mine, as well as other ores, through December 31, 1966 (Chenoweth, 1986).

At Cameron, Julius Chee was issued MP-575 on July 23, 1962, to replace MP-444, which covered the Julius Chee No. 3 open pit that had been operated by L.V. Trettle. The assignment of the mining rights were approved to Leon Sterling, Jr., on August 16, 1962. With a new contract with the AEC, the El Paso mill began receiving ore in November 1962. Later that month, Sterling made a 45.57-ton shipment that averaged 0.16 percent U_3O_8 from the clean up of the old pit. Total production in 1962 declined to only 235.19 tons of ore averaging 0.22 percent U_3O_8 (Table 3).

While operating the Jack Daniels No. 1 mine in 1960, Page Blakemore determined that the orebody in the southwest portion of the pit extended west under the right-of-way of U.S. Highway 89. After the highway was relocated in 1961, Denetso was issued MP-559 (Jack Daniels No. 5) on July 19, 1961, covering 40 acres where ore was projected. The assignment of the permit to Blakemore was approved on August 14, 1962. In January 1963, Blakemore shipped 322.32 tons averaging 0.27 percent U_3O_8 from a small open pit he had excavated on the former highway right-of-way. Also in January 1963, Leon Sterling, Jr., shipped 22.67 tons averaging 0.13 percent U_3O_8 from the Julius Chee No. 3 open pit. These two shipments in January 1963 represent the last uranium ore production from the Cameron area. Production in 1963 totalled 344.99 tons, which averaged 0.26 percent U_3O_8 (Table 3). Shipments from

the Jack Daniels No. 5 and Julius Chee No. 3 in 1962 and 1963 were made under the Navajo Tribe's blanket allocation.

SUMMARY

During the 13 years (1951-63) that the mines in the Cameron area were active, 100 separate properties produced 289,247.96 tons of ore containing 1,211,812.48 pounds of U_3O_8 and averaging 0.21 percent U_3O_8 (Tables 1, 3, and 4). The bulk of the ore was mined from the Petrified Forest Member of the Chinle Formation: 70 properties produced 98 percent of the uranium (Table 1). Twenty-seven properties in the Shinarump Member of the Chinle Formation produced 2 percent of the uranium (Tables 1 and 8). Two properties in the Kayenta Formation and a single mine in a breccia pipe produced the remaining uranium (Table 1). Properties acquired by Charlie Huskon produced 474,121.16 pounds of U_3O_8, or 39 percent of the total uranium mined in the Cameron area (Table 9). The AEC purchased all of the uranium concentrate produced from the Cameron ores.

Mining in the Cameron area diminished in the early 1960's when operators could not maintain sufficient volume of ore to continue economic mining operations. The mechanical upgrading of low-grade uraniferous material in the Shinarump Member northeast of Black Point was also found to be uneconomical.

The density of past drilling precludes the possibility of discovering additional large, shallow deposits similar to those that were mined. If the price of uranium increases, however, considerable material that is now considered to be uneconomic might become ore.

AEC records indicate that between July 1953 and December 1962, inclusive, approximately 1,005,000 feet of surface drilling was performed in the Cameron area (Table 7). This footage was attributed to approximately 20,000 holes. It included exploration drilling to locate new deposits and development drilling to delineate orebodies before mining commenced. Drillers commonly used a grid pattern, spacing the drill holes 500 feet apart and then decreasing the spacing to 50 feet when they found ore-grade material. They drilled with a noncore rotary rig, typical of those used in seismograph surveys, and rarely saved the cuttings. Uranium values were interpreted from meter readings of an electronics system using a Geiger-Müller tube lowered into the drill hole on a cable.

The drilling was initially centered around outcropping deposits and radioactive anomalies in both the Petrified Forest and Shinarump Members of the Chinle Formation. Expanding from the surface deposits, usually along the strike of the beds, explorationists found many additional deposits that had no surface exposure. The most intensely drilled area was on the northeast side of the Little Colorado River between Moenkopi Wash on the north and Tohachi Wash on the south (Plate 1). North of Cameron, the drilling extended to Five Mile Wash but was generally limited to a belt 1 to 1.5 miles wide on the east side of the river. The intensely drilled area extended south of Baah Lakaa Ridge near Kish Zhini Wash, where the Charles Huskon No. 4 deposit had been previously discovered. This drilling tested the basal Petrified Forest Member and rarely exceeded 100 feet in depth, the limit at which most operators felt they could economically mine. Some minor drilling occurred near the foot of Ward Terrace at anomalies and deposits, but rarely did this drilling exceed 50 feet in depth.

The orebodies in the lower part of the Petrified Forest Member were contained in lenticular channel sandstones. The channel sandstone containing the Yazzie No. 312, Juan Horse Nos. 3 and 4, Boyd Tisi No. 2, and Manuel Denetsone No. 2 ore deposits was plotted from logs of drill-hole cuttings. This channel was traced for 4 miles in a N. 18° W. direction before it lost its entity. The average width of this channel was 5,000 feet, and it had a maximum thickness of 35 feet. Smaller channels are present, and several have been noted in the open pits, but the subsurface information to trace them for any distance was unavailable. Within the lower part of the Petrified Forest Member, ore-bearing channel sandstones have been delineated near the Little Colorado River. Past exploration did not test these host

rocks at any depth. The possibility is good that additional ore-bearing channel sandstones are present at depth in the lower part of the Petrified Forest Member, east of the Little Colorado River.

Almost without exception, in the well-explored uranium districts on the Colorado Plateau, the shallow, oxidized, near-surface deposits were smaller and of lower grade than their unoxidized counterparts at depth. There is no known reason to expect any difference at Cameron. Possible higher grade and more continuous orebodies should present an attractive exploration target in the future.

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Table 1. Uranium ore production by host rock, Cameron area, Coconino County, Arizona.

HOST ROCK	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8	POUNDS V_2O_5	PERCENT[1] V_2O_5
Kayenta Formation	182.04	547.68	0.15	1,494.04	0.40
Petrified Forest Member, Chinle Formation	278,616.46	1,186,889.66	0.21	203,680.11	0.05
Shinarump Member, Chinle Formation	9,941.05	20,535.99	0.10	6,608.62	0.10
Moenkopi Formation (breccia pipe)	508.41	3,839.15	0.38	331.00	0.03
TOTAL	289,247.96	1,211,812.48	0.21	212,113.77	0.05

[1] Grade based on actual tons analyzed for vanadium oxide.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 2. Uranium mines in the Cameron area, Navajo Indian Reservation, with names other than the Navajo permittee.

