GEOLOGICAL SURVEY CIRCULAR 312

YELLOW CANARY URANIUM DEPOSITS, DAGGETT COUNTY, UTAH

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UNITED STATES DEPARTMENT OF THE INTERIOR
Douglas McKay, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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Washington, D. C., 1953

Free on application to the Geological Survey, Washington 25, D. C.

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ABSTRACT

The Yellow Canary uranium deposit is on the west side of Red Creek Canyon in the northern part of the Uinta Mountains, Daggett County, Utah. Two claims have been developed by means of an adit, three opencuts, and several hundred feet of bulldozer trenches. No uranium ore has been produced from this deposit.

The deposit is in the pre-Cambrian Red Creek quartzite. This formation is composed of intercalated beds of quartzite, hornblendite, garnet schist, staurolite schist, and quartz-mica schist and is intruded by dioritic dikes. A thick unit of highly fractured white quartzite near the top of the formation contains tyuyamunite as coatings on fracture surfaces. The tyuyamunite is associated with carnotite, volborthite, iron oxides, azurite, malachite, brochantite, and hyalite. The uranium and vanadium minerals are probably alteration products of primary minerals.

The uranium content of 15 samples from this property ranged from 0.000 to 0.57 percent.

INTRODUCTION

Carnotite has been known in the Red Creek Canyon area since 1920 (Butler, 1920, p. 605), but there was little prospecting for uranium until C. E. Green and William Allen located the Yellow Canary No. 1 and No. 2 claims, on July 10, 1948. In 1950, part interest in the uranium deposit was sold to F. W. Bailey and J. R. McDermott, and subsequently the Canary Mining Co. was incorporated with F. W. Bailey of Rock Springs, Wyo., as the president.

The uranium deposit at the Yellow Canary claims was brought to the attention of the U. S. Geological Survey by H. D. Bailey of Stibnite, Idaho, who submitted a sample from these claims that contained 1.38 percent uranium. In August 1950, F. A. McKeown and E. P. Beroni, of the U. S. Geological Survey, made a brief examination of the deposit, and recommended further investigation. During August 1951, V. R. Wilmarth and R. C. Vickers spent 5 days in the area and mapped the geology and topography of an area about one-tenth square mile surrounding the outcrop of the

