THE GRANTS URANIUM REGION

Geologic Map 31, revised 1979

by James W. Melvin

INTRODUCTION

The Grants region is the largest uranium province in the United States. Located in west-central New Mexico (southern part of Colorado Plateau), the region encompasses all of the known large uranium deposits in the state. At present the region extends from the Rio Puerco (17 mi west of Albuquerque) to northeast of Gallup (136 mi west of Albuquerque)—a distance of about 100 mi. Maximum width (northeast-southwest) is about 25 mi. The region, situated in Sandoval, Valencia, and McKinley Counties, is divided into three mining districts: Laguna on the east, Ambrosia Lake in the middle, and Church Rock (also called the Gallup district) on the west. An area composed of the eastern part of the Church Rock district and the western part of the Ambrosia Lake district is referred to by some as the Smith Lake district.

Most of the region is a semiarid terrain of mesas, cuestas, and broad valleys. Lava flows are extensive between Laguna and Grants. Mount Taylor (11,301 ft), a later Tertiary volcano 18 mi northwest of Laguna, is heavily forested. The uranium-producing localities range in elevation from about 5,700 ft to about 7,400 ft.

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HISTORY

Carnotite, a yellow uranium vanadate, was recognized in the region about 1920. A chance discovery in 1950 of uranium in the Todilto Limestone at Haystack Butte northwest of Grants resulted in the first uranium ore production; a mill to treat this "limestone ore" was completed by the Anaconda Company in 1953. Airborne radiometric surveillance led to the discovery in 1951 of a large uranium deposit in the Jackpile sandstone near Laguna; modification of the Anaconda mill to treat this ore was completed in 1955. Also in 1951 the first commercial uranium deposit in sandstone in the Ambrosia Lake district was discovered (Melancon, 1963, p. 4). This sandstone unit is named the Poison Canyon tongue of the Westwater Canyon Member of the Morrison Formation. The discovery drew attention to adjacent areas on the north where the same beds are concealed by younger rocks. In 1955, the discovery of radioactive cuttings at an abandoned oil test near Ambrosia Lake prompted the drilling that found the Dysart No. 1 deposit, the first of the large uranium mines producing from the Westwater Canyon Member.

By 1959 five mills and dozens of mines were in operation. A period of expansion and consolidation ensued, followed by an interval of reduced mining and exploration in the late 1960's and early 1970's. Increase in demand for uranium led to a sustained second generation of exploration and development that began in 1974, with many firms participating. By the end of 1978 the region had produced about 66 million tons of ore containing 135,000 tons of U_3O_8, a 40-percent share of all United States uranium production (U.S. Department of Energy, 1979). Several current mine-construction projects will have shaft depths of 2,000 to 3,400 ft. These installations entail production lead times of six to eight years and aggregate financial outlays amounting to several billions of dollars.

GEOLOGY

The geology of the Grants uranium region is well documented (bibliographies are listed in references at end).

Uranium ores have been produced from the following stratigraphic units: Dakota Formation, Morrison Formation, Summerville Formation. Todilto Limestone, and Entrada Sandstone. The very minor uranium occurrences in the Summerville Formation and the Entrada Sandstone seem to be localized near deposits in Todilto Limestone (Late Jurassic). The Todilto deposits themselves, though numerous, are negligible in quantity relative to the deposits in the Morrison Formation. Radiometric dating of Todilto ores gives calculated ages of 105 m.y. to 180 m.y. (Squyres, 1969, p. 135-137); uranium deposits in the Todilto Limestone may have been formed before the Morrison Formation was deposited. Uranium ore has been produced from several small- to medium-sized deposits in the Dakota Formation.

Almost all of the region's production has come from deposits in sandstones of the Morrison Formation (Upper Jurassic); **only Morrison-host deposits are shown on the map.** Some of these deposits are very large. Several, operating as single mines, contain more than 10 million pounds of U_3O_8. A few deposits are believed to contain more than 50 million pounds of U_3O_8. Gulf's Mount Taylor deposits, under development (map letter H and no. 37), may contain an aggregate of more than 100 million pounds of U_3O_8 over a length of several miles.

In this region, the Morrison Formation is composed of three members. The Recapture Member (at the base of the Morrison) contains only traces of uranium mineralization. The overlying Westwater Canyon Member, the principal host rock for the uranium deposits, consists of sandstone interbedded with lesser amounts of mudstone. Overlying the Westwater is the Brushy Basin Member (at the top of the Morrison), which is composed mostly of mudstone; however, the Brushy Basin includes scattered sandstone beds, some containing substantial uranium deposits. The Poison Canyon tongue is one of these beds. Another sandstone bed, at the top of the Brushy Basin Member (in the Laguna district), is the Jackpile sandstone, the host rock for Anaconda's Jackpile and Paguate orebodies at the site of the United States' largest open-pit uranium mine.

The sandstone host-rocks and their uranium deposits have many persistent characteristics in common. The sandstones are continental fluvial deposits, poorly sorted, crossbedded, and arkosic; they contain scattered organic debris of twigs and logs. Tuffaceous fragments (Cadigan, 1967, p. 81) and sanidine (Austin, 1963, p. 40) are common. The uranium deposits occur at localities where finely dispersed carbonaceous material is especially abundant; consequently, most of the ore is black or gray. The carbonaceous material is a primary control of uranium mineralization (Kelley, Kittel, and Melancon, 1968, p. 767) and is evidently a humate residue (Swanson and Palacas, 1965). Principal uranium minerals are coffinite and uraninite. Many other uranium minerals have been identified (Granger, 1963; Kelley, Kittel, and Melancon, 1968). Radiometric dating of Morrison Formation ores has given calculated ages of 100 m.y. to 113 m.y. (Squyres, 1969, p. 135-137).