MINE NAME	PERMITTEE
A & B Nos. 2, 5	Harry Walker
A & B Nos. 3, 7, 13	Paul Huskie
Casey No. 3	Scott Preston
Jack Daniels Nos. 1, 2, 4, 5	Denetso
Jackpot Nos. 1, 5, 40	Ned Hatathli
Jeepster	William Robbins
June	Jessie Sloan
Kachina No. 6	William Robbins
Martin Johnson No. 4	David Tsosie, Willie John
Montezuma Nos. 1, 2, 7A, 7B, 7C	William Robbins
Ramco No. 20	Calvin Semallie
Ramco No. 21	Dan McClellan
Ramco No. 22	Elvin Gordy
Ramco No. 24	Dan Webster
Ryan Nos. 1, 2	Clay Bigman
Thomas No. 1	Ancil Thomas
Tommy	Jessie Sloan
Ward Terrace	Hosteen Nez
Yazzie Nos. 1, 2, 312	Maxwell Yazzie
Yazzie Nos. 101, 102	George Yazzie
Yellow Jeep Nos. 7A, 7B	Ben and Pete Semallie

Source: Navajo Tribal Mining Department, unpublished records; in files of U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 3. Annual uranium ore production, Cameron area, Coconino County, Arizona.

YEAR	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8	POUNDS V_2O_5	PERCENT V_2O_5	NO. OF OPERATORS	NO. OF MINES SHIPPING ORE
1951	1.05	8.65	0.41	4.85	0.23		1
1952	90.20	386.43	0.21	214.56	0.56	2	2
1953	8,104.54	41,713.56	0.26	13,725.88	0.08	1	9
1954	11,366.50	51,550.00	0.23	17,234.47	0.08	7	20
1955	1,606.53	6,756.56	0.21	1,756.01	0.05	7	11
1956	84,799.13	363,508.40	0.21	80,101.00	0.05	19	55
1957	78,219.55	326,236.75	0.21	85,684.00	0.05	18	51
1958	57,347.84[1]	233,994.08	0.20	13,393.00	0.03	17	42
1959	27,705.79	111,983.06	0.20	NA	—	16	31
1960	13,029.03	48,667.05	0.19	NA	—	16	25
1961	6,397.62	24,186.29	0.19	NA	—	5	14
1962	235.19	1,032.96	0.22	NA	—	3	3
1963	344.99	1,788.69	0.26	NA	—	2	2
TOTAL	289,247.96	1,211,812.48	0.21	212,113.77	0.05		

[1] Only 22,321.67 tons were analyzed for vanadium oxide in 1958.
NA: No analysis.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 4. Operators and mines, showing year of ore production. Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Hosteen Nez Mining Co.
  Hosteen Nez

1952

Arrowhead Uranium Co.
  Charles Huskon No. 1
Hosteen Nez Mining Co.
  Hosteen Nez

Arrowhead Uranium Co.
  Charles Huskon Nos. 1, 2, 3, 4, 5, 6, 7, 8, 10

A and B Mining Co.
  A and B Nos. 2, 3, 5, 7, 13
  Earl Huskon No. 1
  Henry Sloan No. 1
Arrowhead Uranium Co.
  Charles Huskon Nos. 1, 2, 3, 4, 9, 10, 12, 17
Bloomfield, J.W.
  Earl Huskon No. 1
F and B Mining Co.
  Thomas No. 1
Five Star Mining Co.
  Amos Chee No. 3
Nordell, A.C.
  Section 1
Wilson, Howard
  Taylor Reid No. 2

A and B Mining Co.
  A and B No. 3
  Earl Huskon No. 3
Arrowhead Uranium Co.
  Charles Huskon Nos. 1, 2, 17
Diamond Uranium Corp.
  Lemuel Littleman No. 3
Five Star Mining Co.
  Amos Chee Nos. 3, 8
Kachina Uranium Corp.
  Montezuma No. 2
Shooting Star Uranium Co.
  Liba Group
Vermillion Cliffs Uranium Co.
  Max Huskon Nos. 1-7

1956

B C Associates
  Charles Huskon No. 5
  Julius Chee No. 2
  June
  Tommy
Black, C.S.
  Liba Group
Chesser and Co.
  Yazzie Nos. 101, 102
Diamond Uranium Corp.
  L. Littleman No. 7
Filmore, Robert
  Grub No. 14 (Section 16)
Five Star Mining Co.
  Amos Chee Nos. 2, 8
Foley Brothers, Inc.
  Foley No. 5
  Yazzie No. 1
Harbough and Chinn
  Henry Sloan No. 1
  Jackpot Nos. 1, 5, 40
  Paul Huskie No. 21
Howell and Glasscock
  Murphy Group
Johnson, Martin
  Martin Johnson No. 4
Kachina Uranium Corp.
  Jeepster No. 1
  Montezuma Nos. 1, 2, 7A, 7B, 7C
Lauderdale Mining and Development Corp.
  Howard No. 1
  Luster No. 1
Marcy Exploration and Mining Co.
  Jack Daniels Nos. 1, 3, 4
Maynard and Ryan
  Ryan No. 2
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 7, 8, 10, 12, 14, 17
  Ramco Nos. 20, 21, 22
Trettle, L.V.
  Julius Chee No. 3
United Exploration Syndicate
  Ward Terrace Tract (Hosteen Nez)
Utah Southern Oil Co.
  Emmett Lee No. 1
  Julius Chee No. 4
  Max Johnson No. 1
Utco Uranium Corp.
  Charles Huskon Nos. 4, 9, 18
  Paul Huskie No. 3
  Riverview

1957

Diamond Uranium Corp.
L. Littleman No. 2
Foley Brothers, Inc.
Yazzie Nos. 1, 2
Harbough and Chinn
Jackpot Nos. 5, 40
Kachina Uranium Corp.
Jeepster No. 1
Kachina No. 6
Montezuma Nos. 2, 7A
Kaibab Uranium Corp.
Casey No. 3
Klaner and Associates
Boyd Tisi No. 2
Marcy Exploration and Mining Co.
Jack Daniels No. 1
Mescalero Mining Co.
Emmett Lee No. 3
Pelan, Dave
Boyd Tisi No. 1
Rare Metals Corp. America
Charles Huskon Nos. 1, 2, 3, 6, 7, 8, 10, 11, 12, 17, 27
Ramco Nos. 20, 21, 22, 24
Section 9
Ryan and Maynard
Ryan Nos. 1, 2
Sequoia Mining Co.
A. Maloney No. 2
Skiles Oil Co.
Elwood Canyon No. 2
Steinberger Drilling Co.
Alyce Tolino Nos. 1-3
Julia Semallie
Trettle, L.V.
Julius Chee No. 3
Utah Southern Oil Co.
Emmett Lee No. 1
Julius Chee No. 4
Max Johnson Nos. 1, 7
Yazzie Nos. 101, 312
Utco Uranium Corp.
Charles Huskon Nos. 4, 9, 18, 19, 20
Evans Huskon No. 34
Harry Walker No. 16
Riverview
Yellow Jeep Mining Co.
Yellow Jeep Nos. 7A-B

