Abstract

The Dakota Sandstone of Late Cretaceous age contains significant uranium deposits in the Gallup–Grants area of McKinley County, New Mexico. U.S. Atomic Energy Commission (AEC) records indicate that, during the period 1952–1970, eleven properties produced 117,815 tons of ore that averaged 0.21% uranium oxide and contained 501,169 pounds of uranium oxide. In addition to the uranium, these ores contained 115,296 pounds of vanadium oxide, which was also purchased by the AEC and/or private companies. Orebodies in the Dakota are found most commonly in carbonaceous, distributary-channel sandstones in the basal part of the formation where the underlying Brushy Basin Member is thin or has been removed by pre-Dakota erosion. A few deposits occur in areas of Tertiary faulting. Uranium-bearing solutions probably entered the Dakota from the uranium-rich Westwater Canyon Member of the Morrison Formation.

Introduction

The southern San Juan Basin of New Mexico is well known for its large resources of uranium that occur in sandstone beds of the Morrison Formation of Late Jurassic age. The Gallup–Grants area of the basin also contains uranium deposits in the Dakota Sandstone of Late Cretaceous age (Fig. 1).

The purpose of this report is to present the most accurate information available concerning ore production from deposits in the Dakota Sandstone and to summarize their geologic setting. Examination of available data indicates that, during the period 1952–1970, eleven properties produced 117,815 tons of ore averaging 0.21% U₂O₅ and containing 501,169 pounds U₂O₅. The oxidized ores in the Dakota Sandstone contained enough vanadium to be of economic importance. A total of 61,602 tons of the uranium ore was analyzed for V₂O₅. These ores contained 115,296 pounds of V₂O₅. Individual shipments ranged from 0.02 to 0.39% V₂O₅, but overall the shipments averaged only 0.09% V₂O₅. Most of the vanadium was purchased by the U.S. Atomic Energy Commission (AEC) under the Domestic Uranium Program Circular 5, Revised. Some vanadium was also purchased by Kerr-McGee Oil Industries, Inc. and the Vanadium Corporation of America.

Because this report deals mainly with historical production data, the reader is referred to reports by Chico (1959), Gabelman (1956), Mirsky (1953), Reimer (1969), and the U.S. Atomic Energy Commission (1959) for details on the geology and ore occurrence. Pierson and Green (1980) have summarized depositional environments of Dakota host rocks, ore controls, and concepts on the source of uranium in the Dakota Sandstone.

FIGURE 1—Index map of the Gallup–Grants area, New Mexico showing areas where uranium mines and deposits are found in the Dakota Sandstone (stippled); 1, Diamond No. 2 and Eunice Becenti mines; 2, Hogback No. 4 mine; 3, Delter prospect; 4, Churchrock mine; 5, U and Rats Nest mines on Christensen Mesa; 6, Silver Spur, Section 5, and Junior mines.

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Hilpert (1969, p. 89) noted that nine deposits in the Dakota Sandstone in northwestern New Mexico yielded about 110,000 tons of ore with an average grade of 0.22% U₃O₈ during the period 1952–62. Mclemore (1977, table 1, p. 260) stated that nine deposits in the Dakota Sandstone in the Grants mineral belt produced 246 tons U₃O₈ (492,000 pounds U₃O₈) during 1951–50. Mecklo (1983) reported 512,917 pounds U₃O₈ produced from the Dakota. The latter two figures were taken from a computer listing of uranium ore production that was generated by the Grand Junction office of the AEC, prior to an estimate of the production from the Dakota Sandstone at the Churchrock mine. At the Churchrock mine (Fig. 1) ore was produced from both the Dakota and Morrison Formations. Since this information has been published, more detailed information has been located in the AEC files and is presented here.

Database

Uranium production statistics were routinely compiled for the New Mexico Bureau of Mines and Mineral Resources while I was employed at the Grand Junction office of the U.S. Atomic Energy Commission (AEC) and succeeding agencies, the Energy Research and Development Administration (ERDA), and the Department of Energy (DOE). This report is an outgrowth of that project and summarizes briefly the uranium production from the Dakota Sandstone in the Gallup–Grants area.

A review of notes made by Ingles M. Gay, a mining engineer in the AEC’s Grants field office during the 1950’s and 1960’s, indicated the following discrepancies in the production records: 1) a 1952 shipment labeled Horse Mountain did not come from the Horseback claims near Gallup (Fig. 1); and 2) a 1952 shipment credited to the Silver Spur mine near Prewitt (Fig. 1) actually came from a nearby mine in the Todilto Limestone Member of the Wanakah Formation. Gay’s records were also helpful in determining the time and amount of production from the Dakota at the Churchrock mine.

Records of the AEC ore-buying station at Bluewater indicated the actual amount of production from the Junior mine in the Dakota. In the computer listing this Dakota production is included in production from the Pat mine (in the Morrison Formation) in the same quarter section. Details of these corrections are discussed in the individual mine descriptions.

As the result of this current study, the production from the Dakota Sandstone in the Gallup–Grants area is believed to be 501,169 pounds U₃O₈. The change comes from a review of information on the Churchrock mine.

Stratigraphy and depositional environments of the Dakota Sandstone

In west-central New Mexico, the informal name “main body of the Dakota Sandstone” has been applied to that part of the formation occurring below the Whitewater Arroyo Tongue of the Manos Shale (Landis et al., 1973).

It is within this unit that the uranium deposits of the Gallup–Grants area occur. The main body of the Dakota Sandstone in this area ranges in thickness from 70 to 180 ft and generally is separated into two parts. The lower part, which was probably deposited in a delta-plain environment, consists of interbeds of crossbedded, fine- to coarse-grained, or locally conglomeratic sandstone of the distributary channel and levee; silty, carbonaceous sandstone of the crevasse splay; sandy, carbonaceous siltstone of the well-drained sand; and clayey siltstone, lignite, and coal of the poorly drained swamp environment. The upper part consists of thick-bedded to massive, fine- to medium-grained, beach or barrier-island sandstone. The lower part usually constitutes from one-third to one-half, and the upper part from one-half to two-thirds of the total thickness of the main body (Pierson and Green, 1980).

Pre-Dakota erosion has produced an important unconformity at the base of the Dakota. In the Gallup area, all of the Brushy Basin Member and part of the Westwater Canyon Member of the Morrison Formation have been removed by pre-Dakota erosion. Thus, basal Dakota uranium host rocks lie in direct contact with uranium-bearing fluvial sandstone units of the underlying Westwater Canyon Member of the Morrison Formation.

