Historical review of uranium production from the Todilto Limestone, Cibola and McKinley Counties, New Mexico

by *William L. Chenoweth*, Consulting Geologist, Grand Junction, CO 81506

Introduction

The Grants area 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 area is also one of the few localities in the United States where economic deposits of uranium occur in limestone beds.

During the period 1950 through 1981, mines on 31 different sections of land in the Grants area produced 3,335.76 tons of uranium oxide (U_3O_8) from the Jurassic Todilto Limestone (Table 1). This represents slightly more than 2% of the total uranium that has been mined in the Grants area. The Todilto has been the most productive limestone host rock for uranium in the United States, if not the entire noncommunist world.

The principal area of Todilto deposits is northwest of Grants and straddles the Cibola–McKinley county line (Fig. 1). The relative size of the deposits and their geographic distribution are given in Table 2. These data show that 64% of the uranium produced from the Todilto Limestone has come from four sections of land.

Because this report deals only with the historical production data, the reader is referred to reports by Kelley (1963), Hilpert (1969), Rautman (1980), and McLemore (1983b) for descriptions of the geology and ore deposits. A report by Albrethsen and McGinley (1982) gives the details of the AEC's uranium procurement program and a history of the uranium mills. Reports by Reyner and Sheridan (1950) and Rapaport (1952) give descriptions of the properties at the time mining was starting, and a report by Anderson (1981) describes the recent conditions of the mines, all of which are now abandoned or inactive. The names of the individual mines are given in Table 3.

It should be noted that at certain deposits, such as the Sandy and the Zia, ore also occurs in the underlying Entrada Sandstone. At others (e.g., the Haystack No. 2) mineralization extends upward into the basal beds of the overlying Summerville Formation. No attempt has been made to exclude these nonlimestone ores from this tabulation.

Database

During the time I was employed by 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), uranium production statistics were routinely compiled for the New Mexico Bureau of Mines and Mineral Resources. This article is an outgrowth of that work and briefly summarizes the uranium production from the Todilto Limestone in the Grants area.

The uranium production data given in this paper were compiled on a property-by-prop-

