Report of Investigation
Utah Geological and Mineral Survey

No. 143

Mineral Resource Inventory of the Paradox Salt Basin, Utah and Colorado

by
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and staff of
Utah Geological and Mineral Survey

October, 1979

Prepared for
Battelle Project Management Division
Office of Nuclear Waste Isolation
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MINERAL RESOURCE INVENTORY OF THE PARADOX SALT BASIN, UTAH AND COLORADO

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ABSTRACT

A study was made of mineral potential of the Paradox salt basin which is located in southeastern Utah and southwestern Colorado. This study was undertaken by the Utah Geological and Mineral Survey under contract no. E515-01800 from Battelle Project Management Division, Office of Nuclear Waste Isolation, to help evaluate the salt beds as possible waste repository sites.

Large amounts of uranium, oil and gas, and potash have been produced in the region and have the most potential for future development. Copper has recently been mined and coal is currently being mined in one locality for a generator plant. All other minerals are only of minor importance.

Conclusions:

(1) The potential uranium, copper and coal producing horizons lie above the salt beds which are the tentative waste disposal sites. Only the surface facilities of the mining operations could be in conflict with a waste disposal site.

(2) The potential oil, gas and potash areas do have a conflict with waste disposal sites in that they all are in the salt section of the Paradox Formation. Buffer zones would be needed to separate these conflicting operations.

Four specific areas were studied in detail and a summary follows:

Gibson Dome and Elk Ridge Areas are simple geologic structures with deep salt beds (± 2,000 feet) and very little other mineral potential.

Lisbon Anticline area has deep salt beds (± 2,000 feet) with a simple to moderate non-piercement type salt structure. There are major uranium mines and oil fields in the area with an excellent potential for additional discoveries of both uranium and petroleum deposits. Potash exploration found the salt to be highly deformed and exploration stopped. The several activities within this area makes a problem for any waste disposal site to be located here.

Salt Valley Area is a complex and faulted structure with the Paradox salt beds within a few hundred feet of the surface. The uranium and copper potential are not in conflict with any disposal site. The oil and gas and potash have potential in the area and also have potential within the salt section. A disposal site in the vicinity of the breached anticline, where the salt is very shallow, would not interfere with oil and gas exploration. The potash potential is also very good in this same area. Any site proposal will have to provide for a buffer zone to separate the disposal site from the area of oil and potash exploration or development.

INTRODUCTION

This study and review of the mineral resources of the Paradox salt basin is submitted as the final report to Contract No. E515-01800 between the Battelle Memorial Institute, Office of Nuclear Waste Isolation, 505 King Avenue, Columbus, Ohio 43201 and the Utah Geological and Mineral Survey. The Battelle Memorial Institute project management division is a prime contractor to the United States Department of Energy (DOE), and this contract is a furtherance of U. S. Government Contract EY-76-C-06-1830. The contract requires the submittal of maps depicting the locations of all the identified mineral resources of the Paradox Basin other than salt, such as coal, oil and gas, uranium, potash, and base metals and to provide a report making an analysis of possible conflict among such competing uses as oil and gas production, uranium production, and a nuclear waste repository for the Salt Valley anticline, Lisbon Valley anticline, and Gibson Dome. Later the contract was amended to include the Elk Ridge area.

Many geologic studies have been done on all or part of the area in the past for various reasons and are available in the literature. This report reviews these studies, bringing them up-to-date, and gears the information to the needs of the contractor. Salt deposits, such as those that underlie the Paradox Basin, are being studied to see if they are practical and safe environments into which radioactive or other noxious wastes can be safely deposited. This report hopes to identify areas in the Paradox Basin where such projects would conflict with the mineral potential of the region.

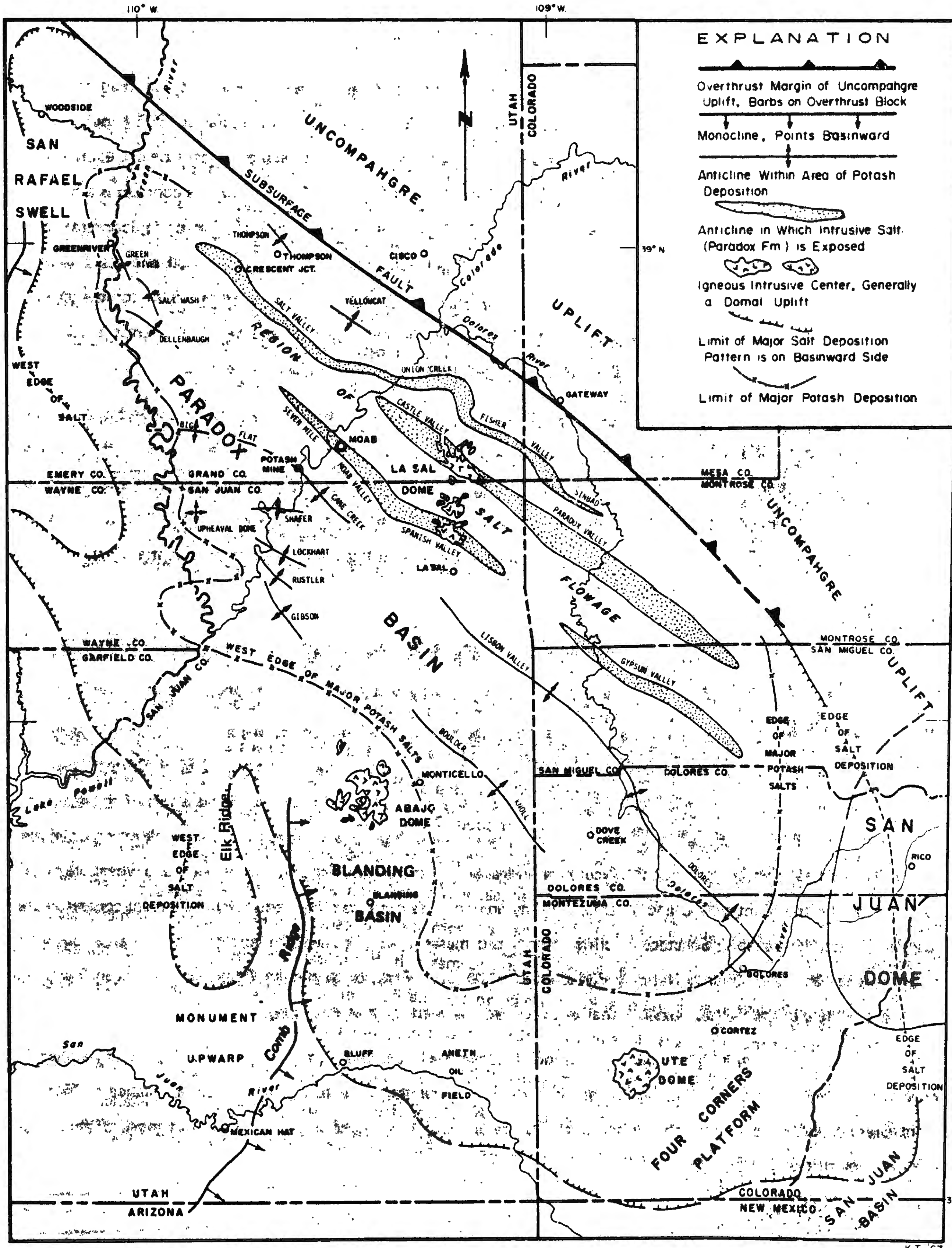
GEOGRAPHY

The Paradox Basin is an elongated oval-shaped basin that trends northwesterly in southeastern Utah and southwestern Colorado (figure 1). It covers an area about 180 miles long and 100 miles wide and is a part of the Colorado Plateau physiographic province. The area itself is sparsely populated; the principal towns are Moab, Utah (population circa 7,000), Monticello, Utah (population circa 2,000), and Blanding, Utah (population circa 2,500). Cortez, Colorado lies just outside the study area and has a population of about 7,000 people. The principal industries of the region include uranium, vanadium, copper, potash mining and milling, oil and gas production, associated exploration activities, agriculture, and tourism. The principal agricultural endeavor is cattle production, but pinto beans and wheat are raised on dry farms in the Monticello-Blanding area, and hay and corn are produced along the principal stream courses where irrigation water is available. Spectacular cliffs, buttes and mesas invite thousands of tourists into the area each year to see Arches and Canyonlands National Parks, Dead Horse State Park, or to run the Colorado and Green Rivers on rafts. The climate of the Paradox Basin is that of a high latitude steppe (mild semi-arid).

The main line of the Denver and Rio Grande Western Railroad, and Interstate Highway 70, which parallels it, cross the northern part of the basin from east to west. A railroad spur extends south to Moab, a distance of 36 miles, from Crescent Junction. All of the principal towns are connected by paved State highways, but most of the area is accessible by dirt or gravel roads.

GEOLOGIC SETTING

The Paradox Basin, in which the saline sequences were deposited, is a structural downwarp that originated in Pennsylvanian time. It covers parts of San Juan, Garfield, Wayne, Emery, and Grand Counties, Utah, and extends eastward into Mesa, Montrose, San Miguel, Dolores, and Montezuma Counties of southwest Colorado. The basin's



from UGMS Special Studies 24 Pt. 1.

0 10 20 30
Scale in Miles

Figure 1. Index map of the Paradox Basin, southeastern Utah, southwestern Colorado.

Geologic Era		Formation	Thickness (ft)	Symbols as used in this report	Oil and gas occurrences
Pennsylvanian	Hermosa Group	Honaker Trail Fm (incl. "Rico" Fm)	1000-2500	Ph	Oil, Gas--Lisbon, Andy's Mesa, Big Indian Cu
Pennsylvanian	Hermosa Group	Paradox Fm (incl. cyclic sequences of Ls, Sh, evaporites. Potash beds locally).	2000-7000	Pp	Oil, Gas--Long Canyon, Big Flat, Lisbon K_2O
Pennsylvanian	Hermosa Group	Pinkerton Trail Fm	0-200	Ppt	
Pennsylvanian		Molas Fm	0-50	Pm	
Miss		Leadville Ls	100-700	M	Oil, Gas--Lisbon, Big Flat, McIntyre Canyon Big. Indian, Salt Wash
Dev		Ouray Ls	0-175	D	Oil=Lisbon
Dev		Elbert Fm	100-200	D	
Dev		McCracken Ss M	25-100	D	
Cambrian		Aneth, "Lynch," Ignacio undifferentiated	500-1000	€	
P€		Granite, Quartz Monzonite	----	p€	

Geologic Era	Formation		Thickness (ft)	Symbols as used in this report	Oil and gas occurrences
Tert/Quat	Gravels, Sands, Fanglomerates		0-500		Au
Oligocene	Quartz Monzonite Dikes and Sills, Diorite Porphyry Laccoliths		?		Au
Cret	Mancos Shale		0-1100	Km	
Cret	Dakota Ss		100-200	Kd	Cu Oil, Gas Shows
Jurassic	Burro Canyon Fm		80-250	Kd	Cu
Jurassic	Morrison Fm	Brushy Basin Sh Member	250-700	Jmb	U
Jurassic	Morrison Fm	Salt Wash Ss Member	200-550	Jms	Oil, Gas Shows Mn, Cu, U
Jurassic	Summerville Fm		20-80	Js	Mn
Jurassic	Entrada Ss		350-700	Je	Cu
Jurassic / Triassic	Navajo Ss		0-400	Jn	
Triassic	Kayenta Fm		140-260	TRk	
Triassic	Wingate Ss		150-300	TRw	
Triassic	Chinle Fm	Upper Chinle Member	260-500	TRc	
Triassic	Chinle Fm	Basal Member	0-200	TRcm	Cu, U
Triassic	Moenkopi Fm		0-940	TRm	
Permian	White Rim Ss M		0-250		
Permian	Cutler Fm (arkosic facies) Subdivides in West to: Organ Rock Tongue Cedar Mesa Ss Halgaito Tongue		400-3000	Pc	Gas--Andy's Mesa Cu, U

Figure 2. Stratigraphic Section of Paradox Fold and Fault Belt

outline, the structural features surrounding it, and its political subdivisions can all be examined in figure 1. It is bounded on the northeast by the Uncompahgre Uplift, on the northwest by the San Rafael Swell, on the southwest by the Monument Upwarp and on the southeast by the Four Corners Platform.

Stratigraphy

Early in Paleozoic time, the site of the Paradox Basin was located between the Cordilleran Geosyncline (miogeosyncline) to the west and the Transcontinental Arch to the southeast, east, and northeast. Because sediments of moderate thickness lapped onto this intermediate, or shelf area, from the west, these early Paleozoic rocks generally thin from west to east across what is now the Paradox Basin. Figure 2 shows the generalized stratigraphic section of the basin. The nomenclature applies particularly to the central portion of the basin, in which potash and other saline deposits are found. The Precambrian shelf upon which these early Paleozoic units were deposited consists of granite or quartz monzonite where penetrated.

Cambrian rocks include a basal transgressive sandstone, the Lower Cambrian Tintic Quartzite in the west and the Upper Cambrian Ignacio Quartzite in the east. This sedimentary series is succeeded by finer clastics and finally by thin-bedded dolomite ascribed to the Aneth Formation. A major hiatus, due to erosion and/or non-deposition, accounts for the omission of Ordovician through Middle Devonian rocks. The Devonian and Mississippian rocks are dominantly carbonates: limestone and dolomite, with some marine sandstone occurring in the basal and medial portions of the Devonian. The Devonian units include the Elbert Formation with the McCracken Sandstone Member at the base, and the Ouray Limestone. The Leadville Limestone is the only Mississippian unit, which is directly correlatable with the Redwall Limestone of the Grand Canyon region. The entire Cambrian through Mississippian section ranges in thickness from 2,500 feet in the west to 1,500 feet in the east.

At the beginning of Pennsylvanian time, the Paradox Basin region was an area of low to moderate relief. Most of the relatively thin and incomplete lower Paleozoic section that had been deposited across the site of the basin was laid down in Mississippian time, when uplift caused the withdrawal of the Mississippian seas, and an erosional topography (karst surface) developed on the exposed Leadville Limestone. The Molas Formation, a fossil soil (regolith), formed across the irregularities of the karst surface. The unit, which consists of siltstone, limestone rubble, and red and purple shale, varies from a thin veneer to 50 feet in thickness. It is the basin's oldest Pennsylvanian formation. As Pennsylvanian time proceeded, the Uncompahgre Uplift, to the east and northeast, began to rise on the site of the early Paleozoic Transcontinental Arch. Initial downwarping of the Paradox Basin site accompanied the uplift. The basin assumed a general northwest-southeast trend, and a marked asymmetry; a deep actively subsiding portion on the northeast adjacent to the Uncompahgre Uplift, and a shallow shelf area to the southwest. The Emery, Circle Cliffs, Kaibab and Defiance Uplifts, which border the basin from northwest to southeast, furnished some of the basin's sediment content, but the Uncompahgre Uplift was responsible for great volumes of coarse clastics dumped westward into the Paradox trough. This rapid contribution of coarse clastics, termed the "Cutler arkose", contined through Pennsylvanian and into Permian time.

Pennsylvanian seas advanced into the Paradox Basin from the southeast and, possibly to a limited extent, rolled in from the northwest around the flanks of the Emery Uplift. The Pinkerton Trail Formation carbonates and black shale of the Hermosa Group were the first deposits of these seas, and average 200 feet in thickness across the basin. As tectonic activity heightened along the Uncompahgre Uplift, ocean waters no longer freely circulated with those in the basin. Whether the basin was ever completely cut off from the sea is not known, but evaporation rates were high enough to cause concentration and deposition of anhydrite, halite, potash salts and other less common saline minerals. The area of saline deposition was concentrated mainly in the center part of the basin, which tended to be crowded to the west by periodic outpourings of coarse clastics from the rising Uncompahgre. The cyclical sequences of limestone, shale, and evaporites are known as the Paradox Formation, with thicknesses of beds of 2,000 to 7,000 feet being deposited (see figure 3, Generalized sedimentary pattern, Pennsylvanian, Paradox Basin).

Saline deposition gave way to normal marine conditions thereafter, and the marine Honaker Trail Formation of the Hermosa Group was laid down across the basin. Dolomites, limestones, and sandstones and shales of the Honaker Trail Formation range from 700 to 2,500 feet (averaging about 1,000 feet) in thickness. In Permian time, the seas withdrew to the west, and the Paradox Basin was for the most part a site of nonmarine deposition. The Permian Cutler Formation (arkose and conglomerate) continued to accumulate, reaching an 8,000-foot thickness in the eastern part of the basin. Thinner sections of continental redbeds and dune sandstones were deposited elsewhere. Pelagic deposition took place to the west, and thin tongues of nearshore sandstones and sandy limestones are found projecting into the marine section from the west and southwest. Therefore in the western and southwestern parts of the basin the upper part of the Permian is represented by the (in ascending order) Halgaito Tongue, Cedar Mesa Sandstone, Organ Rock Tongue, and the White Rim Sandstone. With the close of Permian time, marine deposition in the Paradox Basin ended, until Cretaceous time. Although the Pennsylvanian units are the oldest exposed in the Paradox Basin area, the Permian units are the first to be extensively seen in outcrop. The Cutler Formation contains some uranium and copper deposits, which have been productive in a number of areas. The western members of the Cutler are generally barren of mineralization.

Formations of the Triassic and Jurassic are dominated by non-marine redbeds and dune sandstones, with some fluvial and floodplain deposits. A few shallow seas encroached upon the area from time to time. The Triassic Moenkopi Formation is exposed around the periphery of the Monument Upwarp, and in parts of the Paradox fold and fault belt. In most places, the Moenkopi can be subdivided into the lower Hoskinnini Member (not always present) and an upper member. The Hoskinnini is a red brown nodular-weathering, sandy mudstone that ranges up to 120 feet in thickness. The upper Moenkopi ranges from 60 to 940 feet in thickness. It locally is absent near the salt anticlines; it consists of evenly bedded brown to red brown mudstone and siltstone, interbedded with ripple-marked brown to gray sandstone, sporadic limestone lenses, and clay gall conglomerate. The upper part of the Moenkopi is occasionally mineralized by uranium and copper. The Triassic Chinle Formation is next, and can roughly be divided into a basal member and an upper member. The basal member is usually cliffy and composed of sandstone, conglomerate, and minor shale and siltstone. The basal member varies stratigraphically from south to north and is an important producer of uranium, vanadium, and copper in the Paradox area. To the south the basal member is known as the Shinarump and it pinches out

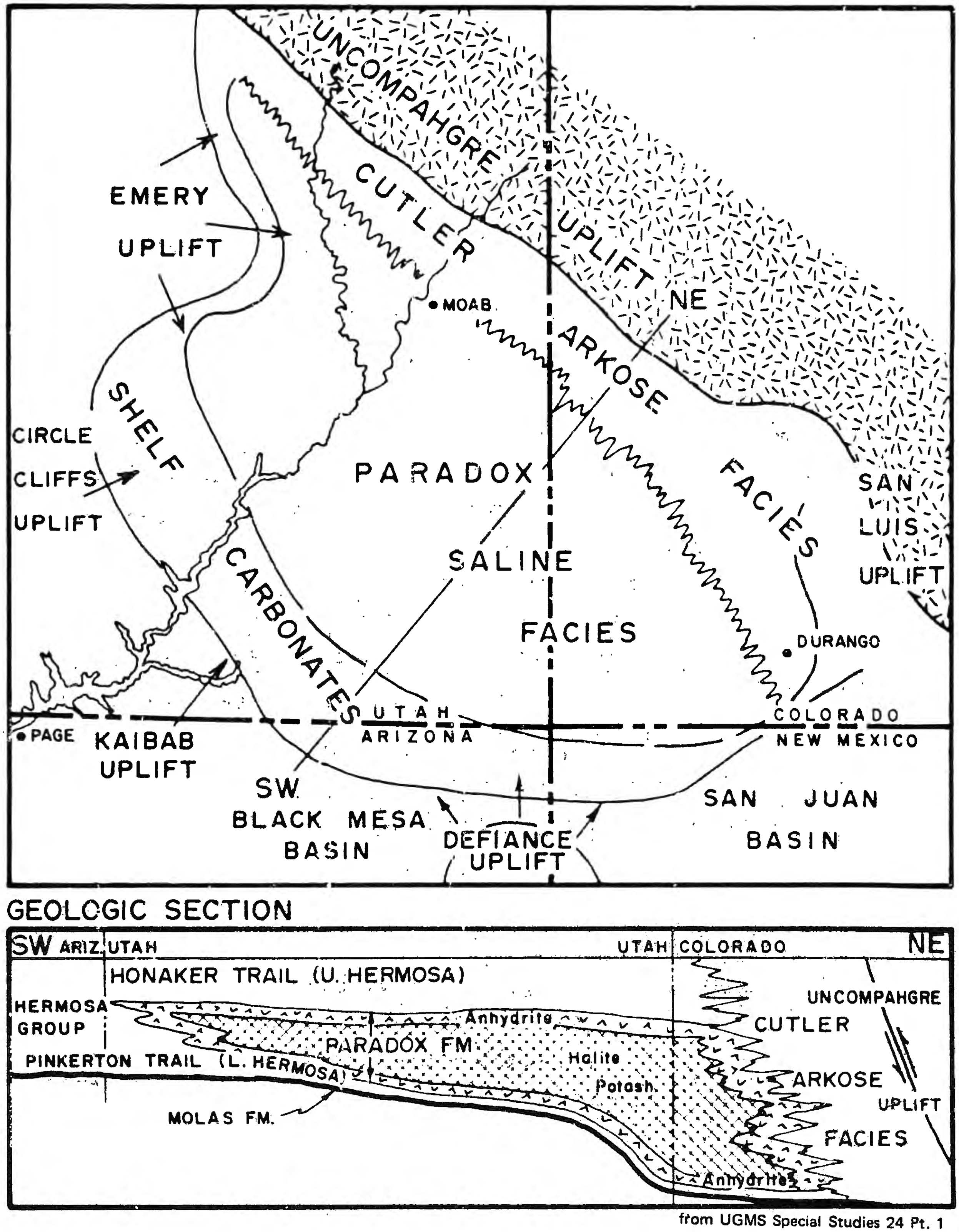


Figure 3. Generalized sedimentary pattern, Pennsylvanian, Paradox Basin.

north of Elk Ridge. The Shinarump is then replaced by the overlying Monitor Butte Member as the basal member, but it too, pinches out north of Monticello. It in turn is replaced by the overlying Moss Back Member. In each case the unit in contact with the underlying Moenkopi Formation is the one that is usually mineralized. The basal member rarely exceeds 90 feet in thickness; however, the thickest known section is 200 feet thick. The upper Chinle, composed mainly of variegated mudstone and thin sandstone beds, also contains limestone beds, limestone conglomerate, lenses of quartz grit, and siltstone. Many of the mudstone beds are calcareous and many are bentonitic. Fossil remains of fresh water invertebrates, silicified and carbonaceous wood, and reptilian bones and teeth are fairly common. In most places, the upper Chinle weathers to a concave slope, broken by benches where more resistant; thin sandstone beds and lenses occur. The upper Chinle ranges in thickness from 260 to 500 feet in the Paradox area.