Exploration

Soon after the discovery of economic uranium deposits in the Todilto Limestone near Haystack Butte (Fig. 1) in 1950 and in sandstones of the Morrison Formation in the nearby Poison Canyon area in 1951, surface and airborne prospecting spread westward toward Gallup.

Discoveries were made in the Dakota Sandstone in the Nutria monochine (Gallup Hogback) in early 1952 and in the Haystack Butte area at about the same time. Other discoveries were made the following year on Christensen Mesa, east of Gallup. By 1955 all known outcropping occurrences had been found and were being explored. Deposits in the subsurface in the Churchrock area were located in 1957 by extensive drilling programs in the Pinadel area (Fig. 1).

Marketing

In response to development of the uranium mines in the Shiprock and Grants areas of northwestern New Mexico, the AEC established ore-buying stations near those two settlements in early 1952. The station at Shiprock opened on January 17, 1952, and the one near Bluewater opened on June 8, 1952. These stations purchased ore under the terms of the Domestic Uranium Program Circular No. 5, Revised, which included payment for vanadium oxide in “carnotite type” ores. The minimum grade of ore purchased by the AEC was 0.10% U₃O₈. A third ore-buying station was established at Milan, New Mexico in July 1956 to provide a market for the ores being produced in the Ambrosia Lake area. The Bluewater station ceased to pay for vanadium after January 1, 1956, and the Milan station ceased payments for vanadium on July 1, 1957 because most of the ore from the Grants area had been determined not to be the “carnotite type.” However, the oxidized ores in the Dakota contained significant vanadium, so mine operators constantly changed their delivery point to the nearest station that paid for vanadium.

The Bluewater station closed in March 1958, Shiprock in June 1958, and Milan in September 1958. The AEC then sold stockpiled ore to nearby mills operated by private companies. Only the mill operated by Kerr–McGee Oil Industries, Inc. at Shiprock recovered vanadium. In 1963 this plant was acquired by the Vanadium Corporation of America.

After the AEC buying stations closed, mill operators were required to pay at least Circular 5, Revised prices, premiums, and allowances for purchased ores (Albrethsen and McGinley, 1982). This policy was in effect until March 31, 1962. After that date, mill operators were required to pay “reasonable” prices for purchased ores (Albrethsen and McGinley, 1982). In most cases the prices paid were less than Circular 5, Revised prices, but lower grade material, less than 0.10% U₃O₈ was accepted. Only the mill at Shiprock continued to pay for vanadium, and when it closed in May 1968, there was no longer a market in New Mexico for vanadiferous ores.
Production history

Production began in early 1952 and with the exception of 1962-63 continued until the summer of 1970 (Table 1). The following sections summarize the geologic setting of each mine or deposit as well as its production history. Table 2 on page 26 lists production by individual property, years in which the property was operated, and by whom.

Diamond No. 2 mine

The portal of the Diamond No. 2 mine is located in the N1/2NE1/4 sec. 33, T15N, R17W. This mine produced ore from three properties: 1) the Mike Smith lease, 2) the Largo Nos. 1 and 2 claims, and 3) the Naomi Becenti lease (Fig. 2). The mine is located on the Gallup Hogback where the beds strike N35°W and dip 28° southwestward in the Nutria monoclinal. The Diamond No. 2 mine is the largest mine in the Dakota Sandstone in New Mexico. Three major orebodies were mined, each approximately 100 ft wide, 250 ft long, and 4½ ft thick. Ore grades and thicknesses were erratic within each orebody but each was elongated roughly parallel to the strike of the beds. The uranium is hosted by medium- to coarse-grained, carbonaceous, distributary-channel sandstones in the base of the Dakota. This unit is about 18 ft thick and fills a scour in the Westwater Canyon Member of the Morrison Formation. The channel sandstones are overlain by a lenticular, lignitic, carbonaceous shale unit about 4 ft thick, which represents a poorly drained swamp environment. The ore-bearing sandstones contain numerous mudstone lenses and much carbonized vegetal debris. Ore minerals, including uraninite, possibly coffinite, metatuyumunite, probably turyumunite and carnotite, limonite, jarosite, and some marcasites are all associated with carbonaceous debris (Hippert, 1969). The ore is mostly oxidized above the 450-ft level (Chico, 1959).

Mike Smith lease and the Largo Nos. 1 and 2 claims—The property known as the Mike Smith lease is fee land in the N1/2NE1/4 sec. 33, T15N, R17W. The 80-acre tract was patented to Esda Alts-Issigi on June 5, 1911 as Patent No. 203103. This Navajo Indian claimed ownership to the land under the 1848 Treaty of Guadalupe Hidalgo, which specified that the United States was to respect the Spanish land grants in the territory the United States won from Mexico. The N1/2NE1/4 sec. 33 is public domain where the Largo Nos. 1-6 claims were staked. Ore production records of the AEC do not divide production between the two properties, so their production statistics are combined.

In late 1952, recorded in some AEC records as 1951, Albert Smith made a 12-ton shipment to the AEC ore-buying station at Bluewater. In August 1954, mining was started on two claims including the Mike Smith and the Largo Nos. 1 and 2 claims. During this time, the Mike Smith lease was operated by the Mike Smith, Sr., and his wife, Natanbah Cowboy and his wife, and Johanna Hashelstine and her husband. On March 3, 1953 these Navajos leased the N1/2NE1/4 sec. 33 to Adee Dodge Enterprises of Santa Fe, New Mexico.

A 28° decline bearing S45°W was started on the ore-bearing outcrop. This coincided with the dip of beds on this portion of the Gallup Hogback. The first ore was sold at the Bluewater ore-buying station in April 1953. Mining levels were established at depths of 13, 21, 35, 50, and 88 ft off the decline as additional ore was located by drilling down-dip from the outcrop. On July 15, 1953 Adee Dodge Enterprises became known as the General Uranium Mining Corporation. Mining continued until May 1954 when the Diamond No. 2 mine closed. During the year Dodge and General Uranium operated the mine, they produced 3,014 tons of ore that averaged 0.18% U3O8 and 0.10% V2O5. This ore was shipped to Bluewater.