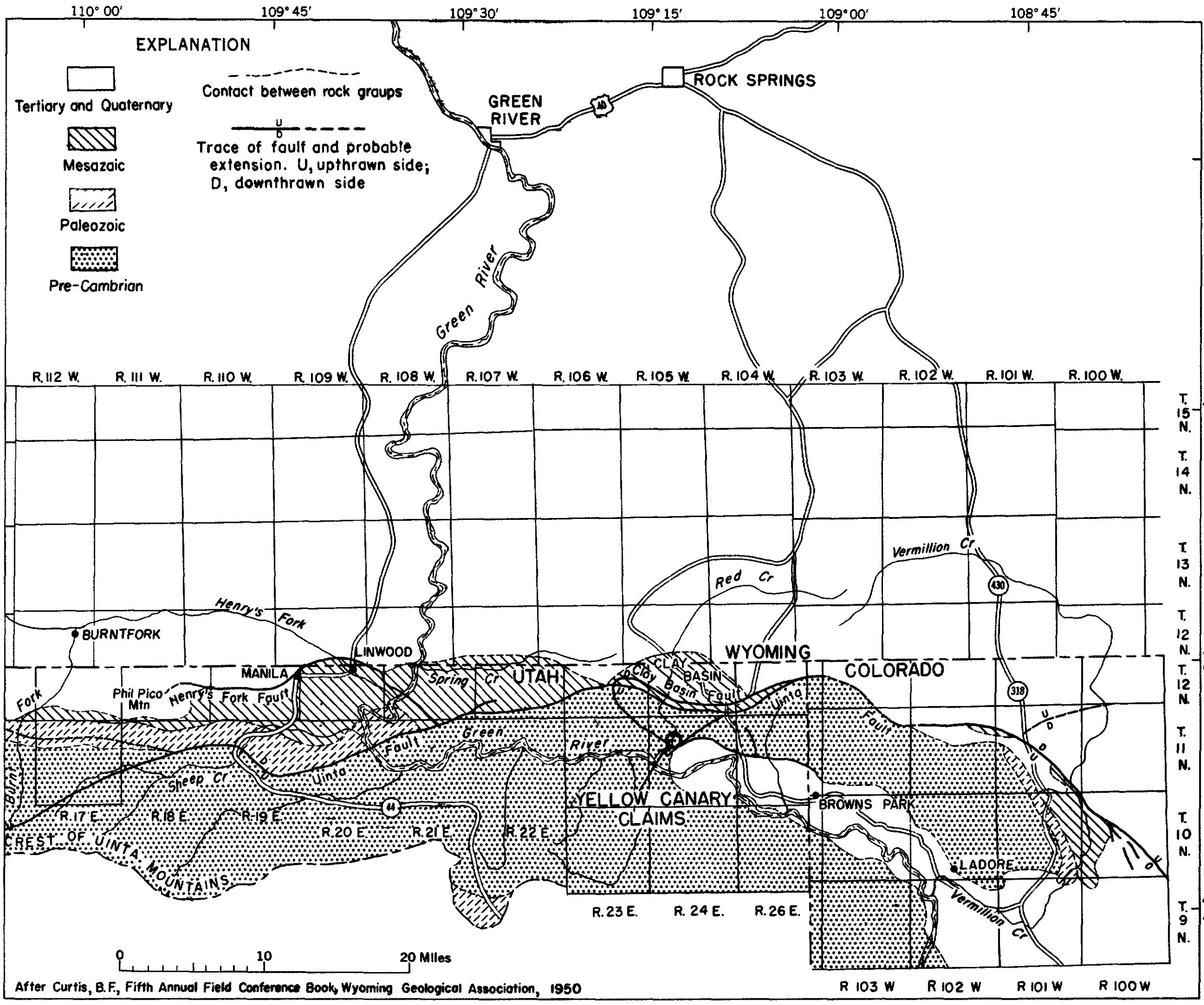

Figure 1.—Generalized geologic map of the north flank of the Uinta Mountains, Colorado, Utah, and Wyoming; showing location of the Yellow Canary No. 1 and No. 2 claims, Daggett County, Utah.

deposit on a scale of 100 feet to the inch. Radiometric examination of the surface outcrops and sampling of the deposit were also completed.

Location and accessibility

The Yellow Canary uranium deposit, in secs. 4 and 5, T. 2 N., R. 24 E., Salt Lake meridian, is in the northern part of Daggett County in northeastern Utah (fig. 1). The Yellow Canary claims are located on the west side of Red Creek Canyon in the northern part of the Uinta Mountains (fig. 1) and are 70 miles by road south from Rock Springs, Wyo., and 62 miles by road northwest from Sunbeam, Colo. The roads to the claims are generally open throughout the year.

Mine workings

The deposit is explored by three opencuts, one adit, about 700 feet of bulldozer trenches, and several prospect pits (fig. 2). Exposed in pit 1 is a northwest-trending fracture zone that contains the richest uranium-bearing quartzite. The 190-foot long exploration adit was driven to intersect this zone about 100 feet below the surface, and the bulldozer trenches were dug primarily to explore the uranium-bearing quartzite west of pit 1.

GEOLOGY

Rock units

The rocks exposed in the northern part of the Uinta Mountains (fig. 2) include a basement complex of pre-Cambrian Red Creek quartzite and the

