Uranium industry in New Mexico—history, production, and present status

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Introduction

Uranium production in New Mexico has surpassed production in all other states since 1956. From 1948 to 1982, more than 200 mines in New Mexico (Fig. 1) produced 163,010 tons of U_3O_8, 40% of the total United States uranium production for that period (Table 1). More than 99% of the New Mexico production has come from the Grants district in McKinley and Cibola Counties (Tables 2 and 3). Eight mills in New Mexico recovered 155,614 tons of U_3O_8 from New Mexico and adjacent states from 1948 to 1982, 41% of the total United States concentrate production (Table 1). These production statistics and the history and present status of the uranium industry in New Mexico are discussed in this article.

Production statistics have been compiled by the U.S. Atomic Energy Commission (AEC) and its succeeding agencies, the U.S. Energy Research and Development Administration (ERDA) and the U.S. Department of Energy (DOE). Production figures for individual mines in New Mexico that sold uranium to the federal government from 1948 to 1970 have been released recently by DOE and are presented in McLemore (1983). Production statistics have been compiled by year, by county, and by geologic host formation and are tabulated in Tables 1, 3, and 4. Uranium production in the San Juan Basin (including the Grants district) from 1948 to 1982 is given by geologic host formation in Table 2.

The history of the uranium industry in New Mexico has received much attention in the literature. Some of the best accounts are by Melancon (1963), Holmquist (1970), Chenoweth (1976, 1977), Chenoweth and Holen (1980), Chenoweth and Learned (1980), and Albrethsen and McGinley (1982).

Exploration and mining

Although the uranium industry was born during World War II, the first commercial interest in uranium deposits in New Mexico occurred in 1918, when John Wade discovered uranium and vanadium mineralization in the Salt Wash Member (Jurassic Morrison Formation) in the Carrizo Mountains in San Juan County, New Mexico, and Apache County, Arizona (Fig. 1; Chenoweth and Learned, 1980). In the 1920's, small quantities of radium ore were shipped from the Carrizo Mountains to an ore-buying station in Colorado and used for therapeutic purposes and in luminous paints. Radium was discovered and produced from the White Signal district in Grant County (Gillerman, 1964) and the Scholle district in Torrance County (U.S. Bureau of Mines, written communication, 1949). By 1925 the production from high-grade pitchblende deposits in Africa had a devastating economic effect on the radium industry in the United States, ending the first "uranium boom" in New Mexico.

Not until World War II did uranium-vanadium deposits become of economic interest again. From 1942 to 1946, the Vanadium Corporation of America (VCA) produced 10,216 tons of ore (2.47% V_2O_5) from the East Reservation lease in the Carrizo Mountains (Chenoweth and Learned, 1980; Bureau of Indian Affairs, written communication, 1942–46). Much of the uranium left in the mill tailings was reprocessed at Durango, Colorado, for use in the Manhattan Project. In 1943, the first evaluation of known uranium deposits in New Mexico was completed by the Union Mines Development Corporation (UMDC). UMDC was a division of Union Carbide and Carbon Corporation, the prime contractor to the Army Corps of Engineers for the Manhattan Project. The Carrizo Mountains contained most of the state's known uranium reserves at that time.

The creation of the AEC in 1947 and the succeeding uranium procurement program sparked extensive exploration, development, and production of uranium deposits in New Mexico and elsewhere. The first shipments of uranium ore in two decades from New Mexico occurred in 1948 from the Carrizo Mountains. Even though uranium was first discovered in the Grants area in the 1920's, not until Paddy Martinez rediscovered similar mineralized outcrops of the Todilto Limestone (Jurassic) in 1950 did commercial exploration begin in that area (Melancon, 1963). The first ore taken from a rim cut in sec. 9, T. 12 N., R. 9 W. in the Todilto Limestone was shipped in December 1950. By early 1951, uranium was discovered in the Poison Canyon Sandstone (Morrison Formation) north of Grants. In November 1951, Anaconda discovered a radiometric anomaly near Laguna by aerial reconnaissance. Subsequent drilling delineated the ☞