During 1954, General Uranium Mining Corporation became the Largo Uranium Corporation with headquarters in Albuquerque, New Mexico. Largo Uranium staked the Largo Nos. 1-6 claims in the N1/2NW1/4 sec. 33. Largo Uranium, including the Diamond No. 2 mine, was acquired by Four Corners Uranium Corporation of Denver, Colorado in May 1955. Four Corners began operating the Diamond No. 2 mine under the name of Largo Uranium Corporation, which was a subsidiary. One of the first activities of the new operator was to deepen the decline. In August it was at the 400-ft depth with mining levels cut at 200 and 300 ft. Monthly production was about 200 tons. The marketing point was changed in November 1955 from Bluewater to the AEC ore-buying station at Shiprock. In April 1956, the decline was at a depth of 485 ft with mining levels at 400 and 450 ft. Production was about 1,000 tons per month averaging 0.21% U3O8 with most of the ore coming from the Largo No. 1 claim (Fig. 2).

Exploratory drilling located the north orebody in early 1956. The decline was deepened to the 500-ft level, and a haulage drift was started on the 500-ft level to reach the north orebody. In August 1956, the delivery point was changed once again from Shiprock to the AEC ore-buying station at Milan (Fig. 1). By February 1957, the drift on the 500-ft level was out 1,100 ft to the northwest, and mining commenced in the part of the north orebody on the Largo Nos. 1 and 2 claims (Fig. 2). In May 1957, the drift was out 1,400 ft from the bottom of the decline and production was at the rate of about 1,500 tons per month with a grade of 0.24% U3O8. Some of this ore was mined from the adjacent Naomi Becenti lease.

In November 1957, the delivery point was changed from Milan back to Shiprock in order to be paid for the vanadium. Because of insufficient economic-grade ore, the Diamond No. 2 mine was closed in March 1959. Production had been continuous since June 1955. Ore mined from the Mike Smith lease and the Largo Nos. 1 and 2 claims amounted to 37,365 tons averaging 0.22% U3O8 and 0.10% V2O5. During April, May, and June 1959 an underground longhole drilling project was conducted; no ore of any consequence was found so the mine was stripped of equipment and abandoned. The mine was dry, but considerable water was encountered below the 500-ft level (Chico, 1959).

On May 20, 1964, the A and B Mining Company of Moab, Utah leased the Mike Smith property and on July 10, 1964, they

![New Mexico Geology May 1989](image-url)
obtained a lease on the Largo claims from the Four Corners Oil and Minerals Corporation, previously known as Four Corners Uranium Corporation. All uranium produced after March 31, 1952 had been subject to the AEC's allocation system; allocations (market quotas) were based on ore reserves developed prior to November 14, 1958. A and B applied to the AEC and received allocations for the Mike Smith lease and Largo claims, and the Naomi Becenti lease. These allocations were 825 and 4,440 pounds U₃O₈ per year, respectively. The allocations were based on reserves located and developed by Largo Uranium, which A and B had demonstrated to the AEC remained on the properties. In August 1964, A and B began cleanup mining in the Mike Smith-Largo part of the mine. This phase continued until early 1967. A and B's production was 5,942 tons of ore that averaged 0.21% U₃O₈ and 0.09% V₂O₅. Most of this ore came from pillars between the 500- and 400-ft levels of the mine. All of A and B's production was shipped to the mill at

![Diagram of mine workings](image)

FIGURE 2—Map of the workings of the Diamond No. 2 mine, January 1959 (from Hilpert, 1969, with permission).
Shiprock, which was then operated by the Vanadium Corporation of America.

Shiprock Ltd. of Grand Junction, Colorado obtained a 50% interest in the Mike Smith lease and the Largo claims from A and B Mining Company on June 28, 1967. Shiprock Ltd. began some limited development mining and exploratory drilling to find ore below the 500-ft level. The exploration was not successful and only 484 tons of ore averaging 0.09% U₃O₈ were shipped from the Mike Smith-Largo portion of the mine in 1970. This ore was shipped to the Homestake-Sapin Partners mill near Ambrosia Lake. The Diamond No. 2 mine closed for the last time in the summer of 1970. Total production from the Smith-Largo part from 1952 through 1970 was 47,181 tons averaging 0.21% U₃O₈ and 0.09% V₂O₅ (Table 2).

Naomi Becenti lease—This lease is a Navaajo allotment located in the SW¼ sec. 28, T15N, R17W. This allotment was leased by Four Corners Uranium Corporation in late 1955. Drilling on this property by the Largo Uranium Corporation (a Four Corners subsidiary) in February 1956 located the north orebody of the Diamond No. 2 mine. The haulage drift on the 500-ft level of the mine reached the property in mid-1957, and mining commenced later that year. During 1957 through early 1959, Largo Uranium Corporation mined 6,829 tons of ore that averaged 0.26% U₃O₈ and 0.12% V₂O₅. The ore was originally shipped to the AEC ore-buying station at Milan but beginning in November 1958 was shipped to the station at Shiprock.

Four Corners Uranium Corporation subsequently became known as Four Corners Oil and Minerals Corporation. They apparently cancelled their lease on the Becenti allotment in the early 1960’s. After A and B Mining Company obtained a new lease in August 1964, they did some cleanup mining, such as pulling pillars from above the bottom level in 1964 and in 1966. Total production by A and B from the Becenti lease was 1,210 tons averaging 0.19% U₃O₈ and 0.15% V₂O₅. This ore was shipped to the Vanadium Corporation of America mill at Shiprock.

Shiprock Ltd. obtained a lease on the Becenti property on June 24, 1967 and did some cleanup mining in 1968 and 1969. Their production, shipped to the Homestake-Sapin Partners mill near Ambrosia Lake, was 497 tons of ore that averaged 0.12% U₃O₈. Total production from the Naomi Becenti lease from 1957 through 1969 was 8,536 tons of ore that averaged 0.25% U₃O₈ and 0.13% V₂O₅ (Table 2).

Eunice Becenti mine

The Eunice Becenti mine is located in the S½SW¼ sec. 28, T15N, R17W. The ore is in the same stratigraphic horizon as at Diamond No. 2 mine immediately to the southeast. Oxidized uranium minerals occur in the upper part of a 10-15-ft, fine- to medium-grained, crossbedded, carbonaceous, distributary-channel sandstone at the base of the Dakota Sandstone. This sandstone rests on the Westwater Canyon Member of the Morrison Formation. Overlying the host sandstone is a 4-ft bed of carbonaceous shale. The beds at the mine dip 31˚ westward in the Nutria monocline. Gruner et al. (1954) identified meta-autunite, metatyuyamunite, and uranophane from the mine. The deposit was mined from a small open pit with a short decline off the pit wall.