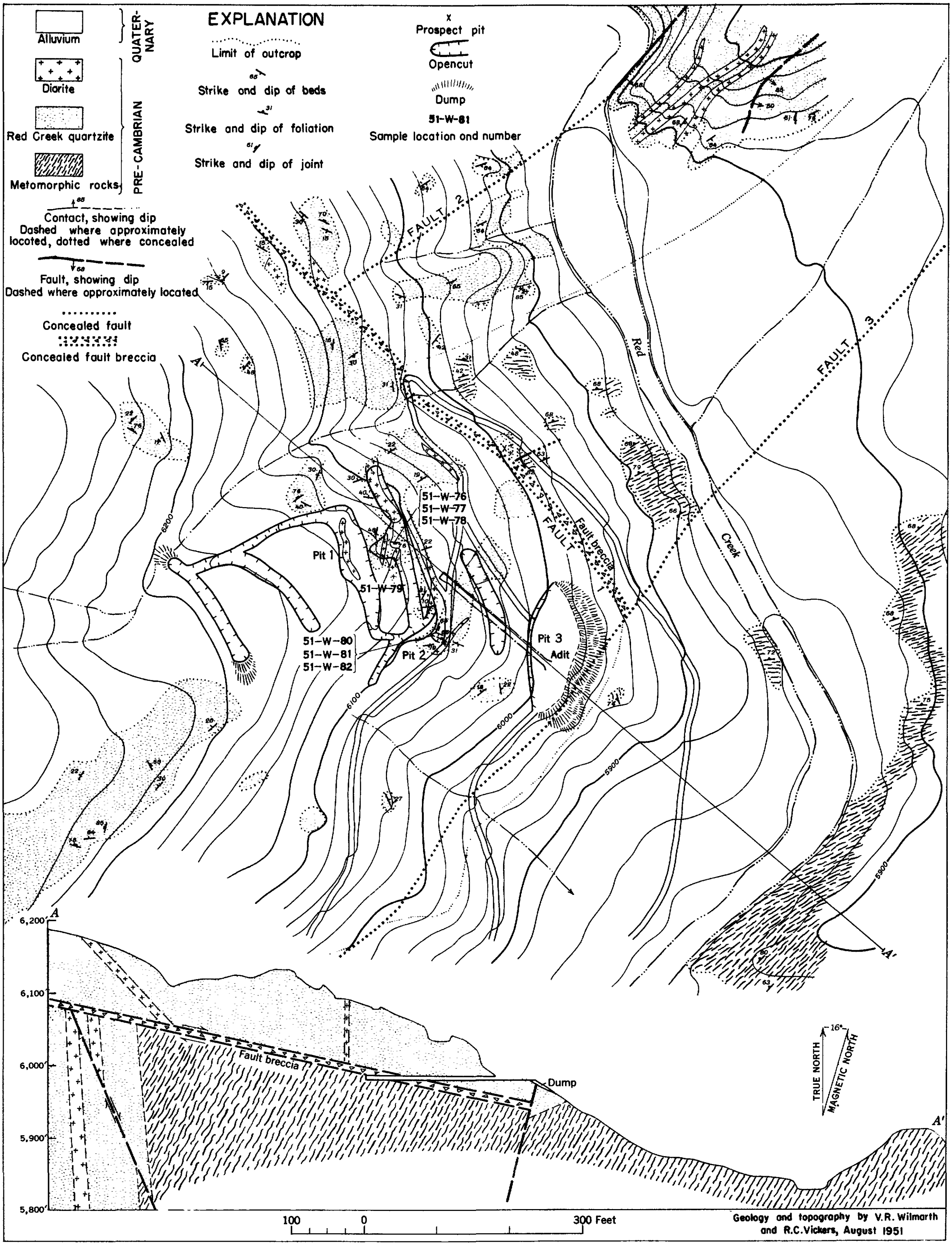

Figure 2.—Geologic map and section of part of the Yellow Canary No. 1 and No. 2 claims.

Uinta Mountain group in fault contact with a thick series of sedimentary rocks of Paleozoic age. The Paleozoic section is overlain by sedimentary rocks of Mesozoic, Tertiary, and Quaternary age. Dioritic dikes, probably pre-Cambrian, intrude the Red Creek quartzite in the Red Creek area. The uranium deposit described in this report is in the quartzite.

The rocks exposed in the area of the Yellow Canary No. 1 and No. 2 claims include the pre-Cambrian Red Creek quartzite, probably pre-Cambrian dioritic dikes, and Recent alluvium deposits.

Red Creek quartzite

The Red Creek quartzite is exposed over much of the mapped area (fig. 2). It is described by Powell (1876, p. 137) as very crystalline and white with intercalated beds of hornblende, chloritic, and micaceous schist, all greatly implicated. Schultz (1920, p. 24) remapped the Red Creek quartzite and stated that the intercalated schists are intrusive. In the northern part of the Uinta Mountains, the Uinta Mountain group unconformably overlies the Red Creek quartzite; this contact is about 1 mile east of the mapped area. The Red Creek quartzite (fig. 2) within the area mapped includes a thick unit of white quartzite that unconformably overlies a complex sequence of hornblendite, garnet schist, staurolite schist, quartz-mica schist, and dark-gray quartzite.