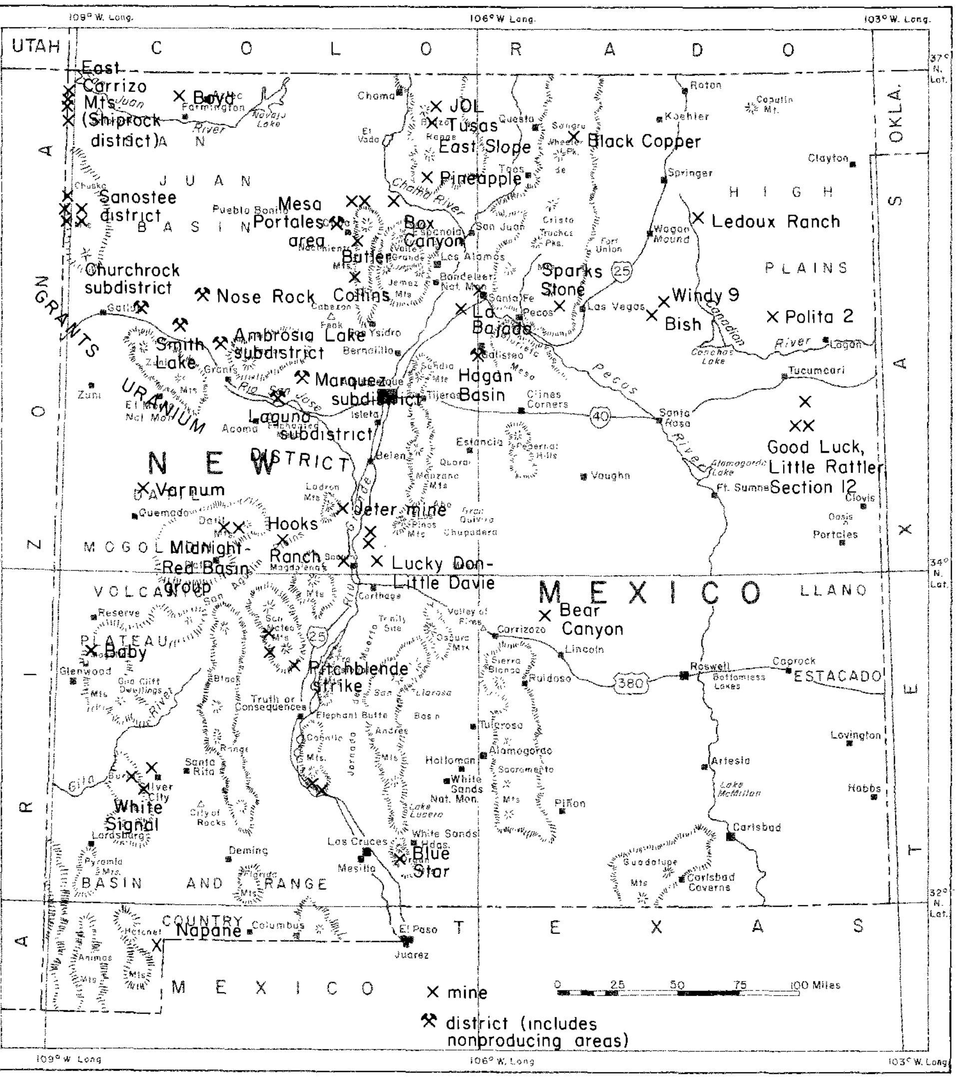

FIGURE 1—Producing uranium mines and districts in New Mexico from 1948 to 1982; x may indicate more than one deposit.

TABLE 1—URANIUM ORE PRODUCTION IN NEW MEXICO FROM 1948 TO 1982 (U.S. DOE, Statistical Data of the Uranium Industry, 1968–1982; U.S. AEC ore and mill receipts tabulated by William Chenoweth and Elizabeth Learned, U.S. DOE). [1]Includes only ore mined in New Mexico; does not include production from in situ leach, mine water, or heap leach. Ore production from 1948 to 1970 includes only "pay" and "no-pay" ores received by AEC. AEC did not pay for shipments less than 0.10% U_3O_8; hence, these shipments were known as "no-pay" ores. [2]Includes production from in situ leach, mine water, and heap leach. Also includes some concentrate production that was mined out of state. [3]Yearly average price of uranium, not spot or market price. [4]Number of producing properties may vary in accordance with the definition of a particular property. For example, Anaconda's Jackpile–Paguate mine is considered one property. [5]New Mexico 1948 and 1949 production was entirely from Carrizo Mountains in San Juan County.

	ORE RECEIVED AT MILLS AND BUYING STATIONS[1]					CONCENTRATE PRODUCTION FROM MILLS OPERATING IN NEW MEXICO[2]					
Calendar year	Tons of U_3O_8 in New Mexico	Grade % U_3O_8	Tons of U_3O_8 in U.S.	Grade % U_3O_8	New Mexico as % U.S. total	Tons of U_3O_8 in New Mexico	Tons of U_3O_8 in U.S.	New Mexico as % U.S. total	Average price per pound U_3O_8 (dollars)[3]	Number of properties in New Mexico	Number of operators[4]
1948	4[5]	0.29	80	0.26	5	—	102	—	7.50	8	1
1949	8[5]	0.17	500	0.29	2	—	177	—	8.77	12	1
1950	11	0.32	800	0.32	1	—	459	—	10.76	19	12
1951	11	0.24	1,100	0.32	1	—	766	—	10.30	19	17
1952	34	0.20	1,300	0.30	3	—	874	—	11.85	37	31
1953	215	0.25	2,300	0.31	9	9	1,163	1	12.27	50	36
1954	666	0.35	3,500	0.32	19	181	1,700	11	12.43	59	45
1955	618	0.23	4,400	0.29	14	847	2,784	30	11.94	68	58
1956	2,888	0.26	8,400	0.28	34	2,891	5,958	49	11.10	58	51
1957	2,585	0.22	9,800	0.27	26	2,534	8,482	30	9.82	55	49
1958	4,032	0.21	14,000	0.27	29	3,604	12,437	29	8.86	53	44
1959	6,982	0.21	17,400	0.25	40	6,772	16,239	42	8.64	60	41
1960	7,892	0.21	18,800	0.23	42	7,760	17,637	44	8.35	57	41
1961	7,848	0.22	18,500	0.23	42	7,750	17,348	45	7.88	57	34
1962	7,894	0.23	17,100	0.24	46	7,293	17,008	43	7.92	57	30
1963	5,132	0.22	14,700	0.25	35	5,512	14,217	39	8.00	46	33
1964	4,716	0.23	13,900	0.26	34	4,747	11,846	40	8.00	42	29
1965	4,709	0.23	10,500	0.24	44	4,591	10,442	44	8.00	36	20
1966	4,892	0.24	9,900	0.23	48	5,076	10,589	48	8.00	41	21
1967	5,816	0.21	10,900	0.21	53	5,933	11,253	53	8.00	33	13
1968	6,443	0.20	12,800	0.21	50	6,192	12,368	50	8.00	31	12
1969	6,210	0.20	12,600	0.20	49	5,943	11,609	51	5.86	29	11
1970	6,057	0.21	13,100	0.20	46	5,771	12,905	45	5.56	32	12
1971	5,594	0.23	13,100	0.21	43	5,305	12,273	43	—	29	9
1972	5,722	0.25	13,900	0.21	41	5,464	12,900	42	—	34	11
1973	4,984	0.23	13,800	0.20	36	4,634	13,235	35	7.10	26	6
1974	5,435	0.18	12,600	0.18	43	4,951	11,528	43	7.90	23	5
1975	5,484	0.18	12,300	0.16	45	5,191	11,600	45	10.50	25	8
1976	6,485	0.19	14,000	0.15	46	6,059	12,747	48	16.10	32	14
1977	7,586	0.18	16,700	0.15	45	6,779	14,940	45	19.75	36	12
1978	9,371	0.15	20,200	0.13	46	8,539	18,490	46	21.60	41	15
1979	8,198	0.12	20,700	0.11	40	7,423	18,730	40	23.85	43	13
1980	8,160	0.12	23,300	0.12	35	7,751	21,850	35	28.15	50	14
1981	6,573	0.12	19,600	0.11	34	6,206	19,240	32	28.70	39	13
1982	3,755	0.18	10,520	0.12	36	3,906	13,430	29	32.41	28	10
TOTAL	163,010		407,100		40	155,614	379,326	41			