The NW¼ sec. 28 is a Navaajo allotment held by Eunice Becenti. Mining rights were assigned to A. W. Tucker, Tom Hyde, and E. D. Davenport on May 12, 1952 by Lease J-149-IND-9294 issued by the Bureau of Indian Affairs. The initial shipment from the property was delivered to the AEC ore-buying station at Shiprock on June 17, 1952. It consisted of 20 tons of ore averaging 0.26% U₃O₈ and 0.13% V₂O₅. In early 1953, the delivery point was changed to the AEC ore-buying station at Bluewater but was changed back to Shiprock in early 1954. With the exception of a 97-ton shipment made in late 1953 by Hagens, Fitzhugh, and Davenport, all shipments made between 1952 and 1954 were by Tucker, Hyde, and Davenport, the original lessors. Production in 1953 and 1958 by A. W. Tucker was shipped to the ore-buying station at Shiprock. Tucker’s 1959 production was shipped to the Homestake-New Mexico Partners mill near Ambrosia Lake. Total production from the Eunice Becenti property was 846 tons of ore averaging 0.20% U₃O₈ and 0.14% V₂O₅ (Table 2).

Hogback No. 4 mine

The Hogback No. 4 mine is located in the E½NE¼ sec. 12, T15N, R18W on the Gallup Hogback. Although early production came from claim no. 3 and some of the deeper production was from claim no. 5, most of the ore came from claim no. 4 and hence the name. Uranium at the Hogback property occurs in a 3-5-ft-thick black, fine-grained carbonaceous shale with carbonaceous plant remains. Locally it is nearly peaty. The environment of the host rock has been interpreted as being a well-drained swamp (Pierson and Green, 1980). Below the ore-bearing shale is about 35 ft of distributary-channel sandstone, which forms the crest line of the Gallup Hogback. At the Hogback property the beds dip 42˚ westward in the Nutria monocline.

The Hogback nos. 1-18 claims were located on March 14, 1952 by A. W. Tucker, A. W. Hyde, Tom Hyde, and E. D. Davenport. The initial mining was from an open pit on claim no. 3 on the west side of the Gallup Hogback. Production began in April 1952. After the profitable ore was depleted, the mine was shut in early 1954. By that time, Tucker, A. W. Hyde, and Davenport had mined 1,403 tons of ore that averaged 0.18% U₃O₈ and 0.03% V₂O₅. A few early shipments were made to the AEC ore-buying station at Shiprock, but most of the ore went to the station at Bluewater.

Exploratory drilling during 1955 discovered an extension downdip of the surface ore zone. A. W. Hyde, doing business as Hyde Uranium Company, sank an inclined shaft at the south end of the open pit; by October 1955, the shaft was 155 ft deep and a drift was started at the 150-ft level. After shipping 204 tons of ore that averaged 0.15% U₃O₈ and 0.03% V₂O₅, Hyde shut the mine in January 1956.

Calumet and Hecla, Inc. leased the property in April 1956 and did some exploratory drilling, which indicated additional ore at depth. In 1957, Calumet and Hecla contracted with Bob Mathis of Silver City, New Mexico who deepened the shaft to 285 ft and began a drift to mine the ore. In March 1958, Calumet and Hecla gave Mathis and his brother the lease on the property. The firm had been disappointed with the grade of ore that had been mined. At depth the ore was found to be out of equilibrium; material that would measure 0.17% equivalent U₃O₈ on a gamma-ray instrument would assay only 0.02% U₃O₈ in the laboratory (T. A. Boyden, pers. comm. 1989). Mathis had mined a total of 1,926 tons averaging 0.16% U₃O₈ and 0.03% V₂O₅ for Calumet and Hecla. After Mathis and his brother had mined 937 tons averaging 0.27% U₃O₈ and 0.03% V₂O₅, the Mathis brothers cancelled their lease in the summer of 1958. All the ore mined by Hyde, Calumet and Hecla, and Mathis and Mathis was shipped to the ore-buying station at Shiprock.

In March 1959, the See Tee Mining Company of Grants took over the property but dropped their lease several months later after shipping 1,419 tons of ore that averaged 0.19% U₃O₈.

Winsor Mining Company of Gallup reopened the mine in June 1960 but abandoned it in the fall after shipping 476 tons of ore averaging 0.19% U₃O₈. Both See Tee and Winsor marketed their ore to the Kermac Nuclear Fuels mill at Ambrosia Lake. Total production from the Hogback property was 6,365 tons of ore that averaged 0.19% U₃O₈ and 0.03% V₂O₅ (Table 2). Included in this total were 105 tons of “no pay ore” that averaged 0.05% U₃O₈. The AEC did not pay for material that contained less than 0.10% U₃O₈ shipments that assayed less than that were referred to as “no pay ore.”

As mentioned previously on page 23, Albert Smith, in late 1952, shipped 12 tons of ore averaging 0.10% U₃O₈ and 0.08% V₂O₅ to the ore-buying station at Bluewater. The source of the ore was identified as the Hogback Mountain property; therefore, the AEC computer listing of uranium production credited this shipment to the Hogback No. 4 mine. However, notes in the AEC files indicate the shipment came from surface exposures on the Mike Smith lease (Table 1).

Delter prospect

The Delter prospect is located in 5NW¼ of 4NW¼ sec. 36, T16N, R17W on White Rock Mesa. The NW¼ sec. 36 is a Navaajo allotment and the uranium occurrence is undeveloped. Here carnitite occurs in a sandy, carbonaceous shale about 10 ft above the base of the Dakota. The uranium-bearing unit is
part of the fill of a channel cut into the Westwater Canyon Member of the Morrison Formation. The channel is 200 ft wide, 30 ft deep, and trends N30°E into the mesa. The distributary-channel sediments are fine-grained to conglomeratic sandstones with interbedded, black, carbonaceous shales.