The next three formations are collectively named the Glen Canyon Group, all of which are sandstone units. In ascending order these include the Wingate Sandstone, Kayenta Formation, and the Navajo Sandstone. The lower two units are generally considered to be Triassic and the upper part of the Navajo is thought to be Jurassic in age. The 150- to 300-foot Wingate Sandstone is a pale reddish brown, buff, or orange, fine- to medium-grained eolian sandstone that is usually found as a cliff in outcrop. The middle unit of the Glen Canyon Group is the Kayenta Formation, which represents a fluvial interval, in contrast to the eolian lithology of the Wingate below, or the Navajo above. The 140- to 260-foot Kayenta consists of irregularly bedded, lenticular sandstone, with subordinate shale and conglomerate. The unit is absent in Paradox and Gypsum Valleys. The Navajo Sandstone is a massive, cross-bedded, yellowish-gray to pale-orange sandstone, containing sporadic lenses of gray, fresh-water limestone. It weathers into steep cliffs, modified by alcoves, niches, and narrow fracture-controlled canyons. Near the top, weathering creates rounded domes, mounds, and other irregular shapes. Its thickness ranges from 0 feet northeast of the San Miguel River in Colorado to more than 400 feet in the western part of the Paradox area. The Navajo is an excellent aquifer and many springs issue from it. Some uranium and copper mineralization has been noted along faults and fractures in the vicinity of salt anticlines in all three of these units, but total production and potential is insignificant.

The next three units are all Jurassic in age and are called the San Rafael Group: the Carmel Formation, Entrada Sandstone, and Summerville Formation. The Carmel Formation overlies the Navajo Sandstone as a thin, reddish scab. It is considered to be a nearshore littoral deposit, consisting of red and white, earthy, lumpy, unevenly bedded sandstone, red mudstone, and lenses of gray limestone. The formation thins eastward and is very thin across the study area, so much so, that we chose to omit it from figure 2. It is absent near the Utah-Colorado border and gradually increases in thickness to 230 feet near Cataract Canyon along the Colorado River. The Entrada Sandstone, 350 to 700 feet thick, is mostly orange red to tan, fine- to medium-grained sandstone. In southern Grand County, Utah and northern San Juan County, Utah, an upper white, crossbedded, fine-grained sandstone is known as the "Moab Tongue". Uranium and copper mineralization is occasionally found in the Entrada Sandstone associated with faults in the Paradox and Gypsum Valley areas. This mineralization has, so far, proven much less important than that in the Chinle and Morrison

Formations. The Summerville Formation is partly a red to brown-colored siltstone and partly a calcareous claystone unit that has sporadic layers of reddish brown sandstone. Thin veinlets of gypsum are common. It either weathers to red, clay-covered slopes or ribbed, vertical cliffs. The thickness of the formation varies from 20 to 80 feet. The Summerville is thin near Moab and southern Grand County and thickens in the central and southern parts of San Juan County, and is absent near several of the salt anticlines. Manganese mineralization is present in the Summerville Formation northwest of Moab.

The Morrison and Burro Canyon Formations are the uppermost Jurassic units in the Paradox Basin area. The Morrison Formation has two members: a lower Salt Wash Member and the upper Brushy Basin Member. The lower is 200 to 550 feet thick and consists of grayish orange, light brown to white lenticular sandstone, locally conglomeratic, interbedded with greenish gray and grayish red shale and siltstone. Sandstone lenses, alternating with shale, produce a step-like topography on the weathered surface. Thick sandstone lenses are often mineralized along the bottoms and sides with uranium and vanadium and in all locations should be considered a potential source of these commodities. The Brushy Basin Member consists mostly of bentonitic shale. The shales are variegated; red and purplish colors dominate. Thin limestone, conglomerate, or sandstone lenses are often found interbedded with the shale. The thickness ranges from 250 to 700 feet and the unit weathers to rounded slopes. The Brushy Basin Member is often weakly mineralized with uranium, but production has been small. The Burro Canyon Formation forms the rim of the Sage Plain area east of the Abajo Mountains, and its area of outcrop extends into Colorado. It is a sequence of conglomerate, sandstone, shale, and thin lenses of limestone. The light gray to light brown sandstone beds are poorly sorted, lenticular, irregular in thickness and form, and cross-stratified. In some areas, the lower contact interfingers with the Brushy Basin; elsewhere it is unconformable with it. Uranium minerals are known to occur in the Burro Canyon Formation in a claim northwest of Naturita, Colorado, and some uranium-vanadium-copper mineralization has been found adjacent to faults in the Lisbon Valley area. The Dakota-Burro Canyon Formation in the Abajo Mountains is the host rock for copper mineralization at the Copper Queen mine. To the present, the mineral potential for the Burro Canyon Formation has proven slight.

The Cretaceous Period is represented by the Dakota Sandstone and the Mancos Shale. The Dakota Sandstone is an irregularly bedded, coarse-grained, gray to yellowish brown conglomeratic sandstone, with interbedded light gray sandy shale. Locally, it contains carbonaceous shale and coal. The thickness ranges to a maximum of 200 feet; the formation is thinner in the northern and western parts of the area. Copper minerals occur in the Dakota, in Lisbon Valley, and on the flanks of the Abajo Mountains. The Mancos Shale consists of dark gray marine shales, interrupted at intervals by yellowish gray sandstone. Up to 1100 feet of this unit have been measured in the Paradox Basin area. Excepting igneous units, this is the youngest consolidated unit exposed.

Up to 500 feet of unconsolidated gravel, sand, and fanglomerate of Tertiary and Quaternary age complete the list of rocks in the Paradox Basin area. Economically these units are important for their commercial gravels and as ground water aquifers. Gravel bars along some of the principal rivers and gravels in the creeks heading in either the LaSal or Abajo Mountains often contain small quantities of gold.

Igneous Rocks

Igneous rock outcrops are limited in the Paradox Basin area. Two laccolithic centers, the Abajo and LaSal Mountains, contain most of the exposures. The principal rock types of these Tertiary intrusives are diorite and quartz monzonite porphyry. The other, smaller stocks, dikes and sills of the area were emplaced at this time as well. The laccolithic centers were forcefully intruded into the sediments, doming and piercing them. Fissure type precious and base metal mineralizations are known in both mountain areas, particularly in the LaSal Mountains.

Structure

The principal structural elements of the Paradox Basin are (1) the fold and fault belt of the Paradox Basin, (2) the Monument Upwarp, and (3) the Blanding Basin. These are approximately located on figure 1.

The Paradox fold and fault belt is a zone paralleling the Uncompahgre Uplift, which bounds the basin to the northeast. The belt is dominated by northwesterly trending folds and faults, including several highly deformed anticlines having salt cores. The area is underlain by salt beds that slope away from the Uncompahgre Uplift and subsurface salt movement is believed to have been the major factor in the folding and faulting of the overlying formations. As some Mesozoic formations in the Paradox fold and fault belt were not deposited over salt anticlines, these movements have apparently been taking place throughout post-Pennsylvanian time, and have influenced the configuration of sedimentary deposition. In at least 4 anticlines the salt broke through the overlying units with attendant collapse and faulting. Salt deformation is believed to have continued into Recent time. The collapse and differential erosion over the salt cores have formed deep valleys, with flat bottoms, bounded by paralleling faults and high vertical cliffs. The LaSal Dome or laccolithic center was emplaced into the Paradox fold and fault belt in Tertiary time; some of the laccoliths were emplaced in the collapsed salt anticlinal areas.

The Monument Upwarp is a broad north-trending elongated uplift 30 miles wide and 100 miles long southwest of the Paradox fold and fault belt. Its east limb is the Comb Ridge monocline which dips up to 60 degrees to the east. The Monument Upwarp reflects the influence of tectonic activity that occurred prior to the deposition of the Chinle Formation. The Moenkopi and even older formations were variably disturbed and eroded and channels were cut in these formations. The topographic high was centered in what is now the middle portion of the Monument Upwarp. Streams were forced to flow around the margins of this high or through its structural sags.

The Blanding Basin is located to the east of the Comb Ridge monocline in the southern part of the Paradox Basin, south of the Paradox fold and fault belt. It is a shallow feature with gentle subfolds that trend westerly or northwesterly. The Abajo Dome or laccolithic center is emplaced in its northwest corner.

A thorough knowledge of the various structural elements of the basin is essential to understanding the potential of the mineral commodities of the region. The succeeding sections of the report will emphasize this.

MINERAL COMMODITIES OF THE PARADOX BASIN

The Paradox Basin has had important oil and gas, uranium and vanadium, potash, and copper production. Small quantities of manganese, gold and silver, and coal have been produced. The area also has potential for producing clay, construction materials, dimension stone, gypsum, iron, limestone, and semiprecious stones. This report will describe each in relationship to the potential use of the salt beds for nuclear waste isolation.

Oil and Gas

History Of Oil & Gas Development

There was oil exploration in the early 1900s in the Paradox Basin area for the structural type of surface traps, but limited success soon slowed this exploration. In the mid 1950s a major discovery of oil at Aneth in an algal reef, detrital bank, and associated reservoirs immediately renewed oil exploration in the area.

The discovery of oil in 1960 in the Lisbon Field, from the Leadville Limestone of Mississippian age, initiated a new cycle of oil activity that mainly used seismic methods to define pre-evaporite structures. There were some minor successes but none of real significance.

The entire area of study is included in the area described by Spencer (1975, p. 270) as being an "underachiever" in terms of oil or gas shows. The reason for this may be that the early Paleozoic Formations have been too tectonically active causing oil to migrate out of most of the structural oil traps. This is indicated by the many oil shows in the top few feet of porosity in the Leadville Formation but with only a very few productive fields. The numerous shows of oil and gas in the "intra-salt section" of the Paradox Formation may be explained by a lack of reservoirs for the petroleum to enter from the organic rich black shale source beds. These conditions would cause high pressure oil and gas to form in any fracture or other type of porosity found in the stratigraphic section.

The apparently slow exploration and development of the area's potential for oil and gas may be due to the following reasons listed by Schneider, et. al. (1971) p. 470.

1) Relatively high costs of exploration.

2) Poor surface accessibility of the region that is needed to develop seismic control.

3) Prohibition of access in National Parks and other restricted use of areas.

Other reasons for slow exploration programs could be lack of multiple horizons as potential pays, the poor discovery rate of profitable fields, and excessive governmental regulations.

The Paradox Salt Basin study area includes a Utah cumulative oil production (through 1977) of 41,761,800 bbls; and 326,248,500 mcf gas (*Utah Oil, Gas and Mining* production report, December 1977) and a Colorado cumulative (through December 1977) of 1,581,700 bbls oil and 36,647,000 mcf gas (*Colorado Geological Survey*, 1978) or a grand total of 43,343,500 bbls oil and 362,895,500 mcf gas (table 2).

Oil And Gas Potential

The potential for finding new oil and gas deposits in the Paradox Basin remains great. The amount and depth of drilling has only explored a small percentage of the area in question. A study published by the American Association of Petroleum Geologists (Parker, 1977) estimated the "undiscovered most likely" oil potential of the Devonian, Mississippian, and Pennsylvanian strata of the Paradox-San Juan Basin to be 144 million barrels of oil. The cumulative production from the same beds is listed at 366 million barrels for the Paradox-San Juan Basin area (Parker, 1977, table 4).

Table 1 Summary of Oil and Gas Shows - From DST or Production Tests in Paradox Salt Basin, Utah & Colorado

Symbols	Formation
Km	Mancos
Kd	Dakota
Jm	Morrison
Jc	Entrada
Pc	Cutler
Ph	Hermosa
Pp	Paradox Incl. Salt
M	Mississippian
D	Devonian
C	Cambrian

Sec.	Operator	Well Name	T.D.	Deepest Formation	Shows
Grand County Utah					
	T.21 S., R.19 E.				
7	Oil Securities & Gas	3 - Govt.	3,694	Jm	Show Gas Jm
7	Kanab Uranium	1 - Govt.	4,229	Je	Gas Show Jm 3,500 mcf.
7	Oil Securities & Uran.	2 - Govt.	3,300	Kd	289 mcf. after acid Kd
33	Potash Co. of Am.	2	5,012	Pp	Show O Jn; Show gas Pp
	T.21 S., R.21 E.				
33	Pac. Wash. Oil	1	13,767	Pp	Show Gas Jm
	T.21 S. R. 22 E.				
2	Physiographic Ints	2 - State	1,609	Jm	Jm 1p 288 BOPD 288 mcf. Pd
16	Walton Kearns	1 - Callister State	2,890	Km	Km oil show 5 gal/hr.
	T.22 S., R.19 E.				
4	Crescent Eagle Oil Company	1	4,006	Pp	Pp G & O Blowouts
4	Potash Co. of Am.	1	5,005	Pp	Jm Oil Sat. Jk Oil Show
4	Defense Plant	1 (Gus Pongratz)	10,350	Pp	O & G down to 3,150
10	Big Six Oil	1	1,710	Jn	Kd Oil Show
16	Kimball Oil	1 - State	1,202	Jm	Prod 20 BD in 16 hrs.
16	Potash Co. of Am.	1	5,250	Pp	? Prod. 130 bbl. @ 1,603

Table 1 continued

Sec.	Operator	Well Name	T.D.	Deepest Formation	Shows
	T.23 S., R.21 E.				
32	So. Union	1 - Balsley	6,120	Pp	Show Oil Pp
	T.24 S., R.19 E.				
22	Mt. Fuel	2 - Klondike	7,830	Pp	Show Oil Pc on DST
	T.25 S., R.18 E.				
21	Shell	1-25 Fed.	6,875	Pp	DST. Oil Show Pp
	T.25 S., R.19 E.				
27	Pure Oil	5 - Big Flat	7,253	Pp	Flow 450 BOPD Pp
	T.25 S., R.20 E.				
12	Columbia Crude	1	4,243	Pp	Show Oil-Gas Pp
	T.25 S., R.21 E.				
18	Delhi Oil	2 - Utah	9,424	M	Prod. Oil Pp
34	Big Six Oil	1	5,345	Pr	Show O & G Pp
	T.25 S., R.23 E.				
16	Goldbar Resources	1 - Castle Valley	6,502	Pp	GTS/1 min. Pp
	T.26 S., R.19 E.				
11	Tidewater	74-11	8,338	D	Show O & G M
11	Ruby	1-BFU	8,213	D	Show O & Gas M
11	Pure	2 BFU	7,860	M	99 BOPD-M
14	Pure	Unit 2	7,810	M	85 BOPD-M
14	Pure/Ruby	Unit 1	7,954	M	p. 250 BO./D
23	Pure	Unit 3	8,600	C	98 BOPD M
	T.26 S., R.20 E.				
8	Helis Est.	8-44 Skyline Fed.	8,082	D	Show Oil D
9	So. Nat. Gas	1 - Long Canyon	8,138	D	660 BOPD Salt
9	So. Nat. Gas	2 - Long Canyon	7,791	M	266 BOPD Salt

Table 1 continued

Sec.	Operator	Well Name	T.D.	Deepest Formation	Shows
	T.26 S., R.20 E. (Cont.)				
36	Modco	2 - Govt.	?	Pp	Pp Oil Show
	T.26 S., R.21 E.				
31	American Petroleum	1 - Mason	5,762	Pp	Oil Show Salt
31	Utah Southern	1 - Fed.	5,000	Pp	Burned Rig down in Pp
San Juan County Utah					
	T.26 S., R.20 E.				
31	Midwest/Ut. South	1	5,000	Pp	OWDD Oil Salt
36	Texas Gulf Prod	1 - X Fed.	8,010	D	90' oil DST Salt
36	Modco	2 - Govt.	7,355	Pp	140 BOPD Salt
	T.27 S., R.20 E.				
4	Underwood	3 - Shafer Can.	6,198	Pp	480 BOPD Salt
6	So. Nat. Gas	USA - 1	6,002	Pp	600 BOPD Salt
	T.28 S., R.19 E.				
18	Shell	1 - Murphy Range	7,193	D	Show Oil DST M
	T.28 S., R.20 E.				
23	Pan. Am.	1 - USA Lockhart	5,630	D	Show Oil Ph
	T.28 S., R.21 E.				
33	Kimbark	1 - Fed. Hatch	8,010	D	Oil Salt Ph
	T.28 S., R.23 E.				
2	Calif. Co.	1 - Mule Sho.	10,516	M	Gas Show Ph
	T.29 S., R.23 E.				
15	Husky Oil	6 - 15 Husky Fed.	8,420	D	Gas DST M

Table 1 continued:

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
	T.29 S., R.24 E.				
24	Gulf	1 - Wilson Canyon	9,955	D	147 BOPD Salt
25	Husky Oil	15 - 25 Fed.	9,578	D	Gas Well M
19	Pure	1 - LaSal - USA	9,807	M	Gas Test M
33	Pure	1 - Big Indian	11,143	C	Gas Well M
	T.29 S., R.26 E.				
5	Superior	1 - 5 Horse-thief Unit	11,990	C	Ph 48 MCF Pd
17	Chambers & Kennedy	1 - Horn Fed.	11,565	M	Ph 714 MCF Pd
	T.29½ S., R.20 E.				
32	Belco Petro.	1 - State Gibson Dome	10,636	C	129 MCF Salt
35	Reynolds	Gibson Dome	6,035	M	Free Oil in Salt
	T.29½ S., R.24 E.				
32	Belco	1 - Belco St. E	10,636	C	129 MCF Salt
	T.30 S., R.24 E.				
3	Pure Oil	C - 2 NW Lisbon	10,706	D	Oil Well Salt
3	Pure Oil	C - 3 NW Lisbon	8,425	C	Oil Well M
4	Pure Oil	C - 74 NW Lisbon	9,015	M	Oil M
4	Pure Oil	C - 1 NW Lisbon	9,133	C	G & O M
4	Pure Oil	C - 84 Lisbon	8,963	D	Oil M
4	Pure Oil	C - 94 Lisbon	8,859	D	Oil M
4	Union	B - 84 Lisbon	8,766	M	O & G M
9	Pure Oil	C - 69 Lisbon	8,848	M	O & G M

Table 1 continued:

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
9	Elliott Prod.	1 - C Lisbon Valley	9,533	C	Oil M
9	Pure Oil	H - 1 Lisbon	8,853	D	Oil M
9	Pure Oil	B - 99 Lisbon	8,697	M	Oil M
10	Pure Oil	1 - NW Lisbon	8,440	C	O & G M
10	Pure Oil	A - 2 NW Lisbon	9,310	C	Oil D
12	Pubco	1 - Fed.	9,170	C	O & G M
13	Pure Oil	D - 2 Lisbon	9,054	M	Oil M
13	Pure Oil	A - 713 Lisbon	9,450	D	Oil M
14	Pure Oil	B - 1 Lisbon	9,022	D	Oil D & M
14	Pure Oil	B - 2	9,305	M	O & G M
14	Union	D - 814 Lisbon	8,965	D	Oil M
14	Pure	A -814 Lisbon	9,015	M	O & G M
15	Pure Oil	D - 714 Lisbon	8,896	M	Oil M
15	Calif. Co.	21 - 15 Arnold	9,050	C	Oil M & D
15	Pure Oil	A - 715 Lisbon	8,605	M	Oil M
15	Pure Oil	E - 1 NW Lisbon	9,029	D	Oil M
15	Pure Oil	B - 815 Lisbon	8,561	D	Oil
16	Belco Petro.	2 - Belco State	9,120	D	Oil M
16	Pure Oil	B - 616 Lisbon	8,689	M	Oil M

Table 1 continued

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
16	Pure Oil	D - 816 Lisbon	8,666	M	Oil M
16	Belco Petro.	4 - Belco State	8,730	M	Oil M
22	Eliott	1 - 22-C	8,662	M	Show Oil M
	T.30 S., R.25 E.				
10	Pure Oil	3 Big Ind. Unit	5,895	Ph	O & Gas Well Ph
14	Pure Oil	4 Big Ind. Unit	5,360	Ph	Gas Well Ph
16	Cordillera	1 - State	9,661	M	Gas Well M
21	Pubco Petro.	2 - 21-F Lisbon	9,560	M	Gas Well M
21	Mesa Petro.	3 - Lisbon Fed.	9,953	M	Gas Tested M
28	Pac. Nat. Gas	1 - Little Valley	9,712	M	Gas Show Salt
29	Pac. Nat. Gas	2 - Little Valley	9,000	Pp	Gas Show Salt
	T.31 S., R.32 S.				
	(NO SHOWS)				
	T.33 S., R.25 E.				
16	WH Canyon Mining	4 - Sitton	6,083	Pp	Show Gas Pp
17	Byrd-Frost	1 - Sitton	5,831	Pp	Prod. Test Pp
20	WH Canyon Mining	2 - Sitton	5,862	Pp	Gas Show Pp
21	WH Canyon Mining	3 - Sitton	6,083	Pp	Gas Show Fp
22	Mt. Fuel	2 - Piute Knoll	6,100	Pp	Gas Well Pp
25	Mt. Fuel	3 - Piute Knoll	6,073	Pp	Gas Show Pp
26	Mt. Fuel	1 - Piute Knoll	6,031	Pp	Gas Well
	T.33 S., R.26 E.				
32	Mt. Fuel (Carter)	1 - Leverton State	5,982	Pp	Gas Well

Table 1 continued:

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
	T.34 S., R.25 E				
13	Mobil	1 A- Utah	5,998	Pp	Test Gas Pp
	T.34 S., R.26 E.				
16	Mt. Fuel	1 - Locerby State Kerby St.	6,050	Pp	Test Gas Pp
29	Reynolds	1 - Meyer	5,883	Pp	Test Gas Pp
	T.35 S., R.22 E.				
33	Std. Calif.	1 - Johnson Creek	6,444	Pp	Test Gas Pp
	T.35 S., R.25 E.				
15	Gulf	1 - Coalbed Canyon	5,912	Pp	Test Gas Pp
20	Gulf	2 - Coalbed Canyon	8,440	C	Test Gas Pp
	T.36 S., R.21 E.				
25	Skelly	1 - Blanding Fee	5,934	Pp	Test Gas Pp
	T.36 S., R.25 E.				
13	Amerada Hess	1 - Fed. Connely	5,918	Pp	Test Gas Pp
	37 S., R.18 E.				
1	Danvers	1 - Govt.	3,889	M	Test Gas Pp
	T.37 S., R.23 E.				
15	Conoco	1 - Alkali Can.	6,440	Pp	Oil Well Pp
22	Buttes G & O	1 - 22 Fed.	6,482	Pp	Oil Well Pp
25	Gulf	1 - Aztec -Fed.	6,190	Pp	Oil Test Pp
	T.38 S., R.22 E.				
8	Conoco	1 - Fed.-Miller	6,510	Pp	Oil Test Pp
28	Lion	1 - Clark	6,118	Pp	Oil Well Pp
32	Triton	1 - Bluff Bench	5,940	Pp	Oil Well Pp

Table 1 continued:

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
	T.38 S., R.24 E.				
15	Reynolds Mining	1 - Fed.	6,047	Pp	Oil & Gas Well Pp
19	Skelly	1 - Parks	6,234	Pp	Oil Well
	T.38 S., R.25 E.				
9	Mt. Fuel	1 - Patterson Can		Pp	Oil Well Pp
5	Wexpro	3 - Patterson Can		Pp	Oil Well Pp
35	Glasco/Shell	1 - Govt.		Pp	Test Gas Salt
Colorado Mesa County Colorado					
	T.49 N., R.19 W.				
16	Huber	1 - Sinbad Unit	10,316	Pp	Gas Show Pp
Montrose County, Colorado					
	T.46 N., R.19 W.				
6	Pure Oil	3 - Wray Mesa Unit	11,301	D	Gas Show Pa
30	Miami	1 - Coyote Wash Unit	10,650	M	Gas Show Pc
	T.46 N., R.18 W.				
24	Grynberg/Gulf	32 - 24 Wild Steer	7,533	Ph	Gas Well Pc
	T.45 N., R.16 W.				
4	Conoco	1 - Kirby Govt.	7,476	Pp	Gas Well Pc Gas Well Ph
	T.40 N., R.16 W.				
26	Conoco	1 - Lone Dome	9,950	M	Gas Test Pp
San Miguel County					
	T.44 N., R.19 W.				
5	Pure	1 - SE Lisbon	9,972	C	Gas Well M
8	Pure	2 - McIntyre Can	9,170	C	Gas Well M

Table 1 continued:

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
16	Pure	3 - McIntyre Can	9,524	C	O & G Well M
18	Belco	Egnar Unit	8,860	D	Gas Well M
30	Belco	1 - Egnar	9,642	C	Gas Well M
	T. 45 N., R.18 W.				
26	Anadarko Prod.	1 - Hamm Canyon	10,649	Pp	Gas Test Pc
	T.45 N., R.17 W.				
20	Union Oil	1 - E - 20 USA	10,915	Pp	Gas Test Ph
	T.44 N., R.19 W.				
20	Gruenerwald	1 - Horse Range	9,422	D	Gas Well M
18	Union	6 - H - 18 McIntyre Can	8,860	D	Gas Well D
	T.44 N., R.17 W.				
36	Shell	1 - Big Gyp Valley	9,363	M	Gas Show Pp
	T.44 N., R.16 W.				
35	Union	7 - Andy's Mesa	10,857	D	Gas Well Pc
34	Union	1 - Andy's Mesa	8,509	Pp	Gas Well Pc
34	Union	11-E-34 Andy's Mesa	7,185	Pp	Gas Well Pc
20	Union	3 - Andy's Mesa	8,544	Pp	Gas Well Pc & Ph
28	Union	10-E-28 Andy's Mesa	8,308	Ph	Gas Well Ph
27	Union	2 - Andy's Mesa	8,494	Ph	Gas Well Pc & Ph
21	Union	6 - Andy's Mesa	8,637	Ph	Gas Well Pc
20	Union	4 - Andy's Mesa	7,637	Ph	Gas Well Ph
	T.43 N., R.17 W.				
8	Read & Stevens	1 - Slick Rock	9,923	D	Gas Well Pp
7	Read & Stevens	1 - Suekla	9,272	M	Gas Show Ph

Table 1 continued:

Sec.	Location	Well Name	T.D.	Deepest Formation	Shows
	T.43 N., R.16 W.				
3	R. Fulton	1 - Pure Fed.	7,506	Pp	Gas Show Pp
Dolores Co. Colorado					
	T.42 N., R.19 W.				
9	Allison Prestridge	1 - Long	6,211	Pp	Gas Show Ph
	T.42 N., R.18 W.				
14	Calif. Co.	3 - Egnar	3,662	Ph	Gas Show Pc
	T.41 N., R.18 W.				
17	Conoco	1 - Big Canyon	9,515	D	Gas Show Ph
	T.41 N., R.17 W.				
11	Carter	1 - Glade Unit	6,255	Pp	Gas Show Pp
Montezuma County Colorado					
	T.39 N., R.19 W.				
19	C & P Coal & Mining	1 - Pribble "A"	6,305	Pp	Gas Well Pp
29	C & P Coal & Mining	1 - Young Govt.	6,269	Pp	Gas Show Ph
30	C & P Coal & Mining	1 - Husky Unit	6,330	Pp	Oil Well Pp
31	C & P Coal & Mining	1 - Pribble Govt.	6,281	Pp	O & G Well Pp
32	C & P Coal & Mining	1 - Hampton Govt.	6,251	Pp	O & G Well Pp
	T.38 N., R.19 W.				
3	Western Nat.	1 - A Byrd, Frost, Driscoll	8,286	M	O & G Well Pp
7	Cherokee & Pitt C & M	1 - Cross Canyon	6,200	Pp	Gas Show Pp
33	Three State	2 - White	6,202	Pp	Gas Well Pp

Table 2. Utah Oil and Gas Produced by Field in Study Area To 1-1-78. from Utah Division of Oil Gas & Mining Monthly Oil & Gas Report, December 1977.

Grand County		
Crescent Junction	Paradox Salt	
Cumulative Oil	?	
Cumulative Gas	?	
Bartlett Flat	Paradox Salt	
Cumulative Oil	39,400	Bbls. Oil
Cumulative Gas	22,100	MCF Gas
Long Canyon	Paradox Salt	
Cumulative Oil	737,900	Bbl. Oil
Cumulative Gas	817,000	MCF Gas
San Juan County		
Shafer Canyon	Paradox Salt	
Cumulative Oil	67,500	Bbls. Oil
Cumulative Gas	63,800	MCF Gas
Wilson Canyon	Paradox Salt	
Cumulative Oil	57,700	Bbls. Oil
Cumulative Gas	96,300	MCF Gas
Little Valley	Paradox Salt	
Cumulative Oil	30,352	Bbls. Oil
Cumulative Gas	3,002,000	MCF Gas
Lisbon	Mississippian	
Cumulative Oil	40,595,700	Bbls. Oil
Cumulative Gas	303,600,200	MCF Gas
Big Iindian	Mississippian	
Cumulative Oil	131,370	Bbls. Oil
Cumulative Gas	18,514,300	MCF Gas
Alkali Canyon	Paradox Salt	
Cumulative Oil	3,900	Bbls. Oil
Cumulative Gas	40,100	MCF. Gas

Hatch	Paradox Salt	
Cumulative Oil	15,267	Bbls. Oil
Cumulative Gas	40,890	MCF Gas
Utah Cumulative Oil Totals	41,761,789	
Utah Cumulative MCF Totals	326,248,490	

Table 2. Colorado Gas and Oil Production by Fields in Study Area To 1-1-78 from Colorado State Oil & Gas Commission 1977 Oil & Gas Statistics.

Dolores County		
Papoose Canyon	Paradox Formation	
Cumulative Oil	1,383,000	Bbls. Oil
Cumulative Gas	8,628,000	MCF Gas
Montezuma County		
Dove Creek	Paradox Formation	
Cumulative Oil	79,000	Bbls. Oil
Cumulative Gas	915,000	MCG Gas
San Miguel County		
Andy's Mesa	Paradox & Cutler Formations	
Cumulative Oil	10,700	Bbls. Oil
Cumulative Gas	12,800,000	MCF Gas
SE Lisbon (McIntyre Canyon)	Mississippian	
Cumulative Oil	109,000	Bbls Oil
Cumulative Gas	20,304,000	MCF Gas
Colorado Cumulative Oil Totals	1,581,700	
Colorado Cumulative MCF Totals	36,647,000	

The proven reserves, as of 1975, were 217 million barrels of oil. The combining of the Paradox Basin with the heavily drilled San Juan Basin masks the potential for oil in the sparsely drilled Paradox Basin. A study by Lyth (1971) combines the Paradox and San Juan Basins and states that "this area has a very good potential for future development of significant oil and gas reserves from Paleozoic rocks". The postulated recoverable oil in the probable, possible, and speculative reserves are 2.1 billion barrels of oil. Plate 1, Petroleum Geology Data Base, is a map showing all the well locations and oil and gas fields in the Paradox Basin area.

In the area covered by this report, which is restricted to the north and central parts of the Paradox Basin, there is an unusually high number of oil shows in relationship to oil discoveries, especially in the Devonian and Mississippian tests. Only 2.2 percent of the holes drilled so far have adequately tested the Mississippian and Devonian, assuming that one hole evaluates 640 acres of land (Spencer, 1975, p. 263).

Stratigraphy and Oil Potential by Age

Cambrian rocks are made up of quartzitic sandstones, dolomites, and shales. The upper sandstones have a little porosity. There have been reported oil shows, but there has been no oil produced. The thickness of the sediments ranges from 500 to 1,000 or more feet. There is practically no oil potential from Cambrian sediments.

Ordovician and Silurian rocks were not deposited in the region.

Devonian formations are composed of dolomites, limestones, sandstones and shales. There has been minor oil production from the McCracken Member of the Elbert Formation as well as minor production from the Ouray Limestone in the Lisbon and McIntyre units. The Devonian sediments, having very low permeability and porosity, have only a fair potential for oil and gas production.

The Mississippian Leadville Formation is composed of limestones and dolomites and is the major producer of oil and gas in the study area. Most is produced from a lower porous dolomite zone; an upper limestone zone has been essentially non-productive. Often a good show of oil is encountered in a porous zone near the top. This porosity will usually give up several hundred feet of salt water in a drill-stem test. Apparently the oil has been mobile enough to have been either flushed through or out of the area. The Mississippian oil fields discovered thus far are located in structures that have no surface expression. Mississippian structures often parallel structures exposed at the surface, but are offset and masked by overlying salt features. The most favorable areas are on the flanks of the salt anticlines that appear to be step-faulted downward toward the deeper parts of the basin (towards the Uncompahgre Uplift to the northeast), leaving a faulted Mississippian structure which may contain hydrocarbons. With the lack of test holes in the Mississippian, no areas can be eliminated as possible oil and gas sources except for the Abajo and LaSal laccolithic centers. The Lisbon, McIntyre, and Salt Wash fields are presently producing from the Leadville Formation, and several other fields have been either shut-in or else abandoned. There have been abundant shows of oil and gas in the Leadville Formation throughout the region and its beds should be considered very good as an objective for oil and gas exploration. Plate 2, entitled, Oil and Gas Fields and Major Petroleum Potential of Mississippian Strata, shows the locations of the producing fields plus all wells that have penetrated the Mississippian excepting those in the producing fields. The well symbols indicate whether the hole was dry or had an oil or gas show. A coarsely hachured field indicates the area of greatest oil and gas potential in the Mississippian rocks of the Paradox Basin. In addition, table 1 gives a listing of all wells in the region that have oil and gas shows.

There is a very good to excellent potential for finding more small- to medium-sized oil and gas fields in the Mississippian rocks similar to the Lisbon field which produced 41,470,000 barrels of oil and 321,770 million cubic feet of gas from 1962 through December, 1978 (*Utah Oil, Gas and Mining* monthly production report, December 1978). Additional Mississippian fields include the Lisbon fields, Salt Wash field, McIntyre Canyon field and the Big Flat field.

The Pennsylvanian rocks of the region are a complex system of sediments that includes a reworked regolith, shallow marginal limestones with some algal reefing, organic shales, salts, anhydrites, dolomites, and arkosic sands. The interfacings of these sediments have been highly folded, faulted, and deformed with abundant oil and gas shows, and a small amount of production. The giant Aneth oil field, which has produced over 292 million barrels of oil from 1956 through 1978 (*Utah Oil, Gas and Mining* monthly production report, December, 1978) from the Pennsylvanian Paradox Formation lies immediately to the south of the study area. Several small gas and oil fields are found in the study area that produce from the Paradox Formation, both in salt and in post-salt sections, and from the Honaker Trail Formation. The evaporite section of the Paradox Formation includes cycles of salt, anhydrite, dolomite and shale. A maximum number of 29 cycles is recognized in the central part of the basin as reported by Hite (1960).

The Paradox Formation contains both the cyclic evaporite sequences with intra-salt bed clastic sections, and upper carbonate bioclastic sediments that include the reefs that are the major petroleum producers in the Greater Aneth field. In the study area small amounts of oil and gas have been produced from the upper carbonates of the Paradox Formation. There are many oil and gas shows within the salt section of the unit. Many completions have been attempted in the salt section, but only one well, the Southern Natural well, Long Canyon No. 1, has had a prolonged production history. This well has produced 760,000 barrels of oil from 1962 to the end of 1978 (*Utah Oil, Gas and Mining* monthly production report, December 1978). Other wells have produced oil for a short time from the intra-salt section before the production declined and stopped, sometimes due to mechanical problems such as collapsed casing. Several oil rigs have burned down while drilling into the oil and gas zones in the Paradox Formation. The oil and gas shows are found in both the pure salt sections and in the "clastic" sections (marker beds) of the evaporite section. The major production and shows have been in the "clastic" beds and from probable fracture reservoirs. There have been cores recovered that contain small amounts of free oil inclusions in the salt.

Plate 3, Oil and Gas Fields and Major Petroleum Potential of Pennsylvanian Strata, indicates the favorable areas for exploration. Wells are keyed to show whether they are dry, have oil or gas shows, or whether they are producers. The geologic unit in which the interesting shows are located is also given. A hachured area shows the best potential area for intra-salt oil and gas, whereas the remainder of the area is good oil and gas potential in the carbonate zones. Almost the entire area of this report underlain with salt beds is considered a potential oil and gas producer. The best places for exploration seem to be associated with the structures found within the salt basin, where folding may have caused the fracturing of the inter-salt clastic zones assumed to be the source of the petroleum. Additional drilling will give a better understanding of this potential petroleum source and additional oil production will be attained. See table 1 for a listing of the wells with oil and gas shows.

The Texas Gulf Incorporated Cane Creek potash Mine located near Moab, has reported both methane gas and oil leaking from holes drilled for roof bolting in the mine. Safety precautions were taken by drilling bleed-off holes into the marker beds prior to mine advance. At this writing underground mining has been abandoned in favor of solution mining because of the danger of methane gas explosions. Examples of production from the Paradox Formation in the study area include the Long Canyon unit, Lisbon C-2 Gulf Wilson Creek well, Bartlett Flat area, Cane Creek area, Seven Mile area, Salt Valley anticline area.

The Permian sediments in the area of study are mainly arkosic sandstones and shales. There has been some gas production from the lower Cutler Formation in southwest Colorado (Andys Mesa) and there have been numerous shows elsewhere. There is only a fair potential for oil and gas from Permian beds in the Paradox Basin, but there are large deposits of tar sands in an area a few miles to the west. Plate 4, Oil and Gas Fields and Major Petroleum Potential of Permian Strata, indicates the best areas for Permian exploration in the Paradox Basin and table 1 lists the oil and gas shows.

There are no reported oil shows in the Triassic marine-continental sands and shales. There are fossil oil deposits (heavy oil) in areas to the west of the Paradox Basin area. There is little potential for oil or gas in the Triassic beds.

There are shows of oil and gas reported from the Jurassic continental sediments and one field is producing from Jurassic-Triassic strata to the north of the study area (a northwest extension of the Salt Valley anticline). No commercial deposits have been found in the study area in Jurassic or Cretaceous rocks. However, there is a fair potential for oil and gas in the vicinity of salt structures in the north and north-central parts of the study area.

Oil and Gas Potential Summary

The Paradox salt basin area is a complex geologic province which is difficult to explore for oil and gas. Because of the problems of limited or very difficult access, the area is still relatively unexplored in the remote areas and also in the deeper stratigraphic horizons. The limited exploration leaves the region with a very good potential for new discoveries of oil and gas in the future. The potential hydrocarbon horizons and areas are:

1) *Mississippian and Devonian Formations* that exist in buried structural traps and stratigraphic traps that could be found by seismic and other subsurface methods.

2) *Lower and middle Paradox strata* containing abundant shows and "blow-outs" in the salt section. New methods will be found to complete these wells when new studies become available.

3) *Upper Paradox Formation* reefs and bioclastic zones and other stratigraphic and structural traps will be found with stratigraphic studies and improved seismic methods, as well as with wildcat drilling.

4) *Permo-Pennsylvanian section* stratigraphic and structural traps will be found when additional well data is available and seismic information is developed.

5) *The flanks of the salt anticline structures* have good potential for oil and gas in structural traps. There have been some gas wells completed in the carbonate as well as the sandstone sections of the Honaker Trail Formation near the faults associated with the salt anticlines. These faults can also form the conduits for the

hydrocarbons to migrate upward into non-marine reservoirs. There are additional oil fields near some structures just outside the study area and there is no reason to not expect more discoveries in the future. At present there is a fair to good potential for hydrocarbon production from the areas on the flanks of the surface anticlines in the area of study. Most of the surface anticlines have been drilled at their crests in the past, but the flanks of these anticlines have not been adequately explored. Examples of this type of production are Big Indian Wells on the upthrown side of Lisbon Fault in Lisbon Valley, and Andy's Mesa Unit.

6) *The deep part of the Paradox Basin*, next to the Uncompahgre Uplift, is the site of very thick clastic wedge of sandstones and arkoses of Permo-Pennsylvanian age. There is a good potential for additional hydrocarbons to be found and developed in the deep part of the Paradox Basin when the economics allow deeper exploration. Examples of this type of production have not been developed, but there are many good shows of gas in Colorado.

The entire Paradox Basin has a very good, near-future oil and gas potential, considering the energy shortages and the accompanying necessity to explore even the more remote areas. The Paradox Basin of Pennsylvanian age is one of the many evaporite basins that contain large petroleum resources. The organic rich marine black shales and carbonates are the source for the hydrocarbons.

URANIUM POTENTIAL

The occurrences and locations of uranium and the other mineral deposits in the study area are listed in table 3. Uranium and associated vanadium and copper mineralization has been discovered in almost every exposed geologic unit in the Paradox Basin area. However, the units with the most potential include the Permian Cutler Formation, the Triassic Moenkopi and Chinle Formations, and the Jurassic Entrada Sandstone and Morrison Formation. The basal sandstone members of the Chinle and the Salt Wash Member of the Morrison are by far the most important in terms of past production and future potential.

The Paradox Basin study area includes two major uranium producing areas, the Uravan Mineral belt which is located in westernmost Colorado and extends southwestward into Utah, and the Big Indian mining district which is located on the Lisbon Valley anticline. These two districts together have produced approximately 145,000,000 pounds of uranium. This area ranks third in uranium production in the U. S. behind Wyoming and the Grants district of New Mexico. Table 3 is a tabulation of the uranium and other mines of significant value located within the area of study.

The Permian Cutler Formation contains uranium and copper deposits, which have been productive in a number of areas. From the Uncompahgre Uplift westward to the confluence of the Colorado and Green Rivers the unit consists of brown, red, or purple arkose, arkosic sandstone, siltstone, and mudstone, with sporadic thin beds of cherty unfossiliferous limestone. This facies, with its highly lenticular sandstone and arkose beds, is suggestive of a fluvial origin, and has been called the Bogus Tongue Member, and it is several thousand feet thick. These arkosic lenses and adjoining rock contain copper, uranium and some vanadium minerals. Such lenses occur in a north-south trending belt, extending northward from Indian Creek mining area to the lower Cane Creek and Interriver areas. Some ore parallels the faults

Table 3.

Uranium Occurrences

Name	Location	Size
Grand County, Utah		
Unknown	Sec. 19, T.22 S., R.25 E.	Small
School Section 32	Sec. 32, T.22 S., R.25 E.	Small
Cactus Rat Group	Sec. 33, T.22 S., R.25 E.	Medium
Unknown	Sec. 34, T.22 S., R.23 E.	Small
Unknown	Sec. 34, T.22 S., R.23 E.	Small
Flat Top #1 Claim	Sec. 25, T.22 S., R.22 E.	Small
Windy Point	Sec. 26, T.22 S., R.22 E.	Small
Mineral Treasure	Sec. 34, T.22 S., R.22 E.	Small
Black Jack Mine	Sec. 31, T.22 S., R.22 E.	Medium
Blackstone Incline	Sec. 31, T.22 S., R.22 E.	Medium
Unknown	Sec. 31, T.22 S., R.22 E.	Small
Unknown	Sec. 31, T.22 S., R.22 E.	Medium
Unknown	Sec. 31, T.22 S., R.22 E.	Medium
M.C. Group	Sec. 36, T.22 S., R.21 E.	Small
Ringtail Mine	Sec. 36, T.22 S., R.21 E.	Medium
CIE Dog	Sec. 29, T.22 S., R.20 E.	Small
Salt Valley Claim	Sec. 36, T.22 S., R.19 E.	Small
Buckhorn	Sec. 4, T.23 S., R.25 E.	Small
Unknown	Sec. 9, T.23 S., R.24 E.	Small
Unknown	Sec. 12, T.23 S., R.23 E.	Small
Barco Claims	Sec. 12, T.23 S., R.23 E.	Small
Squaw Park Group	Sec. 3, T.23 S., R.23 E.	Medium
Unknown	Sec. 5, T.23 S., R.23 E.	Small
Little Pittsburg Mine	Sec. 5, T.23 S., R.22 E.	Small
Paris #25	Sec. 6, T.23 S., R.22 E.	Medium
Little Eva	Sec. 6, T.23 S., R.22 E.	Small
Unknown	Sec. 6, T.23 S., R.22 E.	Medium
Unknown	Sec. 6, T.23 S., R.22 E.	Medium
Unknown	Sec. 6, T.23 S., R.22 E.	Small
Parco Mines	Sec. 6, T.23 S., R.22 E.	Medium
AEC Group #3	Sec. 6, T.23 S., R.22 E.	Small
AEC Group #1	Sec. 6, T.23 S., R.22 E.	Small
AEC Group #2	Sec. 6, T.23 S., R.22 E.	Small
Rube Mine	Sec. 6, T.23 S., R.22 E.	Small
Black Ape Mine	Sec. 7, T.23 S., R.22 E.	Medium
Memphis	Sec. 7, T.23 S., R.22 E.	Small
Unknown	Sec. 6, T.23 S., R.22 E.	Small
Johns Incline	Sec. 1, T.23 S., R.21 E.	Medium
Unknown	Sec. 1, T.23 S., R.21 E.	Small
Consolidation	Sec. 12, T.23 S., R.21 E.	Small
Unknown	Sec. 12, T.23 S., R.21 E.	Small
Unknown	Sec. 12, T.23 S., R.21 E.	Small
Unknown	Sec. 12, T.23 S., R.21 E.	Small
Telluride Mines	Sec. 12, T.23 S., R.21 E.	Medium
Virgin Mary #1	Sec. 13, T.23 S., R.21 E.	Small
Yellow Bird Mine	Sec. 13, T.23 S., R.21 E.	Small
Unknown	Sec. 11, T.23 S., R.21 E.	Small
Silver Moon Deposit	Sec. 11, T.23 S., R.21 E.	Small
Juanita Group	Sec. 23, T.23 S., R.21 E.	Small

Table 3.

