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Abstract

The Cebolleta uranium project in northwestern New Mexico is the site of five sandstone-hosted uranium deposits contained within the Jackpile Sandstone Member of the Upper Jurassic Morrison Formation. The uranium mineralization, which has been well-delineated by numerous drill holes, two open-pit and three underground mines, is a series of tabular shaped bodies that were deposited within individual sandstone lenses of the Jackpile Sandstone. Uranium deposits in the project area exhibit characteristics of "trend," "redistributed," and "remnant" types of deposits, as described elsewhere within the Grants mineral belt. Significant uranium resources are present in the project area.

Introduction

The Cebolleta uranium project of Uranium Resources, Incorporated (URI), is located in the Laguna mining district of northeastern Cibola County, New Mexico (Fig. 1). Situated in northwestern New Mexico east of Mount Taylor, the project is approximately 72 km west of the city of Albuquerque and 16 km north-northeast of the Pueblo of Laguna. The Cebolleta project lies in an area of valleys and mesas along the southeastern margin of the San Juan Basin. Elevations within the project area range from approximately 1,798 to 1,983 m above sea level.

The project area (Fig. 2), which hosts five significant sandstone-hosted uranium deposits, is positioned near the eastern end of the so-called Grants mineral belt, which

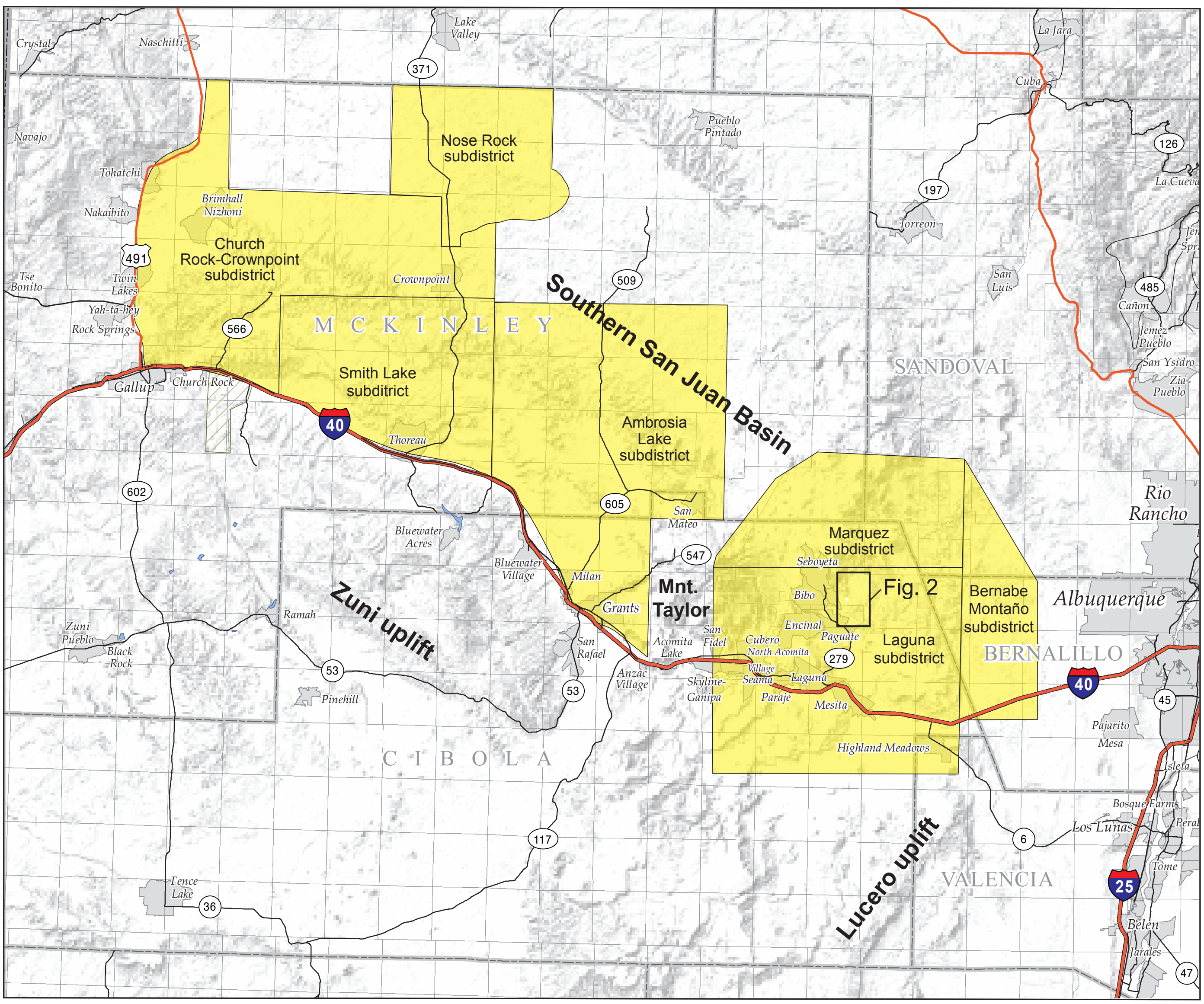
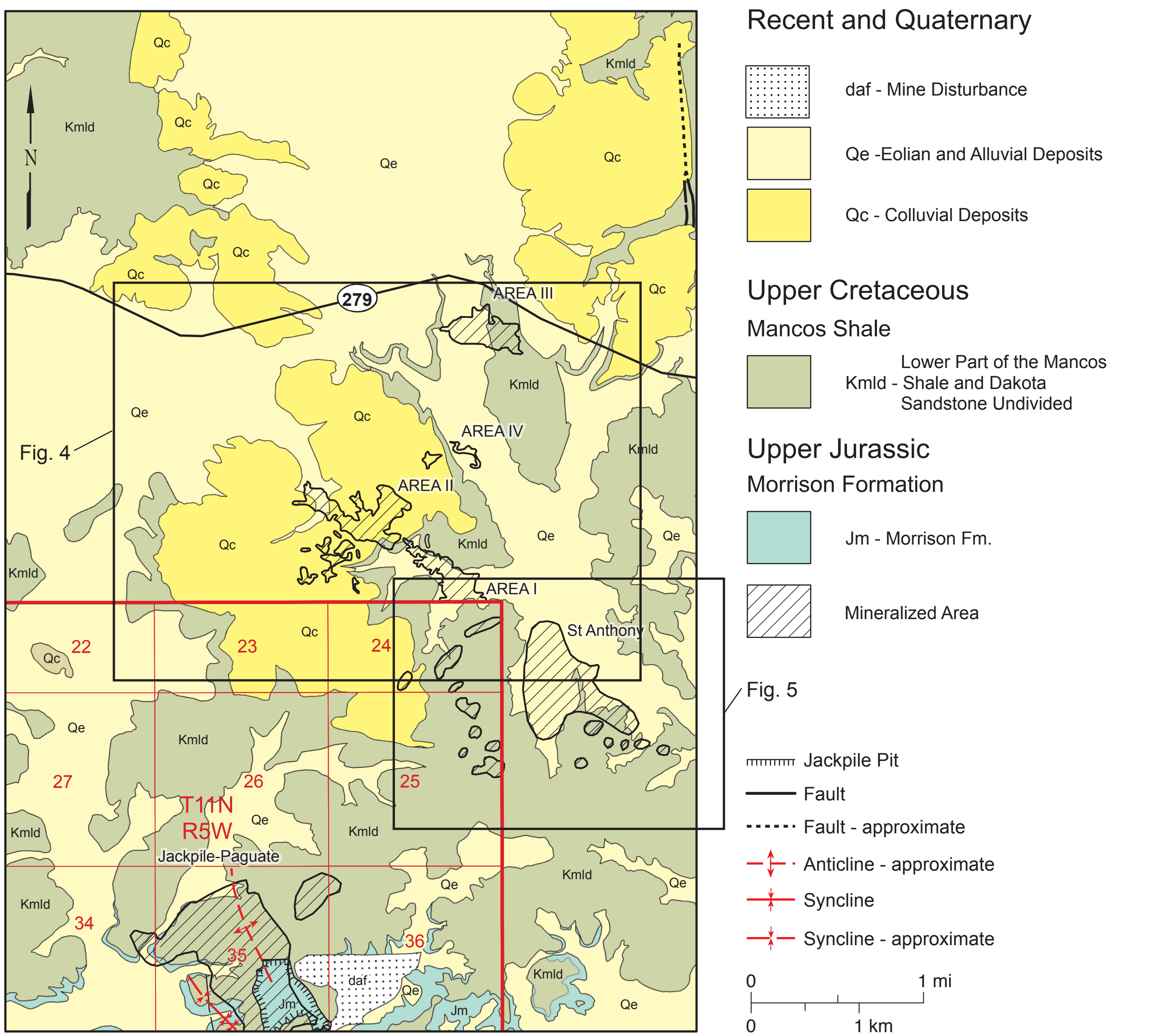


