

**THE GEOLOGY AND PRODUCTION  
HISTORY OF THE URANIUM DEPOSITS  
IN THE TOREVA FORMATION, BLACK  
MESA, APACHE COUNTY, ARIZONA**

by

William L. Chenoweth  
Consulting Geologist  
Grand Junction, Colorado

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

*Includes 1 Plate (Figure 2)*

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**INTRODUCTION**

Black Mesa, located in northeastern Arizona, is a southwest-dipping cuesta, nearly circular in plan, with a diameter of approximately 60 miles (Figure 1). The mesa is capped with sedimentary rocks of the Upper Cretaceous Mesaverde Group.

During the 1954 to 1968 period, 16,779.90 tons of ore grading 0.17%  $U_3O_8$  and containing 55,739.44 pounds uranium oxide ( $U_3O_8$ ) were produced from 13 properties in the Toreva Formation. With the exception of two properties near Yale Point, all production came from properties located on both sides of the upper drainage of Polacca Wash in Apache County, Arizona (Figure 2).

In the 1950's the Bureau of Indian Affairs established a day school near Ruin Mesa, using a group of trailers, this settlement was known as Tah Chee School. The mines in the drainage of Polacca Wash were accessible by unimproved dirt roads which commence in the vicinity of Tah Chee School. The two mines in the Yale Point area were accessible by roads built to them from the vicinity of Rough Rock Trading Post. Ore was mined by shallow open pits, rim cuts, and in four places by underground methods.

The area, in Apache County, is part of the Navajo Indian Reservation and is under the jurisdiction of the Bureau of Indian Affairs, U.S. Department of the Interior and the Navajo Tribal Council. All prospectors, Navajos and non-Navajos must have a prospecting permit. Once a discovery is made, only a Navajo can apply for a mining permit. The permit holder can assign his mining rights to a company or individual under Tribal regulations. Mining permits are good for two years, subject to renewal for an additional two years.

Non-Navajos can apply for a mining lease which have a ten year term. The maximum amount of land an individual Navajo or company can hold is 960 acres. Drilling and exploration permits, issued for 120 days, are not renewable.

Until the settlement of the Navajo-Hopi land dispute in the early 1980's, the area to the west of the mining area, in Navajo County, was part of the Navajo-Hopi Joint Use Area. The Joint Use Area was closed to all prospecting and mining. Now this area, west of the 110th meridian, is now part of the Navajo Indian Reservation.

The information presented in this report was obtained while the author was employed by the U.S. Atomic Energy Commission (AEC) on the Navajo Indian Reservation. Similar reports dealing with other uranium mining areas on the reservation are: Carrizo Mountains (Chenoweth, 1984; 1985a); Sanostee (Chenoweth, 1985b); Lukachukai Mountains (Chenoweth, 1988); and Rough Rock (Chenoweth, 1989).

Information on mining permits and leases was supplied to the AEC by Leo L. Denetsone of the Navajo Tribal Minerals Department, Window Rock, Arizona. Some new information recently reviewed in the AEC records, stored in the archives of the U.S. Department of Energy's Grand Junction Projects office, clarified some details of the mining activities during 1964 through 1967. Hence, the production statistics for Claims 7 and 10 are slightly different than those given by Scarborough (1981).

**GEOLOGIC SETTING**

Regional Stratigraphy

Rocks of the Mesaverde Group of Upper Cretaceous age occur on Black Mesa. Repenning and Page (1956) subdivided these rocks into three formations. The formations in ascending order are: Toreva Formation, Wepo Formation, and Yale Point Sandstone. They represent a complex intertonguing of marine and non-marine beds. Franczyk (1988) in her investigation of the Toreva Formation in the northeastern and eastern parts of Black Mesa (Figure 1), revised the stratigraphy of the Toreva and named two new units; the Rough Rock Sandstone and the Wind Rock Tongue of the Mancos Shale. The nomenclature changes and recorrelation of the Toreva Formation are shown in Figure 3.