1958

Diamond Uranium Corp.
L. Littleman No. 2
Foley Brothers, Inc.
Yazzie No. 2
Howell, Sheppard and Bosley
Murphy group
Kachina Uranium Corp.
Kachina No. 6
Klaner and Associates
Boyd Tisi No. 2
Marcy Exploration and Mining Co.
Jack Daniels No. 1
Mescalero Mining Co.
Emmett Lee No. 3
Navajo Leytso Mining Co.
Thomas No. 1
Rankin, C.L.
Navajo No. 26
Section No. 1
Section No. 9
Rare Metals Corp. America
Charles Huskon Nos. 1, 2, 3, 6, 7, 10, 11, 12, 17
Ramco Nos. 20, 21, 22, 24
Ryan and Maynard
Ryan Nos. 1, 2
Steinberger Drilling Co.
Juan Horse No. 4
Julia Semillie
Stevenson, W.W.
B.P. Group (Navajo No. 26)
Utah Southern Oil Co.
Emmett Lee No. 1
Julius Chee No. 4
Max Johnson No. 7
Yazzie Nos. 101, 312
Utco Uranium Corp.
Charles Huskon Nos. 4, 9, 18
Evans Huskon No. 35
Julius Chee No. 2
Paul Huskie No. 3
Wells Cargo, Inc.
Juan Horse No. 3
Max Johnson No. 9
Woodson Exploration Co.
Jack Huskon No. 3

1959

Blakemore, Page P.
Elwood Canyon No. 2
Cramer, Louis W.
Max Johnson No. 10
Diamond Uranium Corp.
L. Littleman No. 2
Domino Mining Co.
Charles Huskon No. 8
Paul Huskie No. 20

Foley Brothers, Inc.
  Yazzie No. 2
Kachina Uranium Corp.
  Kachina No. 6
  Montezuma No. 1
Lynch, J.W.
  Jack Huskon No. 3
Murchison Ventures, Inc.
  C O Bar Livestock (Section 9)
Rankin, C.L.
  Section 9
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 10, 11, 12, 17
  Ramco Nos. 20, 21, 22
Steinberger Drilling Co.
  Alyce Toleno No. 1
  Juan Horse No. 4
Travis, L.L.
  Liba group
Utah Southern Oil Co.
  Max Johnson Nos. 1, 7
  Yazzie No. 312
Utco Uranium Corp.
  Charles Huskon No. 4
Wells Cargo, Inc.
  Juan Horse No. 3
  Manuel Dentsone No. 2
  Max Johnson No. 9
Woodson Exploration Co.
  Jack Huskon No. 3

1960

Blakemore, Page P.
  Elwood Canyon No. 2
  Jack Daniels No. 1
  Liba Group
Cramer, Louis W.
  Max Johnson No. 10
Diamond Uranium Corp.
  L. Littleman Nos. 2, 7
Domino Mining Co.
  Charles Huskon No. 8
Foley Brothers, Inc.
  Yazzie No. 2
Kachina Uranium Corp.
  Kachina No. 6
Murchison Ventures, Inc.
  C O Bar Livestock (Section 9)
Navajo Leytso Mining Co.
  Thomas No. 1
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 11, 17
  Ramco No. 20
Rogers, Harold F.
  Yazzie No. 101
Steinberger Drilling
  Alyce Toleno No. 1
Travis, L.L.
  Liba Group
Twilight Co.
  Elwood Thompson No. 1
Utah Southern Oil Co.
  Max Johnson No. 1
  Yazzie Nos. 101, 312
Utco Uranium Corp.
  Charles Huskon No. 4
Wells Cargo, Inc.
  Max Johnson No. 9

Foley Brothers, Inc.
  Yazzie No. 2
Rare Metals Corp. America
  Charles Huskon Nos. 1, 2, 3, 6, 10, 11, 12, 17
Rodgers, Harold F.
  Charles Huskon No. 4
Twilight Co.
  Elwood Thompson No. 1
Utah Southern Oil Co.
  Max Johnson No. 1
  Yazzie Nos. 101, 312

Milestone Hawaii, Inc.
  Milestone No. 1
Rare Metals Corp. America
  Charles Huskon No. 17
Sterling, Leon, Jr.
  Julius Chee No. 3

Blakemore, Page P.
  Jack Daniels No. 5
Sterling, Leon Jr.
  Julius Chee No. 3

Table 5. Uranium-vanadium production of mines in the Cameron area, Coconino County, Arizona, shown on Plate 1

No. on Plate 1[1]	Mine Name	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5[2]	Operator(s)	Year(s) of Production
	Earl Huskon No. 1	369.95	1426.03	0.19	3,111.31	0.42	J.W. Bloomfield	1954
							A & B Mining Corp.	1954-55
2	Paul Huskie No. 21	12.40	64.48	0.26	5.00	0.02	Harbough & Chinn	1956
3	Earl Huskon No. 3	1,835.36	8,826.28	0.24	,198.54	0.03	A & B Mining Corp.	1954-55
4	A & B No. 5	304.68	788.40	0.13	243.74	0.04	A & B Mining Corp.	1954
5a,b	Henry Sloan No. 1	352.87	1,273.00	0.18	322.52	0.05	A & B Mining Corp.	1954
							Harbough & Chinn	1956
7	A & B No. 13	50.82	91.48	0.09	91.48	0.09	A & B Mining Corp.	1954
8	A & B No. 7	24.49	39.18	0.08	132.22	0.27	A & B Mining Corp.	1954
9	Charles Huskon No. 5	320.86	,668.26	0.26	1,103.32	0.17	Arrowhead Uranium Co.	1953
							B.C. Associates	1956
11	Charles Huskon No. 6	746.99	3,023.69	0.20	229.33	0.05	Arrowhead Uranium Co.	1953
							Rare Metals Corp. Amer.	1956-61
12	Lemuel Littleman No. 7	98.54	181.86	0.09	13.00	0.03	Diamond Uranium Corp.	1956,60
13	Jeepster No. 1	1,127.58	4,061.91	0.18	848.00	0.04	Kachina Uranium Corp.	1956-57
14	Montezuma No. 7C	365.96	93.52	0.13	43.00	0.06	Kachina Uranium Corp.	1956
15a,b,c	Montezuma No. 7B	38.01	91.22	0.12	38.00	0.05	Kachina Uranium Corp.	1956
16	Montezuma No. 7A	57.34	131.71	0.11	53.00	0.05	Kachina Uranium Corp.	1956-57
17a,b	Montezuma No. 2	192.63	475.01	0.12	200.79	0.05	Kachina Uranium Corp.	1955-57
18	Casey No. 3	16.50	39.60	0.12	13.00	0.04	Kaibab Uranium Corp.	1957
19	Kachina No. 6	1,451.70	4,043.87	0.14	65.00	0.02	Kachina Uranium Corp.	1957-60
21	Evans Huskon No. 34	1,853.07	6,017.51	0.16	1,452.00	0.04	Utco Uranium Corp.	1957
22	Charles Huskon No. 20	1,037.56	4,996.09	0.24	1,320.00	0.06	Utco Uranium Corp.	1957
23	Charles Huskon No. 19	696.35	1,903.17	0.14	275.00	0.02	Utco Uranium Corp.	1957
24	Jack Daniels No. 1	39,440.14	176,208.84	0.22	40,779.00	0.06	Marcy Explor. & Mining Co.	1956-58,60
24	Jack Daniels No.3	12.22	26.89	0.11	10.00	0.04	Marcy Explor. & Mining Co.	1956
24	Jack Daniels No. 4	33.85	94.78	0.14	47.00	0.07	Marcy Explor. & Mining Co.	1956
24	Jack Daniels No. 5	322.32	1,728.40	0.27	N/A		Page P. Blakemore	1963
25	Charles Huskon No. 12	1,779.66	6,293.97	0.18	207.99	0.27	Arrowhead Uranium Co.	1954
							Rare Metals Corp. Amer.	1956-59,61
26	A & B No. 3	585.97	1,457.87	0.12	514.95	0.04	A & B Mining Corp.	1954-55
27	Max Johnson No. 1	5,678.29	25,818.29	0.23	2,815.00	0.03	Utah Southern Oil Co.	1956-57,59-61
28a,b	Lemuel Littleman No. 2	5,819.05	23,966.36	0.21	758.00	0.02	Diamond Uranium Corp.	1957-60
29	Charles Huskon No. 1	23,126.98	100,406.62	0.22	51,691.68	0.14	Arrowhead Uranium Co.	1952-55
							Rare Metals Corp. Amer.	1956-61
30	Max Johnson No. 10	195.78	1,094.10	0.28	NA		Louis W. Cramer	1959-60
31	Max Johnson No. 9	1,374.55	5,264.60	0.19	NA		Wells Cargo, Inc.	1958-60
32	Elwood Canyon No. 1	874.42	3,638.36	0.21	81.00	0.02	Skiles Oil Corp.	1957
							Page P. Blakemore	1959-60
34	Alyce Tolino Nos. 1,3	1,811.17	8,114.75	0.22	2,478.00	0.06	Steinberger Drilling Co.	1957,60
35	Evans Huskon No. 2	11,776.55	42,692.27	0.18	3,051.55	0.02	Arrowhead Uranium Co.	1955
							Rare Metals Corp. Amer.	1957-61
36	Yazzie No. 101	4,954.54	21,702.47	0.22	1,884.00	0.02	Chesser & Co.	1956
							Utah Southern Oil Co.	1957-58,60-61
37	Yazzie No. 312	7,376.46	32,242.97	0.22	628.00	0.03	Foley Brothers, Inc.	1956
	(Foley No. 5)						Utah Southern Oil Co.	1957-61
38	Boyd Tisi No. 2	793.61	4,758.43	0.30	599.00	0.06	Klaner & Assoc.	1957-58
39	Juan Horse No. 3	2,342.80	9,070.37	0.19	NA		Wells Cargo, Inc.	1958-59