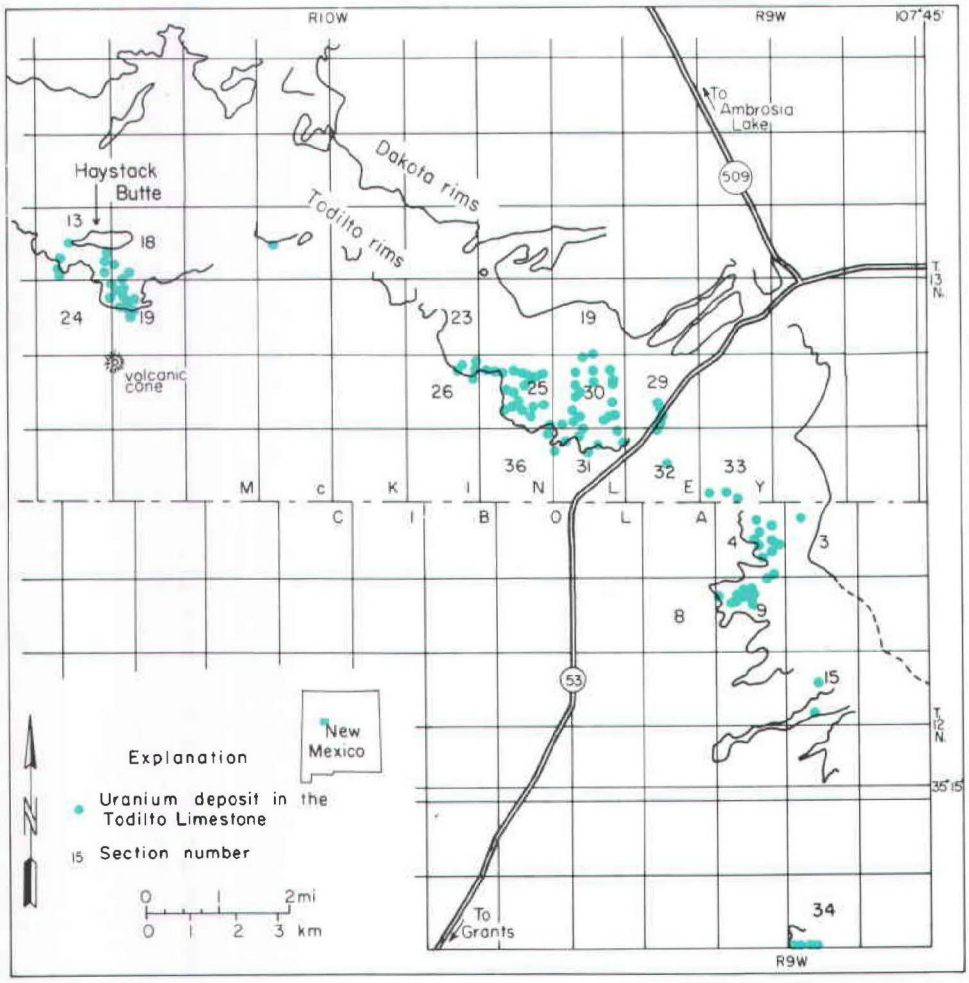

FIGURE 1—Index map showing the principal area of uranium deposits in the Todilto Limestone, modified from Kelley (1963, p. 137).

TABLE 1—Uranium production from the Todilto Limestone, Grants area, New Mexico. Figures are given in tons U_3O_8 in ore; **w** = withheld due to the limited number of operators.

Year	Valencia County [now Cibola]	McKinley County	Total
1950	0.03	—	0.03
1951	0.10	0.06	0.16
1952	3.49	22.91	26.40
1953	26.69	72.42	99.11
1954	53.61	145.77	199.38
1955	60.68	170.70	231.38
1956	43.67	152.09	195.76
1957	37.71	154.93	192.64
1958	85.98	158.06	244.04
1959	64.81	228.57	293.38
1960	9.07	198.87	207.94
1961	5.49	158.85	164.34
1962	13.28	131.59	144.87
1963	4.20	84.54	88.74
1964	3.35	75.05	78.40
1965	3.21	56.74	59.95
1966	0.04	57.71	57.75
1967	1.11	5.16	6.27
1968	—	8.10	8.10
1969	—	1.38	1.38
1970	—	13.65	13.65
1971	w	w	7.76
1972	w	w	74.25
1973	w	w	97.80
1974	w	w	65.33
1975	w	w	57.35
1976	w	w	77.28
1977	w	w	118.09
1978	—	149.46	149.46
1979	—	162.08	162.08
1980	—	153.60	153.60
1981	—	59.09	59.09
Totals	698.40	2,637.36	3,335.76

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TABLE 2—Geographic distribution of uranium production from the Todilto Limestone, Grants area, New Mexico. Note that mines in four sections produced 64% of the U_3O_8. *Western end of orebody is in sec. 33, major portion is in sec. 34; production cannot be separated. †Orebody is in sec. 3, T12N, R9W; portal of the decline is in sec. 34.

Tons U_3O_8	Number of sections	Section, township, range	Percent of tons U_3O_8
801–900	1	30–13–9	25
701–800	0	—	—
601–700	0	—	—
501–600	1	25–13–10	16
401–500	1	34–12–9*	13
301–400	1	19–13–10	10
201–300	2	19–13–9, 13–13–11	16
101–200	2	4–12–9, 29–13–9	8
51–100	3	9–12–9, 23–13–10, 24–13–11	7
1– 50	12	8–8–5, 22–9–5, 20–11–9, 8–12–9, 15–12–9, 31–13–9, 32–13–9, 34–13–9†, 18–13–10, 26–13–10, 36–13–10, 19–14–11	5
<1	8	6–8–6, 4–11–9, 8–11–9, 33–13–9, 16–13–10, 18–14–11, 28–14–11, 24–14–12	<1
Totals	31		100

erty basis from the year-end production summaries prepared by the Grand Junction Office. Only the tons of U_3O_8 in ore mined were consistently recorded; hence, the grade of the ore usually cannot be calculated for individual properties.