All of the uranium deposits occur in the fluvial upper sandstone member of the Toreva, which consists of 25-120 feet of very coarse to fine-grained arkosic to subarkosic sandstone that grades upward into coal, carbonaceous shale, siltstone, and finer grained sandstone in the overlying carbonaceous member of the Wepo Formation. This ore-bearing unit has been called the main ledge of the Toreva (O'Sullivan and others, 1972), a name now abandoned (Franczyk, 1988).

### Local Stratigraphy and Depositional Environment

The following description of the upper sandstone member of the Toreva Formation is taken from Green and others (1982). The fluvial sandstone complex which is host for the uranium deposits of the area is generally a yellowish gray to grayish orange pink and very pale orange, fine- to very coarse grained, granule bearing and locally conglomeratic, subrounded to subangular, moderately well to poorly sorted, quartzose sandstone. The feldspar content increases upward through the unit (Repenning and Page, 1956; and Clinton, 1956). The average grain size is 0.43 mm (Repenning and Page, 1956) and the unit coarsens to the southwest where it is conglomeratic with chert and silicified limestone clasts as large as 7.5 cm. The sandstone is noncalcareous to slightly calcareous, locally burrowed and micaceous. Organic debris is common and locally abundant. The unit is dominantly trough crossbedded with moderate- to low-angle cross laminations in lenticular sets from 4 inches to 5 feet thick. Ripple-laminated beds are common at the top of crossbedded units and horizontally laminated and planar crossbedded units are less common.

Interbedded carbonaceous shales, fine-grained carbonaceous sandstones, and locally subbituminous-lignite coals occur as thin beds and increase in thickness upwards in the section. The mudstones are ripple laminated, burrowed and locally bioturbated. They contain abundant organic material and are typically dark brown and various shades of gray in color.

The entire host unit is an overall fining upwards sequence with internal fining-upward depositional units. A typical sequence is illustrated in Figure 4. These fining upward units have been interpreted as migrating point bar deposits with overlying partially abandoned and abandoned channel fill segments (Green and others, 1982).

The overall distribution of facies suggests a sediment source to the southwest with conglomeratic facies in the southwest fining to the northeast. This orientation is also in accord with northwest-southeast shoreline orientations. Scanty trough directional data (12 readings) from measured sections varied from N5°W to N45°E with an average of N25°E (Green and others, 1982). Crossbedding dip directions in individual mines were found to be quite variable (Clinton, 1956) and may reflect local flow directions on migrating the paludal rocks above, below and in the upper sandstone member suggest that this unit may have been a delta distributary system supplying sediments for the coastal barrier sandstones. These stream channels coalesced laterally and vertically to form an extensive sheet-like body of sand probably by processes of lateral accretion, evulsion and channel abandonment.

The fluvial sandstone complex is interpreted to be a meandering (and possibly distributary) stream system. most of the sandstones within the fluvial unit are interpreted as point bar sequences and the lesser amounts of fine-grained carbonaceous sandstones, carbonaceous shales, siltstones, and coal are interpreted as overbank, partially abandoned, and

abandoned channel-fill deposits (Green and others, 1982). In the area of the ore deposits, the upper sandstone member varies from 50 to 120 feet in thickness (Franczyk, 1988).

### Ore Deposits

The uranium-vanadium deposits occur in tabular and lenticular sandstone units in the uppermost part of the upper sandstone member of the Toreva Formation. Lenses of carbonaceous shale and siltstone are commonly interbedded with the sandstone in the ore-bearing zone. Some uranium occurs in the carbonaceous plant material, but most is disseminated in the sandstone. In general, the ore occurs immediately below carbonaceous beds. The deposits consist of pods of ore-grade material surrounded by lower grade material. Individual ore pods vary in size from a pod ten feet long, four feet wide or less, and one foot thick to a large tabular body 180 feet long, 60 feet wide and averaging three feet thick. Clusters of pods may occur to form an ore deposit within an area 400 by 100 feet having an average thickness of less than two feet.

The ore bodies are interpreted to occur in the uppermost fine-grained carbonaceous sandstone of abandoned and partially abandoned channel-fill deposits and in the upper fine-grained carbonaceous sandstones of point bar sequences in the upper sandstone member (Green and others, 1982).