No. on Plate 1[1]	Mine Name	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5[2]	Operator(s)	Year(s) of Production
40	Lemuel Littleman No. 3	11.88	54.63	0.23	16.63	0.07	Diamond Uranium Corp.	1955
41	Juan Horse No. 4	2,418.09	11,171.79	0.23	NA		Steinberger Drilling Co.	1958-59
43	Charles Huskon No. 14	46.54	102.39	0.11	19.00	0.02	Rare Metals Corp. Amer.	1956
44	Montezuma No. 1	10.66	21.32	0.10	NA		Kachina Uranium Corp.	1959
45	Manuel Denetsone No. 2	337.82	1,332.99	0.20	NA		Wells Cargo, Inc.	1959
47	A & B No. 2	121.90	679.70	0.28	318.74	0.13	A & B Mining Corp.	1954
48	Jack Huskon No. 3	1,263.95	4,606.48	0.19	NA		Woodson Exploration Co.	1958-59
							J.W. Lynch	1959
49a, b,c,d	Charles Huskon No. 3	27,249.05	110,261.19	0.20	8,267.82	0.02	Arrowhead Uranium Co.	1953-54
							Rare Metals Corp. Amer.	1956-61
52	Paul Huskie No. 20	22.72	68.16	0.15	NA		Domino Mining Co.	1959
53	Charles Huskon No. 7	2,500.73	15,306.31	0.31	2,871.13	0.06	Arrowhead Uranium Co.	1953
							Rare Metals Corp. Amer.	1956-58
54	Yazzie No. 102	1,610.38	9,574.64	0.30	2,529.00	0.09	Chesser & Co.	1956
							H.F. Rogers	1960
55a,b	Charles Huskon No. 10	17,084.39	75,036.72	0.22	20,599.80	0.07	Arrowhead Uranium Co.	1953-54
							Rare Metals Corp. Amer.	1956-59,61
58a,b	Charles Huskon No. 8	626.20	2,901.73	0.23	474.81	0.07	Arrowhead Uranium Co.	1953
							Rare Metals Corp. Amer.	1956-57
							Domino Mining Co.	1959-60
59	Boyd Tisi No. 1	37.22	96.78	0.13	67.00	0.09	Dave Pelan	1957
60	Evans Huskon No. 35	63.71	169.89	0.13	NA		Utco Uranium Corp.	1958
63	Ryan No. 1	311.08	1,086.89	0.17	137.00	0.02	Ryan & Maynard	1957-58
64	Taylor Reid No. 2	91.30	587.77	0.32	199.00	0.11	Howard Wilson	1954
65	Charles Huskon No. 26	18.06	43.35	0.12	11.00	0.03	Rare Metals Corp. Amer.	1957
66	Charles Huskon No. 11	2,776.92	6,518.06	0.12	92.00	0.02	Rare Metals Corp. Amer.	1957-61
67a,b	Section 1 Lease	43.92	197.32	0.22	113.59	0.16	A.C. Nordell	1954
							C.L. Rankin	1958
68a,b	New Liba Group	1,845.42	5,917.91	0.16	183.64	0.04	Shooting Star Uranium	1955
							C.S. Black	1956
							L.L. Travis	1959-60
							Page P. Blakemore	1960
70	Howard No. 1	24.59	127.87	0.26	49.00	0.10	Lauderdale Mining & Dev.	1956
71a,b,c	Section 9 Lease	361.55	916.87	0.13	4.00	0.01	Rare Metals Corp. Amer.	1957
							C.L. Rankin	1958-59
							Murchison Ventures	1959-60
72a,b	Ramco No. 21	5,471.48	26,825.11	0.25	3,903.00	0.08	Rare Metals Corp. Amer.	1956-59
73,75	Ramco No. 22	16,608.94	77,040.28	0.23	4,828.00	0.05	Rare Metals Corp. Amer.	1956-59
74,75	Ramco No. 20	22,642.06	99,226.33	0.22	19,259.00	0.05	Rare Metals Corp. Amer.	1956-60
75	Ryan No. 2	2,066.35	9,422.40	0.23	2,897.00	0.08	Maynard & Ryan	1956-58
79	Yazzie No. 1	342.51	1,310.85	0.19	447.00	0.07	Foley Brothers, Inc.	1956-57
80	Yazzie No. 2	5,646.11	22,668.78	0.20	1,337.00	0.03	Foley Brothers, Inc.	1957-61
81	Navajo No. 26	94.61	341.65	0.18	NA		W.W. Stevenson	1958
							C.L. Rankin	1958
82	Luster No. 1	319.61	929.08	0.14	219.00	0.03	Lauderdale Mining & Dev.	1956
83	Grub No. 14	13.14	42.04	0.16	8.00	0.03	Robert Fillmore	1956
84	Charles Huskon No. 17	4,868.83	20,234.26	0.21	1,218.80	0.02	Arrowhead Uranium Co.	1954-55
							Rare Metals Corp. Amer.	1956-62
85	Jackpot No. 40	152.07	599.13	0.20	215.00	0.07	Harbough & Chinn	1956-57
86	Jackpot No. 1	151.39	540.19	0.18	79.00	0.03	Harbough & Chinn	1956

