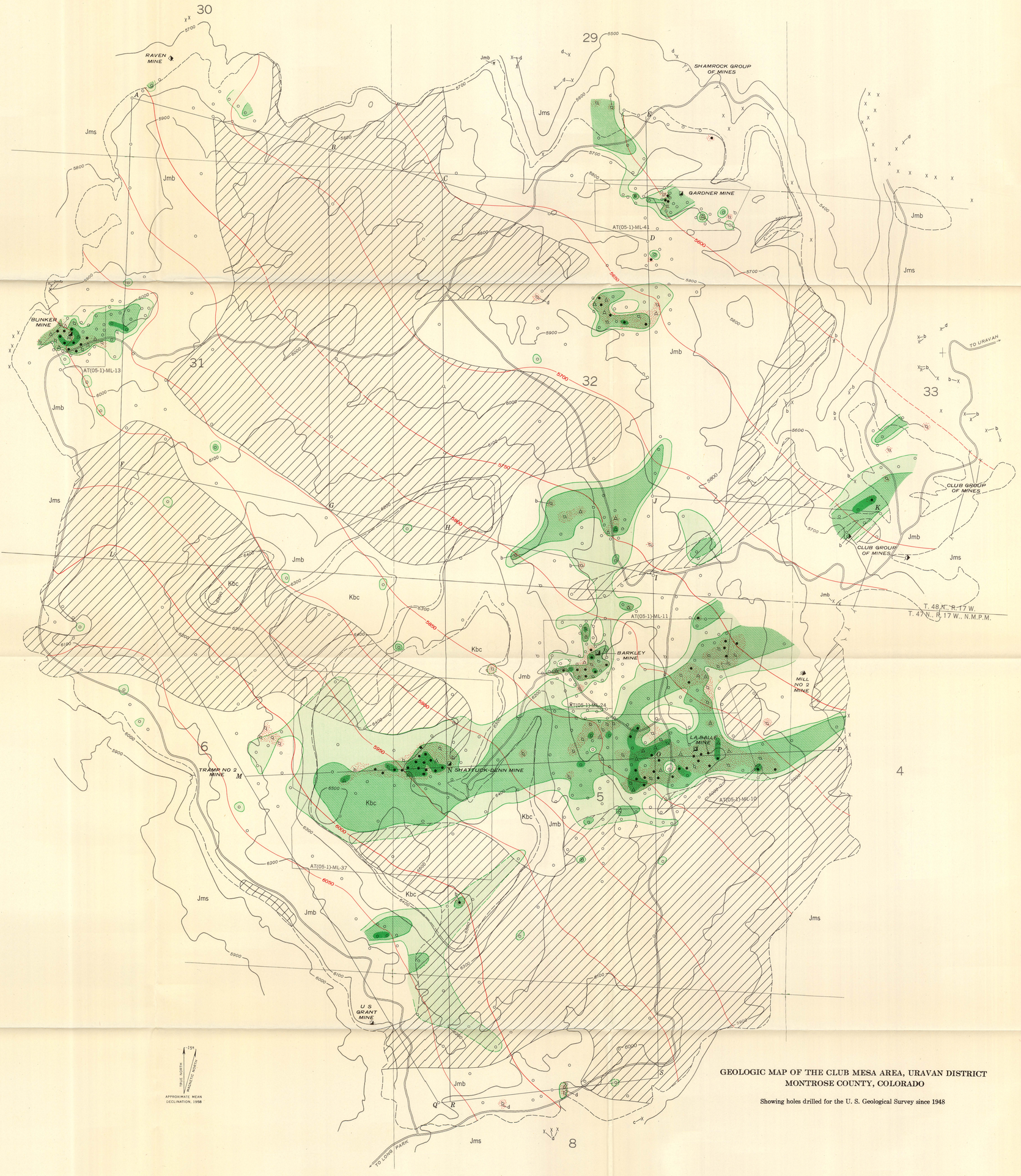
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
U.S. ATOMIC ENERGY COMMISSION

