Uranium deposits in the Poison Canyon Trend, Ambrosia Lake Subdistrict, Grants Uranium District, McKinley and Cibola counties, New Mexico

Virginia T. McLemore
2021, pp. 159-170. https://doi.org/10.56577/FFC-71.159

in:
Geology of the Mount Taylor area, Frey, Bonnie A.; Kelley, Shari A.; Zeigler, Kate E.; McLemore, Virginia T.; Goff, Fraser; Ulmer-Scholle, Dana S., New Mexico Geological Society 71st Annual Fall Field Conference Guidebook, 310 p. https://doi.org/10.56577/FFC-71

This is one of many related papers that were included in the 2021 NMGS Fall Field Conference Guidebook.

Annual NMGS Fall Field Conference Guidebooks

Every fall since 1950, the New Mexico Geological Society (NMGS) has held an annual Fall Field Conference that explores some region of New Mexico (or surrounding states). Always well attended, these conferences provide a guidebook to participants. Besides detailed road logs, the guidebooks contain many well written, edited, and peer-reviewed geoscience papers. These books have set the national standard for geologic guidebooks and are an essential geologic reference for anyone working in or around New Mexico.

Free Downloads

NMGS has decided to make peer-reviewed papers from our Fall Field Conference guidebooks available for free download. This is in keeping with our mission of promoting interest, research, and cooperation regarding geology in New Mexico. However, guidebook sales represent a significant proportion of our operating budget. Therefore, only research papers are available for download. Road logs, mini-papers, and other selected content are available only in print for recent guidebooks.

Copyright Information

Publications of the New Mexico Geological Society, printed and electronic, are protected by the copyright laws of the United States. No material from the NMGS website, or printed and electronic publications, may be reprinted or redistributed without NMGS permission. Contact us for permission to reprint portions of any of our publications.

One printed copy of any materials from the NMGS website or our print and electronic publications may be made for individual use without our permission. Teachers and students may make unlimited copies for educational use. Any other use of these materials requires explicit permission.
This page is intentionally left blank to maintain order of facing pages.
URANIUM DEPOSITS IN THE POISON CANYON TREND, AMBROSIA LAKE SUBDISTRICT, GRANTS URANIUM DISTRICT, MCKINLEY AND CIBOLA COUNTIES, NEW MEXICO

VIRGINIA T. McLemore
New Mexico Bureau of Geology and Mineral Resources, 801 Leroy Place, Socorro, NM, 87801; virginia.mclemore@nmt.edu

ABSTRACT—The Poison Canyon uranium discovery was an important economic event in the Grants Uranium District, New Mexico. Not only was it the first sandstone-hosted uranium deposit discovered and mined that ultimately led to the larger Ambrosia Lake Trend, but the main types of uranium deposits, primary and redistributed, were first recognized in the Poison Canyon Trend. More than 10 million lbs of U3O8 were produced from mines in the Poison Canyon Trend and additional historic resources remain. The Poison Canyon Trend is south of the Ambrosia Lake Trend, north of Grants and Milan in the southern San Juan Basin. The uranium deposits are hosted by the Poison Canyon sandstone, an informal name (economic usage) of one of the uranium-bearing sandstone units at the top of the Westwater Canyon Member or the lower part of the overlying Brushy Basin Member of the Jurassic Morrison Formation. Many of the uranium deposits in the Poison Canyon Trend have been mined out and what uranium remained at these older mines is probably uneconomic to recover, especially in the western portion of the area. The mineral-resource potential for uranium in the unmined portions of the Poison Canyon Trend is high, especially in the eastern portion of the trend. However, it is unlikely that any of these deposits will be mined in the near future because of economic conditions and numerous challenges to mine uranium in New Mexico.

INTRODUCTION

Most of the economic uranium deposits in New Mexico are hosted by sandstones, and most of the uranium production in New Mexico has come from the Westwater Canyon and Brushy Basin members of the Jurassic Morrison Formation in the Grants Uranium District in McKinley and Cibola (formerly Valencia) Counties (Hilpert, 1969; McLemore, 1983; McLemore and Chenoweth, 1989, 1991, 2017). The Grants District represents one large area in the southern San Juan Basin, extending from east of Laguna to west of Gallup and consists of eight subdistricts (Fig. 1; McLemore and Chenoweth, 1989, 2017). During a period of nearly three decades (1951–1980), the Grants District yielded nearly 347 million lbs of U3O8, almost all of New Mexico’s production, and more uranium than any other district in the United States (McLemore and Chenoweth, 1989, 2017). Although there are no operating mines in the Grants District today, numerous companies have acquired uranium properties and plan to explore and develop deposits in the district in the future.

