RME-125

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UNITED STATES ATOMIC ENERGY COMMISSION
GRAND JUNCTION OPERATIONS OFFICE
PRODUCTION EVALUATION DIVISION

URANIUM DEPOSITS OF THE URAVAN MINERAL BELT

by

H. B. Wood

and

M. A. Lekas

June, 1958
(Grand Junction, Colorado)

OFFICE MEMORANDUM . UNITED STATES GOVERNMENT

TO : R. D. Nininger, Assistant Director for Exploration, DRM, Washington
DATE:

FROM : Elton A. Youngberg, Assistant Manager for Operations, Grand Junction

SUBJECT: TRANSMITTAL OF REPORT RME-125

SYMBOL : P:DDB

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INTRODUCTION

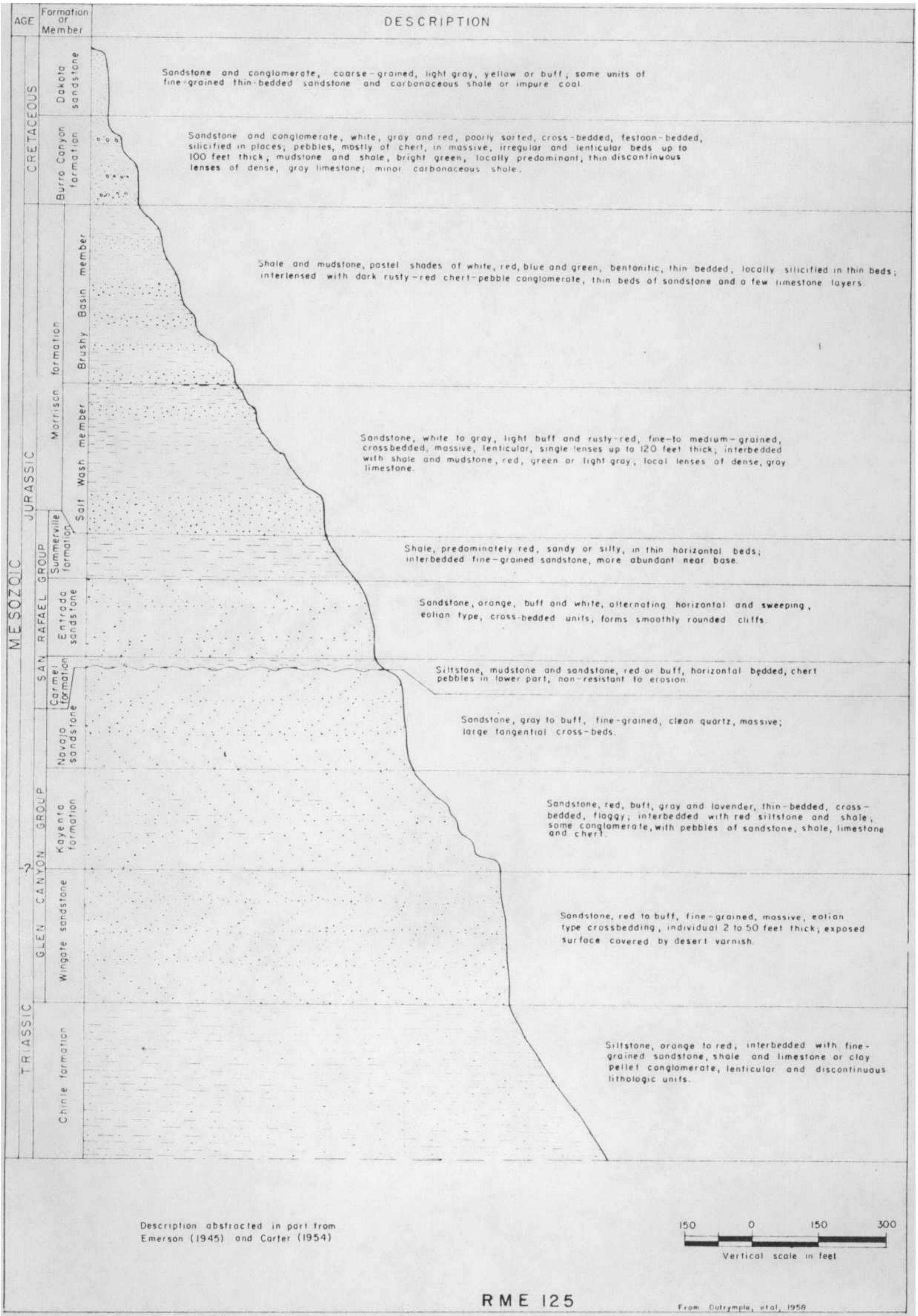
The Uravan Mineral Belt in southwestern Colorado (fig. 1) is "a narrow, elongate area in which the carnotite deposits generally have closer spacing, larger size, and higher grade than those in the adjoining areas and the region as a whole" (Fischer and Hilpert, 1952).

Mining of uranium-vanadium deposits began in the Roc Creek area of Montrose County, Colorado, in 1881. The mineral carnotite was first described and named from a specimen collected from this area in 1898 (Coffin, 1921). From 1904 until 1914 mining for radium was widespread throughout the Belt from Slick Rock to Gateway. Shipments averaged 1 to 2 percent U_3O_8 and 2 to 5 percent V_2O_5. In 1922 radium from the Belgian Congo depressed the market, and most of the Uravan mines closed. Mining for vanadium became important in 1936 and continued until 1944 when the government ore purchasing program terminated. The district was again dormant until 1948 when the Atomic Energy Commission established an ore-buying schedule for uranium. Further stimulation came in 1951 when the AEC raised the base price for uranium and established an initial production bonus and other benefits. From 1948 to January 1, 1958, 680 mines have shipped 3,408,300 tons of uranium-vanadium ore with an average value of $29.50 per ton. During the last half of 1957 production averaged 55,311 tons per month from 403 mines. Two processing mills are completely dependent upon ore from this area, and 3 other mills are partially dependent.

Between November 1947 and April 1956 the U. S. Geological Survey under memorandum agreement with the U. S. Atomic Energy Commission had 2,047,762 feet of exploration drilling done in the Belt. Between May 1949 and October 1955 the Atomic Energy Commission had 642,752 feet drilled. Private drilling during this period is estimated to have been many times as much as government drilling.

STRATIGRAPHY AND STRUCTURE

A brief summary of the stratigraphy is shown in fig. 2. The Salt Wash member of the Morrison formation is the host rock for practically all of the uranium deposits. The Morrison is divided into two members: an upper Brushy Basin member, 290 to 500 feet thick, and the Salt Wash member, 280 to 400 feet thick. Total thickness of the Morrison ranges from 600 to 800 feet. The Salt Wash " . . . was formed as a large alluvial plain or "fan" by an aggrading system of braided streams diverging to the north and east from an apex in south-central Utah . . . the member was derived mainly from sedimentary rocks. The Salt Wash deposits grade from predominantly coarse texture at the apex of the "fan" to predominantly fine texture at the margin of the "fan" . . . the Brushy Basin member consists mainly of variegated claystone with a few lenticular conglomeratic sandstone strata . . . It consists of sediments formed in fluvial and lacustrine environments and contains large amounts of clay, part of which is bentonitic and was probably



Sandstone and conglomerate, coarse-grained, light gray, yellow or buff; some units of fine-grained thin-bedded sandstone and carbonaceous shale or impure coal.

Sandstone and conglomerate, white, gray and red, poorly sorted, cross-bedded, festoon-bedded, silicified in places; pebbles, mostly of chert, in massive, irregular and lenticular beds up to 100 feet thick; mudstone and shale, bright green, locally predominant; thin discontinuous lenses of dense, gray limestone; minor carbonaceous shale.

Shale and mudstone, pastel shades of white, red, blue and green, bentonitic, thin bedded, locally silicified in thin beds; interlensed with dark rusty-red chert-pebble conglomerate, thin beds of sandstone and a few limestone layers.

Sandstone, white to gray, light buff and rusty-red, fine-to medium-grained, crossbedded, massive, lenticular, single lenses up to 120 feet thick; interbedded with shale and mudstone, red, green or light gray; local lenses of dense, gray limestone.