The typical Red Creek quartzite is a white, thin- to thick-bedded rock that has been folded and fractured extensively. It is almost wholly composed of quartz grains, but the granular structure of the rock is apparent in only a few places. Petrographic study shows the quartzite to be very pure with the individual grains of uniform size, for the most part. All the quartz grains show undulatory extinction and many are drawn out as if by dynamic metamorphism. Most of the grains are corroded and many are in part replaced by muscovite at the edges of the grains. Tyuyamunite, carnotite, volborthite, hematite, brochantite, malachite, hyalite, azurite, quartz, sericite, calcite, and manganese oxide are abundant locally. Many fractures in the quartzite have been cemented with hematite, calcite, and chalcedony, but others are open. Fluorescent hyalite coats fracture surfaces in the quartzite near pits 1 and 2, but none was found in other parts of the mapped area.

The hornblendite, a fine- to medium-grained, dark-green to black rock, occurs in beds from 2 to 10 feet thick, which can be traced along the strike for 80 feet. Many veins of chalcedony, not more than an inch thick, fill fractures in the hornblendite near its contact with the white quartzite; 1 to 2 inch-wide veins of epidote cut across and parallel the foliation in the hornblendite. The hornblendite is locally bordered by a 2 to 4 inch-wide zone composed of hornblende in a fine-grained groundmass of quartz, muscovite, and biotite. Staurolite and garnet schist commonly are in contact with the hornblendite. In thin section the hornblendite has a granular texture and is composed of 78 percent hornblende, 15 percent quartz, 4 percent magnetite, and 3 percent of fine-grained muscovite. The hornblende crystals are subhedral to anhedral and range from 0.04 millimeter to 0.8 millimeter in length, and average 0.06 millimeter in width. The hornblende is rimmed with chlorite and interstitial to the grains are minor quantities of muscovite and magnetite.

Garnet schist layers, as much as 2 feet wide, are exposed for as much as 300 feet along the strike. The schist is composed of porphyroblasts of almandine in a fine-grained groundmass of quartz and muscovite. The porphyroblasts range from 1 millimeter to 18 millimeters in diameter and locally make up 30 percent of the rock. The garnet schist grades laterally into garnet-staurolite schist.

The light- to dark-gray staurolite schist contains porphyroblasts of staurolite in a fine-grained groundmass of quartz, muscovite, and biotite. The staurolite porphyroblasts range from 1 millimeter to 60 millimeters in width, and constitute as much as 50 percent of the rock.

The light-gray fine- to medium-grained quartz-mica schist is composed of quartz, muscovite, biotite, and accessory hematite. Interbedded with the quartz-mica schists are layers of dark-gray, medium-grained quartzite composed of quartz with accessory muscovite and biotite.

Dike rock

The igneous rocks in the Red Creek area, as described by Butler (1920, p. 600-601), are dark-green dioritic rocks that have been considerably altered. The dikes intrude the Red Creek quartzite and are probably pre-Cambrian. In the mapped area (fig. 2), the dikes are typically dark-green to black fine-grained rocks that are heavily stained with hematite. They range from 2 to 15 feet in thickness, and are exposed for as much as 200 feet along the strike. In thin section the dike rock has a hypautomorphic-granular texture and is composed of hornblende, 64 percent; plagioclase, 14 percent; quartz, 17 percent; and the accessory minerals, apatite, 2 percent, and magnetite, 3 percent. Clay and sericite, formed by alteration of the plagioclase, are abundant locally. The hornblende occurs in subhedral to anhedral grains that average 0.06 millimeter in width and 0.16 millimeter in length. The hornblende grains have been altered locally to chlorite along the edges and most of the grains have been elongated probably by dynamic metamorphism. Quartz and plagioclase are interstitial to the hornblende.

Structure

The Red Creek area is in the Uinta Mountains, which were formed by dissection of a west-trending asymmetric anticline. Movements along faults in the Red Creek area of the Uinta Mountains have placed pre-Cambrian metamorphic rocks against sedimentary rocks of Paleozoic and Mesozoic ages. Curtis (1950, p. 93) believes this faulting is in part responsible for the exposure of Red Creek quartzite, and Schultz (1920, p. 24) has mapped a northeast-trending anticlinal and synclinal structure in this area.