No. on Plate 1[1]	Mine Name	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5[2]	Operator(s)	Year(s) of Production
87	Jackpot No. 5	77.39	405.22	0.26	26.00	0.02	Harbough & Chinn	1956-57
88	Black Point-	.,768.57	7,470.30	0.21	.,378.00	0.04	Howell & Glassock	1956
	Murphy Group						Howell, Sheppard, & Bosley	1958
89	Amos Chee No. 8	100.86	391.86	0.19	85.76	0.04	Five Star Mining Co.	1955-56
90	Max Johnson No. 7	280.34	901.97	0.16	149.00	0.03	Utah Southern Oil Co.	1957-59
91	Charles Huskon No. 9	617.17	2,215.58	0.18	177.55	0.02	Arrowhead Uranium Co.	1954
							Utco Uranium Corp.	1956-58
92	Elwood Thompson No. 1	3,261.32	15,548.16	0.24	NA		Twilight Co.	1960-61
93	Riverview	508.41	3,839.15	0.38	331.00	0.03	Utco Uranium Corp.	1956-57
94	Emmett Lee No. 1	839.56	3,158.11	0.19	306.00	0.02	Utah Southern Oil Co.	1956-58
94	Julius Chee No. 4	1,042.27	3,835.59	0.18	264.00	0.01	Utah Southern Oil Co.	1956-58
94	Julius Chee No. 3	217.56	757.69	0.17	30.00	0.01	L.V. Trettle	1956-57
							Leon Sterling, Jr.	1962-63
94,95	Julius Chee No. 2	637.44	2,211.22	0.17	231.00	0.02	B.C. Associates	1956
							Utco Uranium Corp.	1957-58
96a,b	Ramco No. 24	2,828.04	12,013.08	0.21	NA		Rare Metals Corp. Amer.	1957-58
96b	Harry Walker No. 16	50.98	121.28	0.12	50.00	0.05	Utco Uranium Corp.	1957
97,98	Charles Huskon No. 4	33,821.10	121,244.63	0.18	13,709.61	0.02	Arrowhead Uranium Co.	1953-54
							Utco Uranium Corp.	1956-60
							H.F. Rodgers	1961
98	Paul Huskie No. 3	3,925.32	14,371.72	0.18	2,472.00	0.03	Utco Uranium Corp.	1956,58
99	Charles Huskon No. 18	613.70	1,965.14	0.16	353.00	0.03	Utco Uranium Corp.	1956-58
100	Julia Semallie	1,622.78	8,193.49	0.25	1,229.00	0.05	Steinberger Drilling Co.	1957-58
100	Emmett Lee No. 3	228.69	1,469.84	0.32	104.00	0.03	Mescalero Mining Co.	1957-58
	Milestone No. 1[3]	23.93	47.86	0.10	NA		Milestone Hawaii, Inc.	1962

[1] The following numbers are not listed in this table (see first column) but are listed on Plate 1: 6, 10, 20, 33, 42, 46, 50, 51, 56, 57, 61, 62, 69, 76, 77, and 78. The missing numbers refer to uranium deposits that were never mined because of their small size or low grade.

[2] Grade based on actual tons analyzed for vanadium oxide.

[3] Upgraded material from T. 27 N., R. 10 E., secs. 9 and 16 (Nos. 71 and 83).

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

Table 6. Uranium-vanadium production of mines not shown on Plate 1.

Mine Name	Location T R S	Tons of Ore	Pounds U_3O_8	Percent U_3O_8	Pounds V_2O_5	Percent V_2O_5	Operators(s)	Year(s) of Production
Tommy	39 7 23	39.93	295.35	0.37	16.00	0.02	B.C. Associates	1956
June	39 7 26	22.67	99.75	0.22	9.00	0.02	B.C. Associates	1956
Thomas No. 1	38 7 22	153.85	294.38	0.10	NA		F & B Mining	1954
							Navajo Leytso	1958, 1960
Martin Johnson No. 4	32 9 11	37.51	120.04	0.16	23.00	0.03	Martin Johnson	1956
Max Huskon Nos. 1, 5	31 9 26	56.71	45.13	0.04	22.69	0.02	Vermillion Cliffs Mining	1955
Hosteen Nez	27 12 33	60.81	142.25	0.12	147.04	0.12	Hosteen Nez Mining	1951-52
							United Exploration	1956
Yellow Jeep No. 7A,B	28 11 10	121.23	405.43	0.17	1,344.00	0.55	Yellow Jeep Mining	1957
Amos Chee Nos. 2, 3	25 11 24	88.98	299.28	0.17	2,395.73	1.35	Five Star Mining	1954-56
A. Maloney No. 2	25 11 24	23.52	32.93	0.07	98.00	0.21	Sequoia Mining	1957

NA: No analysis.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 7. Surface drilling for uranium, Cameron area, Coconino County, Arizona.

YEAR	FOOTAGE
1953	135,000
1954	40,000
1955	48,000
1956	70,000
1957	90,000
1958	150,000
1959	150,000
1960	196,000
1961	96,000
1962	30,000
1963	0
TOTAL	1,005,000

Source: Unpublished field notes, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 8. Mines in the Cameron area that have produced from the Shinarump Member, Chinle Formation.

NAME	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8	POUNDS V_2O_5	PERCENT V_2O_5[1]
A and B No. 2	121.90	679.70	0.28	318.74	0.13
A and B No. 3	585.97	1,457.87	0.12	514.95	0.04
A and B No. 5	304.68	788.40	0.13	243.74	0.04
A and B No. 7	24.49	39.18	0.08	132.22	0.27
Casey No. 3	16.50	39.60	0.12	13.00	0.04
Charles Huskon No. 6	746.99	3,023.69	0.20	299.33	0.05
Charles Huskon No. 11	2,776.92	6,518.06	0.12	92.00	0.02
Charles Huskon No. 12	1,779.66	6,293.97	0.18	702.99	0.27
Charles Huskon No. 14	46.54	102.39	0.11	19.00	0.02
Charles Huskon No. 26	18.06	43.35	0.12	11.00	0.03
Earl Huskon No. 1	369.95	1,426.03	0.19	3,111.31	0.42
Grub No. 14	13.14	42.04	0.16	8.00	0.03
Howard No. 1	24.59	127.87	0.26	49.00	0.10
L. Littleman No. 3	11.88	54.63	0.23	16.63	0.10
Liba Group	1,845.42	5,917.16	0.16	183.64	0.04
Luster No. 1	319.61	929.08	0.15	219.00	0.03
Max Huskon Nos. 1, 7	56.71	45.13	0.04	22.69	0.02
Milestone No. 1	23.93	47.86	0.10	NA	
Montezuma No. 1	10.66	21.32	0.10	NA	
Montezuma No. 2	192.63	475.01	0.12	200.79	0.05
Montezuma No. 7A	57.34	131.71	0.12	53.00	0.05
Montezuma No. 7B	38.01	91.22	0.12	38.00	0.05
Montezuma No. 7C	35.97	93.52	0.13	43.00	0.06
Paul Huskie No. 20	22.73	68.16	0.15	NA	
Section 1	43.92	197.32	0.22	113.59	0.16
Section 9	361.55	916.87	0.12	4.00	0.01
Taylor Reid No. 2	91.30	587.77	0.32	199.00	0.11
TOTAL	9,941.05	20,535.99	0.10	6,608.62	0.10

[1] Grade based on actual tons analyzed for vanadium oxide.
NA: No analysis.
Source: Unpublished records, U.S. Atomic Energy Commission, Grand Junction, Colorado.