Shale, predominately red, sandy or silty, in thin horizontal beds; interbedded fine-grained sandstone, more abundant near base.

Sandstone, orange, buff and white, alternating horizontal and sweeping, eolian type, cross-bedded units, forms smoothly rounded cliffs.

Siltstone, mudstone and sandstone, red or buff, horizontal bedded, chert pebbles in lower part, non-resistant to erosion.

Sandstone, gray to buff, fine-grained, clean quartz, massive; large tangential cross-beds.

Sandstone, red, buff, gray and lavender, thin-bedded, cross-bedded, flaggy; interbedded with red siltstone and shale; some conglomerate, with pebbles of sandstone, shale, limestone and chert.

Sandstone, red to buff, fine-grained, massive, eolian type crossbedding, individual 2 to 50 feet thick; exposed surface covered by desert varnish.

Siltstone, orange to red; interbedded with fine-grained sandstone, shale and limestone or clay pellet conglomerate, lenticular and discontinuous lithologic units.

Description abstracted in part from Emerson (1945) and Carter (1954)

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From Dalrymple, et al, 1958

Figure 2. Geologic column, Bull Canyon, Colorado

derived from falls of volcanic ash. The source area for many of the fluvial deposits of the Brushy Basin member may have been the same as that for the Salt Wash member . . ." (Craig and others, 1955, pp. 125-126).

The Uravan Belt crosses a series of northwest-trending salt anticlines within the Paradox Basin. The north end of the Belt trends west to northwest, subparallel to the anticlines, but the southern part crosses the anticlines nearly at right angles. The crests of the Paradox and Gypsum Valley anticlines have collapsed and most of the collapsed blocks have been removed by erosion. Commercial uranium deposits occur in some of the dropped blocks of Salt Wash sandstone in Little Gypsum Valley and Paradox Valley.

LITHOLOGIC AND SEDIMENTARY FEATURES RELATED TO ORE DEPOSITS

The Salt Wash member is a series of fluvial mudstone and sandstone lenses. The sandstone lenses crop out in three to eight cliffs or "rims" with intervening mudstone slopes. The uppermost rim contains most of the ore deposits, but some occur in lower sandstone lenses. There are a rew ore deposits in coarse conglomeratic sandstones at the base of the overlying Brushy Basin member. Individual sandstone lenses may be traced for as much as half a mile along the outcrop (fig. 3), and lenses as much as 2 miles wide and more than 6 miles long have been traced by drilling. Larger ore deposits normally occur near the edge of the thicker sandstone units where there is transition to a sandy mudstone.

The sandstone lenses are separated laterally by areas of higher ratios of mudstone to sandstone and vertically by fairly persistent mudstone beds. The sandstone lenses represent the coarse material deposited in scoured-out stream channels and vary in direction of elongation from northeast to east to southeast. These are normally the lenses which constitute favorable ore-bearing ground. The channel sandstones are characterized by poor sorting, angular conglomerates, and an intricate pattern of sedimentary structures such as torrential cross-bedding, scour and fill features, interbedded thin mudstones, contorted bedding and even brecciation. The latter features are probably due to compaction and slumpage contemporaneous with deposition and consolidation. Mudstone lenses a few inches thick and mudstone "galls" and angular fragments are common within the sandstone units.

Near ore deposits the outcropping sandstone units are normally pale to light yellow-brown or tan and speckled with brown limonite stain. Mudstone lenses within the host rock are gray to gray-green, and the top of a mudstone unit underlying a sandstone lense is normally bleached from red-brown to gray-green for a vertical distance of 6 inches to 5 feet. Slickensides and brecciation slump structures are common in the mudstones, particularly along the edges of the thicker sandstone lenses and in "roll" type deposits. Some mudstone units are highly uraniferous and are mined as ore. Hard barren sandstone pods, cemented with calcite, often border part of the deposit or surround it as an irregular halo 5 to 15 feet away.

ORE DEPOSITS

Much of the ore occurs in small pods of only 10 to 500 tons. Clusters of such pods close enough together to be mined as a unit form typical

Fig. 3 Upper ore-bearing sandstone of Salt Wash member, Morrison formation. Sandy mine, Atkinson Mesa, Montrose County, Colorado.

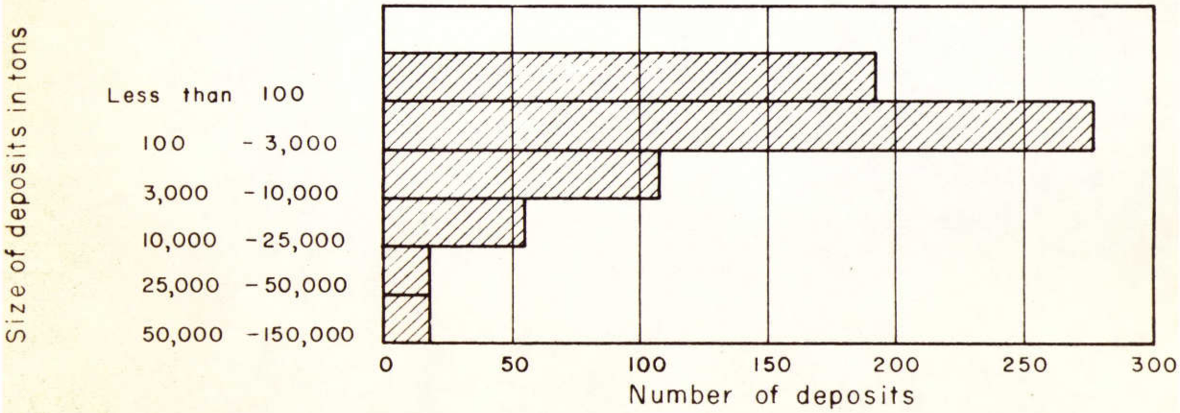


Fig. 4 Size distribution of 666 uranium deposits in the Uravan Mineral Belt

ore bodies. These ore bodies range up to 150,000 tons, but 70 percent of them are less than 3,000 tons. There are a few continuous ore bodies larger than 25,000 tons in every mining district, but these are not common. Figure 4 shows the statistical distribution of the size ranges of 666 ore deposits.

The average deposit mined is between 2 and 9 feet thick, but in larger deposits the ore may be as much as 30 feet thick. Ore occurs in both bedded and roll type deposits. The bedded type as a flat, pancake shape. The roll type ore bodies are elongate, continuous or contiguous bodies as much as 600 feet long with either an hour-glass or crescent cross-section (fig. 5). They are usually as thick, normal to the bedding, as they are wide. The rolls often display color banding and faint curved fractures parallel to the banding. Normally the concave surface of a C or crescent, roll faces the thicker section of the sandstone lens. As described by Shawe (1956), "Many rolls of uranium-vanadium ore show concentric layering parallel to ore surfaces. Commonly, the concave surfaces of rolls show sharp transitions into barren rock, whereas the convex sides of rolls commonly show more gradual transition into barren rock or may even be continous laterally into tabular ore bodies."

The roll ore bodies are often elongated parallel to the sedimentary trends and parallel to the edges of the sandstone lenses in which they occur.

MINERALOGY

Weeks (1956) has described the mineralogy of the uranium-vanadium deposits. Common ore minerals of the unoxidized, black, normally wet deposits are uraninite ($UO_2 \cdot UO_3$), coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$, montroseite ($VO(OH)$, and vanadium hydromica or clay. Carnotite ($K_2(UO_2)_2(VO_4)_2 \cdot 1\text{-}3\ H_2O$), tyuyamunite ($Ca(UO_2)_2(VO_4)_2 \cdot 7\text{-}10.5\ H_2O$), corvusite ($V_2O_4 \cdot 6V_2O_5 \cdot nH_2O$), a variety of bright-colored vanadates, and vanadium hydromica or clay are common in oxidized, gray to yellowish-gray, fairly dry, near surface deposits. The ore minerals occur principally as impregnations of sandstone and mudstone with some replacement of carbon, calcite, silica, and clay.

Bulk of the ore mined has been from oxidized deposits. Average grade is 0.28 percent U_3O_8 and 1.62 percent V_2O_5. The ratio of uranium to vanadium varies from 1:4 at the north end of the Uravan Belt to 1:8 at the south end.