In the mapped area (fig. 2) the metamorphic rocks have a pronounced foliation that trends northeast and dips steeply to the northwest. At two localities, however, the foliation trend deviates widely: at one locality west of the road the foliation strikes N. 20° W., and dips 74° SW.; at the second locality in the stream valley west of Red Creek the foliation strikes N. 76° W., and dips 48° S. No satisfactory explanation for these discrepancies can be made at this time; however, these local variations suggest that the rocks have been complexly folded.

The folded and faulted Red Creek quartzite overlies the metamorphic rocks with a marked angular unconformity. In the vicinity of the uranium deposit the Red Creek quartzite has been folded extensively (fig. 2). West of pit 1 bedding in the quartzite has an average strike of approximately N. 45° E. and dips 20° to 64° NW., whereas, east of Red Creek the quartzite bed has an average strike of N. 50° E. and dips 25° to 76° S. Minor folds in the quartzite are many and reflect the complexity of the major folding.

In the vicinity of the uranium deposit (fig. 2) the major structures are three normal, northeast-trending, longitudinal faults. Fault 1 is a low-angle fault that is exposed only near the end of the 190-foot exploration adit. It strikes N. 60° E., dips 13° S., and is marked in the adit by a fault breccia zone as much as 10-feet thick which contains quartzite boulders up to 4 feet in diameter, abundant sericite, clay, and small fragments of white quartzite. On figure 2 is shown the surface projection of this fault breccia zone. This breccia zone crops out near the center of the mapped area and about midway between faults 2 and 3. The owners report (oral communication) that two of the quartzite boulders were found coated with yellow and green uranium and vanadium minerals. Fault 1 has placed a mass of folded white quartzite over the undifferentiated metamorphic rocks (fig. 2). The vertical displacement along this fault is not known but the horizontal displacement is nearly 600 feet. In the northeast part of the mapped area, fault 2 strikes N. 40° to 45° E., dips 68° S. and has a vertical displacement of about 75 feet. Although this fault is not exposed west of Red Creek it is probably older than fault 1. Fault 3 trends northeast, dips 76° NW and intersects fault 1 near the portal of the exploration adit. This fault is exposed about 500 feet southwest of the mapped area, where it strikes N. 40° E. and dips 76° NW. The vertical displacement along fault 3 was not determined accurately but the displacement must be greater than 100 feet or fault 1 would be exposed in the metamorphic rocks east of Red Creek (fig. 2, sec. A-A').

Joints are numerous in the quartzite in this area. The most prominent joints strike N. 62° to 85° W. and many of them strike about N. 80° W. The joint planes are vertical or dip steeply northeast or southwest. Another set of joints that is not so well-developed and not nearly so extensive has an average strike of N. 65° E. and dips steeply to the northwest. In pit 1 the prominent joints are the loci for the deposition of the uranium and vanadium minerals, whereas most of the minor joints are not mineralized.

Ore deposits

Before the discovery of uranium at the Yellow Canary claims, the Red Creek area had been prospected extensively for copper. The copper deposits were not studied in detail but they have been described briefly by Butler (1920, p. 604-605). They consist of fissure veins of quartz or of quartz and carbonates and contain metallic sulfides. The veins strike northeast and dip steeply to the northwest and southeast and are associated with diorite dikes and amphibolite. In the copper deposits, chalcopyrite and chalcocite, the most abundant sulfides, are associated with minor quantities of carnotite, hematite, bornite, malachite, azurite, and quartz. In 1948 secondary uranium minerals, tyuyamunite and carnotite, were found at an abandoned copper prospect on the Yellow Canary Claims in Red Creek Canyon. It is not known whether the occurrence at this property is that referred to by Butler (1920, p. 605). The uranium minerals occur as fracture fillings in quartzite and are associated with volborthite, hematite, malachite, azurite, brochantite, hyalite, and quartz.

Uranium deposits

At the Yellow Canary claims, yellow uranium minerals, carnotite and tyuyamunite, are disseminated sparsely in the highly fractured and contorted white quartzite of the pre-Cambrian Red Creek quartzite. In August 1951, the only visible uranium minerals were found in a 3- to 6-foot wide fracture zone in the white quartzite in pit 1; however, McKeown and Beroni[1] report yellow uranium minerals in a small pit, now covered, about 100 feet southeast of pit 1. In pit 1 this fracture zone trends northwest, dips steeply southwest, and can be traced for a few feet along the strike. A 6-foot channel sample (table 1) across this zone in pit 1 contains 0.05 percent uranium, but in the bulldozer trenches west of pit 1, where the fracture zone is poorly exposed, no uranium minerals were found. Several small isolated boulders that contain yellow uranium mineral as coatings on fracture surfaces were found in the bulldozer trench just east of pit 1 and in the breccia zone in the adit. The size and shape of the uranium deposit is not known, because of the small extent of outcrop of the uranium-bearing quartzite.