This compilation indicates that during the period from 1950 through 1981, 3,335.76 tons U_3O_8 were produced from mines in the Todilto Limestone. Before this compilation was made, a production total of 3,368 tons U_3O_8 was compiled by the DOE Grand Junction Office for McLemore (1983a). Considerable effort has been spent on trying to resolve the difference of 32.24 tons (64,480 lbs), U_3O_8.

In the Grand Junction records system, from 1950 to 1984, production was tabulated every three months and coded for computer storage. During that time, the type of host rock—sandstone, limestone, lignite, etc.—was designated by code. The Todilto production statistics provided to McLemore (1983a) were generated by a computer. After checking the individual properties, on a year-by-year basis, I believe that some early production statistics from sec. 19, T13N, R9W (Poison Canyon mine, Morrison Formation) were confused with sec. 19, T13N, R10W (Haystack Butte mine, Todilto Limestone), both of which were operated by the Haystack Mountain Development Company and incorrectly coded as limestone. Thus, the production total given in this report is probably more accurate. The year-by-year production statistics for the Todilto Limestone are given in Figure 2 and Table 1.

Production history

Although yellow uranium minerals had been known to exist in the Grants area for several years, it was the discovery by Paddy Martinez, a Navajo sheepherder, that triggered the uranium boom. In the spring of 1950, Martinez collected samples of Todilto Limestone from the foot of Haystack Butte that contained yellow uranium minerals. He showed the samples to Carrol Gunderson, a Grants merchant and, at the time, mayor. Gunderson contacted E. O. Hemenway, Land Commissioner for the Santa Fe Pacific Railroad Company, who controlled the mineral rights on sec. 19, T13N, R10W, where the samples originated (Evans, 1951, p. 1).

The Engineering Department of the Atchison, Topeka and Santa Fe Railway Company, parent company of the Santa Fe–Pacific, began a reconnaissance of the railroad's holdings from Cubero to Gallup, which included nearly every odd-numbered section of land. A field office was established at Baca railroad siding near Prewitt, New Mexico. The best exposures were found to be on sec. 19, T13N, R10W, and the Santa Fe Pacific Railway Company began an exploration program of drilling, sampling, and test pitting on November 21, 1950 (Evans, 1951, p. 13). Uranium was also discovered on sec. 13, T13N, R11W, secs. 17, 23, and 25, T13N, R10W, and on sec. 31, T13N, R9W. (Mining World, 1951).

The news of this uranium discovery brought hoards of prospectors into the Grants area. This activity would lead to the discovery of other deposits in the Todilto Limestone as well as deposits in exposures of the Morrison and Dakota Formations, which triggered the uranium boom in west-central New Mexico.

Development of orebodies on the Santa Fe lands, with the exception of sec. 19, T13N, R10W, was hindered by litigation. Santa Fe had sold the surface rights to their holdings in previous years, but had retained rights to "coal, oil, gas, and minerals, whatsoever" (Rapaport, 1952, p. 1). The ranchers who acquired the surface rights claimed that the uranium was superficial and, therefore, belonged to them. The case was heard in May 1952, and the court decided in favor of the railroad (Rapaport, 1952).

The first shipment of uranium ore from the Todilto Limestone was recorded in December 1950 when Fred Glover shipped 10 tons of ore averaging 0.35% U_3O_8 to the AEC buying station at Monticello, Utah. The shipment was labeled "Private Property," but notes in the AEC files indicate that the shipment came from sec. 9, T12N, R9W, where Mark Elkins owned the mineral rights.

The Anaconda Copper Mining Company secured numerous leases in January and February 1951 and began an extensive exploration and development program in March. In August 1951, uranium in the Todilto Limestone on the Laguna Indian Reservation was discovered by Joy Sinyella, a Supai Indian living on the Laguna Reservation (Towle and Rapaport, 1952).