Uranium Occurrences
Grand County, Utah (continued)

School Section 2	Sec. 2, T.23 S., R.21 E.	Small
Fools Luck	Sec. 3, T.23 S., R.21 E.	Small
Unknown	Sec. 15, T.23 S., R.21 E.	Small
Bare Spot	Sec. 5, T.23 S., R.21 E.	Small
Unknown	Sec. 1, T.23 S., R.20 E.	Small
Cobalt #1	Sec. 9, T.23 S., R.20 E.	Small
Unknown	Sec. 15, T.23 S., R.20 E.	Small
Slick Rock 1,2,3	Sec. 28, T.23 S., R.20 E.	Medium
Bertha #5	Sec. 34, T.23 S., R.20 E.	Medium
Ghost Claim	Sec. 6, T.23 S., R.18 E.	Small
Lucky Valley	Sec. 5, T.23 S., R.18 E.	Small
Random Group	Sec. 4, T 24 S., R.19 E.	Small
Kellog #1	Sec. 24, T.24 S., R.20 E.	Small
Thornburg Memorian Mine	Sec. 27, T.24 S., R.20 E.	Large
Shinarump #1,#3,#4	Sec. 34, T.24 S., R.20 E.	Large
Copper King #1, #2A	Sec. 34, T.24 S., R.20 E.	Medium
Rae Marie #4,#5,#6	Sec. 33, T.24 S., R.26,E.	Medium
Rae Marie	Sec. 33, T.24 S., R.26 E.	Small
Big Louie	Sec. 21, T.24 S., R.26 E.	Small
Lone Pine #2, Lucky Pine #2	Sec. 28, T.24 S., R.26 E.	Small
Jumbo	Sec. 25, T.24 S., R.25 E.	Small
Pittsburg	Sec. 25, T.24 S., R.25 E.	Small
Petrified Tree #9	Sec. 35, T.24 S., R.25 E.	Medium
FW #3	Sec. 35, T.24 S., R.25 E.	Medium
Unknown	Sec. 35, T.24 S., R.25 E.	Medium
Unknown	Sec. 35, T.24 S., R.25 E.	Small
Louise A, Louise A#2	Sec. 26, T.24 S., R.25 E.	Small
Mineral Polar 22	Sec. 26, T.24 S., R.25 E.	Medium
Helen F.	Sec. 26, T.24 S., R.25 E.	Small
Rimrock, Skyrock Fraction	Sec. 26, T.24 S., R 25 E.	Medium
Unnamed	Sec. 34, T.24 S., R.25 E.	Small
Elva M. Group	Sec. 34, T.24 S., R.25 E.	Large
Eppie F. Mine	Sec. 34, T.24 S., R.25 E.	Medium
Thompson	Sec. 34, T.24 S., R.25 E.	Medium
Foster	Sec. 34, T.24 S., R.25 E.	Medium
New Armstrong	Sec. 34, T.24 S., R.25 E.	Medium
Mary #3, Petrified Tree #8	Sec. 27, T.24 S., R.25 E.	Medium
Captain Jack	Sec. 27, T.24 S., R.25 E.	Small
Red Head Deposits	Sec. 22, T.24 S., R.23 E.	Small
Cottonwood	Unsurveyed T.25 S., R.17 E.	Large
Bowknot	Unsurveyed T.25 S., R.17 E.	Small
Larry #1	Unsurveyed T.25 S., R.17 E.	Small
Unknown	Unsurveyed T.25 S., R.17 E.	Small
Green Dragon	Sec. 11, T.25 S., R.20 E.	Small
Unknown	Sec. 11, T.25 S., R.20 E.	Small
Unknown	Sec. 11, T.25 S., R.20 E.	Small
Azurite #1	Sec. 11, T.25 S., R.20 E.	Small
Klondike	Sec. 13, T.25 S., R.20 E.	Small
Copper #1	Sec. 13, T.25 S., R.20 E.	Small
Copper #2	Sec. 11, T.25 S., R.20 E.	Small
Beggar Group	Sec. 11, T.25 S., R.20 E.	Small

Table 3.

Uranium Occurrences
Grand County, Utah (continued)

Canyon #4	Sec. 8, T.25 S., R.26 E.	Small
Canyon #1	Sec. 8, T.25 S., R.26 E.	Small
Prospect #9	Sec. 7, T.25 S., R.26 E.	Small
Bananza #1, #2	Sec. 20, T.25 S., R.26 E.	Medium
Prospect #2	Sec. 18, T.25 S., R.26 E.	Small
Alta	Sec. 19, T.25 S., R.26 E.	Small
Polar King	Sec. 2, T.25 S., R.25 E.	Small
Polar #2	Sec. 10, T.25 S., R.25 E.	Medium
Polar #3	Sec. 10, T.25 S., R.25 E.	Small
Pinto Jack	Sec. 10, T.25 S., R.25 E.	Small
Polar #7	Sec. 3, T.25 S., R.25 E.	Small
Vivian	Sec. 3, T.25 S., R.25 E.	Small
Emma	Sec. 3, T.25 S., R.25 E.	Small
Freeport	Sec. 1, T.25 S., R.25 E.	Small
Yellow Jacket	Sec. 1, T.25 S., R.25 E.	Small
Avis	Sec. 1, T.25 S., R.25 E.	Medium
Unknown	Sec. 24, T.25 S., R.23 E.	Small
Horse Thief 6 & 7	*Unsurveyed T.26 S., R.18 E.	Small
Augua	Unsurveyed T.26 S., R.18 E.	Small
Unknown	Unsurveyed T.26 S., R.18 E.	Small
Black Jack Mine	Unsurveyed T.26 S., R.18 E.	Medium
Star #1	Unsurveyed T.26 S., R.18 E.	Small
Star #2	Unsurveyed T.26 S., R.18 E.	Small
Unknown	Unsurveyed T.26 S., R.18 E.	Small
Dragonfly Prospect	Unsurveyed T.26 S., R.18 E.	Small
Matchless	Unsurveyed T.26 S., R.18 E.	Small
Billy Boy Prospect	Unsurveyed T.26 S., R.18 E.	Small
Rocket Junior Mines	Unsurveyed T.26 S., R.18 E.	Medium
Unknown	Unsurveyed T.26 S., R.18 E.	Small
Mineral	Unsurveyed T.26 S., R.18 E.	Small
Matchless #3	Unsurveyed T.26 S., R.18 E.	Medium
A Group	*Unsurveyed T.26 S., R.17 E.	Large
Gray Fault	Sec. 21, T.26 S., R.20 E.	Small
Unknown	Sec. 32, T.26 S., R.21 E.	Medium
Schoolhouse Section #23	Sec. 32, T.26 S., R.21 E.	Large
Big Chief	Sec. 27, T.26 S., R.20 E.	Small
*Discovery	Sec. 36, T.26 S., R.19 E.	Small
School Section 32 Mines	Sec. 32, T.26 S., R.21 E.	Small
Hercules Mine	Sec. 32, T.26 S., R.21 E.	Medium
Unknown	Sec. 32, T.26 S., R.21 E.	Small
Valley View Mine	Sec. 7, T.26 S., R.24 E.	Small
Unknown	Sec. 7, T.26 S., R.24 E.	Small
Columbus Prospect	Sec. 7, T.26 S., R.24 E.	Small
Mistake	Sec. 7, T.26 S., R.24 E.	Small
Unknown	Sec. 7, T.26 S., R.24 E.	Small
North Cloud No.1	Sec. 14, T.26 S., R.23 E.	Small
North Cloud No.2	Sec. 14, T.26 S., R.23 E.	Small

Table 3. Uranium Occurrences

Name	Location	Size
San Juan County, Utah		
Unknown	(unsurveyed) Sec. 23 T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 23, T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 23, T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 25, T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 34, T.27 S., R.19 E.	Small
C Group	(Unsurveyed) Sec. 34, T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 35, T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 34, T.27 S., R.19 E.	Small
Unknown	(Unsurveyed) Sec. 34, T.27 S., R.19 E.	Medium
Unknown	(Unsurveyed) Sec. 35, T.17 S., R.19 E.	Medium
Unknown	(Unsurveyed) Sec. 6 T.27 S., R.19 E.	Small
Moonshine	Sec. 3, T.27 S., R.21 E.	Small
Canary (Big Fault)	Sec. 3, T.27 S., R.21 E.	Small
Atomic King	Sec. 3, T.27 S., R.21 E.	Large
Honey Bee No. 1, Atomic King #2	Sec. 10, T.27 S., R.21 E.	Medium
Colorado 2	Sec. 30, T.27 S., R.21 E.	Medium
Copper Penney	Sec. 19, T.27 S., R.21 E.	Small
Money	Sec. 23, T.27 S., R.20 E.	Small
Poor Calif. No. 1	Sec. 34, T.27 S., R.20 E.	Small
M Group	Sec. 4, T.27 S., R.20 E.	Small
"A Fault There Was"	Sec. 31, T.27 S., R.23 E.	Small
Unknown	Sec. 31, T.27 S., R.23 E.	Small
Black Streak	Sec. 31, T.27 S., R.23 E.	Small
Lucky Strike	Sec. 31, T.27 S., R.23 E.	Medium
Unknown	Sec. 31, T.27 S., R.23 E.	Small
Weekend #1	Sec. 1, T.27 S., R.23 E.	Small
Weekend	Sec. 1, T.27 S., R.23 E.	Small
Buckskin #2	Sec. 5, T.27 S., R.24 E.	Small
Buckskin #1	Sec. 6, T.27 S., R.24 E.	Small
Hatchet #3	Sec. 7, T.27 S., R.24 E.	Small
Chess Ridge	Sec. 7, T.27 S., R.24 E.	Small
Chess Ridge #1	Sec. 7, T.27 S., R.24 E.	Small
Chess Ridge #3	Sec. 7, T.27 S., R.24 E.	Small
Al Rodgers	Sec. 2, T.27 S., R.24 E.	Small
Red Devil	Sec. 28, T.27 S., R.24 E.	Medium
Unknown	Sec. 28, T.27 S., R.24 E.	Small
Canary Prospect	Sec. 30, T.27 S., R.24 E.	Small
North Brumley Prospect	Sec. 15, T.27 S., R.23 E.	Small

Table 3.

Uranium Occurrences
San Juan County, Utah (cont.)

Unknown Mine	Sec. 16, T.28 S., R.23 E.	Small
Prospect on School Section	Sec. 16, T.28 S., R.23 E.	Small
McGee Mine	Sec. 22, T.28 S., R.23 E.	Small
Grey Horse Claims	Sec. 21, T.28 S., R.23 E.	Small
Blue Jay Mine	Sec. 28, T.28 S., R.23 E.	Large
San Juan Mine	Sec. 33, T.28 S., R.23 E.	Small
Sunnyside Mine	Sec. 33, T.28 S., R.23 E.	Small
Yellow Circle Group	Sec. 2, T.28 S., R.23 E.	Large
Unknown	Sec. 2, T.28 S., R.23 E.	Small
Bridger Jack	Sec. 2, T.28 S., R.23 E.	Medium
Saver	Sec. 2, T.28 S., R.22 E.	Small
Unknown	Sec. 2, T.28 S., R,22 E.	Small
Unknown	Sec. 2, T.28 S., R.22 E.	Small
Old Powder Group	Sec. 2, T.28 S., R.22 E.	Small
Black Hat	Sec. 28, T.28 S., R.26 E.	Medium
Blue Cap	Sec. 28, T.28 S., R.26 E.	Large
Hesperus Mine	Sec. 32, T.28 S., R.26 E.	Medium
Vanadium Queen	Sec. 29, T.28 S., R.26 E.	Large
Unknown	Sec. 29, T.28 S., R.26 E.	Small
Unknown	Sec. 30, T.28 S., R.26 E.	Small
Gray Dawn Mine	Sec. 30, T.28 S., R.26 E.	Large
Little Pete Mine	Sec. 30, T.28 S., R.26 E.	Small
Unknown	Sec. 30, T.28 S., R.26 E.	Small
Firefly - Pigmay	Sec. 30, T.28 S., R.26 E.	Large
Little Don Mine	Sec. 30, T.28 S., R.26 E.	Medium
Miss Cheyenne	Sec. 19, T.28 S., R.26 E.	Small
Ida-Prospect	Sec. 25, T.28 S., R.25 E.	Small
Unknown	Sec. 1, T.29 S., R.19 E.	Small
Rainbow Ledge	Sec. 22, T.29 S., R.20 E.	Small
Cup No. 1	Sec. 22, T.29 S., R.20 E.	Small
Cutler	Sec. 27, T.29 S., R.20 E.	Small
Hecla Shaft	Sec. 28, T.29 S., R.24 E.	Large
E. L. Cord Shaft	Sec. 33, T.29 S., R.24 E.	Large
Homestake Mine	Sec. 33, T.29 S., R.24 E.	Large
Columbia Shaft	Sec. 33, T.29 S., R.24 E.	Large
Small Fry Mine	Sec. 34, T.29 S., R.24 E.	Large
San Juan Shaft	Sec. 27, T.29½S., R.24 E.	Large
Ike-Nixon Shaft	Sec. 34, T.29½S., R.24 E.	Large
Rio Algom	Sec. 21, T.29 S., R.24 E.	Large
Unknown Prospect	Sec. 2, T.29 S., R.23 E.	Small
Rattlesnake Mine	Sec. 2, T.29 S., R.23 E.	Large
North Alice Mine	Sec. 28, T.29 S., R.24 E.	Large
Far West Mine	Sec. 28, T.29 S., R.24 E.	Large
Blue Bird	Sec. 3, T.29 S., R.23 E.	Small
Brushy Basin #1	Sec. 28, T.29 S., R.26 E.	Small
Ken	Sec. 18, T.29 S., R.26 E.	Small
Pandora	Sec. 1, T.29 S., R.24 E.	Large
Snowball	Sec. 1, T.29 S., R.24 E.	Large
LaSal Incline	Sec. 1, T.29 S., R.24 E.	Large
Top, Homestake	Sec. 22, T.30 S., R.21 E.	Small
DIP	Sec. 15, T.30 S., R.21 E.	Small

Table 3.

Uranium Occurrences
<u>San Juan County, Utah</u> (cont.)

Unknown	Sec. 14, T.27 S., R.23 E.	Small
Unknown	Sec. 14, T.27 S., R.23 E.	Small
Black Ace #1	Sec. 10, T.27 S., R.23 E.	Small
Black Ace #2	Sec. 10, T.27 S., R.23 E.	Small
Hattie	Sec. 10, T.27 S., R.23 E.	Small
Black Ace #3	Sec. 10, T.27 S., R.23 E.	Small
Chipmonk #1	Sec. 15, T.27 S., R.23 E.	Small
Blue Goose	Sec. 15, T.27 S., R.23 E.	Small
Chipmonk #2	Sec. 16, T.27 S., R.23 E.	Small
Chipmonk #3	Sec. 16, T.27 S., R.23 E.	Small
Chipmonk #5	Sec. 16, T.27 S., R.23 E.	Small
Renegade	Sec. 14, T.27 S., R.23 E.	Small
Freeda #2	Sec. 16, T.27 S., R.23 E.	Small
Unknown #34	Sec. 32, T.27 S., R.23 E.	Small
Buster Group	Sec. 19, T.27 S., R.23 E.	Small
Fault #1 Prospect	Sec. 35, T.27 S., R.23 E.	Medium
Unknown Prospect	Sec. 35, T.27 S., R.23 E.	Small
Hidden Log	Sec. 34, T.27 S., R.23 E.	Small
Unknown Prospect	Sec. 34, T.27 S., R.23 E.	Small
Unknown Prospect (Cedar Claims)	Sec. 33, T.27 S., R.23 E.	Small
Snowflake	Sec. 28, T.27 S., R.23 E.	Large
Pinion	Sec. 33, T.27 S., R.23 E.	Small
Unknown	Sec. 35, T.27 S., R.22 E.	Small
Big Bowl	Sec. 31, T.27 S., R.23 E.	Small
Unknown	Sec. 36, T.27 S., R.23 E.	Small
Unknown	Sec. 36, T.27 S., R.23 E.	Small
Hope (I)	Sec. 35, T.27 S., R.23 E.	Small
Unknown	Sec. 30, T.27 S., R.22 E.	Small
Unknown	Sec. 31, T.27 S., R.22 E.	Small
Unknown	(Unsurveyed) Sec. 3, T.28 S., R.19 E.	Small
Unknown-C Group	(Unsurveyed) Sec. 3, T.28 S., R.19 E.	Small
George #31 Prospect	(Unsurveyed) Sec. 1, T.28 S., R.19 E.	Small
Sailor Group	(Unsurveyed) Sec. 29, T.28 S., R.19 E.	Small
Rainy Day Group	(Unsurveyed) Sec. 28, T.28 S., R.19 E.	Small
Rainbow Group	(Unsurveyed) Sec. 24, T.28 S., R.18 E.	Small
Lockhart, Lulu (claims)	Sec. 14, T.28 S., R.20 E.	Small
Marie, Imogene Claims	Sec. 11, T.28 S., R.20 E.	Small
List, Nancy Ann	Sec. 4, T.28 S., R.20 E.	Small
Blue Bonnet Top	Sec. 6, T.28 S., R.23 E.	Small
Pate Mine	Sec. 6, T.28 S., R.23 E.	Small
Porcupine Prospect	Sec. 7, T.28 S., R.23 E.	Small
Last Chance	Sec. 18, T.28 S., R.23 E.	Medium
Dip Prospect	Sec. 17, T.28 S., R.23 E.	Small
Lizard	Sec. 17, T.28 S., R.23 E.	Small

Table 3.

Uranium Occurrences
San Juan County, Utah (cont.)

Unknown	Sec. 1, T.30 S., R.21 E.	Small
Queen of Hearts	Sec. 4, T.30 S., R.21 E.	Small
Ivy Mine	Sec. 10, T.30 S., R.24 E.	Small
Texwood Incline	Sec. 11, T.30 S., R.24 E.	Large
Standard Two Mine	Sec. 11, T.30 S., R.24 E.	Large
Little Beaver Mine	Sec. 15, T.30 S., R.24 E.	Medium
Big Buck Mine	Sec. 11, T.30 S., R.24 E.	Large
Mi Vida Mine	Sec. 11, T.30 S., R.24 E.	Large
Bow Mine	Sec. 35, T.30 S., R.24 E.	Small
Wilson Mine	Sec. 35, T.30 S., R.24 E.	Large
Blackbird Mine	Sec. 26, T.30 S., R.25 E.	Medium
Costanza Mine	Sec. 26, T.30 S., R.25 E.	Medium
Unknown	Sec. 32, T.30 S., R.25 E.	Small
Unknown	Sec. 36, T.30 S., R.25 E.	Small
West Incline & Continental Incline	Sec. 36, T.30 S., R.25 E.	Large
May Field Mine	Sec. 35, T.30 S., R.25 E.	Small
Divide Incline	Sec. 35, T.30 S., R.25 E.	Large
Red Rock Incline	Sec. 35, T.30 S., R.25 E.	Small
Serviceberry Mine	Sec. 34, T.30 S., R.25 E.	Medium
Yellow Jacket	Sec. 35, T.30 S., R.25 E.	Small
Spiller Canyon Mine	Sec. 13, T.30 S., R.25 E.	Medium
Louise Tunnel	Sec. 13, T.30 S., R.24 E.	Large
Standard Tunnel	Sec. 13, T.30 S., R.24 E.	Large
Cup, Chukar, Blue Goose	Sec. 17, T.31 S., R.21 E.	Small
Unknown	Sec. 9, T.31 S., R.21 E.	Small
Moki Mine	Sec. 13, T.31 S., R.21 E.	Large
Jean No. 1 Mine	Sec. 14, T.31 S., R.21 E.	Large
Blue Hill Group	Sec. 3, T.31 S., R.21 E.	Small
Paymaster	Sec. 3, T.31 S., R.21 E.	Small
Old Rattler	Sec. 11, T.31 S., R.24 E.	Medium
Nonesuch	Sec. 21, T.31 S., R.24 E.	Medium
Bonanza	Sec. 27, T.31 S., R.24 E.	Small
Bonanza Group	Sec. 27, T.31 S., R.24 E.	Large
Unknown	Sec. 22, T.31 S., R.24 E.	Small
Stateline	Sec. 23, T.31 S., R.24 E.	Small
Gilman	Sec. 6, T.31 S., R.25 E.	Medium
Good Hope	Sec. 6, T.31 S., R.25 E.	Large
Rickey Lode Mine	Sec. 6, T.31 S., R.25 E.	Small
Dime Mine	Sec. 6, T.31 S., R.25 E.	Small
Unknown	Sec. 6, T.31 S., R.25 E.	Medium
Unknown	Sec. 6, T.31 S., R.25 E.	Small
Unknown	Sec. 6, T.31 S., R.25 E.	Small
Jimbo Bob Encline	Sec. 7, T.31 S., R.25 E.	Small
Old Jimbo Bob Mine	Sec. 7, T.31 S., R.25 E.	Small
Good Hope #2	Sec. 7, T.31 S., R.25 E.	Small
Pot #5 Mine	Sec. 7, T.31 S., R.25 E.	Medium
Good Hope #3	Sec. 8, T.31 S., R.25 E.	Medium
Geneva Mine	Sec. 1, T.31 S., R.24 E.	Medium
Bee Mine	Sec. 8, T.31 S., R.25 E.	Medium
Peach #1 Mine	Sec. 9, T.31 S., R.25 E.	Medium

Table 3.