Jackpile–Paguate deposit which became the site of the largest open-pit uranium mine in the world. The Jackpile–Paguate mine closed in March 1982 as a result of low demand and low-grade ore; however, reserves are still present at the mine. Additional deposits were discovered and developed in the Laguna, Gallup, Churchrock, and Thoreau areas.

In 1955, Louis Lothman used driller's logs and cuttings from an oil and gas test drilled on Ambrosia dome to estimate the drilling depths to the Morrison sandstones around the dome (Saucier, 1979, p. 15). In April 1955, Lothman began a wildcat drilling program for Mrs. Stella Dysart in the Ambrosia Lake area and encountered mineralized sandstones in the Westwater Canyon Member (Morrison Formation) in his second hole. Additional discoveries were made in quick succession in the Ambrosia Lake area.

Exploration diminished in the 1960's as the end of the AEC's procurement program neared. By the late 1960's and early 1970's exploration soared once again to meet an increase in demand for uranium by the electric power companies. In 1970, Bokum Resources Corporation discovered uranium ore bodies near Mt. Taylor. The Mt. Taylor deposit, now owned by Gulf Oil Corporation, is in the Westwater Canyon Member and is the deepest and largest sandstone deposit to be mined by conventional shaft technology. This mine is now on standby status. Additional ore bodies were discovered in the Laguna, Marquez, Mariano Lake, Crownpoint, and Nose Rock areas.

Exploration and production outside the San Juan Basin have not been very successful. During the 1950's, ore was shipped from 45 properties (Fig. 1); however, only 15 of these properties produced over 100 lbs of U_3O_8. Many of these properties delivered "no-pay" ore to the mills, so-called because the AEC did not pay for shipments assaying less than 0.10% U_3O_8. Only four of these deposits produced over 1,000 lbs of U_3O_8: the Jeter mine in Socorro County produced 58,562 lbs, the La Bajada mine in Santa Fe County produced 27,111 lbs, the Lucky Don–Little Davie in Socorro County produced 4,229 lbs, and the Midnight group in the Datil Mountains in Catron County produced 1,097 lbs. Only the Jeter mine and the Datil Mountains area are believed to contain potential uranium resources today (U.S. Department of Energy, 1980).

Small- to medium-sized low-grade sandstone uranium deposits have been discovered in the Hagan Basin near Cerrillos (Moore, 1979), in the Datil Mountains–Red Basin area in Catron County (Chamberlin, 1981), and on Mesa Portales near Cuba (U.S. Department of Energy written communication, 1979). Only the Datil Mountains–Red Basin area (Midnight group) produced ore; the other areas remain unproductive. Uranium also occurs in the Galisteo Formation (Eocene) in the Hagan Basin area. Union Carbide Corporation began sinking a decline in the late 1970's, but the project was abandoned prior to development of the orebody as a result of poor market conditions. Chamberlin (1981) interprets the uranium deposits in the Red Basin area to have formed at the base of a lateritic-weathering profile developed on the uppermost bed of the Crevasse Canyon Formation (Cretaceous) prior to deposition of the Baca Formation (Eocene). Low-grade uranium mineralization was discovered by New Cinch Uranium Company in the Mesa Portales area in the late 1970's. The Ojo Al-

TABLE 2—URANIUM PRODUCTION IN SAN JUAN BASIN, NEW MEXICO, FROM 1948 TO 1982 (from U.S. DOE records, 1982). [1]Member of Morrison Formation; [2]approximate figures (rounded to nearest 1,000 lbs).

AREA	HOST FORMATION	PRODUCTION (LBS U_3O_8)	PERIOD
Nacimiento, Farmington	Ojo Alamo, Fruitland, Dakota, Morrison, Todilto, Chinle, and Cutler Formations	2,298	1954-59
Shiprock-Carrizo Mts. and Sanostee	Salt Wash Member[1]	160,772	1948-1968
Sanostee	Recapture Member[1]	335,000[2]	1951-1981
	Todilto Limestone	14	1954
Grants district	Dakota Sandstone	512,917	1951-1970
	Morrison Formation (Brushy Basin and Westwater Canyon Members, Jackpile sandstone, Poison Canyon sandstone)	313,690,000[2]	1951-1981
	breccia pipe	134,014	1953-56
	Todilto Limestone	6,736,000[2]	1950-1981
	mine water	4,113,000[2]	1963-1981
	TOTAL	325,684,015	1948-1981

TABLE 3—URANIUM PRODUCTION (INCLUDING HEAP-LEACH AND MINE-WATER RECOVERY) BY COUNTY IN NEW MEXICO FROM 1948 TO 1970; U.S. government contracts only. From U.S. AEC ore production receipts (mill receipts). These figures include total ore that was received at ore-buying stations, including "no-pay" ores (containing less than 0.10% U_3O_8). Grades represent an average of total shipments by county and do not include lbs of uranium obtained from heap-leach and mine-water recovery.