Figure 1. Map showing locations of the Cebolleta project (Fig. 2), mining districts shown in yellow, and other areas mentioned in the text.



Source: Dillinger, 1990, USGS Map C-118-A

Figure 2. Generalized geologic map of the Cebolleta project area showing outlines of uranium deposits (geology modified from Dillinger, 1990). Unsurveyed portion of map is the Cebolleta Land Grant. Locations of Figures 4 and 5 are outlined.

encompasses several mining districts in the southern part of the San Juan Basin. The Grants mineral belt is one of the largest concentrations of sandstone-hosted uranium deposits in the world. Uranium mineralization at the Cebolleta project occurs as a series of tabular bodies hosted within the Jackpile Sandstone Member of the Upper Jurassic Morrison Formation. Historical uranium production from the project area was derived from three underground and two open-pit mines, and significant uranium resources remain in the area.

Project History

The Laguna mining district has been an area of considerable interest to the U.S. uranium industry since the early 1950s, when indications of near-surface uranium mineralization were discovered by geologists and engineers of the Anaconda Copper Company in late 1951 (Beck and others, 1980). Anaconda's identification of surface exposures of uranium mineralization led to the subsequent discovery of the Jackpile-Paguate uranium deposit complex, which was later developed as the largest uranium mine in the U.S. During this time Anaconda undertook a regional exploration drilling program on the nearby Evans Ranch, northeast of the Jackpile mine, continuing this exploration effort until 1957 when they terminated their property interest. The Evans Ranch, also known as the L-Bar Ranch, along with a portion of La Merced del Pueblo de Cebolleta (Cebolleta Land Grant) is the site of the Cebolleta project. During the period of Anaconda's exploration program they completed more than 350 drill holes on the Evans Ranch, but did not advance the project beyond the exploration stage (Geo-Management, 1972, unpublished report).

The first mining in the Cebolleta project area was undertaken by Hanosh Mines, Inc., who extracted 167 tons (151 tonnes) of material that averaged 0.09% U_3O_8 (Chenoweth, 2016, personal communication; ore grades are reported as weight percent U_3O_8). Drilling by the

Climax Uranium Company during the period 1954 to 1956 resulted in the discovery of a substantial uranium deposit, which became the site of the so-called M-6 mine, in Section 30, Township 11 North, Range 4 West. Production from the M-6 mine began in July, 1957 and continued until October, 1960 (Chenoweth, 2016, personal communication). Total production from the M-6 deposit was reported to be 78,555 tons (71,264 tonnes) averaging 0.20% U_3O_8 and yielding 320,647 pounds of U_3O_8 (Chenoweth, 2016, personal communication).

At a later date United Nuclear Corporation and its subsidiary Teton Exploration Drilling Company carried out an extensive exploration program in the vicinity of the former M-6 (Climax) mine, and discovered significant and widespread uranium mineralization. In 1975 United Nuclear developed two small open pits and one underground mine on lands leased from the Cebolleta Land Grant (Baird, and others, 1980). These mines are known as the St. Anthony mines. Ore from the St. Anthony mines was processed primarily at the United Nuclear Northeast Church Rock mill near Gallup, NM. Mining was suspended at St. Anthony in 1979, and the milling of stockpiled material was completed in 1980. Total production from the St. Anthony mines was approximately 1.6 million pounds of U_3O_8 for the period 1975 through 1980 (Moran and Daviess, 2014, unpublished report).

Reserve Oil and Minerals purchased the Evans Ranch in 1968 and formed a joint venture with Sohio Western Mining to identify and develop uranium deposits on the property. Sohio operated the joint venture (then known as the L-Bar joint venture) and discovered extensive uranium mineralization on the property, leading to the development of an underground mine and construction of a uranium mill (the JJ #1 mine and L-Bar mill), which operated from late 1976 to mid-1981 and produced approximately 898,600 tons (815,000 tonnes) of material averaging 0.123% U_3O_8 and yielding 2,218,800 pounds of U_3O_8 (Boyd and others, 1984, unpublished report).

Overall, production of approximately 3.8 million pounds of U_3O_8 was derived from uranium deposits in the Cebolleta area, based on production statistics from the United Nuclear Northeast Church Rock and the L-Bar (Sohio) mills. Uranium mining and processing ceased in the project area in 1981. Neutron Energy (now a subsidiary of URI) acquired a mineral lease for the project in 2006. Since then Neutron Energy/URI have conducted technical studies on the distribution of uranium in the five deposits and have carried out environmental surveys of the project area.