In late 1951, the Santa Fe Railway Company made a few small test shipments from secs. 19 and 25, T13N, R10W to the AEC

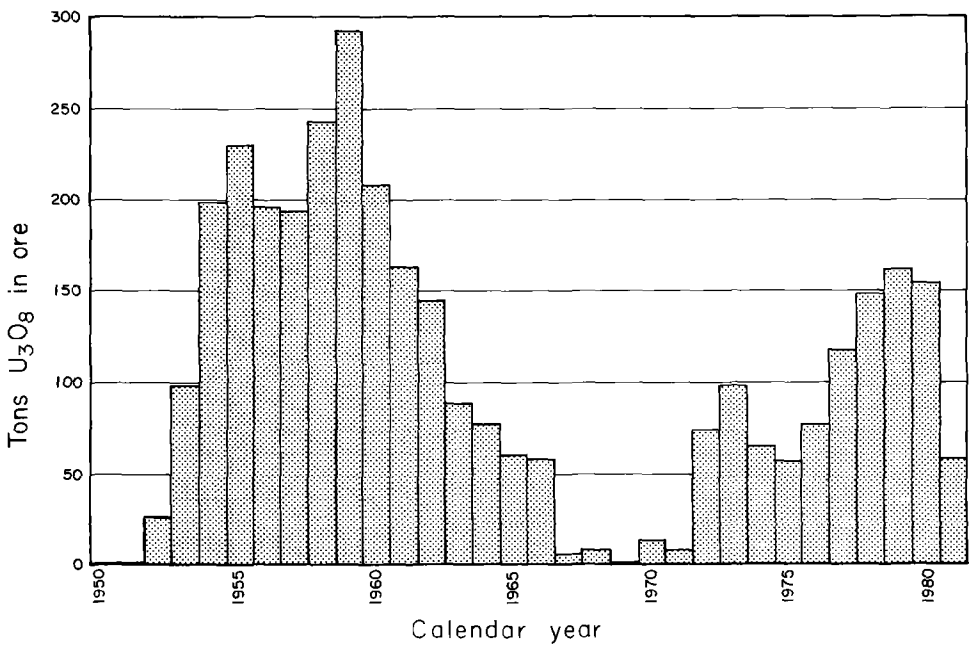

FIGURE 2—Uranium production from the Todilto Limestone, Grants area, New Mexico.

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TABLE 3—Names of mines in the Todilto Limestone, Grants area. Parentheses indicate aliases.

Section, Township, Range	Name of mine and/or property
Valencia [now Cibola] County	
8–8–5	Crackpot
6–8–6	Paisano
22–9–5	Sandy
4–11–9	Tom 13
8–11–9	Lone Pine 3
20–11–9	Cedar 1 (Section 20) (Yucca)
4–12–9	Bunny, Blackhawk, Christmas Day 1, Red Bluff 2 and 4, Red Bluff 3, 5, and 9, Red Bluff 7, 8, and 10, Gay Eagle, UDC–5 (Sutton Group).
8–12–9	Last Chance
9–12–9	Section 9 (Private Property)
15–12–9	Zia, La Jara
34–12–9	F–33
McKinley County	
19–13–9	Hope
29–13–9	Faith (Section 29)
30–13–9	Barbara J 1, Barbara J 2 (Dalco), Barbara J 3, Flat Top 1–5, Piedra Trieste, Rimrock 1, 2, and 3, Roundy Lease, Whitecap
31–13–9	Section 31
32–13–9	Section 32 (Moe 4)
33–13–9	Charlotte
34–13–9	Vallejo (Double Jerry) (Farris 1)
16–13–10	Red Point
18–13–10	Section 18 (Brown Vandever Allotment) (Williams Lease)
19–13–10	Section 19 (Haystack Butte)
23–13–10	Section 23
25–13–10	Section 25, Section 25 shaft
26–13–10	Section 26 (Hanosh) (Desidero Allotment)
36–13–10	Rimrock School Section (Section 36)
13–13–11	Bibo Trespass, NM–B–1, SW1/4 Section 13 (Haystack 2)
24–13–11	Section 24 (Nana-A-Bah Vandever Allotment)
18–14–11	Red Top 1 and 2
19–14–11	Billy the Kid (Section 19)
28–14–11	T Group, Red Cap
24–14–12	Elkins

buying station at Monticello, Utah. Small shipments also were made in 1951 by the Shaw Company and by William Barlow from the Red Point and Last Chance properties, respectively. Early in 1952, Warren McCormack made a shipment to Monticello from the Billy the Kid property, north of Prewitt, New Mexico.