The first economic discovery of uranium in sandstone in the Grants District was made on January 4, 1951, east of Haystack Butte in the southern Ambrosia Lake Subdistrict of the Grants District (Fig. 2). The area was named Poison Canyon for the abundance of locoweed, a poisonous plant. The host rock is either a tongue of the Westwater Canyon Member or the lower part of the overlying Brushy Basin Member of the Morrison Formation (Hilpert, 1969). This unit would later be called the Poison Canyon sandstone, an informal name of economic usage.

Many published and unpublished reports have been released before 1990 describing the uranium deposits in the Grants Dis-
FIGURE 2. Uranium deposits in the Poison Canyon Trend, Ambrosia Lake Subdistrict (revised from Chapman, Wood and Griswold, Inc., 1979; McLemore and Chenoweth, 1991). A color version is in the color plates section of this guidebook and in supplemental material. PLSS=Public Land Survey System

district (cited in McLemore, 1983; McLemore and Chenoweth, 1989, 2017), but few reports have updated the status of the deposits in the Poison Canyon area (McLemore et al., 2013). The Poison Canyon uranium discovery was an important economic event in the Grants District. Not only was it the first sandstone-hosted uranium deposit discovered and mined that ultimately led to the larger Ambrosia Lake Trend, but the main types of uranium ore deposits in the Grants District, primary and redistributed, were first recognized in the Poison Canyon Trend. More than 10 million lbs of U₃O₈ were produced from mines in the Poison Canyon Trend, and additional historic resources remain that could be mined in the future (Tables 1, 2). Most of the recent studies on the Grants District have focused on reclamation, while only a few recent reports have discussed the uranium geology and future economic potential of these deposits.

The purpose of this report is to summarize the history, stratigraphy, and mineralized deposits in the Poison Canyon Trend (including uranium production), as well as provide some insights into the age, source and future mineral-resource potential of the uranium deposits in the Poison Canyon Trend. Most of the mines in the Poison Canyon Trend have been or are being reclaimed, and studies on their reclamation are discussed elsewhere. The Poison Canyon Trend, as defined in this report, is from the Section 14 prospect near the Bobcat and Blue Peak mines (southeast of Mesa Montanosa) southeastward to the San Mateo Mine, which is west of the village of San Mateo (Fig. 2; Rapaport, 1963).

METHODOLOGY

All known uranium mines, mills, deposits, and occurrences are entered into the New Mexico Mines Database (McLemore et al., 2002). Since its creation in 1927, the New Mexico Bureau of Geology and Mineral Resources (NMBGMR) has collected published and unpublished data on the districts, mines, deposits, occurrences, and mills, including uranium mines, and is slowly converting these data into a relational database, the New Mexico Mines Database, using Microsoft Access. The New Mexico Mines Database provides data available on mines and districts in New Mexico. The available data for this database is from a variety of published and unpublished reports (including theses and dissertations) and miscellaneous unpublished files in the NMBGMR mining archive, and includes information on location, production, reserves, resource potential, significant deposits, geology, geochemistry (rock, water, etc.), well data, mining methods, maps, ownership, and other data, if available. The New Mexico Mines Database provides detailed information on the mineralogy, host rock lithology, and metal association of each mine or mining district. The database also includes limited geochemical data of both solid (host rock, ore, mine wastes, tailings, stream sediments, etc.) and water (surface, ground, pit lakes, etc.) samples. New information is continuously becoming available and is incorporated into the database regularly. See McLemore et al. (2002) for a more detailed description of the database. Much of the information in this paper is summarized from the database, and includes information from field investigations, published papers
A detailed mineral deposit map of the Poison Canyon Trend was compiled in ArcMap using USGS topographic maps as the map base at a scale of approximately 1:12,000, the New Mexico Mines Database, as well as digitized outlines of mineralized deposits from NMBGMR file data, published reports, and unpublished company data (Fig. 2; color version is in the color plates section of this guidebook and in supplemental material). Most of the outlines of the ore deposits were obtained from the mining companies in the mid-1980s (Rapaport, 1963; Chapman, Wood and Griswold, Inc., 1979; McLemore and Chemnoweth, 1989, 1991) and updated by recent reports.

The production and resources figures in Tables 1 and 2 are the most recent data available and were obtained from published and unpublished sources (NMBGMR file data). Production and resources figures are subject to change as new data are obtained. The resource and reserve data presented in Table 2 are historical and are provided for information purposes only, and do not conform to Canadian National Instrument NI 43-101 or U.S. Securities and Exchange Commission requirements.

