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URANIUM IN THE GUNNISON COUNTRY, COLORADO*

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INTRODUCTION

Uranium prospecting spread eastward from the Colorado Plateau in the middle and late 1950s to a more hard-rock environment in the area surrounding Gunnison. Two major uranium districts (Cochetopa and Marshall Pass) were discovered during that time, as were numerous uranium occurrences elsewhere in the area. More recently, in the late 1970s, the Gunnison country experienced renewed and more intense uranium exploration and development.

Approximately 1.2 million kg of L.1308 have been produced from the Gunnison country; over 99 percent of this has come from the Cochetopa and Marshall Pass districts. Uranium in both districts and many of the other occurrences is associated closely with fault and shear zones which cut brittle host formations (dolomites and sandstones) of Paleozoic and Mesozoic age. Minor uranium occurrences are in pegmatites and shear zones in Precambrian rocks, Cambrian vein material, and sandstones of early Tertiary age. Much of the information and basic data on the various uranium occurrences for this paper were collected from 1977-1979 during the evaluation of the Montrose (1°x2°) quadrangle by Bendix Field Engineering Corporation, under contract to the U.S. Department of Energy for the National Uranium Resource Evaluation (NURE) program. The reader is referred to the Montrose quadrangle evaluation report (folio) for additional information on uranium occurrences (many others having less than 0.01 percent U308) and favorability (Goodknight and Ludlam, 1981).

The area of Gunnison country for this paper is somewhat restricted to within the Montrose 1°x2° quadrangle boundary, and also excludes the area around Lake City; the boundary of the area described in this paper is shown in Figure 1. An index map (fig. 1) shows all the known occurrences of material containing at least 0.01 percent U308.

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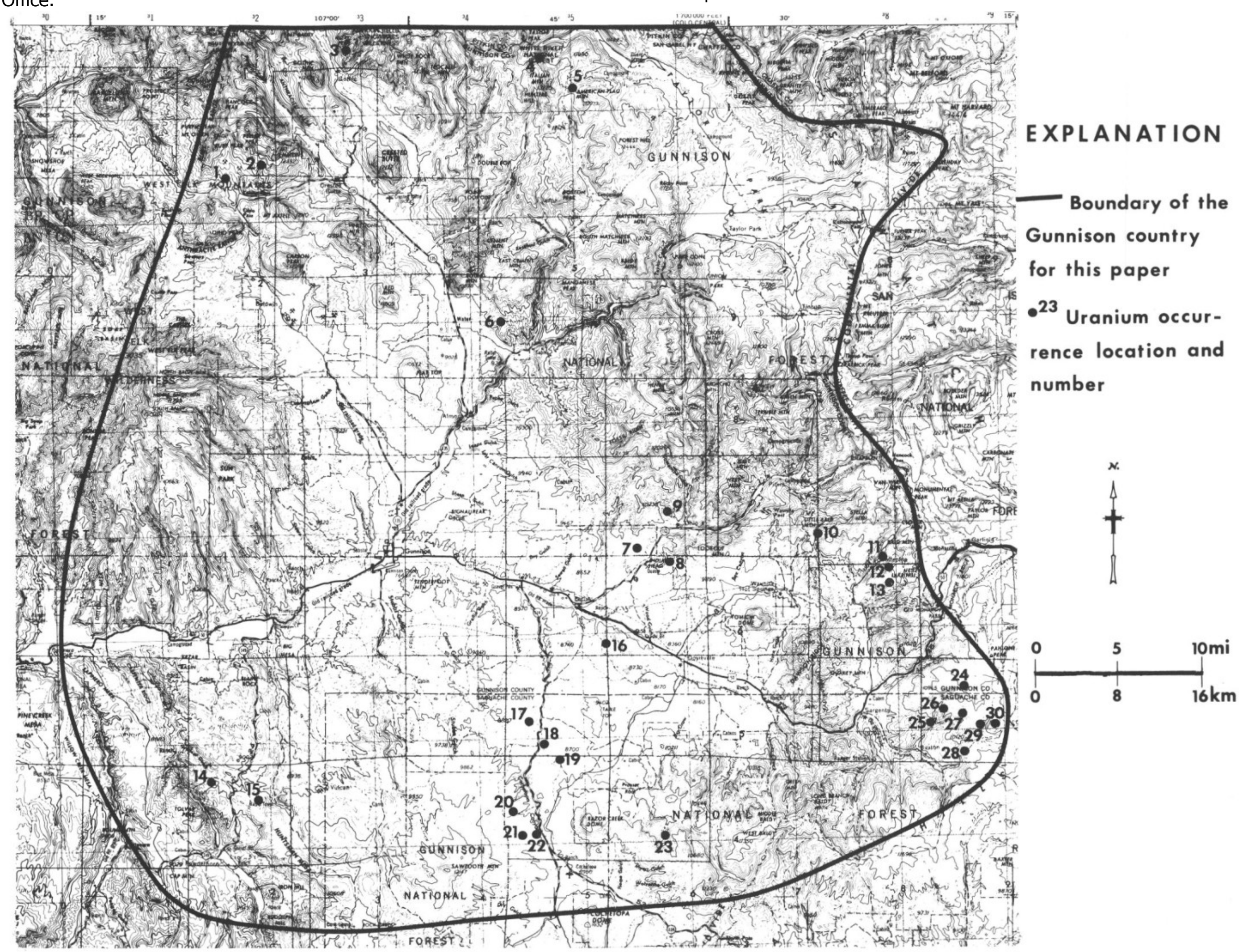