Mineralogy

Tyuyamunite, a hydrated calcium uranium vanadate, is the principal ore mineral recognized at the deposit. It was identified by X-ray powder pattern by M. E. Thompson of the U. S. Geological Survey. Spectrographic analysis of the tyuyamunite showed uranium, vanadium, and silica to be major constituents; calcium, aluminum, and iron were minor constituents; and magnesium and copper were trace constituents. Tyuyamunite occurs, for the most part, as thin coatings, less than 3 millimeters thick, on fracture surfaces and as crystalline aggregates that partially fill small vugs, as much as 5 centimeters across, in the quartzite. The tyuyamunite grains are commonly thin bright-lemon-yellow to pale-yellow, nonfluorescent, tabular to subhedral flakes with their flat sides parallel to the surface on which they occur. Small but well-developed tabular crystals coat the more open fracture surfaces in the quartzite. The largest and best developed crystals of tyuyamunite were found in the hematite-filled vugs. Locally, botryoidal masses of tyuyamunite less than 1 millimeter across occur on the massive tyuyamunite fracture coatings. Gradations from the bright yellow characteristic of the tyuyamunite crystals to the pale-yellow tyuyamunite grains on the fracture surfaces may be found.

[1]McKeown, T. A., and Beroni, E. P., 1951, A preliminary report on the Yellow Canary carnotite claims, Dagget County, Utah: U. S. Geol. Survey Trace Elements Rept. (In files of U. S. Geol. Survey, Denver, Colo.)

Table 1.—Spectrographic analyses of samples from Yellow Canary No. 1 and No. 2 claims, Daggett County, Utah.[1]