According to Shawe, Simmons and Archbold (1957, p. 59-60), ore deposits in the Slick Rock district also contain about 0.07 percent copper, 0.018 percent lead, 0.0014 percent cobalt 0.0008 percent nickel, 0.022 percent zinc, 0.021 percent arsenic, 0.0044percent molybdenum, and less than 0.0001 percent antimony.

ORIGIN OF THE DEPOSITS

Despite intensive study of the Uravan Mineral Belt by numerous geologists, there is no general agreement as to origin of the uraniferous deposits.

Waters and Granger (1953) believe that the uranium may have been derived from rhyolitic tuffs in the Brushy Basin member, or from Tertiary hydrothermal solutions; Shawe, Simmons and Archbold (1957, p. 63) suggest that heated

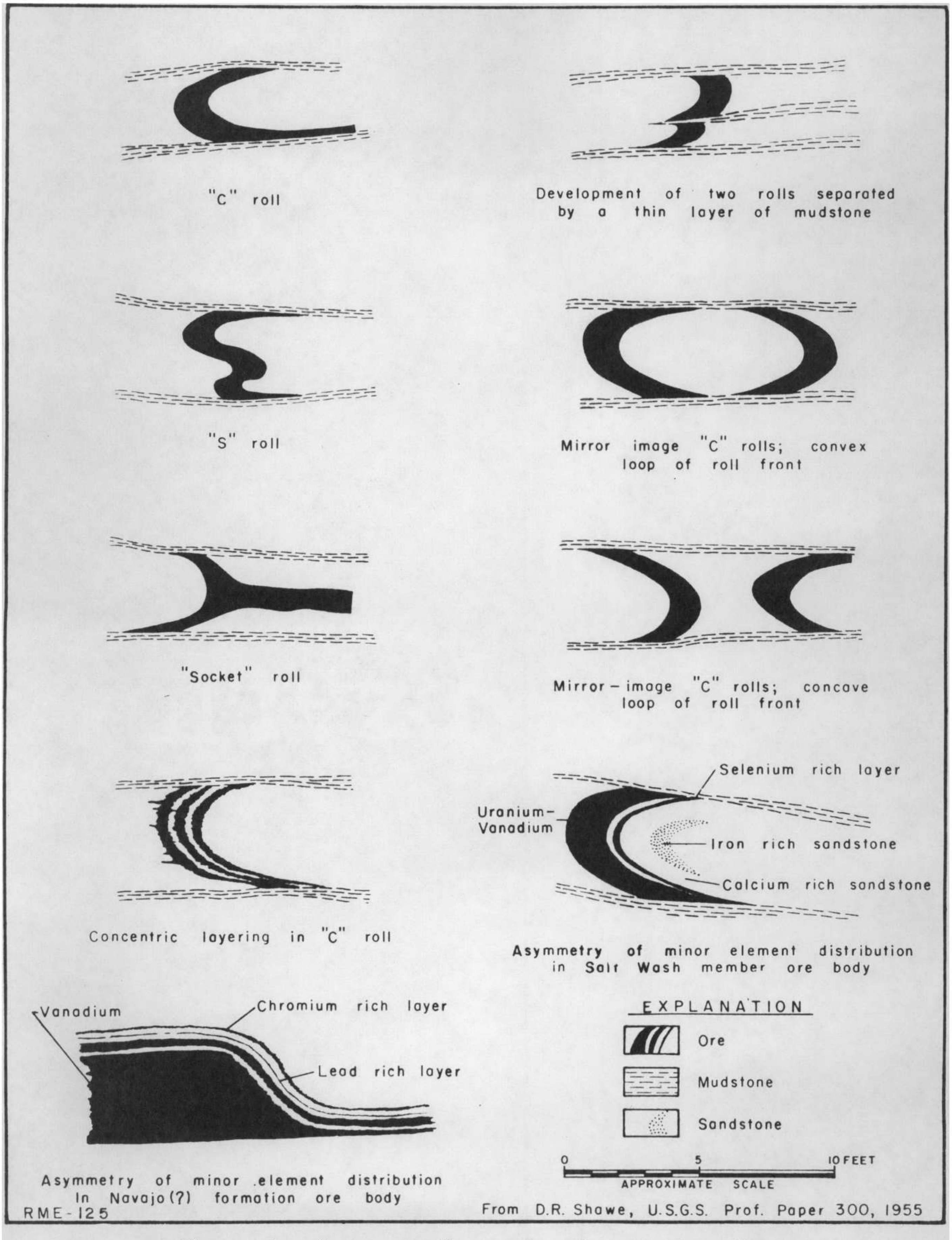


Figure 5. Cross-sections of roll ore deposits

connate water leached uranium from detrital heavy minerals in sedimentary rocks. Concentration of the uranium content of ground waters in the host rock, by evaporation and plant transpiration during Morrison time, is suggested by Phoenix (1958, p. 416). A hydrothermal source from the La Sal Mountain intrusives, or deep-seated intrusives, has been suggested by many geologists, and Reinhardt (1952, pp. 4-7) has described the Uravan deposits as forming part of two disconnected rings around the La Sal Mountains.

The ore solutions may have been connate, meteoric, hydrothermal, or groundwater, or any of these commingled. In the Salt Wash, the movement of solutions was lateral through the host sandstone, with the flow controlled by the permeability of the rock (Phoenix, 1956). Permeability was largely controlled by lithology, although in some cases it appears to have been increased by fractures.

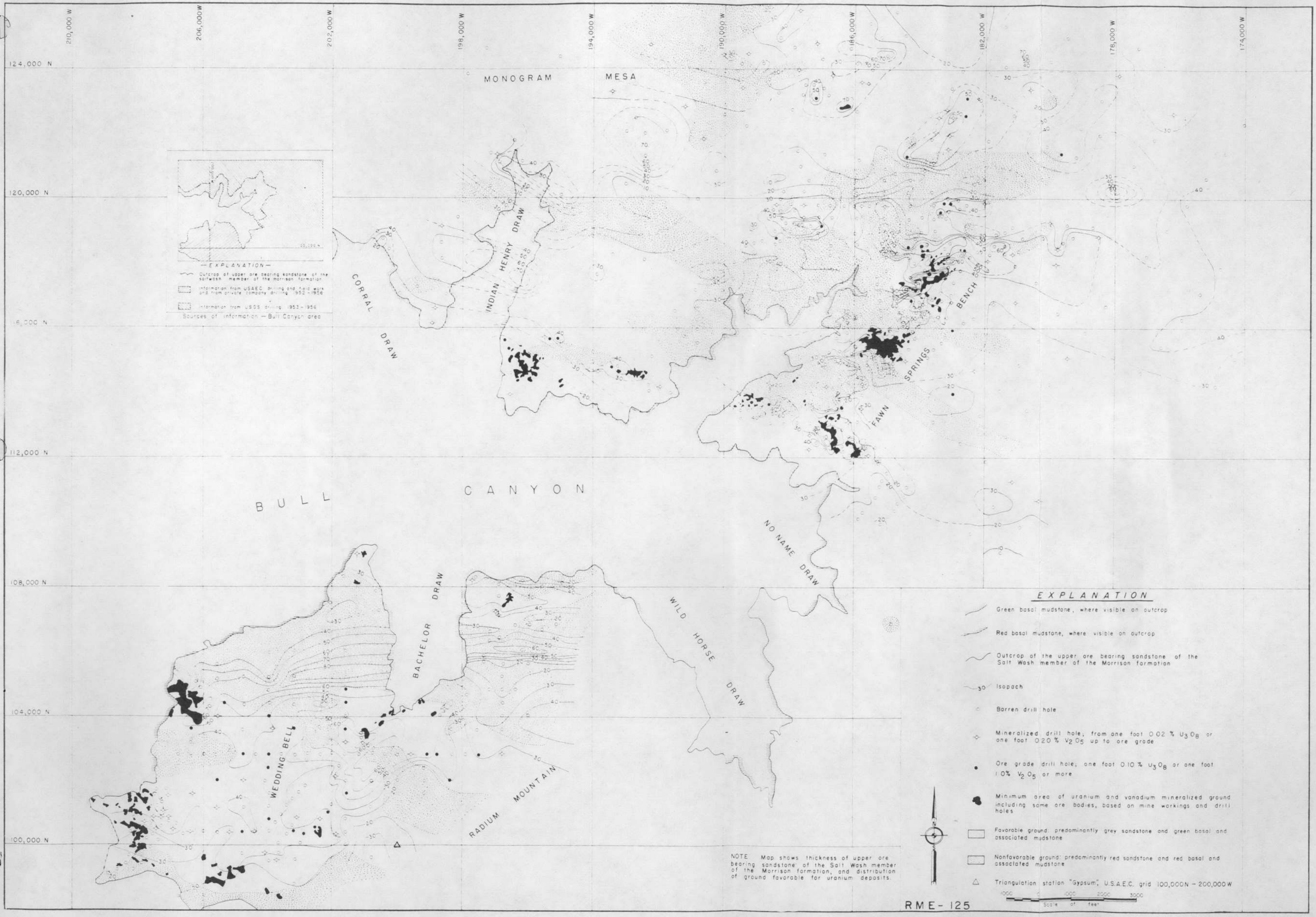
Precipitation of the ore minerals appears to have been caused by change in equilibrium of the transporting solutions largely through changes in the oxidation state, or acidity, of the solution. This could have been caused by carbon (reduction and increase in acidity), decrease in pressure associated with constriction in the solution pathways (exsolution of volatiles) (Roach and Wallace, 1957), or precipitation at an interface between solutions of different composition and density (Shaw, 1956).

