

# LISBON VALLEY, UTAH'S PREMIER URANIUM AREA, A SUMMARY OF EXPLORATION AND ORE PRODUCTION

by  
William L. Chenoweth

Consulting Geologist  
Grand Junction, Colorado

THE PUBLICATION OF THIS PAPER  
IS MADE POSSIBLE WITH MINERAL LEASE FUNDS

A primary mission of the UGMS is to provide geologic information of Utah through publications; the formal publication series is reserved for material whose senior author is a UGMS staff member. This Mineral Lease publications provide an outlet for non-UGMS authors without necessarily going through extensive policy, technical, and editorial review required by the formal series. It also provides a means for UGMS and non-UGMS authors to publish more interpretive work with the knowledge that readers will exercise some degree of caution.

## C O N T E N T S

	Page No.
Abstract . . . . .	1
Introduction . . . . .	2
Location . . . . .	2
Purpose . . . . .	2
Sources of Data . . . . .	4
Geologic Setting of the Ore Deposits . . . . .	5
Exploration and Production History . . . . .	8
Early Activities . . . . .	8
The Boom Years, 1953-1961 . . . . .	
AEC Allocations and Stretchout, 1962-1970 . . . . .	24
The Private Market, The Beginning And The Boom, 1971-1979 . . . . .	30
The Domestic Market Collapses, 1980-Present . . . . .	35
Summary . . . . .	37
Outlook And Potential Resources . . . . .	39
Acknowledgements . . . . .	41
References . . . . .	42
Appendix . . . . .	45

## I L L U S T R A T I O N S

	Page No.
Figure 1. Location map, Lisbon Valley mining area, San Juan County, Utah.....	3
2. Map of the Lisbon Valley anticline showing the mines and orebodies.....	Attached
3. Uranium ore production, Lisbon Valley Utah.....	16
4. Aerial view looking southwest into Steen's Canyon showing the surface facilities of the Mi Vida mine.....	20
5. Aerial view looking northwest across drill sites of Rio Algom's Lisbon orebody.....	32

## T A B L E S

Table 1. Uranium ore production, Lisbon Valley, Utah, 1948-1970.....	11
2. Uranium ores analyzed for vanadium, Lisbon Valley, Utah, 1948-1970.....	12
3. Uranium ore production, Lisbon Valley, Utah, 1971-1988.....	38
4. Summary of uranium ore production, Lisbon Valley, Utah, 1948-1988.....	40

## A B S T R A C T

Uranium ore deposits in the Lisbon Valley area are in a arcuate belt, 16 miles long by one mile wide, on the southwestern flank of the Lisbon Valley anticline. The principal host rock is the Moss Back Member of the Triassic Chinle Formation. Significant orebodies also occur in the underlying Permian Cutler Formation. Although small oxidized deposits occurred in the area, wildcat drilling by a single individual in 1952 discovered a major unoxidized deposit. The following surge of exploration drilling discovered most of the deposits by 1956.

Annual ore production reached a record high in 1959 when over 6.6 million pounds  $U_3O_8$  were produced, but production declined there after due to ore purchase restrictions by the U.S. Atomic Energy Commission (AEC). When the AEC program ended in 1970, Lisbon Valley had produced 53.6 million pounds  $U_3O_8$ , which represented 12 percent of the total uranium produced in the United States during the 1948-1970 period. The majority of the ore was processed at a mill in Moab, Utah.

Wildcat drilling in 1964 and 1965 on the northwestern nose of the anticline discovered ore on the downdropped, northeast, side of the Lisbon Valley fault. This deep, 2,500 foot  $\pm$ , discovery lead to the development of the Lisbon mine and mill which began producing in 1972. High uranium prices and a strong market in the mid-1970's were responsible for a second boom in the area, and several additional deposits were discovered including a major deposit in the Cutler Formation in the southwestern part of the area.

Declining prices and a weak market in the early 1980's forced many of the mines and the Moab mill to close in early 1984, and the Lisbon mine and mill to close in late 1988. During the 41 years, 1948-1988, that the uranium mines in Lisbon Valley were operating, a total of 12,778,662 tons of ore containing 77,913,378 pounds of  $U_3O_8$  were produced.

## I N T R O D U C T I O N

### Location

The Lisbon Valley uranium mining area is situated on the southwestern flank of the Lisbon Valley anticline in northeastern San Juan County, Utah. The center of the area is approximately 10 miles south of the settlement of La Sal, Utah (Figure 1). Paved roads heading south from Utah Highway 46, east of La Sal, and east from U.S. Highway 191, south of La Sal Junction, provide easy access to the area (Figure 1).

Uranium discoveries in the late 1940's and early 1950's were made on the southwest rim of Big Indian Wash, the main drainage of Big Indian Valley. Hence, early reports refer to the uranium area as the Big Indian Wash district. As exploration and mining expanded to the northwest and to the southeast, along the flank of the anticline, the name Lisbon Valley replaced Big Indian Wash as the name of the mining area (Figure 2).

Copper ore has been produced at a few locations along the Lisbon Valley fault, from the Burro Canyon and Dakota Formations, and uranium-vanadium ore has been mined from the Salt Wash Member of the Morrison Formation in nearby areas, however this report is concerned only with the uranium ore deposits in the Moss Back Member of the Triassic Chinle Formation and in the Cutler Formation of Permian age. The uranium ore deposits extend from the central part of T.29S., R.24E. to the northwest corner of T.31S., R.26E., Salt Lake Baseline and Meridian.

### Purpose

The Lisbon Valley area has produced more uranium than any other area in the State of Utah. The majority of the deposits occur in the Moss Back Member of the Chinle Formation, making Lisbon Valley the most productive uranium area in the Chinle Formation on the entire Colorado Plateau. Other significant, but smaller uranium areas in the Chinle Formation include White

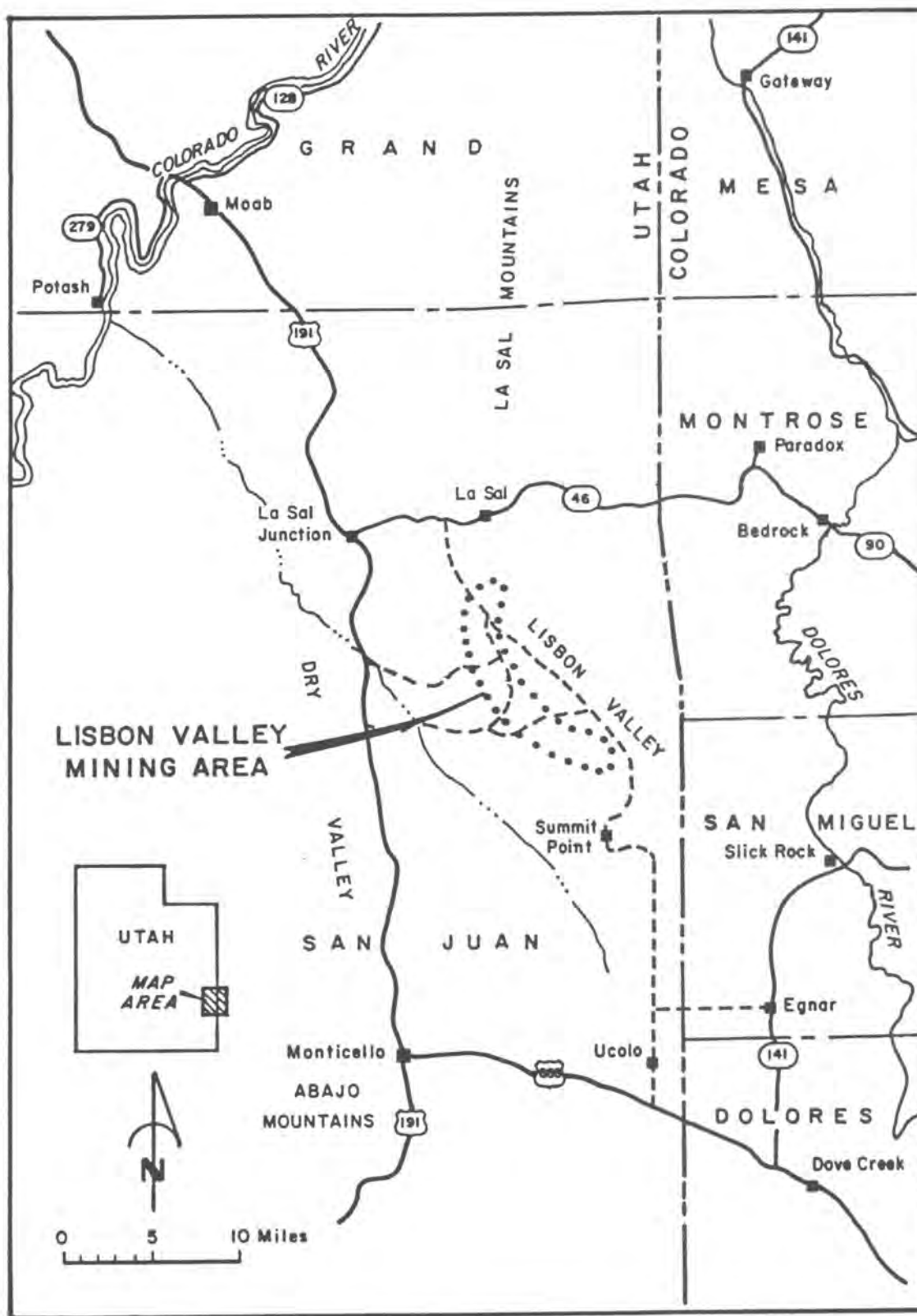


Figure 1. Location map, Lisbon Valley mining area, San Juan County, Utah

Canyon and the San Rafael Swell, Utah, Monument Valley, Arizona and Utah, and Cameron, Arizona. Lisbon Valley is also the premier area of uranium production from the Cutler Formation.

Mining of the Lisbon Valley deposits for uranium commenced in the spring of 1948 and continued until October, 1988. The purpose of this report is to summarize the pertinent historical events in the exploration and development of the area, and to compile the ore production statistics.

#### Sources of Data

A considerable amount of the information used in this report was obtained while the author was employed by the U.S. Atomic Energy Commission (AEC) and succeeding agencies, the U.S. Energy Research and Development Administration, and the U.S. Department of Energy (DOE). A review of certain AEC documents in DOE archives at Grand Junction, Colorado aided in the compilation of data.

Most of the historical dates given were obtained from AEC Circular 6 files dealing with eligibility for the initial production bonus. The AEC annual ore production records for 1948 through 1970, listing ore production by individual mines were examined and the results tabulated in Tables 1 and 2. For the years 1971 through 1982, only the annual production totals for the Lisbon Valley area were obtained. Annual production figures for individual mines, after the AEC purchase program ended, are considered company confidential by the DOE. The Grand Junction office of the DOE ceased collecting uranium production data after 1982.

Carl H. Dixon, Atlas Minerals Division, Atlas Corporation provided data on uranium ores produced and obtained by Atlas during 1983 and 1984, and Mervyn D. Lawton, Rio Algom Corption, retired, provided similar data for Rio Algom during the 1983-1988 period.



## GEOLOGIC SETTING OF THE ORE DEPOSITS

Since this report deals mainly with the exploration and mining history of the area, the reader is referred to reports by Lekas and Dahl (1957), AEC (1959a), Wood (1968) and Huber (1981) for detailed geologic descriptions of the ore deposits. Campbell and Steele-Mallory (1979) have described the host rocks of the Cutler Formation in the area, and Purvance (1978) has described the geology of the Lisbon mine. An excellent summary of the U.S. Geological Survey's observations in the area during 1954-1959 is given by Weir and Puffett (1981).

The uranium ore deposits in the Lisbon Valley area form a mineralized belt on the southwestern flank of the Lisbon Valley anticline approximately 16 miles long and one-half to one mile wide (Figure 2). A five mile portion of the south central part of the ore belt has been removed by erosion, leaving about six miles of large deposits to the northwest and about five miles of scattered smaller deposits to the southeast (Figure 2). The cluster of nearby coalesced deposits at the north end of the belt has produced 43 million pounds of uranium oxide ( $U_3O_8$ ), and the cluster in the center of the belt has produced nearly 24 million pounds  $U_3O_8$ . A few scattered deposits between the northern and central clusters account for about 4.5 million pounds  $U_3O_8$ . Production from the southeastern part of the belt has been approximately 6 million pounds  $U_3O_8$ .