All of the known deposits lie above the regional water table and are oxidized. E.B. Gross (in Clinton, 1956) identified tyuyamunite, metahewettite, melanovanadite, and vanadium clays as the ore minerals. Other minerals that have been identified include carnotite, metatyuyamunite, and rauvite (Table 1). The uranium to vanadium ratios for the ores are approximately 1:1.1. Production records for the initial 4,391.51 tons of ore shipped to the AEC ore-buying stations indicate an average vanadium content of 0.30%  $V_2O_5$  and an average uranium content of 0.27%  $U_3O_8$  (Tables 3 and 4).

At ore-buying stations, the AEC assayed for, and paid for vanadium in "carnotite type ores," in accordance with Domestic Uranium Program Circular 5, Revised. Since the Toreva ores were considered to be a "carnotite type" the ore from the Black Mesa area was assayed for vanadium ( $V_2O_5$ ).

## PRODUCTION HISTORY

### AEC Activities

Uranium-bearing outcrops in the vicinity of Taashdi Dzil (Ruin Mesa), in the upper drainage of Polacca Wash, were brought to the attention of AEC geologists in January, 1954 by Charlie James, a Navajo prospector. On the Bureau of Indian Affairs base map of the area, this drainage was referred to as Burnt Corn Wash, and that name is used in early AEC reports.

Since this discovery was in a new area of the Colorado Plateau, and in a formation that was previously unproductive, the AEC began a ground and aerial reconnaissance of the Toreva Formation in the eastern part of Black Mesa. This reconnaissance took place between mid-February to mid-November, 1954. Some 32 radioactive anomalies were located in Lohali Point - Yale Point area. Also, three anomalies were found in the upper drainages of Burnt Corn Wash (at that time called East and West Polacca Washes) and two anomalies were indicated along Oraibi Wash, north of Pinon, Arizona. These initial AEC investigations have been summarized by Clinton (1956).

The AEC returned to the area during the summer of 1955. During the period of May through November, a road was built up onto Dry Run Mesa and Clinton's mineralized outcrops 14, 16, and 33 were cleaned off using a bulldozer. The stripped areas were mapped and

sampled by Meador (1956). Meador also mapped and sampled the newly developed Etsitty No. 1 and Frank Todecheenie No. 1 mines. Although several of the anomalies were caused by radioactive bearing mineral accumulations (Murphy, 1956) many of the anomalies developed into mines and prospects (Table 2).

### Early Prospecting and Mining

The discovery of uranium near Ruin Mesa created a surge of prospecting activity on Black Mesa from Lohali Point to Yale Point. The first Navajo Tribal Mining Permit (MP) to be issued in the area was number 102 granted to Tacheene Etsitty on April 13, 1954. This permit was assigned to M.F. Sayan, Golden Nelson and G.V. Galbraith of Van Nuys, California, effective April 14, 1954. Sayan and others, operating as Tri-State Mining Co., did 400 feet of wagon drilling behind the mineralized outcrop and developed a small orebody. An initial ore shipment from a rim cut on the Etsitty No. 1 property was made to the AEC ore-buying station at Bluewater, New Mexico in May.

MP-151 was issued to George Belinte on July 31, 1954 to cover mineralized outcrops in the upper drainage of Burnt Corn Wash. This permit was assigned to Menapace and Marra of Gallup, New Mexico, effective August 6, 1954. Menapace and Marra did some 5,000 feet of non-core drilling and then abandoned the project for lack of ore. Parcel 1 of Belinte's mining permit was found to be located in Navajo County, in the Navajo-Hopi Joint Use Area, which was closed to prospecting and mining. Their assignment was cancelled July 20, 1955.

On July 26, 1954, MP-152 was issued to J. Cabone for a discovery northwest of Yale Point and MP-228 was issued to Dan Taylor on December 14, 1954 for two discoveries east of Yale Point. All production in 1954 came from the Etsitty No. 1 mine. It consisted of 71.07 tons of ore that averaged 0.16%  $U_3O_8$  and 0.39%  $V_2O_5$  (Tables 3 and 4).