### GEOLOGIC SETTING

The Morrison Formation is Late Jurassic (Kimmeridgian-Tithonian) and extends throughout much of western United States (Hilpert, 1969; Dunagan and Turner, 2004; Dickinson, 2018). Sedimentary units within the formation were deposited in a variety of environments, including alluvial plain,olian, lacustrine, and nearshore marine. The formation is divided...
into the Salt Wash (oldest), Recapture, Westwater Canyon, and Brushy Basin (youngest) members; overlies the Jurassic Bluff Sandstone and Summerville Formation; and is overlain by the Cretaceous Dakota Formation (see stratigraphic chart, back cover). The Salt Wash Member is not found in the Ambrosia Lake Subdistrict. The Ambrosia Lake Subdistrict is one of the most faulted areas of the Grants District where high-angle normal faults either trend north to northeast, northeast to east, or northwest. Most of the faults are younger than the Dakota Formation and have displacements of 15 to 30 m.

The Poison Canyon sandstone is an informal name (economic usage) of one of the uranium-bearing sandstone units in the Morrison Formation (Fig. 3; Zitting et al., 1957; Hilpert and Corey, 1956; Hilpert and Freeman, 1956; Hilpert, 1969). There has been a controversy among economic geologists as to whether the Poison Canyon sandstone is the uppermost sandstone unit at the top of the Westwater Canyon Member (Santos, 1963; Tessendorf, 1980; Condon, 1989) or the lowest sandstone at the base of the Brushy Basin Member (Hilpert, 1963; Turner-Peterson et al., 1980; Turner-Peterson, 1985; Bell, 1986; Dahlkamp, 2010). Furthermore, other economic geologists (Hoskins, 1963) use this name to designate any persistent sandstone in the Brushy Basin Member in the Ambrosia Lake and Smith Lake subdistricts. The relationship between the Westwater Canyon and Brushy Basin contact is a stratigraphic difficulty inherent with interfingering fluvial units, and picking the contact between the two units can be difficult and arbitrary. However, for the purposes of this report, the Poison Canyon sandstone refers to the specific sandstone found in the Poison Canyon Trend that is separated from lower Westwater Canyon sandstones by a regional, 4.6- to 7.6-m thick, greenish shale, often called the K shale (Fig. 3). Stratigraphic relationships can be confusing because the Poison Canyon sandstone is a braided-stream deposit formed at the top of the Westwater Canyon wet alluvial fan system (Galloway, 1980) prior to the deposition of the predominantly shale units of the Brushy Basin Member that has local persistent streams cutting through the shale sequences (Fig. 3). These stratigraphic naming problems are in part, a result of the depositional nature of the units and some geologists use geophysical logs and cuttings in addition to outcrops and measured sections to determine the stratigraphic relationships, whereas other geologists use only outcrops and measured sections.

The Poison Canyon sandstone generally consists of three units: a lower sandstone, middle shale, and upper sandstone. The sandstone is yellow to gray, fine- to coarse-grained, poorly sorted, cross-bedded arkosic sandstone approximately 15 m thick at the Poison Canyon Mine, and varies from 10 to 25 m thick elsewhere. Volcanic rock fragments are common along with clay balls and lenses. It extends to the east and north from the mine and vertically grades upwards into the Brushy Basin Member. Most of the uranium deposits are near the base of the sandstone, and most of the deposits are found where the Poison Canyon sandstone is greater than 15 m thick (Hilpert, 1969). Paleocurrent studies of the Poison Canyon sandstone indicate predominantly east to northeast current directions, whereas the older upper Westwater Canyon sandstones indicate predominantly east to southeast current directions (Turner-Peterson et al., 1980; Turner-Peterson, 1985). The lower Westwater Canyon sandstones flowed east-southeast (Turner-Peterson et al., 1980; Turner-Peterson, 1985).

The regional presence of extensive zeolites in the Brushy Basin Member was previously interpreted to represent deposition in a shallow alkaline lake (Lake T’oo’dichi’; Turner-Peterson, 1980, 1985; Turner-Peterson and Fishman, 1991; Demko et al., 2004; Turner, 2010a,b), but re-evaluation of the geochemistry and sedimentology has led to a revised interpretation. Revised interpretations have redefined Lake T’oo’dichi’ as widespread, discontinuous wetlands of isolated ponds and marshes (Anderson and Lucas, 1997; Turner, 2004) fed by groundwater from a regional aquifer (Dunagan and Turner, 2004; Turner, 2010a,b; Dickinson, 2018). The Poison Canyon sandstone is interpreted as a local fluvial sandstone flowing into or across the Lake T’oo’dichi’. The gray smectite mudstones were deposited marginally to the lake.