The deposits range in size from 500 tons to 1,500,000 tons of ore, and in thickness from a few inches to 45 feet, with an average thickness of six feet. All the deposits are irregular, amoeba-shaped masses that are concordant with the bedding of the host rocks. The ore-bearing portion of the Moss Back is a gray, poorly sorted, fine- to coarse-grained, calcareous, arkosic, quartzose sandstone containing some interbedded mudstone and limestone pebble conglomerates and some mudstone and siltstone lenses. The highest- grade ore is in semi-permeable, fine-grained, sandy lenses that contain less than 30 percent calcium carbonate as cement or as clastic limestone grains. There is an abundance of mudstone pebbles and coalified wood-trash either in or directly overlying the host rock.

Small deposits in the Cutler crop out along the west escarpment of Big Indian Valley about 100 feet stratigraphically below the Permian-Triassic disconformity and between 1,000 and 1,500 feet up dip and northeast of the eastern limit of the Triassic ore belt. Other orebodies in these massive Cutler sandstone units occur where they subcrop under the Moss Back ore deposits. Some orebodies in the Cutler Formation, especially in the southeastern part of the area, are not associated with overlying orebodies in the Moss Back. Some orebodies within the Cutler Formation occur as much as 40 feet below the unconformity, but most are within six feet of it. Cutler host rocks consist of alternating beds and lenses of light pink, orange, and buff mudstone, calcareous siltstone, and arkosic sandstone. The sandstone beds are well-sorted, are fine- to medium-grained, have a saccharoidal texture, and are as much as 50 feet thick. The sandstone is comprised of quartz, feldspar, and biotite, with clay as the predominant binder, but locally calcite may be the main cement. The Cutler sandstone beds, where exposed in the mine workings, appear to be more extensively bleached than they are on the rim outcrops. The thickness of this bleached zone below the nonconformity does not appear to be directly related to the size or position of the overlying orebodies but does appear to be related to the thicker and more porous Cutler sandstone beds.

The angle of discordance between the beds of the Cutler and Chinle Formations at the northwest end of the ore belt is less than two degrees; at the Standard-Big Buck mine near the central part of the ore belt, it is about six degrees; and at the southeast end of the belt it is three to four degrees (Wood, 1968). The paleotopography of the unconformity varies from a fairly smooth, undulating surface with less than five feet of relief to a deeply scoured surface with over 30 feet of relief. Elongated scours or troughs are common, but no pattern or common orientation is evident. Some large scours parallel the strike of the Cutler subcrops, and other scours trend down the dip of the Cutler beds, but there are no persistent or well defined channels, such as the Shinarump channels of the White Canyon area.

Uraninite is the principal uranium ore mineral. Small amounts of coffinite and the vanadium minerals montroseite, doloresite, and vanadium clay and/or hydromica are intimately associated with the uraninite. Secondary uranium and vanadium minerals, such as metatyuyamunite, pascoite, and corvusite, are present in areas of oxidation, but they are of no quantitative importance. High-grade uraninite ore specimens, usually replacements of coalified wood, have been collected from many of the mines; some samples assay about 80 percent  $U_3O_8$ . In the central and southeastern deposits, the vanadium content of the ores was high enough for that metal to be recoverable. Vanadium ( $V_2O_5$ ) content of the ore shipments to the ore-buying stations and/or processing mills, during the AEC ore procurement programs, is shown in Table 2. Analyses for  $V_2O_5$  were not made in the 1967-1970 period.

Ore minerals are most abundant in the interstices between grains of sand, but they also replace calcite, carbonaceous plant remains, and to a lesser extent, detrital quartz and feldspar grains and other accessory minerals. Ore shipments from deposits in the Moss Back have averaged about 15 percent  $CaCO_3$ , but the content differs considerably from deposit to deposit within the ore belt and also within the individual orebodies. The calcium carbonate concentration is highest where it occurs as a cement and as detrital grains. Rarely does high-grade Moss Back ore contain more than 20 percent  $CaCO_3$ . Although most of these deposits are hundreds of feet above the present water table, the low permeability, due to cementation by calcite, has protected them from oxidation.

All of the mining is underground with access to the orebodies via vertical shafts, inclined shafts, adits and declines (Figure 2). A report by the AEC (1959b) listed the pertinent data on each of the major mines. Mining methods used at the following mines are described in these reports: School Section 36 (Dare, 1957), Big Buck-Standard (Dare and Durk, 1956), Mi Vida (Steen et al, 1953), La Sal (Dare and Delicate, 1957), and the Radon (Lindstrom, 1964).

## EXPLORATION AND PRODUCTION HISTORY

### Early Activities

The first discovery of uranium-vanadium ore on the Lisbon Valley anticline was made in 1913, at the southeast end of the anticline on outcrops of a basal sandstone in Chinle Formation (Wood, 1968). Vanadium production from the Chinle Formation at the Divide and Service Berry mines on Three Step Hill in Sections 34 and 35, T.30S., R.25E., was reported in 1917, 1940 and 1941 (Dare, 1956, R.P. Fischer, personal communication, 1989). Records in the AEC files show that the Divide and Service Berry claim groups were relocated in June 1940.

The U.S. Atomic Energy Commission (AEC) was formed in January 1947 and later that year it began a domestic uranium procurement program. On April 11, 1948, the agency issued its initial ore purchase schedule and bonus incentives in the form of Domestic Uranium Program Circulars 1, 2 and 3. Circular 1 guaranteed for 10 years a minimum price for certain high-grade uranium ores. Circular 2 offered a \$10,000 bonus for the discovery and production of high-grade uranium ores from new domestic deposits. Circular 3 provided for minimum prices, specifications and conditions under which the AEC would purchase carnotite and roscoelite - type ores at Monticello, Utah. Circular 3 also established payment of \$0.31 a pound for vanadium ( $V_2O_5$ ) contained the ores. Ores containing in excess of 6 percent  $CaCO_3$  (high lime) were not acceptable (Albrethsen and McGinley, 1982). The United States' need for uranium for national defense was so urgent that the AEC created numerous incentives for prospectors and miners to search for and produce uranium. The activities created by these incentives would soon grow into huge proportions.

On June 1, 1948, the AEC issued Circular 4. It was a revision of Circular 3 and added an additional \$0.50 per pound premium for ores assaying 0.20 percent  $U_3O_8$  or more, and set forth a haulage allowance of \$0.06 per ton mile, for distances up to 100 miles.



While prospecting along the central part of the southwestern flank of the anticline (Big Indian Valley), in the spring of 1948, Dan Hayes of Monticello, Utah, discovered uranium - bearing exposures in the upper part of the Cutler Formation. Hayes, in partnership with James Bentley and W.S. Brewer, located 12 Big Buck claims on May 29, 1948. These claims covered the exposures of the upper Cutler in Section 11, T.30S., R.24E. The claims were relocated on August 9, 1948 and included the Big Buck 4A, 5, 6, 7, 8, 8A, 9, 9A, 10, 10A, 11, 11A, 12, and 12A. The relocated claims extended southeastward into Sections 12 and 13. These 14 claims covered an area 1,400 feet wide and 8,000 feet long along the southwestern rim of Big Indian Valley.

Hayes acquired his partner's interest and formed a new partnership with Donald T. Adams. The Big Buck claims were leased to L. Gribble and E. Bryant for mining. The initial shipment was delivered to the newly opened AEC ore-buying station at Monticello, Utah on August 3, 1948. Due to the low grade of the ore, mining ceased in the fall of 1948. At that time, a total of 852 tons of ore averaging 0.13 percent  $U_3O_8$ , 0.21 percent  $V_2O_5$  and 4.86 percent  $CaCO_3$  had been delivered to Monticello (Rasor, 1949).

Charles A. Rasor, an AEC geologist, examined the workings in November and December 1948 and noted 600 feet of rim stripping and five short adits on the Big Buck 4A and 5 (Rasor, 1949). He also recommended the AEC study the area, as this was a new uranium host formation.

In the fall of 1948, Pat Patterson shipped 36 tons of ore averaging 0.88 percent  $U_3O_8$  and 1.89 percent  $V_2O_5$  from the Service Berry mine. About 15 tons were shipped to the Vanadium Corporation of America (VCA) mill at Naturita, Colorado and 21 tons to Monticello, Utah.

North of the Big Buck exposures, additional uranium - bearing outcrops in the upper Cutler Formation were discovered in Section 34, T.29S., R.24E. and in Section 35, T.29½S., R.24E. In April 1948, Southwestern Development Corporation located the Small Fry 1-20, Rattlesnake, Mill View, Calico Dyke and Uranium Spot claims to cover these exposures, and the ground in between.

On February 1, 1949, the AEC issued Circular 5. It consolidated Circulars 3 and 4 and increased the price for  $U_3O_8$  in ore, and established premium prices for higher grade ore. In order to provide a market for high-lime uranium-vanadium ores of the Colorado Plateau, the AEC announced on July 10, 1949, that it would purchase such ores at Monticello, Utah under special arrangements to be negotiated with individual producers (U.S. Atomic Energy Commission, 1949).

The only production recorded in 1949 was a 37 ton shipment from the Divide mine which averaged 0.30 percent  $U_3O_8$  and 0.83 percent  $V_2O_5$  (Tables 1 and 2). The shipper was listed as Bailey and Nielson. In 1950 small shipments were made from the Big Buck 4A, 6, Service Berry, and Divide mines. A total of 31 tons averaging 0.17 percent  $U_3O_8$  and 0.52 percent  $V_2O_5$  were shipped (Tables 1 and 2). A nine ton shipment, from the Big Buck No. 6 claim, was sent to the U.S. Vanadium Corporation's (USV) ore-buying station at Thompson, Utah, for shipment by rail to the company's mill at Rifle, Colorado.

Circular 5 was revised and broadened on March 1, 1951. Circular 5, Revised, stayed in effect until April 1, 1962. More important was the fact that the prices set forth in Circular 5, Revised, became the base of the industry's economics while it was in effect.

Circular 6, issued June 29, 1951, established an initial production bonus for new discoveries. This bonus could amount to as much as \$35,000 on the first 10,000 pounds  $U_3O_8$  produced from a new property. This Circular expired March 31, 1960.

During 1951 small scale shipments continued from the Big Buck Nos. 5, 6, Service Berry and Divide mines. The Big Buck and Divide shipped to Rifle, Colorado and the Service Berry to Monticello. A 400 pound shipment from the Service Berry to the Climax Uranium Company's mill in Grand Junction, Colorado averaged 2.84 percent  $U_3O_8$  and 3.73%  $V_2O_5$ . During the year a total of 392 tons of ore averaging 0.17 percent  $U_3O_8$  and 0.38 percent  $V_2O_5$  was shipped by the three properties (Tables 1 and 2).

It was these deposits that attracted Charles A. Steen, a Texas prospector, to the area. On March 7, 1951, Steen located

Table 1: Uranium Ore Production, Lisbon Valley,  
San Juan County, Utah, 1948 - 1970

Year	Tons of Ore	Pounds $U_3O_8$	Percent $U_3O_8$
1948	888	2,768	0.16
1949	37	244	0.30
1950	31	104	0.17
1951	392	1,361	0.17
1952	537	2,499	0.23
1953	50,957	458,738	0.45
1954	187,600	1,178,300	0.31
1955	334,122	2,567,695	0.38
1956	502,313	3,666,431	0.36
1957	641,386	5,034,429	0.39
1958	774,911	6,416,891	0.41
1959	814,619	6,687,646	0.41
1960	668,064	4,447,743	0.33
1961	660,018	4,061,834	0.31
1962	439,672	3,891,689	0.44
1963	455,464	4,209,658	0.46
1964	494,048	4,686,113	0.47
1965	167,648	1,327,241	0.40
1966	70,360	612,597	0.44
1967	141,788	884,559	0.31
1968	266,965	1,254,731	0.23
1969	201,715	828,518	0.21
1970	<u>316,311</u>	<u>1,414,332</u>	<u>0.22</u>
TOTAL	7,184,846	53,636,121	0.37

Source: Unpublished mine production records, U. S. Atomic Energy  
Commission, Grand Junction, Colorado office.

Table 2: Uranium Ores Analyzed For Vanadium, Lisbon Valley,  
San Juan County, Utah, 1948 - 1970

Year	Tons of Ore	Pounds V <sub>2</sub> O <sub>5</sub>	Percent V <sub>2</sub> O <sub>5</sub>
1948	888	4,948	0.28
1949	37	619	0.83
1950	31	322	0.52
1951	392	2,991	0.38
1952	400	7,046	0.88
1953	48,828	1,076,320	1.10
1954	183,176	2,531,743	0.69
1955	228,167	2,209,467	0.48
1956	502,313	3,144,735	0.31
1957	535,484	2,330,446	0.22
1958	574,504	2,396,023	0.21
1959	594,742	4,247,449	0.36
1960	28,858	480,463	0.83
1961	1,866	16,826	0.45
1962	963	7,347	0.38
1963	1,202	19,933	0.83
1964	385	760	0.10
1965	2,353	21,476	0.46
1966	170	1,462	0.43
1967	- <u>1/</u>	-	-
1968	-	-	-
1969	-	-	-
1970	-	-	-
TOTAL	2,704,759	18,500,376	0.34

1/ No ores were analyzed for vanadium during 1967 - 1970.