MINERAL INVESTIGATIONS
FIELD STUDIES MAP MF 169



EXPLANATION

Kbc — Burro Canyon formation (CRETACEOUS)

Jmb / Jms — Morrison formation (JURASSIC)
Jmb, *Brushy Basin member*; Jms, *Salt Wash member*

Contact
Dashed where approximately located

6000 / 6050 — Structure contour
Drawn on top of Salt Wash member of Morrison formation. Long dashes where approximately located; short dashes where projected above the surface. Contour interval 50 feet

M——N——O——P — Lines of section of fence diagram

Land section corner
Located by plane-table survey methods; other corners located approximately

AT(05-1)-ML-13 — Boundary of U.S. Atomic Energy Commission lease showing lease number

Vertical shaft

Vertical shaft
Sunk on drill hole in barren rock

Vertical shaft
Sunk on drill hole in mineralized rock

Inclined shaft

Adit

Prospect
Note: Mine or prospect is in sandstone unit "a" unless designated "b", "c", or "d" (Salt Wash member of Morrison formation) or "Jmb" (Brushy Basin member of Morrison formation)

Ground underlain by uranium-vanadium-bearing rocks
Found in the Salt Wash member of Morrison formation by drilling for U.S. Geological Survey and projected to inferred outer edges of mineralized layers. Some layers overlap and are not connected between adjacent drill holes. Mineralized rock is in sandstone unit "a" unless designated "b" or "d" (Salt Wash member of Morrison formation)

Drill hole in barren rock

Drill hole in weakly mineralized rock
(Salt Wash member of Morrison formation)

Drill hole in weakly mineralized rock
(Brushy Basin member of Morrison formation)

Drill hole in ore-grade rock
(Salt Wash member of Morrison formation)

Drill hole in ore-bearing rock
(Salt Wash member of Morrison formation)
Diamond-drill holes, 1948-1955. Classification by grade (based on radiometric and chemical assays, and gamma-ray data of doubtful reliability) and thickness. Drill holes located by plane table, transit, and stadia. (Numbers on drill-hole standpipes in field have prefix CM-.)
Weakly mineralized.—*Contains less than 0.10 percent U_3O_8 and 1.0 percent V_2O_5, but 0.020 percent or more U_3O_8 or 0.10 percent or more V_2O_5 by chemical assay, or registers gamma-ray values within the range from 0.020 percent to 0.099 percent eU_3O_8.*
Ore grade.—*Contains 0.10 percent or more U_3O_8 or 1.0 percent or more V_2O_5 by chemical assay, or registers gamma-ray values of 0.10 per cent or more eU_3O_8, but is less than 1 foot thick.*
Ore bearing.—*Contains 0.10 percent or more U_3O_8 or 1.0 percent or more V_2O_5 by chemical assay, or registers gamma-ray values of 0.10 percent or more eU_3O_8, and is 1 foot or more thick*

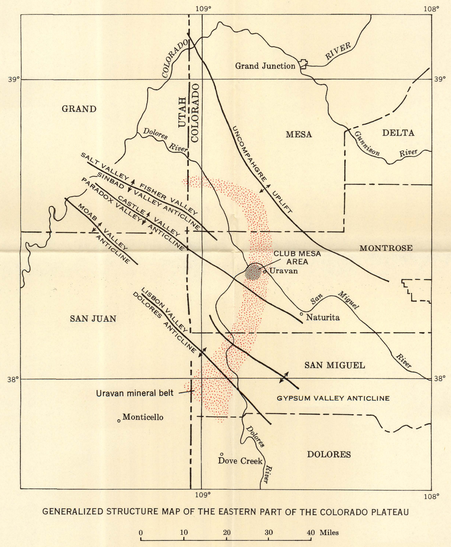
Area of ore-bearing sandstone units in the upper part of the Salt Wash member of the Morrison formation that are less than 30 feet thick