Field no.	Material	U[2]	Si	Al	Ti	Mn	Fe	Ca	Mg	Na	Ba	Be	Co	Cr	Cu	Ca	Mo	Ni	Pb	Sr	V	Y	Zr	B	Ag	Bi	Sn	Sc
51-W-86	Grab sample of hornblendite, ½ mile south of mine.	---	XX	XX	0.X	0.X	XX	X	X	0.X	0.00X	Tr.	0.00X	0.0X	0.0X	0.00X	0.00X	0.00X	0.00X	0.00X	0.0X	0.00X	0.00X	0.00X	0.00X	---	0.00X	0.00X
51-W-87	Grab sample of diorite dike northwest of pit 1.	---	XX	XX	.X	.X	XX	0.X	X	.X	.00X	---	.00X	.0X	X	.00X	.000X	.00X	.00X	.000X	.0X	.00X	.00X	.00X	.00X	---	.00X	.00X
51-W-88	Grab sample of hornblendite, 1 mile south of mine.	---	XX	XX	.X	.X	XX	X	X	.X	.00X	---	.00X	.0X	.0X	.00X	.000X	.00X	.00X	.00X	.0X	.00X	.00X	.00X	.00X	---	.00X	.00X
FK-7-13	Grab sample from dump, tyuyamunite-bearing quartzite.	0.56	XX	0.X	.0X	.0X	X	X	0.0X	---	.0X	Tr.	.0X	.00X	X	---	.00X	.00X	.0X	.000X	.X	.00X	---	.000X	.000X	.00X	---	---
FK-7-14	---do---	.10	XX	.X	.0X	.0X	X	.X	.0X	---	.0X	0.000X	.00X	.00X	.X	---	.00X	.00X	.00X	.000X	.0X	.00X	---	.000X	.000X	.00X	---	---
FK-7-15	---do---	.57	XX	.X	.0X	.0X	X	.X	.0X	---	.0X	Tr.	.0X	.00X	.X	---	.00X	.00X	.0X	.000X	.X	.00X	.00X	.000X	Tr.	.00X	---	---
FK-7-16	9-foot chipped front channel sample, tyuyamunite-bearing quartzite from pit 1.	.11	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	----	---	---	---	---	---	---	---	---	---
51-W-76	5-foot channel sample, tyuyamunite-bearing quartzite from pit 1.	.029	XX	.X	.0X	.0X	X	.0X	.00X	---	.00X	.000X	.00X	.00X	.0X	---	.00X	.00X	.00X	---	.X	.00X	.00X	---	---	---	---	---
51-W-77	4.5-foot channel sample, quartzite from pit 1.	.006	XX	.X	.0X	.0X	X	.0X	.00X	---	.00X	---	Tr.	.00X	.00X	---	.00X	.00X	.00X	---	.00X	---	.00X	---	---	---	---	---
51-W-78	6-foot channel sample of tyuyamunite-bearing quartzite from pit 1.	.050	XX	.X	.0X	.0X	X	.0X	.00X	---	.00X	.000X	.00X	.00X	.0X	---	.00X	.00X	.00X	---	.0X	.00X	.00X	---	---	---	---	---
51-W-79	2.5-foot channel sample of diorite dike southeast of pit 2.	.001	XX	X	X	.0X	XX	X	X	X	.0X	.000X	.00X	.00X	.0X	.00X	.00X	.00X	.000X	.0X	.0X	.00X	.0X	---	---	---	----	---
51-W-80	7-foot channel sample of quartzite from north side pit 2.	.001	XX	.X	.0X	.0X	X	.0X	.0X	---	.00X	---	.000X	.00X	.00X	---	.00X	.00X	---	---	.00X	---	.00X	---	---	---	---	---
51-W-81	8-foot channel sample of quartzite from west side pit 2.	.001	XX	.X	.0X	.0X	X	.0X	.0X	---	.00X	---	.000X	.00X	.0X	---	.00X	.00X	---	---	.00X	---	---	---	---	---	---	---
51-W-82	5-foot channel sample of quartzite from south side pit 2.	.000	XX	.X	.0X	.0X	X	.0X	.0X	---	.00X	---	Tr.	.00X	.00X	---	.00X	.00X	---	---	.00X	---	---	---	---	---	---	---
51-W-84	Grab sample of quartzite from end of lower road.	.001	XX	.X	.0X	.0X	X	.0X	.0X	---	.00X	---	Tr.	.00X	.00X	---	.00X	.00X	---	---	---	---	---	---	---	---	---	---
51-W-85	2.5-foot channel sample of diorite dike near pit 2.	.001	XX	X	X	.X	XX	X	X	X	.0X	.000X	.00X	.00X	.00X	.00X	.00X	.00X	---	.0X	.0X	.00X	.0X	---	---	---	---	---

[1]Spectrographic analyses by P. U. Dunton, Trace Elements Section, Denver laboratory.

[2]Chemical analyses of uranium by Trace Elements Section, Denver laboratory.

A lemon-yellow finely crystalline uranium mineral, identified as carnotite by X-ray powder pattern, is associated with tyuyamunite and volborthite. It occurs, for the most part, interstitial to the flakes of tyuyamunite in specimens from pit 1.

Volborthite, a hydrous vanadate of copper and barium, is much less abundant than tyuyamunite. Its mode of occurrence is similar to that of tyuyamunite, but it is most commonly found in specimens from pit 2. It occurs as dark olive-green masses of finely crystalline radial aggregates and as coatings less than 2 millimeters thick on fractures in the quartzite. The volborthite locally coats the tabular crystals of tyuyamunite in vugs.

Malachite and azurite, green carbonates of copper, are abundant as fracture coatings and as vug fillings in the quartzite specimens from pit 2. Clear brilliant-green crystals of malachite, as much as 20 millimeters in length and 3 millimeters in width, are associated with volborthite, tyuyamunite, azurite, and brochantite. Locally the vanadium and uranium minerals are intermixed with the malachite. The dark-blue azurite grades into the pale-green malachite. In general, the secondary copper minerals were deposited later than tyuyamunite.

Calcite, quartz, and hematite are the common gangue minerals. The calcite occurs as thin coatings on fractures in the quartzite and generally is later than the copper, uranium, and vanadium minerals. Calcite crystals as much as 6 millimeters across locally fill vugs in the quartzite. Dark red-brown massive hematite forms thin coatings on the fractures and locally fills small vugs in the quartzite. Clear, glassy, quartz crystals as much as 5 millimeters in length line the vugs and open fractures in the quartzite. The quartz crystals are oriented in such a manner that their long dimensions are parallel to the walls of the fractures. Quartz is the earliest mineral deposited.