Geologic Setting

The Grants mineral belt and its associated uranium deposits are located between the southern part of the San Juan Basin and the northeastern part of the Zuni uplift (Fig. 1). Sedimentary rocks exposed in this area range in age from Middle Jurassic through Late Cretaceous. Jurassic sedimentary rocks, including the economically important Morrison Formation (the predominant host for the major uranium deposits) are exposed in a narrow band that generally parallels the northwest-trending axis of the Zuni uplift. Cretaceous rocks are exposed in the northerly portion of the mineral belt and partially cover exposures of the Morrison Formation toward the south. The Mt. Taylor volcanic field covers a portion of the eastern part of the mineral belt immediately to the west of the Cebolleta project area (Moench and Schlee, 1967; Goff and others, 2015).

The belt of uranium deposits includes six major mining districts (from east to west-northwest): Laguna, Marquez (that portion of the Laguna district that contains uranium deposits hosted only in the Westwater Canyon Member of the Morrison Formation), the Ambrosia Lake-San Mateo area (north of Grants), Smith Lake, Crownpoint, and Church Rock. Collectively, the deposits of the Grants mineral belt have produced more than 340 million pounds of U_3O_8, ranking it as one of the largest uranium-producing regions in the world (McLemore and others, 2013); it is arguably the world's largest concentration of sandstone-hosted uranium deposits (Dahlkamp, 1993).

Uranium deposits of the Grants mineral belt are hosted principally in the Westwater Canyon Member, the Poison Canyon sandstone (an informal unit of economic usage), the Brushy Basin Member and the Jackpile Sandstone Member of the Morrison Formation. Limestone-hosted uranium deposits have been developed in the Middle Jurassic Todilto Formation (Moench and Schlee, 1967); however, these deposits have produced limited amounts of uranium in comparison with the Morrison Formation.

Stratigraphy

In the vicinity of the Cebolleta project the sequence of sedimentary rocks that are present near the surface range in age from Late Jurassic through Late Cretaceous (Baird et al., 1980; Jacobsen, 1980; Moench and Schlee, 1967; Schlee and Moench, 1963). The upper part of the Jurassic Morrison Formation is the host unit for uranium deposits in the project area. The Morrison Formation is unconformably overlain by the Dakota Sandstone, which in turn interfingers with and is overlain by the Mancos Shale, and is underlain by rocks of the Jurassic San Rafael Group. The stratigraphic nomenclature for the Morrison Formation and underlying San Rafael Group has evolved as correlations of Jurassic stratigraphic units across the Four Corners region continue to be worked out (e.g., Anderson and Lucas, 1995; Lucas and Anderson, 1997). The stratigraphic nomenclature in common use by mine geologists working in the Laguna mining district and Cebolleta project area is depicted in Fig. 3. The four member-rank divisions of the Morrison Formation are, in ascending order, the Recapture, Westwater Canyon, Brushy Basin and Jackpile Sandstone members (Fig. 3).

The Recapture Member is about 15 m thick in the project area (Moench and Schlee, 1967). It is composed of interbedded mudstone, siltstone, sandstone, and minor limestone. Moench and Schlee (1967) report that the unit is grayish-red on surface exposures, while fresh exposures of the various lithologies are gray (limestone), grayish-green (mudstone), or grayish-yellow (sandstone).

The Westwater Canyon Member ranges from 3 to 27 m in thickness in the project area. It consists of grayish-yellow to pale orange sandstone. The sandstones are poorly sorted, range from fine to coarse grained, and are sub-arkosic to arkosic in composition (Moench and Schlee, 1967). In the Marquez Canyon area, approximately 24 km north of the Cebolleta project, the Westwater Canyon also contains lenses of mudstone and siltstone; intercalated fine-grained intervals are less well developed in the Cebolleta area, based on available drill hole data.

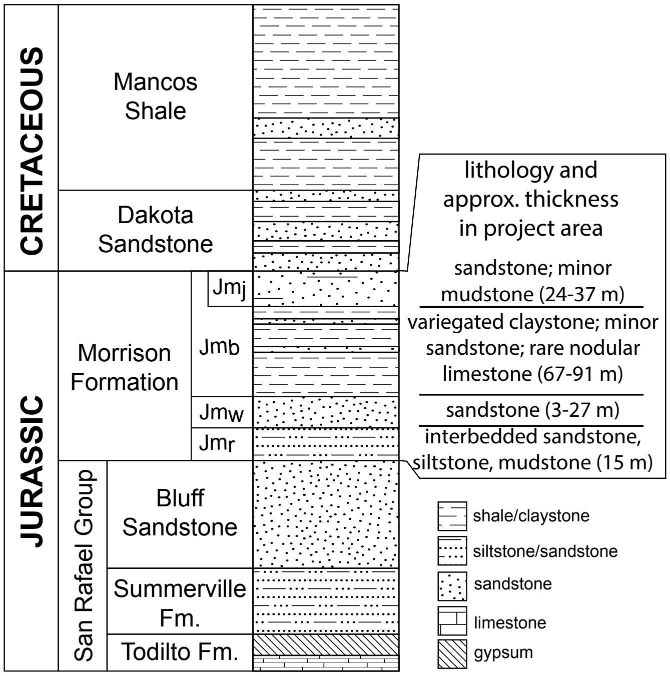


Figure 3. Stratigraphic column for the Laguna mining district, with Morrison Formation nomenclature used in this paper (modified from Rautman, 1980, inside cover). The stratigraphic divisions of the Morrison Formation discussed in historical mining reports for the study area are generally as depicted here, namely the Recapture (Jmr), Westwater Canyon (Jmw), Brushy Basin (Jmb), and Jackpile (Jmj) members.

The Brushy Basin Member ranges in thickness from 67 to 91 m in the general project area. It consists primarily of variegated mudstone and claystone with lesser sandstone beds that are hosts for uranium mineralization in some areas. Some authors (e.g., Aubrey, 1992; Santos, 1970) have noted the presence of volcanic ash beds in the Brushy Basin Member.

The Jackpile Sandstone (Owen and others, 1984; Aubrey, 1992) is a local (present in the eastern part of the Grants mineral belt, including the Laguna mining district) and distinctive unit that is the host for the major uranium deposits at the former Jackpile-Paguate, Woodrow, St. Anthony, and L-Bar mines. The Jackpile Sandstone extends in a northeasterly trending belt that may be up to 21 km wide and more than 105 km long (Jacobsen, 1980). Locally it is up to 61 m thick. In the St. Anthony mine complex the Jackpile ranges from 24 to 37 m in thickness (Baird et al., 1980), while at the adjoining L-Bar mine it is from 24 to 30 m thick (Jacobsen, 1980).