0.1 to 0.5 feet thick — 0.5 to 3.0 feet thick — 3.0 feet or more thick

Thickness of green or gray mudstone in contact with ore-bearing sandstone units in the upper part of the Salt Wash member of the Morrison formation

GEOLOGIC MAP OF THE CLUB MESA AREA, URAVAN DISTRICT MONTROSE COUNTY, COLORADO

Showing holes drilled for the U. S. Geological Survey since 1948

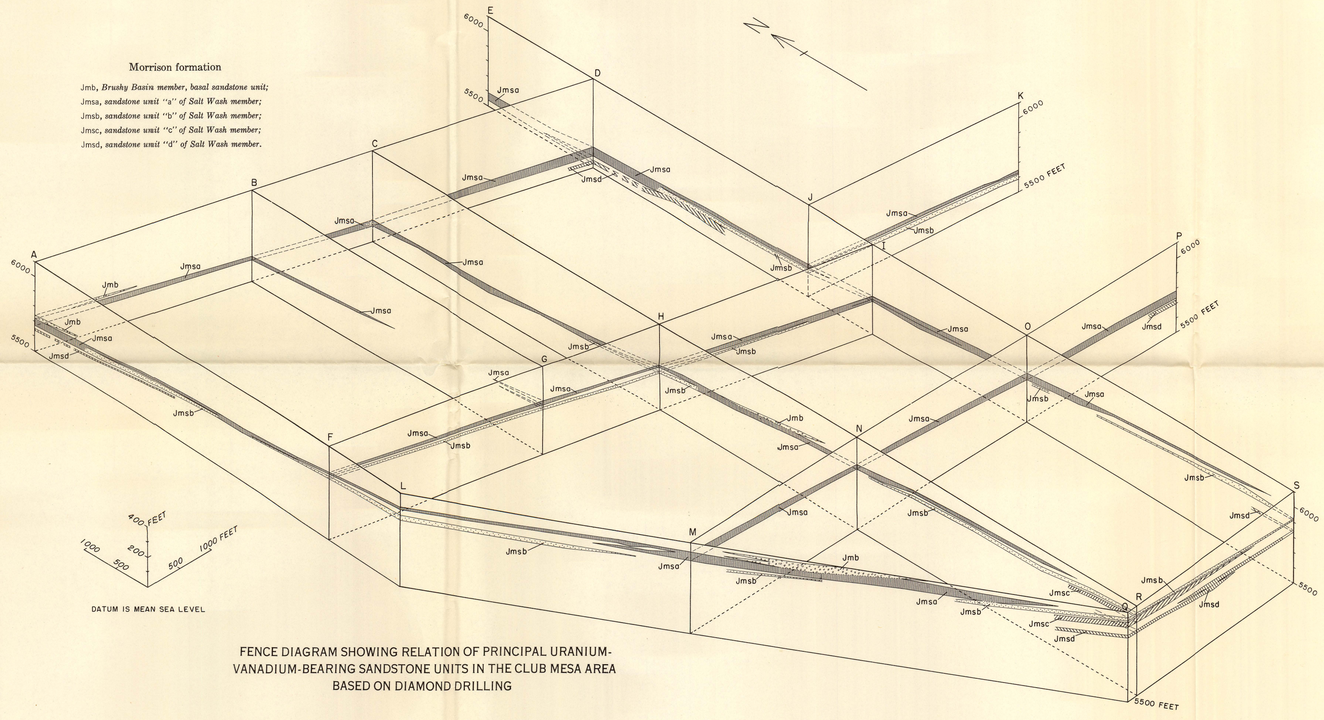


GENERALIZED STRUCTURE MAP OF THE EASTERN PART OF THE COLORADO PLATEAU

0 10 20 30 40 Miles

Morrison formation

Jmb, *Brushy Basin member, basal sandstone unit;*
Jmsa, *sandstone unit "a" of Salt Wash member;*
Jmsb, *sandstone unit "b" of Salt Wash member;*
Jmsc, *sandstone unit "c" of Salt Wash member;*
Jmsd, *sandstone unit "d" of Salt Wash member.*