![FIGURE 3. Schematic cross-section from Gallup to east of Laguna showing relationship of the Poison Canyon sandstone to the Westwater Canyon and Brushy Basin Members of the Morrison Formation (modified from Hilpert, 1969).](image-url)
Three types of uranium deposits are found in the Morrison Formation (including the Westwater Canyon Member, Poison Canyon sandstone, Brushy Basin Member, Jackpile Sandstone, and extending into the Cretaceous Dakota Formation in the Church Rock-Crownpoint Subdistrict): 1) primary, tabular (also called trend or blanket), 2) redistributed (also called roll-type or stack), and 3) remnant-primary sandstone uranium deposits (Hilpert, 1969; Saucier, 1981; Adams and Saucier, 1981; McLemore and Chenoweth, 1989, 2017). A fourth type of uranium deposit, tabular sandstone uranium-vanadium deposits are found in the Salt Wash and Recapture members of the Morrison Formation in the western San Juan Basin (McLemore and Chenoweth, 1989, 2017). It is important to note that the older Jurassic Todilto Limestone is mineralized south of the Poison Canyon Trend (Berglof and McLemore, 2003; McLemore, 2020). The descriptions of the economic geology and uranium deposits are found in numerous reports, many cited in McLemore (1983), Hilpert (1969), McLemore and Chenoweth (1989, 1991, 2017), McLemore et al. (2013), and Dahlkamp (2010).

DESCRIPTION OF SELECTED URANIUM DEPOSITS

Sandstone uranium deposits in the Poison Canyon Trend are a cluster of similar ore bodies that are spatially close together, that formed by similar geologic processes, and that could have been mined as one to three large mine operations (Holen and Finch, 1982). But the ownership of the Poison Canyon Trend deposits was complicated with various sections owned by private owners, state of New Mexico, Navajo Indian allotments, and federal lands (referred to as checkerboard ownership), resulting in the numerous underground operations (albeit no longer operating). Therefore, the entire Poison Canyon Trend could be considered one large uranium deposit (similar to a mine producing multiple ore shoots along one vein) that was operated by different mining companies.

Appendix 1 is a summary of the location and other data of the uranium mines, prospects, and unmined deposits in the Poison Canyon Trend. Production from the uranium mines in the Poison Canyon Trend is in Table 1, and estimates of the remaining uranium resources are in Table 2. Figure 2 shows the trend of the uranium deposits (a color version of this figure is in the color plates portion of this volume). Figure 4 shows grade-tonnage relationships of uranium deposits, comparing the Grants uranium deposits with other world-class uranium deposits. Descriptions and mining history of selected Poison Canyon Trend mines are below.

Blue Peak Mines

In 1951, yellow uranium minerals (predominantly carnitite, tuuyamunite, autunite, schroeckingerite; Dodd, 1955; Rapaport, 1963) were found associated with black carbonaceous material (humates) in limonitic sandstone outcrops, just above the K shale layer. Blue Peak Mining Co. began operating the Blue Peak mines in March 1951 from seven adits and stripping along the rim (Holmquist, 1970). The Blue Peak mines were the first sandstone operations in the Ambrosia Lake Subdistrict

the primary uranium minerals (Konigsmark, 1958); pascoite, a vanadium mineral, and ilsemannite, a molybdenum mineral, also are reported (Tessendorf, 1980). Some of the redistributed uranium was vertically distributed or stacked along the fault and was up to 12 m thick. The uranium bodies were 3-15 m to 137 m wide in the shear zone. Underground mining started in 1955 (Holmquist, 1970), and Farris Brothers continued operations in 1960. Subsequently, Reserve Oil and Minerals Corp. located additional uranium deposits in 1976 and mined underground at the mine through 1980 (Tessendorf, 1980). Total production from all companies amounted to 217,066 short tons of ore yielding 1,004,594 lbs U₃O₈ (0.23% U₃O₈) and 338,094 lbs V₂O₅ from 1952 to 1980 (Table 1). Not all production was reported between 1970 and 1980, although most of the uranium deposits were mined out.