EXPLORATION AND MINING METHODS AND COSTS

Most deposits were discovered by prospectors searching the outcrops of Salt Wash sandstone for radioactivity and for coloring by oxidized uranium and vanadium minerals. The outcrops have been thoroughly prospected, and various geophysical and geochemical techniques have given negative or inconclusive results. Prospecting is now largely limited to drilling or drifting. Most of the exploration has been carried on where the Salt Wash has lithologic characteristics considered favorable for occurrence of ore deposits, and is at a depth of less than 400 feet.

Criteria of favorable ground (fig. 6) vary from area to area, but the characteristics first used by geologists of the U. S. Geological Survey (Weir, 1952), and now used with some modifications by mining companies, are generally applicable. A table of favorability criteria is established for each area and a relative value is assigned to each lithologic feature in order that a number value for favorability may be assigned to each hole drilled. Favorability standards are established from experience in an area, and these are the bases for delineation of favorable ground for additional drilling of offset or in-between holes. The following is a hypothetical example of criteria for the upper sandstone unit. The importance of criteria and their values will vary from area to area:

	Value
1. Composite thickness of the upper sandstone unit	
Thickness 30 to 60 feet	10
Thickness greater than 60 feet	6
Thickness 15 to 30 feet	6



NOTE Map shows thickness of upper ore bearing sandstone of the Salt Wash member of the Morrison formation, and distribution of ground favorable for uranium deposits.

Figure 6. Favorability and isopach map of the upper ore bearing sandstone, Bull Canyon area, Montrose and San Miguel Counties, Colorado

	Value
2. Color of sandstone host rock	
Light gray with greenish-gray mudstone splits and stringers	7
Light gray and massive	5
Light brown and massive with limonite speckling	3
3. Color and thickness of mudstones either over or under the potential host rock	
Greenish-gray mudstone 4 feet thick or thicker	7
Greenish-gray mudstone 1 to 4 feet thick	5
Greenish-gray mudstone less than 1 foot thick	3
4. Clay pebble conglomerate bed or a mixture of mudstone and sandstone indicating slump structure or turbulent deposition	
5 feet thick or more	5
1 to 5 feet thick	2
5. Abundance of woody carbon as trash, logs or stringers	5
Scattered carbon	2
6. Ratio of sandstone to mudstone of 2:1 to 3:1 in the upper unit	4
7. Host rock at or below water table	4
8. Abundance of gypsum seams filling fractures or bedding planes	3
9. Ribs or knobs of hard calcareous sandstone	3

The sum criteria-values in each hole provides a figure for a favorability contour map of the area. The summation number may classify the hole as follows: 34 to 48 favorable; 20 to 34 semi-favorable, and below 20 unfavorable.

Favorable ground may also be delineated statistically by grid drilling an area with holes spaced 200 to 400 feet apart. If a certain percentage of the holes are found to be ore or mineralized, the entire area drilled is considered favorable; if not, the area is abandoned.

Exploration drilling is normally carried out in three stages: First, wide space grid drilling, with holes 500 to 1,000 feet apart, is used to delineate favorable areas. Within the favorable areas, second stage holes are located 75 to 500 feet apart, depending upon the target size, to locate mineralized ground. In the third stage, offset holes are drilled around the ore or mineralized holes to delineate ore. Square grid patterns are common, but a diamond grid is often used with the acute angle in the direction of ore trends.

Economic factors impose a limit on depth of mining and exploration. Table 1 gives representative costs for mining various sized ore bodies at various depths. Unless ore has been found, spacing holes at less than half the drilling depth is generally impractical, but exceptions occur,

Table 1 - Minimum size ore body that can be mined profitably at various depths, Uravan Mineral Belt

Size 1/ (tons)	Depth (ft.)	Drill hole spacing 1st Stage (ft.)	 2nd Stage (ft.)	 3rd Stage (ft.)	Cost per ton Expl. Drlg. 2/	 Mining 3/	Equipment Cost 4/	Cost of shaft or incline	Cost per ton	Gross Value 5/
1,500	75-100	500	80	40-20	$5	$12-15	$ 8,000	$ 6,000 (incline)	$26.33 to 28.33	42,750
5,000	150-180	500	150	75-50	5	12-15	20,000	18,000 (incline)	24.60 to 27.60	142,500
10,000	350-400	500	200	125	5	11-14	40,000	50,000 (shaft)	25.00 to 28.00	285,000
20,000	600-700	1,000	300	150	5	11-14	75,000	100,000 (shaft)	24.75 to 27.75	570,000
50,000	1,000-1,200	1,000	500	250	5	11-14	150,000	275,000 (shaft)	24.50 to 27.50	1,425,000

Explanation:

1/ Average thickness 3 feet; grade 0.25% U_3O_8, 1.25% V_2O_5; weight 2 tons/cu. yd.

2/ Exploration drilling costs include 1st through 3rd stages.

3/ Mining costs include labor, supplies, engineering, ventilation, pumping, camp maintenance and operating overhead; but do not include equipment, development, royalties, or interest.

4/ No allowance is included for equipment salvage.

5/ AEC Circular 5 revised value $28.50 per ton (exclusive of initial production bonus).

dependent on variations in drilling costs and on estimated size of ore target. If ore is not encountered nor a strongly mineralized area delineated by the minimum spacing of the second drilling stage, then the area is usually abandoned because exploration costs at that depth would be excessive in proportion to value of the ore body.

The cost of drilling depends on the type and depth (table 2).

	Cost per Foot		
Depth	Wagon Drilling	Non-core Rotary	Core Drilling
To 100 ft.	$0.50	$1.85	$2.50
200	0.90	1.85	2.50
300		1.85	3.00
400		1.85	4.00
500		1.85	4.50
600		1.85	4.75
1,000		2.40	6.00

Table 2 - Representative drilling costs in the Uravan Mineral Belt. January 1958

Where the host rock is less than 200 feet deep and the ground is fairly dry, air percussion drilling (wagon drilling) is usually employed. Cuttings may be collected for a chemical assay, but the normal practice is only to probe the hole with a Geiger counter.

Where the host rock is 200 to 600 feet deep, rotary drilling with roller bits is commonly used. Hole diameters vary from 3 to 5 inches and the holes are probed with Geiger counters. The anticipated ore horizon, which normally includes the lower 40 to 80 feet, is usually cored. Whenever possible, air is used as a circulating medium since water causes the hole to cave. Furthermore, wet holes must be logged immediately after drilling or the logging probe will not descend freely, and may be stuck and lost.

When wet ground is encountered or when drilling deeper than 600 feet, water is used as the circulating medium. Where drilling is carried out in untested areas and geologic information is desired, diamond core drilling is often used. Water, sometimes mixed with drilling muds, is used as a circulating medium.