**U mine**

The property known as the U mine is located in the S½ sec. 4, T15N, R16W. The mines are located on the south rim of a Dakota-capped mesa locally called Christensen Mesa. In this area the basal part of the main body of the Dakota Sandstone is about 40 ft thick and is composed of distributary-channel sandstone lenses with interbedded, paludal, carbonaceous shale. Uranium mineralization at the U mine occurs in carbonaceous shale and lignite 15 to 20 ft above the base of the Dakota. The ore zone is about 3 to 5 ft thick. Tyuyamunite has been identified locally where uranium is concentrated (Hilpert, 1969). At Christensen Mesa the Dakota Sandstone rests on the Brushy Basin Member of the Morrison Formation, which is nearly all sandstone because of a facies change.

On April 22, 1953, George Christensen located the Christian 1–20 claims covering the S½ sec. 4. The claims were leased to Williams and Reynolds who began mining on the Christian 16 claim in the E½SW½ sec. 4 in late 1953. Mining continued until mid-1954 when Williams and Reynolds shut the mine. They shipped a total of 1,302 tons of ore av-

### TABLE 2—Uranium-vanadium production, by property, from the Dakota Sandstone, McKinley County, New Mexico.

<table>
<thead>
<tr>
<th>Property</th>
<th>Period of production</th>
<th>Operator</th>
<th>Ore production (tons)</th>
<th>UO₂ (pounds)</th>
<th>V₂O₅¹ (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mike Smith lease and Largo Nos. 1 and 2 claims¹</td>
<td>1952</td>
<td>Albert Smith</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1953</td>
<td>Adee Dodge Enterprises</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1953–54</td>
<td>General Uranium Mining Corp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1955–59</td>
<td>Largo Uranium Corp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1964–67</td>
<td>A and B Mining Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1970</td>
<td>Shiprock Ltd.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>47,181</td>
<td>0.21</td>
<td>202,440</td>
<td>0.09</td>
</tr>
<tr>
<td>N. Becenti lease²</td>
<td>1957–59</td>
<td>Largo Uranium Corp.</td>
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<td></td>
<td>1964, 1966</td>
<td>A and B Mining Co.</td>
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<td>1968–69</td>
<td>Shiprock Ltd.</td>
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</tr>
<tr>
<td></td>
<td>total</td>
<td>8,536</td>
<td>0.25</td>
<td>42,499</td>
<td>0.13</td>
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<td>E. Becenti mine (Section 28)</td>
<td>1952–54</td>
<td>Tucker, Hyde, Davenport</td>
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<tr>
<td></td>
<td>1953</td>
<td>Hagens, Fitzhugh, Davenport</td>
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</tr>
<tr>
<td></td>
<td>total</td>
<td>846</td>
<td>0.20</td>
<td>3,350</td>
<td>0.14</td>
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<td>Hogback No. 4 mine (Hogback Nos. 3–5)</td>
<td>1952–54</td>
<td>Tucker, Hyde, Davenport</td>
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<tr>
<td></td>
<td>1955–56</td>
<td>Hyde Uranium Co.</td>
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</tr>
<tr>
<td></td>
<td>1957–58</td>
<td>Calumet and Hecla Inc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1959</td>
<td>Mathis and Mathis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1960</td>
<td>See Tee Mining Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>6,365</td>
<td>0.19</td>
<td>24,289</td>
<td>0.03</td>
</tr>
<tr>
<td>U mine (Christian Nos. 1–20)</td>
<td>1953–54</td>
<td>Williams and Reynolds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1955</td>
<td>Frontier Uranium Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1957</td>
<td>George Christensen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1957</td>
<td>Rem Uranium Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1958</td>
<td>WCT Engineering Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>2,560</td>
<td>0.17</td>
<td>8,460</td>
<td>0.09</td>
</tr>
<tr>
<td>Rats Nest mine (Section 3) (Santa Fe Christensen)</td>
<td>1957</td>
<td>George Christensen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1957–58</td>
<td>Rem Uranium Co.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>332</td>
<td>0.28</td>
<td>1,850</td>
<td>0.11</td>
</tr>
<tr>
<td>Churchrock mine, 489-ft level</td>
<td>1960–61</td>
<td>Phillips Petroleum Corp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1961</td>
<td>Quinta Corp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>45,997</td>
<td>0.21</td>
<td>188,686</td>
<td>—</td>
</tr>
<tr>
<td>Silver Spur mines</td>
<td>1952</td>
<td>Charles Davis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1952–53</td>
<td>Silver Spur Mining Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1955–56</td>
<td>Holly Uranium Co.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1957–59</td>
<td>Febc Mines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1958</td>
<td>Holly Corp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1966</td>
<td>Farris Mines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>5,937</td>
<td>0.25</td>
<td>29,454</td>
<td>0.25</td>
</tr>
<tr>
<td>Section 5 mine</td>
<td>1958</td>
<td>Westvaco Minerals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>23</td>
<td>0.12</td>
<td>54</td>
<td>—</td>
</tr>
<tr>
<td>Junior mine</td>
<td>1953</td>
<td>Dakota Mining Co.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>38</td>
<td>0.11</td>
<td>87</td>
<td>0.16</td>
</tr>
<tr>
<td>TOTAL</td>
<td>117,815</td>
<td>0.21</td>
<td>501,169</td>
<td>0.09</td>
<td>115,296</td>
</tr>
</tbody>
</table>

¹Grade calculated on the actual amount of ore analyzed for vanadium oxide.
²Mined through the Diamond No. 2 decline on the Mike Smith Lease.
(Names in parenthesis are aliases.)
eraging 0.15% U₃O₈ and 0.08% V₂O₅ to the ore-buying station at Bluewater. Frontier Uranium Company leased the property in early 1955 and continued mining until Aug. 1955. Frontier shipped 544 tons of ore averaging 0.20% U₃O₈ and 0.09% V₂O₅ usually to the ore-buying station at Shiprock.

George Christensen began mining in early 1957 on the Christian 9 claim in the W₁/₄NW₁/₄ sec. 3, T15N, R16W on the south rim of Christensen Mesa. The ore occurrence at this property is identical to that at the U mine in the adjacent section to the west. Uranium ore at the Rats Nest occurs in carbonaceous shales and lignite interbedded with distributary-channel sandstones in the basal Dakota.

The mineral rights to sec. 17 are owned by the Santa Fe Pacific Railroad Company. The surface rights are controlled by the Navajo tribe. Sec. 17 was leased to the Quinta Corporation on March 27, 1957. Phillips Petroleum Corporation acquired a partial assignment of the section in April 1957 and furnished the money for exploration and development. Surface drilling consisting of approximately 300 holes with a total footage of 308,000 ft discovered significant ore deposits in the NE₁/₄ sec. 17 and in the SE₁/₄ of adjacent sec. 8. The ore in the Dakota Sandstone was limited to sec. 17.