Uranium Occurrences
San Juan County, Utah (cont.)

Jimbo Bob Shaft	Sec. 12, T.31 S., R.24 E.	Medium
Swazey Mine	Sec. 18, T.31 S., R.26 E.	Small
Velvet Shaft	Sec. 3, T.31 S., R.25 E.	Medium
Bluebird-Suspenders	Sec. 13, T.31 S., R.25 E.	Medium
Columbus Incline	Sec. 30, T.31 S., R.25 E.	Large
Sunset Mine	Sec. 30, T.31 S., R.25 E.	Medium
Blackbottom Mine	Sec. 19, T.31 S., R.25 E.	Medium
Nipples Mine	Sec. 19, T.31 S., R.25 E.	Medium
Frisco Mine	Sec. 25, T.31 S., R.25 E.	Large
Frisco Twin Mine	Sec. 36, T.31 S., R.25 E.	Medium
Ute Mine	Sec. 5, T.31 S., R.25 E.	Medium
Unknown	Sec. 36, T.31 S., R.25 E.	Small
Woods Mine	Sec. 1, T.31 S., R.25 E.	Large
Rim Shaft	Sec. 29, T.31 S., R.25 E.	Large
Unknown	Sec. 9, T.32 S., R.23 E.	Small
Lookout Mine	Sec. 4, T.32 S., R.23 E.	Large
Black Hawk 1&2	Sec. 12, T.32 S., R.23 E.	Small
Navajo 1&2	Sec. 12, T.32 S., R.23 E.	Small
Johnnie Mine Prospect	Sec. 2, T.32 S., R.23 E.	Small
Unknown	Sec. 12, T.32 S., R.23 E.	Small
Loya Ray	Sec. 6, T.32 S., R.24 E.	Medium
Happy Jack	Sec. 13, T.32 S., R.23 E.	Medium
Wilson Shaft	Sec. 22, T.32 S., R.26 E.	Large
Calliharn	Sec. 33, T.32 S., R.26 E.	Large
Sage	Sec. 34, T.32 S., R.26 E.	Medium
Cap Mine	Sec. 1, T.32 S., R.25 E.	Small
Lake Claim	Sec. 10, T.33 S., R.22 E.	Small
Indian Creek #2	Sec. 10, T.33 S., R.22 E.	Medium
Harts Draw Deposits	Sec. 2, T.33 S., R.22 E.	Small
Abe Mine	Sec. 33, T.33 S., R.20 E.	Large
Betty Mine	Sec. 28, T.33 S., R.20 E.	Large
Horseshoe No. 1 Mine	Sec. 7, T.33 S., R.20 E.	Medium
Horseshoe Mine	Sec. 8, T.33 S., R.20 E.	Small
Unknown	Sec. 3, T.33 S., R.20 E.	Small
Shay Road Deposit	Sec. 17, T.33 S., R.22 E.	Small
Shay Mtn. Mines	Sec. 11 - 14, T.33 S., R.21 E.	Medium
Robertson Pasture Deposit	Sec. 20, T.33 S., R.22 E.	Small
Marcy 1,2&3	Sec. 32, T.34 S., R.20 E.	Large
Payday	Sec. 30, T.34 S., R.20 E.	Large
Western Payday Mine	Sec. 36, T.34 S., R.20 E.	Medium
Lifter	Sec. 27, T.34 S., R.24 E.	Small
Wheeler	Sec. 27, T.34 S., R.24 E.	Small
Blue Eagle No. 6	Sec. 22, T.34 S., R.24 E.	Small
Blue Eagle No.	Sec. 34, T.34 S., R.24 E.	Small
Avalanche #9	Sec. 34, T.34 S., R.20 E.	Medium
King Edward Mine	Sec. 34, T.34 S., R.20 E.	Large
Ransome South Mine	Sec. 34 T.34 S., R.20 E.	Medium
Ransome Mine	Sec. 34, T.34 S., R.20 E.	Small
Avalanche #3	Sec. 7, T.34 S., R.20 E.	Large
King James Mine	Sec. 27, T.34 S., R.20 E.	Large
Unknown	Sec. 27, T.34 S., R.20 E.	Small

Table 3.

Uranium Occurrences
San Juan County, Utah (cont.)

Glade Mine	Sec. 4, T.34 S., R.20 E.	Large
Little Dick I	Sec. 6, T.35 S., R.25 E.	Small
Little Dick 3	Sec. 6, T.35 S., R.25 E.	Small
Notch #1 & #4	Sec. 7, T.35 S., R.20 E.	Medium
Carl - Look #4	Sec. 6, T.35 S., R.20 E.	Large
Payday #3	Sec. 6, T.35 S., R.20 E.	Small
Dolly Dee	Sec. 2, T.35 S., R.20 E.	Small
Laura Mine	Sec. 10, T.35 S., R.20 E.	Medium
Laura Bell	Sec. 10, T.35 S., R.20 E.	Small
Morrison Mine	Sec. 2, T.35 S., R.20 E.	Small
Notch #5	Sec. 8, T.35 S., R.20 E.	Medium
Little Dian	Sec. 17, T.35 S., R.20 E.	Medium
Waben	Sec. 3, T.35 S., R.19 E.	Small
Texstar	Sec. 31, T.35 S., R.19 E.	Small
Rex Group	Sec. 28, T.35 S., R.19 E.	Medium
Unknown	Sec. 9, T.35 S., R.19 E.	Medium
Susie	Sec. 34, T.35 S., R.19 E.	Medium
Al Mines	Sec. 28, T.35 S., R.18 E.	Small
High Hopes	Sec. 23, T.35 S., R.21 E.	Small
Unknown	Sec. 13, T.35 S., R.21 E.	Small
Pretty Girl Mine	Sec. 13, T.35 S., R.21 E.	Small
Lucky Lady	Sec. 11, T.35 S., R.21 E.	Large
Notch #6 Mine	Sec. 8, T.35 S., R.21 E.	Small
Black Diamond	Sec. 14, T.35 S., R.24 E.	Small
Falls	Sec. 19, T.35 S., R.24 E.	Small
Unknown	Sec. 20, T.35 S., R.24 E.	Small
Slum	Sec. 28-29, T.35 S., R.24 E.	Small
Fiddle #2	Sec. 28, T.35 S., R.24 E.	Small
Lucky Boy	Sec. 34, T.35 S., R.24 E.	Medium
Verdure	Sec. 34, T.35 S., R.24 E.	Medium
Cottonwood Mine	Sec. 35, T.35 S., R.24 E.	Medium
Unknown	Sec. 35, T.35 S., R.24 E.	Small
Strawberry	Sec. 35, T.35 S., R.24 E.	Medium
Sunshine	Sec. 26, T.35 S., R.24 E.	Small
Rusty Can	Sec. 1, T.35 S., R.24 E.	Small
Rainbow	Sec. 35, T.35 S., R.24 E.	Small
Coyote #1	Sec. 36, T.35 S., R.24 E.	Small
Titus #3	Sec. 31, T.35 S., R.25 E.	Medium
Yellowbird #2	Sec. 11, T.35 S., R.25 E.	Small
Peavine Queen Mine	Sec. 7, T.36 S., R.19 E.	Small
East Woodenshoe	Sec. 3, T.36 S., R.18 E.	Medium
Oakie Mine	Sec. 23-24, T.36 S., R.18 E.	Large
Unknown	Sec. 24, T.36 S., R.18 E.	Small
Sandy No. 3 Mine	Sec. 17, T.36 S., R.18 E.	Medium
Sandy No. 2 Mine	Sec. 17, T.36 S., R.18 E.	Large
Happy Surprise	Sec. 3, T.36 S., R.18 E.	Medium
Big Red	Sec. 16, T.36 S., R.18 E.	Medium
Blue Jay	Sec. 15, T.36 S., R.18 E.	Small
Unknown	Sec. 18, T.36 S., R.18 E.	Medium
Unknown	Sec. 9, T.36 S., R.24 E.	Small
Lookover	Sec. 34, T.36 S., R.24 E.	Small

Table 3.

Uranium Occurrences
San Juan County, Utah (cont.)

Dixie #1	Sec. 34, T.36 S., R.24 E.	Medium
Best	Sec. 34, T.36 S., R.24 E.	Small
Splendid #16	Sec. 14, T.36 S., R.24 E.	Small
Calley	Sec. 36, T.36 S., R.24 E.	Small
Mill	Sec. 36, T.36 S., R.24 E.	Small
Montezuma #1	Sec. 35, T.36 S., R.24 E.	Medium
Delaware Chief	Sec. 26, T.36 S., R.24 E.	Small
Dollar #1 and #2	Sec. 26, T.36 S., R.24 E.	Small
Unknown	Sec. 23, T.36 S., R.24 E.	Small
Yellowcake	Sec. 12, T.36 S., R.24 E.	Small
Unknown	Sec. 15, T.36 S., R.25 E.	Small
East Cliffhouse #5	Sec. 15, T.36 S., R.25 E.	Large
Cottonwood #1	Sec. 15, T.36 S., R.25 E.	Small
West Cliffhouse #8	Sec. 15, T.36 S., R.25 E.	Large
Big Bluff	Sec. 9, T.36 S., R.25 E.	Small
Hangover (MTZCN)	Sec. 33, T.36 S., R.25 E.	Small
Pickett #3	Sec. 34, T.36 S., R.25 E.	Small
Dusty #4 and #9	Sec. 26, T.36 S., R.25 E.	Small
Rusty Can #2	Sec. 26, T.36 S., R.25 E.	Small
Unknown	Sec. 26, T.36 S., R.25 E.	Small
Unknown	Sec. 18, T.36 S., R.26 E.	Small
Canary #1	Sec. 18, T.36 S., R.26 E.	Medium
Unknown	Sec. 26, T.36 S., R.25 E.	Medium
Point	Sec. 26, T.36 S., R.25 E.	Small
Black Hawk #2	Sec. 26, T.36 S., R.25 E.	Small
Pure Luck	Sec. 35, T.36 S., R.25 E.	Medium
V8	Sec. 4, T.37 S., R.21 E.	Medium
Ridge #1	Sec. 15, T.37 S., R.21 E.	Medium
Seldom-Waterloo	Sec. 15, T.37 S., R.21 E.	Medium
Unknown	Sec. 15, T.37 S., R.21 E.	Small
Basin #1 Mine	Sec. 3, T.37 S., R.21 E.	Medium
Found	Sec. 3, T.37 S., R.21 E.	Medium
Unknown	Sec. 3, T.37 S., R.21 E.	Medium
Big Hole Mine	Sec. 3, T.37 S., R.21 E.	Medium
Cottonwood #2	Sec. 3, T.37 S., R.21 E.	Medium
Cottonwood	Sec. 10, T.37 S., R.21 E.	Medium
Royal Flush	Sec. 4, T.37 S., R.21 E.	Medium
Bugs	Sec. 4, T.37 S., R.21 E.	Medium
Simpatica #3	Sec. 4, T.37 S., R.21 E.	Medium
Cedar Bird	Sec. 9, T.37 S., R.21 E.	Small
Spring Creek	Sec. 9, T.37 S., R.21 E.	Medium
Unknown	Sec. 9, T.37 S., R.21 E.	Small
Unknown	Sec. 4, T.37 S., R.21 E.	Small
Last Chance	Sec. 4, T.37 S., R.21 E.	Medium
Point	Sec. 4, T.37 S., R.21 E.	Medium
Unknown	Sec. 4, T.37 S., R.21 E.	Large
View	Sec. 4, T.37 S., R.21 E.	Large
Unknown	Sec. 4, T.37 S., R.21 E.	Large
Unknown	Sec. 4, T.37 S., R.21 E.	Small
Unknown	Sec. 4, T.37 S., R.21 E.	Small
Unknown	Sec. 4, T.37 S., R.21 E.	Small
Unknown	Sec. 4, T.37 S., R.21 E.	Small

Table 3.

Uranium Occurrences
San Juan County, Utah (cont.)

Unknown	Sec. 4, T.37 S., R.21 E.	Small
Lucky Strike	Sec. 14, T.37 S., R.24 E.	Small
Dixie #1 & Bradford #7	Sec. 5, T.37 S., R.24 E.	Small
Unknown	Sec. 5, T.37 S., R.24 E.	Small
Elmer #1 & Red Cone	Sec. 5, T.37 S., R.24 E.	Small
Bradford 8	Sec. 5, T.37 S., R.24 E.	Medium
Sally #1	Sec. 9, T.37 S., R.24 E.	Small
Leo J.	Sec. 9, T.37 S., R.24 E.	Small
Bradford 5	Sec. 9, T.37 S., R.24 E.	Medium
Unknown	Sec. 9, T.37 S., R.24 E.	Medium
Morning Star	Sec. 11, T.37 S., R.24 E.	Small
Cabalco #2	Sec. 3, T.37 S., R.24 E.	Small
Ritz	Sec. 32, T.37 S., R.26 E.	Small
Red Bird	Sec. 32, T.37 S., R.26 E.	Small
Payday	Sec. 32, T.37 S., R.26 E.	Small
R and Double H	Sec. 17, T.37 S., R.25 E.	Small
Blue Jay #2	Sec. 16, T.37 S., R.25 E.	Small
Dixie #2	Sec. 19, T.37 S., R.25 E.	Small
Dixie #3	Sec. 19, T.37 S., R.25 E.	Small
Buckhorn	Sec. 23, T.37 S., R.25 E.	Small
Coal Bed Canyon Unknown	Sec. 22, T.37 S., R.25 E.	Small
Gold Butte	Sec. 4 & 9, T.38 S., R.21 E.	Small
Gold Butte Group	Sec. 16, T.38 S., R.21 E.	Small
Sunshine	Sec. 32, T.38 S., R.21 E.	Medium
Perkins Prospect	Sec. 7, T.38 S., R.25 E.	Small
Tree Mine	Sec. 25, T.38 S., R.22 E.	Small

Table 3. Copper Occurrences

Name	Location	Size
Blue Span Mine	Sec. 19, T.22 S., R.26 E.	Small
Unknown #4	Sec. 23, T.26 S., R.24 E.	Small
Unknown #5	Sec. 23, T.26 S., R.24 E.	Small
Skylark No's 1 & 2	Sec. 14, T.26 S., R.24 E.	Small
M.I.F. Adit, North & South	Sec. 14, T.26 S., R.24 E.	Small
McCoy Adit	Sec. 24, T.26 S., R.24 E.	Small
High Ore	Sec. 14, T.26 S., R.24 E.	Small
Venus Mine	Sec. 14, T.26 S., R.24 E.	Small
Little Dot	Sec. 14, T.26 S., R.24 E.	Small
Alamo Adit	Sec. 23, T.26 S., R.24 E.	Small
Dewey Group	Sec. 23, T.26 S., R.24 E.	Small
Sure Fire	Sec. 31, T.26 S., R.24 E.	Small
Unknown	Sec. 5, T.26 S., R.24 E.	Small
Big Indian Mine	Sec. 34, T.29 S., R.24 E.	Small
Unknown	Sec. 18, T.30 S., R.24 E.	Small
Unknown	Sec. 18, T.30 S., R.24 E.	Small
Unknown	Sec. 25, T.30 S., R.25 E.	Small
Copper Prospect	Sec. 8, T.31 S., R.26 E.	Small
Profit Copper Prospect	Sec. 7, T.31 S., R.26 E.	Small
Profit #2 Copper Prospect	Sec. 7, T.31 S., R.26 E.	Small
Copper Queen Mine (unsurveyed)	Sec. 35, T.33 S., R.22 E.	Small
Tuffy Copper Deposit	Sec. 5, T.33 S., R.22 E.	Small

Table 3. Gold Occurrences

Name	Location	Size
Unknown	Sec. 11, T.22 S., R.24 E.	Small
Double Standard Shaft and Adit	Sec. 14, T.26 S., R.24 E.	Small
McCormick Aidt	Sec. 23, T.26 S., R.24 E.	Small
Dillon Adit	Sec. 15, T.26 S., R.24 E.	Medium
Leland #1 & #2	Sec. 22, T.26 S., R.24 E.	Small
Tornado #1 & #2, West Slope	Sec. 22, T.26 S., R.24 E.	Small
Indiania Adit	Sec. 22, T.26 S., R.24 E.	Small
Wheat Adit, Lower & Upper Level	Sec. 15, T.26 S., R.24 E.	Small
About Time & Others	Sec. 22, T.26 S., R.23 E.	Small
North Murphy	Sec. 22, T.26 S., R.23 E.	Small
Gold Queen Mine (unsurveyed)	Sec. 11, T.34 S., R.22 E.	Small
Danish Girl "	Sec. 11, T.34 S., R.22 E.	Small
Bluebird "	Sec. 13, T.34 S., R.22 E.	Small
Marvin Tunnel "	Sec. 15, T.34 S., R.22 E.	Small
Dream Mine "	Sec. 15, T.34 S., R.22 E.	Small
Duckett Mine "	Sec. 18-17, T.34 S., R.22 E.	Small

Table 3. Manganese Occurrences

Name	Location	Size
Little Valley	Sec. 28, T.22 S., R.20 E.	Small
Manganese Prospect	Sec. 18, T.26 S., R.24 E.	Small
Mole Shoe Wash	Sec. 19, T.28 S., R.23 E.	Small
West Courthouse	Sec. 28, T.24 S., R.20 E.	Small
East Courthouse	Sec. 15, T.24 S., R.20 E.	Small

Table 3. Iron Occurrences

Name	Location	Size
Unknown	Sec. 13, T.30 S., R.20 E.	Small

Table 3. Uranium Occurrences

Name	Location	Size
Mesa County, Colorado		
Arrowhead 1 & 7	Sec. 3, T.50 N., R.18 W.	Medium
Arrowhead 5	Sec. 3, T.50 N. R.18 W.	Medium
Arrowhead 20 & 20 A	Sec. 2, T.50 N., R.18 W.	Medium
Arrowhead 21	Sec. 2, T.50 N., R.18 W.	Medium
Arrowhead 28	Sec. 10, T.50 N., R.18 W.	Medium
Arrowhead Incline 6	Sec. 10, T.50 N., R.18 W.	Medium
Arrowhead Incline 2	Sec. 3, T.50 N., R.18 W.	Medium
Arrowhead Incline 12&23	Sec. 3, T.50 N., R.18 W.	Medium
Arrowhead Incline	Sec. 3, T.50 N., R.18 W.	Medium
Atlas 1,2,3	NW¼ Sec. 6, T.50 N., R.19 W.	Medium
Belmont 1 & 2	Sec. 3., T.50 N., R.18 W.	Medium
Big Seven	N½ Sec. 32, T.50 N., R.17 W.	Medium
Black Mama	NW¼ Sec. 29, T.51 N., R.18 W.	Medium
Black Streak	Sec. 31 T.50 N., R.17 W.	Medium
Blue Ribbon 3	Sec. 10, T.50 N., R.18 W.	Medium
Blue Ribbon Group	Sec. 3, T.50 N., R.18 W.	Medium
Bonanza 2	Sec. 26, T.51 N., R.20 W.	Large
Bonanza 3	Sec. 25, T.51 N., R.20 W.	Medium
Bonanza 5	Sec. 26, T.51 N., R.20 W.	Medium
Bonanza 6	Sec. 26, T.51 N., R.20 W.	Medium
Buick	Sec. 31, T.51 N., R.18 W.	Medium
Cedar Pt. 3	Sec. 23, T.51 N., R.19 W.	Medium
Cliff Dweller	Sec. 22, T.50 N., R.18 W.	Medium
C-G-26A, DOE Lease Tract	Sec. 4, T.50 N., R.18 W.	Medium
C-G-27, DOE Lease Tract	Sec. 12, T.50 N., R.18 W.	Medium
C-G-27A., DOE Lease Tract	SW¼ Sec. 17, T.50 N., R.17 W.	Medium
Climax Residue	Unknown	Medium
Cottonwood 3 & 5	Sec. 14, T.50 N., R.18 W.	Medium
Crows Nest	Sec. 11, T.50 N., R.18 W.	Medium
Depression No. 6	Sec. 15, T.50 N., R.18 W.	Medium
Depression N. 4 & 5	Sec. 18, T.50 N., R.18 W.	Medium
Elizabeth 17 & 18	Sec. 29, T.50 N., R.17 W.	Medium
Elizabeth No. 7,8,9.10	Sec. 4, T.49 N., R.17 W.	Medium
Gateway Tailings	Sec. 10, T.51 N., R.18 W.	Medium
Hanson-Negus	Sec. 17, T.50 N., R.17 W.	Medium
Hubbard Homestead & Pack Rat	Sec. 35, T.51 N., R.20 W.	Large
Incline 2 G 2	SE¼, Sec. 18 T. 50 N., R.17 W.	Medium
Incline 3 G 3	NE¼, Sec. 13, T.50 N., R.18 W.	Medium
Incline 4 G 4	NE¼, Sec. 13, T.50 N., R.18 W.	Medium
J.W.L. Fraction	SW¼, Sec. 36, T.51 N., R.20 W.	Medium
Jody Group	Sec. 33, T.50 N., R.17 W.	Medium
Joe	Sec. 31, T.51 N., R.18 W.	Medium
John Brown 14 & 15	Sec. 1, T.50 N., R.19 W.	Medium
Johnnie Mae 3	Sec. 36, T.51 N., R.10 W.	Medium
July	Sec. 12, T.50 N., R.18 W.	Medium
Karns Incline	Sec. 12, T.50 N., R.20 W.	Medium
LaSal	Sec. 25, T.50 N., R.20 W.	Medium
LaSal	Sec. 36, T.51 N., R.20 W.	Medium
LaSal No. 1 & 2	Sec. 36, T.51 N., R.20 W.	Medium
LaSal No. 4	Sec. 36, T.51 N., R.20 W.	Medium

Uranium Occurrences
Mesa County, Colorado (cont.)