Radiometric logging of drill holes with Geiger and scintillation probes has been used extensively since 1954. Most logging units are small hand-operated reels with which a gamma-ray detector is lowered into the hole. The radioactivity is registered on a meter at the surface. Larger units that automatically record the depth and radioactivity on a permanent strip log (Stead, 1956) are preferable for quantitative results. For greatest accuracy the instruments must be carefully calibrated in model holes where ore of known thickness and grade is used as a standard. Less accurate calibration may be achieved by comparing the gamma ray log with the radiometric and chemical assays of a number of cored holes in the same area. The model holes used by the AEC, which are available to the public, have a 2½-foot radius of ore, which for all practical purposes is an approach to infinity.

Models with a lesser radius of ore do not duplicate the volume of radioactive material which influences the counting rate of the detector in exploration bore holes. The greater count recorded from a larger mass, of same grade, in the exploration hole is usually erroneously interpreted to mean higher grade.

Selective mining is essential in the Uravan Mineral Belt. Mining methods vary from scraping out rich pockets with hand tools and hauling the ore out by wheelbarrow, to mechanized drilling, loading and hauling operations. Mule-drawn mine carts have been common, but are being replaced by diesel-powered, rubber-tired "Scoot-cretes" of one to two-ton capacity. Most of the major producers use small rail-mounted, air-powered muckers, and rail haulage with one- to three-ton cars pulled by compressed air or electric trams. Jackleg type drills are usually used for drilling blast holes. Operations range from two men mining 2 to 5 tons per day, to 40 men mining 100 tons per day. Production depends on the amount of development work that has to be done, the hauling distance and the method of entry.

Mining costs are fairly standard for the major producers. Table 1 gives representative costs for mining ore bodies of various sizes at various depths. Direct mining costs are about $9.00 to $12.00 per ton, exclusive of exploration, amortization and depreciation. Indirect mining costs, exclusive of exploration drilling, range up to $5.00 per ton. More than half of the mines are operated by small mining companies. Three large companies control the remainder. The mining companies may own or lease their properties. Royalty to the claim owners ranges from 10 percent to 30 percent. The small claim owner may lease his property for a royalty and the lessee becomes the controlling operator. The large companies usually operate their own or controlled property by contracting for surface drilling, road building and shaft sinking. After the orebody has been defined by drilling and access provided by shaft or incline, the mining is often by contract for a percentage payment of the gross ore receipts. This ranges from 50 percent to 70 percent depending on the size and grade of the ore body. The contractor may be reimbursed for a portion of his costs by additional payments per foot of underground development work. The contract-miner system produces a great number and variety of small mining operations.

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Fig. 1

URANIUM-VANADIUM DEPOSITS
of the
URAVAN MINERAL BELT

by R.S. Hague, S.J. Goldenstein, E. Blakey

January 15, 1957 Revised May 1, 1958

EXPLANATION

× Uranium-vanadium deposits, production and reserves up to 100 tons

○ Uranium-vanadium deposits, production and reserves over 100 tons

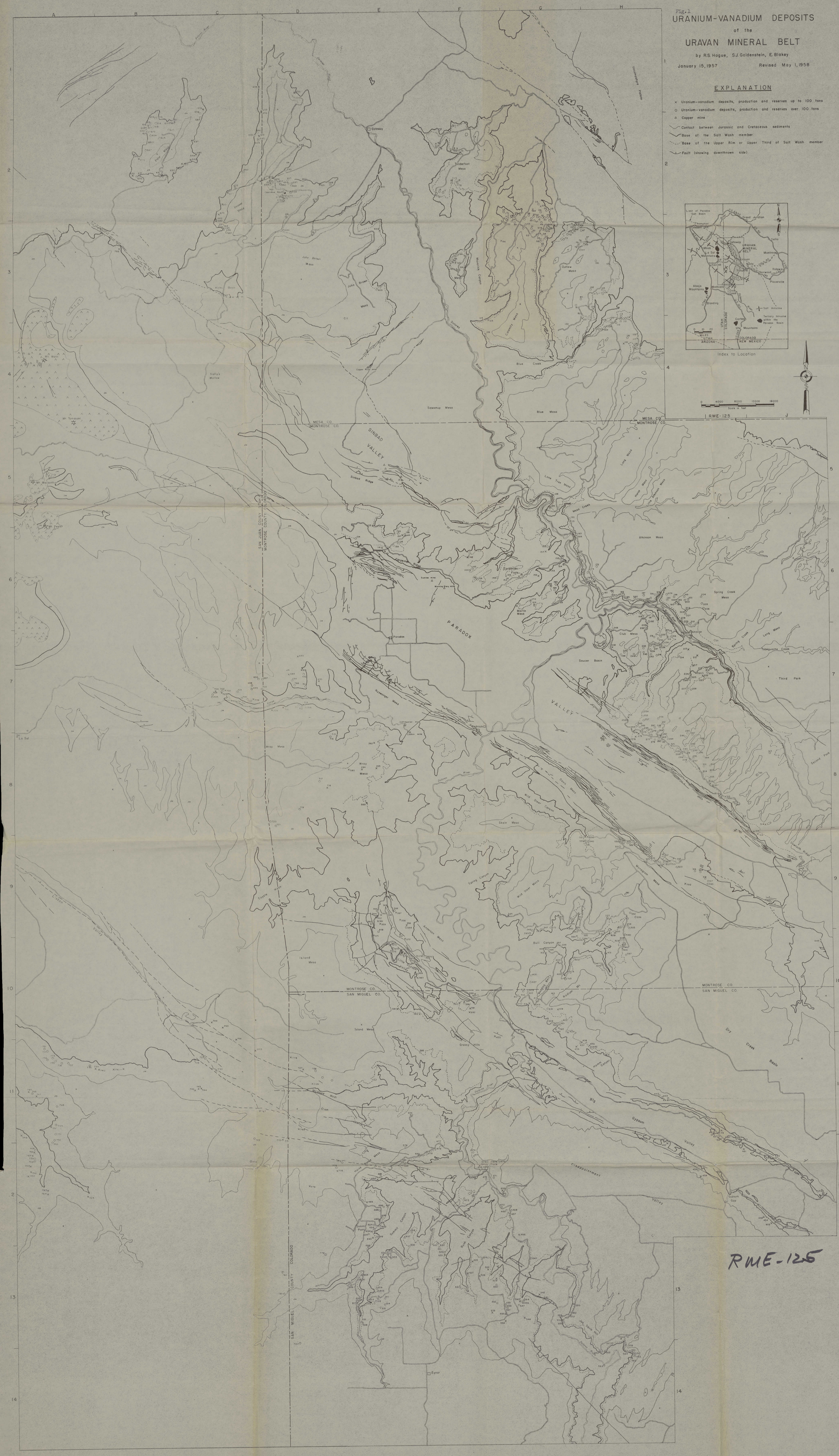
△ Copper mine

Contact between Jurassic and Cretaceous sediments

Base of the Salt Wash member

Base of the Upper Rim or Upper Third of Salt Wash member

Fault (showing downthrown side)