FENCE DIAGRAM SHOWING RELATION OF PRINCIPAL URANIUM-VANADIUM-BEARING SANDSTONE UNITS IN THE CLUB MESA AREA BASED ON DIAMOND DRILLING

EXPLORATION FOR URANIUM-VANADIUM DEPOSITS BY THE U. S. GEOLOGICAL SURVEY IN THE CLUB MESA AREA URAVAN DISTRICT, MONTROSE COUNTY, COLORADO

By
Robert L. Boardman, Linus R. Litsey, and Howard E. Bowers

INTRODUCTION

The Club Mesa area is in the western part of the Uravan district, Montrose County, Colo.; it covers about 6 square miles in Tps. 47 and 48 N., R. 17 W., New Mexico principal meridian. (See index map.) The area is immediately west of Uravan, Colo., and is bounded approximately by the San Miguel River to the north and northeast, the Dolores River to the northwest, Saucer Basin to the southwest, and Hieroglyphic Canyon to the southeast.

Club Mesa is one of the most productive areas for uranium-vanadium ore in southwestern Colorado. The average grade of this ore has ranged from about 0.25 to 1.50 percent U_3O_8 and 1.5 to 5.0 percent V_2O_5.

Between 1948 and 1953, the U. S. Geological Survey, on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission, conducted diamond-drill exploration in the Club Mesa area to find minable uranium-vanadium deposits and to appraise uranium-vanadium reserves. Most of the drilling was done in unexplored ground away from known deposits and all drilling was contracted for by the U. S. Geological Survey. Private industry has done a like amount of drilling, mostly in the vicinity of mines or prospects or near outcrops of the ore-bearing strata. In 1943 51 holes were drilled for the U. S. Bureau of Mines and the U. S. Geological Survey (Huleatt, Hazen, and Traver, 1946) in the vicinity of the Shamrock group of mines, in sec. 29 (see geologic map). Only the holes drilled for the Geological Survey since 1948 are shown on the geologic map. Most of the interpretations of the subsurface geology are based on this drilling; therefore, interpretations are incomplete near the older mines and prospects and in areas drilled by private companies.

This publication summarizes some of the results of U. S. Geological Survey investigations in the Club Mesa area, and presents a compilation of available geologic data that would be helpful in future exploration. Detailed geologic logs of holes drilled for the Survey in the Club Mesa area on public land that is no longer withdrawn from mineral entry are on open file for public inspection in the U. S. Geological Survey office, Grand Junction, Colo.

Many Survey geologists contributed to the exploration program in the Club Mesa area. Leonid Bryner directed most of the exploration work. In addition, the geology and ore deposits of four 7½ minute quadrangles, each including part of the Club Mesa area, have been described by Carter (1955); Cater, Butler, and McKay (1955); and McKay (1955a,b).

Detailed studies of surface geology and mine workings were made in the Club Mesa area in 1945-1946 by the Union Mines Development Corp. on behalf of the Manhattan District, predecessor of the U. S. Atomic Energy Commission. The results of these studies (C. T. Smith, written communication, 1946) were helpful in interpreting stratigraphic relationships and in correlating drill-hole and outcrop data.

GEOLOGY

Rocks exposed in the Club Mesa area are sedimentary formations of Mesozoic age that dip about 3° NE. Pre-Morrison formations of Triassic and Jurassic age are exposed in the canyon walls that surround all but the southernmost part of the area. The Morrison formation of Late Jurassic age crops out in much of the Club Mesa area and is the host formation for all uranium-vanadium deposits known in the area. It is overlain in the south-central part of the mesa by sandstone and conglomerate remnants of the Burro Canyon formation of Early Cretaceous age.