During September 1954, Duke and Palmer drove a 24-foot adit on Edward Steve's MP-137 to explore Clinton's mineralized outcrop no. 24. Ray Starr did some drilling on the permit in July 1955. In the fall of 1955, a Mr. Golden reported to the Navajo Tribal Minerals Department that he had shipped two loads of ore from the property. This report must have been in error, as the AEC has no record of this shipment.

Due to confusion resulting from the applications from individual Navajos for mining permits for overlapping claims and the uncertainty of which companies and individuals were dealing with Navajos for the assignment of mining permits, the Navajo Tribal Council closed the area in the vicinity of Tah Chee School to all prospecting and mining. The Tribal Minerals Department established four Mineral Monuments in the area (Figure 5) and then proceeded to survey all the applications of mining permits. This was done to establish their correct location and relationship to each other.

On February 8, 1955, MP's 274, 275, 276, and 277 were issued to Kasewood Bahe Nez, Sam Charley, Frank Todecheenie, and Thomas Begay respectively to cover mineralized outcrops these individuals had located along the upper drainage of Sagebrush Canyon. The four permits were contiguous and their size and location were based on a compromise reached by the Tribal Minerals Department. The assignment of these four permits to Klaner and Associates was approved April 20, 1955. This partnership was composed of Joseph F. Klaner, Pittsburgh, Kansas; John E. Reynolds, Joplin, Missouri; and Paul E. Bradley, Joplin, Missouri. A shallow open pit was stripped on Frank Todecheenie's permit and in September a 19.79 ton shipment averaging 0.31%  $U_3O_8$  and 0.31%  $V_2O_5$  was made to the AEC ore-buying station at Bluewater, New Mexico. Additional shipments in 1955 would be to the AEC ore-buying station at Shiprock, New Mexico. In December 1955, an initial shipment of 12.23 tons averaging 0.35%  $U_3O_8$  and 0.59%  $V_2O_5$  was made from the Kasewood Bahe No. 1 mine on the south side of Sagebrush Canyon (Figure 2).

Also in 1955, the initial, and only shipments would be made by the Magor Mining Company from Homer Scott's Arrowhead No. 2 property (MP-165), and by the Glen Ray Rock

Company from Jim Lee Smiley's property (MP-168), called the Black Mountain Vase. Both properties were on the rim of Black Mesa north of Alkali Water Gap (Figure 2). No information concerning these two mining permits could be located. Although records at the ore-buying station listed Magor's shipment as Arrowhead No. 1, field investigations by the author indicated it came from parcel no. 2 of MP-165.

Dan Taylor's MP-228, near Yale Point, was assigned to La Glorieta Oil & Gas Co., in early 1955. After some road building and drilling, production from the Dan Taylor No. 1 mine commenced in July 1955 and continued through December 1955. After producing 289.84 tons of ore that averaged 0.15%  $U_3O_8$  and 0.31%  $V_2O_5$  in 1955 the underground mine was abandoned. La Gloria also drilled behind the mineralized exposure on the No. 4 parcel of Dan Taylor's mining permit, but did not locate any ore. La Gloria cancelled their assignment on December 14, 1956.

J. Cabone's MP-151 west of Yale Point was assigned to Gilbralter Uranium Co. and Falcon Uranium Co., on October 25, 1955. This joint venture began building a road from near Rough Rock Trading Post up the side of Black Mesa to the property.

During 1955 production continued at the Etsitty No. 1 mine, now an underground operation. Small shipments were made to Shiprock in the spring and fall. Production during 1955, from all six active mines totalled 597.71 tons of ore which averaged 0.21%  $U_3O_8$  and 0.32%  $V_2O_5$  (Tables 3 and 4).

The AEC opened an ore-buying station near Tuba City, Arizona on February 1, 1956. The distance by road from Tah Chee School to the station was 135 miles, but it was a much easier route than the road across the Lukachukai Mountains to Shiprock.

By the spring of 1956 the final shipments had been made from the Etsitty No. 1 mine and the property was abandoned. Sayan and others cancelled their assignment on April 14, 1957.

Shipments by Gibraltar and Falcon from MP-151, called the Rough Rock Slope No. 9 mine, commenced in May 1956. By fall, a total of 67.20 tons of ore averaging 0.25%  $U_3O_8$  and 0.93%  $V_2O_5$  had been produced from a small adit.