Table 9. Uranium production from mines on Charles Huskon's mining permits, ranked by size.

MINE NO.	TONS OF ORE	POUNDS U_3O_8	PERCENT U_3O_8
4	33,821.10	121,244.63	0.18
3	27,249.05	110,261.19	0.20
	23,126.98	100,406.62	0.22
10	17,084.39	75,036.72	0.22
17	4,868.83	20,234.26	0.21
11	2,776.92	6,518.06	0.12
7	2,500.73	15,306.31	0.31
12	1,779.66	6,293.97	0.18
20	1,037.56	4,996.09	0.24
6	746.99	3,023.69	0.20
19	696.35	1,903.17	0.14
8	626.20	2,901.73	0.23
9	617.17	2,215.58	0.18
18	613.70	1,965.14	0.16
5	320.86	1,668.26	0.26
14	46.54	102.39	0.11
26	18.06	43.35	0.12
TOTAL	117,931.09	474,121.16	0.20

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

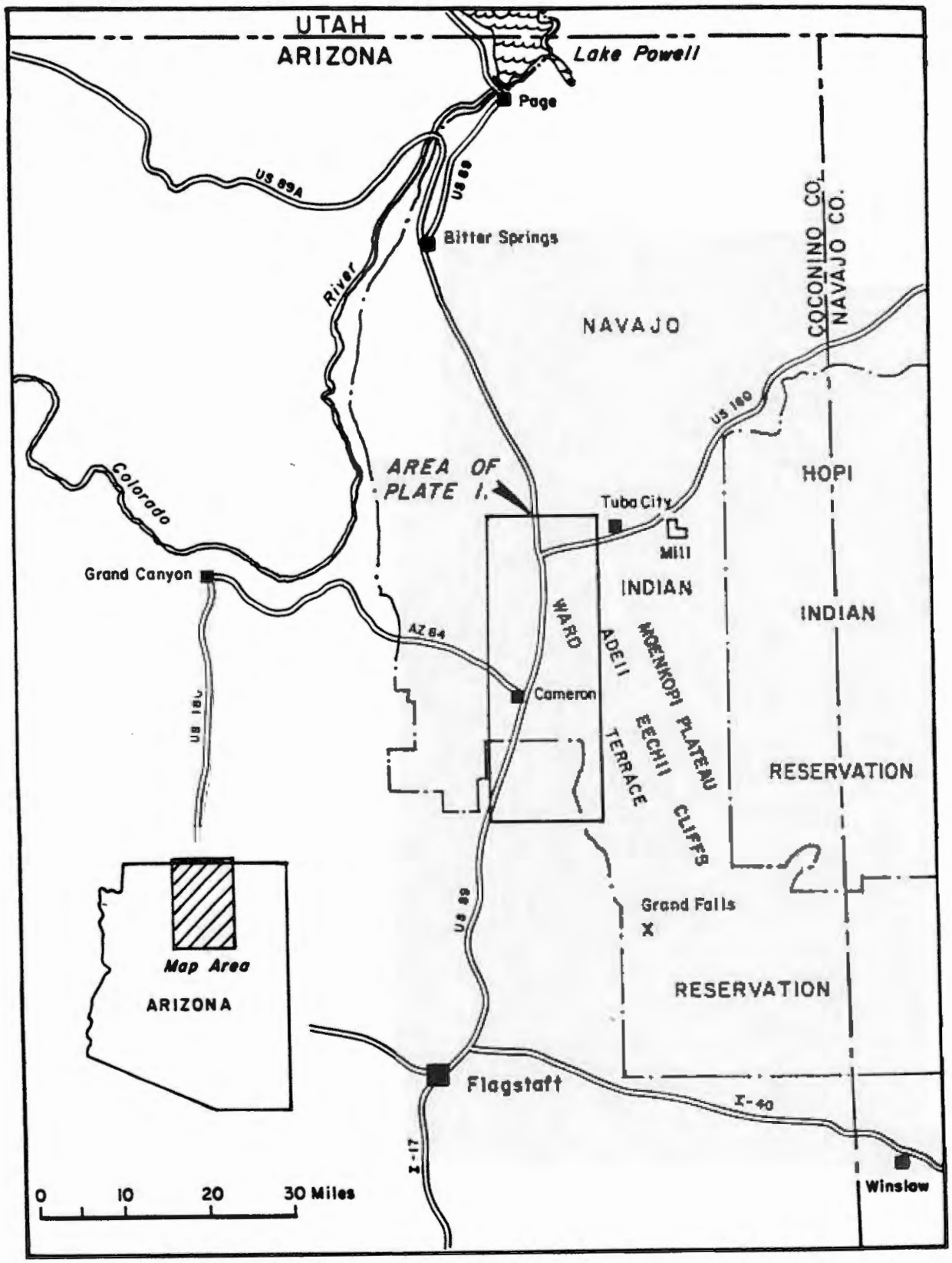


Figure Index map of north central Arizona showing the location of the Cameron uranium mining area