The Jackpile Sandstone was deposited in a northeasterly-flowing braided stream complex (Aubrey, 1992), and is characterized as having few persistent shale or mudstone interbeds. Instead it is dominated by fine- to medium-grained, cross-bedded, feldspathic (sub-arkosic) sands (with local zones of coarse-grained material) that often contain channel scours into underlying sandstones. It displays some variability both laterally and vertically, as demonstrated in the former JJ #1 mine, where it was subdivided into upper and lower units (FitzGerald and others, 1979, unpublished report), with the upper unit comprised primarily of quartzose sandstone with essentially no mudstone and the lower unit comprised of feldspathic to arkosic sandstone interbedded with numerous green mudstone lenses. In contrast, where exposed in the walls of the two open pits at St. Anthony, the Jackpile is white to light tan to light gray sandstone, locally exhibiting a pinkish hue where feldspar content is relatively high.

Quartz grains in the sandstone exhibit some frosting, likely due to mechanical abrasion, and are commonly coated with kaolinite. Individual sandstone lenses are cemented primarily with kaolinitic clay, and sometimes by calcite. Baird et al. (1980) reported the presence of minor amounts of pyrite in the Jackpile. Alteration within the St. Anthony portion of the project area is manifested primarily by the partial conversion of feldspar to kaolinite. Accessory minerals in the Jackpile Sandstone include trace amounts of zircon, tourmaline, garnet, and rutile. Nash (1968) noted from exposures at the Jackpile mine that biotite, amphibole, magnetite and pyroxene are absent.

Baird et al. (1980) discuss the presence of two types of carbonaceous material within the Jackpile Sandstone in the Willie P underground mine in the St. Anthony area. They reported the presence of plant material "coalified in situ" and as "sand-sized material" interstratified in cross-beds. They also report the presence of humate, occurring primarily as pore fillings between sand grains. Carbonaceous material is present in some exposures along the south wall of the St. Anthony North pit, and this material occurs as small (51 to 152 mm), vertical, rod-shaped structures, and as local accumulations of carbonaceous detritus on bedding planes. In the L-Bar area, carbonaceous material is also present as detritus and as humate accumulations. Jacobsen (1980) reports that no significant uranium mineralization occurs where carbonaceous material is absent.

Structure

The Cebolleta project and the adjoining Jackpile-Paguate group of uranium deposits lie within a feature known as the Acoma Sag (Nash, 1968), a regional syncline that is bounded on the west by the southeastern end of the Zuni uplift and on the east by the Lucero uplift. Rocks in the project area dip very gently to the north and northwest into the San Juan Basin, at less than 2 degrees. Several small-scale normal faults, generally down-dropped to the west, have been mapped on the surface several miles north of the project, and two similar structures, down-dropped to the east, have been mapped northeast and southwest of the project area (Schlee and Moench, 1963). No major faulting has been recognized in the project area. Several small-scale high-angle faults were observed in the workings of the former JJ #1 underground mine (Jacobsen, 1980), but these structures do not appear to have offset uranium mineralization, nor do they appear to have influenced the localization of mineralization.

A very small fold or structural dome was reported to be present in the southern part of the Willie P underground mine. There was an increased concentration of carbonaceous material in the north flank of this small-scale feature with a corresponding increase of uranium mineralization. A second, larger northeasterly-trending fold is present in the area of the Lobo Camp 4.8 km northeast of St. Anthony (Schlee and Moench, 1963). Overall, however, there is little in the way of deformation of rocks of the Laguna district (Moench and Schlee, 1967).

Ground Water

Throughout the Grants mineral belt sandstones of the Morrison Formation and the Dakota Sandstone are aquifers. As reported by Hatchell and Wentz (1981) and various reports concerning the former L-Bar mine, ground water discharge from the Jackpile Sandstone into the mine ranges from 113 to 454 liters/m. Water wells capable of producing between 113 and 159 liters/m were completed in the Jackpile sandstone at L-Bar, and other wells capable of producing between 159 and 227 liters/m from the Westwater Canyon Member (Geo-Management, 1972, unpublished report) were also completed in the area.

Uranium Mineralization

Nearly all of the uranium mineralization in the Grants mineral belt (which includes the Laguna mining district that encompasses the Cebolleta project) occurs as sandstone-hosted deposits in fluvial clastic rocks of the Morrison Formation. Three types of sandstone-hosted deposits have been identified in the area (Kittel et al., 1967; Granger and Santos, 1986):

- "Trend deposits," which have also been described by various workers in the district as "pre-fault" or "primary" deposits. Trend deposits are broad, undulatory layers of uranium mineralization controlled primarily by the texture or fabric of the host sandstones. Mineralization in trend deposits is localized around accumulations of humates, which acted as a reductant to precipitate dissolved uranium from ground water;

- "Redistributed deposits," which have also been described as "post-fault," "stack," or "secondary" deposits, are irregularly shaped zones of mineralization that were controlled by both the stratigraphic characteristics and the possible presence of structural features within the host rocks. Redistributed deposits are thought to be the product of destruction of trend deposits by oxidation, and have little humate associated with the mineralized zone; and

- "Remnant deposits" are, as the name implies, remnants of trend deposits that have been partially mobilized and redistributed. Remnant deposits tend to be discrete bodies of mineralization entirely enclosed within oxidized host rocks.

While the classification of sandstone-hosted deposit types is based on uranium mineralization in the Westwater Canyon Member, the classification is also applicable to Jackpile-hosted deposits with one important caveat. That is, the shapes of trend deposits in the Jackpile Sandstone do not necessarily reflect the overall geometry or architecture of individual Jackpile depositional channels, whereas in the Westwater Canyon- hosted accumulations they generally do.

Some investigators in the Grants mineral belt have discussed the presence of "roll-front" uranium deposits at various locations within the area (Clark, 1980; McCarn, 1997), and some former workers at the St. Anthony mines also suggested the presence of roll-front mineralization in the Cebolleta area. Nonetheless, geologic mapping of the Jackpile-hosted mineralization in the two St. Anthony open pits by the author and his colleagues, as well as detailed examination of several thousand gamma-ray logs from holes at Cebolleta have not revealed the presence of features that are consistent with typical roll fronts.

Individual uranium deposits in the Grants mineral belt range from a few tons to several millions of tons in size. Many of the deposits in the Westwater Canyon Member are roughly tabular, locally irregular in shape, and are elongate in a west-northwest direction, reflecting the general shape of individual channel sandstone units of the Westwater Canyon Member. Individual deposits range in size from 1 to 3 m in width and length to deposits that may be 5 to 15 m in thickness, 100 to 259 m in width, and 300 to 1,800 m in length (Fitch, 1980). Redistributed deposits hosted by the Westwater Canyon are often more irregular in their plan-view shape, and rarely conform to the geometry of their precursor trend deposits. The thicknesses of redistributed deposits may range from 1.5 to 30 m, and the deposits may have lateral extents of 61 to 610 m in length and width.