Shipments from the Frank Todecheenie No. 1 mine ceased by late summer, 1956. At the same time a small, and final shipment was made from the Kasewood Bahe No. 1 mine. An initial, and only shipment was made from the adjacent Thomas Begay No. 1 property. The properties were abandoned in the fall of 1956 as all of the economic ore had been mined. Klaner and Associates cancelled their assignments of three mining permits on February 8, 1957. The assignment of the fourth, Thomas Begay No. 1, was cancelled on April 20, 1957.

Total production by individual properties is given in Table 5. Production from the five active properties in 1956 totalled 1,233.08 tons of ore which averaged 0.23%  $U_3O_8$  and 0.33%  $V_2O_5$  (Tables 3 and 4).

#### The Lease Sale

In May 1956, the Navajo Tribal Minerals Department issued a map of the area that had been withdrawn from prospecting. The area was subdivided into four tracts with the individual claims shown in each tract (Figure 5). The Tribe planned to hold a lease sale, with leases to be granted to the highest bidder. When the sealed bids were opened on May 31, 1956, the bids were as follows: Tract 1, Uranium Industries, Inc., Grand Junction, Colorado, \$2,700.00; Tract 2, Harry E. Frank, Boston, Massachusetts, \$2,910.00; Tract 3, F.J. Flick, Portsmouth, Ohio, \$200.00; and Tract 4, no bids. The Tribe rejected Mr. Flick's bid on Tract 3.

Uranium Industries interested the Ampet Corporation of Denver, Colorado in the area, and Ampet was issued a prospecting permit on July 13, 1956. After examining the area, Ampet was issued a drilling permit in the summer of 1957. Ampet drilled some 127 holes with a total footage of 6,000 feet on Claim 28 and discovered a significant orebody behind the

mineralized exposure on the rim (Table 2). Ampet selected four claims to be leased from Tract 1, and three leases were issued on September 13, 1957. Lease no. 14-20-603-3183 covered Claims 27 and 29, lease 3184 covered Claim 28, and lease 3185 was for Claim 30. Each of the claims was about 45.4 acres in size (Figure 5).

While waiting for the lease to be finalized a small open pit was stripped and the initial shipment to Tuba City was made in September 1957. This initial shipment consisted of 24 tons of ore that averaged 0.12%  $U_3O_8$  and 0.12%  $V_2O_5$  and 0.06%  $CaCO_3$ . Sustained production continued through December. Total production in 1957 was 1,551.21 tons which averaged 0.30%  $U_3O_8$  and 0.30%  $V_2O_5$ .

Production by Ampet from the open pit on Claim 28 continued until September 1958, when the mining ceased. Production by Ampet totalled 2,833.73 tons of ore with an average grade of 0.26%  $U_3O_8$  and 0.27%  $V_2O_5$ . Ampet cancelled lease 14-20-603-3185 on September 13, 1958 and leases 3183 and 3184 on July 29, 1959.

The AEC ore-buying station at Tuba City was closed in mid-1958. At that time, the mill operator, Rare Metals Corporation of America, sampled and purchased independent ore for the AEC. Rare Metals did not sample for, or pay for vanadium.

Mr. Frank, d.b.a. Richland Uranium Corporation, selected four claims to be leased from Tract 2. Richland Uranium Corp. was issued lease no. 14-20-603-4399 for Claim 31, no. 4400 for Claim 35, no. 4401 for Claim 36, and no. 4402 for Claim 38. All four leases were approved on June 10, 1958. In late June 1958, Richland made a 14.69 ton shipment to Tuba City. This shipment identified as Claim 31, averaged 0.08%  $U_3O_8$ . Since the grade of the shipment was below 0.10%  $U_3O_8$ , the AEC did not pay for the material.

Claim 31 covered Clinton's mineralized outcrop no. 1 on the southeast rim of Ruin Mesa. Field investigations by the author indicated that this exposure was never mined. The source of the shipment was found to be a small mineralized outcrop, northwest of Ruin Mesa actually covered by Claim 35 (Figures 2 and 5). Richland cancelled their leases on July 10, 1958, a few days after learning the results of their shipment.