LaSal No. 5 & 7	Sec. 36, T.51 N., R.20 W.	Medium
Liberty Bell	Sec. 36, T.51 N., R.19 W.	Medium
Little Johnny	Sec. 31, T.51 N., R.18 W.	Medium
Lost Dutchman 17	Sec. 25, T.51 N., R.20 W.	Large
Lumsden No. 2 & 6	Sec. 36, T.51 N., R.20 W.	Medium
Lumson 1	Sec. 36, T.51 N., R.20 W.	Medium
Mammoth	Sec. 31, T.51 N., R.18 W.	Medium
Mesa 8	Sec. 12, T.50 N., R.18 W.	Large
Mesa No. 5	E½ Sec. 12, T.50 N., R.18 W.	Medium
Mineral Channel 10 & 12	Sec. 7, T.50 N., R.17 W.	Medium
Newheisel	Sec. 31, T.51 N., R.19 W.	Medium
October Adit	S½ Sec. 4, T.50 N., R.19 W.	Large
Outlaw-Economy	Sec. 12, T.50 N., R.18 W.	Medium
Pack Rat 1 & 2	Sec. 35, T.51 N., R.20 W.	Medium
Peach 10 Incline 1 & 2	Sec. 25, T.50 N., R.18 W.	Medium
Protector	Sec. 31, T.51 N., R.18 W.	Medium
Rae Marie Group	Sec. 33, T.24 S., R.26 E.	Medium
Rajah 11 & 63	Sec. 35, T.51 N., R.20 W.	Medium
Rajah 30	Sec. 1, T.50 N., R.20 W.	Large
Rajah 67&68,61,62,63	Sec. 36, T.51 N., R.20 W.	Large
Ronnie 1	Sec. 12, T.50 N., R.18 W.	Medium
Ronnie 2	Sec. 13, T.50 N., R.18 W.	Medium
Small Spot	Sec. 9, T.50 N., R.18 W.	Medium
Snow Shoe	Sec. 12, T.50 N., R.18 W.	Medium
Spring	Sec. 12, T.50 N., R.18 W.	Medium
Sunflower	Sec. 4, T.50 N., R.18 W.	Medium
Sunspot, Cloud 1, Thundercloud	Sec. 32, T.51 N., R.19 W.	Medium
Thorton Tunnel	Sec. 31, T.51 N., R.19 W.	Medium
Yellow Jacket 2	Sec. 3, T.50 N., R.18 W.	Medium
Yellow Jacket Incline 1	Sec. 3, T.50 N., R.18 W.	Medium
Zee Lease Rajah 49	Sec. 6, T.50 N., R.19 W.	Large

Montrose County, Colorado

30-30	Sec. 1, T.45 N., R.18 W.NMPM	Medium
13, AEC Mining Lease	NW¼, Sec. 31, T.48 N., R.17 W.	Medium
Abajo 1-5	Sec. 19, T.48 N., R.17 W.	Medium
Adak	Sec. 11, T.48 N., R.18 W.	Medium
All Stars - Evening Star	Sec. 28, T.48 N., R.17 W.	Medium
Altair Capella Vega	Sec. 13, T.46 N., R.18 W.	Medium
American Eagle Group	W½, Sec. 10, T.45 N., R.19 W.	Medium
Anna May 1	Sec. 17, T.46 N., R.17 W.	Medium
Anna May 1 Dumps	Sec. 18, T.46 N., R.17 W.	Medium
Arcturus	Sec. 18, T.46 N., R.17 W.	Medium
Arrowhead	Sec. 28, T.47 N., R.17 W.	Medium
Austin	Sec. 21, T.48 N., R.17 W.	Medium
Aztec	Sec. 20, T.46 N., R.17 W.	Medium
Babe Ruth	NW¼, Sec. 14, T.45 N., R.18 W.	Medium
Baby Fawn	Sec. 6, T.45 N., R.17 W.	Medium
Badger	Sec. 19, T.47 N., R.17 W.	Medium
Badger and Crown Prince	Sec. 23, T.48 N., R.18 W.	Medium
Bagger	Sec. 20, T.47 N., R.17 W.	Medium

Table 3.

Uranium Occurrences
Montrose County, Colorado (cont.)

Beaver	Sec. 32, T.48 N., R.17 W.	Medium
Bernard	Sec. 20, T.47 N., R.17 W.	Medium
Batter B #7	W½ Sec. 31, T.48 N., R.17 W.	Medium
Betty Jean	SE¼, Sec. 22, T.48 N., R.18 W.	Medium
Big Bull	Sec. 12, T.45 N., R.18 W.	Medium
Big Dick	Sec. 19, T.48 N., R.17 W.	Medium
Bill Bady - Lucky Boy	Sec. 18, T.46 N., R.17 W.	Medium
Bitter Creek	Sec. 12, T.46 N., R.17 W.	Large
Black Dinah	Sec. 28, T.47 N., R.17 W.	Medium
Black Tom	Sec. 20, T.46 N., R.17 W.	Medium
Blackburn	Sec. 21, T.46 N., R.17 W.	Medium
Blackfoot Rattlesnake	Sec. 11, T.47 N., R.17 W.	Medium
Blue Bell	Sec. 35, T.47 N., R.17 W.	Medium
Blue Cap	Unknown	Medium
Bob 6-7-8	Sec. 5., T.45 N., R.17 W.	Medium
Bobcat	Sec. 19, T.47 N., R.17 W.	Medium
Brooke 1, 2	Sec. 10, T.45 N., R.19 W.	Medium
Buckhorn - Ureka	Sec. 10, T.48 N., R.19 W.	Medium
Buckshot	Sec. 31, T.48 N., R.17 W.	Medium
Butterfly	Sec. 13, T.47 N., R.20 W.	Medium
C-AM-19, DOE Lease Tract	NE¼, Sec. 24, T.48 N., R.18 W.	Large
C-CM-24, DOE Lease Tract	NE¼, Sec. 32, T.48 N., R.17 W.	Medium
C-CM-25, DOE Lease Tract	NE½, Sec. 5, T.47 N., R.17 W.	Large
C-JD-5, DOE Lease Tract	Sec. 21, T.46 N., R.17 W.	Medium
C-LP-21, DOE Lease Tract	S1/2SW¼, Sec. 22, T.47 N., R.17 W.	Medium
C-LP-22, DOE Lease Tract	Sec. 21, T.47 N., R.17 W.	Medium
C-LP-22A, DOE Lease Tract	NW¼, Sec. 21, T.47 N., R.17 W.	Medium
C-LP-23, DOE Lease Tract	N½, Sec. 1, T.46 N., R.17 W.	Medium
Calvert 2	Sec. 10, T.45 N., R.18 W.	Medium
Canon 4, 5, 7	Sec. 21, T.48 N., R.18 W.	Medium
Canopus	Sec. 18, T.46 N., R.17 W.	Medium
Carpathia	Sec. 18, T.47 N., R.17 W.	Medium
Cliffdweller	Sec. 24, T.48 N., R.18 W.	Medium
Club 2	Sec. 29, T.48 N., R.17 W.	Medium
Club Group	Sec. 19, T.48 N., R.17 W.	Medium
Coloradium	Sec. 21, T.47 N., R.17 W.	Medium
Cripple Creek 2	Sec. 21, T.47 N., R.17 W.	Medium
Cripple Creek 2 Dump	Sec. 21, T.47 N., R.17 W.	Medium
Cripple Creek	Sec. 21, T.47 N., R.17 W.	Medium
Dads	Sec. 14, T.48 N., R.18 W.	Medium
Dan Patch	Sec. 35, T.47 N., R.17 W.	Medium
Deer	Sec. 28, T.46 N., R.17 W.	Large
Diana	Sec. 14, T.45 N., R.18 W.	Medium
Dolores Mine	Sec. 19, T.48 N., R.17 W.	Medium
Donald L	Sec. 21, T.47 N., R.17 W.	Medium
Donna K	Sec. 30, T.47 N., R.16 W.	Medium
Duchess 2, 3	Sec. 34, T.48 N., R.18 W.	Medium
Echo 6	Sec. 3, T.45 N., R.18 W.	Medium
Equinox	Sec. 11, T.48 N., R.18 W.	Medium
Eula Belle Craig	Sec. 31, T.49 N., R.17 W.	Large
Eva Group	Sec. 13, T.47 N., R.20 W.	Medium
Evening Star	Sec. 11, T.47 N., R.20 W.	Medium
Farmer Girl	Sec. 22, T.48 N., R.18 W.	Medium

Table 3.

Uranium Occurrences
Montrose County, Colorado (cont.)

Fawn Springs 4, 10	Sec. 6, T.45 N., R.17 W.	Medium
Fawn Springs 5	Sec. 6, T.45 N., R.17 W.	Medium
Fawn Springs 9	Sec. 6, T.45 N., R.17 W.	Medium
Fawn Springs 15	Sec. 6, T.45 N., R.17 W.	Medium
Fawn Springs 13	Sec. 6. T.45 N., R.17 W.	Medium
Fawn Springs 18	Sec. 6, T.45 N., R.17 W.	Medium
Fawn Springs 11	Sec. 31, T.46 N., R.17 W.	Medium
Fawn Springs 12	Sec. 31, T.46 N., R.17 W.	Medium
Fawn Springs 21	SE¼, Sec. 6, T.46 N., R.17 W.	Medium
Firebird	Sec. 20, T.47 N., R.17 W.	Medium
Firecracker	Sec. 35, T.47 N., R.17 W.	Medium
First National Bank	Sec. 20, T.47 N., R.17 W.	Medium
Florence Nellie, 75 50, 50 50, 25 50, 10 50	S½, Sec. 9, T.47 N., R.17 W.	Medium
Fox Cistern	Sec. 30, T.48 N., R.17 W.	Medium
Fraction	Sec. 19 T.48 N., R.17 W.	Medium
Gilbert	Sec. 32, T.46 N., R.17 W.	Medium
Grass Roots	Sec. 27, T.48 N., R.17 W.	Medium
Gray	Sec. 13, T.46 N., R.18 W.	Medium
Greagor Group	Sec. 4, T.45 N., R.18 W.	Medium
Great Western	SW¼, Sec. 20, T.46 N., R.17 W.	Medium
Green Back	Sec. 18, T.46 N., R.17 W.	Medium
Ground Hog	Sec. 20, T.47 N., R.17 W.	Medium
Guadalcanal	Sec. 27, T.47 N., R.17 W.	Large
Gyp Lease	Sec. 10, T.45 N., R.19 W.	Medium
Happy Jack	Sec. 4, T.45 N., R.19 W.	Medium
Happy St.	Sec. 20, T.47 N., R.17 W.	Medium
Happy Thought	Sec. 18, T.46 N., R.17 W.	Medium
Henry Clay Dumps	Sec. 29, T.47 N., R.17 W.	Medium
Henry Clay Mine	Sec. 29, T.47 N., R.17 W.	Medium
Hidden Basin	Sec. 20, T.47 N., R.17 W.	Medium
Honeymoon Dumps	Sec. 20, T.47 N., R.17 W.	Medium
Horsehair 1	Sec. 1, T.45 N., R.18 W.	Medium
Hummer	NW¼, Sec. 21, T.46 N., R.17 W.	Large
Irene	Sec. 29, T.48 N., R.17 W.	Medium
J. B. Group	Sec. 3, T.47 N., R.17 W.	Medium
J. J.	Sec. 26, T.46 N., R.17 W.	Medium
Joe	Sec. 20, T.48 N., R.17 W.	Medium
Joe Dandy	Sec. 21, T.46 N., R.17 W.	Medium
Joe Riverside	Sec. 29, T.48 N. R.17 W.	Medium
Just Right	Sec. 31, T.48 N., R.17 W.	Medium
Lark	Sec. 11, T.45 N., R.18 W.	Medium
Last Dollar	Sec. 20, T.46 N., R.17 W.	Medium
Little Basin	Sec. 27, T.48 N., R.17 W.	Medium
Little Buckhorn Group	Sec. 10, T.48 N., R.19 W.	Medium
Little Dick	Sec. 30, T.48 N., R.17 W.	Medium
Log Cabin	Sec. 35, T.46 N., R.18 W.	Medium
Lone Pine	Sec. 5, T.48 N., R.19 W.	Medium
Long Park 1	Sec. 27, T.47 N., R.17 W.	Medium
Long Park 2	Sec. 28, T.47 N., R.17 W.	Medium
Long Park 3	Sec. 28, T.47 N., R.17 W.	Medium
Long Park 4	Sec. 28, T.47 N., R.17 W.	Medium
Long Park 6	Sec. 27, T.47 N., R.17 W.	Large
Long Park 6 Dumps	Sec. 27, T.47 N., R.17 W.	Medium
Long Park 9	Sec. 27, T.47 N., R.17 W.	Medium

Table 3.

Uranium Occurrences
Montrose County, Colorado (cont.)

Long Park 10	Sec. 27, T.47 N., R.17 W.	Medium
Long Park 12	Sec. 27, T.47 N., R.17 W.	Medium
Long Park 13	Sec. 27, T.47 N., R.17 W.	Medium
Long Park 16	Sec. 27, T.47 N., R.17 W.	Medium
Lucky Blunder	Sec. 18, T.47 N., R.17 W.	Medium
Lucky Day	Sec. 29, T.48 N., R.17 W.	Medium
Lynx	Sec. 29, T.48 N., R.17 W.	Medium
Maggie C	Sec. 21, T.47 N., R.17 W.	Medium
Margie Group	Sec. 30, T.48 N., R.17 W.	Medium
Marjorie Ann	Sec. 11, T.47 N., R.20 W.	Medium
Martha Belle	Sec. 6, T.48 N., R.17 W.	Large
Mary Ann	Sec. 18, T.46 N., R.17 W.	Medium
Maybe 5 & 6	Sec. 26, T.46 N., R.17 W.	Medium
Media	Sec. 34, T.47 N., R.17 W.	Medium
Merry Widow	Sec. 10, T.47 N., R.17 W.	Medium
Mesa	Sec. 33, T.46 N., R.19 W.	Medium
Mesa 2	Sec. 34, T.46 N., R.19 W.	Medium
Mill 4	Sec. 4, T.47 N., R.17 W.	Medium
Mill No. 2	Sec. 32, T.47 N., R.17 W.	Large
Mineral Joe Group	Sec. 26, T.46 N., R.17 W.	Large
Mineral Park 2	Sec. 27, T.47 N., R.17 W.	Medium
Mineral Park 4,5,6	Sec. 35, T.47 N., R.17 W.	Medium
Modeen	Sec. 33, T.46 N., R.19 W.	Medium
Monogram 5	Sec. 22, T.48 N., R.18 W.	Medium
Monogram 12	Sec. 27, T.48 N., R.18 W.	Medium
Monogram Claim	Sec. 18, T.46 N., R.17 W.	Medium
Moonbeam	Sec. 20, T.47 N., R.17 W.	Medium
Morning Star-Moonlite	Sec. 12, T.47 N., R.20 W.	Medium
Mueker	Sec. 28, T.47 N., R.17 W.	Medium
Mustard	Sec. 30, T.48 N., R. 17. W.	Medium
Nil Trace	Sec. 16, T.46 N., R.17 W.	Large
North Star-Unaweep	Sec. 14, T.48 N., R.18 W.	Large
Nucla	Sec. 24, T.48 N., R.18 W.	Medium
Old Grandad	Sec. 6, T.45 N., R.17 W.	Medium
Old Salt Lick	Sec. 29, T.48 N., R.17 W.	Medium
Opera Box	Sec. 20, T.46 N, R.17 W.	Large
Ophir	SE¼, Sec. 24, T.48 N., R.18 W.	Medium
Ophir Bluebird	Sec. 24, T.48 N., R.18 W.	Large
Ophir Dump	Sec. 24, T.48 N., R.18 W.	Medium
Oregon	Sec. 11, T.48 N., R.18 W.	Medium
Oversight Mine	Sec. 21, T.46 N., R.17 W.	Large
Pain-Obnoxious	Sec. 32, T.46 N., R.17 W.	Medium
Paradox 4,5&6	Sec. 15, T.46 N., R.17 W.	Large
Paradox C	Sec. 22, T.46 N., R.17 W.	Medium
Paradox D	NE¼, Sec. 21, T.46 N., R.17 W.	Medium
Patty 5	Sec. 3, T.45 N., R.18 W.	Medium
Pay Day	Sec. 22, T.48 N. R.18 W.	Medium
Picket Corral	SW¼, Sec. 34, T.46 N., R.18 W.	Large
Pluto	Sec. 12, T.46 N., R.18 W.	Medium
Point-Empire	Sec. 23, T.48 N., R.18 W.	Medium
Prayer No. 8&9	Sec. 14, T.47 N., R.20 W.	Medium
Production West	Sec. 20, T.47 N., R.17 W.	Medium
R.A.L. 1 & 2	Sec. 23, T.48 N., R.18 W.	Medium

Table 3.

Uranium Occurrences
Montrose County, Colorado (cont.)

R.A.M.	Sec. 33, T.48 N., R.17 W.	Large
R.A.M. Dump	Sec. 33, T.48 N., R.17 W.	Medium
Radium Cycle	Sec. 8, T.48 N., R.19 W.	Medium
Radium Hill 7	Sec. 10, T.45 N., R.18 W.	Medium
Radium Hill 10	Sec. 10, T.45 N., R.18 W.	Medium
Radium Hill 31	Sec. 9, T.48 N., R.18 W.	Medium
Radium Queen 13	Sec. 16, T.48 N., R.18 W.	Medium
Rainy Day	Sec. 35, T.45 N., R.18 W.	Medium
Rajah	Sec. 6, T.48 N., R.18 W.	Medium
Rambler Dumps	Sec. 33, T.48 N., R.17 W.	Medium
Rattlesnake	Sec. 2, T.47 N., R.20 W.	Medium
Rattlesnake Turnover	Sec. 13, T.47 N., R.18 W.	Medium
Raven	Sec. 3, T.45 N., R.19 W.	Medium
Red Bird No. 1, 2	Sec. 9, T.48 N., R.19 W.	Medium
Red Bird No. 20	Sec. 5, T.48 N., R.19 W.	Medium
Red Sox, Yankees	Sec. 23, T.48 N., R.18 W.	Medium
Redbird, Yellowbird	Sec. 33, T.46 N., R.19 W.	Medium
Renegade Group	Sec. 12, T.48 N., R.18 W.	Medium
Republican	Sec. 20, T.47 N., R.17 W.	Large
Rex Mine	Sec. 10, T.47 N., R.17 W.	Large
Rigel Mine	Sec. 13, T.46 N., R.18 W.	Medium
Rimrock	Sec. 2, T.45 N., R.18 W.	Medium
Rimrock Blues 5	Sec. 2, T.45 N., R.18 W.	Medium
Rimrock Blues 9	Sec. 2, T.45 N., R.18 W.	Medium
Rimrock Blues 6, 14	Sec. 3, T.45 N., R.18 W.	Medium
Rimrock Group	Sec. 16, T.45 N., R.18 W.	Large
Rimrock No. 5	Sec. 15, T.45 N., R.18 W.	Medium
Rock Raven	SW¼, Sec. 35, T.48 N., R.17 W.	Medium
Sam	Sec. 36, T.46 N., R.18 W.	Medium
Saturn	N½ Sec. 13, T.46 N., R.18 W.	Medium
Saucer Basin Group	Sec. 6, T.47 N., R.17 W.	Medium
September Morn	Sec. 14, T.45 N., R.18 W.	Medium
Sesmo	NE¼, Sec. 24, T.47 N., R.18 W.	Medium
Shamrock	Sec. 29, T.48 N., R.17 W.	Medium
Sharkey	Sec. 20, T.47 N., R.17 W.	Medium
Sphinx	Sec. 20, T.47 N., R.17 W.	Medium
St. Patrick	Sec. 20, T.47 N., R.17 W.	Medium
St. Patrick 9	Sec. 10, T.47 N., R.20 W.	Medium
Star 3,4	Sec. 28, T.48 N., R.17 W.	Medium
Star No. 5	Sec. 21, T.48 N., R.17 W.	Medium
Star No. 13	N½ Sec. 28, T.48 N., R.17 W.	Medium
Starlight	Sec. 33, T.46 N., R.18 W.	Medium
Steer 1,8	Sec. 14, T.46 N., R.18 W.	Medium
Sunbeam Group	Sec. 10, T.47 N., R.17 W.	Medium
Sunflower	Sec. 16, T.47 N., R.17 W.	Medium
Sunrise Group	Sec. 34, T.46 N., R.18 W.	Medium
Teapot Dome 2,3	Sec. 6., T.45 N., R.17 W.	Medium
Terrible	N½, Sec. 10, T.45 N., R.19 W.	Medium
Three Jacks	Sec. 14, T.47 N., R.20 W.	Medium
Thunderbolt	Sec. 23, T.46 N., R.17 W.	Medium
TNT 3	Sec. 21, T.47 N., R.17 W.	Medium
Too High Mine 2	Sec. 36, T.47 N., R.20 W.	Medium
Town House	Sec. 20, T.48 N., R.17 W.	Medium
Tramp 2	Sec. 6, T.47 N., R.17 W.	Medium

Table 3.

Uranium Occurrences
Montrose County, Colorado (cont.)