On December 27, 1951, the AEC entered into a contract with the Anaconda Copper Mining Company to purchase uranium concentrates produced by Anaconda at a site near Bluewater, New Mexico. In order to stimulate exploration and ore production in the Grants area, the AEC engaged Anaconda to operate an ore buying station at the Bluewater site. The station opened on June 9, 1952, and ores were bought from independent operators until early 1958.

At the beginning of the AEC program, ore producers were paid for their ores under the terms of the AEC's Circular 5, Revised (U.S. Atomic Energy Commission and U.S. Geological Survey, 1951). This schedule contained a base price of \$3.50/lb U_3O_8 for ores containing 0.20% or greater U_3O_8. Ores containing less than 0.20% U_3O_8 received a base price grading down to \$1.50/lb U_3O_8 in ores containing the minimum acceptable grade of 0.10% U_3O_8. All ores received a mine development allowance of \$0.50/lb U_3O_8, and ores containing 0.21% U_3O_8 and better received a \$0.75/lb grade premium. The AEC also paid a \$0.06 per ton-mile haulage allowance for the first 100 miles.

The high-lime ores of the Todilto were not amenable to acid leaching and required use of the hot carbonate leach process. To develop this process, Anaconda constructed and operated a pilot plant at the Bluewater site from March to October 1953. The original 300-ton-per-day carbonate leach mill began operating in October 1953 and was expanded to 1,200 tons per day in 1955 when it was equipped to treat both limestone and sandstone ores.

With a market for high-lime ores established in the area, production from the Todilto Limestone began to increase in 1952. Exploration, which had begun at rim exposures, gradually progressed downdip with drilling depths exceeding 200 feet. The Santa Fe Railroad Company established a mining subsidiary, Haystack Mountain Development Company, and began an extensive exploration program. They were joined by a large number of companies and individuals. In 1955, Anaconda commenced mining at their F–33 mine in the SE1/4 sec. 33, T12N, R9W on the East Grants Ridge. By 1959, the underground workings had extended nearly 2,000 feet into adjacent sec. 34.

During 1955, 231.38 tons of uranium oxide were produced, which made that year the third highest production year on record (Fig. 2). Of the total, approximately 44% came from ore that had been stockpiled on sec. 19, T13N, R10W by Haystack Mountain Development Company.

Public Land Order 964, dated May 13, 1954, mandated withdrawal of 13,700 acres from mineral entry for the purpose of exploration by the AEC. The lands were located in T12N, R9W; T13N, Rs9,10,11W; and T14N, R11W. With the exception of NE1/4, S1/2 sec. 3, sec. 11, and SE1/4, S1/2 N1/2 sec. 13, T13N, R11W all lands were restored in 1956. In order to test the validity of the withdrawal, Art Bibo mined a total of 3,736 tons averaging 0.22% U_3O_8 from an open pit in the SE1/4 sec. 13, T13N, R11W during 1956–1961. The court ruled in favor of the government and Bibo was found to be trespassing. In 1974, the AEC leased sec. 13 for mining.

During the mid-1950's exploration drilling for undiscovered deposits was done on areas of the Todilto bench where drilling depths exceeded 400 feet, and by 1958 orebodies on sec. 30, T13N, R9W were being mined from vertical shafts of similar depths.

On May 24, 1956, the AEC announced the establishment of a new domestic uranium procurement program for the period April 1, 1962, through December 31, 1966. The new program guaranteed a government market for 500 tons of U_3O_8 in concentrate per year from any one mining property, or operation, at a flat price of \$8.00/lb. Thus, in 1956, the stage was set for a continuing AEC concentrate procurement program after March 31, 1962, with an established price for concentrates rather than for ores. The prices, premiums, and allowances paid under Circular 5, Revised (U.S. Atomic Energy Commission and U.S. Geological Survey, 1951), would no longer be in effect. After March 31, 1962, the AEC required that the mill operator pay "reasonable" prices to independent producers. The May 1956 announcement resulted in continued exploration for deeper orebodies in the Todilto.