### Later Exploration and Mining

Early in 1959, Claude E. McLean and Son was granted a drilling permit covering the 1,054 acres of Tract 4 (Figure 5). During April, several holes were drilled on Claims 3 and 7. The drilling was apparently successful as McLean applied to the Tribal Council for a lease in January, 1960. This application was never approved.

On July 19, 1961 Tachine Yazzie and Etsiddy Bitsie were granted MP-556 covering Claim 27. On this same date, Yazzie, Bitsie, and Charles James were granted MP-557 covering Claim 28. Both of these claims were the same ground formerly leased by Ampet in Tract 1 (Figure 5). The assignment of both these permits to the LaSalle Mining Co. of Grand Junction, Colorado was approved by the Bureau of Indian Affairs on August 17, 1961. The extent of LaSalle's activities is not known but the assignment of both permits was cancelled on July 19, 1962.

Texas-Zinc Minerals Corp. (TZM), Grand Junction, Colorado was granted a drilling permit covering a large area of the former lease sale in the fall of 1961. During September-November 1961, TZM did some 30,000 feet of exploration drilling in the area. Some holes were drilled near the Frank Todecheenie No. 1 mine and few holes were drilled to the west up Tah Chee Wash, but the majority of the drilling was done in the vicinity of the old claims (1-14) in Tract 4 (Figure 5). This area was drilled on a grid using northwest-trending fences, 1,000 feet apart. On a fence, holes were spaced 500 feet apart. According to Louis Tauber, TZM geologist (personal comm., November, 1961) some 250,000 tons of material averaging 0.05%  $U_3O_8$  were located in the area of Claim 7.

On January 12, 1962, Bahe Burbank was granted MP-564 for Claim 6, Homer Scott was granted MP-565 and MP-566 for Claims 7 and 10. All of these claims were the same ground

described in Tract 4 of the 1956 lease sale (Figure 5). The assignment of all three claims was approved to TZM on April 18, 1962. After further drilling and evaluation, TZM cancelled their assignments on February 4, 1963. Exploration by TZM located some 600,000 tons of material averaging 0.079%  $U_3O_8$  at an average depth of 130 feet, and with an average thickness of 5.2 feet (Louis Tauber, personal comm., December, 1989).

After studying the TZM data, Joseph I. Costanza of Moab, Utah, d.b.a. Pioneer Drilling Co., became interested in the ore production possibilities on Tract 4. On February 5, 1964 he received the assignment of MP-565 for Claim 7, and on June 10, 1964, the assignment of MP-566 for Claim 10. Using Grant Shumway of Blanding, Utah as a mining contractor, shipments from Claim 7 began in July, 1964. The ore was shipped to the mill at Mexican Hat, Utah operated by A-Z Minerals, an Atlas Corporation subsidiary. During 1964, some 2,299.51 tons of ore averaging 0.14%  $U_3O_8$  were shipped from Claim 7. Shipments from Claim 10 began in early 1965 with the ore shipped to the Atlas mill at Moab, Utah after the Mexican Hat plant closed in February 1965. Production from Claim 10 in 1965 was 2,357.84 tons averaging 0.16%  $U_3O_8$ .

On July 2, 1963, Herman Tsosie was granted MP-593 for Claim 4, and Denny Lee received MP-594 for Claim 3. The assignment of these two mining permits to Joseph I. Costanza was approved on January 21, 1965. During the summer of 1965, Grant Shumway drilled out an orebody on Claim 3. Mining from a shallow open pit began in the summer of 1966 with the ore being shipped to the United Nuclear-Homestake Partners (UNHP) mill near Grants, New Mexico. During 1966, Gilbert Shumway took over the exploration and mining from Grant Shumway, and in June 1966 Wendell Jones became a partner in the operation with Gilbert. Mining continued during 1966 from the shallow open pits on Claims 7 and 10. Adits were driven off the pit walls to reach orebodies outside the limits of the pits (Figure 6). The ore from Claim 10 was shipped to the UNHP mill with the shipper being listed as Joseph I. Costanza. Claim 10 was mined out during the summer of 1966 and no shipments were made from Claim 7 in 1966.