The Morrison formation in the Club Mesa area is divided into the Salt Wash member and the overlying Brushy Basin member. The Salt Wash member ranges in thickness from about 200 to 300 feet and is composed of fluvial sandstone and mudstone beds. Commonly, 3 to 5 sandstone units, each 20 feet or more thick, are present in the Salt Wash member. These units are dominantly lenticular and pinch or swell in short distances; they split or merge in many places, as shown on the fence diagram. They range from a few hundred feet to several thousand feet in horizontal extent. The sandstone units at the top and base of the Salt Wash generally are the thickest and most continuous. The thicker sandstone units in the upper 100 feet of the Salt Wash are the principal host beds for uranium-vanadium deposits in the Club Mesa area. The sandstones in the Salt Wash range from medium to fine grained and are light brown, gray, light red, or white. They contain varying amounts of limonite and pyrite, and carbonized plant material. The sandstones commonly exhibit abundant primary sedimentary structures including festoon cross-bedding, cut-and-fill structures, and current lineation marks. Mudstone beds are interbedded with the sandstone units of the Salt Wash, and they are red, red brown, green, or gray and contain sparse carbonaceous material and disseminated pyrite in many places. Thin seams and lenses of mudstone and beds of clay-pebble conglomerate are present locally in the sandstone units.

The overlying Brushy Basin member ranges in thickness from 400 to 450 feet. It consists of variegated mudstone with lesser amounts of sandstone, conglomeratic sandstone, and siliceous limestone. Only a few small uranium-vanadium deposits are in the Brushy Basin in the Club Mesa area; they are in sandstone or conglomeratic sandstone beds near the base of the member.

The contact between the Salt Wash and Brushy Basin members is gradational and has been placed by the authors at the top of the uppermost recognizable sandstone unit of the Salt Wash member. Over most of the Club Mesa area this contact conforms to the top of sandstone unit **a** of the Salt Wash (geologic map and fence diagram). In the southern part of the area, where this unit is missing, the contact is placed at the top of sandstone unit **b** of the Salt Wash.

The Club Mesa area is about midway down the northeast flank of the Castle Valley-Paradox Valley anticline (index map). The principal joint set in the rocks parallels the northwest strike of the regional folds. Another joint set strikes approximately normal to this trend but is not well defined. No faults are known in the explored area.

ORE DEPOSITS

Nearly all of the known uranium-vanadium deposits in the Club Mesa area are in sandstone units in the upper part of the Salt Wash member. The deposits are irregularly shaped and contain a few tons of ore to many thousand tons of ore. The mineralized rock is mostly sandstone impregnated with uranium and vanadium minerals. Lesser amounts of these minerals impregnate mudstone pebbles, films, and seams. Some of the richest bodies of ore are fossil tree trunks and branches that have been impregnated or replaced by uranium and vanadium minerals. The mineralized rock forms layers that are essentially parallel to the host sandstone beds, but in places the ore layers curve across bedding planes in the sandstone to form rolls. Uranium-vanadium ore and the habits of ore bodies in the upper part of the Salt Wash have been described by Fischer (1942).

In the Club Mesa area, ore ranges from the gray and yellow oxidized type, most common near the surface, to the blue-black, partly oxidized type, prevalent in the deepest workings. Carnotite and tyuyamunite (yellow uranium-vanadium minerals), gray vanadium silicate minerals, and blue-black vanadium-bearing corvusite are the principal ore minerals.

The Club Mesa area lies within and along the western margin of the Uravan mineral belt (index map; Fischer and Hilpert, 1952). The parallelism of easterly trends of ore, trends of ground appraised as favorable for ore, and trends of primary sedimentary structures in the Club Mesa area has been described by Boardman, Ekren, and Bowers (1956). No relation has been found between known fractures in the area and the origin and localization of ore.

The most productive mines or groups of mines in the area are labeled on the geologic map. The Club group of mines (sec. 33) and the La Salle (sec. 5), Tramp No. 2 (sec. 6), and Bunker mines (sec. 31) have been the largest producers, in decreasing order. Prior to 1942 the Club group of mines had yielded more than 150,000 short tons of ore (Fischer, 1942), and there has been intermittent production from the group since that time. Ore deposits at or near the surface constituted the only deposits mined before 1950. Since then large ore bodies have been found under deeper cover and mining operations have been carried on at progressively greater depths. The Shattuck-Denn (sec. 5) and La Salle mines are the deepest in the Club Mesa area; their vertical shafts are about 500 and 250 feet deep, respectively.