Uranium deposits hosted by the Jackpile Sandstone can also be quite large. This is demonstrated by the Jackpile-Paguate deposits, which are contiguous with the south boundary of the Cebolleta project (Fig. 2). For example, the Jackpile mine deposit is several thousand meters long and averages 609 m wide. Individual mineralized zones rarely exceed 4.5 m in thickness, but the aggregate thickness of several "stacked" layers is up to 15 m. Thus, Moench (1963) described the Jackpile mine uranium deposits as "composed of one or more semi-tabular layers". In plan view the layers range from nearly equant to strongly elongate. Viewed in vertical section, the layers are suspended within sandstone intervals; only locally do they extend to stratigraphic discontinuities such as prominent mudstone beds, diastems, or formational contacts. The distribution or architecture of mineralized zones in the St. Anthony and L-Bar deposits within the Cebolleta project area are generally similar, although the average width of mineralized zones rarely exceeds 305 m.

According to Dahlkamp (2010), the Cebolleta uranium deposits were formed by the mobilization of uranium from either granitic rocks of the ancestral Mogollon highlands, located southwest of the project area, or from the devitrification of tuffaceous rocks contained in the host sandstones and particularly in the Brushy Basin Member. In this model the uranium was mobilized and transported by alkaline ground waters. Ultimately, uranium minerals were deposited in the host sandstones, where chemical reactions associated with humic acids derived from plant material caused precipitation of dissolved uranium from the ground water (Adams and Saucier, 1981).

As currently defined (from mineral resource estimate modeling) there are five discrete uranium deposits at the Cebolleta project (see Figs. 4 and 5):

- Area I (former Sohio L-Bar);
- Area II and V (former Sohio L-Bar);
- Area III (former Sohio L-Bar);

- St. Anthony North and South pits (including the former M-6 underground deposit); and
- Willie P (St. Anthony underground).

The uranium deposits in the project area share a common set of geological characteristics:

- Essentially all of the mineralization is hosted by the Jackpile Sandstone, although minor mineralization is hosted in sandstones of the Brushy Basin Member;
- Most of the mineralization is hosted in medium to coarse-grained sandstones that exhibit large-scale tabular cross-stratification (Baird and others, 1980);
- Near the margins of the deposits the mineralization thins appreciably, although halos of low-grade mineralization surround the deposits;
- Higher grade mineralization usually occurs in the centers of the mineralized zones;
- Strong mineralization appears to be concentrated in the lowermost portions of the Jackpile, although anomalous concentrations of uranium are present throughout the entire vertical extent of the unit (Jacobsen, 1980);
- Most of the mineralization in the Cebolleta area appears to be associated with reducing redox conditions, with only isolated, discontinuous pods (primarily in the Willie P underground mine) exhibiting appreciable oxidation (Baird and others, 1980);
- Individual deposits do not show an overall preferred orientation or trend, and do not reflect the northeasterly orientation of the main Jackpile Sandstone channel trend. Indeed, current resource modeling efforts have demonstrated a NNW-SSE trending orientation for the product of grade and thickness (GT product) of mineralized zones; and
- Nearly all of the deposits are associated with carbonaceous material, although the mineralized zones exposed in the high walls of the two St. Anthony open pits are not.

The deposits range in depth from approximately 61 m at St. Anthony, to nearly 213 m in the vicinity of the Sohio Area II and Area III deposits in the central and northern (down-dip) parts of the project area. In the southern part of the project area (Fig. 5), the mineralization in the St. Anthony South pit appears to be a “remnant” deposit that has been partially depleted of uranium, which was redeposited in the nearby (down-dip) North pit area. In the northern part of the project

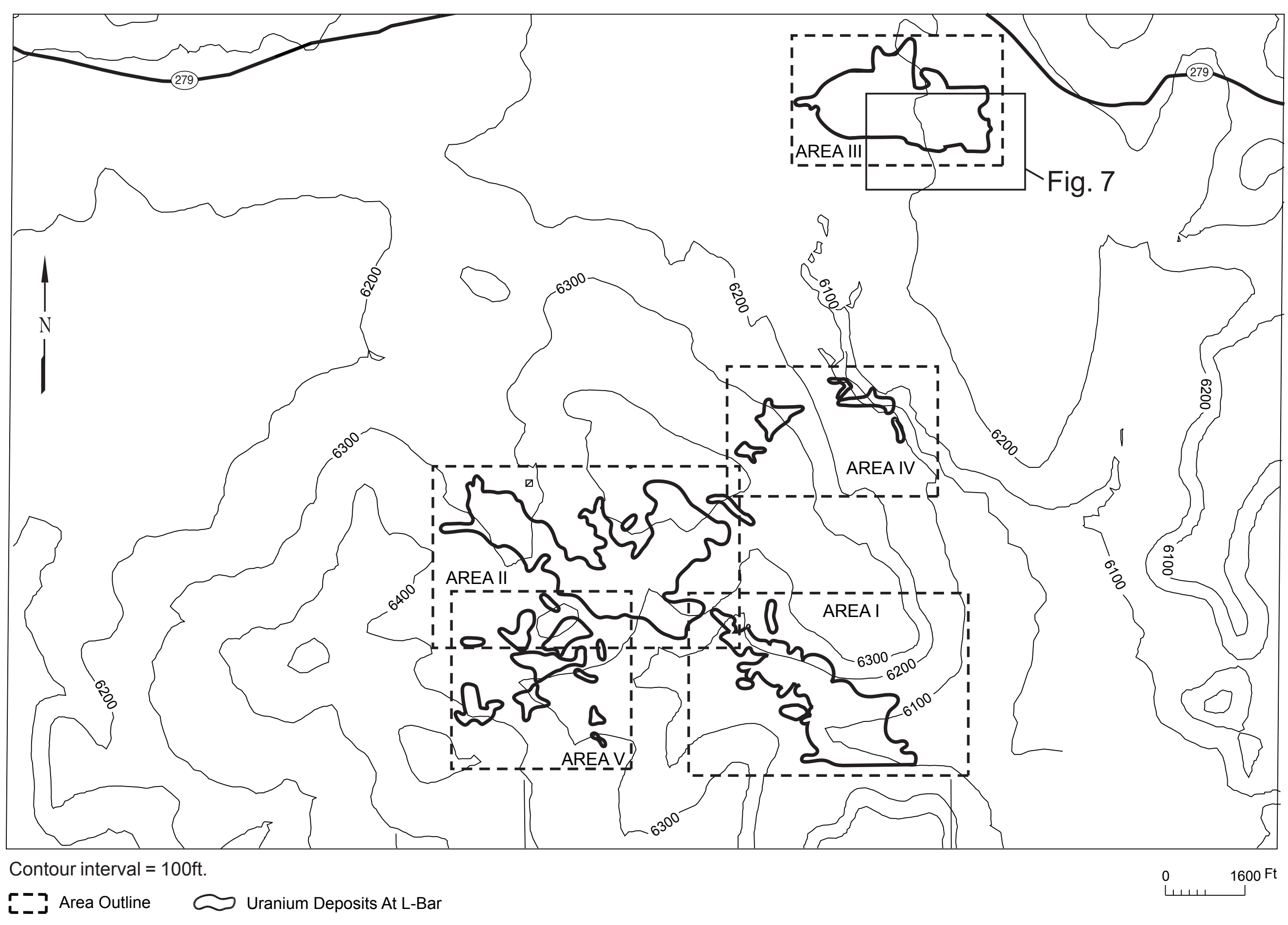


Figure 4. Index map of uranium deposits in the northern part of the Cebolleta project area (formerly referred to as the Sohio or L-Bar deposits). Location of Figure 7 is outlined.