COUNTY	TONS ORE	LBS U_3O_8	GRADE % U_3O_8	YEARS PRODUCING	NUMBER OF PROPERTIES
Catron	502	1,208	0.12	1954-57	4
Cibola	10,612,755	50,341,835	0.24	1952-1970	23
Doña Ana	12	14	0.06	1955	1
Grant	465	1,367	0.15	1953-56	3
Harding	1	2	0.15	1955	1
Hidalgo	9	35	0.19	1955	1
Lincoln	3	1	0.02	1954	1
McKinley	27,597,842	120,391,873	0.22	1951-1970	95
Mora	11	9	0.04	1954	1
Quay	83	91	0.05	1955-58	2
Rio Arriba	227	456	0.09	1954-57	9
Sandoval	438	1,291	0.15	1954-59	3
San Juan	70,803	301,079	0.21	1948-1970	45
San Miguel	64	113	0.09	1955-56	3
Santa Fe	9,661	27,123	0.14	1956-57	2
Sierra	174	453	0.13	1955-1960	6
Socorro	10,104	63,553	0.31	1954-1963	7
Taos	5	3	0.03	1954-57	1
TOTAL	38,303,159	171,130,506	0.22		208

amo Sandstone (Tertiary) is the host for these sandstone uranium deposits.

Uranium milling

Early production from the Carrizo Mountains was processed at the VCA mill in Durango, Colorado. The first limestone and sandstone uranium ores from the Grants area were shipped to the AEC ore-buying station at Monticello, Utah. In January 1952, the first AEC ore-buying station in New Mexico began receiving ore at Shiprock (O'Rear, 1966). The Shiprock buying station closed in 1954 when Kerr–McGee's Shiprock mill began processing ores from the Lukachukai Mountains in Arizona and from the Carrizo Mountains. In January 1955, Kerr–McGee delivered the first shipments of uranium concentrate to the AEC. VCA (later called Foote Minerals) assumed control of the Shiprock mill in 1963 and closed it in 1968. Uranium mills that have operated in New Mexico are listed in Table 5, which includes the years of operation, maximum capacity, and the metallurgical process used.

A second AEC ore-buying station was established at Bluewater in June 1952 because of the availability of groundwater. It remained open until the first Anaconda Bluewater mill began processing ores in September 1953 (O'Rear, 1966). Anaconda's original mill processed only limestone ores from the Grants–Bluewater area. In 1955, Anaconda began construction of a second mill at Bluewater to accommodate sandstone ores. Anaconda's limestone mill was closed in 1959, and the sandstone mill was closed in early 1982 (Table 5).

A third AEC ore-buying station opened near Milan in 1956 to receive the newly discovered ores at Ambrosia Lake (O'Rear, 1966). Four mills began operation in 1958 in the Ambrosia Lake area and were operated by Kerr–McGee, Homestake–New Mexico Partners, Homestake–Sapin Partners, and Phillips Petroleum (Table 5). The Homestake–New Mexico Partners and the Homestake–Sapin Partners mills were consolidated in 1962, and a smaller Homestake–New Mexico Partners mill was closed. United Nuclear later acquired Sapin and the controlling interest in the mills. In March 1981, Homestake and United Nuclear Corporation dissolved their joint mining and milling operations, and Homestake now owns the mines and mill. In 1963, United Nuclear Corporation bought the Phillips Petroleum mill and mines; however, the newly purchased mill was closed later that year. Only two uranium mills are presently operating at reduced production in New Mexico: the Kerr–McGee mill and the Homestake mill at Ambrosia Lake (Table 5).

Sohio Petroleum (Sohio Western) and Reserve Oil and Minerals Corporation began operating the Laguna mill in 1977, but they were forced to close it in June 1981, as a result of poor market conditions (Table 5). Ore from the JJ No. 1 mine and United Nuclear Corporation's St. Anthony mines was processed at this mill. In 1982 Sohio and Reserve settled a financial dispute; Sohio obtained 100% ownership of the mill and mine. The mine and mill are currently on standby status.

United Nuclear Corporation began operating a mill at Churchrock in 1979. In July 1979, a breach occurred in the earthen tailings dam, and mill tailings were discharged into the Rio Puerco. The mill was closed until October 1979, and operated only intermittently from that time until its final closure in May 1982.

Construction is 90% complete on Bokum Resources Corporation's Marquez mill. Legal proceedings and financial difficulties have halted construction on the mill and placed the nearby Marquez mine on standby status. Construction has not yet begun on the proposed Gulf mill at Mt. Taylor.

Production statistics

The AEC bought most of the uranium ore produced in New Mexico from 1948 through 1970, although chemical companies may have purchased minor amounts of ore. Some companies in the Grants district began selling uranium to utility companies in 1967, prior to the termination of the AEC program on December 31, 1970. Two hundred and eight properties reported production from 1948 to 1970 (Fig. 1). Annual production of uranium in New Mexico from 1948 to 1982 is graphically illustrated in Fig. 2 and listed in Table

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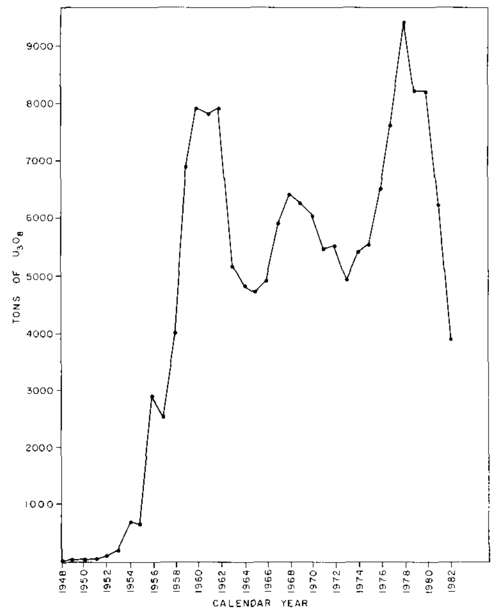

FIGURE 2—Uranium production in New Mexico from 1968 to 1982 (U.S. DOE, Statistical Data of the Uranium Industry, 1968–1982).

1. Most of the production after 1964 was from the Grants district in McKinley and Cibola Counties, with minor production from the Sanostee area in San Juan County (Table 2).