All the large deposits in the area are in the uppermost sandstone unit of the Salt Wash member of the Morrison formation except in the northwest part of the Club group of mines where ore is found in the next lower sandstone unit. Less than 1 percent of the total uranium-vanadium production from the Club Mesa area has come from deposits in the lower part of the Salt Wash member and in the Brushy Basin member.

GEOLOGIC GUIDES TO ORE

Several geologic features are useful in prospecting for uranium-vanadium deposits in the Club Mesa area. These features are commonly associated with ore deposits and with ground near ore deposits; thus they provide broader targets than do the deposits themselves.

McKay (1955c) noted that in the Uravan district, uranium-vanadium deposits are more prevalent in areas where the upper sandstone unit of the Salt Wash member of the Morrison formation is predominantly lenticular, exhibits scour-and-fill bedding, and is underlain by continuous green or gray mudstone. These guides are useful in appraising the relative favorableness of ground close to the outcrop.

Other geologic features in the vicinity of uranium-vanadium deposits can be recognized in drill cores and have been shown by Weir (1952) to be useful small-scale guides to ore in appraising the upper sandstone units of the Salt Wash member in southwestern Colorado. The geologic criteria that are the most useful small-scale guides for exploration in the Club Mesa area are listed below in the order of their importance.

1. Interstitial mudstone grains in the ore-bearing sandstone units and most mudstone beds in contact with these ore-bearing units are green or gray near ore deposits, instead of red or red brown. In general, the host sandstone unit becomes more favorable as the thickness of these green or gray beds increases.
2. Ore-bearing sandstone units are 30 feet or more thick and are dominantly light brown or light gray, instead of red or white, in the vicinity of large ore deposits.
3. Ore-bearing sandstone units commonly contain abundant carbonized plant remains and abundant limonite or disseminated pyrite near ore deposits.

The relationship between mineralized ground, thickness of ore-bearing sandstone units, and relative amounts of green or gray mudstone in contact with these units is shown on the geologic map.

DIAMOND DRILL EXPLORATION

Diamond drilling began in the Club Mesa area on March 6, 1948, and was completed on January 6, 1953. The drilling was done on seven contracts and consisted of 662 holes totaling 170,095 feet. The average depth of the holes was 257 feet. The location and classification of 660 holes are shown on the geologic map; two holes are not shown because they were abandoned before penetrating beds of the Salt Wash member of the Morrison formation. Most of the drill holes were logged by a gamma-ray logging instrument.

Drilling in the Club Mesa area was planned to explore the principal uranium- and vanadium-bearing sandstone units in the upper part of the Salt Wash member. Most of the holes drilled during the first contract were spaced at about 1,000-foot intervals along three north-trending lines about 3,000 feet apart; these lines were perpendicular to the eastward trend of the known deposits, and they were planned to locate and roughly delimit ground appraised as geologically favorable for ore. During succeeding contracts, additional wide-spaced holes (more than 500 feet apart) were drilled to outline more precisely the favorable ground; moderate-spaced holes (200-500 feet apart) were drilled to search for deposits in favorable ground; and close-spaced holes (less than 200 feet apart) were drilled to delimit the most promising deposits discovered by moderate- and wide-spaced drilling. About 30 percent of the total footage was expended in wide-spaced holes, about 25 percent in moderate-spaced holes, and about 45 percent in close-spaced holes. In general, holes that penetrated mineralized rock in mining claims were not offset as the discovery was considered sufficient incentive to the claim owner to block out the deposit. About 95 percent of the total footage drilled was in unexplored public land that had been withdrawn from mineral entry; the remaining footage drilled was in mining claims staked prior to the land withdrawal.