Figure 1. Index map of the Gunnison country showing locations of selected uranium occurrences (at least 0.01 percent U_3O_8).

DESCRIPTION OF URANIUM OCCURRENCES IN AREAS (OR DISTRICTS)

Ruby-Irwin District

Uranium has been found in the southeastern part of the Piceance Creek basin in the Ruby-Irwin base- and precious-metal mining district. In this district, centered about 10 km west of Crested Butte, uranium is in the Ruby Anthracite Creek area and at the Standard mine. Prospectors in the mid-1950s found uranium in the lower part of the Eocene Wasatch Formation along Ruby Anthracite Creek at the Yellowdog and Pearl B claims (locality 1, fig. 1 and Table 1). Workings on the claims in the E1/2 sec. 4, T. 14S., R. 87W. consist of several prospect pits and one short adit; no uranium was produced. During quadrangle evaluation (Goodknight and Ludlam, 1981) in 1978, high radioactivity was found in some dump material from the abandoned Standard mine in the SE% sec. 25, T. 13 S., R. 87 W. (loc. 2). The anomalously radioactive dump material came from the Paleocene Ohio Creek Formation and/or the Eocene Wasatch Formation; the exact location of the material was uncertain because the entrance to the mine (formerly a large producer of lead, zinc, and silver) was caved.

Uranium mineralization in the Ruby Anthracite Creek area is in iron-stained, fine- to medium-grained feldspathic sandstone that contains a moderate amount (up to several percent) of carbonaceous material and minor pyrite along bedding. Uranium is associated with carbonaceous material, mainly near the base of poorly developed stream channel systems that trend west or northwest. Samples of mineralized rock taken during quadrangle evaluation contain up to 0.035 percent U308; no uranium minerals have been identified.

The uranium occurrence at the Standard mine is in gray, fine-grained sandstone with clay and carbonaceous clasts, probably from a fluvial channel. A sample of radioactive material taken during quadrangle evaluation from the mine dump contained 0.59 percent U308 and uranium (uraninite?) is associated with carbonaceous material which composes about two percent of the rock. The mine is within the body of base-metal mineralization related to the Redwell Basin intrusive complex of Oligocene age, centered about 2-3 km to the east. Uranium was probably emplaced by groundwaters in the carbonaceous sandstone before the episode of base-metal mineralization which provided pyrite, sphalerite, argentiferous galena, chalcopyrite, and pyrrhotite.

Elk Mountains

The part of the Elk Mountains shown in Figure 1 extends from Gothic on the west to the Taylor River on the south and east. Four areas of uranium cocurrences have been found in this (southern) part of the Elk Mountains.

On the west side of Virginia Basin about 2.5 km north of Gothic in the NW% NE% sec. 34, T. 12 S., R. 86W. (loc. 3), low-grade stratiform uranium enrichment occurs in a thin, gray, freshwater lime-

Table 1. Selected uranium occurrences (at least 0.01 percent U_3O_8) and their host formation(s) in the Gunnison country.