Source: Unpublished mine production records, U. S. Atomic Energy  
Commission, Grand Junction, Colorado office.



12 claims contiguous with, and west of the Big Buck claims in Section 11, T.30S., R.24E. These 12 claims were named the Mujer Sin Verguenza, Mi Corazon, Besame Mucho, Pisco, Fundadora, Te Quiero, Mi Vida, Linda Mujer, Mi Amorcita, Ann, Bacardi, and Mi Alma. In documents filed with the AEC, Steen referred to these claims as the Linda Mujer group.

Steen built a four-mile long road to the claim group and began drilling a core hole to test the Big Buck ore horizon in the Cutler Formation on July 3, 1952. The hole was located at the end of the road near the center of the Mi Vida claim. On July 6, 1952 at a depth of 70 feet., the coring encountered a dark colored sandstone. This material was cored for a total thickness of 14 feet (Steen et al, 1953). Steen was looking for carnotite in the Cutler Formation and did not immediately realize he had encountered unoxidized uranium minerals in the basal Chinle Formation, 100 feet above the horizon he planned to test.

Instead of outlining his discovery with further drilling, Steen decided to sink a test shaft. On October 4, 1952 the sinking of an eight-foot by eight-foot timbered shaft was started 30 feet southeast of the discovery hole (Steen et al, 1953). The shaft was declined 83 degrees to the southeast. While sinking was in progress, Steen, his mother, and associates, formed the Utex (Utah-Texas) Exploration Company on October 24, 1952. On November 20, 1952, relocation notices were filed for the Linda Mujer claim group.

The first ore was hoisted from Steen's shaft on December 4, 1953, and shipments to USV's ore-buying station at Thompson, Utah, 70 miles away, on December 6. During December a total of 152 tons of ore averaging 0.37 percent  $U_3O_8$  and 1.40 percent  $V_2O_5$  was shipped to USV.

During 1952, various individuals operated the Big Buck 4A, 5, and 6 claims in the Cutler Formation. Small shipments were made to the VCA mill at Durango, Colorado, the USV mill at Urayvan, Colorado, the USV ore-buying station at Thompson, Utah, the AEC ore-buying station at Monticello, Utah and the Climax Uranium

Company's mill at Grand Junction, Colorado. Lyle Francis operated both the Divide and Service Berry mines with small shipments to Monticello and Thompson. A 220 pound shipment to Climax from the Service Berry mine assayed 8.90 percent  $U_3O_8$  and 6.95 percent  $V_2O_5$ . Total production from Lisbon Valley in 1952 was 537 tons of ore which averaged 0.23 percent  $U_3O_8$  and contained 2,499 pounds  $U_3O_8$  (Table 1).

#### The Boom Years, 1953-1961

The news of the Steen discovery set off an extensive rush of claim staking throughout the entire southwestern flank of the Lisbon Valley. This discovery was especially interesting as it was made in a host rock which did not contain mineralization, on the outcrop, in the immediate area. This basal sandstone of the Chinle Formation would be officially named the Moss Back Member in 1957 by Stewart (1957).

As a follow-up to Rasor's (1949) recommendations, and studies by Dix (1953), the AEC commenced a drilling project in the area in June 1953. The project was completed in September 1953 with a total of 19,785 feet of diamond drilling in 93 holes (Teichman et al, 1956 and Hilleary, 1957). This drilling located a considerable tonnage of ore in the Moss Back sandstone in the vicinity of the Small Fry claims in SW $\frac{1}{4}$  Section 34, T.29S., R.24E., E $\frac{1}{2}$  Section 27, NE $\frac{1}{4}$  Section 34, T.29 $\frac{1}{2}$ S., R.24E. In all probability if Steen had not made his discovery, the AEC would have found uranium in the Moss Back with their planned drilling a year later. At the time of the AEC drilling there were only three privately operated drill rigs drilling in the Lisbon Valley area. This number increased dramatically in the next few years.

On February 11, 1953, Utex Exploration Company, signed a two year lease with G and G Mining Company of Cortez, Colorado to mine a 200-foot by 600-foot area of the Mi Vida claim. Under the terms of the lease, G and G agreed to drive a 10-foot by 10-foot declined adit into the orebody beginning at a point 400 feet southwest of the shaft. A few years later, Utex would drive a 2,240 foot adit, decline at a minue 15 degree angle, into the

orebody to provide sublevel haulage. The portal of the adit was in NE $\frac{1}{4}$  SW $\frac{1}{4}$  Section 11, T.30S., R.24E. (Figure 2).

Standard Uranium Corporation leased the Big Buck 8 and 8A claims from Dan Hayes and his partners on June 24, 1953. This lease became known as the Brunke lease. Standard began a drilling program to test the Moss Back and Cutler. An orebody in the Moss Back was discovered and production, via a 150 foot decline, began during the summer of 1953. The portal of the incline was located on the Mi Vida claim. Besides the orebody on claims 8 and 8A, some ore was also found on adjacent claim 7. This was later mined from the workings on claim 8. Also making shipments in 1953 were Western Mines Development Company from their Utah State Lease No. 4606 on the SW $\frac{1}{4}$  Section 2, T.30S., R.24E., and Southwestern Development Corporation from the Small Fry claims in W $\frac{1}{2}$ , W $\frac{1}{2}$  Section 35, T.29 $\frac{1}{2}$ S., R.24E. Shipments by these two operators came from the Cutler Formation. Increased production on the Mi Vida claim by both G and G and Utex would increase the total production from Lisbon Valley for 1953 to 50,957 tons of ore containing 458,738 pounds U<sub>3</sub>O<sub>8</sub> and averaging 0.45 percent U<sub>3</sub>O<sub>8</sub> (Table 1, Figure 3). Due to the high lime content (up to 35 percent CaCO<sub>3</sub>) of the Moss Back ores, producers were forced to sell to various mills or buying stations, wherever they could obtain a market for these refractory ores. At mills using an acid leach process, ores containing in excess of six percent CaCO<sub>3</sub> were penalized \$1.00 per ton per the first percent and \$0.30 per ton for each additional percent CaCO<sub>3</sub>. Hence, ores containing 15 percent CaCO<sub>3</sub> were penalized \$3.40 per ton, and ores with 20 percent CaCO<sub>3</sub> were penalized \$4.90 per ton.

During 1953, Vitro Corporation of America, operator of a processing mill at Salt Lake City, provided an ore-loading facility on the Denver Rio Grande and Western Railroad at Green River, Utah. Considerable ore from Lisbon Valley was shipped to Salt Lake for processing. The ore was delivered to the AEC ore-buying station at Murray, Utah, which operated under contract by the Utah Ore Sampling Company. (Albrethsen and McGinley, 1982). The ore-buying station closed in late 1957. After the Murray station closed, Vitro added an ore-buying station to their mill in Salt Lake City.