Tramp Dumps	Sec. 6, T.47 N., R.17 W.	Medium
Triangulation	Sec. 34, T.47 N., R.17 W.	Medium
Tripod	Sec. 20, T.47 N., R.17 W.	Medium
Tripod Low Grade	NW¼, Sec. 20, T.47 N., R.17 W.	Medium
Twilight 1-2	Sec. 2, T.48 N., R.18 W.	Medium
U.S. Grant	Sec. 8, T.47 N., R.17 W.	Medium
URA	Sec. 29, T.46 N., R.17 W.	Large
Uranium Girl	Sec. 14, T.47 N., R.20 W.	Medium
Uranus	Sec. 18, T.46 N., R.17 W.	Medium
Uravan No. 2	SE¼, Sec. 4, T.47 N., R.17 W.	Medium
Vaden View	Sec. 13, T.46 N., R.18 W.	Medium
Vanadite	Sec. 29, T.47 N., R.17 W.	Medium
Vanadium King 1-8	Sec. 22, T.47 N., R.17 W.	Medium
Virgin Mine 3	Sec. 22, T.47 N., R.17 W.	Medium
Wedge	SE¼, Sec. 2, T.47 N., R.20 W.	Medium
Wednesday & Thursday	Sec. 22, T.47 N., R.17 W.	Medium
West Martha Belle	Sec. 31, T.49 N., R.17 W.	Medium
White Face	Sec. 34, T.47 N., R.17 W.	Medium
Whitney	Sec. 35, T.47 N., R.17 W.	Medium
Wild Horse	E½, Sec. 11, T.48 N., R.18 W.	Medium
Wright	Sec. 27, T.48 N., R.17 W.	Medium
Yellow Bird	Sec. 13, T.47 N., R.20 W.	Medium
Yellow Jacket	Sec. 33, T.48 N., R.17 W.	Medium
Wedge 1	Sec. 10, T.47 N. R.17 W.	Medium

San Miguel County, Colorado

April	Sec. 27, T.44 N., R.19 W.	Medium
Ava Jay	Sec. 25, T.44 N., R.20 W.	Medium
Bachelor	S½, Sec. 15, T.45 N, R.18 W.	Medium
Bald Eagle	Sec. 30, T.44 N., R.16 W.	Medium
Bean 4, 5	Sec. 5, T.43 N., R.19 W.	Medium
Bean 10	Sec. 32, T.44 N., R.19 W.	Medium
Bean Patch	Sec. 5, T.43 N., R.19 W.	Medium
Bear Creek	Sec. 4, T.42 N., R.10 W.	Medium
Black Jack	Sec. 28, T.43 N., R.19 W.	Medium
Black Spider	NW¼, Sec. 30, T.43 N., R.19 W.	Medium
Burro Point	Sec. 16, T.45 N., R.18 W.	Medium
Burro Tunnel	Sec. 30, T.44 N., R.18 W.	Large
Butterfly	Sec. 32, T.42 N., R.9 W.	Unknown
C-SR-10, DOE Lease Tract	W½, Sec. 28, T.43 N., R.19 W.	Large
C-SR-11, DOE Lease Tract	E1/2SW1/4S1/2BW¼, Sec. 18 T.43 N., R.19 W.	Large
C-SR-12, DOE Lease Tract	Sec. 32, T.43 N., R.18 W.,NMPM	Medium
C-SR-13, DOE Lease Tract	W½, and lots 1-4, Sec. 32, T.44 N., R.18 W.	Medium
C-SR-13A, DOE Lease Tract	NW¼, Sec. 30, T.44 N., R.18 W.	Medium
C-SR-14, DOE Lease Tract	Sec. 5 E½, Sec. 6, T.43 N., R.18 W.	Medium
C-SR-15, DOE Lease Tract	S½, Sec. 23, T.44 N., R.19 W.	Medium
C-SR-16, DOE Lease Tract	Sec. 10, T.43 N., R.19 W.	Medium
C-SR-16, DOE Lease Tract	Sec. 10, T.43 N., R.19 W.	Medium
C-SR-16A, DOE Lease Tract	N1/2E1/2SE1/4, Sec. 14, T.43 N., R.19 W.	Medium
Carnation	SW¼, Sec. 13, T.44 N., R.16 W.	Large

Table 3.

Uranium Occurrences
San Miguel County, Colorado (cont.)

Chief 1&3	NW¼, Sec. 21, T.43 N., R.19 W.	Medium
Cone 1-6	Sec. 30, T.44 N., R.19 W.	Medium
Dalpaz	Unknown	Medium
Deluxe & Master Deluxe	Sec. 22, T.44 N., R.19 W.	Medium
Deremo	NE1/4N½, Sec. 2, T.42 N., R.20 W.	Large
Falcon	SW¼, Sec. 21, T.43 N., R.19 W.	Medium
Fall Creek Group	Sec. 18, T.43 N., R.10 W.	Medium
Firefly	Sec. 21, T.43 N., R.19 W.	Medium
France	Sec. 20, T.43 N., R.19 W.	Medium
Frenchy 2	Sec. 29, T.43 N., R.19 W.	Medium
Full Moon Group	Sec. 5, T.43 N., R.18 W.	Medium
GMG	Sec. 13, T.44 N., R.18 W.	Medium
Golden Rod 2	Sec. 14, T.43 N., R.19 W.	Medium
Golden Rod 4	Sec. 14, T.43 N., R.19 W.	Medium
Gopher	Sec. 21, T.45 N., R.18 W.	Medium
Grass Flats	Sec. 32, T.44 N., R.18 W.	Medium
Ground Hog	Sec. 21, T.45 N., R.18 W.	Medium
Ground Hog Dump	Sec. 21, T.45 N., R.18 W.	Medium
Gypsum Homestead	Sec 33, T.45 N., R.18 W.	Medium
Hangover	NW¼, Sec. 21, T.43 N., R.19 W.	Medium
Hawk-Frankie	Sec. 16, T.43 N., R.19 W.	Medium
Horseshoe 5	Sec. 6, T.42 N., R.17 W.	Medium
Horseshoe Bend 1	Unknown	Medium
Hot Shot	Sec. 16, T.45 N., R.18 W.	Medium
Hoyman Lease	Sec. 27, T.44 N., R.18 W.	Medium
Jack Knife	Sec. 21, T.45 N., R.18 W.	Medium
Jack Knife No. 3	Sec. 21, T.45 N., R.18 W.	Medium
Jackie Walls 3	Sec. 36, T.44 N., R.20 W.	Medium
LaSalle	Sec. 30, T.44 N., R.19 W.	Medium
Lonesome 34	Sec. 36, T.45 N., R.18 W.	Medium
Long Ridge & Long Ridge 2	Sec. 23, T.44 N., R.17 W.	Medium
Lookout	NW¼, Sec. 36, T.45 N., R.18 W.	Large
Magpie 2	Sec. 25, T.45 N., R.18 W.	Medium
Magpie	Sec. 10, T.44 N., R.18 W.	Medium
Mainstreet	Sec. 16, T.45 N., R.18 W.	Medium
Marne Group	Sec. 32, T.43 N., R.18 W.	Medium
Mary Jane	Sec. 22, T.45 N., R.18 W.	Medium
Midnight	NE¼, Sec. 27, T.44 N., R.19 W.	Medium
Moqui Jug	W½, Sec. 29, T.43 N., R.18 W.	Medium
Norma Jean No. 1 & 2	Sec. 29, T.43 N., R.18 W.	Medium
North Slope 2	Sec. 5, T.43 N., R.19 W.	Medium
Northern 5 & 6	Sec. 22, T.44 N., R.19 W.	Medium
Parrot Group	SW¼, Sec. 26, T.43 N., R.18 W.	Medium
Peanut Group	Sec. 31, T.45 N., R.17 W.	Large
Penigal	Sec. 24, T.43 N., R.19 W.	Medium
Pitchfork	Sec. 32, T.44 N., R.16 W.	Medium
Pond	Sec. 23, T.44 N., R.17 W.	Medium
Prospectors Fortune Grp.	Sec. 25, T.45 N., R.19 W.	Medium
Radium	Sec. 5, T.43 N., R.19 W.	Medium
Radium 4	Sec. 4, T.43 N., R.19 W.	Medium
Radium 5 & 6	Sec. 8, T.43 N., R.19 W.	Medium
Radium 7	Sec. 8, T.43 N., R.19 W.	Medium
Radium 8	Sec. 9, T.43 N., R.19 W.	Medium
Radium 12	Sec. 4, T.43 N., R.19 W.	Medium
Radium 9, 10 & 11	Sec. 4, T.43 N., R.19 W.	Large

Table 3.

Uranium Occurrences
San Miguel County, Colorado (cont.)

Radium 24	Sec. 5, T.43 N., R.19 W.	Medium
Radium No. 29	NE¼, Sec. 8, T.43 N., R.19 W.	Medium
Rainy Day	Sec. 25, T.45 N., R.18 W.	Medium
Rainy Day	Sec. 35, T.45 N., R.18 W.	Medium
Rambler	SW¼, Sec. 9, T.44 N., R.17 W.	Medium
Red Horse	SE¼, Sec. 26, T.45 N., R.18 W.	Medium
Red Rock 4	Sec. 35, T.43 N., R.18 W.	Medium
Red Rock 5	Sec. 35, T.43 N., R.18 W.	Medium
Roy Lee	Sec. 34, T.43 N., R.18 W.	Medium
S. B. Group	Sec. 11, T.42 N., R.18 W.	Medium
Sage 11	Sec. 32, T.43 N., R.19 W.	Medium
San Miguel	Sec. 8, T.43 N., R.19 W.	Medium
Snyder	SE¼, Sec. 2, T.42 N., R.20 W.	Large
Spud Patch	Sec. 29, T.43 N., R.18 W.	Medium
Strawberry Roan	Sec. 32, T.43 N., R.19 W.	Medium
Summit Incline	Sec. 28, T.43 N., R.19 W.	Medium
Suncup	SW¼, Sec. 31, T.43 N., R.17 W.	Medium
Sunday Group	S½, Sec. 13, T.44 N., R.18 W.	Medium
Sunrise	Sec. 5, T.43 N., R.19 W.	Medium
Sunrise 1	Sec. 8, T.43 N., R.19 W.	Medium
Sunrise and Patented Land	Sec. 5, T.43 N., R.19 W.	Medium
Tailholt	SW¼, Sec. 27, T.44 N., R.19 W.	Medium
Tiny	Sec. 30, T.44 N., R.16 W.	Medium
Two Bar	Sec. 24, T.44 N., R.17 W.	Medium
Uintah	Sec. 28, T.45 N., R.19 W.	Medium
Uncle Sam 1	S½, Sec. 10, T.44 N., R.18 W.	Medium
Vanadium Queen	Sec. 12, T.44 N., R.20 W.	Medium
Wally	Sec. 14, T 43 N., R.18 W.	Medium
Wedding Bell Group	NE¼, Sec. 21, T.45 N., R.18 W.	Medium
Windswept	Sec. 15, T.44 N., R.17 W.	Medium
Yellowbird	Sec. 4, T.43 N., R.19 W.	Medium

Coal Occurrences
Montrose County, Colorado

Peabody Nucla	Sec. 24, T.47 N., R.16 W.	Large

Copper Occurrences
Montrose County, Colorado

Cashin Mine	Sec. 13, T.47 N., R.19 W.	Large
Cliffdweller Mine	Sec. 13, T.47 N., R.19 W.	Large
Sunrise Mine	Sec. 23, T.48 N., R.19 W.	Medium

Mesa County, Colorado

Copper Rivet Mine	Sec. 3, T.49 N., R.19 W.	Medium

that cut this formation, and most ore occurs in arkosic lenses in the upper part of the unit. The Cutler has been productive in the Big Indian Wash area, where it lies directly beneath the Triassic Chinle Formation. In places, mineralization has spread downward as much as several hundred feet into the underlying Cutler. Weak mineralization is present in some places where the Cutler is cut by faults adjacent to the salt anticlines of the Paradox fold and fault belt.

The Triassic Moenkopi Formation is exposed around the periphery of the Monument upwarp, and in many parts of the Paradox fold and fault belt. It locally is absent near the salt anticlines and consists mostly of evenly bedded brown to red brown mudstone and siltstone, interbedded with ripple marked brown or gray sandstone. Mineralization in the Moenkopi is always found near the top of the formation in those sandstone or conglomerate lenses in contact with the basal sandstones of the overlying Chinle Formation. One mine in the Elk Ridge area is in a sandstone lens 40 feet below this contact; other isolated occurrences of mineralization have been found along faults near the pierced salt anticlines. Production from the Moenkopi has been minor and mainly associated with Chinle ore bodies.

The Triassic Chinle Formation is one of the more important uranium units in the Paradox Basin and its outcrop, favorable areas and uranium deposits are shown on plate 5. The unit has been divided into six members, the lower three of which contain notable uranium deposits. Nearly all the deposits, except those at Big Indian Wash, are in the bottom of sandstone lenses, occurring in whatever member is in contact with the underlying Moenkopi Formation. The richest ore is found at the bottom of the channels in the deepest scours. As a consequence, the Shinarump Member is ore-bearing in the extreme western part of the area, and the Moss Back Member is ore-bearing in the northern part. The Monitor Butte deposits are in the Elk Ridge area. The Shinarump Member is the lowest and is a gray to yellow, medium to coarse-grained to conglomeratic, crossbedded and lenticular sandstone, interbedded with greenish gray mudstone and siltstone. Silicified and carbonaceous wood and channel slump debris are particularly striking features. Individual beds and lenses vary greatly in thickness, and the entire member, discontinuous over much of the area, ranges up to 210 feet in thickness. Characteristically, the Shinarump fills channels cut into the underlying Moenkopi Formation. The Shinarump deposits are more important south of the Paradox Basin area, but the formation is present in the Elk Ridge area. The unit pinches out completely north and east of Elk Ridge. The Monitor Butte Member generally overlies the Shinarump Member south of the area. Where the Shinarump is absent the Monitor Butte fills channels and, in places, blankets the Moenkopi Formation. The Monitor Butte also pinches out to the north and east and the pinchout zone is located a short distance north of the Shinarump pinchout. The Monitor Butte, which may be as thick as 200 feet, is a gray to greenish gray claystone and clayey sandstone containing sporadic sandstone lenses. Uranium deposits in the study area are limited to the Elk Ridge area. The Moss Back Member overlies the Monitor Butte Member and occurs as a northwest-trending lens that measures 50 miles across from the Clay Hills, south of Red Canyon, to the north side of the Interriver area. Towards its northern edge, the Moss Back becomes discontinuous, and north of the Monitor Butte pinchout, rests directly on the Moenkopi or other underlying units. The Moss Back is a pale orange, light brown to gray, cross-stratified, fine- to medium-grained sandstone containing a few lenses and thin beds of siltstone, mudstone, and conglomerate. The sandstones often contain abundant carbonaceous or siliceous fossil wood and channel debris. It weathers to a relatively resistant ledge, and forms the caprock of many buttes and mesas. It attains a maximum thickness of 200 feet. The Moss Back is the productive member in the Big Indian Wash, Indian Creek, lower Cane Canyon, Interriver, and Sevenmile areas. The remainder of the Chinle Formation is mineralized in a few places, but is essentially unproductive.

Mineralization in the Jurassic Entrada Sandstone is more important for copper than for uranium. The orange red to tan, fine- to medium-grained sandstone contains most of its uranium along faults in the Paradox and Gypsum Valley areas. The copper is often associated with silver and these deposits are discussed in the section on copper. Uranium production from the Entrada Formation has been very small and it can be expected to have only a fair potential.

The Jurassic Morrison Formation, along with the Chinle Formation, is important for uranium mineralization in the Paradox Basin (see plate 6, Uranium Occurrences and Areas of Potential Mineralization in the Morrison Formation). The uranium is often overshadowed by the vanadium content. Over most of the project area, the Morrison Formation is composed of the lower Salt Wash Sandstone Member and the Brushy Basin Shale Member. The Salt Wash is a grayish orange, light brown to white lenticular sandstone, locally conglomeratic, interbedded with greenish gray and grayish red shale and siltstone. Sandstone lenses, thicker than 40 feet, are more apt to contain uranium deposits of commercial size than smaller lenses. Lenses 120 feet thick are known in the area. Total thickness of the Salt Wash may range from 250 to 550 feet. Although several horizons of the Salt Wash contain commercial ore, the most productive ore bodies occur near the top of the member in the Colorado portion and in the immediately adjoining Utah portions. In other areas, the productive lens appears near the base or the middle of the member. Plate 6, Uranium Occurrences and Areas of Potential Mineralizations in the Morrison Formation, shows the Salt Wash outcrops, locations or uranium deposits and potentially favorable areas. The Salt Wash is the productive ore horizon of the Gateway, Paradox, Slick Rock, Uravan, Gypsum Valley, and Moab districts, and of the Montezuma Canyon, Cottonwood, Abajo, Dry Valley and Sage Plains areas of the Monticello district.

Shale beds of the Brushy Basin Shale Member are mostly bentonitic. They are variegated, but red and purplish colors dominate. Thin limestone, conglomerate, or sandstone lenses are interbedded. The unit weathers to rounded slopes and the thickness ranges from 220 to over 700 feet. In many places, sandstone and conglomerate lenses near the base of the Brushy Basin are mineralized, and some lenses at other levels contain ore. The Brushy Basin Member of the Morrison Formation is mineralized in the Paradox and Slick Rock districts, and Montezuma Canyon and Dry Valley areas. The potential for finding new deposits in the Brushy Basin Member is much less than for finding them in the Salt Wash Member.

POTASH POTENTIAL

Economic potash deposits (table 3) are found in the evaporite beds of the Paradox Formation of Pennsylvanian age in the Paradox Basin of southeastern Utah and southwestern Colorado. The potash beds occur in several different horizons and were discovered in 1924 (Dyer, 1945, p. 56). The extent and grade of these deposits were not known until drill-hole logging techniques were improved and many exploratory holes were drilled. The boundary of potash deposition extends from Green River, Utah to Cortez, Colorado and from Monticello, Utah to the Uncompahgre Uplift (see Plate 7, Potash Occurrences and Areas of Potential Potash Mineralization). Much land leasing has occurred over the years, but only one potash deposit has been developed and is presently mined. This is the Texas Gulf Inc. Cane Creek mine located southwest of Moab, Utah, which was opened in 1964. This mine started out as a conventional underground operation but was converted to solution mining at a later date. Additional potash exploration has been done by other companies, but as of now, no new operations are planned for the immediate future.

There are 29 evaporite cycles that occur in the Paradox Basin. Of these, 18 cycles contain potash, but only 11 cycles are potentially valuable (Hite, 1961). Several of the salt beds are exceptionally large. One is known to be 110 miles long, about 30 miles wide, with a thickness in one locale of more than 400 feet. A well which penetrated the salt center of the Salt Valley anticline cored about 300 feet of potash salt. However, most potash-bearing zones are not thick, and many of the thicker sections probably are due to flowage and concentration of salt into the crests of folds. Original thickness of potash salt beds is not known, but thickness of undeformed potash salt beds probably range from a feather edge to 100 feet, averaging about 20 feet. The Paradox salt basin has been folded and faulted in its central position by the formation of several belts of salt anticlines, some of which are the piercement or diapiric type and others of which are the simple or non-piercement type. The piercement anticlines are shown on most of the plates (plates 2 to 6), but were omitted from plate 7 to avoid cluttering.

The depth of the potash zones ranges from a few hundred feet in the piercement salt structures to several thousand feet in the deeper parts of the basin. The principal potash minerals are sylvite (KCl) and carnallite ($K \cdot MgCl_3 \cdot 6H_2O$). The presence of carnallite makes the area a potential source of magnesium as well. The market for potash is presently dominated by Canadian production, but with the expected increase in demand for potash there will be a need to develop the potash resources in the Paradox Basin. Improved technology in solution mining will also help in development of these resources. Plate 7 shows the areas which have been or are presently leased for potash. These leases are located in favorable potash areas that are not too deformed and are at a reasonable depth. The presence or absence of bedded potash, in test wells for oil and gas, usually is known from published sample and core descriptions, or from logs of wells available through commercial electric log libraries. The results of core holes and test wells drilled for potash are not as well publicized; in fact, much of the information is held completely confidential. As a consequence, although the broad outlines of the potash basin are known, detailed figures on thickness of beds, K_2O content and reserves of commercial ore generally are not available. *U. S. Bureau of Mines* Bulletin 630 (1965), estimates potash reserves in the Paradox Basin to be 254 million tons in the known category and 161 million tons in the inferred category.

COPPER POTENTIAL

The occurrences and locations of copper mineralization are shown on table 3.

Salt Valley Anticline

There are several small abandoned copper and copper-silver mines in the area of the Salt Valley anticline. These deposits were worked intermittently from the early 1900s through the 1930s. The pay horizon is in the Morrison Formation in both the Salt Wash and Brushy Basin Members. An important mine, the Hoosier, is located on a fault fissure on the southwest flank of the Salt Valley anticline in section 5, T. 23 S., R. 21 E., Grand County, Utah. It is reported to have produced 100,000 ounces of silver in 8 percent copper ore, which was shipped to the smelters by truck. The silver values were high enough to pay for mining and shipping. The mine has reportedly produced $200,000 in copper (Gail Tibbets, oral communication, 1979 and Fischer, 1936).

In the early 1970s a copper leach operation was begun based on the disseminated copper ore of the Morrison Formation found on the southwest flank of the Salt Valley anticline. About 21,000 tons of ore were mined before the operation was shut down because of inefficiencies. Eight to 10 million tons of low-grade copper ore were reportedly blocked out for this operation (Gail Tibbets, oral communication, 1979).

Dane (1935) reports another copper area west of the Sevenmile fault in which the Moab Tongue of the Entrada Formation is mineralized. There are several abandoned copper mines and an old copper mill in Mill Canyon along the Sevenmile fault zone. Large tonnages of low grade copper have been drilled out in this area which make up a valuable potential resource for the future.

Lisbon Valley Area

The Big Indian copper mine is located in the N½ section 34, T. 29 S., R. 24 E., in San Juan County, Utah, in the Big Indian mining district. The mine is located on the Lisbon Valley fault and has been mined sporadically since 1913. The first copper mill was constructed in 1917 (Butler, 1920, p. 612). The mine was again activated during World War II and again in the late 1960s and early 1970s. Azurite and malachite ores were mined from the Dakota-Burro Canyon formations which form the hanging wall along the Lisbon Valley fault. A heap leach operation was used to recover copper in a new mill constructed in the late 1960s. This operation closed in the early 1970s and has not reopened since.

Copper has been mined from several open pits in sections 17, 26, and 36, T. 30 S., R. 25 E. in the southern part of the Lisbon Valley area. The Centennial Pit is the largest and is located in NW¼ of section 26, T. 30 S., R. 25 E. and contains oxide ores at the surface and sulfide ores at depth. The main sulfide ore contains chalcocite (Cu_2S), which occurs erratically in coal beds of the Dakota Formation. The ore produced and ore reserves left are thought to be in the 10 to 20 million ton range. There is no work being done in the area at the present time. Both copper and uranium mineralization are found along the Lisbon Valley fault, but apparently the copper was emplaced in a different time and perhaps along a different path (Schmitt, 1968).

Other Areas

The Cashin and Cliff Dweller copper-silver mines are located in section 13, T. 47 N., R. 19 W., Montrose County, Colorado, along a mineralized fault zone in the Entrada Sandstone (LaPlata Sandstone of Emmons, 1905). These deposits are in fissure veins associated with high angle faults of small vertical displacement. The ore minerals are native copper, chalcocite, and a little covellite. Production from 1899 through 1905 was 280,000 ounces of silver and 500,000 pounds of copper, not including native copper (Emmons, 1905). The Sunrise and the Copper Rivet mines are located in this vicinity but have had very little economic impact.