Locality Number (fig. 1)	Name	Formation
1	Yellowdog and Pearl B claims	Wasatch Formation
2	Standard mine	Ohio Creek and/or Wasatch Formation
3	Virginia Basin	Morrison Formation
4	Mt. Tilton	Parting Sandstone of Chaffee Group
5	Star Basin	Bog material and fault breccia
6	North Star claims (Jacks Cabin)	Altered Precambrian Y granite
7	Pegmatite No. 783	Precambrian pegmatite
8	Brown Derby mine	Precambrian pegmatite
9	Willow Creek mine	Precambrian pegmatite
10	Margo claim group	Precambrian YX(?) granite
11	Akron Tunnel	Paleozoic sedimentary rock
12	West Point Hill	Leadville Limestone
13	Big Red No. 22 mine and No. 39 prospects	Sawatch Sandstone
14	Spencer area	Iron-rich vein material
15	Mrs. Roberts deeded land	Thorium- and uranium-bearing vein
16	Surefire mining claims	Morrison Formation
17	Post claim group	Junction Creek Sandstone
18	Do Dah claim group	Fault zone in rocks of Precambrian X age
19	Los Ochos mine	Junction Creek Sandstone, Morrison Formation, and brecciated Precambrian rocks
20	Milbob claim group	Junction Creek Sandstone
21	La Rue claims	Dakota Sandstone
22	Bet claim group	Morrison Formation, Junction Creek Sandstone, and brecciated Precambrian rocks
23	Lucky Friday claim group	Junction Creek Sandstone and quartz monzonite of Precambrian X age
24	Little Indian No. 36 mine	Harding Sandstone
25	Apache No. 4 claim	Harding Sandstone
26	Little Indian No. 6 claim	Harding Sandstone
27	Pitch mine	Leadville Dolomite and Belden Formation
28	Chester Fault at Marshall Creek	Pegmatitic granite of Precambrian X age
29	Marshall Pass No. 5 claim and Lookout claim group	Fractured granite gneiss and quartz monzonite of Precambrian X age
30	Hidden Reserve claim group	Precambrian pegmatite

stone bed in the lower part of the Morrison Formation. This occurrence was discovered in the mid-1950s and was investigated in 1978 by Goodknight and Ludlam (1981). A sample from the limestone bed contained 0.01 percent U308; the highest radioactivity was along fractures or joint surfaces. The occurrence is probably epigenetic and may be either an efflorescent or a peneconcordant deposit.

Near the head of Cement Creek on the north side of Mt. Tilton in the SPA sec. 28, T. 12 S., R. 84W. (loc. 4), another low-grade stratiform uranium enrichment occurs—this time in the lowr part of the Parting Sandstone of the Chaffee Group. This occurrence was found in 1978 during quadrangle evaluation (Goodknight and Ludlam, 1981); a sample of the Parting contained 0.017 percent radiometric uranium. High radioactivity occurs in a thin bed of dark brown, quartzose, medium- to fine-grained sandstone in the Parting, which represents a marginal-marine environment during transgression of a sea in Late Devonian time.

On the south side of Star Basin near the head of Italian Creek in secs. 1 and 12, T. 13 S., R. 84 W. are three closely-separated uranium occurrences (all shown by loc. 5, fig. 1). All three occurrences were found in 1978 during quadrangle evaluation and all may possibly be related. Two occurrences On sec. 1) are in black, organic-rich bog material at the sites of highly-radioactive cold springs which overlie Precambrian YX(?) gneissic granite. The third occurrence (in sec. 12) is in limonite-cemented breccia along an east-trending normal fault separating shales of the Pennsylvanian Belden Formation to the south from gneissic granite of Precambrian YX(?) age. The area of the occurrences is along the Castle Creek fault zone of Laramide age bordering the west side of the Sawatch Range; the Oligocene Italian Mountain intrusive complex lies less than 2 km to the west (Cunningham, 1973).

Samples of the bog material at the two occurrences contained just over 0.01 percent U308; however, the radiometric uranium content of one of the samples was 1.3 percent. This high radioactivity at the springs is probably due to radium-226. A sample of the occurrence along the fault zone had 0.016 percent U308. Radium-226, a uranium daughter product that appears at the springs, is probably being transported from a vein-type uranium deposit somewhere along the hydrologic system supporting the springs. The occurrence in the fault breccia may represent a more extensive vein-type uranium deposit at depth or many other faults in the area may host vein-type uranium deposits responsible for high radium contents in the springs.

In the extreme southern Elk Mountains about 10 km north of Almont in the E1/2 sec. 17, T. 15 S., R. 84W. (loc. 6), uranium occurs at the North Star claims in what is commonly referred to as the Jacks Cabin area. Uranium was discovered here in 1955 along the northwest-trending North Star (or Granite) reverse fault. The North Star fault in this area separates Precambrian Y granitic rocks to the northeast from the Belden Formation and younger Mesozoic sedimentary rocks to the southwest. The fault zone is 30-60 m wide and is developed mainly in altered and fractured granite. Uranium (autunite and meta-autunite) occurs along fractures; a sample of fractured granite contained 0.034 percent U308 (Goodknight and Ludlam, 1981). Numerous prospect pits and two caved adits occur along a 2-km length of the fault zone. In the past five years, several companies have conducted exploratory drilling along the fault in this area.