On June 6, 1966 a new mining permit, MP-613 was issued for Claim 28 and on September 6, 1966, MP-615 was issued for Claim 27. Joseph I. Costanza received the assignment of these permits on July 26, and October 14, 1966, respectively. Clean-up mining at the old Ampet open pit on Claim 28 commenced in November 1966, and in December a 2.00 ton shipment averaging 0.19%  $U_3O_8$  was shipped to UNHP. Total production from Claims 3, 10, and 28, during 1966 was 2,572.38 tons of ore with an average grade of 0.12%  $U_3O_8$ . The shipper for the ore from Claims 3 and 28 was listed as Pioneer Drilling Co.

Gilbert Shumway and Wendell Jones continued to mine on Claims 3, 7, and 28 during 1967. Claim 3 was mined out and abandoned in early 1967. The economic ore on Claim 7 was depleted by the fall and the final shipment from Claim 28 was made in January 1968. Ore from all three claims was shipped to the UNHP mill with the shipper listed as Pioneer Drilling Co. Total production in 1967 was 4,661.12 tons of ore which averaged 0.12%  $U_3O_8$ . The 1968 production from Claim 28 was 138.59 tons with an average grade of 0.14%  $U_3O_8$ .

## SUMMARY

During the period 1954 through 1968, thirteen properties, in the Upper Cretaceous Toreva Formation in the eastern part of Black Mesa, produced 16,779.70 tons of ore averaging 0.17%  $U_3O_8$  and containing 55,739.44 pounds  $U_3O_8$ . Black Mesa is the only area in the United States with significant uranium production from rocks of the Mesaverde Group. This area and the Gallup-Grants, New Mexico area are the only areas in the United States with significant uranium production from sedimentary rocks of Late Cretaceous age.

Past exploration of the Toreva Formation has been very spotty. The potential for additional discoveries is excellent, especially in the adjacent parts of Navajo County, and in the area northwest of the existing mines. However, due to the low grade of the known

deposits, the price of uranium will need to be much higher than it is today (January, 1990) for exploration to be warranted.

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TABLE 1

AEC Petrographic Reports with Mineral Identifications,  
Toreva Formation, Apache County, Arizona

<u>Date</u>	<u>Petrographer</u>	<u>Property</u>	<u>Minerals</u>
8/17/54	E.B. Gross	-----	Tyuyamunite
8/18/54	E.B. Gross	Etsitty No. 1	Metaheiwettite
2/02/56	S.R. Austin	Mineralized Otc No. 14	Carnotite, metaheiwettite
2/13/56	E.B. Gross	F. Todecheenie No. 1	rauvite, metaheiwettite
5/04/56	E.B. Gross	Etsitty No. 1	Metatyuyamunite, metaheiwettite
5/04/56	E.B. Gross	K. Bahe No. 1	Metatyuyamunite, metaheiwettite

All of these petrographic reports are available for inspection at the Arizona Geological Survey.

TABLE 2

Mineralized Outcrops that were Developed  
into Mines and Important Prospects

<u>Mineralized Outcrop Number</u> <sup>1</sup>	<u>Mine or Prospect</u>
2	Claim 28
5	Etsitty 1
14	Claim 16
16	Claim 3
18	K. Bahe 1, T. Begay 1
19	F. Todacheenie 1
20, 21	J.L. Smiley
24	Edward Steve
25, 26	George Belinte 2
27	George Belinte 1 <sup>2</sup>
32	Dan Taylor 1
33	Claims 7 & 10
35	Dan Taylor 4
Not located	Arrowhead 2
Not located	Claim 35
Not located	Rough Rock Slope 9
Not located	George Belinte 3

<sup>1</sup>From Clinton (1956).

<sup>2</sup>In Navajo County, not shown on Figure 2.