Exploration for new deposits of uranium became so successful in New Mexico and throughout the western United States that the government felt a need to limit its procurement program. On November 24, 1958, the AEC announced that all concentrates purchased by the AEC in 1962–1966 must be derived from ore reserves developed before November 24, 1958. Under this announcement, the AEC determined which ore reserves were eligible on a property-by-property basis. Properties with eligible ore reserves were given a market quota (allocation). As a result of this announcement, exploration for undiscovered deposits in the Todilto Limestone ceased.

In 1959, production from the Todilto Limestone reached an all-time-high level when 19 properties produced 120,552 tons of ore that contained 293.38 tons U_3O_8 and averaged 0.24% U_3O_8 (Fig. 2). This was largely due to the fact that Anaconda, the only market for limestone ore, announced they would not accept the ore after May 1959. Anaconda's carbonate circuit mill and their F–33 mine in the Todilto Limestone were shut down that month. Operators of other mines in the Todilto such as Haystack Mountain Development Company, Mid-Continent Uranium Corporation, and various independent operators, were forced to find other markets such as the Phillips Petroleum Company mill and the Homestake–New Mexico Partners' mills, both of which had carbonate circuits.

During the time that the AEC maintained a buying station at Bluewater (1952–1958), 320,726 tons of ore that averaged 0.32% U_3O_8 were received and sampled. Anaconda purchased about 182,280 tons from the AEC and the remainder was sold by the AEC to Phillips and to the two mills in which Homestake Mining Company was a partner (Albrethsen and McGinley, 1982).

On November 9, 1961, Homestake–Sapin Partners acquired the assets of the Homestake–New Mexico Partners including their mill, which was adjacent to the Homestake–Sapin mill. Both AEC contracts were replaced with a single contract and the Homestake–New Mexico Partners' mill was shut down on April 14, 1962. Meanwhile, as of April 2, 1962, United Nuclear Corporation was merged with Sabre Piñon Corporation (Sapin) and the surviving corporation was renamed the United Nuclear Corporation.

United Nuclear acquired the uranium assets of Phillips Petroleum in February 1963 and the Phillips' mill was closed in March. Ores that were processed by Phillips were then sent to the Homestake–Sapin Partners'

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mill. Hence, all of the limestone ore mined in the Grants area after March 1963 was processed at the Homestake–Sapin Partners' plant. In April of 1968, the partnership became United Nuclear–Homestake Partners, and in 1981 Homestake Mining Company acquired complete control of the operation.

In 1962, it was apparent to the AEC that the private market for uranium concentrates would not be sufficient to sustain a viable domestic uranium industry by the end of 1966 when the AEC procurement program was scheduled to end. Thus, on November 20, 1962, the AEC announced its "stretch-out" program for 1967 through 1970. Under the program, the milling companies could voluntarily defer delivery of a portion of their 1963–1966 contract commitments until 1967 and 1968 in return for an AEC commitment to purchase, in 1969 and 1970, an additional amount of U_3O_8 equal to the quantity so deferred. The "stretch-out" program was the last of the major policy changes made in the AEC procurement program.

The price to be paid for the deferred material in 1967 and 1968 would be $8.00/lb, the same as the 1962–1966 contracts. The price to be paid in 1969 and 1970 for concentrate produced from properties controlled by the milling company would be calculated with a formula based on costs during the 1963–1968 period, not to exceed $6.70/lb. The price for all concentrates produced from ores purchased from independent producers would be $6.70/lb of contained U_3O_8. In the Grants area, all mills participated in the "stretch-out" program, and Todilto mines that produced in the 1962–1966 period were provided a market through 1970.