Quartz Creek District

Uranium occurrences are known from three of the numerous pegmatite bodies that compose the Quartz Creek mining district, about 24 km east of Gunnison. Uranium in these pegmatites is in small, widely scattered pods of uranium-bearing minerals. The simple and zoned pegmatites in the district are related to the Wood Gulch Granite of Precambrian X age exposed to the south.

Pegmatite No. 783, named on the map by Staatz and Trites (1955), was sampled by Goodknight and Ludlam (1981) in 1979 and found to contain the thorium minerals brockite and greyite and 0.011 percent L.1308; no uranium minerals were identified. This microcline-quartz-pegmatite is in the E1/2 sec. 32, T. 50 N., R. 3 E. (loc. 7).

The Brown Derby mine in the NE% sec. 3, T. 49 N., R. 3 E. (loc. 8) produced about 110 kg of U308 from 365 metric tons of lepidolite and microlite mined during World War II (Nelson-Moore and others, 1978). Chip samples taken during quadrangle evaluation in 1978 from the margin of the Brown Derby No. 1 pegmatite contained several percent U308 from the minerals pyrochlore and uranopyrochlore.

A sample taken during quadrangle evaluation in 1978 from a radioactive part of the Bucky pegmatite at the Willow Creek mine (loc. 9) contained 0.084 percent U308. This mine is near the northern end of the district in the NE1/4 sec. 22, T. 50 N., R. 3 E. Radioactive minerals identified in 1978 from this occurrence include struverite, uranopyrochlore, and monazite.

Tomichi (Whitepine) District

Four areas of uranium occurrence have been found in the Tomichi (and Whitepine) base-metal mining district. The district is on the west flank of the Sawatch Range and is characterized by small remnants of Paleozoic sedimentary rocks bounded by Laramide reverse faults. The remnants have been mineralized by hydrothermal solutions from the nearby Oligocene Mount Princeton batholith to the northeast.

The prospects at the Margo claim group (formerly known as the Delores-Marie or Vicki Lee) along Canyon Creek, about 7 km northwest of Whitepine, are in the E1/2 sec. 25, T. 50 N., R. 4 E. (loc. 10). Uranium has been known in this area since the mid-1950s in shear zones and fractures in pegmatitic granite of Precambrian YX(?) age. The Bald Mountain reverse fault (Dings and Robinson, 1957), which bounds a Paleozoic remnant, is less than 1 km west of the occurrence. A sample taken at a prospect in 1979 during quadrangle evaluation had 0.029 percent U308 and uranium-bearing minerals were identified as euxenite-polycrase, zircon, and xenotime.

Uranium was found by Gallagher and others (1977) in small pieces of dump material from the Akron Tunnel (loc. 11), just south of Whitepine. The haulage tunnel, which has been caved for many years, connected with several mine workings to the east along the north-trending Star reverse fault where replacement deposits of silver, lead, and zinc occur in Paleozoic sedimentary rocks. A sample of radioactive dump material taken during quadrangle evaluation in 1979 had 0.45 percent U308.

In 1978 during quadrangle evaluation, uranium was found near the base of the Leadville Limestone about 1 km southeast of Whitepine on the top of West Point Hill (loc. 12). This occurrence (in the E1/2 sec. 3, T. 49 N., R. 5 E.) is in white to light gray dolomitic sandstone that is anomalously radioactive along strike for about 100 m. A sample of the dolomitic sandstone contained 0.014 percent L1308 (Goodknight and Ludlam, 1981). Uranium in this occurrence may represent a stratiform deposit or it may be related to. the Star reverse fault, about 150 m to the east.

Uranium was discovered in 1957 at the Big Red occurrences in secs. 10 and 11, T. 49 N., R. 5 E. (loc. 13), about 3 km south of

Whitepine. The Big Red No. 22 mine and No. 39 prospects are about 1 km apart in separate small remnants of Upper Cambrian Sawatch Sandstone along the footwall of a northwest-trending reverse fault. Extensive drilling occurred in the summers of 1978 and 1979 along several kilometers of the reverse fault system. The Sawatch in this area rests on granitic rocks of Precambrian YX(?) age.

About 250 kg of U308 of an average grade of 0.22 percent were produced in the later 1950s and early 1960s from the Big Red No. 22 mine (Nelson-Moore and others, 1978). During quadrangle evaluation in 1978, a sample was taken in fault gouge at the Big Red No. 39 prospects that contained 0.064 percent U308 and about 10 percent iron. Autunite is the main uranium mineral at the occurrences and, in addition, torbernite and parsonite are possibly present at the Big Red No. 22 mine (Goodknight and Ludlam, 1981).