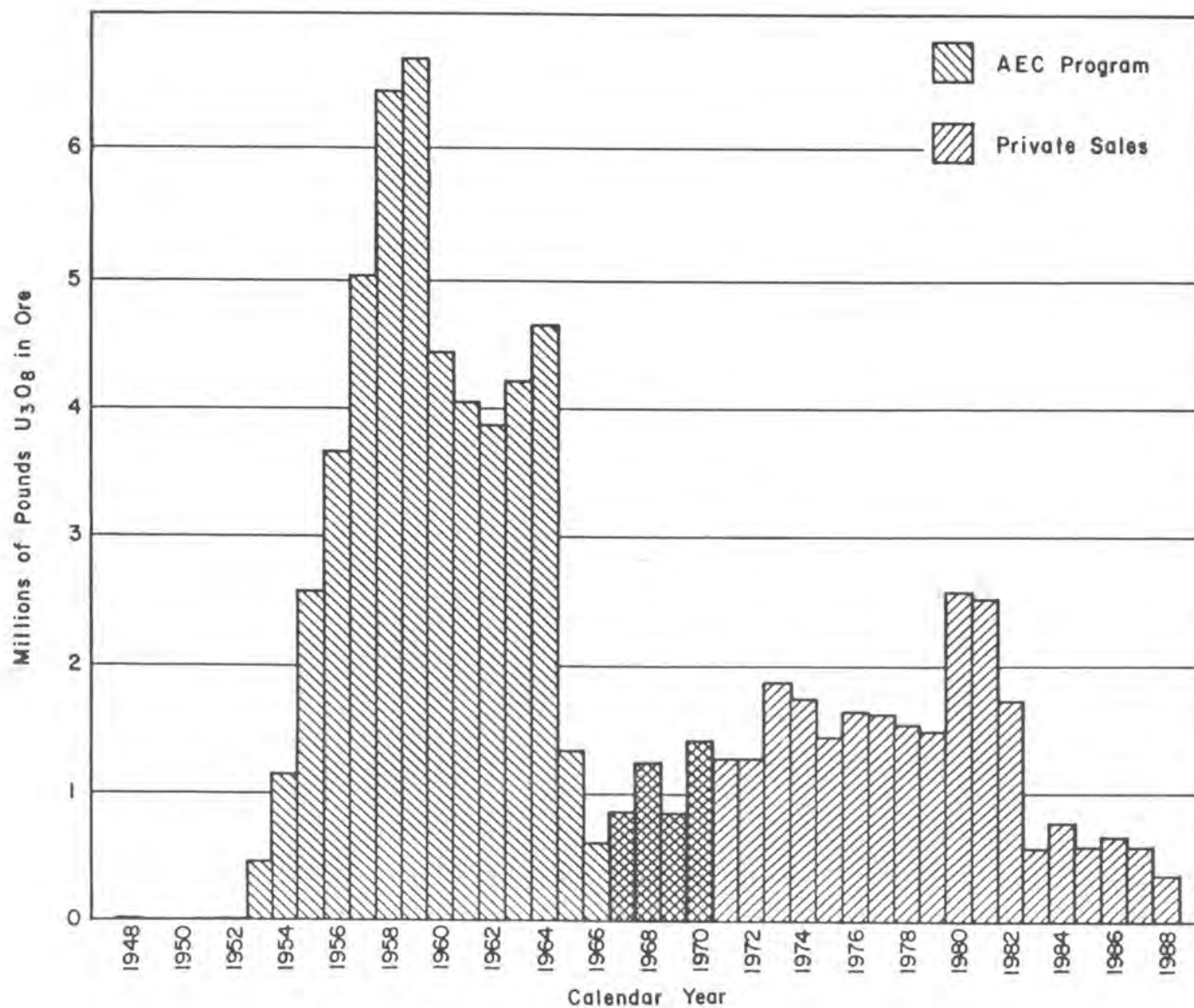


Figure 3. Uranium ore production, Lisbon Valley, Utah

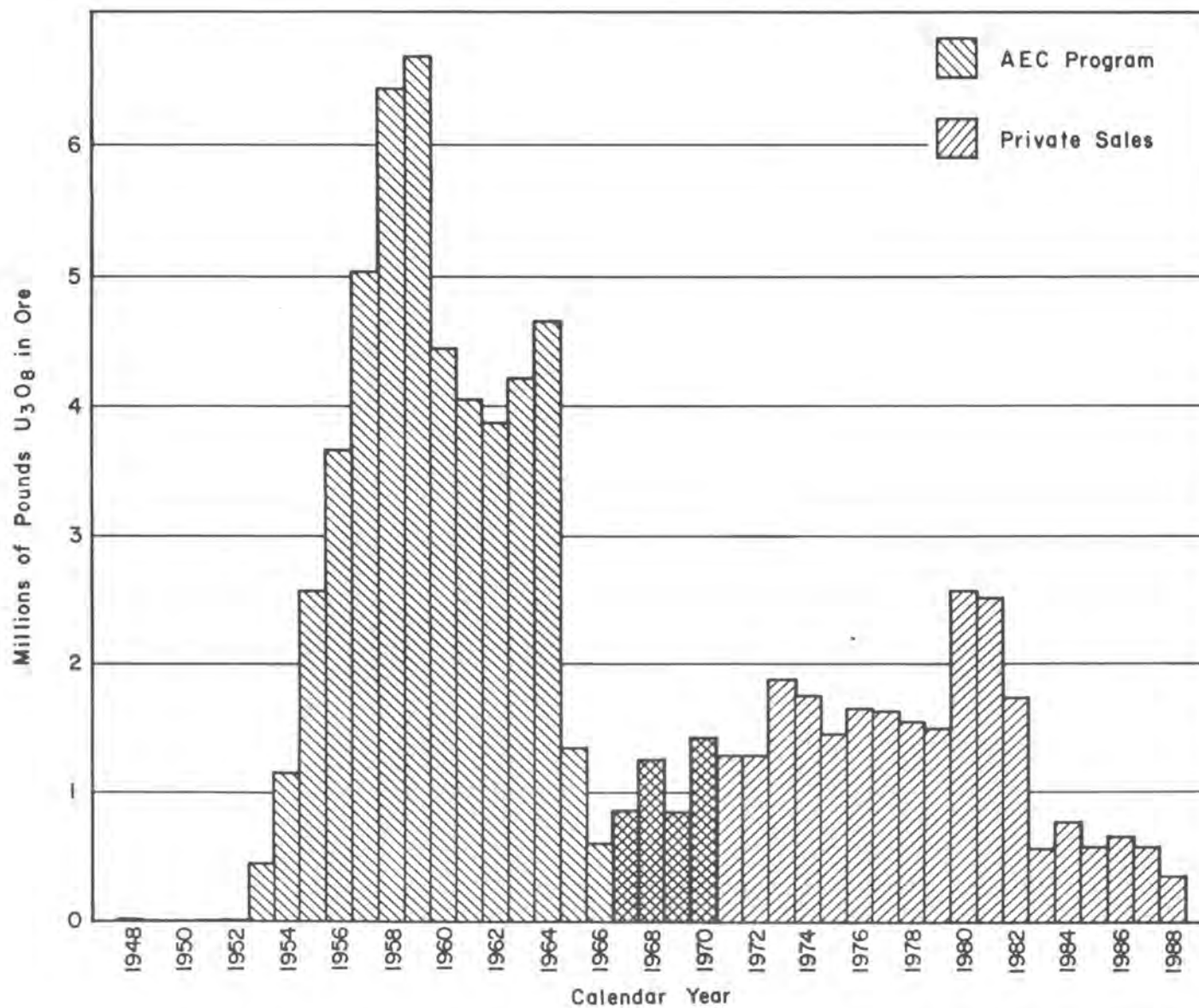


Figure 3. Uranium ore production, Lisbon Valley, Utah



In 1953, many mine operators, who applied for the Circular 6 initial production bonus, discovered that their claims had been staked on lands already covered by federal oil and gas leases. Public Law 250, signed into law by President Truman on August 12, 1953, provided for the creation of valid mining claims on ground staked between July 31, 1939 and January 1, 1953. Claims staked subsequent to January 1, 1953 were invalid (U.S. Atomic Energy Commission, 1954a). Not only were many claims affected in Lisbon Valley, but also in Wyoming and South Dakota. Since by law, all fissionable materials were reserved to the U.S., the AEC issued Domestic Uranium Circular 7, effective January 29, 1954, in order to lease the mining claims back to the claim holder for mining uranium. Many claim holders in Lisbon Valley, including Charlie Steen, took advantage of Circular 7 in order to protect their claims. Public Law 585 of August 13, 1954, eliminated the requirements for the Circular by opening such lands to mining location. The AEC terminated the Circular 7 on December 12, 1954.

Due to some overlapping boundaries of claims that were located during the staking boom in 1953, operators worked out "Boundary Agreements" which were properly recorded in the county records. These agreements legally defined their holdings, especially when applying for the Circular 6 bonus. The exploration drilling that followed the claim staking of late 1952 and early 1953 was very intense. Meyers (1954) reported that as of October 1953, reserves of more than 2,175,000 tons of ore had been drilled out.

Production in 1954 more than doubled over the previous year. A total of 187,600 tons of ore containing 1,178,300 pounds  $U_3O_8$  and averaging 0.31 percent  $U_3O_8$  were shipped (Table 1, Figure 3). During the year initial production was obtained by Cal Uranium Company from the 280-foot San Juan shaft that was sunk to an ore body, originally discovered by AEC drilling. Little Beaver Mining Company (subsidiary of Homestake Mining Company) commenced production from the orebody on the Bobcat and Skunkovich claims via the 3,340-foot long Fraser tunnel (Figure 2). North American Uranium and Oil Company made a small shipment from the Cutler Formation on the Lackey claim in Spiller Canyon,

Section 13, T.30S., R.24E. On Three Step Hill in the southeastern part of the area, Continental Uranium, Incorporated began production from a 230-foot decline at its School Section 36 mine (T.30S., R.25E.), on Utah State Lease No. 5339.

In June 1954, Standard Uranium Corporation purchased the Big Buck claims from Dan Hayes and his partners (Dare and Durk, 1956). The company continued drilling on the claims and began the development of a Moss Back orebody on the Big Buck 9, 9A, 10, and 10A claims. A small shipment was made from the Cutler Formation on the Big Buck 5, 6. The Big Buck mines in the Cutler Formation remained idle until the early 1970's.

Due to the refractory nature, high in  $\text{CaCO}_3$ , the AEC established a provisional ore-buying station at Moab, Utah on May 10, 1954. This station would only receive ores when the producers signed a contract with the AEC regarding sampling, assaying and payment under a temporary agreement (U.S. Atomic Energy Commission, 1954b). Utex Exploration and G and G Mining were the first producers to sign contracts.

The AEC signed a contract, AT (05-1)-266, with Uranium Reduction Co., on June 17, 1955 to purchase uranium concentrates from a mill to be built at Moab. The mill began producing concentrates in November 1956. Uranium Reduction Co. was a partnership between Utex Exploration Company (Steen) and the Combined Metals Reduction Company of Salt Lake City. The mill used an acid leach process with a resin-in pulp uranium recovery circuit, and had the capacity to process 1,500 tons of uranium ore per day. Due to the lime ( $\text{CaCO}_3$ ) content of the ores, the mill converted to an alkaline leach, resin-in pulp process in 1961.

With the mill operating, the AEC put the provisional ore-buying station on standby on November 1, 1956. At that time the station had purchased 687,685 tons of ore that averaged 0.33 percent  $\text{U}_3\text{O}_8$  and 0.49 percent  $\text{V}_2\text{O}_5$ . Most of the ore was purchased from the AEC by Uranium Reduction (Albrethsen and McGinley, 1982).

Ore production from Lisbon Valley in 1955 was 334,122 tons with an average grade of 0.38 percent  $\text{U}_3\text{O}_8$  and containing

2,567,695 pounds  $U_3O_8$ ; more than double the pounds  $U_3O_8$  produced in 1954 (Table 1, Figure 3). Production continued at the Mi Vida, Fraser tunnel, Big Buck Brunke lease, San Juan shaft, and the School Section 36 mines. During the year, five additional mines commenced production.

Homestake Mining Company acquired control of La Sal Mining and Development Company's holdings in May 1954 (Dare and Delicate, 1957), and began production from the 572-foot deep La Sal shaft in January 1955. La Sal continued to be the operator of the property. Standard Uranium Corp. completed the 5,000-foot Standard tunnel in late 1954 and began production from the Big Buck 9-10A in February 1955 (Figure 4). Hecla Mining Company, with an operating agreement with Federal Resources, Incorporated, commenced production from the Radon mine at the 690-foot deep Hecla shaft in the summer of 1955. Almar Minerals, Inc. commenced shipments from the 550-foot deep Far West shaft in the fall of 1955.

North American Uranium Company sank a 360-foot deep shaft on the Pearl claim in the SE $\frac{1}{4}$ , SE $\frac{1}{4}$  Section 11, T.30S., R.24E. during 1954. Early in 1955 some 1,017 tons of ore averaging 0.13 percent  $U_3O_8$  and 0.27 percent  $V_2O_5$  were produced from the shaft which was found to actually be located on the Big Buck no. 10 claim (Dare and Dunk, 1956). The operation was abandoned and the shaft was used for ventilation of Standard Uranium's mine on the Big Buck 9-10A claims. The San Juan shaft was closed in late 1955. It would later be used for ventilation during mining on the nearby Mamie claim.

Beginning in about 1953, exploration drilling by about a dozen companies progressed from the area of Charlie Steen's discovery to both the northwest and the southeast on the southwestern flank of the Lisbon Valley anticline. Drilling reached an all time annual high in 1956 when 647,000 feet were reported to the AEC. After 1956 drilling activity began to taper off.

In the northern half of the area nearly all of the orebodies in the Moss Back Member between the North Alice (Section 28, T.29S., R.24E.) and the Louise (Section 14, T.30S., R.24E.) had been discovered by 1956. At the extreme southeastern



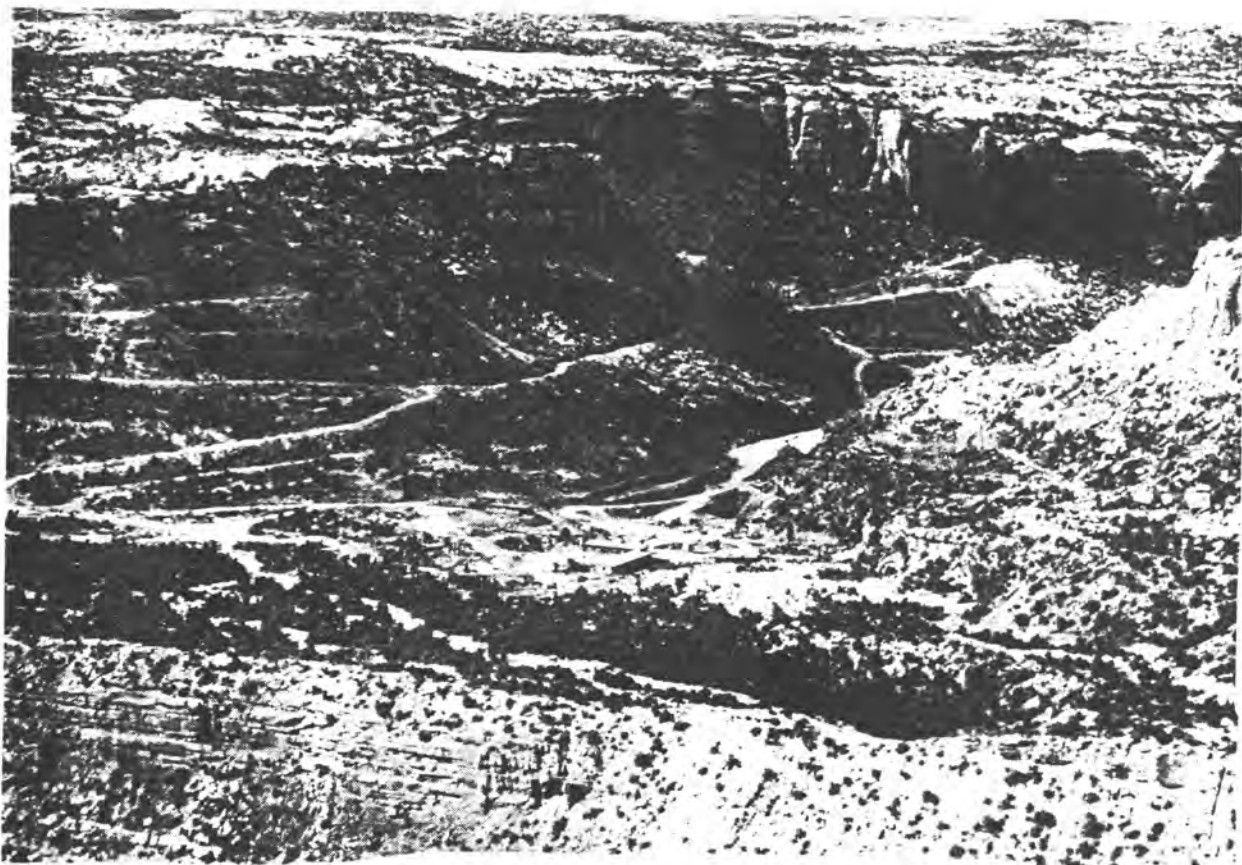


Figure 4. Aerial view looking southwest into Steen's Canyon showing the surface facilities of the Mi Vida mine. Dump in the upper right center is from the Standard tunnel. Moss Back Member of the Chinle Formation overlying the Cutler Formation is the lower foreground with the Wingate Sandstone forming the cliffs in the canyon in the background. Photo from AEC files.

end of the area, drilling in 1953-54 discovered the large School Section 36 orebody (Section 36, T.30S., R.25E.) The Wood orebody in Section 1, T.31S., R.25E. was discovered in the mid 1950's.