Hogan Mine

The Hogan Mine, discovered by drilling in 1957, operated between 1959 and 1979 through a 103.6 m shaft in a thick portion of the Poison Canyon sandstone (24 m thick). Three redistributed, vertical uranium deposits (designated basal, intermediate, and upper zones) in the Hogan Mine were found along an anticlinal fold that is parallel to the San Mateo fault (Rapaport, 1963). The deposit was developed by underground methods typical of the times (Mining World, 1959), and total production amounted to 129,551 short tons of ore containing 1,004,594 lbs U₃O₈ (0.23% U₃O₈) and 338,094 lbs V₂O₅ from 1952 to 1980 (Table 1). Not all production was reported between 1970 and 1980, although most of the uranium deposits were mined out.

Marquez Mine

The Marquez (Marcus) Mine, discovered by drilling in 1955, operated through a 571.5-m incline (Weege, 1963) from 1958 to 1966 and was the largest deposit in the Poison Canyon Trend (Rapaport, 1963) with a production of 717,031 short tons of ore containing 3,759,653 lbs U₃O₈ at a grade of 0.26% U₃O₈ (Table 4). The deposit consisted of northeast-trending, narrow, elongated ore bodies, more than 1.6 km long, mostly at the base of the Poison Canyon sandstone. Uranium is associated with organic matter that consists of humates, coal fragments, and silicified wood fragments within the 7.6-m-thick, upper, medium- to fine-grained, arkosic sandstone. Uranium is associated with humates. During retreat mining and recovery of pillars, the workings started to cave, and some uranium was lost (Johnston, 1963; Holmquist, 1970). Although, some uranium probably remains, it will be difficult and dangerous to mine by conventional techniques.

Mesa Top Mine

The Mesa Top Mine, discovered by drilling in 1954, operated between 1959 and 1968 through a 45.7 m shaft. The Mesa Top shaft closed in 1959, and the ore was hoisted through the nearby Malpais shaft. The mine yielded 108,261 short tons of ore containing 512,965 lbs U₃O₈ (grade of 0.24% U₃O₈) and 144,610 lbs V₂O₅ from 1954 to 1961 (Table 1); an unknown amount of uranium was produced from 1967 to 1968. Most, if not all of the uranium deposits were mined.

San Mateo Mine

The San Mateo deposit is the easternmost deposit in the Poison Canyon Trend and was discovered in 1957 with more than 83,820 m of drilling in 250 holes in 1957-1958 (Holmquist, 1970). The 337-m three-compartment shaft was sunk in 1958 by Centennial Dev. Co. and operated by Rare Metals Co. Water was encountered at 213 m (Holmquist, 1970). Total production from 1959 to 1971 amounted to 842,463 short tons of ore containing 2,863,024 lbs U₃O₈ (grade of 0.24% U₃O₈) and 144,610 lbs V₂O₅ from 1954 to 1961 (Table 1); an unknown amount of uranium was produced from 1967 to 1968. Most, if not all of the uranium deposits were mined.


<table>
<thead>
<tr>
<th>Year</th>
<th>Shipper</th>
<th>Ore (short tons)</th>
<th>Uranium (pounds)</th>
<th>Grade (% U₃O₈)</th>
<th>Grade (% V₂O₅)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>Blue Peak Mining Co.</td>
<td>766</td>
<td>5488</td>
<td>0.36</td>
<td>0.15</td>
</tr>
<tr>
<td>1952</td>
<td>Blue Peak Mining Co.</td>
<td>3998</td>
<td>12,474</td>
<td>0.16</td>
<td>0.08</td>
</tr>
<tr>
<td>1953</td>
<td>Shattuck Denn Corp.</td>
<td>1039</td>
<td>3826</td>
<td>0.18</td>
<td>0.09</td>
</tr>
<tr>
<td>1955</td>
<td>Blue Peak Mining Co., San Michaels College Foundation</td>
<td>148</td>
<td>867</td>
<td>0.29</td>
<td>0.08</td>
</tr>
<tr>
<td>1956</td>
<td>Colohoma Uranium, Inc.</td>
<td>347</td>
<td>2180</td>
<td>0.31</td>
<td>0.13</td>
</tr>
<tr>
<td>1957</td>
<td>Three Jacks Mining</td>
<td>549</td>
<td>2676</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>1958</td>
<td>Three Jacks Mining</td>
<td>219</td>
<td>861</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>1959</td>
<td>Farris Mining Co.</td>
<td>3751</td>
<td>11,146</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>Farris Mining Co., Lloyd O. Sutton</td>
<td>726</td>
<td>3113</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>Lloyd O. Sutton</td>
<td>417</td>
<td>1234</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>Lee Garcia</td>
<td>91</td>
<td>155</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td><strong>Total 1951-1964</strong></td>
<td><strong>12,051</strong></td>
<td><strong>44,020</strong></td>
<td><strong>0.19</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Shipper</th>
<th>Ore (short tons)</th>
<th>Uranium (pounds)</th>
<th>Grade (%U₃O₈)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>Calumet and Hecla</td>
<td>139,958</td>
<td>786,122</td>
<td>0.28</td>
</tr>
<tr>
<td>1960</td>
<td>Calumet and Hecla</td>
<td>132,467</td>
<td>657,674</td>
<td>0.25</td>
</tr>
<tr>
<td>1961</td>
<td>Calumet and Hecla</td>
<td>103,435</td>
<td>609,362</td>
<td>0.28</td>
</tr>
<tr>
<td>1962</td>
<td>Calumet and Hecla</td>
<td>106,933</td>
<td>555,840</td>
<td>0.26</td>
</tr>
<tr>
<td>1963</td>
<td>Calumet and Hecla</td>
<td>104,984</td>
<td>529,468</td>
<td>0.25</td>
</tr>
<tr>
<td>1964</td>
<td>Calumet and Hecla</td>
<td>16,558</td>
<td>92,997</td>
<td>0.28</td>
</tr>
<tr>
<td>1965</td>
<td>United Nuclear</td>
<td>5145</td>
<td>18,268</td>
<td>0.18</td>
</tr>
<tr>
<td>1966</td>
<td>United Nuclear</td>
<td>32,153</td>
<td>137,325</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Total 1959-1966: 717,031 3,759,653 0.26