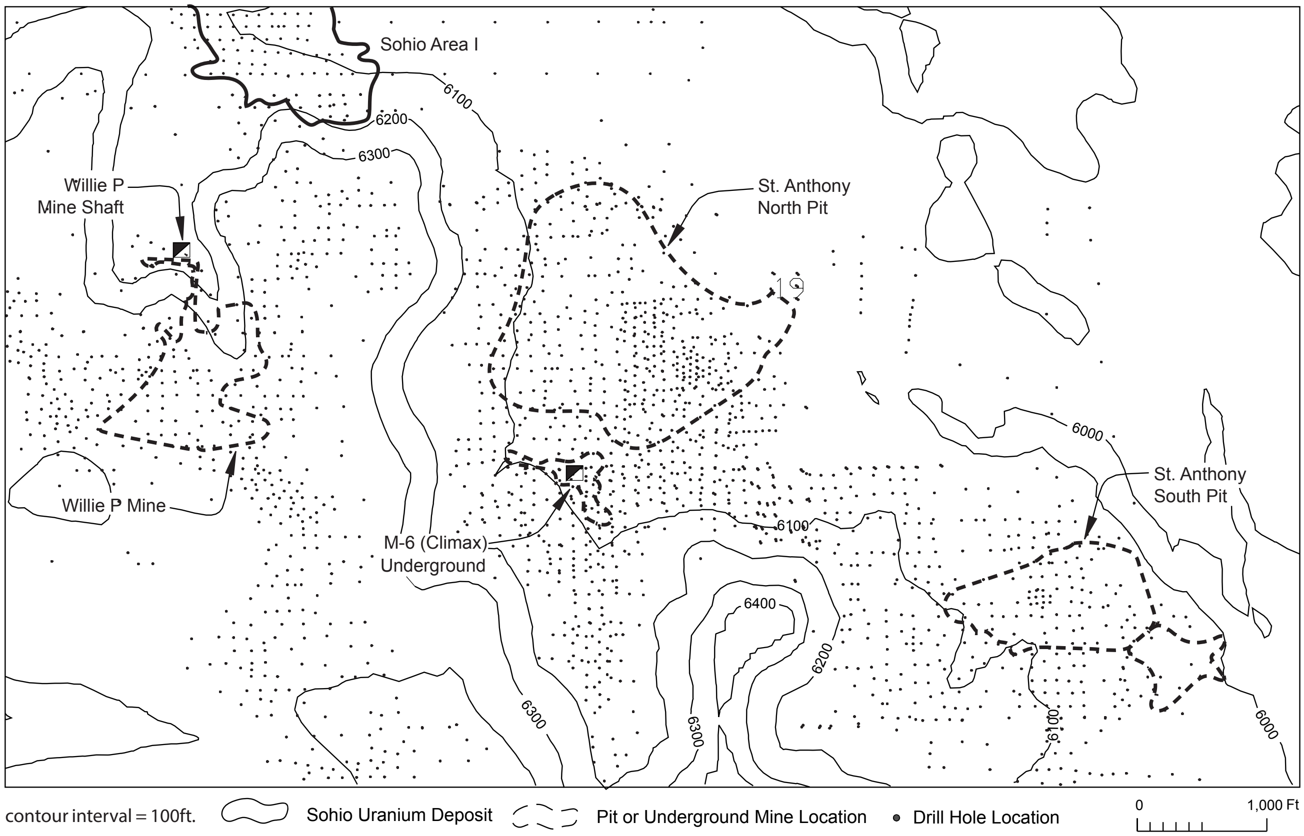


Figure 5. Index map of uranium deposits in the southern part of the Cebolleta project area (formerly referred to as the St. Anthony deposits), showing locations of historical drill holes.

area (Fig. 4), mineralization occurs in tabular bodies that may be more than 305 meters) in length and attain thicknesses of 1.8 to 3.7 m. The upper and lower boundaries of these mineralized bodies are generally quite abrupt. There is some tendency for individual deposits to develop in clusters. Locally, these clusters may be related to the coalescence of separate channel sandstone bodies. In this instance, mineralization is often thicker and of higher grade than adjoining areas.

Extensive chemical and radiometric analyses on core samples by Sohio and United Nuclear (Geo-Management, 1972, unpublished report; Olsen and Kopp, 1982, unpublished report) demonstrate that radiometric (e.g., calibrated gamma-ray measurements, or assays, denoted as "% eU_3O_8") and chemical assays generally yield comparable results in terms of ore grade (wt. % U_3O_8). Evaluation of samples from 47 core holes at St. Anthony, however, indicated that chemical analyses yielded somewhat higher estimates of grade than radiometric assays.

In summary (see figures 3, 4, 5), the northern portion of the Cebolleta project includes three distinct zones of mineralization, known as Area I, Area II-V, and Area III, with mining by Sohio limited to the II-V deposit (the JJ #1 mine). The Area I deposit, located in the southern end of the L-Bar complex (and north of the St. Anthony mines) extends south into the northern St. Anthony area, and additional uranium mineralization is present adjacent to the St. Anthony open pits and the Willie P. underground mine (McLemore and Chenoweth, 1991). Two of the former Sohio (L-Bar) uranium deposits, the Area I and Area III deposits, are described below.

Area I Deposit (part of Area I-II-V Deposit Complex)

At Area I, grade, thickness, and GT (grade times thickness) contour maps were prepared for each of the mineralized horizons. For these maps, uranium grades were calculated using data from gamma-ray logs and are denoted as weight percent "eU_3O_8" (as opposed to grade estimates based on chemical analysis). Mineralized horizons were assigned to one of four zones — "Upper," "Middle," "Lower," and "Basal" zones.

Mineralization in the Middle zone defines a broad, southeast-northwest trending body that is 183 to 244 m wide and approximately 274 m long. Drill-hole intersections of mineralized zones ("mineral intercepts") with a cut-off value of 0.5 GT indicates that the horizon averages 3.1 m thick with an average grade of 0.12% eU_3O_8. Mineralization in the Lower zone occurs as a sinuous, lenticular, southeast-northwest trending body that is 46 to 122 m wide and approximately 731 m long. A composite of mineral intercepts at a 0.5 GT cut-off averages 9.8 feet (2.98 meters) thick with an average grade of 0.153% eU_3O_8.