By the mid-1950's the existence of a narrow ore belt, 15 miles long and 1 mile wide had been established on the southwestern flank of the Lisbon Valley anticline. Lekas and Dahl (1956) stated that the belt "... is confined almost entirely to a strip between the 6,200 and the 6,700-foot contours drawn on the top of the Cutler Formation, although not occupying the full width of the strip. Within the strip, the ore belt rises up dip to the southeast." Drilling down dip from the ore belt was mostly negative, and the chance to discover large orebodies is thought to be poor.

Production in 1956 increased over 1955 by over one million pounds  $U_3O_8$ . During 1956 some 502,313 tons of ore averaging 0.36 percent  $U_3O_8$  were shipped (Table 1, Figure 3). One new mine commenced production in 1956 which would help boost production.

During the latter part of 1956, E.L. Cord began producing from the orebody on the Jen and Jackie claims via the 675-foot deep Cord shaft (Figure 2). International Oil and Metals, Incorporated reopened the Divide mine and made small shipments from the Divide and Yellow Jacket claims. During 1956, Hidden Splendor Mining Company became the operator of the Far West mine. There was no production during the year from the Big Buck Brunke lease.

In June 1957, Homestake Mining Company began production from its North Alice mine on the northern nose of the anticline. Access to the orebodies was via a 3,300-foot decline. Later in the year Lisbon Uranium Corporation began production from Judy Lee orebody via the 550-foot deep Columbia shaft. Also in 1957, shipments commenced from the Dorothy May claim via the Standard tunnel. This was a joint venture between Standard Metals and Col-U-Mex, Incorporated. Production resumed at Standard's Big Buck Brunke lease and Lyle Francis resumed mining at the Service Berry. In 1957, Jen, Incorporated acquired the E. L. Cord properties. Production by Jen would cease in 1960. Lisbon Uranium acquired the properties of the Little Beaver Mining Company and

produced some 14,717 tons averaging 0.35 percent  $U_3O_8$  from the Skunkovich No. 2 claim in 1957. The property would remain idle until 1963.

Under a separate contract, AT(05-01)-753, Uranium Reduction Company began serving as an ore purchasing agent for the AEC in 1957 at a buying station at the Moab mill. This was done to provide a market for independent producers in the area. Total production in 1957 was 641,386 tons of ore averaging 0.39 percent  $U_3O_8$  and containing 5,034,429 pounds  $U_3O_8$  (Table 1, Figure 3). This was an increase of nearly 1.3 million pounds over 1956.

On April 9, 1958, Lisbon Uranium Corporation collected the first, and only, \$10,000 bonus under the AEC's Domestic Uranium Program Circular 2 which expired on April 11, 1958. This bonus was for 20 tons of ore averaging at least 20 percent  $U_3O_8$ . The ore came from the Ike-Nixon shaft and was 22.25 tons which averaged 22.92 percent  $U_3O_8$ . Including the bonus, Lisbon was paid \$61,016.72 for this truckload (Albrethsen and McGinley, 1982). Production by Lisbon Uranium from the Ike-Nixon shaft would continue into 1960, at which time the shaft would be closed.

In May 1958, Lyle Francis began production from the Pats Property mine in the  $N\frac{1}{2}$   $NW\frac{1}{4}$  Section 1, T.31S., R.25E. Access was via a 115-foot decline. When Francis completed mining in 1961 a total of 3,238 tons of ore grading 0.22 percent  $U_3O_8$  and 0.47 percent  $V_2O_5$  had been produced. The mine workings connected with those in the adjacent School Section 36 mine.

Drilling by Anderson Development Corporation in the spring of 1958 located an orebody in the Cutler Formation in the  $NW\frac{1}{4}$  Section 3, T.31S., R.25E. on the Velvet claims. The claims were acquired by Kerr-McGee Oil Industries, Incorporated. Subsequently, Shattuck Denn Mining Corporation, as the operator, began sinking an 840-foot shaft in June 1958. This mine was known as the Bardon shaft and initial production was achieved in early 1959. The ore was shipped to the Kerr-McGee mill at Shiprock, New Mexico.

During 1958, monthly ore production averaged 64,000 tons per month. Some 77 percent of the production went to the Ute mill at Moab, 15 percent mainly Jen, Incorporated, was shipped to

the Vitro mill at Salt Lake City, and 8 percent the low lime, high vanadium ores, were shipped to various mills with vanadium circuits on the Colorado Plateau (AEC, unpublished memo, 1958).

On November 24, 1958, the AEC announced that beginning in 1962, it would only purchase uranium concentrates from ore reserves that had been discovered and proven to exist prior to November 24, 1958. This announcement caused exploration to all but cease. However, development drilling for mine planning etc. continued.

In 1958, production increased by some 1.4 million pounds  $U_3O_8$  over the previous year. During 1958, 774,911 tons of ore averaging 0.41 percent  $U_3O_8$  and containing 6,416,891 pounds  $U_3O_8$  were shipped (Table 1, Figure 3).

Production continued to increase in 1959 and reached an all-time annual record of pounds  $U_3O_8$  produced, some 6,687,646 (Table 1). These pounds were contained in some 814,619 tons of ore that averaged 0.41 percent  $U_3O_8$ . Mines that produced ore in 1959 included (north to south) the North Alice, Far West, Hecla, Cord, Columbia, La Sal, Ike, Mi Vida, Big Buck Brunke lease, Big Buck 9-10A, Dorothy May, Bardon, Divide, Pats Property, and School Section 36. Initial production was achieved in 1959 by Standard Uranium at the Big Buck 11A-12 mine in the NW $\frac{1}{4}$ , NW $\frac{1}{4}$  Section 13, T.30S., R.24E. The initial shipment consisted of 2,558 tons of ore which averaged 0.41 percent  $U_3O_8$ . This mine would not produce again until 1964. Access was via a 1,200-foot adit from the rim of Big Indian Valley (Figure 2).

On June 1, 1959 five uranium companies merged into Atlas Minerals, a subsidiary of the Atlas Corporation. The companies included Hidden Splendor Mining Company, Lisbon Uranium Corporation, Rio de Oro Uranium Mines, Incorporated, Mountain Mesa Uranium Company, and Radium King Mines, Incorporated. This merger would combine major uranium resources in the Lisbon Valley area.

By 1960 uncertainties of the AEC's uranium procurement program were beginning to be seen. Production dropped some 2.3 million pounds  $U_3O_8$  from the previous year. Production in 1960 was 668,064 tons of ore that averaged 0.33 percent  $U_3O_8$  and contained 4,447,743 pounds  $U_3O_8$  (Table 1, Figure 3). One



new mine, the Louise, commenced production in 1960. The orebody on the Louise claim in the NE $\frac{1}{4}$  NE $\frac{1}{4}$  Section 14, T.30S., R.24E., was accessed via a 2,200-foot adit driven from the Elizabeth No. 2 claim in NW $\frac{1}{4}$  NW $\frac{1}{4}$  Section 13 (Figure 2). Rimledge Uranium Company was the operator for Atlas. In 1960 Atlas began production from Mamie claim in Section 27, T.29 $\frac{1}{2}$ S., R.24E., via the Columbia shaft. The claim was owned by Uranium Reduction Company. During 1960 Red Rock Development Company became the operator of the Divide property. Anderson Brothers began operating the School Section 36 mine, under Utah State Lease No. 17661. Also in 1960, Standard Uranium Corporation changed its name to Standard Metals Corporation.

The Columbia No. 1 is a single claim in the NW $\frac{1}{4}$  SE $\frac{1}{4}$  Section 33, T.29S., R.24E. It was jointly owned by Col-U-Mex Incorporated and Standard Metals. During 1960 Atlas mined ore for the owners while mining on the adjacent Judy Lee No. 1 claim. The ore was hoisted via the Columbia shaft. Mining on the Columbia No. 1 would continue into 1963.

During the summer of 1960, the workings of the Bardon shaft extended into the Red Rock claims in adjacent Section 4. Some 1,769 tons of ore averaging 0.33 percent  $U_3O_8$  and 1.85 percent  $V_2O_5$  were shipped from the Red Rock claims in 1960. The Bardon shaft was put on standby by Shattuck Denn in late 1960.

A small decline in production occurred in 1961 when 660,018 tons averaging 0.31 percent  $U_3O_8$  and containing 4,061,834 pounds  $U_3O_8$  were produced (Table 1, Figure 3).

#### AEC Allocations and Stretchout, 1962 - 1970

The AEC allocation system (market quotes) for ores discovered prior to November 24, 1958 went into effect on April 1, 1962. Circular 5, Revised, was no longer in effect and mill operators were required by the AEC to pay independent producers "reasonable prices" for their ore.

During 1962 Anderson Brothers resumed mining at School Section 36, which was inactive in 1961. In August 1962, the

Uranium Reduction Company was merged into the Atlas Corporation and the Atlas Minerals Division became the operator of the mill and the Mi Vida mine.

In 1962 Atlas began producing from the Pearl and Dorothy May claims via the Louise mine. The Pearl claim is contiguous to the Louise claim on the west, and the Dorothy May is contiguous

on the east. Production from the Pearl would continue in 1965 and from the Dorothy May into 1964. Production declined slightly in 1962 when 439,672 tons of ore averaging 0.44 percent  $U_3O_8$  and containing 3,891,689 pounds  $U_3O_8$  were produced (Table 1, Figure 3).

The AEC's "stretchout" program was announced November 17, 1962. This program offered mill operators the option of deferring a portion of the  $U_3O_8$  contracted for delivery to the AEC in 1963-1966, and delivering it in 1967 and 1968. In return, in 1969 and 1970 the AEC would purchase an additional quantity of  $U_3O_8$  equal to the amount deferred. The price to be paid for the deferred material would be \$8 per pound  $U_3O_8$ , the same as in the 1962-1966 contracts. The price to be paid in 1969 and 1970 would not exceed \$6.70 per pound  $U_3O_8$ . On December 10, 1964, Atlas signed a "stretchout" agreement with the AEC, and agreed to defer some 3.5 million pounds of  $U_3O_8$ .

Texwood, Incorporated, a joint venture between Texas Zinc Minerals Corporation and Woodmont, Incorporated, began production in 1963 from School Section 2 (T.30S., R.24E.), Utah State Lease No. 4606. Mining would continue through 1965. The orebody in the SW $\frac{1}{4}$  of the section was mined via a decline which had its portal in the NW $\frac{1}{4}$  Section 11, T.30S., R.24E. (Figure 2). This decline would also provide access for the Atlas orebodies in adjacent Section 3 on the Expectation, Ale, and Stinko claims.

Vanadium Corporation of America (VCA) acquired the Shiprock mill and mining properties of Kerr-McGee in March 1963. Included in this sale was the Bardon shaft on the Velvet claims in southeastern Lisbon Valley. VCA did some clean-up mining during the summer of 1963 at the Bardon and then permanently capped the shaft. Total production from this Cutler ore body was

35,898 tons which averaged 0.38 percent  $U_3O_8$  and 1.15 percent  $V_2O_5$ . Nicols and Stocks reopened the Service Berry mine in 1963. Atlas closed the Far West mine during the year. Production from Lisbon Valley in 1963 was 452,231 tons containing 4,198,808 pounds  $U_3O_8$  and averaging 0.46 percent  $U_3O_8$ .

Drilling in 1962 by Mountain Mesa Uranium Company in Section 26, T.30S., R.25E. established the existence of ore deposits on the northeast (down dropped) side of one of the branch faults of the main Lisbon Valley fault. Previously, ore deposits were only known on the southwest side of the Lisbon Valley fault (Figure 2). Ore on the down dropped side of the fault was confirmed in 1964 during mining at the Costanza mine in adjacent Section 35. The Costanza mine was developed by an inclined shaft in a steeply dipping fault block. This small deposit produced only 1,156 tons of ore averaging 0.38 percent  $U_3O_8$  during 1964.

When the Atlas-operated ore-buying station closed in 1964, it had purchased a total of 154,028 tons of ore averaging 0.54 percent  $U_3O_8$  for the AEC. Nearly all of this ore came from Lisbon Valley. Atlas subsequently bought this ore from the AEC as well as some ore from the AEC ore-buying station in Monticello, that closed on March 31, 1962. In all, Atlas acquired from the AEC some 879,404 tons of ore that averaged 0.39 percent  $U_3O_8$  (Albrethsen and McGinley, 1982).