Section 24 (Chill Wills, Treeline) Deposits

Several, small uranium deposits were discovered in the Poison Canyon sandstone in Section 24 by drilling in the late 1970s. The Section 24 (also known as Chill Wills) Mine yielded 10,950 short tons of ore containing 37,693 lbs of U₃O₈ (0.17% U₃O₈) from 1960 to 1963. In 1978, Conoco identified an historic resource of 593,448 short tons of ore grading 0.13% U₃O₈ elsewhere in Section 24 (also known as Treeline; Table 2; Fig. 2). Currently, enCore Energy Corp. owns the property and is examining it for potential in situ recovery (https://www.encoreenergycorp.com/uranium-assets/isr-projects/treeline/, accessed 1/18/20).


<table>
<thead>
<tr>
<th>Year</th>
<th>Shipper</th>
<th>Ore (short tons)</th>
<th>Uranium (pounds)</th>
<th>Grade (%U₃O₈)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>Rare Metals Corp.</td>
<td>5532</td>
<td>19,248</td>
<td>0.17</td>
</tr>
<tr>
<td>1960</td>
<td>Rare Metals Corp.</td>
<td>4077</td>
<td>12,865</td>
<td>0.16</td>
</tr>
<tr>
<td>1961</td>
<td>Rare Metals Corp.</td>
<td>74,662</td>
<td>234,570</td>
<td>0.16</td>
</tr>
<tr>
<td>1962</td>
<td>Rare Metals Corp., El Paso Natural Gas Co.</td>
<td>85,798</td>
<td>334,288</td>
<td>0.19</td>
</tr>
<tr>
<td>1963</td>
<td>El Paso Natural Gas Co.</td>
<td>100,811</td>
<td>409,609</td>
<td>0.20</td>
</tr>
<tr>
<td>1964</td>
<td>El Paso Natural Gas Co., United Nuclear Corp.</td>
<td>42,220</td>
<td>173,357</td>
<td>0.21</td>
</tr>
<tr>
<td>1965</td>
<td>United Nuclear Corp.</td>
<td>48,508</td>
<td>199,000</td>
<td>0.21</td>
</tr>
<tr>
<td>1966</td>
<td>United Nuclear Corp.</td>
<td>73,934</td>
<td>294,025</td>
<td>0.20</td>
</tr>
<tr>
<td>1967</td>
<td>United Nuclear Corp.</td>
<td>144,102</td>
<td>484,206</td>
<td>0.17</td>
</tr>
<tr>
<td>1968</td>
<td>United Nuclear Corp.</td>
<td>86,345</td>
<td>239,707</td>
<td>0.14</td>
</tr>
<tr>
<td>1969</td>
<td>United Nuclear Corp.</td>
<td>118,989</td>
<td>296,096</td>
<td>0.12</td>
</tr>
<tr>
<td>1970</td>
<td>United Nuclear Corp. (Reserve Oil and Minerals Corp.)</td>
<td>52,134</td>
<td>152,828</td>
<td>0.15</td>
</tr>
<tr>
<td>1971</td>
<td>United Nuclear Corp.</td>
<td>53,511</td>
<td>13,225</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Total 1959-1971: 842,463 2,863,024 0.17