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1.	F2	Pay Rock #15
2.	F2	Pay Rock #1
3.	F2	Pay Rock #3
4.	F2	Ajax Mine
5.	F2	Knot Mine Fordo #6
6.	F2	Pay Rock #14 & #16
7.	F2	Pay Rock #8
8.	F2	Vana King #1
9.	F2	Vana King #2
10.	F2	Nigger Baby
11.	F2	Black Momma
12.	F2	Harvy #1 & #2
13.	F2	Fountain of Youth
14.	F2	Mammoth
15.	F2	Little Johnny
16.	F2	Okan
17.	F2	Lincoln
18.	F2	Liberty Bell #2
19.	F2	Liberty Bell #1
20.	F2	Chico
21.	F2	Humdinger
22.	G2	Arrowhead #2
23.	G2	Arrowhead #1
24.	G2	Arrowhead #18
25.	G2	Arrowhead #19
26.	G2	Arrowhead #4
27.	G2	Maverick
28.	G2	Belmont #1
29.	G2	Sunflower
30.	G3	Belmont #2
31.	G3	Hidden Treasure
32.	G3	Queen of the Hills
33.	G3	Small Spot
34.	G3	Matchless
35.	G3	Blue Ribbon #1
36.	G3	Blue Ribbon #2
37.	G3	Arrowhead #34
38.	G3	Arrowhead #33
39.	G3	Arrowhead #30
40.	G3	Arrowhead #21
41.	G3	Arrowhead #20
42.	G3	Arrowhead #5
43.	G3	Arrowhead #6
44.	G3	Arrowhead #17
45.	G3	Arrowhead #25
46.	G3	Arrowhead #14
47.	G3	Arrowhead #23
48.	G3	Arrowhead #16
49.	G3	Arrowhead #26
50.	G3	Arrowhead #27
51.	G3	Arrowhead #12
52.	G3	Arrowhead #8
53.	G3	Arrowhead #7
54.	G3	Calamity #27
55.	G3	Calamity #21
56.	G3	Calamity #2
57.	G3	Calamity #6
58.	G3	Calamity #20
59.	G3	Calamity #1
60.	G3	Calamity #9
61.	G3	Calamity #15
62.	G3	Calamity #14
63.	G3	Fraction
64.	G3	Sun
65.	G3	Snowshoe
66.	G3	Mineral Channel #1
67.	G3	Mineral Channel #9 & #11
68.	G3	July
69.	G3	Neglected
70.	G3	*Mineral Channel #5*
71.	G3	June
72.	G3	Spring
73.	G3	Crows Nest
74.	G3	Foster #1
75.	G3	Ronnie #1
76.	G3	Ronnie #2
77.	G3	G-3
78.	G3	Lavada
79.	G3	Cliffdweller #1
80.	G3	Peach #10
81.	G3	Peach #7
82.	G3	Klondyke
83.	F3	Radium #7
84.	F3	Blue Ribbon #7
85.	F3	Wasp
86.	F3	Rainbow #1
87.	F3	Rainbow
88.	F3	Depression #6
89.	F3	Depression #5
90.	F3	Depression #4
91.	F3	Depression #3
92.	F3	Depression #2
93.	F3	Depression #1
94.	F3	Big Maverick #1
95.	F3	Lee #4
96.	F3	Lee #1
97.	H3	Mineral Channel #12
98.	H3	Mesa #5 (Foster)
99.	H3	G-1
100.	H3	G-2
101.	H3	Hanson #3
102.	H3	Outlaw #17
103.	H3	Bluebird
104.	H3	Emerson
105.	H3	Blue Mesa View
106.	H1	Yellowbird #1
107.	H4	Yellowbird #3
108.	H4	Yellowbird #5
109.	H4	Yellowbird #6
110.	H4	Yellowbird #2
111.	H4	Turner
112.	H4	Eliz #17
113.	H4	Eliz #18
114.	H4	Eliz #19
115.	H4	Eliz #5
116.	H4	Eliz #9
117.	H4	Eliz #3
118.	H4	Eliz #1
119.	H4	Bonita
120.	H4	Blackbird
121.	G4	Climax
122.	G4	Tee Pee Pole
123.	G4	Stormy Treasure
124.	F4	Kanardo #3
125.	F4	Little Maverick #4
126.	F4	Little Maverick #1
127.	G5	Poor Boy
128.	G5	Quo Vadis
129.	G5	Anchor
130.	G5	Red Cow
131.	G5	Merry Christmas
132.	F5	Rock Creek Group (Rajah)
133.	E5	Redbird
134.	E6	Radium Cycle
135.	E6	Buckhorn #3
136.	E6	Buckhorn #1
137.	E6	Little Buckhorn
138.	E6	Last Chance #7
139.	E6	Last Chance #1
140.	E6	Groundhog #2
141.	E6	Buckhorn #10
142.	F6	Dorothy E
143.	F6	Judy Ann
144.	F6	Patterson Seep
145.	F6	Twin Sisters
146.	F6	Radium King
147.	F6	Copper Jack
148.	F6	Radium Queen #1
149.	G6	Waterloo
150.	G6	Shadow
151.	G6	Jitterbug
152.	G6	Last Hope
153.	G6	Eclipse
154.	G6	Dad
155.	G6	Rimrock
156.	G6	Shamrock
157.	G6	Zella #2
158.	G6	Zella #1
159.	G6	Wildhorse
160.	G6	Adak
161.	G6	Little Joe
162.	G6	North Star
163.	G6	Ral #1 & #2
164.	G6	Blackrock
165.	G6	Farmer Girl
166.	G6	Betty Jean
167.	G6	Badger
168.	G6	Crown Prince
169.	G6	Wildcat
170.	G6	Wildcat #2
171.	G6	Red Rock
172.	H6	ML #39
173.	H6	ML #47
174.	H6	Redsocks
175.	H6	Joker
176.	H6	Cliffdweller
177.	H6	Indians
178.	H6	King Solomon #5
179.	H6	Nucla
180.	H6	Ophir
181.	H6	Bluebird
182.	H6	Little Dick
183.	H6	Last Chance
184.	H6	Fox
185.	H6	Dolores
186.	H6	Club Sandwich
187.	H6	Sandy
188.	H6	Lucky Dog
189.	H6	Big Mitt
190.	H6	Irene
191.	H6	Old Salt Lick
192.	H6	ML #26
193.	I6	Star #3
194.	I6	Block B (San Miguel)
195.	I6	Star #6
196.	I6	Block D
197.	I6	Block C (San Miguel)
198.	I6	Polar Star
199.	I6	Block C (Spring Creek)
200.	I6	Block B (Spring Creek)
201.	I6	Block F (Spring Creek)
202.	I6	Block A (Spring Creek)
203.	I6	Block A (San Miguel)
204.	I6	Block J
205.	I6	Block H
206.	I6	Block I
207.	I6	Star #13
208.	I6	Wright Grp.
209.	I7	Grass Roots
210.	I7	Little Basin
211.	I7	Rock Raven
212.	I7	J. B. #4
213.	I7	Cue Ball
214.	I7	8 Ball
215.	I7	Rambler
216.	I7	Yellow Jacket
217.	I7	Windy Day
218.	I7	Rattle Snake
219.	I7	Blackfoot
220.	I7	Red Fox
221.	I7	Good Hope
222.	I7	Fairy King
223.	I7	Gray Fox
224.	I7	Merry Widow
225.	I7	Wedge #1
226.	I7	Butterfly
227.	I7	Golden Eagle
228.	I7	Forty Five Ninety
229.	H7	J. M.
230.	H7	Mill #1
231.	H7	Beaver
232.	H7	Block #7
233.	H7	Block #16
234.	H7	R. A. M.
235.	H7	Joe Jr.
236.	H7	Surprise
237.	H7	Mill #2
238.	H7	Block #11
239.	H7	ML #11
240.	H7	ML #10 (La Sal)
241.	H7	Mill #4
242.	H7	ML #24
243.	H7	Block #10
244.	H7	ML #37 (Shatlock Dunn)
245.	H7	ML #41
246.	H7	Tramp #2
247.	H7	U. S. Grant
248.	H7	Big Shot
249.	H7	ML #13
250.	H7	Buckshot
251.	H7	Carpathia
252.	H7	Badger #1
253.	H7	Peg Leg #2
254.	H7	Dorothy
255.	H7	CFC
256.	H7	ML #15
257.	H7	Moonbeam
258.	H7	Bobcat
259.	H7	Great Western
260.	H7	Tripod
261.	H7	TNT #3
262.	E8	Morning Glory
263.	E8	Howling Coyote
264.	E8	Sego Lily
265.	H8	Phonograph
266.	H8	Florence Nellie
267.	H8	ML #23
268.	H8	TNT #1
269.	H8	Happy
270.	H8	Republican
271.	H8	Sphinx
272.	H8	St. Patrick