In the late 1960's, the demand for uranium by the electric power companies increased. Uranium production declined in the early 1970's because of a saturated market and a long strike against Kerr–McGee in 1973 (Fig. 2). Production increased again in the mid- to late-1970's, due in part, to the increase in the spot price for uranium from $6 per lb of U_3O_8 in 1970 to over $48 per lb by 1979. New Mexico produced 8,539 tons of concentrate U_3O_8 in 1978, 46% of the total U.S. production; in 1979, 7,423 tons of U_3O_8 were produced, 40% of the total U.S. production (Table 1).

Since 1978, a decrease in the demand for uranium concentrate has resulted in a decrease in production in New Mexico. In 1981 only 6,210 tons of U_3O_8 were produced, 32% of the total U.S. production, and production for 1982 was only 3,906 tons of U_3O_8. The decrease in demand for uranium concentrate is a result of many factors including overestimates of projected requirements of electricity, a change in public attitudes and acceptance of nuclear power (exacerbated by the Three Mile Island accident), increase in construction costs, high interest rates, increase in taxes, and the present economic slump. Not a single power plant has been ordered since 1978 and at least 50 reactors have been cancelled.

Uranium production by geologic host formation is listed in Tables 2 and 4. Relatively minor quantities of uranium have been produced from Jurassic (except the Morrison Formation), Cretaceous, and Permian sediments; Tertiary and Precambrian veins and pegmatite deposits; and Tertiary, Triassic, and Pennsylvanian sediments. Since 1964), however, most of New Mexico's uranium production has come from the Morrison Formation in McKinley, Cibola, and San Juan Counties. All four members of the Morrison Formation (Jurassic)—Salt Wash, Recapture, Westwater Canyon, and Brushy Basin Members—have produced uranium, but the bulk of the mineralization is in the Westwater Canyon Member.

Present status of uranium industry in New Mexico

In 1978, 40–50 mines were in operation in the state. Currently only nine mines, one in

TABLE 4—Uranium production (including heap-leach and mine-water recovery) by host formation in New Mexico from 1948 to 1970; U.S. government contracts only (from U.S. AEC ore production receipts). These figures include total ore received at ore-buying stations, including "no-pay" ores (containing less than 0.10% U_3O_8). Grades represent an average of total shipments by host rock and do not include lbs of uranium obtained from heap-leach or mine-water recovery. *An estimated 52,160 tons of ore containing 200,300 lbs of U_3O_8 mined from the Churchrock mine came from the Dakota Sandstone; remaining ore was from Westwater Canyon Member. The Churchrock mine is counted twice. [1]Members of Morrison Formation.

FORMATION/HOST	TYPE OF DEPOSIT	TONS ORE	LBS U_3O_8	% U_3O_8	NUMBER OF PROPERTIES
COLORADO PLATEAU					
Westwater Canyon Member[1]	sandstone	24,488,191	105,394,561	0.22	40
Jackpile bed[1]	sandstone	9,580,208	46,532,617	0.24	3
Salt Wash Member[1]	sandstone	33,796	160,998	0.24	35
Recapture Member[1]	sandstone	37,071	140,763	0.19	7
Todilto Limestone	limestone	1,063,338	4,631,007	0.22	43
Brushy Basin Member[1] (including Poison Canyon sandstone)	sandstone	2,949,971	12,635,530	0.21	26
*Dakota Sandstone	sandstone, coal	123,945	512,917	0.22	9
Fruitland Formation	sandstone	74	74	0.05	1
Ojo Alamo Sandstone	sandstone	22	48	0.11	1
Mesaverde Group	sandstone	495	1,194	0.12	3
Westwater Canyon Member[1]	breccia pipe	5,326	134,014	1.26	1
Chinle and Cutler Formations	sandstone	95	201	0.11	6
Point Lookout Sandstone	sandstone	8	3	0.02	1
mine water recovery	—	—	893,787	—	—
subtotal		38,282,540	171,037,714	—	176
BASIN AND RANGE					
Tertiary intrusives and volcanics	magmatic-hydrothermal	9,786	27,485	0.14	4
Magdalena Group	magmatic-hydrothermal	12	14	0.06	1
Precambrian Granite	magmatic-hydrothermal	465	1,367	0.15	3
Santa Fe Group	sandstone	12	12	0.05	1
Abo and Madera Formations	sandstone	40	85	0.11	4
Baca Formation	sandstone	87	306	0.18	1
San Andres Limestone, Santa Fe Group, and Madera Formation	vein-type	10,010	63,250	0.32	6
Popotosa Formation	sandstone	14	6	0.02	1
U-Bar Formation	magmatic-hydrothermal	9	35	0.19	1
subtotal		20,435	92,560		22
GREAT PLAINS					
Chinle Formation	sandstone	132	172	0.06	4
Sangre de Cristo Formation	sandstone	11	9	0.04	1
Morrison Formation	sandstone	1	2	0.15	1
subtotal		144	183		6
SOUTHERN ROCKY MOUNTAINS					
Precambrian granite	magmatic-hydrothermal	21	15	0.04	3
Precambrian pegmatite	pegmatite	19	34	0.08	2
subtotal		40	49		5
TOTAL		38,303,159	171,130,506		209*

situ leaching operation, and two mills are operating in New Mexico. Many of the mines and mills that have closed within the last three years are on standby status with small maintenance crews. Employment by the uranium industry in New Mexico has dropped from over 6,800 people in 1979 and 1980 to 2,613 people in 1982 (Table 6; Fig. 3). Land held by uranium companies for exploration, development, and mining has dropped from 4,652,000 acres in 1980 to 3,615,217 acres in 1983 (Table 7). Total surface drilling for uranium in New Mexico has dropped from 11.02 million ft in 1976 to only 0.6 million ft in 1982 (Table 8; Fig. 4). These statistics are further indications of the decline of the uranium industry in New Mexico. The major problem facing the uranium industry today is that the supply of uranium concentrate (yellowcake) exceeds the current demand. In addition, foreign suppliers (for example, Canada and Australia) are selling uranium at prices below domestic production costs, thereby forcing the spot or market price to decline. Aside from lower production costs, uranium deposits in Canada and Australia are higher in grade and tonnage than deposits in the United States. The uranium industry cannot increase the demand for additional uranium concentrate; therefore, the industry cannot expect to recover until current supplies are consumed by operating needs of current or new nuclear power plants. The uranium industry needs to discover higher grade deposits and to reduce production costs in order to adequately compete with foreign producers. In situ leaching of orebodies similar to Mobil's Crownpoint, New Mexico, project may be one example of achieving lower production costs. Domestic uranium producers control a proved and assured uninterrupted supply of uranium which foreign suppliers have yet to demonstrate. The assurance of a continued uranium supply, coupled with the fact that the price of uranium is an insignif- ☞