In 1964, Atlas became the operator of the Radon mine (Hecla shaft), and closed it later in the year. The company resumed mining at the Skunkovich claim with access via the Fraser tunnel. Standard Metals resumed production from the Big Buck 11A-12 mine in 1964 and would continue into 1966. The host rock was the Moss Back sandstone. No production was reported from Standard's Big Buck 9-10A mine in 1964. Homestake closed the La Sal shaft during the year.

Production in 1964 was 494,048 tons of ore with an average grade of 0.47 percent  $U_3O_8$  and containing 4,686,113 pounds  $U_3O_8$  (Table 1, Figure 3). This grade represents the highest annual average for Lisbon Valley production (Table 1).

By the end of 1964, some 2,200,000 feet of drilling had been done on the southwestern flank of the Lisbon Valley anti-

cline. Over 3,000 holes, spaced 200 to 500 feet apart, had been drilled with the ore belt (Wood, 1968).

Humeca Exploration Company, a partnership of Jim Hudson, Don Meyer, and Eldon Card, acquired a land position in 1963-1964 on the northeast side of Lisbon Valley fault at the north end of the anticline. A total of 105 unpatented claims comprising 2,573 acres, were either staked or leased in Sections 15, 21, 22, 23, 26, 27 and 28, T.29N., R.24E. (Rio Algom, 1971). Funds were raised for a drilling project to test the extension of the ore belt across the fault.

Between May 1964 and July 1965, Humeca drilled five deep holes (2,500 feet  $\pm$  each), in the center of Section 21, and in the southwest corner of Section 22. Interpretation of Century Geophysical Company gamma ray logs of these holes indicated that two holes penetrated up to 33 feet of Moss Back sandstone and two to eight feet of uranium ore (Wood, 1968). This discovery established the occurrence of uranium ore in the downthrown block northeast of the main Lisbon Valley fault at the north end of the anticline.

During 1965 production dropped to 1,327,241 pounds  $U_3O_8$ , the lowest level since 1954 (Table 1, Figure 3). This decline was due to cutbacks by many operators due to the "stretchout" program. During 1965 Atlas acquired Rimledge's equity in the Louise mine and operated only it and the Fraser tunnel mines. Other operating mines were Homestake's North Alice, Texwood's Section 2, Anderson's School Section 36, and Red Rock's Divide. Standard Metals shipped from their three Big Buck mines (Brunke lease, 9-10A, 11A-12). By the end of 1965, Atlas had shut their mines down and had laid off all employees except nine, due to uncertainties of the uranium market (Carl H. Dixon, personal communication, 1989).

The only operating mines during 1966 were the North Alice, the Brunke lease, Big Buck 9-10A and 11A-12, and the Divide. Standard Metals produced some ore from the Dorothy May claims, adjacent to Big Buck 12 workings during the year. The Brunke lease (Big Buck 8-8A) was mined out and closed during 1966. As the result of mine closures, production in 1966 was only 70,360 tons that averaged 0.44 percent  $U_3O_8$  and contained 612,597 pounds  $U_3O_8$ .



In 1967, Atlas added an acid leach, solvent extraction circuit to the Moab mill in order to recover vanadium from certain stockpiled ores. The circuit began operating in June 1967 and operated for 18 months before a fire destroyed the solvent extraction systems for both uranium and vanadium. The mill was closed for the first six months of 1969.

During 1967 Atlas resumed mining at the Louise, Fraser tunnel, Columbia shaft, and in Section 3 via the Texwood decline. Atlas also produced some ore from the Small Fry claims via the Columbia shaft. Shipments from the Ann claim, adjacent to the Skunkovich No. 2 began in 1967 and continued through 1969. Access was via the Fraser tunnel. Anderson Brothers resumed mining at School Section 36 and CPS Mining Company worked at the Mi Vida. There was no mining at the Divide mine, but operations continued at the North Alice and at Big Buck 9-10A. Production totalled 141,788 tons of ore that averaged 0.31 percent  $U_3O_8$  and contained 884,559 pounds  $U_3O_8$ . Beginning in 1967 and continuing through the AEC program to 1971, the grades of the annual production dropped as the available, better grade ore was depleted.

During 1968 mining continued by Atlas, Homestake, Standard Metals, and the Anderson Brothers. During the year, Atlas resumed operations at the Mi Vida mine. Shipments from the Pearl claim also resumed. Production was 266,965 tons of ore with an average grade of 0.23 percent  $U_3O_8$  and contained 1,254,731 pounds  $U_3O_8$  (Table 1, Figure 3).

Rio Algom Mines Limited of Canada took an option from Humeca for their acreage, and drilled an additional 75 holes in 1966 and 1967. This drilling indicated an orebody of over a million tons with an average grade of about 0.37 percent  $U_3O_8$  at a depth of 2,550 feet (Rio Algom, 1971).

Based on the evaluations of the drilling results in 1968, Rio Algom Limited made the decision to acquire the Humeca property. Contracts for 8.4 million pounds  $U_3O_8$  were obtained and the development of a mine-mill complex began (Rio Algom, 1971). Some 7.9 million pounds  $U_3O_8$  were contracted to Duke Power Company of Charlotte, North Carolina and an additional 500,000 pounds were to be delivered to a Swedish utility (Rio

Algom, 1980). Construction of the Lisbon mine and mill infrastructure began in 1969. During the exploration drilling, water was encountered in the Entrada and Navajo Sandstones. The holes were plugged with concrete to prevent mixing of the aquifers, but also to prevent water from entering the mine.

Exploration by Atlas Minerals in the late 1960's discovered significant orebodies in the Cutler Formation on the Reprise (Section 3, T.30S., R.24E.) and Bacardi (Section 11, T.30S., R.24E). claims in the central part of the ore belt. The Rio Algom developments created considerable interest in the northeastern flank of the anticline, however, exploration drilling by various companies failed to locate any orebodies.

During 1969, Atlas began production from the Cutler ore body on the Bacardi claim via a new decline. The decline had its portal in Steen Canyon in the SW $\frac{1}{4}$  Section 11, T.30S., R.24E. (Figure 2). During the year, Atlas operated the Cord shaft and produced from the Jen, Jackie and Pasco claims. Other producers included Anderson Brothers, Homestake and Standard Metals. Production in 1969 declined slightly to 201,715 tons of ore which averaged 0.21 percent  $U_3O_8$  and contained 828,518 pounds  $U_3O_8$  (Table 1, Figure 3).

The Reprise orebody in the Cutler Formation began producing in 1970. It was reached via a decline from the workings on the Stinko claims in Section 3, T.30S., R.24E. Production from the Reprise would continue through 1972. Access to the orebodies in Section 3 was via the Texwood decline. There was no production from the School Section 36 mine in 1970, but production continued at Homestake's North Alice and Standard's Big Buck 9-10A mines. Jim Butt reopened the San Juan shaft during the year. He planned to do clean-up mining in the Moss Back orebodies on the Small Fry claims. Production during the year totalled 316,311 tons of ore containing 1,414,332 pounds  $U_3O_8$  and averaging 0.22 percent  $U_3O_8$  (Table 1, Figure 3). The highest level since 1964.

During the period 1948 through 1970 the ore deposits in the Chinle and Cutler Formations in Lisbon Valley produced some 7,184,846 tons of ore containing 53,636,121 pounds  $U_3O_8$  which averaged 0.37 percent  $U_3O_8$  (Table 1). This represents about

12 percent of the total uranium produced in the United States during that time period. Beginning in the late 1960's, the AEC allowed milling companies to make sales of uranium concentrate to private utilities. As the result, some ore was produced for these "outside sales". Records of the AEC indicate that during 1967-1970 only 19,730 tons of ore containing 128,819 pounds  $U_3O_8$  and averaging 0.33 percent  $U_3O_8$  were produced from the North Alice and Big Buck properties for outside sales.

During the AEC program some 2,704,757 tons of Lisbon Valley ore was analyzed for vanadium oxide ( $V_2O_5$ ) at ore-buying stations and at mills in Colorado. These ores contained 18,500,289 pounds  $V_2O_5$  (Table 2). The AEC paid for vanadium (\$0.31/pound) in most ores but it was recovered only at mills with vanadium circuits.

Through 1970, the mill at Moab processed some 6,354,733 tons of ore averaging 0.34 percent  $U_3O_8$  and containing 43,762,217 pounds  $U_3O_8$ . Some 38,498,711 pounds of  $U_3O_8$ , in concentrate was produced for the AEC and 3,420,460 pounds  $U_3O_8$  were for outside sales. In addition, some 1,254,611 pounds of  $V_2O_5$  were recovered (Albrethren and McGinley, 1982). The AEC procurement program ended at midnight December 31, 1970.

#### The Private Market, The Beginning and the Boom 1971-1980

Beginning in 1971, all uranium concentrate produced in the United States was for use in nuclear power plants for the generation of electricity. It was an open market with competition among all producers. At the beginning of 1971, the spot market price for uranium was \$6.20 per pound of  $U_3O_8$  in concentrate. Mills had ore purchase schedules for independent ore producers with the prices depending on their contracts with utilities.

During 1971 production dropped slightly to 349,397 tons of ore averaging 0.18 percent  $U_3O_8$  and containing 1,290,617 pounds  $U_3O_8$  (Table 3, Figure 3). During the year, Atlas Minerals became the operator of the Big Buck claims, and resumed production at the 11A-12 mine and a small shipment was made from the Big Buck 4A-5 (Cutler). The 9-10A mine was closed. Other

mines operated by Atlas in 1971 included the Columbia, Texwood decline, Mi Vida, Bacardi, Fraser tunnel, and the Louise. Mining at the Louise also included production from the adjacent Pearl claim. Homestake continued mining at the North Alice, as did Jim Butt at the San Juan shaft.

Rio Algom Corporation's Lisbon mine commenced production in the spring of 1972 and the first concentrate was produced in October 1972 (Purvance, 1978). This mine was serviced by two 18 foot diameter, concrete lined shafts that were sunk to depths of 2,665 feet and 2,686 feet respectively. The former (northern) was the production shaft and the latter (southern) was the ventilation shaft (Figures 2 and 5). The two shafts were connected with a 4,000-foot sublevel haulage drift. The mill used an alkaline leach process and had a capacity to process 500 tons of ore per day, but was expanded to 750 tons per day (Rio Algom, 1980). The mine was developed and the mill constructed at a cost of more than \$23 million (Rio Algom, 1980).

While doing assessment drilling on the La Sal group of claims in the NW $\frac{1}{4}$  Section 34, T.29 $\frac{1}{2}$ S., R.24E., in the early 1970's, Homestake Mining Company discovered a sizeable orebody in the Cutler Formation. This deposit, named the La Sal No. 2 would not be mined until 1980-1981.

During the years 1971 to 1979 the annual uranium production for Lisbon Valley ranged from between 1,290,617 and 1,886,084 pounds  $U_3O_8$  per year (Table 3, Figure 3). As Rio Algom reached their capacity in 1973, production by Atlas, Homestake and a few small operators began to decline. Approximately 65 percent of the uranium produced during the period 1971 through 1979 came from Rio Algom's Lisbon mine. In 1972, Atlas began shipments from the new Ash mine in Section 13, T.30S., R.24E., but shut it down until 1979. Bejo Mining Company took over the San Juan shaft in 1972 and would continue clean up mining on the Small Fry claims until mid 1974. Red Rock Development shipped ore from the Divide mine in 1972 and 1973.

In 1973 Atlas reduced operations and shipped ore from the Louise, Mi Vida, Bacardi, and Big Buck 11A-12 operations. Trident Mining Company reopened the School Section 36 mine and would produce





Figure 5. Aerial view looking northwest across drill sites of Rio Algom's Lisbon orebody. Note the production shaft near center of photo and the ventilation shaft in the lower left. Photo was taken in 1969 when both shafts were under construction. The Lisbon Valley fault is just to the left of the road in the upper left and the dump of the North Alice mine is on the left center margin. Photo from AEC files.

ore in 1973 and 1974. Atlas closed the Louise mine in 1973. Production in 1973 increased as the Lisbon mine reached its planned capacity (Table 3, Figure 3).