A marked difference exists in the thorium contents of the two Big Red occurrences. Almost no thorium occurs at the Big Red No. 22 mine, whereas, the thorium-to-uranium ratio at the Big Red No. 39 prospects is between 2 and 3. Olson and others (1977) note that the high thorium content at the Big Red No. 39 may be an indication of alkalic magmatism in the area during Cambrian time. Other evidence for alkalic magmatism is a very small thorium-rich carbonatite body near Quakey Mountain, about 10 km to the southwest (Goodknight and Ludlam, 1981).

Powderhorn District

Two uranium occurrences in the Powderhorn district are known in thorium-bearing veins that were emplaced in shear or breccia zones in Precambrian rocks. The veins are numerous and occur 2-20 km north and northwest of the alkalic complex at Iron Hill (carbonatite stock) of Early Cambrian age to which the veins are related; see Armbrustmacher (this guidebook) for a description of the Iron Hill complex. Both occurrences are in the southern part of the Gunnison gold belt which contains gold-bearing quartz veins and thorium-bearing jasperoid veins; see articles about sulfide mineralization in the gold belt by Drobeck and Sheridan and others (this guidebook). It is not known why only a few of the thorium veins are enriched in uranium.

About 2 km southwest of the old townsite of Spencer in the NWA sec. 8, T. 47 N., R. 2 W. (loc. 14), uranium occurs in a northeast-trending, iron-rich vein that cuts a Precambrian leucosyenite plug. This occurrence, found during quadrangle evaluation in 1978, contained 0.23 percent U308 and over 10 percent of both calcium and iron (mainly as specular hematite).

The uranium occurrence known as (being on) Mrs. Roberts deeded land is about 7 km north of Powderhorn in the N1/2 NEA sec. 15, T. 47 N., R. 2W. (loc. 15). Uranium was discovered there in the mid-1950s in a northeast-trending vein along a shear zone in Precambrian Dubois Greenstone. Malan (1955) took vein samples that contained up to 0.28 percent U308 and up to 5.35 percent equivalent thorium.

Cochetopa District

Approximately 650,000 kg of U308 (Nelson-Moore and others, 1978) have been produced from the Cochetopa uranium district, centered about 20 km southeast of Gunnison. This production is only slightly higher than that of the Marshall Pass district (which will soon surpass the Cochetopa in total production).

The Cochetopa district is about 20 km long from north to south; along this axis is Cochetopa Canyon, which splits the district into east and west halves. The geology of many of the uranium deposits in the district is described by Malan and Ranspot (1959). Uranium was first discovered in the district in 1954 at the Los Ochos mine (loc. 19) along the major fault of the same name. Nearly all the uranium produced in the district has come from this mine and several others along the Los Ochos fault, which cuts mainly the Upper Jurassic Junction Creek Sandstone and Morrison Formation and rocks of Precambrian X age. Minor production of about 13 kg of U308 (Nelson-Moore and others, 1978) came from the La Rue claims (loc. 21) in the Dakota Sandstone along the major Cochetopa fault in the southern part of the district.

Uranium mineralization in the district is mainly along normal fault zones (as the Los Ochos and Cochetopa faults) of Laramide to mid-Tertiary age. The width and magnitude of mineralization is controlled generally by the degree of brecciation and fracturing imposed on the wall rocks by faulting. Hydrothermal alteration is well developed and epigenetic marcasite is common at the uranium occurrences. Sandstones along faults are silicified, limonite-stained, and bleached; and Precambrian rocks are kaolinized, chloritized, and sericitized. The district was covered in Oligocene time by ash flows from calderas to the south. Although many characteristics are present to support a hydrothermal origin for uranium in the district, an origin (or enrichment) of uranium in these structures by supergene processes from a source in the overlying volcanic rocks is also likely (Olson, 1976).

The Los Ochos and four other mines are in the N1/2 secs. 2-4, T. 47 N., R. 2 E. along about 4 km of the Los Ochos fault. Ore that was produced from these mines from 1955 until the mid-1960s contained an average of 0.14 percent U308; these mines (as is much of the district) are on Homestake Mining Company claims. Uranium has been produced mainly from fault breccia in the Junction Creek Sandstone and the Morrison Formation. Uranium minerals in the deposit are uraninite, autunite, uranophane, torbernite, johannite, uranopilite, and zippeite.

The other area of production in the district in the mid-1950s was at the La Rue claims (mine) in the SW/4 sec. 29, T. 47 N., R. 2 E., where the average ore grade was 0.20 percent U308. Uraniferous asphaffite, uranociricite, and brannerite occur in this deposit. Samples of the deposit taken during quadrangle evaluation contained up to 0.76 percent U308 and had very high concentrations of arsenic, molybdenum, tungsten, chronium, titanium, yttrium, and lanthanum (Goodknight and Ludlam, 1981).