Centennial Development Company, a contractor for Phillips, began to sink a 10-ft-diameter, concrete-lined shaft in August 1959. The shaft encountered the top of the Dakota Sandstone at 380 ft in November 1959. The station for the first level was located at 489 ft to mine the ore in the Dakota. Actual ore production began in March 1960 with ore being hoisted through a 42-inch vent hole while sinking of the shaft continued.

In March 1960, some 2,400 tons of Dakota ore averaging 0.22% U₃O₈ were shipped to the Phillips mill at Ambrosia Lake. This was done to claim the AEC bonus of $35,000 for the first 10,000 pounds U₃O₈ produced from a new discovery. The program, under Domestic Uranium Program Circular 6, expired at midnight March 31, 1960.

Mineral rights of the Dakota Sandstone at 489-ft level continued during 1960. The host sandstone was highly fractured and hard to manage. Steel sets were used to control the ground but some ore was lost because of caving. A second station was cut at 640 ft and mining of the ore in the upper Westwater Canyon Sandstone began in January 1961. At that time, retreat mining was underway on the Dakota level. The third station in the middle Westwater Canyon was located at 840 ft and the shaft bottomed at 862 ft. The 840-ft level was never mined.

On May 15, 1961, Phillips sold their equity to the Quinta Corporation and Centennial took over as the operator. The 489-ft, or Dakota, level was mined out in November 1961 and all work was concentrated on the 640-ft level; at that time the mine was pumping 1,000 gallons of water per minute. The Churrock mine was closed on May 10, 1962. The pumps in the Churrock shaft were shut off on September 18, 1963 and the mine was allowed to flood. In August the headframe and hoist were sold and shipped to Bayard, New Mexico. At that time water in the shaft stood at 150 ft below the collar of the shaft.

Total production during 1960–62 was 77,965 tons of ore averaging 0.19% U₃O₈ and containing 302,608 pounds U₃O₈. Using all available information in the AEC files, I have estimated that production from the 489-ft level during 1960 and 1961 was 45,997 tons of ore that averaged 0.21% U₃O₈ and contained 188,686 pounds U₃O₈ (Table 2). Prior to this study AEC geologists had estimated 90 tons U₃O₈ (180,000 pounds) for the Dakota from the Churrock mine and that number had been used in an earlier report (Chenoweth, 1977).

The United Nuclear Corporation reopened the Churrock mine (now known as the Old Churrock) in 1976. During the period 1976–1982, the firm produced approximately 570,000 pounds U₃O₈ by conventional mining and uranium recovery from mine water. It is impossible to determine how much uranium in the water was contributed from the Dakota Sandstone.

Sec. 16 deposit

An ore deposit in a Dakota Sandstone channel similar to the deposit at the Churchrock mine was found in the NW₁/₄ sec. 16, T16N, R16W just east of the Churchrock mine. The orebody also extended northward into sec. 8.

The ore rights to sec. 16 are owned by the State of New Mexico. In 1956 Tidewater Oil Company began an extensive drilling program in the Churchrock–Smith Lake area on land leased from the New Mexico and Arizona Land Company and the State of New Mexico. This drilling lasted for nearly two years and located only a marginal orebody in sec. 16 in mid-summer 1957.

The ore in sec. 16 and 8 occurs only in the Dakota Sandstone because only a single drill hole penetrated uranium in the Morrison Formation. Drill-hole logs indicate the channel trends nearly north-south with depth to the orebody between 320 and 480 ft.

Silver Spur mines

The Silver Spur mines, including the Small Stake mine, are located in S₁/₂ sec. 31, T14N, R10W just north of Haystack Butte (Fig. 1). In this area the Dakota Sandstone rests on claystone of the Brushy Basin Member of the Morrison Formation. Several small faults are present in and adjacent to sec. 31. The main body of the Dakota is composed of distributary-channel or tidal-flat sandstones with interbedded, paludal, carbonaceous shales. This sequence is overlain by a massive, beach or barrier-island sandstone (Pierson and Green, 1980).

The uranium in the S₁/₂SW₁/₄ sec. 31 (Small Stake and Silver Spur) occurs in a fine- to medium-grained carbonaceous sandstone, which may be a tidal-flat deposit. This sandstone is approximately 50 ft above the base of the Dakota. Gruner et al. (1954) identified metatyuyuminite in samples from this property. The uranium in the NW₁/₄SE₁/₄ sec. 31 (Silver Spur Nos. 1 and 5) is associated with carbonaceous debris along bedding planes in fine- to medium-grained, well-sorted sand-
stone of the upper Dakota approximately 90 ft above the base of the formation.

Sec. 31 was patented to the Santa Fe Pacific Railroad Company in 1909 as part of a large land grant given to the railroad by the Federal Government. On January 2, 1946, the section was sold to W. A. Berryhill. The language of the deed was confusing about who controlled the mineral rights; one paragraph stated that the railroad reserved "all oil, gas, coal, and minerals whatsoever," another paragraph stated that the railroad reserved "all coal, oil, and gas." In the spring of 1952, the courts decided that the minerals, including uranium, belonged to Mr. Berryhill.

Uranium-bearing outcrops were discovered in the upper part of the Dakota Sandstone in the NW1/4SE1/4 of the section in late 1951. On January 9, 1952, the section was subleased to the Silver Spur Mining Company formed by Duane Berryhill, son of W. A., and Lawrence Elkins. In February and March 1952, Silver Spur shipped 432 tons of ore averaging 0.18% U3O8 and 0.21% V2O5 to the newly opened ore-buying station at Shiprock. This represented the first uranium ore production from the Dakota Sandstone in the Gallup–Grants area. Mining was halted after an injunction was filed by the Santa Fe Pacific Railroad Company.

After the courts decided in favor of the Berryhills, ore shipments began to the AEC ore-buying station that had opened at Bluewater. Mining continued until January 1953 when the near-surface ore was depleted. Between February 1952 and January 1953, Silver Spur mined a total of 1,305 tons of ore that averaged 0.19% U3O8 and 0.22% V2O5. This ore apparently came from some of the open pits in the NW1/4SE1/4 of the section (Mirskey, 1953). These shipments were identified as production from the Silver Spur No. 5 mine.