Two mine areas in the Abajo Mountains have produced a small quantity of copper ore. Both have been inactive for a long time. The Copper Queen mine is located in SE¼ section 35, T. 33 S., R. 22 E. (unsurveyed) and consists of small drifts in the Dakota and Burro Canyon Formations. The mineralizations are coatings on bedding and crossbedding planes and occur as fillings in minute fracture planes. The principal minerals are azurite and malachite, but pyrite, bornite, chalcopyrite, chalcocite, covellite and chrysocolla are also present.

The Tuffy copper mine, SW¼ section 5, T. 33 S., R. 22 E. (unsurveyed), is located on the east side of Shay Mountain on the north side of the Abajo Mountains. The mineralization is in the Entrada Sandstone as disseminations along crossbedding planes. Azurite and malachite are the dominant minerals.

Several lode deposits containing copper, but developed mainly for gold, are found in the stocks and along the margins of laccoliths in the Abajo Mountains. Mines and prospects include the Gold Queen, Dream, Duckett, Blue Bird, and Alma. Mineralization consists of pyrite along fracture zones. Small amounts of chalcopyrite, sphalerite, and galena are present. These can only be identified with the microscope. All mines have been idle since 1943, and previous production (about $6,000 worth of ore) was insignificant.

Lode deposits are also found in the LaSal Mountains, particularly at North Mountain (Miners Basin). Mines and prospects include the High Ore, Tornado, Dewey Group, Zero Group, Skylark, and Reno. These occurrences are characterized by zones of stockworks containing glassy quartz with a little copper, silver, and gold. Some gold is found in associated pyrite. Minerals present include limonite, malachite, chrysocolla, and minor amounts of bornite, chalcocite, and azurite. Most mines have been worked for gold, but one or two emphasized silver and copper. The total value of extracted metals from the LaSal Mountain lode mines is a bit under $9,000.

The copper mines of the Paradox Basin are shown by circles on Plate 8 and the lode mines by triangles.

GOLD POTENTIAL

Quartz vein and placer gold prospects (table 3) were recognized in the vicinity of the LaSal Mountains during the late 1800s and early 1900s, but these achieved very little economic success. The quartz vein prospects were located in Miners and Bachelors Basins in the northern LaSal Mountains and were previously discussed in the section on copper. Placer gold operations were located on Wilson Mesa, west of the LaSal Mountains; on Johnson Creek, south of the Abajo Mountains, and on sand bars on the Colorado River. The total production of gold from both the quartz vein prospects and the placer operations in the LaSal Mountains would probably not exceed $5,000 (Hill, 1911, p. 110).

Gold placer operations have been located in many areas along the Colorado River. Dane (1935, p. 179) reported a small gold placer operation below the Dewey Bridge during 1927 and 1928, with unknown results. Other placer gold operations have been worked sporadically up and down the Colorado River from Moab. There have been recent operations on the Dolores River just above its confluence with the Colorado River. The resultant production figures are unavailable, but the total values recovered are believed to be very small. Fine flour gold occurs in the Colorado River sandbars and is very difficult to recover. Therefore the potential for future gold production will be limited to small sized operations along the Colorado and Dolores Rivers.

MANGANESE POTENTIAL

There are many small deposits of manganese scattered over the southeast Utah area. Most are of small size, but there are two areas in which production has been achieved in the Paradox Basin study area. These are the Needles district and the Point Duma area. The total ore tonnage mined is 12,000 to 16,000 tons of 4 to 40 percent manganese (Baker et. al., 1952, p. 63). The mines were worked sporadically from 1901 until 1918 and again 1939 to 1940. The dominant manganese mineral is pyrolusite along with a little psilomelane and manganite. The mineralization is found in the stratified deposits of the Summerville Formation and in the Salt Wash Member of the Morrison Formation. The ore occurs as nodules in a limestone bed and also as veins and veinlets and as cementing material in sandstones in the Summerville. A few replacement bodies have also been reported (Hill, 1911, p. 117). The richer and shallower deposits have been mined leaving only deeper and lower grade deposits. There are estimates of several hundred thousand tons of manganese ore remaining with a grade of 10 percent or less (Baker, 1952, p. 64). Any future mining activity could only be instigated by a national emergency or extreme shortage of manganese. The inactive manganese mines are all shallow open pits; the areas of surface disturbance are small and should have no impact on subsurface activities.

COAL POTENTIAL

Potential coal areas are also shown on plate 8, principally as a stippled field. The coal-bearing Dakota Formation extends northward from the San Juan Basin of New Mexico through the project area to the Colorado River near Grand Junction. The potential area also extends from the Abajo and LaSal Mountains in Utah eastward to the Uncompahgre Uplift in Colorado. In the Paradox Basin the coals outcrop in many places and are mostly flat lying. Generally, these coals are thin, discontinuous, and of poor quality due to high ash and sulfur content. The coals generally rank as high volatile B and C bituminous.

Several small coal operations have operated sporadically, especially to the southeast, but the only presently operating mine is the one at Nucla. In the Nucla-Naturita area of western Montrose County, Colorado, the Peabody Nucla multiple bench strip mine supplies coal to the Nucla Power Plant which is located south of Uravan, Colorado. There are three strippable seams of coal at this location, three to five feet thick, in the Dakota Formation (Hornbaker, 1973, p. 5). The only known coal resource leasing area (U. S. Geological Survey) is in the Nucla-Naturita area where the present strip mine is located (Jones et. al., 1978). There are some additional areas where coal beds are at strippable depths but lack of continuity and thinness makes most of these areas rate poor to fair for potential coal resources. Where the overburden is greater than 150 feet, the coal potential is almost nil throughout the area (Jones et. al., 1978). Generally speaking, the coals in southeastern Utah are very thin and discontinuous and conditions favoring mining deteriorate from east to west. There is very little potential for important coal production in the area covered by this report.

MISCELLANEOUS MINERALS

Iron, clay, construction materials, dimension stone, gypsum, limestone and semiprecious stones are all noted as being present in the Paradox Basin (table 3). Some of these deposits may never achieve any sort of production because of such economic implications as the small size of a deposit, its low value per ton and/or market distances.

Iron has been reported in the area of the gold-copper lodes of Miners and Batchelors basins in the LaSal Mountains and north of Sixshooter Peak in the Gibson Dome area. Small iron deposits are distributed around the margins of the igneous rocks of the LaSal Mountains and have been prospected, but not exploited. Mineralization, mainly as hematite and specular hematite, occurs as disseminated masses coating joint surfaces in the igneous rock, as veins containing quartz and filling igneous rock fractures, as veinlets transecting sandstone, as layers of disseminated minerals, as veinlets paralleling sandstone beds, as minute botryoidal bodies and finely granular masses in the openings of sandstone breccia, as disseminations in lenses, and as ovoid masses in metamorphosed shale (Carter and Gualtieri, 1965, p. 76). The iron ore potential in the LaSal Mountains is small and of poor quality. The deposit near Sixshooter Peak does not contain adequate reserves to be considered for mining. Hematite cements, coats, and replaces a sandstone lens in the Cutler Formation over a 100 by 60 foot area.

Clays in the Paradox Basin have not been adequately tested. There are no current projects dealing with clays. Clays of high purity and high Al_2O_3 content and structural clays may be present in the Dakota and Mancos Formations; bentonitic clays occur in the upper Chinle, the Monitor Butte Member of the Chinle Formation, and in the Brushy Basin Shale Member of the Morrison Formation.

Semiprecious stones, such as agate, amethyst, azurite, petrified wood, and silicified dinosaur bone have been collected in the Paradox Basin. The most widely distributed of these rock materials, agate, jasper, and other varieties of chalcedony, are found in many formations. Chalcedony occurs as concretionary bodies in the Mancos Shale, the shaly members of the Morrision Formation, the Carmel Formation, the Chinle Formation, and as chert nodules in the Hermosa Formation. Copper deposits, along the Lisbon Valley fault near LaSal, Utah, are associated with the Dakota Sandstone. Coatings of deep-blue azurite often are found in fractures of the rock. Some coatings are as much as an inch thick, and could be worked into ornamental stones. Amethyst, a variety of lavender crystalline quartz, has been reported in the LaSal Mountains. Petrified wood and silicified dinosaur bones are collected for jewelry, bookends, and other appointments. Most of the petrified wood is found in the basal sandstone members of the Chinle Formation, some is found in the upper member, and some in the Salt Wash Member of the Morrison Formation. Many other formations contain occasional specimens of petrified wood. Most of the silicified dinosaur bone has come from the Brushy Basin Member of the Morrison Formation.

The Paradox Member of Pennsylvanian age contains thick gypsum beds. Exposures are scattered along the Colorado River and in the centers of collapsed salt anticlines. The gypsum is 70 feet thick in places, and tremendous tonnages are available. In areas near the salt structures, where much faulting has taken place, gypsum is intimately mixed with shale and limestone. Although present in commercial quantities and qualities, gypsum is not mined. Market conditions and active competition discourage production.

Sandstone suitable for quarrying is known to exist over large areas of the Paradox Basin. Good-quality dimension stone could be recovered from the Morrison, Kayenta, upper Chinle, Shinarump, and Moenkopi Formations. Two quarries are operative in the area. One is located in Grand County near Moab, the other in San Juan County near Blanding. Because these quarries extract stone for local use only, their production is small.

The area also includes deposits of materials suitable for aggregate, riprap, crushed stone, and lightweight aggregate. Unconsolidated Quaternary deposits are scattered over much of the area, and many provide suitable natural aggregate for road metal and other construction needs.

Alluvium is prevalent along major stream courses and near the lower ends of major tributary streams. Deposits of this material, which is excellent for road metal, range up to 100 feet or more in thickness and hold in excess of 500,000 cubic yards of material. Dune sands are found in many areas, especially where large tracts of sandstone deposits are being weathered. Colluvium and pediment deposits, located on most mesas and areas surrounding the laccolithic mountains, could contain excellent sand and gravel deposits. Glacial deposits, mainly in the LaSal Mountains, could be used for this purpose also. Rockslide and boulder-field deposits are plentiful around the LaSal and Abajo Mountains and would make excellent riprap material. Lightweight aggregate deposits have not been developed in the Paradox Basin Bloating clay deposits exist in the Chinle bentonitic members, and prospecting and testing might pinpoint good deposits. The Dakota Sandstone contains a poor quality coal that might be pulverized, pressed, and sintered to yield satisfactory lightweight material.

SPECIAL AREA REPORTS

Four special areas were considered that might be favorable for establishing a nuclear waste disposal area in salt beds: Salt Valley, Lisbon Valley, Gibson Dome, and Elk Ridge. Enlarged maps (plates 9- 12) of these areas were developed showing the location of the principal deposits, with structure contours to show the principal structural elements. The locations of these features are of prime importance in planning for waste disposal site (s).

Salt Valley Area

The Salt Valley anticlinal area is located about 25 miles northwest of Moab, Utah. The northern end of the anticline is crossed by Interstate Highway I-70 and the Denver and Rio Grande Western Railroad. U. S. Highway 163 parallels the southwest flank of the structure. A railroad spur extends southward from Crescent Junction towards Moab and there is a railroad siding at Sevenmile Canyon for loading and unloading freight. There is a dirt road that runs down the central part of the Salt Valley structure. This area has been explored for oil and gas as well as for potash. There have been some copper and associated silver mines on the structure, and active uranium mines are present in the area. Active uranium exploration continues along the flanks of the anticline.

The Salt Valley anticline is a large northwest-trending salt structure about 25 miles long whose axis is faulted and breached, forming a long narrow valley that extends southward into Arches National Park. The Salt Valley anticline is the northernmost extension of the Salt Valley-Cache Valley-Sinbad Valley system and is a faulted structure with residual beds of the Paradox Formation exposed at the surface (Hite and Lohman, 1973, p. 61). Plates 9 and 10 show the structure and a cross section across the area. The northern part of the Salt Valley anticline has been extensively explored by drilling which has been carried out over the past half-century; even so an accurate picture of the complex geology is still not completely known. There are faults on both sides paralleling the axis of the anticline; these faults have allowed the collapse and partial breaching of the anticline to expose part of the Paradox beds. The anticline plunges to the northwest at about 500 feet per mile and has a structural relief of some 7,000 feet on top of the salt.

The thickness of the salt core is estimated to be more than 11,000 feet (Hite and Lohman, 1973, p. 62). The Courthouse syncline lies to the southwest and parallels the anticline. There are many faults in the synclinal area that trend in a westerly-northwesterly direction.

There are abundant oil and gas shows in this and in nearby areas, which indicate that the Salt Valley locale has a good potential for future oil and gas development. Favorable structural elements as well as the potential for good stratigraphic traps make the region a good target. Good oil potential exists in the shallow-lying units of the Cretaceous, Jurassic and Triassic. The Paradox Formation, intra-salt section, and the Mississippian Leadville Limestone should also be good targets. The Salt Valley area has the same geologic relationships as found in the productive Lisbon area.

Potash has a very high potential for commercial development as most of the area either is presently under lease or has been under lease (except for the land located inside Arches National Park). There have been several wells drilled to evaluate the potash beds and plans for new potash developments have been studied. The economics appear to be marginal for potash development at the present but should become better in the near future as the need for potash increases.

High interest in copper exploration and attempted previous milling and leaching operations, as well as the large low-grade copper reserves reported to have been drilled out, gives this area a good potential for further copper operations in the future. The several small copper or copper-silver mines that were worked in the early days tend to support this.

There are two operating uranium mines and several other prospective development areas for mines. There has been some deep drilling (± 2000 feet) in the area as well as abundant shallower drilling. The whole area has a good to excellent potential for additional uranium deposits in both the Chinle and Morrison Formations.

Low-grade manganese reserves within the study area have only a fair potential for further development.

Salt Valley Summary

The Salt Valley area has a good potential for oil and gas, potash, uranium and copper development. The nature of the copper and uranium is such that mineralization is confined to a particular stratigraphic horizon or unit. Therefore the copper and uranium deposits should provide no interference with waste disposal sites in the salt beds beneath. Potash development will certainly come in the future, probably utilizing solution mining. At present engineering and exploration is not complete, so the entire area remains a favorable potash prospect. Solution mining would interfere with the emplacement of a nuclear waste disposal facility in the salt beds. The petroleum potential is also very strong, but exploration has been so inadequate that no areas can be ruled out. Petroleum drill-holes, like those for potash would interfere with salt mining. The least probable targets for petroleum exploration would be in the axial areas of the synclines.

Lisbon Valley Anticline Area

The Lisbon anticline is located about 31 miles southwest of Moab, Utah and about 54 highway miles southwest of the Sevenmile railroad siding. The area has been very active in both oil and gas production as well as uranium and copper mining and milling. Several hundred people work in the general vicinity of the Lisbon anticline; the uranium mines and mill employ from 200 to 300 per day. Additionally there are 40 to 70 people employed by the oil and gas industry including truck drivers who transport the products. The copper mines and mill are presently shut down, but have employed more than 100 people per day during the past.

The Lisbon anticline is a large faulted asymmetrical structure that is one of the major salt structures that dominate the Paradox fold and fault belt. The Lisbon structure is of the non-piercement type, but does have a fault with a maximum throw of 4,000 feet that extends down its axis (Lekas and Dahl, 1956, p. 162). This surface fault does not extend downward through the total Paradox Formation, in which it dies out. A buried structure that is offset and roughly parallels the surface structure produces gas and oil from Mississippian and Devonian Formations in the Lisbon Valley oil field. Plates 11 and 12 show a structure map and a cross section of this area.

The Lisbon anticline area has oil and gas production from the Honaker Trail Formation on the downthrown side of the Lisbon surface fault, from the intra-salt section of the Paradox Formation, and from the Leadville Limestone, Ouray Formation and Elbert Formation. Cumulative oil production is 40,595,700 barrels of oil and 303,600,200 mcf of gas through 1977. Several different structures are productive in the area and the potential is excellent for additional oil and gas fields to be discovered.

The Paradox Formation contains several potash zones in this area. During the 1960s there was extensive potash exploration. Inasmuch as underground mining operations were planned, the complex folding of the potash beds stopped the exploration programs at that time. The potash beds do have potential economic value and could be the sites of future solution mining operations.

The Lisbon anticline area contains one of the major uranium mining districts of the United States; the Big Indian district has produced more than 65 million pounds of U_3O_8 and additional values of vanadium through December, 1978. This mining district includes the famous MiVida mine discovered by Charles Steen. The production of uranium has been from the Moss Back Member of the Chinle Formation along with a smaller amount of uranium and vanadium from the Salt Wash Member of the Morrison Formation. The mining district was thought to be mostly mined out in the mid-1960s, but new discoveries kept the district very much alive and producing until the present time. In the past few years, new major discoveries of ore bodies in both the Salt Wash and Moss Back have been found which are now being developed. The Lisbon anticline as well as other surrounding areas has an excellent potential for the discovery and development of additional uranium deposits.

The long history of copper operations in this area, with both milling and mining operations and large ore reserves remaining, leaves the area with a very high potential that more copper production will begin when the economic climate is right.

Lisbon Anticline Summary

The Lisbon anticline area has excellent potential for more petroleum, uranium-vanadium, and copper production. It is one of the more highly developed regions in the state with respect to exploitation of natural resources. It also has a good chance of being developed for potash, known to be present in the salt beds.

The petroleum potential remains high over the entire area inasmuch as favorable geologic conditions and targets underlie the entire area. The post-salt targets are not quite as favorable in the synclinal area. Drilling has been inadequate to delineate all the pre-salt structures that might contain additional oil and gas resources.

Good zones of potash are known in the Lisbon anticline area. These are in a complex structural situation and so will probably be solution mined. Although this potash underlies the entire map area (plate 10), those localities in the actual anticlinal area, where the depth of drilling the solution holes will be less, will be favored.

The uranium-vanadium potential is excellent, but confined to particular stratigraphic horizons: the Moss Back Member of Chinle Formation and the Salt Wash Member of the Morrison Formation. Prospective salt facilities will lie well below the uranium mine workings and the two would not interfere with each other. Because this is an extremely active uranium area any surface facilities in support of underground waste disposal sites in salt should not be located too close to uranium-vanadium shafts, adits and surface buildings.

Copper deposits in the Lisbon anticline area are mined when copper prices justify activity. These are alined along the Lisbon fault and the best potential for new discoveries lie along this fault. Because structural breaks such as faults are presumed to be detrimental in nuclear waste disposal sites, it is thought that neither usage would compete for the same territory.

Gibson Dome Area

Gibson Dome is located about 25 miles southwest of Moab, Utah near the Colorado River, near the eastern boundary of Canyonlands National Park. It is 76 miles by highway to the rail head at Sevenmile siding north of Moab. Access is by paved road that leaves U. S. Highway 163 eighteen miles north of Monticello, Utah, then continues on 29 miles of pavement and 3 miles of dirt road to the northwest. The area is uninhabited; the nearest ranch is 12 miles distant; the area supports a very limited amount of livestock.

Gibson Dome is a gently folded anticline that lies to the southwest of the principal breached and faulted salt anticlines of the region. There are no known faults that cut the structure or parallel it. Plates 13 and 14 show the structure and a cross section through Gibson Dome. Several oil tests have been drilled in this area with negative results. The surface structure indicates about 200 feet of closure; the steepest dips measured along the flanks reach 4 degrees (Baker, 1933, p. 70). The oldest beds exposed at the surface are part of the Permian Cutler-Rico Formation, which is composed of arkosic sandstones, red siltstones, and thin limestones. Cliffs in the eastern part of the map area (plate 11) are composed of the Triassic Moenkopi, Chinle and Wingate Formations.

The oil and gas drilling in this area has so far been unsuccessful. Subsurface structures may yet be found, but the lack of oil and gas shows in the previously drilled surface structures and the limited size of the area do not indicate a strong potential for future oil and gas development.

Three potash beds are known to be present at Gibson Dome, but receive a low economic potential rating as they are at least 3,000 feet deep (Hite and Lohman, 1973, p. 47). In addition the area is very remote from a railroad and very close to a national park, all factors which disfavor economic development.

Uranium prospects in the general area are found in the Permian Cutler Formation and in the Pennsylvanian Honaker Trail Formation. Production has been achieved, but it has been very small. These deposits contain small tonnages of low grade. Therefore the area has a low to fair potential of having an economic uranium mine or operation.

The low potential for uranium or petroleum production, plus the relatively deep depths of the potash sections would seem to eliminate any interference to a waste repository site. The simple, non-faulted domal structure is also favorable. Nevertheless, the salt is deep, the area is remote and near a national park. The last three factors will provide problems in planning for any installation.

Elk Ridge Area

The Elk Ridge anticline area is located 25 miles west of Blanding, Utah. The area is reached by paved Utah Highway 95 that begins and extends westward from a point about 5 miles south of Blanding, Utah. The distance to the nearest rail head, Sevenmile siding north of Moab, Utah, is about 115 miles. There are no permanent residents in the immediate area, and Natural Bridges National Monument lies a few miles northwest of the locale. The sparse vegetation of the area is capable of supporting only a few grazing animals, but this activity is its principal use.

The Elk Ridge anticline is a rather gentle, north-trending fold that is superimposed on the larger Monument Uplift that trends northward from Arizona into the Big Flat area of Grand County. The Monument Uplift is an asymmetrical anticline with the steeper limb on its east flank. The dips are mostly gentle except at Comb Ridge (monocline) where the dips exceed 30 degrees. The area of study has a part of the gentle Elk Ridge anticline included within the boundary. Plates 15 and 16 show the structure and two cross sections through the anticline.

The Elk Ridge area has only a fair potential for oil and gas. Several oil tests have been unsuccessful; oil and gas shows have been lacking in the dry holes, and additional oil exploration is necessary to determine whether there are favorable subsurface structures.

There is no potential for potash in the Elk Ridge area. The area is underlain with salt, but is outside the potash area.

The immediate area as shown on the map, plate 12, has very little potential for uranium or other mineral deposits. The favorable ore-bearing units have been eroded away leaving the unproductive Permian Cedar Mesa Sandstone exposed.

The Elk Ridge area, as illustrated on plate 12, therefore has very little potential for economic mineral deposits, including oil and gas, potash, and uranium. There would be little to interfere with the development of a waste storage facility if the condition of the Paradox salt is favorable. The area is remote and far removed from railroad access. but there is good highway access and a town within 25 miles.

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