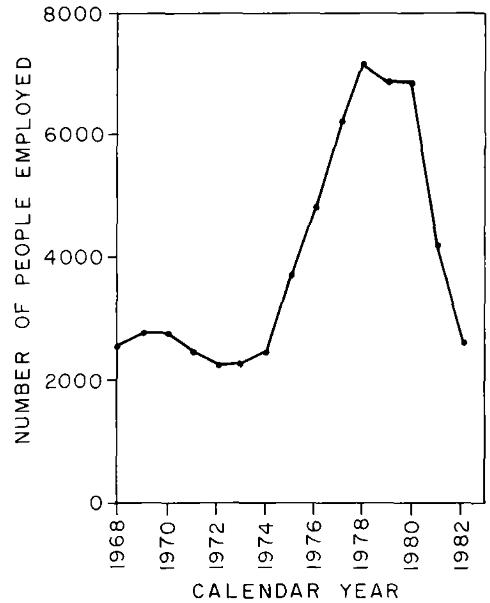

FIGURE 3—Employment in mining and milling of uranium in New Mexico from 1968 to 1982 (U.S. DOE, Statistical Data of the Uranium Industry, 1968–1982).

TABLE 5—URANIUM PROCESSING MILLS IN NEW MEXICO FROM 1953 TO 1983 (Jones, 1977; Chenoweth, 1976; O'Rear, 1966). [1]See Jones (1977) and Merritt (1971) for additional details and mill flow sheets concerning metallurgical processes; [2]VCA (Vanadium Corporation of America).

COMPANY	LOCATION	YEARS OPERATED	MAXIMUM CAPACITY (TONS/DAY)	PLANNED PRODUCTION IN 1983 (TONS/DAY)	PROCESS USED[1]
Kerr-McGee Nuclear Corp. (V.C.A.-Foote Minerals assumed control in 1963)[2]	*Shiprock*	1954-1968	*500*	*closed*	acid *leach*
Anaconda	Bluewater	1953-59 1956-1982	1,200 6,000	closed closed (400 in 1982)	alkaline leach acid leach
Phillips Petroleum (United Nuclear Corp. bought Phillips' *interests in 1963)*	Grants	1958-1963	1,750	closed	alkaline leach
Kerr-McGee Nuclear Corp.	Grants	1958-present	7,000	2,000	acid leach
Homestake-New Mexico Partners (consolidated with UNC-Homestake Partners in 1962)	Grants	1958-1962	750	closed	acid leach
Homestake-Sapin Partners (later United Nuclear Corp.-Homestake Partners, owned exclusively by Homestake since 1981)	Grants	1958-present	3,500	375	alkaline leach
Sohio Western-Reserve (mill owned exclusively by Sohio since 1982)	Laguna	1977-1981	1,660	on standby	acid leach
United Nuclear Corp. (operating 1979-1982 intermittently due to a tailings spill)	Churchrock	1978-1982	3,000	on standby	acid leach
Bokum	Marquez	construction 90% complete	2,000	construction halted	acid leach
Gulf	San Mateo	planned	4,200	planned	acid leach

TABLE 6—NUMBER OF PERSONS EMPLOYED IN MINING AND MILLING OF URANIUM IN NEW MEXICO FROM 1968 TO 1982. These numbers do not include persons working in the exploration field or in in situ leaching operations (U.S. DOE, Statistical Data of the Uranium Industry, 1969–1982).

	NEW MEXICO			UNITED STATES		
YEAR	TOTAL MINING	TOTAL MILLING	TOTAL NEW MEXICO	TOTAL MINING	TOTAL MILLING	TOTAL UNITED STATES
1963	2,003	558	2,561	4,440	1,717	6,157
1969	2,112	590	2,702	4,702	1,725	6,427
1970	2,143	604	2,747	4,428	1,678	6,106
1971	1,860	563	2,423	4,218	1,649	5,867
1972	1,635	543	2,178	3,721	1,530	5,251
1973	1,638	578	2,216	3,516	1,522	5,038
1974	1,857	621	2,478	3,928	1,668	5,596
1975	2,857	852	3,709	5,386	2,237	7,623
1976	3,833	1,046	4,879	7,042	2,727	9,769
1977	5,264	1,021	6,285	10,615	2,448	13,063
1978	6,021	1,127	7,148	12,071	3,053	15,124
1979	5,666	1,160	6,826	12,755	3,236	15,991
1980	5,679	1,145	6,824	11,768	3,251	15,019
1981	3,398	821	4,219	7,473	2,367	9,840
1982	2,029	584	2,613	5,057	1,956	7,013