The Surefire mining claims (loc. 16) at the northern edge of the district reportedly contained autunite-rich float (from the Morrison Formation?) that had 1.0-2.0 percent U308 (Nelson-Moore and others, 1978). Farther south on the Post claim group (loc. 17), uranium mineralization was found in 1978 during quadrangle evaluation in Junction Creek Sandstone that is silicified and heavily impregnated with limonite and hematite. A sample from this occurrence in the NEA NW/4 sec. 29, T. 48 N., R. 2 E. contained 0.021 percent U308 and high concentrations of arsenic and molybdenum.

The Do Dah (also known as Belle Lode) claim group (loc. 18) is just east of Cochetopa Canyon in the NW1A sec. 33, T. 48 N., R. 2 E. Here, uranium occurs in gouge material along a fault trending north-northeast that cuts metasedimentary rocks of Precambrian X age; a sample of the gouge taken in 1979 during quadrangle evaluation contained 0.042 percent U308. Another uranium occurrence is about 2 km to the north along the same fault. Samples from both occurrences contain very large amounts of arsenic and copper. Homestake Mining Company has claims in this area and conducted drilling at the Do Dah occurrence in the late 1970s.

Uranium occurs in three areas on the Milbob claim group (loc.

20) in the southwest part of the district. Two occurrences in the NE% sec. 19, T. 47 N., R. 2 E. are along the same normal fault that trends east-northeast. The other occurrence is along a fault of similar trend in the SEA sec. 13, T. 47 N., R. 1 E. All the occurrences are in Junction Creek Sandstone faulted against Precambrian X quartz monzonite of Cochetopa Creek. Samples taken in 1978 and 1979 during quadrangle evaluation had up to 0.056 percent U308 in the sec. 19 occurrences and 0.035 percent U308 at the sec. 13 occurrence.

At the south end of the district, the Bet claim group (loc. 22) (also called the Elisha group or Mercury mine area) contains three uranium occurrences along several fault systems. The faults trend generally east and may be related to subsidence of the Cochetopa Creek caldera to the south. One occurrence is in silicified sandstone of the Morrison Formation along a fault zone in the NENsec. 29, T. 47 N., R. 2 E., just east of the old Mercury mine. A small body of rhyolite (Oligocene?) intruded along the fault in the area of the occurrence. A sample of the sandstone taken in 1979 during quadrangle evaluation had 0.63 percent U308 and visible uranophane and autunite; the sample also had high concentrations of arsenic, lanthanum, and molybdenum.

A uranium occurrence was found during quadrangle evaluation in brecciated Cochetopa Creek quartz monzonite along a fault about 500 m east of the Morrison occurrence. A sample from this occurrence had 0.012 percent U308 and contained high amounts of thorium, barium, chronium, lanthanum, and lead. The third occurrence is in Junction Creek Sandstone along a fault on the east side of Cochetopa Canyon in the NWIA sec. 28, T. 47 N., R. 2 E. A sample from this occurrence taken during quadrangle evaluation had 0.097 percent U308 (mainly in uraninite and brannerite) and high amounts of molybdenum and lead.

Uranium occurs in two areas on the Lucky Friday (also known as Anna) claim group (loc. 23) in the southeast edge of the district, east of Razor Creek Dome. Both occurrences are in the NW% sec. 27, T. 47 N., R. 3 E., one east of West Gismo Creek in altered Cochetopa Creek quartz monzonite along a northeast-trending fault zone and the other in silicified Junction Creek Sandstone west of West Gismo Creek. Samples taken for quadrangle evaluation in 1979 contained 0.01 percent U308 (from the quartz monzonite) and 0.023 percent U308 (from the sandstone). The quartz monzonite had high amounts of thorium, barium, lanthanum, lead, yttrium, and zinc, and the sandstone was high in lanthanum, molybdenum, and lead.

Marshall Pass District

From 1956 until 1972, about 600,000 kg of U308 at an average grade of nearly 0.6 percent U308 was produced from four mining areas in the Marshall Pass uranium district. Nearly all the production from the district, located about 60 km east of Gunnison, has come from the Pitch mine (loc. 27) along the Chester fault zone. Other areas of minor production are the Little Indian No. 36 mine (loc. 26) at the north end of the Chester fault and the Marshall Pass No. 5 claim and Lookout claim group, both about 2 km east of the Chester fault (loc. 29) (see Nash, this guidebook).