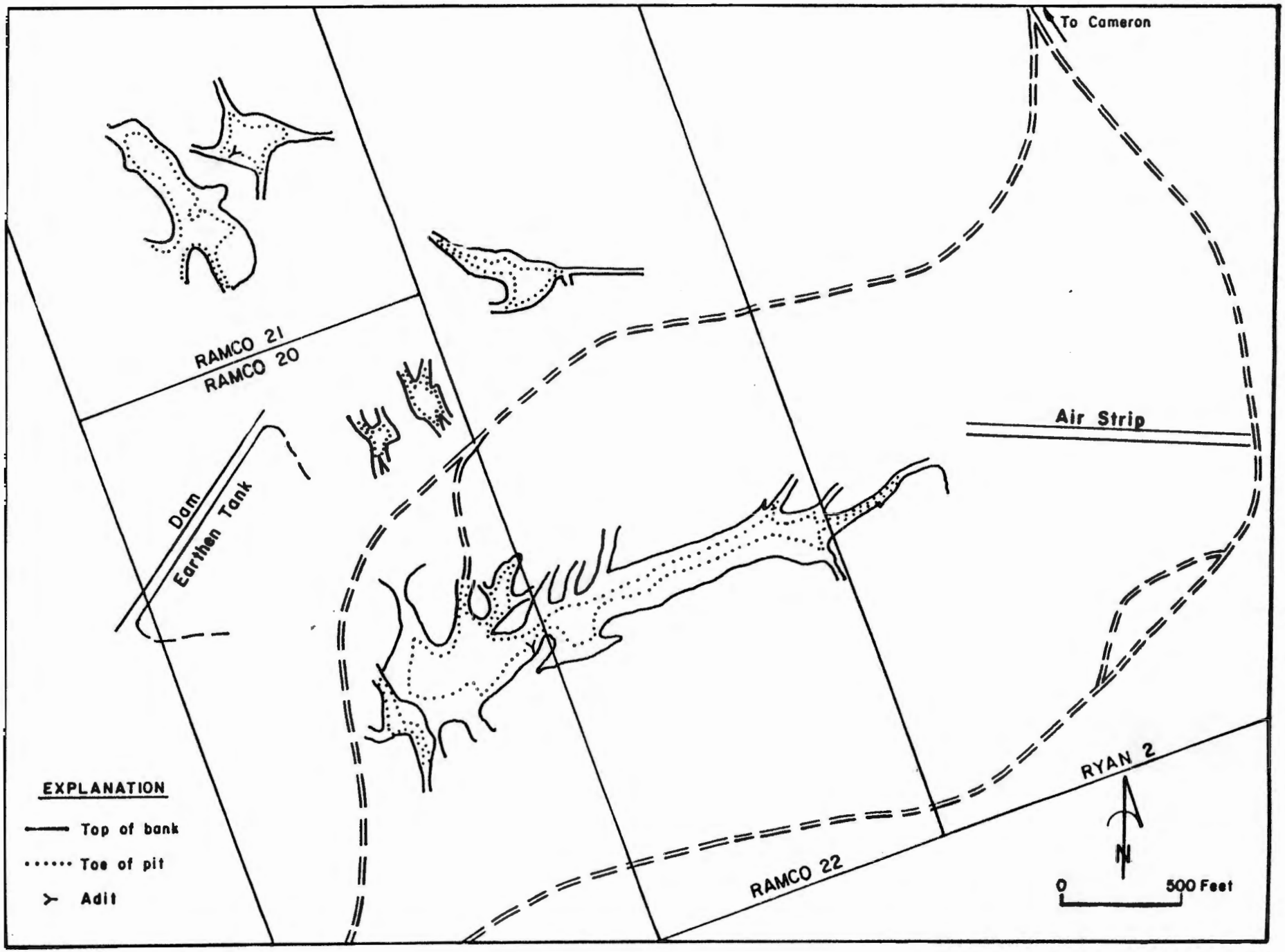


Figure 2. Map showing the mines on the Ramco 20,21,22 and Ryan 2 mining permits, Cameron area, Coconino County, Arizona

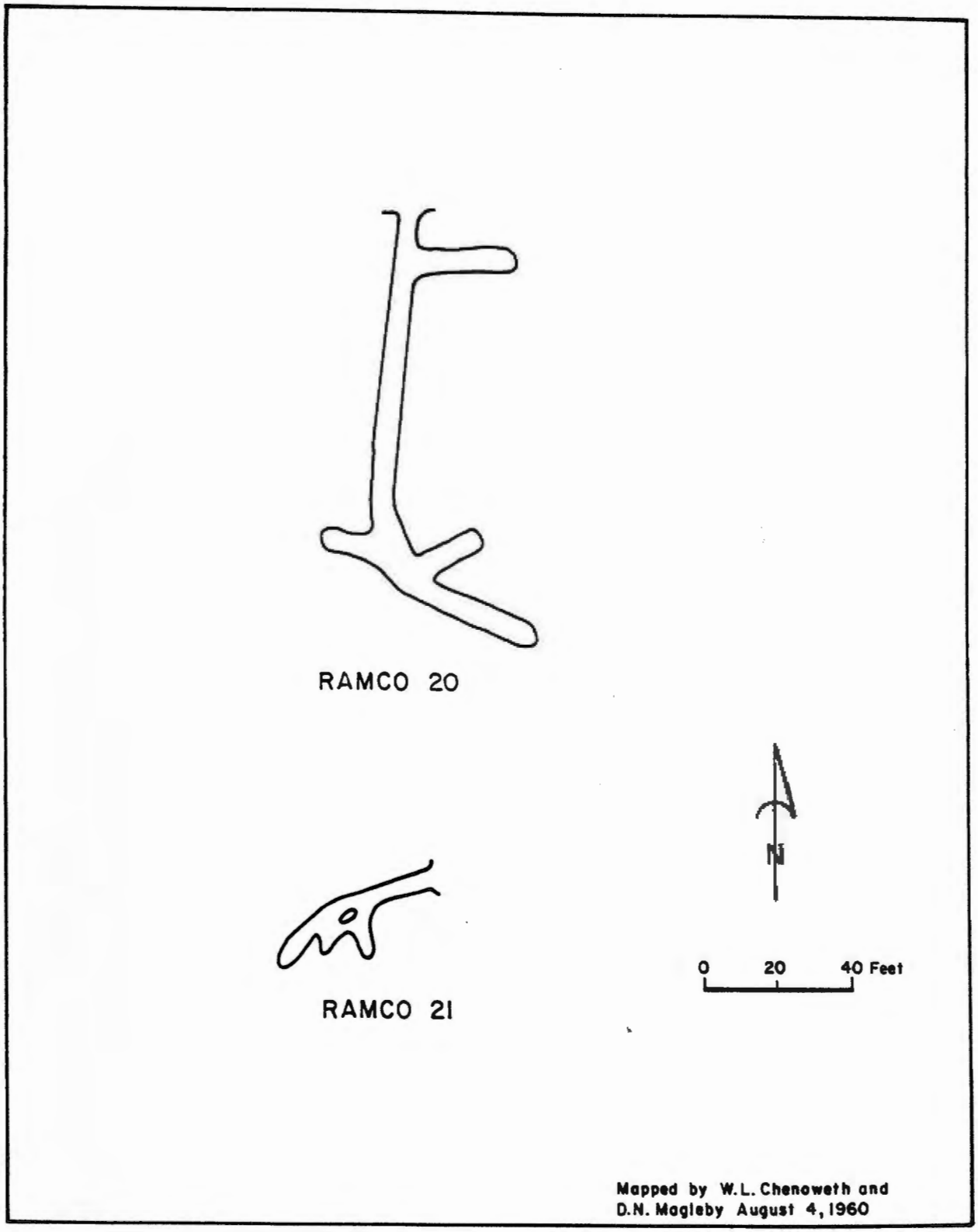
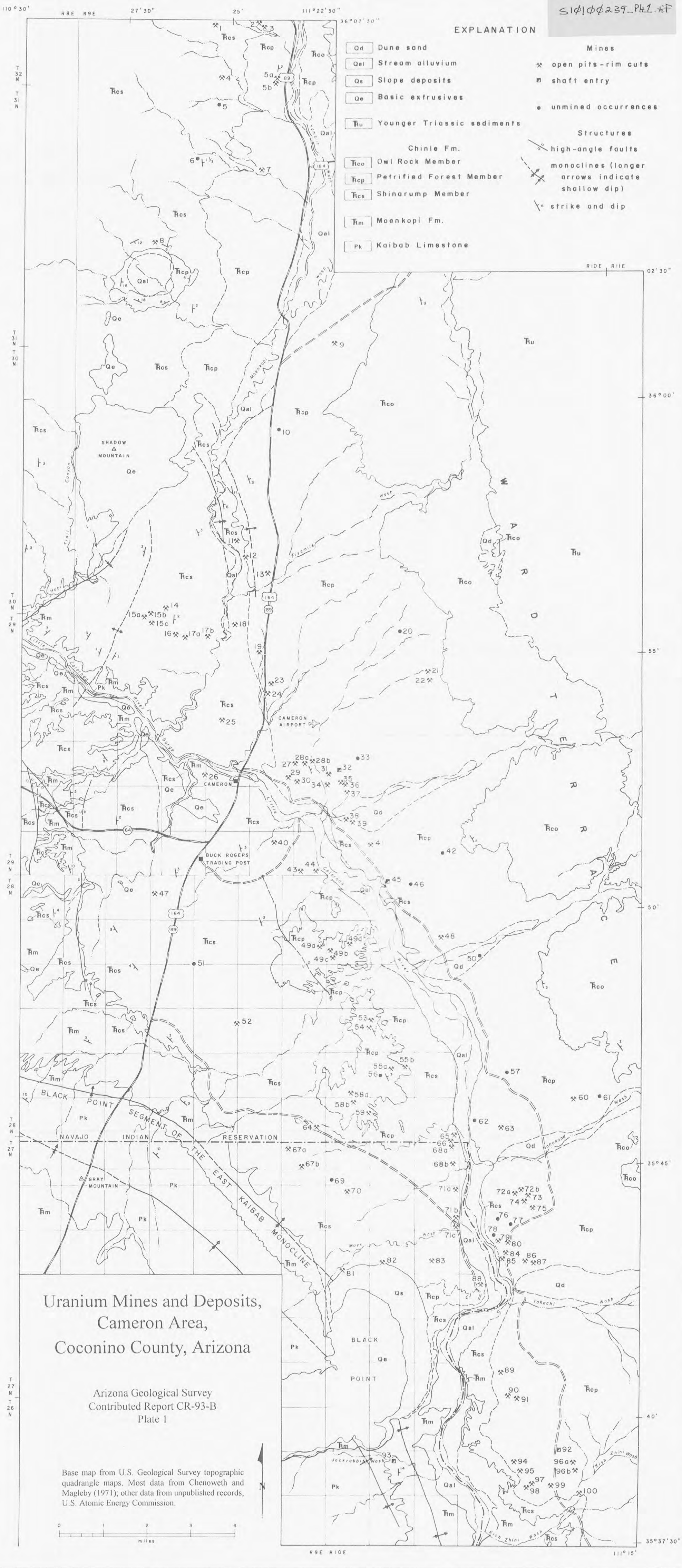