AGE AND SOURCE OF URANIUM MINERALIZATION

The age of the uranium deposits in the Grants District is constrained by numerous isotopic studies (Table 6, Fig. 5; McLemore, 2011) and supports a potential Jurassic volcanic arc as a source of uranium (Christiansen et al., 2015). Jurassic volcanism, intra-arc sedimentation and plutonism are well documented throughout the Jurassic volcanic arc west and southwest of the San Juan Basin (Fig. 6; Saleeby and Busby-Spera, 1992; Miller and Busby, 1995; Blakey and Parnell, 1995; Lawton and McMillan, 1999; Kowallis et al., 2001; du Bray, 2007). Uranium and vanadium concentrations show a decrease in the volcanic ash beds, consistent with uranium and vanadium being derived from volcanic ash from the Jurassic arc (Christiansen et al., 2015). Zircon ages from the Brushy Basin and Westwater Canyon Member are consistent with the Jurassic volcanic arc as a source, as well as Proterozoic basement rocks (Dickinson and Gehrels, 2008). The uranium also could be from groundwater derived from a volcanic highland to the southwest (Sanford, 1982, 1992).

⁴⁰Ar/³⁹Ar ages of plagioclase and alkali feldspar from the younger Brushy Basin Member of the Morrison Formation range from 145 to 153 Ma (Kowallis et al., 1991, 1999). Rb/Sr isochrons of clay minerals from the Poison Canyon sandstone indicated minimum ages of 105 Ma and 130 Ma (Brookins, 1980, 1989), but the isochrons are disturbed because of alteration. Primary, tabular uranium deposits in the older Westwater Canyon Member of the Ambrosia Lake and Smith Lake subdistricts are 130-140 Ma (references in Table 6; Fig. 5). The primary, tabular uranium deposits in the Poison Canyon Trend are likely of similar age. Younger, redistributed uranium deposits in the Ambrosia Lake Subdistrict are much younger, 3-12 Ma in age (references in Table 6; Fig. 5).

ORIGIN OF URANIUM MINERALIZATION

There is no consensus on the origin of the primary, tabular sandstone uranium deposits (Sanford, 1992; McLemore and Chenoweth, 2017). The majority of the proposed models for formation of the Ambrosia Lake sandstone uranium deposits suggest that deposition occurred at a groundwater interface between two fluids of different chemical compositions and/or oxidation-reduction states.

Subsequent models, such as the lacustrine-humate and brine-interface models, have refined or incorporated portions of these early theories. In the lacustrine-humate model, groundwater was expelled by compaction from lacustrine muds formed by a large playa lake (Turner-Peterson, 1985; Turner-Peterson and Fishman, 1986). The ground-
water was expelled into the underlying fluvial sandstones where humate or secondary organic material precipitated as a result of flocculation into tabular bodies within sandstone hosts. During or after precipitation of the humate bodies, uranium was precipitated from groundwater (Turner-Peterson, 1985; Turner-Peterson and Fishman, 1986). This model proposes the humate bodies were formed prior to uranium deposition.

In the brine-interface model, uranium and humate were deposited during diagenesis by reduction at the interface of meteoric fresh water and groundwater brines (Granger and Santos, 1986). In another variation of the brine-interface model, groundwater flow is driven by gravity, not compaction (Sanford, 1982, 1992). Groundwater flowed down dip and discharged in the vicinity of the uranium deposits. Uranium

<table>
<thead>
<tr>
<th>Depositional Event</th>
<th>Age</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Todilto limestone deposits</td>
<td>Tertiary, 3-7 Ma</td>
<td>Berglof (1989)</td>
</tr>
<tr>
<td>Redistributed uranium deposits (Cretaceous Dakota Sandstone, Jurassic Brushy Basin and Westwater Canyon Sandstone members)</td>
<td>Tertiary, 3-12 Ma</td>
<td>Miller and Kulp (1963), Nash and Kerr (1966), Nash (1968), Brookins et al. (1977), Brookins (1980), Ludwig et al. (1982), Hooper (1983)</td>
</tr>
<tr>
<td>Uranium in the Jackpile sandstone</td>
<td>110-115 Ma</td>
<td>Lee (1976)</td>
</tr>
<tr>
<td>Deposition of the Morrison Formation units</td>
<td>Unknown, estimated before 130 Ma</td>
<td>Miller and Kulp (1963), Nash and Kerr (1966), Nash (1968), Brookins et al. (1977), Brookins (1980), Ludwig et al. (1982), Hooper (1983)</td>
</tr>
<tr>
<td>Todilto limestone uranium deposits</td>
<td>155-150 Ma</td>
<td>Berglof (1970, 1989)</td>
</tr>
<tr>
<td>Deposition of the Todilto limestone</td>
<td>Before 155 Ma</td>
<td></td>
</tr>
</tbody>
</table>