The mineralized zones and lenses appear to be somewhat continuous throughout the Area I deposit. However, Area I appears to have a higher frequency of thin, less continuous mineralized horizons than are observed at other deposits in the northern part of the project area. The better (higher grade) and more laterally continuous uranium deposits are in the Middle and Lower zones.

Additional mineralization at the base of the Jackpile Sandstone and in the underlying Brushy Basin Member corresponds with the Basal zone in the Area I uranium deposits. Mineralization in the Basal zone at Area I is in several relatively small, discontinuous, lenticular pods. A composite of mineral intercepts at a 0.5 GT cut-off averages 2.13 m thick with an average grade of 0.14% eU_3O_8.

Area III Deposit

Geologic and mineralization sections were constructed across the Area III deposit utilizing the mineral intercept data from the Sohio drill-hole maps and individual gamma-ray/electric logs (Fig. 6). Mineralization is observed to be continuous from section to section in tabular or lenticular bodies of a few feet to tens of feet in thickness. Grades greater than 0.10% eU_3O_8 are commonly present, with numerous intercepts of 0.20% eU_3O_8 or better. This mineralization occurs throughout the Jackpile Sandstone, which is 24 to 30.5 m thick at Area III.

Area III mineralization, as at Area I, was assigned to four levels, designated as Upper, Middle, Lower, and Basal zones. The better and more laterally continuous mineralized bodies are in the middle to lower portion of the sandstone sequence, corresponding to the Middle and Lower zones. Mineralization is also present in the Brushy Basin Member at and immediately below the base of the Jackpile Sandstone, in the Basal zone.

Mineralization in the Middle zone occurs in an arcuate, east-west trending, elongate body that is 61 to 152 m wide and approximately 640 m long (Fig. 7). A composite of mineral intercepts at a 0.5 GT cut off averages 2.5 m in thickness with an average grade of 0.183% eU_3O_8. Mineralization in the Lower zone is represented by a continuous, lenticular, east-west trending body that is 91 to 152 m wide and approximately 670 m long. A composite of mineral intercepts at a 0.5 GT cut off averages 3.1 m thick with an average grade of 0.172% eU_3O_8.

Controls on Mineralization

Principal controls on uranium mineralization at the Cebolleta project are primary sedimentary structures in the Jackpile Sandstone (Jacobsen, 1980; Baird and others, 1980), and concentrations of carbonaceous material that served as a reductant to precipitate uranium from circulating ground water. The distribution of carbonaceous material tends to be localized, as observed in the former L-Bar mine (Jacobsen, 1980) and in the pit walls of the two St. Anthony open pits. Jacobsen (1980) notes that there are no significant accumulations of uranium without carbonaceous material; the same relation has been noted by UNC geologists (Baird and others, 1980) in the former Willie P underground mine at St. Anthony. However, the author has not observed significant accumulations of carbonaceous material associated with low-grade (0.03% to 0.06% U_3O_8) uranium mineralization in the walls of the St. Anthony North pit. This may reflect the "redistributed" type of mineralization in the St. Anthony North pit (see previous discussions), and the uranium-precipitating mechanism remains to be determined.

Baird and others (1980) noted the distinct association of substantial zones of uranium mineralization with medium to coarse-grained sandstones that exhibit large-scale tabular cross-bedding in the Willie P underground mine. Similar relationships between uranium mineralization and sedimentary structure/texture have been noted in the south high wall of the St. Anthony North pit.

While there is a strong northeasterly trend to the thickness contours of the Jackpile sandstone in the Laguna district (which includes all of the Cebolleta project area), there appears to be no consistent lateral trends in the individual uranium deposits in the Laguna district.

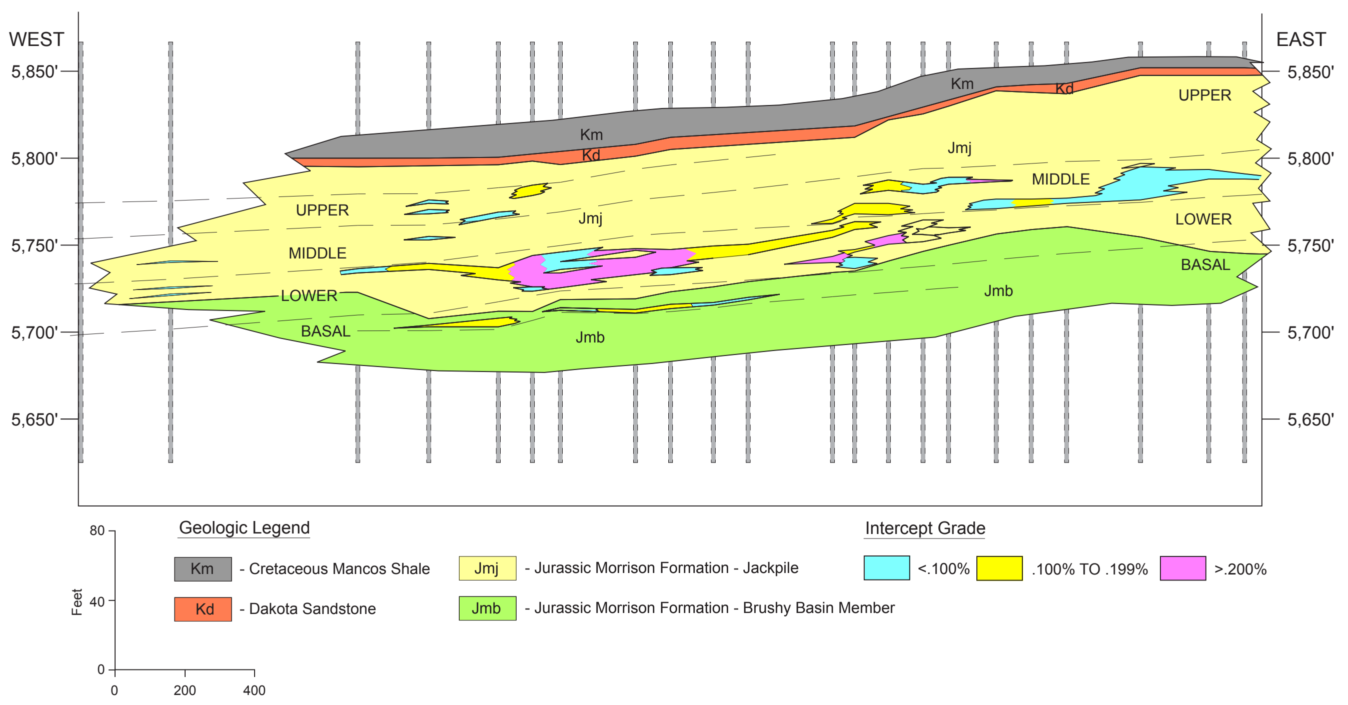


Figure 6. East-west cross section (looking north) of the Area III uranium deposit, depicting geologic units intersected by drill holes (thick vertical grey lines), as well as mineralized zones as derived from calibrated gamma-ray logs. The "Lower" mineralized zone demonstrates lateral continuity over a distance of more than 396 m at grades of 0.10% eU_3O_8 or more. Line of cross section is shown on Figure 7.