The Marshall Pass district (contained within T. 48 N., R. 6 E.) is split roughly into east and west halves by the north-trending Chester fault. The fault is an upthrust that developed during the Laramide along part of the western side of the Sawatch Range. Metasedimentary and metavolcanic rocks and pegmatitic granite, all of Precambrian X age, are east of the fault and sedimentary rocks of Cambrian to Pennsylvanian age are in a synclinal remnant west of the fault. Because the fault dip steepens with depth, the Precambrian rocks of the upthrust block have been placed above and west of footwall Paleozoic rocks that have been deformed into an overturned syncline (Nash, 1979). Oligocene volcanic rocks (ash flow and waterlaid tuffs) cover the south end of the Chester fault and at one time probably covered all of the district (Olson, 1979).

The Pitch mine (earlier called the Erie No. 28 claim or Pinnacle mine) produced about 550,000 kg of U308, mainly from 1956 to 1962. Homestake Mining Company gained control of the Pitch mine in the early 1970s (and now has claims over most of the district) and began an intensive drilling program around the mine that has established a reserve of about 3.2 million kg of 1.1308 at an average grade of 0.17 percent U308 (Ward, 1978). Since 1978, Homestake has been developing an open-pit mine (on their recently-patented mining claims) along the Chester fault on and around the site of the old Pitch mine. This development, called the Pitch Project, also includes the construction of a mill south of the mine; ore production will eventually be 550 metric tons per day. The new open-pit mine is in the area where secs. 15, 16, 21, and 22 meet.

Uranium occurs at the Pitch mainly in brecciated Leadville Dolomite of Mississippian age in the footwall of the Chester fault zone. The dominant role of the Leadville Dolomite in hosting uranium at the Pitch mine is discussed by Nash (1979, and this guidebook). Other rocks hosting uranium along the fault are sandstone, siltstone, and carbonaceous shale of the Pennsylvanian Belden Formation (Pitch mine), the Ordovician Harding Sandstone (Little Indian No. 36 mine), and Precambrian rocks (both mines). Uranium minerals identified from the Pitch are uraninite, meta-torbernite, coffinite, and sabugalite (Ward, 1978). Epigenetic pyrite and marcasite are present in the deposit as are enriched amounts of lead and molybdenum. Hydrothermal alteration patterns are poorly developed along the Chester fault; only minor silicification and hematization are present. Nash (1979, 1980) and Olson (1979) conclude that the Oligocene volcanic rocks that once covered the Chester fault were viable sources of uranium which migrated down into the broad zone of structural permeability created by the upthrust and formed epigenetic uranium deposits.

The first uranium discovered in the district was in 1955 at the Little Indian No. 36 mine in the SE% sec. 9. Here, the brittle sedimentary unit present adjacent to the Chester fault is the steeply-dipping Harding Sandstone On most places a quartzite) from which about 31,000 kg of U308 at an average grade of 0.44 percent U308 were produced during the late 1950s (Nelson-Moore and others, 1978). Uranium minerals present in this deposit are uranophane, uraninite, autunite, gum mite, and boltwoodite.

The Chester Fault is exposed on the north side of Marshall Creek in the SWIA sec. 27 (loc. 28), about 3 km south of the Pitch mine. Here, uranium occurs in pegmatitic granite on the west side of the fault. A sample taken during quadrangle evaluation contained 0.013 percent U308 and the minerals euxenite and ilmenorutile were identified (Goodknight and Ludlam, 1981). These radioactive minerals are normally associated with rare-earth pegmatites, indicating that uranium at this locality may not be related to the Chester fault.

In the Harry Creek area, about 2 km east of the Chester fault, are the small mines and numerous prospects on the Marshall Pass No. 5 claim (NE% sec. 22) and the Lookout claim group (NE% sec. 27 and SE% sec. 22). About 170 kg of U308 at an average grade of 1.06 percent U308 were produced in 1956 from the Marshall Pass No. 5 claim (Nelson-Moore and others, 1978). This high-grade uranium was mined from colluvium overlying quartz monzonite of Precambrian X age and the main ore mineral was uraninite. A sample of fractured quartz monzonite taken on the claim during quadrangle evaluation was enriched in copper, lead, and zinc and contained kasolite (lead uranyl silicate), and radioactive barite.