Hyalite, which contains enough uranium to fluoresce a brilliant yellow green, is abundant in the quartzite near pits 1 and 2. It occurs as white to yellowish-white botryoidal masses and as thin coatings on fractures. An ultraviolet light survey of the mapped area (fig. 2) showed that the fluorescent hyalite was found only in the immediate vicinity of the uranium-bearing quartzite. Future prospecting in the Red Creek Canyon area with an ultraviolet light may lead to the discovery of other uranium deposits.

Specimens of quartzite from pit 1 contain a black powdery mineral as thin coatings on the fractures. Although no definite minerals have been identified, spectrographic analysis of this material showed the major elements to be aluminum, manganese, iron, and silica; the minor elements to be copper, cobalt, and vanadium, and traces of calcium, magnesium, lead, and nickel. This material is apparently a mixture of several secondary copper and vanadium minerals.

The owners report that a black sooty highly radioactive material—possibly sooty pitchblende—was found along fractures in the quartzite at the portal of the caved tunnel. The writers did not find any of this material during the examination of the property; however, the presence of sooty pitchblende may indicate primary uranium minerals at depth.

Radioactivity

Examination for radioactivity of the Yellow Canary No. 1 and No. 2 claims was made with a beta-gamma survey meter. The average background of the instrument, which was neither calibrated nor standardized, was 3 divisions on the 0.2 scale. Abnormal radioactivity, which caused deflections that ranged from 15 on the 0.2 scale to 15 on the 2.0 scale, was detected in pits 1 and 2. Survey of the surface outcrops in the immediate vicinity of the pits indicated no abnormal radioactivity; nor was radioactivity above normal background detected in the metamorphic rocks that underlie the white quartzite.

A reconnaissance survey for radioactivity of the copper deposits in Red Creek and Jessie Ewing Canyons indicated no abnormal radioactivity in the deposits.

Grade

At the Yellow Canary deposit uraniferous quartzite is exposed only in pit 1 of the surface workings. The richest sample collected by the writer contains 0.57 percent uranium; it was hand picked from pit 1 as the highest grade material there. The uranium content of the other samples (table 1) ranged from 0.000 to 0.56 percent.

Suggestions for prospecting

Uranium is not found over a very large area at the Yellow Canary mine. Because boulders of white quartzite in the fault breccia zone contain secondary uranium and vanadium minerals, the movement along fault 1 probably occurred after uranium deposition, and, therefore, the most favorable ground for prospecting is in the footwall of the fault, northwest of pit 1. Any prospecting in this area might be most profitably carried on by shallow bulldozer trenches or shafts.

Origin

The origin of the uranium deposit at the Yellow Canary claims can only be inferred from a study of the small exposure of uranium-bearing quartzite in pit 1. The concentration of the uranium, vanadium, and copper minerals along fractures in the white quartzite indicates that the deposition of the ore was controlled by structures and rock types. The absence of uranium and vanadium minerals in the copper-bearing hornblendite and their close association with copper minerals in the Red Creek quartzite, is evidence that there were two periods of mineralization: first, the deposition of primary copper sulfides in the hornblendite, and second, the deposition of primary copper, uranium, and vanadium minerals from solutions introduced along fractures in the quartzite. The secondary minerals, tyuyamunite, volborthite, and copper carbonates exposed in pit 1 were formed by alteration of the primary minerals.

Road log from Colorado State line to Yellow Canary claims

	Distance in miles	
	To Yellow Canary claims	From Colo. State line
Colorado State line (end of Moffat County road 10)	50.6	0
Road junction; follow road straight ahead	52.3	1.7
Road junction; follow road to left	53.6	3.0
Radosevich ranch to right; follow road to left	54.1	3.5
Road junction; follow road straight ahead	54.4	3.8
Road junction; follow road straight ahead	54.8	4.2
Road junction; follow road to left	55.0	4.4
Road junction; J. G. Taylor ranch to left; follow road to right	56.1	5.5
Road junction; follow road to left; road to right leads up Jessie Ewing Canyon and to Clay Basin; road follows river	57.7	7.1
End of road at mine	62.5	11.9

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