During 1974, Atlas closed the Mi Vida and Big Buck 11A-12 mines and reopened the Brunke lease. In 1974, Atlas opened up a new mine in the SW $\frac{1}{4}$  SE $\frac{1}{4}$  Section 2, T.30S., R.24E., Utah State Lease No. 23489, known as School Section 2 (Figure 2). This was a Cutler ore deposit which was a northwesterly continuation of the ore on the Big Buck nos. 4A and 5 claims. Mining of this low grade (0.10 percent  $U_3O_8$ ) would continue into 1979. Mining continued at the Bacardi. A 2,000 ton clean-up shipment by Atlas, from the dump of the Bardon shaft averaged only 0.07 percent  $U_3O_8$ . Ore was also shipped from the Brunke lease. Homestake shipped some 70,000 tons of material from the dumps of the North Alice and La Sal shaft during the year, which averaged 0.07 percent  $U_3O_8$ . During 1974, Atlas drove a new decline, named the Patti Ann, to replace the Columbia shaft for access to orebodies in the SE $\frac{1}{4}$  Section 33, T.29S., R.24E. (Figure 2). Overall, production during 1974 showed a slight decline to 1,721,352 pounds  $U_3O_8$  (Table 3, Figure 3). Exploration drilling by Atlas in 1974 discovered the Cub orebody in southeastern Lisbon Valley in SE $\frac{1}{4}$ , Section 26, T.30S., R.25E. (Figure 2). The orebody was in a downfaulted block, between branch faults of the main Lisbon Valley fault. This ore would not be mined until 1980.

Production declined in 1975 to 376,365 tons of ore averaging 0.19 percent  $U_3O_8$  and containing 1,448,034 pounds  $U_3O_8$  (Table 3, Figure 3). This decline was mainly due to the fact that no independent operators, including Homestake, shipped during the year. Atlas continued mining at its Bacardi and commenced production at the Patti Ann decline. Final shipments would be made from the Bacardi deposit in 1976. The Wood Lease mine on Three Step Hill, E $\frac{1}{2}$  E $\frac{1}{2}$  Section 1, T.31S., R.25E., at the southeastern end of the mining area commenced production in 1975. This Moss Back orebody was mined via a 400-foot decline. An orebody in the Cutler Formation adjacent to the Wood mine, in Section 6, T.31S., R.26E., was discovered, but never mined.

Uranium prices increased markedly in the mid 1970's, and by August 1976 were over \$40 per pound of  $U_3O_8$  in concentrate. This increased price allowed operators to mine lower grade material for sales on the spot market. Long term contracts such as those of Rio Algom and Atlas generally were at lower prices.

During 1976 Minerals West, Incorporated of Monticello, Utah, reopened the Mi Vida mine. Homestake's mining contractor, JRJ Mining Company, resumed shipments from the North Alice. Atlas continued mining at the Patti Ann and Wood mines. Shipments were made from the Brunke lease, Louise, and School Section 2 ore-bodies. Atlas reopened the Far West shaft in 1976 and would continue production into 1978. Production during 1976 was 517,053 tons of ore which averaged 0.16 percent  $U_3O_8$  and contained 1,629,184 pounds  $U_3O_8$  (Table 3, Figure 3).

During the early and mid 1970's there was little exploration drilling due to the depressed uranium market. As uranium prices rose and the demand increased in the late 1970's there was a slight increase in exploration especially in the southeastern part of the district. Using a mineralized hole drilled by VCA, southeast of the Bardon shaft as a guide, drilling by Atlas in the late 1970's discovered a large orebody in the Cutler Formation southeast of the Bardon shaft (Figure 2). This deposit, the Velvet, was developed by a 3,500-foot long decline (Figure 2). Production from the Velvet mine commenced in late 1979.

During 1975-1977, Ranchers Exploration and Development Corporation drilled on the Small Fry claims in the E $\frac{1}{2}$  Section 27 and the NE $\frac{1}{4}$  Section 34, T.29 $\frac{1}{2}$ S., R.24E. This exploration located a significant tonnage of low grade ore. A few years later, some 169,000 tons of material averaging 0.09 percent  $U_3O_8$  was mined from the deposit and stockpiled on the property (John Motica, personal communication, 1990).

Production during 1977 remained nearly the same as the previous year although the average grade increased from 0.16 to 0.20 percent  $U_3O_8$  (Table 3). The average grade of ore produced by mines in the area reached an all time low of 0.15%  $U_3O_8$  in 1978 (Table 3). This was in response to the high

uranium (\$43.00) price on the spot market. During 1978 a clean-up shipment was made from the Pats Property mine and Dee Reay began mining at the Big Buck 11A-12 mine. In 1978, Homestake Mining Company closed their North Alice mine which had commenced production in 1957 and had produced slightly over 4.5 million pounds  $U_3O_8$ .

During 1979, Energy Fuels Nuclear Incorporated became the operator of the Mi Vida mine and Mineral Recovery Corporation reopened the School Section 36 mine. Dee Reay made a small shipment from the Big Buck 11A-12 mine. Atlas continued mining at the Wood and Patti Ann mines and resumed operations at the Ash mine. Production from the new Velvet mine began in late 1979. The School Section 2 mine closed in 1979.

#### The Domestic Market Collapses, 1980-Present

During 1980, the spot market price for uranium dropped from \$40 to \$27 per pound  $U_3O_8$ . Only existing contracts kept the mill operators alive. Shipments from Atlas' Velvet mine would boost the 1980 production from Lisbon Valley to 431,335 tons averaging 0.30 percent  $U_3O_8$  and containing 2,587,860 pounds  $U_3O_8$  (Table 3, Figure 3). This represents the highest annual production in Lisbon Valley in the post-AEC period (Figure 3). Atlas also operated the Louise, Patti Ann, Wood, Ash and Texwood decline (Section 3) mines. Kelmines Corporation's Cub mine commenced production in late 1980. This mine is located in a fault block in SE $\frac{1}{4}$  SE $\frac{1}{4}$  Section 26, T.30S., R.25E., approximately  $\frac{1}{4}$  mile north of the Costanza mine. Homestake Mining Company commenced production from an orebody in the Cutler Formation at the La Sal No. 2 mine. The orebody in the NW $\frac{1}{4}$  34, T.29 $\frac{1}{2}$ S., R.24E. and the portal of the 3,200 foot long decline is in NW $\frac{1}{4}$  of adjacent Section 35. Minor production continued at the Big Buck 11A-12, Mi Vida and School Section 36 mines.

Atlas closed the Wood, and Texwood (Section 3) mines in 1980, but continued at the Velvet, Ash, and Patti Ann in 1981. The latter two would be closed later in the year. Mining continued at the La Sal No. 2, Cub, Mi Vida, Big Buck 11A-12 and School



Section 36. Total production during 1981 remained fairly high, due to the Velvet, at 408,053 tons of ore averaging 0.31 percent  $U_3O_8$  and containing 2,510,460 pounds  $U_3O_8$  (Table 3, Figure 3). Although Homestake closed the La Sal No. 2 mine in 1981, significant reserves remain on the property.

Rio Algom Corporation's contract with Duke Power was fulfilled in 1981. New contracts and spot market sales kept the Lisbon mine-mill operating. After completion of its Duke contract, Rio Algom installed equipment, to sample and purchase independent ores. This allowed Rio to begin custom and/or toll milling in 1983 for other operators in Lisbon Valley and in the Moab area. Production continued to decline in 1982 as only 263,998 tons with an average grade of 0.33 percent and with 1,722,965 pounds  $U_3O_8$  were shipped (Table 3, Figure 3). The principal producers were the Velvet and Lisbon mines. Other active mines were the Cub, Mi Vida, Big Buck 11A-12, and School Section 36.

During 1983, due to low spot market prices, which ranged from \$20 to \$24 per pound  $U_3O_8$ , production fell sharply to 573,734 pounds  $U_3O_8$ . This was over a million pounds less than the previous year.

Due to continued low uranium prices, Atlas Minerals closed all of their mines, which included the Velvet in southeastern Lisbon Valley, and mill in March 1984. When the Velvet mine was closed it had produced approximately 400,000 tons of ore which graded 0.46 percent  $U_3O_8$  and 0.64 percent  $V_2O_5$ . Also in 1984, Rio Algom took over the Mi Vida mine and continued small scale production. After Atlas closed, all ore from the Mi Vida was removed via the Fraser tunnel. Operators at the Cub and Big Buck mines shipped their ore to Rio Algom as did Hecla Mining Company who shipped much of the Small Fry stockpile. Although Atlas closed early in the year, production from Lisbon Valley during 1984 increased slightly to 784,750 pounds  $U_3O_8$  (Table 3, Figure 3).

During the period 1978 through 1984, Atlas Minerals recovered some 5,760,000 pounds  $V_2O_5$  from Lisbon Valley ores. The majority

of this vanadium came from the Velvet ores, but also contributing were the Wood, Cub, Mi Vida, and Big Buck mines.

Between 1985 and 1988, the annual ore production from Lisbon Valley, Rio Algom's Lisbon mine plus a few smaller operations such as the Cub, Big Buck, and Mi Vida ranged from between 344,000 and 656,000 pounds  $U_3O_8$  (Table 3, Figure 3).

In October 1988, Rio Algom Corporation closed it's Lisbon mine and mill, due to a depressed uranium market. The spot price for uranium in October 1988 was \$13.75 per pound  $U_3O_8$ . Since 1972, Rio's Lisbon mine had produced over 13 million pounds  $U_3O_8$  in ore that averaged 0.25 percent  $U_3O_8$  (M. D. Lawton, personal communication, 1989).

In spite of the depressed market a small amount of exploration drilling took place in the southeastern part of the area during the mid 1980's. Much of this was due to Atlas' discovery of the Velvet deposit in an area once thought to have been well explored. About 1987, Uranerz USA, Incorporated announced a discovery in southeastern Lisbon Valley. This discovery on Three Step Hill in Section 7, T.31S., R.26E., is reported to contain some 2.5 million pounds  $U_3O_8$  (Figure 2).

At about the same time of this discovery, Energy Fuels Nuclear, Incorporated acquired most of the properties on the southwest side of the Lisbon Valley fault from the Mi Vida mine northwesterly to the Far West mine (Figure 2). Energy Fuels did drilling in 1987 and 1988 to evaluate the ore potential of the Cutler Formation. The results were reported as favorable but further work was put on hold due to the current (1990) depressed condition of the uranium market. In the summer of 1989, Umetco Minerals Corp. acquired the Velvet mine from Atlas Minerals. Umetco's interest in the property was due to the vanadium content of the remaining reserves.

#### S U M M A R Y

During the 41 years, 1948-1988, the uranium mines in Lisbon Valley were operating, a total of 12,778,662 tons of ore contain-

Table 3: Uranium Ore Production, Lisbon Valley  
San Juan County, Utah, 1971-1988

Year	Tons of Ore	Pounds $U_3O_8$	Percent $U_3O_8$
1971	349,397	1,290,617	0.18
1972	340,605	1,293,100	0.19
1973	384,722	1,886,084	0.25
1974	408,706	1,721,352	0.21
1975	376,365	1,448,034	0.19
1976	517,053	1,629,184	0.16
1977	410,659	1,619,316	0.20
1978	503,863	1,531,872	0.15
1979	429,256	1,495,463	0.17
1980	431,335	2,587,860	0.30
1981	408,057	2,510,460	0.31
1982	263,998	1,722,965	0.33
1983		573,750	
1984		784,800	
1985	769,800 <u>1/</u>	593,006	0.23 <u>1/</u>
1986		656,300	
1987		589,000	
1988		344,100	
TOTAL	5,593,816	24,277,257	0.22

1/ Estimated

Source: 1971 - 1982, Unpublished resource area production records, U.S. Department of Energy, Grand Junction, Colorado office.  
1983 - 1988, Data provided by Atlas Minerals Division and Rio Algom Corporation.

ing 77,913,378 pounds of  $U_3O_8$  were produced (Table 4). This amounts to slightly over nine percent of the total domestic uranium produced by mines during the same period (Energy Information Administration, 1989, p. 27).

Based on all available information, at least 6,355,000 pounds  $U_3O_8$  were produced from the Cutler Formation in the Lisbon Valley area (see appendix). This would account for eight percent of the total production from the area. Not included in this amount is Cutler ore which would have been mined from the Lisbon, Far West, Hecla, and Cord mines where ore-bearing Cutler rocks were observed in the mine workings.

In addition to the uranium, over 19 million pounds of vanadium oxide ( $V_2O_5$ ) were known to be associated with some of the ores, especially in the central and southern parts of the area. Vanadium was recovered at various mills on the Colorado Plateau, including the alkaline leach circuit at the Moab mill. No vanadium was recovered at the Vitro mill at Salt Lake City.

Uranium production during the AEC procurement period, 1948-1970, was 53,636,121 pounds  $U_3O_8$  (Table 1), or 69 percent of the total uranium produced from the area. The original 12 claims staked by Charles A. Steen produced approximately 12.3 million pounds  $U_3O_8$ , or nearly 16 percent of the total Lisbon Valley production. With the exception of the Jackpile - Paquate area in Cibola County, New Mexico, Lisbon Valley, Utah has produced more uranium than any area of similar size in the United States.