TABLE 3

Annual Uranium Production, Black Mountain-Yale Point area,  
Apache County, Arizona

<u>Year</u>	<u>Tons of Ore</u>	<u>Pounds U<sub>3</sub>O<sub>8</sub></u>	<u>% U<sub>3</sub>O<sub>8</sub></u>	<u>Producing Mines</u>
1954	71.072	26.96	0.16	Etsitty 1
1955	597.71	2,502.12	0.21	Arrowhead 2, K. Bahe 1, Etsitty 1, J. Smiley, D.Taylor 1, F. Todecheenie 1
1956	1,233.08	5,378.85	0.23	K. Bahe 1, T. Begay 1, Etsitty 1, Rough Rock Slope 9, F. Todecheenie 1
1957	1,551.21	9,271.78	0.30	Claim 28
1958	1,297.21	5,346.63	0.27	Claim 28, Claim 31
1964	2,299.51	6,237.66	0.14	Claim 7
1965	2,357.84	7,467.84	0.16	Claim 10
1966	2,572.38	7,853.44	0.12	Claim 3, Claim 10, Claim 28
1967	4,661.12	11,055.03	0.12	Claim 3, Claim 7, Claim 28
1968	<u>138.59</u>	<u>399.13</u>	<u>0.14</u>	Claim 28
TOTALS	16,779.70	55,739.44	0.17	

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

TABLE 4

Vanadium Associated with Uranium ores, Black Mountain-Yale Point area,  
Apache County, Arizona

<u>Year</u>	<u>Tons of Ore</u>	<u>Pounds V<sub>2</sub>O<sub>5</sub></u>	<u>% V<sub>2</sub>O<sub>5</sub></u>	<u>Producing Mines</u>
1954	71.07	554.21	0.34	Etsitty 1
1955	597.71	3,781.66	0.32	Arrowhead 2, K. Bahe 1, Etsitty 1, J. Smiley 1, D. Taylor 1, F. Todecheenie 1
1956	1,233.08	8,223.41	0.33	K. Bahe 1, T. Begay 1, Etsitty 1, Rough Rock Slope 9, F. Todecheenie 1
1957	1,551.21	9,272.00	0.30	Claim 28
1958	<u>938.44</u>	<u>4,128.06</u>	<u>0.22</u>	Claim 28
TOTALS	4,391.51	25,959.34	0.30	

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

Table 5. Uranium-Vanadium Production, by Mine, Black Mountain-Yale Point area, Apache County, Arizona

NAME	OPERATOR	TONS OF ORE	POUNDS U3O8	% U3O8	POUNDS V2O5	% V2O5
Arrowhead No. 2	1955 -- Magor Mining Co.	5.89	16.47	0.14	12.94	0.11
Kasewood Bahe No. 1	1955-56 -- Klaner & Associates	25.61	232.73	0.45	288.27	0.56
Thomas Begay No. 1	1956 -- Klaner & Associates	11.86	111.45	0.47	74.00	0.31
Claim 3 (Denny Lee No. 3)	1966-67 -- Pioneer Drilling Co.	745.20	2,214.30	0.15	NA	NA
Claim 7 (Homer Scott No. 7)	1964 -- Joseph Costanza 1967 -- Pioneer Drilling Co.	5,613.55	14,593.87	0.13	NA	NA
Claim 10 (Homer Scott No. 10)	1965-66 -- Joseph Costanza	4,323.30	13,472.47	0.16	NA	NA
Claim 28	1957-58 -- Ampet Corp. 1966-68 -- Pioneer Drilling Co.	4,181.08	17,327.37	0.21	13,400.06	0.27
Claim 31	1958 -- Richland Uranium Corp.	14.69	23.50	0.08	NA	NA
Etsitty No. 1	1954-56 -- Sayan, Nelson, & Galbraith	128.78	459.69	0.18	1,573.36	0.61
Rough Rock Slope No. 9	1956 -- Gibraltar U Co. & Falcon U Co.	67.20	336.33	0.25	1,255.00	0.93
Jim Smiley (Black Mountain Vase)	1955 -- Glen Ray Rock Co.	11.18	26.83	0.12	17.88	0.08
Dan Taylor No. 1	1955 -- La Gloria Oil & Gas Co.	289.84	798.81	0.14	1,792.62	0.31
Frank Todecheenie No. 1	1955-56 -- Klaner & Associates	1,361.52	6,125.62	0.22	7,545.24	0.28
TOTALS		16,779.70	55,739.44	0.17	25,959.34	0.30

NA = No Analysis. Parens indicate mine synonyms.

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