Figure 3. Maps of the underground mines, Ramco 20 and 21 mining permits, Cameron area, Coconino County, Arizona

INDEX	NAME
47	A & B No. 2
26	A & B No. 3
4	A & B No. 5
8	A & B No. 7
7	A & B No. 13
69	Ada and Nordell
34	Alyce Tolino No. 1 & 3
89	Amos Chee No. 8
51	Blackhair No. 4
59	Boyd Tisi No. 1
38	Boyd Tisi No. 2
18	Casey No. 3
29	Charles Huskon No. 1
49	Charles Huskon No. 3
97	Charles Huskon No. 4
9	Charles Huskon No. 5
11	Charles Huskon No. 6
53	Charles Huskon No. 7 (MP-65)
5	Charles Huskon No. 7 (MP-357)
58a, b	Charles Huskon No. 8
91	Charles Huskon No. 9
55a, b	Charles Huskon No. 10
66	Charles Huskon No. 11
25	Charles Huskon No. 12
43	Charles Huskon No. 14
84	Charles Huskon No. 17
99	Charles Huskon No. 18
23	Charles Huskon No. 19
22	Charles Huskon No. 20
65	Charles Huskon No. 26
1	Earl Huskon No. 1
3	Earl Huskon No. 3
32	Elwood Canyon No. 1
92	Elwood Thompson No. 1
94	Emmett Lee No. 1 and Julius Chee No. 3 & 4
100	Emmett Lee No. 3 and Julia Semallie
35	Evans Huskon No. 2
21	Evans Huskon No. 34
60	Evans Huskon No. 35
10	Foley No. 1
83	Grub No. 14
96a, b	Harry Walker No. 16 and Rameo No. 24
33	Harvey Begay No. 1
5a, b	Henry Sloan No. 1
70	Howard
24	Jack Daniels No. 1-5
50	Jack Huskon No. 1
48	Jack Huskon No. 3
86	Jackpot No. 1
87	Jackpot No. 5
78	Jackpot No. 6
76	Jackpot No. 7
77	Jackpot No. 8
85	Jackpot No. 40
13	Jeepster No. 1
46	Jefferson Canyon No. 1
39	Juan Horse No. 3
41	Juan Horse No. 4
100	Julia Semallie/Emmett Lee No. 3
95	Julius Chee No. 2
94	Julius Chee No. 3,4 and Emmett Lee No. 1
19	Kachina No. 6
12	Lemuel Littleman No. 1 & 7
28a, b	Lemuel Littleman No. 2
40	Lemuel Littleman No. 3
6	Lemuel Littleman No. 6
57	Lloyd House
82	Luster No. 1
45	Manuel Denetsone No. 2
27	Max Johnson No. 1
61	Max Johnson No. 4
90	Max Johnson No. 7
31	Max Johnson No. 9
30	Max Johnson No. 10
62	Mel Gardner
44	Montezuma No. 1
17a, b	Montezuma No. 2
16	Montezuma No. 7A
15a-c	Montezuma No. 7B
14	Montezuma No. 7C
88	Murphy mine (Black Point)
81	Navajo 26
68a, b	New Lina
42	Pat Lynch
52	Paul Huskie No. 1 & 2
98	Paul Huskie No. 3
20	Paul Huskie No. 4
52	Paul Huskie No. 20
2	Paul Huskie No. 21
74	Rameo No. 20
72a, b	Rameo No. 21
73	Rameo No. 22
96a, b	Rameo No. 24 and Harry Walker No. 16
93	Riverview
63	Ryan No. 1
75	Ryan No. 2
67a, b	Section No. 1
71a-c	Section No. 9
64	Taylor Reid No. 2
79	Yazzie No. 1
80	Yazzie No. 2
36	Yazzie No. 101
54	Yazzie No. 102
56	Yazzie No. 105
37	Yazzie No. 312



Uranium Mines and Deposits, Cameron Area, Coconino County, Arizona

Arizona Geological Survey
Contributed Report CR-93-B
Plate 1

Base map from U.S. Geological Survey topographic quadrangle maps. Most data from Chenoweth and Magleby (1971); other data from unpublished records, U.S. Atomic Energy Commission.

compiled by Peter Kreson, Arizona Bureau of Geology, August, 1980