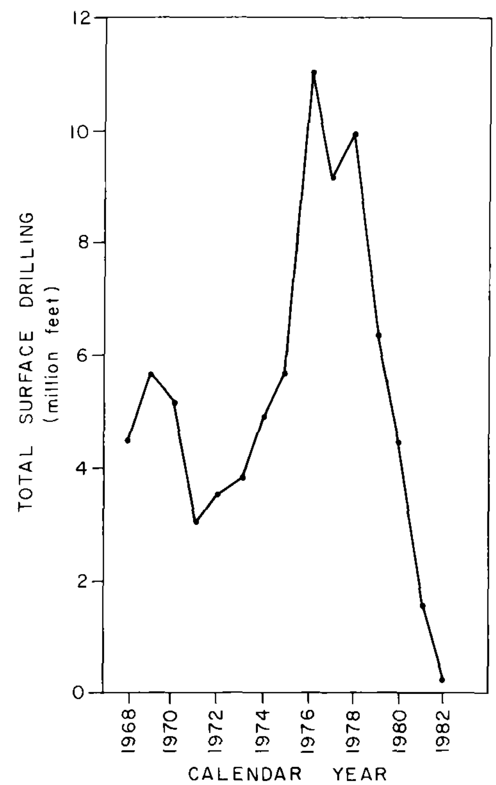

FIGURE 4—Total surface drilling in New Mexico from 1968 to 1982 (U.S. DOE, Statistical Data of the Uranium Industry, 1968–1982).

icant cost of the overall investment of a nuclear power plant, may encourage utility companies to purchase domestic uranium.

Approximately 35% of the total \$50 per lb uranium reserves in the United States is in New Mexico, which amounts to 201,000 tons of U_3O_8 (Table 9). New Mexico contains only 2% of the total \$30 per lb probable potential resources in the United States, which amounts to 16,000 tons of U_3O_8 (McLemore, 1981). With the recovery of the uranium industry, New Mexico will continue to supply a considerable portion of the United States' uranium requirements. The question remains: if and when will the demand for domestic supplies of uranium increase?

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TABLE 7—LAND HOLDINGS (AS OF JANUARY 1, 1983) FOR URANIUM EXPLORATION AND MINING FROM 1968 TO 1983 IN ACRES (U.S. DOE, Statistical Data of the Uranium Industry, 1969–1982).

YEAR	NEW MEXICO	TOTAL UNITED STATES	% OF UNITED STATES TOTAL
1968	6,292,000	16,836,000	37
1969	7,228,000	21,341,000	34
1970	8,065,000	27,279,000	30
1971	4,717,000	24,406,000	19
1972	4,119,000	19,007,000	22
1973	3,109,000	17,677,000	18
1974	3,158,000	18,774,000	17
1975	3,378,000	21,276,000	16
1976	3,663,000	22,911,000	16
1977	3,885,000	27,083,000	14
1978	3,855,000	29,311,000	13
1979	4,279,000	32,668,000	13
1980	4,652,000	35,161,000	13
1981	4,392,000	35,635,000	12
1982	3,685,000	34,310,000	11
1983	3,615,217	32,859,000	11

TABLE 8—TOTAL SURFACE DRILLING STATISTICS FOR NEW MEXICO FROM 1968 TO 1982; these figures are used as a measure of exploration activity (U.S. DOE, Statistical Data of the Uranium Industry, 1969–1982).

CALENDAR YEAR	NEW MEXICO TOTAL SURFACE MILLION FEET	UNITED STATES TOTAL SURFACE MILLION FEET	% TOTAL UNITED STATES
1968	4.50	23.80	19
1969	5.65	29.90	19
1970	5.18	23.53	22
1971	3.05	15.45	20
1972	3.55	15.42	23
1973	3.89	16.42	24
1974	4.86	22.00	22
1975	5.70	26.00	22
1976	11.02	34.00	32
1977	9.10	41.00	22
1978	9.90	47.00	21
1979	6.30	40.80	15
1980	4.45	27.85	16
1981	1.51	14.12	11
1982	0.60	6.10	10

TABLE 9—DISTRIBUTION OF URANIUM RESERVES IN NEW MEXICO AS OF JANUARY 1, 1983 (U.S. Department of Energy, written communication, 1983) [1]Includes \$30 reserves; NA, not available.

	New Mexico Tons of U_3O_8	United States Tons of U_3O_8	% U.S. Total
\$30 Reserves	73,000	NA	NA
\$50 Reserves[1]	201,000	576,000	35

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NMGS Fall Field Conference

The 34th annual field conference of the New Mexico Geological Society will be held in the Socorro area October 13, 14, and 15, 1983. The field trip will be by 4-wheel drive vehicles and will visit some spectacular canyon and mesa country that few people have seen. The Registration Chairman, Dr. Richard M. Chamberlin, can be reached at the New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801 (505) 835-5310. A registration brochure will be mailed to NMGS members in August. An idea of the breadth of subjects to be covered can be gleaned from the following preliminary list of papers to be published in the guidebook.

History and archaeology

The refounding of Socorro, 1816, by *Marc Simmons*, Cerrillos, NM

The Civil War in New Mexico: Tall tales and true, by *S. Wilson* and *R. A. Bieberman*, NMIMT and NMBMMR

Gustav Billing, the Kelly mine, and the great smelter at Park City, Socorro County, New Mexico, by *R. W. Eveleth*, NMBMMR

Excavation of a Piro Indian Pueblo near Socorro, by *Linda Cordell* and *Amy Earle*, UNM

Cultural-historical reconstructions of Pueblo Indians in the Socorro area, by *M. P. Marshall*, Corrales, NM

Tectonics, structure, and geophysics

Tectonic map of the Socorro region, by *C. E. Chapin*, NMBMMR

Composite residual total intensity aeromagnetic map of the Socorro region, by *Lindrith Cordell*, USGS

Bouguer gravity anomaly map of the Socorro region, by *G. R. Keller*, UTEP

Cenozoic domino-style crustal extension, Lemitar Mountains, New Mexico, by *R. M. Chamberlin*, NMBMMR

Structural problems along the east side of the Socorro Basin, by *C. T. Smith*, NMIMT

Laramide Sierra uplift: evidence for major pre-rift uplift in central and southern New Mexico, by *S. M. Cather*, University of Texas at Austin

Geodetic evidence for contemporary vertical deformation in the Socorro area, by *S. C. Larsen*, *R. E. Reilinger*, and *J. E. Oliver*, Cornell University

Effects of uplift on the Rio Grande above the Socorro magma body, by *Shunji Ouchi*, Colorado State University