Baird and others (1980) state that there is an apparent northwest trend with respect to mineralization in the St. Anthony area. This apparent northwest trend, which was not observed by Sohio geologists at the former JJ #1 mine (Jacobsen, 1980), has perhaps been created to some extent by the erosional retreat of the Jackpile Sandstone outcrop (Baird, 1980), and the subsequent oxidation and redistribution of uranium mineralization.

Mineralogy

Uranium minerals at the Cebolleta project are reported to be coffinite [$U(SiO_4)_{1-x}(OH_{4x})$], uraninite [UO_2], organo-uranium complexes, and unidentified, oxidized uranium complexes (Robertson & Associates, 1978, unpublished report). The author is unaware of any published reports or studies regarding the mineralogy of the Cebolleta uranium deposits.

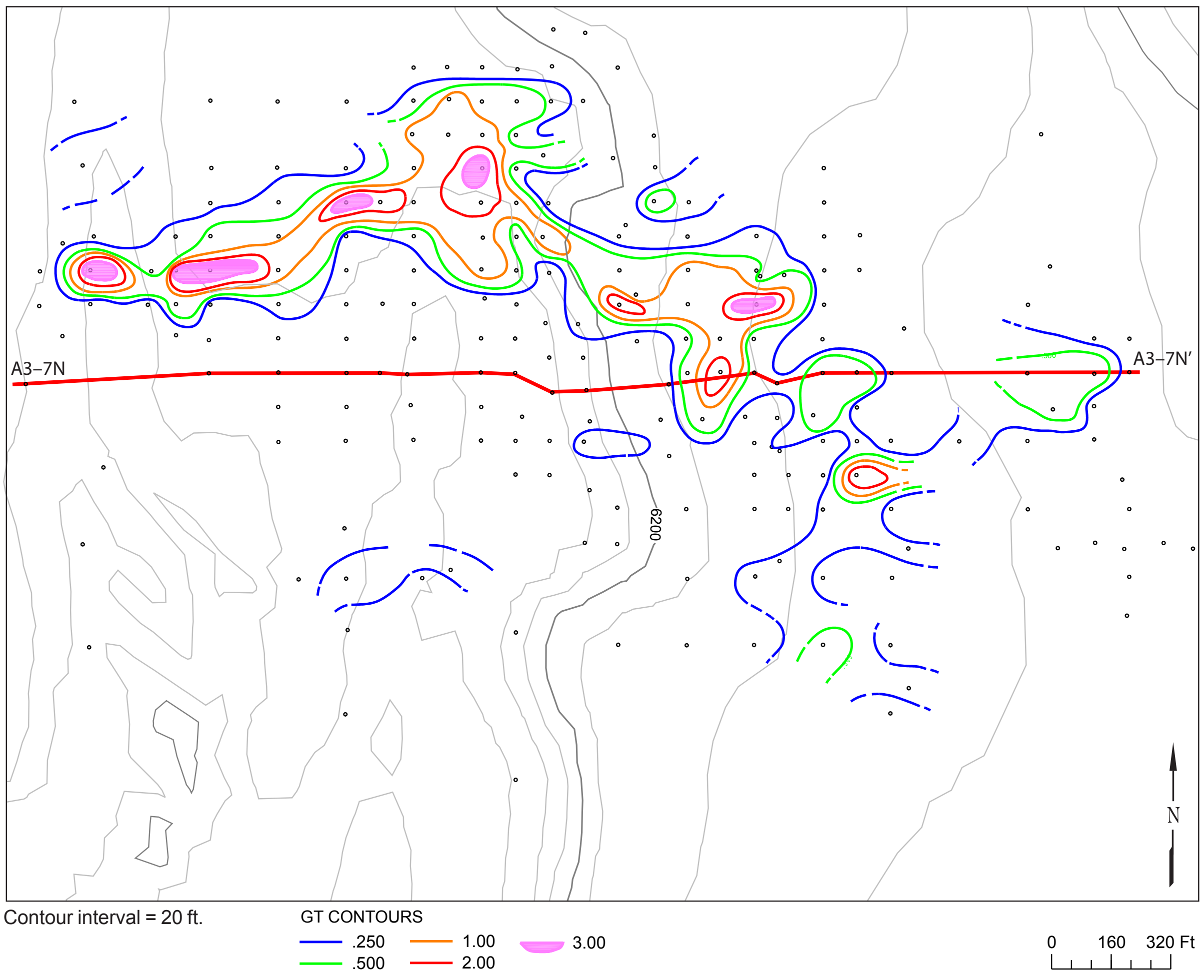


Figure 7. Grade times thickness (GT) contour map of the "Middle" mineralized zone at Area III. The location of the Fig. 6 cross section is shown. The Middle zone at Area III demonstrates good lateral continuity of mineralization in a general east-west direction at a GT cut-off of 0.50.

TABLE 1: In-Place inferred mineral resources for Cebolleta Project

Deposit	Cut-off Grade (% eU_3O_8)	Grade (% eU_3O_8)	Tons (short)	Contained Pounds eU_3O_8
Area I-II-V	0.08	0.173	4,564,000	15,748,000
Area III	0.08	0.162	998,000	3,232,000

Notes:

1. Mineral resources are not mineral reserves and do not have demonstrated economic viability;
2. Mineral resources are reported in accordance with Canadian Securities Administrators (CSA) National Instrument 43-101 (NI 43-101) and have been estimated in conformity with generally accepted Canadian Institute of Mining, Metallurgy and Petroleum (CIM) "Estimation of Mineral Resource and Mineral Reserves Best Practices" guidelines;
3. Resources are stated at a 0.08% eU_3O_8 cut-off grade; sufficient to define potentially underground mineable resources; however mineable underground shapes have not yet been defined;
4. A tonnage factor of 16.0 cubic ft per ton was used for all tonnage calculations;
5. Mineral resource tonnage and contained metal have been rounded to reflect the accuracy of the estimate, and numbers may not add due to rounding.

Mineral Resource Estimates

Mineral resources for the Cebolleta project were estimated for the former Sohio Area I, II, III, and V deposits (Moran and Daviess, 2014, unpublished report) using data from the Sohio drilling programs and a geostatistical model. The adjoining St. Anthony deposits, in and surrounding the St. Anthony open pits, have not yet been synthesized into a useable database for resource estimation. The estimates for the individual Area I, II, III, and V deposits have been combined into Areas I-II-V and Area III, and are listed in Table 1. In accordance with Canadian mining standards and guidelines (see Table 1 notes), these estimates are formally classified as "inferred resources".

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