Of the 660 holes completed, 195 penetrated mineralized rock (rock containing 0.02 percent or more U_3O_8 or 0.10 percent or more V_2O_5). The mineralized layers are in the upper part of the Salt Wash member in 181 holes and in the lower part of the Brushy Basin member in 14 holes.

In the Salt Wash member, 74 holes penetrated material classed as "ore" (rock 1 foot or more thick containing 0.10 percent or more U_3O_8 or 1.0 percent or more V_2O_5), and 37 penetrated mineralized layers of ore grade but less than 1 foot thick. The mineralized rock in all but 2 of these 111 holes is in the uppermost sandstone unit of the Salt Wash member. The ore layers are in the bottom half of the host sandstone unit in about 90 percent of the holes in ore and in the bottom quarter of the unit in over 60 percent of these holes. None of the mineralized layers penetrated in the Brushy Basin member are ore grade.

Indicated and inferred reserves of "ore" (see above) discovered as a result of the drilling conducted by the U. S. Geological Survey total about 200,000 short tons averaging about 0.35 percent U_3O_8 and 1.80 percent V_2O_5. About 80 percent of the estimated reserves were included in the six mining leases (see geologic map) granted by the U. S. Atomic Energy Commission on deposits discovered by the drilling, and a large part of these reserves have subsequently been mined. About 15 percent of the estimated reserves were in mining claims, and 5 percent in small deposits in public land. Bush and Stager (1956) defined the types of reserves, and described the method of their calculation and the probable accuracy of ore-reserve estimates for uranium-vanadium deposits on the Colorado Plateau.

All the large uranium-vanadium deposits found by the drilling in the Club Mesa area are in or near the thickest parts, locally, of the host sandstone units, and generally are within a few hundred feet of appreciable thinning of these units. Where ore was penetrated, the host sandstone units range in thickness from 25 to 96 feet and average about 50 feet in thickness. About 75 percent of the holes in ore, accounting for nearly 90 percent of the estimated ore reserves, penetrated host sandstone units ranging in thickness from 30 to 60 feet.

Results of the drilling in the Club Mesa area show the relative thickness of the ore-bearing sandstone units of the Salt Wash member and the amount of green or gray mudstone in contact with these units to be the most consistent recognizable geologic criteria associated with mineralized rock and ore deposits. Approximately 86 percent of the holes in mineralized sandstone units of the Salt Wash and 93 percent of the holes in ore penetrated host sandstone units 30 feet or more thick that are in contact with at least 6 inches of green or gray mudstone (see geologic map). These mudstone beds may be at the top, base, or included in the host sandstone unit. If these minimum thicknesses are used as cutoffs to determine ground favorable for ore, about 10 percent of the Club Mesa area explored by the Survey can be classified as favorable and contains nearly all the ore reserves discovered. Most of the favorable ground so defined lies in an eastward trending zone ranging from 1,000 to 3,000 feet in width and approximately 2 miles long, extending from the Tramp No. 2 mine on the west to the Club group of mines on the east. About 85 percent of the ore reserves found by drilling are in this zone. In addition, several smaller areas of favorable ground are present: (1) in sec. 32, between the Barkley and Gardner mines; (2) in sec. 31, east of the Bunker mine; and (3) in secs. 5 and 6, north-northeast of the U. S. Grant mine (see geologic map). Many of these smaller areas have been explored by only a few drill holes and probably will be the most rewarding areas for future exploration.

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EXPLORATION FOR URANIUM-VANADIUM DEPOSITS BY THE U.S. GEOLOGICAL SURVEY IN THE CLUB MESA AREA, URAVAN DISTRICT, MONTROSE COUNTY, COLORADO

By
R. L. Boardman, L. R. Litsey, and H. E. Bowers

Topography by U.S. Geological Survey, 1949

Geology mapped in 1955

Scale 1:7200

500 0 500 1000 1500 2000 2500 Feet

Contour interval 100 feet
Datum is mean sea level

1958

MINERAL INVESTIGATIONS
FIELD STUDIES MAP MF 169

For sale by U. S. Geological Survey, price 75 cents