In June 1952, Charles Davis subleased the SW1/4 sec. 31 from Silver Spur. On June 19, 1952, he shipped 32 tons of ore averaging 0.14% U3O8 and 0.28% V2O5 to Bluewater from a small adit in the lower part of the Dakota Sandstone in the S1/2SW1/4. This shipment was identified as production from the Small Stake mine. Davis cancelled his lease in late 1952.

Holly Uranium Company leased the section in late 1954 and began an exploratory drilling program in January 1955. In April 1955, Holly did some rim stripping and began to ship ore to Bluewater. After shipping approximately 214 tons that averaged 0.32% U3O8 and 0.29% V2O5, Holly turned the property back to the owners in January 1956. Some of the ore was produced from a rim cut in the NW1/4SE1/4 of the section. Shipments by Holly were identified with the Silver Spur No. 1 mine.

In December 1956, Febco Mines (a partnership of Farris, Elkins, and Burns) took over the lease and started a new underground mine in the SW1/4SW1/4 of the section. Shipments by Febco began in January 1957 and continued through May 1959 when mining ceased. Febco’s production totaled 4,278 tons of ore that averaged 0.26% U3O8 and 0.27% V2O5. Shipments were made to the AEC ore-buying station at Milan until early 1958 when the delivery point was changed to the station at Shiprock. The final shipment of 388 tons averaging 0.15% U3O8 was made to the Kern Nuclear Fuels mill at Ambrosia Lake during the summer of 1959. Shipments by Febco were identified with the Silver Spur No. 5 mine.

In the summer of 1958, 81 tons of ore averaging 0.27% U3O8 and 0.28% V2O5 were delivered to the ore-buying station at Shiprock. The property was identified as the Silver Spur No. 1 mine, and the shipper was listed as the Holly Corporation. This ore was probably shipped by Febco from ore mined previously by Holly, but no details are available.

In December 1966, Farris Mines made the final shipment from sec. 31. It consisted of 27 tons of ore averaging 0.15% U3O8 delivered to the Phillips Petroleum mill at Ambrosia Lake. Total production from sec. 31 was 5,937 tons of ore that averaged 0.25% U3O8 and 0.25% V2O5 (Table 2).

In late 1952, W. A. Greer shipped 19 tons of ore averaging 0.11% U3O8 and 0.11% V2O5 to the ore-buying station at Bluewater. This production was credited to the Small Stake mine. Notes in the AEC records indicate this shipment actually came from sec. 19, T14N, R11W in the Todilto Limestone.

Sec. 5 mine
The Sec. 5 mine is located in the SE1/4NW1/4 sec. 5, T13N, R10W. This section is a Santa Fe Pacific Railroad Company section that was leased by Westvaco Minerals in the mid-1950’s. Westvaco was a subsidiary of the Food Machinery and Chemical Corporation. In the summer of 1958, a mining contractor, Farris Brothers, drove a short adit into the basal Dakota Sandstone near a fault. A total of 23 tons of ore averaging 0.12% U3O8 were shipped to the AEC ore-buying station near Milan (Table 2).

Junior mine
The Junior mine is located in the SW1/4SE1/4 of the section, T13N, R10W. It consists of a small rim cut along a fault that brings the Dakota Sandstone in contact with the Westwater Canyon Member of the Morrison Formation. The uranium ore at the Junior mine occurs in a carbonaceous sandstone in the basal Dakota. The Junior mine is approximately 500 ft west of the portal of the Dakota (Pat) mine in the Westwater Canyon Member.

Early in 1953, a total of 38 tons of ore averaging 0.11% U3O8 and 0.16% V2O5 was shipped to the AEC ore-buying station at Bluewater by the Dakota Mining Company (Table 2). In the AEC computer listing, the total production for the NE1/4 sec. 4 is shown as 5,069 tons of ore averaging 0.12% U3O8 and containing 12,645 pounds U3O8, with no breakdown between the Junior or Dakota (Pat) mines. Hence, the Junior mine was not included in Chenoweth’s 1977 tabulation.

Other mines in the Dakota Sandstone
The only other property in New Mexico to produce uranium ore from the Dakota Sandstone is the Butler Brothers No. 1 mine in Sandoval County. This mine, located approximately 15 mi southwest of Cuba in the W1/4NE1/4 sec. 23, T19N, R1W, is on a hogback along the west flank of the Nacimiento Mountains. Here, uranium occurs in a 1-ft-thick bed of carbonaceous shale or peat at the base of the Dakota; the bed dips 45° southwestward. This deposit has been described by Gabelman (1956).

During 1954 and 1957, R. W. and V. L. Butler made shipments from this deposit. These totaled 23 tons of ore averaging 0.63% U3O8 and 0.12% V2O5 and containing 290 pounds U3O8 and 56 pounds V2O5.

Summary
Most of the uranium deposits in the Dakota Sandstone in the Gallup–Grants area are found in distributary-channel sandstones in the basal part of the Dakota. The exceptions are deposits at one of the Silver Spur mines, which is in a beach or barrier-island sandstone of the upper Dakota, and deposits at the Hogback No. 4 mine, which occur in sandy, paludal shale of the lower Dakota.

In the lower Dakota Sandstone, carbonaceous shale beds interbedded with the permeable sandstone act as aquicludes. At the Silver Spur mine the amount of impermeable shale in the lower Dakota is small, so uranium solutions in the underlying Morrison sandstone were able to reach the upper part of the main body of the Dakota. Caprock at the Silver Spur is the Whitewater Arroyo Tongue of the Mancos Shale. At the Hogback No. 4 the uranium may have entered the sandy shale laterally because the unit below the shale is relatively impermeable.

In the Gallup area, Dakota uranium deposits are associated spatially with the pre-Dakota unconformity where the impermeable mudstones of the underlying Brushy Basin Member of the Morrison Formation were eroded. The organic-rich Dakota host rocks are in contact with uranium-rich sandstones of the Westwater Canyon and Brushy Basin Members. To the east in the Haystack Butte area near Grants, Dakota deposits are associated with Tertiary faulting that could have provided conduits for Morrison ground water to reach Dakota host rocks.