Magma bodies in the Rio Grande rift in central New Mexico, by *A. R. Sanford*, NMIMT

Seismicity of the Socorro area of the Rio Grande rift, by *A. R. Sanford*, *L. H. Jaksha*, and *D. Wieder*, NMIMT

Magnetotelluric soundings along the COCORP seismic profile in the central Rio Grande rift, by *P. S. Mitchell* and *G. R. Jiracek*, San Diego State University

Precambrian geology

Geology and U-Pb geochronology of Proterozoic rocks in the vicinity of Socorro, New Mexico, by *S. A. Bowring*, *S. C. Kent*, and *W. Sumner*, University of Kansas and NMBMMR

Transposition structures in Precambrian rocks of New Mexico, by *J. F. Callender*, UNM

Stratigraphy, sedimentology, and paleontology

The Pennsylvanian System, Socorro region, New Mexico: stratigraphy, petrology, depositional environments, by *W. T. Siemers*, Phillips Petroleum Company

Paleocurrent analysis of early Permian Abo Formation, Cerros de Amado area, Socorro, New Mexico, by *J. A. Cappa* and *J. R. MacMillan*, FMC Corp. and NMIMT

Plant fossils and lithostratigraphy of the Abo Formation (Lower Permian) of the Socorro area and plant biostratigraphy of Abo red beds in New Mexico, by *Adrian Hunt*, NMIMT

Stratigraphy, paleontology, depositional framework, and nomenclature of marine Upper Cretaceous rocks, Socorro County, New Mexico, by *S. C. Hook*, *W. A. Cobban*, and *C. M. Molenaar*, Getty Oil Co., and USGS

The thick splay depositional style of the Crevasse Canyon Formation, Cretaceous of west-central New Mexico, by *Steven Johansen*, University of Texas at Austin

Late Cretaceous (Turonian) vertebrate paleontology, Joyita Hills, by *D. L. Wolberg*, NMBMMR

Lacustrine deposits of the Eocene Baca Formation, western Socorro County, New Mexico, by *S. M. Cather*, University of Texas at Austin

The Baca Formation and the Eocene–Oligocene boundary in New Mexico, by *S. G. Lucas*, UNM

Cenozoic stratigraphy of the northeastern Mogollon–Datil volcanic field: an introduction, by *G. R. Osburn* and *C. E. Chapin*, NMBMMR

Fossil plants from the Early Neogene Socorro flora, central New Mexico, by *H. W. Meyer*, University of California at Berkeley

Plio–Pleistocene mammals from Ojo de la Parida, by *D. L. Wolberg*, NMBMMR

Volcanic geology

Ash-flow tuffs and cauldrons in the northeastern Mogollon–Datil volcanic field: a summary, by *G. R. Osburn*, NMBMMR

Preliminary results from a paleo- and rock-magnetic study of Oligocene ash-flow tuffs, Socorro County, New Mexico, by *W. C. McIntosh*, NMBMMR

Miocene rhyolitic volcanism in the Socorro area of New Mexico, by *D. J. Bobrow*, *P. R. Kyle*, and *G. R. Osburn*, NMIMT and NMBMMR

Economic geology

Petroleum exploration in Socorro County, by *R. F. Broadhead*, NMBMMR

Petroleum exploration along the southern margin of the Colorado Plateau, by *B. A. Black*, Black Oil, Inc.

Coal resources of Socorro County, New Mexico, by *J. Cima Osburn*, NMBMMR

Uranium in the Socorro area, New Mexico, by *V. T. McLemore*, NMBMMR

Carbonatites in the Lemitar and Chupadera Mountains, Socorro County, New Mexico, by *V. T. McLemore*, NMBMMR

Lithium-enriched altered ashes of the Popotosa Formation, Lemitar Mountains, by *S. Asher-Bolinder*, USGS

Geology, alteration, and genesis of the Luis Lopez manganese district, New Mexico, by *T. L. Eggleston*, *D. I. Norman*, *C. E. Chapin*, and *S. Savin*, NMIMT and Case Western Reserve University

Epithermal manganese mineralization, Luis Lopez manganese district, by *D. I. Norman*, *T. L. Eggleston*, and *K. Bazrafshan*, NMIMT

Mississippi Valley-type lead-fluorite-barite deposits of the Hansonburg mining district, by *B. R. Putnam III*, *D. I. Norman*, and *R. W. Smith*, Newmont Exploration, Ltd., NMIMT and St. Joe Minerals Corp.

History and geology of precious metal occurrences in Socorro County, by *R. M. North*, NMBMMR

Preliminary investigation of the origin of the Riley "travertine," northwestern Socorro County, New Mexico, by *J. M. Barker*, NMBMMR

Geomorphology and Quaternary geology

Progress report on the Late Cenozoic geologic evolution of the lower Rio Puerco, by *D. W. Love* and *J. D. Young*, NMBMMR

Pleistocene Lake Trinity, an evaporite basin in the northern Jornada del Muerto, New Mexico, by *J. T. Neal*, *R. E. Smith*, and *B. F. Jones*, Sandia Natl. Labs., U.S. Minerals Management Service, and USGS

Rock glaciers on the west slope of South Baldy, Magdalena Mountains, Socorro County, New Mexico, by *J. W. Blagbrough* and *H. G. Brown III*, U.S. Forest Service

Hydrogeology and engineering geology

Hydrogeology of the Socorro and La Jencia Basins, by *S. Anderholm*, USGS

Ground-water circulation in the Socorro geothermal area, by *G. W. Gross* and *R. Wilcox*, NMIMT

Hydrological investigations near Socorro, New Mexico, using electrical resistivity, by *G. R. Jiracek*, San Diego State University

The Rio Salado at flood, by *A. C. Simcox*, NMIMT

Floods and recharge relationships of the lower Rio Puerco, by *D. Heath*, NMIMT

Engineering geology of the Socorro area, by *G. D. Johnpeer*, and *B. M. Hamil*, NMBMMR