273.	H8	Honeymoon
274.	H8	Bagger
275.	H8	Valley View
276.	H8	Paradox View
277.	H8	Henry Clay
278.	H8	Vanadate
279.	H8	Production
280.	H8	Maggie C
281.	H8	Cripple Creek
282.	H8	Colcradium
283.	H8	Donald L
284.	H8	First National Bank
285.	H8	Vanadium King #2
286.	H8	Virgin #3
287.	H8	Wednesday
288.	H8	Block J —— Brushy Basin member
289.	H8	Block I
290.	H8	Long Park
291.	H8	Block E
292.	H8	Guadalcanal
293.	H8	Mineral Park #1
294.	H8	Mineral Park #3
295.	H8	Long Park #1
296.	H8	Medea
297.	I8	Long Park #13
298.	I8	Long Park #10
299.	I8	Long Park #6
300.	I8	Long Park #9
301.	I8	Triangulation
302.	I8	Mineral Park #5
303.	I8	Whitney
304.	I8	Dan Patch
305.	I8	Firecracker
306.	I8	Birthday #2
307.	I8	Birthday #1
308.	I8	Paradox View #2
309.	I8	Paradox View #1
310.	I8	Colombus
311.	I8	Bitter Creek (Buckeye)
312.	I8	Van
313.	J8	Double Jack #1
314.	J8	Bertis Beauty #1 —— Brushy Basin member
315.	J9	Hardrock #1
316.	J9	Hardrock #2
317.	I9	JJ
318.	I9	Thunderbolt
319.	I9	Mineral Joe #8 & #9
320.	I9	Mineral Joe Incline
321.	I9	Oversight
322.	H9	Hummer
323.	H9	Blackburn
324.	H9	Joe Dandy
325.	H9	Opera Box
326.	H9	Aztec
327.	H9	Monogram
328.	H9	Bobtail
329.	H9	Happy Thought
330.	H9	Anna Mae
331.	H9	Mary Ann #4 & Dorothy Jean #2
332.	H9	Zebra
333.	H9	Sam
334.	H9	Fawn Springs #2
335.	H9	Fawn Springs #9
336.	H9	Peanut #30
337.	G9	Wang Doodle
338.	G9	Joe Pete
339.	G9	Little Alice
340.	G9	Vaden View
341.	G9	Wild Steer
342.	G9	Buckskin
343.	G9	West
344.	G9	Two Bits
345.	G9	Hobo
346.	G9	Starlight #7
347.	G9	Sunrise #5
348.	G9	Sunrise #3
349.	G9	Sunrise #4
350.	G9	Black Jack
351.	G9	Log Cabin
352.	G9	Rimrock Blues #2
353.	G9	Rimrock Blues #5
354.	E9	Cliffdweller
355.	E9	Cliffdweller #2
356.	E9	Watchman
357.	E9	Little Jewel
358.	E9	Cedar Ridge —— Brushy Basin member
359.	E9	Cedar Ridge #2 —— Brushy Basin member
360.	E9	Cottonwood
361.	E9	Modeen #1
362.	E9	Modeen
363.	E9	Modeen #2
364.	E9	Aztec
365.	E9	Franklin
366.	E9	Black Prince
367.	E9	Mesa #2
368.	E9	Mesa #1
369.	E9	Mesa
370.	E9	Morning Star
371.	E10	Canyon View
372.	E10	Roosevelt
373.	E10	Happy Jack
374.	E10	Raven
375.	E10	Whiz Bang
376.	E10	Brook #1
377.	E10	Terrible
378.	E10	Jumbo
379.	E10	American Eagle #8
380.	E10	Gyp #1
381.	E10	Chipmunk
382.	E10	Sunday
383.	E10	Joker #1 —— Entrada sandstone
384.	E10	Joker —— Entrada sandstone
385.	F10	Franklin
386.	F10	Golden Eagle #15
387.	F10	Golden Eagle #11
388.	F10	Bluebird Fraction
389.	F10	Faultless
390.	F10	Giant
391.	F10	Faultless #1
392.	F10	New Moon
393.	G10	Redbird
394.	G10	Horsehair
395.	G10	School Marm
396.	G10	Horsehair
397.	G10	Calverts
398.	G10	Echo #6
399.	G10	Echo #2
400.	G10	Echo #4
401.	G10	Hatch #1
402.	G10	Lark #8
403.	G10	April
404.	G10	Diana
405.	G10	September Morn
406.	G10	Rimrock #2
407.	G10	Rimrock
408.	G10	Burro Point
409.	G10	Hotshot #2
410.	G10	Main Street
411.	G10	Larimer Street
412.	G10	Jack Knife #3
413.	G10	Bachelor
414.	G10	Groundhog #5
415.	G10	Groundhog —— Brushy Basin member
416.	G10	Gopher
417.	G10	Jack Knife
418.	G10	Navajo —— Brushy Basin member
419.	G10	McKee #1
420.	G10	Mary Jane
421.	G10	Broadway
422.	G10	Lost Brother
423.	G10	Edna Mae
424.	G10	Chesta
425.	H10	Big Bull
426.	H10	Old Grandad
427.	H10	Fawn Springs #15
428.	H10	Fawn Springs #7
429.	H10	Tea Pot Dome #2
430.	H10	Baby Fawn
431.	H10	Quarrel
432.	H10	Horsehair
433.	H10	Rim Rock Blues #6
434.	E11	Colorado Cat —— Brushy Basin member
435.	F11	Haymaker
436.	G11	Duncan
437.	G11	Red Horse
438.	G11	Chilli #1
439.	G11	Old Mexico
440.	H11	New Mexico
441.	H11	Lookout Mine
442.	H11	Cliffdweller #1
443.	H11	Cliffdweller
444.	H11	Rambler
445.	J10	Black Eagle
446.	I11	Vanadium
447.	I11	Pond
448.	J12	Pitchfork #1
449.	J12	Bald Eagle
450.	J12	Tiny
451.	J12	Margaret C #2
452.	J12	Margaret C #1
453.	J12	Fervanite
454.	J12	Victor
455.	J12	Brown Mule
456.	I12	Lone Ridge #2
457.	I12	Lone Ridge
458.	I12	Sunshine
459.	I12	Big Chief
460.	I12	Early Morn —— Hermosa formation
461.	I12	Wilmarth
462.	I12	Early Morn #3 —— Hermosa formation
463.	I12	Early Morn #2 —— Hermosa formation
464.	I12	Early Morn #1 —— Hermosa formation
465.	H12	Margaret C
466.	G12	Full Moon #4
467.	G12	Full Moon #1 —— Brushy Basin member
468.	G12	Full Moon —— Brushy Basin member
469.	F12	ML #44
470.	F12	ML #21
471.	F12	ML #32
472.	F12	ML #30
473.	F12	ML #27
474.	F12	ML #42
475.	F12	ML #17
476.	F12	ML #46
477.	F12	ML #6
478.	F12	ML #20
479.	F12	Lookout
480.	E12	Midnight
481.	E12	Sundown
482.	E12	Tail Holt
483.	E12	Durango
484.	E12	May Flower
485.	E12	Radium #1
486.	E12	Radium #2
487.	E12	Lone Star
488.	E12	Radium #12
489.	E12	Radium #3
490.	E12	Radium #9
491.	E12	Radium #5
492.	E12	Radium #6
493.	E12	Radium #7
494.	E12	Jackie L
495.	E12	Blackbird
496.	E12	Radium #8
497.	E12	ML #43
498.	E12	ML #8
499.	E13	Brighton
500.	E13	ML #45
501.	E13	Frankie #2
502.	E13	Frankie
503.	E13	Hawk #1
504.	E13	Hawk #2
505.	E13	Hacket
506.	E13	France
507.	E13	Hogback
508.	E13	Victor #5
509.	E13	Hangover
510.	E13	Falcon
511.	E13	ML #18
512.	E13	ML #1
513.	E13	ML #29
514.	E13	Blackjack
515.	E13	Uintah
516.	E13	Lara's Pengent
517.	E13	Governor
518.	E13	Strawberry Roan
519.	F13	ML #25
520.	F13	ML #48
521.	F13	ML #7
522.	F13	Keystone
523.	F13	Santa Maria
524.	F13	Little Helen
525.	F13	Queen of Spades