Production from all the Lookout claims (mainly in the late 1950s) was about 6300 kg U308 at an average grade of just over 1.0 percent U308 (Nelson-Moore and others, 1978). Most of this production was from the Lookout No. 22 claim (mine) where very high grade material was initially recovered from colluvium and veins were mined later. Samples of fractured granite gneiss and pegmatitic granite of Precambrian X age taken during quadrangle evaluation had up to 2.9 percent U308. These samples contained meta-autunite and kasolite (as fracture filling and surface coating), as well as enriched amounts of lead, zinc, arsenic, niobium, tungsten, yttrium, and zirconium. Uranium minerals identified by Gross (1965) from the Lookout No. 22 were uraninite, shoepite, epiianthinite, becquerelite, soddyite, boltwoodite, zeunerite, meta-zeunerite, and hydrated autunite. The fractures and minor faults that host uranium minerals at the Lookout claims (and the Marshall Pass No. 5 claim) may represent normal faults produced during arching of the upthrust block of the Chester fault (Nash, 1980); uranium could then have been introduced to these structures by supergene processes from overlying volcanic rocks.

The Hidden Reserve claim group was located in 1955 on a hilltop east of Harry Creek in the SW% sec. 23 (loc. 30). Thorium and uranium occur on the claims in biotite-rich pegmatites that contain rare-earth minerals. Samples taken during quadrangle evaluation from radioactive pegmatites on the claims contain yttrocolumbite and high amounts of lanthanum, lead, yttrium, zirconium, and niobium; these samples also contained up to 0.09 percent U308 and 0.17 percent equivalent thorium (Goodknight and Ludlam, 1981). These uranium occurrences are clearly pegmatite-related and probably not related to the Chester fault system.

Uranium occurs in the western part of the Marshall Pass district On the Indian Creek area) in the upper Harding Sandstone of Middle Ordovician age. Ranspot and Spengler (1957) and Malan (1959) describe the uranium mineralization found in the Harding (and elsewhere in the district) during early development of the district. The Harding is part of a remnant of Paleozoic sedimentary rocks that has been preserved in a syncline west of the Chester fault. A "trashy," oxidized carbonaceous facies (probably deposited in a lagoon behind an offshore bar) about 1.5 m thick in the upper third of the Harding hosts uranium enrichment in this district and in several other areas to the east and southeast of Gunnison country. The carbonaceous facies contains abundant asphaltic pellets and phosphatic fossil fragments; and the uranium minerals uranophane and autunite (or meta-autunite) occur within or along the edges of the fragments. The widespread uranium enrichment in the carbonaceous facies of the Harding averages probably about 0.01 percent U308.

About 100 holes were drilled in the mid-1950s on the Apache No. 4 claim (loc. 25) in the S1/2 sec. 19; this claim was part of the Big Indian claim group. The holes encountered a 1.5 m-thick zone in the Harding containing 0.03 to 0.04 percent U308. A sample taken during quadrangle evaluation from an outcrop of the carbonaceous facies near the claim contained 0.10 percent U308. Drilling in 1955 on the Little Indian No. 6 claim (loc. 26) in the SE% SW% sec. 17 reportedly encountered 0.10 percent U308 (Ranspot and Spengler, 1957).

POSSIBILITIES FOR ADDITIONAL DISCOVERIES

The greatest potential for additional uranium discoveries is in the eastern part of the Gunnison country. Additional deposits, similar to that at the Pitch mine, are likely to exist in brittle, extensively fractured Paleozoic sedimentary rocks in the footwall of Laramide upthrust faults along the west side of the Sawatch Range. The most favorable areas are where these faults are or were once overlain by mid- to late-Tertiary volcanic rocks which were a major source of uranium. These and other types of faults may also be favorable if they are near plutons that are sources of uranium such as the uranium-enriched Oligocene Mount Princeton batholith and certain other plutons as old as Precambrian X age. The highest favorability must be assigned to those faults that cut both Precambrian rocks and Paleozoic sedimentary rocks; however, faults that cut solely Precambrian rocks may also host uranium deposits if these rocks are brittle. Some areas of faulting within the eastern part of Gunnison country that have some of the favorable characteristics mentioned above are: the Star Basin area near Italian Mountain (Castle Creek fault zone), North Star (Granite) fault, faults in the Texas Creek area, faults in the Cross Mountain to Broncho Mountain area, faults in the area from Canyon Creek to Pitkin, Crookton fault, and faults in the Whitepine area.

Information that could greatly enhance the possibility of new uranium discoveries in the eastern part of Gunnison country are the two detailed surveys done in addition to the Montrose quadrangle evaluation report (Goodknight and Ludlam, 1981). A detailed uranium hydrogeochemical and stream sediment reconnaissance (HSSR) (Maassen, 1981) was done for the Sawatch Range portion of the Montrose quadrangle, which includes most of the eastern Gunnison country. A detailed aerial gamma ray and magnetic survey was done for three areas within eastern Gunnison country; these were three of five areas chosen for surveys in the Montrose quadrangle (GeoMetrics, Inc., 1980). Two of the areas that have detailed aerial surveys also have detailed HSSR data.

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