The orebodies occur in two distinctive habits. One type of deposit called primary ore (trend, or pre-fault ore) occurs in elongate discontinuous podlike masses up to many hundreds of feet wide and over a mile long. With few exceptions, the long dimension trends northwesterly, roughly parallel to the orientation of the Grants uranium region. The upper and lower margins of these deposits are crudely parallel to stratification and are generally near horizontal; thickness ranges from a few inches to as much as 20 ft or, rarely, 50 ft.

The second type of deposit is called redistributed (stack, or post-fault) ore. These deposits have undergone a more recent process of remobilization and redeposition. They differ from primary ore principally in geometry, tending to be roughly equant laterally, up to several hundred feet across, and with vertical thickness from a few tens of feet to more than 100 ft.

The grade of uranium mineralization is similar in both types of deposits. Maximum uranium content of ores varies from about 0.25 percent U_3O_8 to, rarely, about 5 percent U_3O_8. The minimum grade limit is determined by economic factors that have varied over the years. Material grading as low as 0.05 percent U_3O_8 has been mined. For many years the average production grade was 0.22 percent U_3O_8; however, the 1978 average production grade was 0.15 percent. This reflects a gradual decline in recent years of the minimum mill-feed grade, in response to changes in production economics.

Some attributes of the geologic processes that generated the uranium deposits of the Grants region continue to be the subject of intensive research and of lively discussion. The "envelope" or "roll-front" model (Bailey, 1964; Melin, 1964), frequently cited in studies of sandstone-host uranium deposits in other regions, has not been widely invoked in the Grants region, although it clearly applies to certain deposits. Several kinds of genetic processes seem to have been operative in the Grants region (Adams and others, 1978; Galloway, 1978; Melvin, 1976).

RESERVES AND POTENTIAL RESOURCES

The U.S. Department of Energy (1979) estimates uranium reserves in New Mexico at the end of 1978 as follows:

Tons of ore	309,700,000
Average grade	0.12% U_3O_8
Contained pounds U_3O_8	750,000,000
Percent of total U.S. U_3O_8	54%

These reserves are considered producible at a forward cost of $30 per pound U_3O_8 (1979 dollars); virtually all are located in the Grants uranium region, 99 percent in deposits in the Morrison Formation (Hilpert, 1969, p. 145). The DOE quantities provide for mining losses and mining dilution but not for mill recovery. The $30 forward-cost basis does not include any pre-estimate expenditures, such as property acquisition, exploration, and mine and mill construction; taxes, cost of money, and profit are also excluded. Hence, the actual production cost for an appreciable portion of the reserves cited will be considerably more than $30 per pound U_3O_8.

The ultimate potential of the Grants uranium region remains indefinite. Referring to all of northwestern New Mexico, Hilpert (1969, p. 1), concluded:

> Undiscovered or potential reserves probably are several times the combined production and mine reserves estimated as of January, 1966, and may amount to as much as 200 million tons of material, expected to average about 0.15 percent U_3O_8. These resources are expected to be almost entirely peneconcordant deposits, principally in large ones in sandstone lenses in the Morrison Formation, but important deposits are also anticipated in sandstone lenses in the Dakota Sandstone and in limestone beds in the Todilto Limestone. Most of these resources probably are concentrated in the southern San Juan mineral belt, now generally referred to as the Grants mineral belt.

Major discoveries announced since January 1966 total about 100 million tons of ore (indicated and inferred reserves) at an average grade close to Hilpert's expectation. These discoveries, especially those in new localities such as Nose Rock and Bernabe, support his estimate of the resource potential of the region. An intriguing recent event in the region has been a 26-hole program of stratigraphic-reconnaissance core-drilling by DOE in the East Chaco Canyon area (T. 18-21 N., R. 6-10 W.). This project, still in progress at press time, has found very significant uranium mineralization (U.S. Department of Energy, 1978); however, the formidable depths, ranging from 3,975 to 4,670 ft, may preclude development in the foreseeable future of any deposits present.

EXPLORATION METHODS

Exploration is conducted by means of rotary drills mounted on trucks. On the flanks of Mount Taylor and in other localities where drilling depths exceed 3,000 ft, down-hole whipstocks have been used to reduce costs. Drill holes are probed radiometrically using truck-mounted equipment. Most explorationists obtain a few cores as a check on radiometric logging. Radiometric/chemical disequilibrium seldom exceeds 10 percent. A recent innovation in the region has been the use of neutron-activated logging tools (DFN and PFN) to make direct down-hole measurement of chemical uranium content (Givens and others, 1976).

With the exception of deposits found at outcrops in the early years of the region's development, the uranium deposits are blind, lacking any kind of surface expression. Hence, exploration strategies in the region are based on either one of two assumptions: distribution of deposits is random, or distribution of deposits is systematic. The first assumption leads to exploration decisions based on statistics (Griffiths and Singer, 1970). The second assumption leads to exploration decisions based on geologic interpretation of the distribution and attributes of the known deposits. Many explorationists combine elements of both strategies.

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