In 1964, Congress passed the Private Ownership of Special Nuclear Materials Act. This act initiated the transition from a government uranium market to a commercial uranium market, which would supply the nuclear power plants. Although several mines in the Grants area supplied uranium to both the government and private industry in the late 1960's, all Todilto production during that time was acquired by the AEC.

After reaching an all-time-high peak in 1959, production declined to a low of 1.38 tons U_3O_8 in 1969; ore reserves that were eligible under the AEC's November 24, 1958, announcement were depleted by then. A final cleanup effort of the mines in sec. 30, T13N, R9W resulted in an increase of production to 13.65 tons U_3O_8 in 1970, the final year of the AEC's procurement program. An AEC tabulation of Grants production by I. M. Gay (pers. comm., 1972) indicates that through 1970 mines in the Todilto Limestone produced 1,053,744 tons of ore that contained 4,627,357 lbs U_3O_8 and averaged 0.22% U_3O_8. Because my data is recorded in tons U_3O_8 it is necessary to convert Gay's pounds U_3O_8 to tons (by dividing by 2,000) for a comparison. Converting pounds to tons U_3O_8, Gay's number of 2,313.68 tons, checks extremely well with my independent tabulation of 2,313.67 tons.

Beginning on January 1, 1971, the uranium market was entirely supported by the electric utilities for use in their nuclear power plants. Prices were dictated by what the utilities would pay, and because they were less than the previous government prices, only the higher grade, lower cost operations continued.

In 1971, Homestake Mining Company leased the F–33 mine from Anaconda. Production from this property resumed in the same year and continued into 1977.

At an AEC lease sale held on May 15, 1974, George F. Warnock was the successful bidder to lease the SE1/4, S1/2N1/2 sec. 13, T13N, R11W for uranium mining. Warnock's royalty bid of 5.55% on the first 190,000 lbs U_3O_8 produced was the highest percentage received. The lease was approved on June 12, 1974, and after a period of exploration drilling, mining commenced in October 1975. The lease, designated NM–B–1 by the federal government, was reassigned to the Todilto Exploration and Development Corporation on March 23, 1976. In addition to producing ore from new underground mines on the lease block, Todilto Exploration located and mined a new orebody in the SW1/4 sec. 13, a Santa Fe Railway Company lease (Haystack No. 2). Production from the mines on the lease block and in the southwest quarter continued until 1981 and 1979, respectively.

A sharp rise in uranium prices, beginning in about 1974, resulted in renewed interest in Todilto orebodies. Hence, exploration and mining increased in the late 1970's. Exploration drilling by Ranchers Exploration and Development Corporation located orebodies in the Todilto Limestone in the southern portion of sec. 19, T13N, R9E, the railroad section where the Poison Canyon mine (Morrison Formation) is located. A 440-ft shaft, named the Hope mine, was sunk to the orebody. Production began in 1977 and continued into 1981. In 1979, approximately 50% of the total Todilto production came from the Hope mine.

Todilto Exploration and Development Corporation located additional ore in the northern part of sec. 30, T13N, R9W. Todilto sunk a 1,000-ft-long decline, named the Piedra Trieste mine, which produced ore in 1979 and 1980.

In addition to the properties already mentioned, five other mines also produced in the post AEC period (1971–1981): Sec. 19, T13N, R10W; Sec. 25, T13N, R10W; Roundy Lease; Billy the Kid; and the Red Bluff.

Declining uranium prices, beginning in early 1980, forced the closure of the mines in the Todilto. The last production from the Todilto Limestone was recorded in August 1981 from the Hope mine. In the future, when uranium prices rise, mining of orebodies in the Todilto Limestone will no doubt resume.

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Arizona Geological Society field trip

The Arizona Geological Society and the University of Arizona will co-sponsor a two-day conference entitled "Frontiers in geology and ore deposits of Arizona and the Southwest" on March 20–21, 1986, in Tucson, Arizona. Several one- and two-day field trips will be held before and after the conference. For further information, contact the University of Arizona Conference Department, 1717 E. Speedway Blvd., Room 3201, Tucson, Arizona, 85719, phone (602) 621–1232.

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