## OUTLOOK AND POTENTIAL RESOURCES

When mining ceased at Lisbon Valley, due to the depressed uranium market of the 1980's, considerable reserves remained developed, especially at mines such as the Velvet. The current (May, 1990) spot market price of \$8.80 per pound  $U_3O_8$  does not inspire mining in the near future. However, a price of \$20 - \$30 per pound in the 1990's would likely revive uranium production in Lisbon Valley.

Table 4: Summary of Uranium Ore Production, Lisbon Valley,  
San Juan County, Utah, 1948-1988

Period	Tons of Ore	Pounds $U_3O_8$	Percent $U_3O_8$
1948 - 1970	7,184,846	53,636,121	0.37
1971 - 1988	<u>5,593,816</u>	<u>24,277,257</u>	<u>0.22</u>
TOTAL	12,778,662	77,913,378	0.30



The ore deposits in the Moss Back Member of the Chinle Formation on the southwest flank of the Lisbon Valley anticline occur in a well defined mineralized belt. Exploration drilling, to date, has failed to locate extensions of the belt at both the northwest and southeast parts of the area. The density of drilling within the belt precludes the discovery of new ore deposits in the Moss Back.

Deposits in the Cutler Formation, especially in the southeastern part of the area, do not occur within the belt, as seen at the Velvet and Uranerz deposits (Figure 2). Past exploration within the northern half of the belt has generally been restricted to the Moss Back. Here, the potential to locate additional deposits in the Cutler Formation, such as the Bacardi, Reprise, La Sale No. 2 is excellent.

#### A C K N O W L E D G E M E N T S

This report would not have been possible without the assistance of the following people. Peter Mygatt, Public Affairs Specialist with the Department of Energy's Grand Junction Projects Office allowed access to the AEC files and other material stored in the archives. Linda M. Edwards of UNC Geotech, DOE's prime contractor, helped locate considerable material in the archives. Carl H. Dixon, Atlas Minerals Division, provided invaluable information on overall activities in the area for the past 30 years. Mervyn D. Lawton, retired president of the Rio Algom Corporation provided information on Rio Algom activities. Eugene W. Grutt, Carl W. Appelin, and Gary C. Huber reviewed the manuscript; their comments are greatly appreciated.

## R E F E R E N C E

- Albrethsen, H., Jr., and McGinley, F. A., 1982, Summary history of domestic uranium procurement under U.S. Atomic Energy Commission contracts, final report: U.S. Department of Energy Report GJBX-220(82) 162 p.
- Campbell, J. A., and Steele-Mallory, B. A., 1979, Uranium in the Cutler Formation, Lisbon Valley, Utah, in Baars, D. L., editor, Permianland, a field symposium: Four Corners Geological Society, Guidebook, Ninth Field Conference, p. 23-32.
- Dare, W. L., 1957, Mining methods and costs, Continental Uranium Inc., Continental No. 1 mine, San Juan County, Utah: U.S. Bureau of Mines Information Circular 7801, 20 p.
- Dare, W. L., and Delicate, D. T., 1957, Mining methods and costs--La Sal Mining and Development Co., La Sal uranium mine, San Juan County, Utah: U.S. Bureau of Mines Information Circular 7803, 48 p.
- Dare, W. L., and Durk, R. R., 1956, Mining methods and costs, Standard Uranium Corp., Big Buck mine, San Juan County, Utah: U.S. Bureau of Mines Information Circular 7766, 51 p.
- Dix, G. P., Jr., 1953, The uranium deposits of Big Indian Wash, San Juan County, Utah, with drilling recommendations: U.S. Atomic Energy Commission Open File Report RME-10, p. 17-23.
- Energy Information Administration, 1989, Uranium industry annual 1988: U. S. Department of Energy Report DOE/EIA - 0478(88), 121 p.
- Hilleary, J. K., 1957, Drilling in the Big Indian Wash area, San Juan County, Utah, engineering report: U.S. Atomic Energy Commission Report TM-146, 6 p.
- Huber, G. C., 1981, Geology of the Lisbon Valley uranium district, southeastern Utah, in Epis, R. C., and Callender, J. F., editors, Western Slope Colorado: New Mexico Geological Society 32nd Guidebook, p. 177-182.
- Lekas, M. A., and Dahl, H. M., 1956, The geology and uranium deposits of the Lisbon Valley anticline, San Juan, Utah, in Geology and economic deposits of east central Utah: Intermountain Association of Petroleum Geologists Guidebook 7th Field Conference, p. 161-168.
- Lindstrom, P., 1964, Experience at the Radon uranium mine: Mining Engineering, vol., 16, no. 12, p. 56-59.
- Meyers, B., 1954, Big boom at Big Indian: Engineering and Mining Journal, vol. 155, no. 4, p. 96-99.

- Purvance, D., 1978, Geology of the Lisbon mine, San Juan County, Utah, in Shawe, D. R., editor, Guidebook on fossil fuels and metals, eastern Utah and western-southwestern-central Colorado: Colorado School of Mines Professional Contributions No. 9, p. 53-54.
- Rasor, C. A., 1949, Interim report on examination of Big Indian Wash uranium properties, San Juan County, Utah: U.S. Atomic Energy Commission Open File Report RMO-1014, 19 p.
- Rio Algom Corporation, 1971, Applicants environmental report, operating license stage for uranium concentrator: Rio Algom Corporation report, 104 p.
- Rio Algom Corporation, 1980, Lisbon operations: Rio Algom Corporation Report RAC 1-3R1, 9 p. [mine visitors handout]
- Steen, C. A., Dix, G. P., Jr., Hazen, S. W., Jr., McClellan, R. R., 1953, Uranium- mining operations of the Utex Exploration Co. in Big Indian District, San Juan County, Utah: U.S. Bureau of Mines Information Circular 7669, 13 p.
- Stewart, J. H., 1957, Proposed nomenclature of part of Upper Triassic strata in southeastern Utah: American Association of Petroleum Geologists Bulletin, vol. 41, no. 3, p. 441-465.
- Teichman, R. A., Jr., Fisk, I. T., and McLelland, J. I., 1956, Preliminary drilling report, Big Indian Wash district, San Juan County, Utah, Contract No. AT(05-1)-225: U.S. Atomic Energy Commission Technical Memorandum 80, 10 p.
- U.S. Atomic Energy Commission, 1949, Information for the press: U.S. Atomic Energy Commission Press Release No. 5, 1 p.
- U.S. Atomic Energy Commission, 1954a, AEC issues regulation providing for uranium leases: U.S. Atomic Energy Commission Press and Radio Release No. 52, 2 p.
- U.S. Atomic Energy Commission, 1954b, Provisional uranium ore-buying station established at Moab, Utah: U.S. Atomic Energy Commission Press and Radio Release No. 70, 2 p.
- U.S. Atomic Energy Commission, 1956, Photogeologic map of the Lisbon Valley anticline and surrounding area, San Juan County, Utah: U.S. Atomic Energy Commission Preliminary Map No. 3, scale 1" = 4,000 ft.
- U.S. Atomic Energy Commission, 1959a, Big Indian district, in Guidebook to uranium deposits of western United States: U.S. Atomic Energy Commission Report RME-141, p. 2-31-2-44.
- U.S. Atomic Energy Commission, 1959b, Monticello district, in Mine operation data report: U.S. Atomic Energy Commission Report AEC-PED-1, p. 110-123.

- Weir, G. W., and Puffett, W. P., 1981, Incomplete manuscript on stratigraphy and structural geology and uranium-vanadium and copper deposits of the Lisbon Valley area, Utah-Colorado: U.S. Geological Survey Open File Report 81-0039, 306 p.
- Wood, H. B., 1968, Geology and exploration of uranium deposits in the Lisbon Valley area, Utah, in Ridge, J. D., editor, Ore deposits of the United States, 1933-1967: American Institute Mining, Metallurgical, and Petroleum Engineers, Inc., vol. 1, p. 770-789.

# A P P E N D I X

Estimated ore production from the Cutler Formation.

MINE NAME	LOCATION			POUNDS $U_3O_8$
	S	T(S)	R(E)	
LaSal No. 2	34	29½	24	45,000
School Section 2	2	30	24	380,000
Reprise*	3	30	24	295,000
Big Buck 4A, 5,6	11	30	24	7,000
Bacardi	11	30	24	1,153,000
Bardon	3	31	25	275,000
Velvet	3	31	25	<u>4,200,000</u>
Total				6,355,000

\*Mined via the Texwood decline

Note: Cutler mines shown in italics on Figure 2.



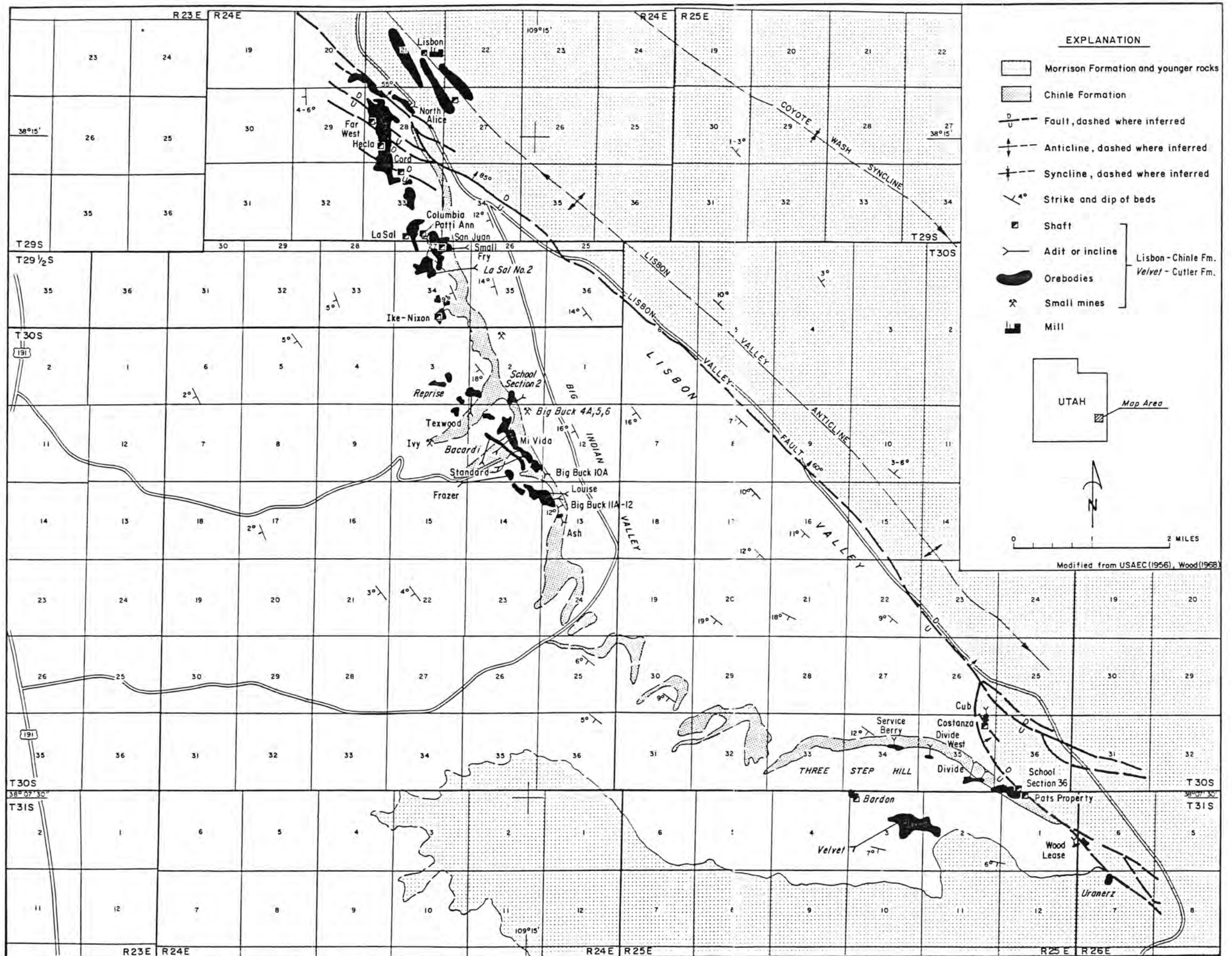


Figure 2. Map of the Lisbon Valley Anticline showing mines and orebodies, San Juan County, Utah