Pierson and Green (1980) speculated about an origin for the deposits in the Dakota Sandstone. According to them, the formation of uranium deposits in the Dakota could be controlled by five main factors: 1) previous existence of a ground-water flow with a stratigraphically upward component; 2) introduction into the Dakota of uranium-bearing solutions derived from oxidation of pre-existing Morrison uranium deposits or by leaching of the arkosic sediments that compose the Morrison; 3) sufficient transmissiv-
ity within the Dakota to allow passage of the solutions; 4) presence of an impermeable caprock to contain the solutions, which are thought to have risen stratigraphically during their migration northward toward the San Juan Basin or westward toward the Gallup sag; and 5) availability of organic material in the Dakota to reduce and thereby precipitate the uranium from the rising solutions. The author's observations agree with those of Pierson and Green (1980).

**Acknowledgements**—This report would not have been completed without the encouragement of Virginia T. McLemore of the New Mexico Bureau of Mines and Mineral Resources. Thanks are owed to Leo E. Little, Manager of the Grand Junction projects office of the DOE for access to the AEC records stored in the DOE archives at Grand Junction. Raymundo J. Chico provided some details of the early history of the Diamond No. 2 mine. John Gabelman, Charles Pierson, Morris Green, and Orin Anderson reviewed the manuscript; their comments are greatly appreciated.

**References**


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**Platinum-group metals in New Mexico**

by Virginia T. McLemore, Robert W. Eveleth, Lynn A. Brandvold, and James M. Robertson, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801

**Introduction**

Platinum-group metals (PGM) consist of six elements: platinum (Pt), palladium (Pd), rhodium (Rh), iridium (Ir), osmium (Os), and ruthenium (Ru); platinum and palladium are the most abundant of the group. The PGM typically occur together as natural alloys (for example, osmiridium—an alloy of osmium and iridium) and to a lesser extent as sulfides and arsenides. All the metals are rare (Table 1) and therefore expensive. PGM are used primarily as catalysts in the automotive, chemical, and petroleum-refining industries (U.S. Bureau of Mines, 1987).

Periodically, the NM BMMR is asked to provide information on the occurrence of PGM in the state. More recently, increasing numbers of investors are being approached by speculators to invest in alleged PGM-mining ventures in New Mexico. NO PGM DEPOSITS ARE CURRENTLY KNOWN IN NEW MEXICO THAT CONTAIN CONCENTRATIONS RICH ENOUGH AND/OR LARGE ENOUGH TO ECONOMICALLY MINE (Eveleth and Bieberman, 1984) despite numerous claims to the contrary. It is possible that a small amount of PGM could be recovered from the anode slimes produced from a large porphyry copper deposit such as Chino. For example, the concentrates produced by Inspiration Consolidated Copper in Arizona contained a mathematically calculated 0.0000026 troy oz PGM per ton of ore (Phillips, 1980; Eveleth and Bieberman, 1984). There is no documented production of PGM from New Mexico.

Recently the U.S. Geological Survey (USGS) reprinted a map of reported PGM occurrences in the conterminous United States (Blair et al., 1977). That report lists UNVERIFIED PGM occurrences in New Mexico as cited in the literature. Not one of those “occurrences” has been found to actually contain PGM.

The purpose of this report is to briefly summarize and evaluate historical reports of PGM occurrences in New Mexico and to consider possible geologic environments in New Mexico that might contain undiscovered PGM.

**TABLE 1—Abundance of platinum-group metals in crustal rocks (from Greenwood and Earnshaw, 1984).**

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Atomic no.</th>
<th>Abundance (ppm)</th>
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</thead>
<tbody>
<tr>
<td>Palladium</td>
<td>Pd</td>
<td>46</td>
<td>0.015</td>
</tr>
<tr>
<td>Platinum</td>
<td>Pt</td>
<td>78</td>
<td>0.01</td>
</tr>
<tr>
<td>Osmium</td>
<td>Os</td>
<td>76</td>
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<tr>
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<td>Ir</td>
<td>77</td>
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<tr>
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<td>Ru</td>
<td>44</td>
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</tr>
<tr>
<td>Rhodium</td>
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<td>45</td>
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</tr>
</tbody>
</table>

---

**PGM reported in New Mexico**

(Blair et al., 1977)

**Tampa mine, Bromide district, Rio Arriba County**

The Tampa mine in the northern part of the county is one of the largest mines in the Bromide district with a 400-ft shaft and 800–1000 ft of drifts (Bingler, 1968). Sulfide replacement veins containing chalcopyrite, molybdenite, pyrite, malachite, and some free gold occur in schist and granite gneiss of Precambrian age (Lindgren et al., 1910).

"In the Tampa mine, assays frequently show good values in platinum; this is the only place in New Mexico where this rare metal is actually known to exist" (Jones, 1904a). Subsequently, Jones (1904b, 1908, 1915) and Northrop (1959) reported the Tampa mine as a PGM occurrence. However, Lindgren et al. (1910, p. 132) reported that assays of copper ore from the Tampa mine show NO DETECTABLE PLATINUM. In fact, L. C. Graton deliberately visited the Tampa mine with the idea of confirming the presence of platinum as reported previously by Jones. He had samples assayed for platinum, something very rarely requested, by Ledoux & Company, probably the best private laboratory at the time, but no platinum was found (Lindgren et al., 1910, p. 132, footnote a).

**Red River district, Taos County**

The Red River district, near Red River, consists of numerous mines and prospects ranging from Precambrian ore-bearing quartz veins (copper, tungsten, gold, silver, and other ore minerals) to Tertiary ore-bearing veins and disseminated deposits (molybdenite, galena–sphalerite–chalcopyrite, chalcopyrite, galena–sphalerite, and pyrite–gold veins) to Tertiary–Quaternary placer deposits. Mineral deposits occur in Precambrian granite and metamorphic rocks and Tertiary volcanic and intrusive rocks (Schilling, 1960).

In 1910, Fain (1910, p. 3) stated, "there are also indications of... sperrylite (PlAs)... in the Red River district. Northrop (1959) stated, "I know of no subsequent report of this mineral." PGM have yet to be verified from the Red River district.

**Ortiz mine, Old Placers district, Santa Fe County**

The Ortiz mine is one of the oldest mines in the district. The mine is located on the Cunningham Gulch volcanic vent and follows an irregular gold–quartz vein as much as 4 ft wide and 1 mi long (Lindgren et al., 1910; Elston, 1967). Most of the mining occurred between 1832 and 1870 although several attempts have been made recently. Owen and Cox (1865, p. 15) reported an