FIGURE 6. Approximate location of the Jurassic arc in relation to the Morrison Basin (from McLemore, 2011; McLemore and Chenoweth, 2017). The gray polygon represents the chain of volcanoes formed during the Jurassic Period, with the Morrison Basin in beige. Three subbasins also are delineated, including the Grants District in the southern San Juan Basin. From Kowallis et al. (1999), du Bray (2007), and Lawton and McMillan (1999).
precipitated in the presence of humates at a gravitationally stable interface between relatively dilute, shallow meteoric water and saline brines that migrated updip from deeper in the basin (Sanford, 1982, 1992). Modeling of the regional groundwater flow in the Colorado Plateau during Late Jurassic and Early Cretaceous times supports the brine-interface model (Sanford, 1982). The groundwater flow was impeded by up-thrown blocks of Proterozoic crust and forced upwards. These zones of upwelling are closely associated with uranium-vanadium deposits throughout the Colorado Plateau (Sanford, 1982).

Uranium leached from the altered volcanic ash and from erosion of the Proterozoic granitic highland could have been carried by groundwater and surface waters into the Morrison Formation, forming the uranium deposits found in the Ambrosia Lake Subdistrict. The presence of organic material caused the precipitation of the uranium in the deposits. After formation of the primary, tabular sandstone uranium deposits during Tertiary time, oxidizing groundwater migrated through the uranium deposits and remobilized some of the primary, tabular sandstone uranium deposits (Saucier, 1981). Uranium was precipitated ahead of the oxidizing waters forming redistributed sandstone uranium deposits. Where the sandstone host surrounding the primary deposits was impermeable and the oxidizing waters could not dissolve the deposit, remnant-primary sandstone uranium deposits remain.

MINERAL-RESOURCE POTENTIAL

Many of the uranium deposits in the Poison Canyon Trend have been mined out and what uranium mineralization remained at these mines is probably uneconomic to recover, especially in the western portion of the Poison Canyon Trend. Historic resources were determined in a few deposits that were never mined (Table 2; McLemore et al., 1986, 2013, this report). The mineral-resource potential for uranium in the unmined portions of the eastern portion of the Poison Canyon Trend is high (Table 2). However, it is unlikely that any of these deposits will be mined in the near future because of economic conditions and numerous challenges to mine uranium in New Mexico, as summarized by McLemore et al. (2013).

SUMMARY

The Poison Canyon Trend is from the Section 14 prospect near the Bobcat and Blue Peak mines (southeast of Mesa Montana) southeastward to the San Mateo Mine, which is west of the village of San Mateo. The first economic discovery of uranium in sandstone in the Grants District was made in the Poison Canyon Trend of the Ambrosia Lake Subdistrict. Not only was it the first sandstone-hosted uranium deposit discovered and mined that ultimately led to the larger Ambrosia Lake Trend, but the main types of uranium ore deposits in the Grants District, primary and redistributed, were first recognized in the Poison Canyon Trend. More than 10 million lbs of UO₂ were produced from mines in the Poison Canyon Trend, and additional historic resources remain that could be mined in the future. The primary, tabular uranium deposits in the Poison Canyon Trend are likely 130-140 Ma. Younger, redistributed uranium deposits in the Poison Canyon and Ambrosia Lake Trends are much younger, 3-12 Ma in age. There is no consensus on the origin of the primary, tabular sandstone uranium deposits; however, the majority of the proposed models for formation of the Ambrosia Lake sandstone uranium deposits suggest that deposition occurred at a groundwater interface between two fluids of different chemical compositions and/or oxidation-reduction states. The mineral-resource potential for uranium in the unmined portions of the eastern portion of the Poison Canyon Trend is high, but, it is unlikely that any of these deposits will be mined in the near future because of economic conditions and numerous challenges to mine uranium in New Mexico.

REFERENCES


Turner, C.E., 2010b, Montezuma Creek: Brushy Basin and Lake T’oo’dichi’: New Mexico Geological Society, Guidebook 61, p. 31-32.


Appendices can be found at http://nmgs.nmt.edu/repository/index.cfml?rid=2020002