526.	F13	Rattlesnake
527.	F13	Katie
528.	F13	Virginia
529.	F13	Montezuma
530.	F13	Canyon
531.	F13	Lucky Day
532.	F13	Pay Streak
533.	F13	Star
534.	F13	Sunday
535.	F13	Moqui Jug
536.	F13	Depression
537.	F13	May Day
538.	F13	Jupiter
539.	G13	Rosa L
540.	G13	Full Moon #7
541.	G13	Mule Shoe #6
542.	G13	Little Roy
543.	G13	Curtis
544.	G13	*Norma Jean*
545.	G13	*Norma Jean #2*
546.	G13	Little Max
547.	G13	Big Chief
548.	G13	Betty Ruth
549.	G13	Sarah Ellen
550.	G13	Mystery
551.	G13	Parrot #2
552.	G13	Parrot #1
553.	G13	Buckhorn
554.	G13	Buckhorn #2
555.	G13	Roy Lee
556.	H13	Red Top
557.	H14	Mucho Grande
558.	H14	Horse Shoe #1
559.	H14	Horse Shoe #5
560.	H14	Horse Shoe #4
561.	H14	Horse Shoe #6
562.	H14	Horse Shoe #7
563.	H14	Clear View #2
564.	H14	Bull Snake —— Chinle formation
565.	H14	Canary
566.	H14	Rim
567.	G10	Starlight #8
568.	G2	Maverick #6
569.	H4	Black Streak
570.	H4	Homestead
571.	F8	Black Dinah
572.	G9	Pattie #5
573.	F12	Burro #3
574.	F12	Burro #5
575.	F12	Burro #7
576.	E12	Northern #5
577.	I9	Lone Cedar —— Burro Canyon formation
578.	G3	Calamity #16
579.	G3	Calamity #13
580.	E8	Lilly Love
581.	H9	Block A (Monogram)
582.	G10	Lost Brother #1
583.	G10	Lost Brother #2
584.	G10	Lost Brother #3
585.	F11	Chipmunk #1
586.	G11	Lost
587.	G3	Calamity #7
588.	G3	Calamity #17
589.	E9	Long John
590.	H6	Riverside
591.	H6	Austin Town House
592.	H9	Uranus
593.	I9	Paradox D
594.	I9	Mineral Joe Shaft #12 & #14
595.	I9	Mineral Joe Shaft #11
596.	H9	Fawn Springs #10
597.	H10	Old Grandad #2
598.	E13	Sage #11
599.	G6	Equinox
600.	F12	Big S
601.	E2	Durango #2
602.	E3	Mother Dee
603.	E3	Lopaz #2
604.	E12	Lee C
605.	E12	San Miguel
606.	H6	All Star
607.	H9	Fawn Springs #11
608.	H9	Fawn Springs #13
609.	B1	Skyrocket Fraction
610.	B1	Rimrock
611.	B2	Helen
612.	B2	Louis A
613.	B2	Louis
614.	B2	Mineral Polar #22
615.	B2	Captain Jack
616.	B2	Mary #3
617.	B2	Petrified Tree #8
618.	B2	P. T. #6
619.	B2	P. T.
620.	B2	Elva M.
621.	B2	Thomas B.
622.	B2	Elva M. #2
623.	B2	P. T. #9
624.	B2	Effie F.
625.	B2	F. W. #3
626.	B2	Thompson C.
627.	B2	Foster
628.	B2	Vivian
629.	B2	Emma
630.	B2	Earl
631.	B2	Polar King
632.	B2	Polar #2
633.	B2	Pinto Jack
634.	B2	Polar #3
635.	D1	Big Louie
636.	D1	Lode
637.	D1	Lone Pine
638.	D1	Lucky Pine
639.	C1	Pittsburg
640.	D2	Rae Marie #3
641.	D2	Rae Marie #5
642.	D2	Rae Marie #4
643.	D2	Rae Marie #6
644.	D2	Cedar Point
645.	C2	Avis
646.	D2	Ajax
647.	C2	Dotsy
648.	C2	P.F.G.E.
649.	C2	Yellow Jacket
650.	C2	Free Port
651.	C2	Black Jack
652.	C2	Doctor Jr.
653.	D2	Lost Dutchman
654.	D2	Lost Dutchman
655.	D2	Pack Rat #2
656.	D2	Pack Rat #1
657.	D2	Lumsden #1
658.	C1	Jumbo
659.	D2	Hubbard
660.	D2	Shakie Quakie
661.	D2	Homestead
662.	D2	Lumsden #2
663.	D2	Lumsden #3
664.	D2	La Salle
665.	D2	La Sal #1
666.	D2	La Sal #2
667.	D2	Austin #4
668.	D2	Captain Jack
669.	D2	La Sal #3
670.	D2	La Sal #5
671.	D2	Austin #8
672.	D2	La Sal #4
673.	D2	J.W.L. Fraction
674.	D2	Rajah #13
675.	D2	Lost Indian
676.	C2	Canyon #4
677.	C2	Canyon #1
678.	C2	Prospect #7
679.	C2	Prospect #4
680.	C2	Prospect #1
681.	D2	Rajah #28
682.	C3	Prospect #2
683.	C3	Grandeo #3
684.	C3	Grandeo #2
685.	C3	Grandeo
686.	C3	Corvusite Mine
687.	C3	Bananza #1 & #2
688.	D3	Karms
689.	D3	John Brown
690.	D7	Gramlich Group
691.	D7	Vista Grande
692.	D7	Confusion & Angle
693.	D7	Summer
694.	D7	Marjorie Ann
695.	D7	New Yellow Spot
696.	D7	Lion
697.	D7	Ella
698.	C7	Big Joe
699.	C7	Little Joe
700.	D7	Black Hat
701.	D7	Morning Star
702.	C7	Little Peter
703.	C7	Vanadium Queen
704.	C7	Fire Fly
705.	C7	Pigmy
706.	C7	Vanadium Queen #2
707.	C7	Hesperus
708.	C7	Peggy
709.	D7	Emergency
710.	D7	Maud
711.	D7	Three Jacks
712.	D7	Yellow Bird Group
713.	D7	Butterfly
714.	D7	Eva
715.	D8	Elroy
716.	D8	Lucky
717.	D8	Too High
718.	D8	Yucca
719.	D8	Yip Yip
720.	D8	Brushy Basin #1
721.	D8	Brushy Basin #3
722.	C7	Bobcat
723.	C7	Little Don
724.	C7	Grey Dawn
725.	C11	Bench
726.	C11	Lone Star
727.	D11	Mint #13
728.	D11	Happy Jack
729.	H10	Empire Group
730.	C11	Lucky Strike (copper)
731.	A11	Pocket
732.	A11	Roanoak
733.	A11	Gilman
734.	A11	Jumbo Bob #13
735.	A11	Dime
736.	A11	Logan
737.	A11	Good Hope
738.	A11	Bee
739.	A11	Red Patch
740.	*A11*	*Red Match*
741.	*B11*	*Peach Group*
742.	B11	Queen Mary #2
743.	B11	Queen Mary #1
744.	B11	Queen Mary #3
745.	A11	Green Fly
746.	A11	Blue Bird
747.	A11	South Slope
748.	A11	Nipple Group
749.	A11	Black Bottom
750.	A11	Velvet
751.	A11	Profit
752.	A11	Humbug
753.	A11	Sunset
754.	A11	Jefferies
755.	A12	Spider
756.	A12	Midvale
757.	A12	Neighbor
758.	A12	Vanadium
759.	A12	School Section #36
760.	A12	Zannet Lease
761.	A12	Camp Ground
762.	A12	Camp Ground #1
763.	A12	Horse Fly
764.	A12	Camp Ground #7
765.	A12	M.F.S. #4
766.	D11	Yellow Girl
767.	C11	Little Indian
768.	C11	Federal
769.	C11	Liberty
770.	C11	Blue Clay
771.	C11	State Line
772.	D12	Bench
773.	D12	La Salle #1
774.	D12	Buck Horn
775.	D12	Pinto #1
776.	D12	Nigger Head
777.	D11	North Side
778.	D11	Mint #1
779.	D13	Letty Jones Lease
780.	D13	Wilson Lease
781.	D13	Knuckles Lease
782.	D13	Deremo Lease
783.	G6	Betty Jean
784.	G10	Babe Ruth
785.	J8	Donna K
786.	B3	Bear Point
787.	D2	Jumbo
788.	D7	Evening Star
789.	C10	Vanadium Wonder
790.	C10	Vanadium Wonder #2
791.	C11	Vanadium Wonder #3
792.	I9	Deer Shaft