Results of Diamond Drilling and Geologic Investigation of the Shirley May (Garo) Deposit Park County, Colorado

By

V. R. Wilmarth, U. S. Geological Survey
and
L. E. Smith, U. S. Atomic Energy Commission

Trace Elements Investigations Report 277

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Geology - Mineralogy

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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by V. R. Wilmarth 1/ and L. E. Smith 2/

ABSTRACT

The Shirley May (Garo) uranium deposit near Garo, Park County, Colo., consists of tyuyamunite and carnotite that occur as disseminations and as fracture fillings in three beds of medium- to coarse-grained sandstone. The sandstones are in the Maroon formation of Permian age. This deposit was explored by means of 12 core-drill holes, totalling 2,003 feet.

The deposit is on the northeast flank of the Garo anticline, a local structure that probably is related to Tertiary tectonic movement. In the vicinity of the deposit the sedimentary rocks strike northwest and dip steeply. They are cut by numerous northerly-trending faults that have horizontal displacements of as much as 1,000 feet. The ore minerals tyuyamunite, carnotite, volborthite, calciovolborthite, malachite, azurite, chalcocite (?), and an unidentified yellow to dark-red vanadium oxide are restricted to a complexly faulted area. The ore body that has yielded most of the uranium ore is in the uppermost ore-bearing sandstone (bed no. 1) and is stratigraphically 50 and 150 feet above the ore horizons in sandstones nos. 2 and 3, respectively.

The uranium content of samples from the mine workings ranges from 0.001 to 0.48 percent uranium; dump samples contain as much as 2.39 percent uranium. A total of 40 tons of uranium ore, averaging 1.0 percent uranium, was produced in 1919.

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INTRODUCTION

Radium and uranium ores were produced in 1919 and in 1951-52, respectively, from a uranium-vanadium-copper deposit, three-fourths of a mile south of Garo, in central Park County, Colo. (fig. 1). The Shirley May deposit, known locally as the Garo uranium deposit, is in the NE 1/4 sec. 16, T. 11S., R. 76 W., 6th Principal meridian. The property is currently under lease by W. H. Gaddis of Colorado Springs, Colo.; the surface rights are owned by N. C. Cargill of Fairplay, Colo. The deposit is easily accessible over State Highway No. 9 from Fairplay, the nearest supply center, 11 miles northwest of Garo. The nearest railhead is at Buena Vista, Colo., 37 miles by road west of Fairplay, over U. S. Highways No. 285 and No. 24. The nearest uranium mill is the U. S. Vanadium Mill at Rifle, Colo., approximately 150 miles northwest of Buena Vista.

According to Riley (1946) the deposit was first prospected in about 1917, and in 1919 approximately 40 tons of ore that contained 1 percent U_3O_8 was mined. Although the area was prospected extensively in 1917, as evidenced by many small pits northwest of the mine, no other uranium deposits were found. The mine was idle until 1951, when W. H. Gaddis commenced open-pit mining and rehabilitation of the underground workings.

Geologic investigations

In 1944, Guilotte (1944) briefly described the uranium deposit near Garo and in 1946, Riley (1946) indentified carnotite, volborthite, calciovolborthite, malachite, and azurite in specimens of dump material. According to Stark and others (1949) copper-vanadium minerals occur in carbonaceous-rich sandstones near Garo. The deposit was examined and sampled in 1950 by Anderson (1950) of the Atomic Energy Commission and in 1951 by King (1951) of the U. S. Geological Survey. The first comprehensive geologic investigation of the deposit was undertaken by Gott and Dellwig (1951) of the U. S. Geological Survey. They mapped a small area surrounding the deposit on a scale of 1 inch equals 40 feet.

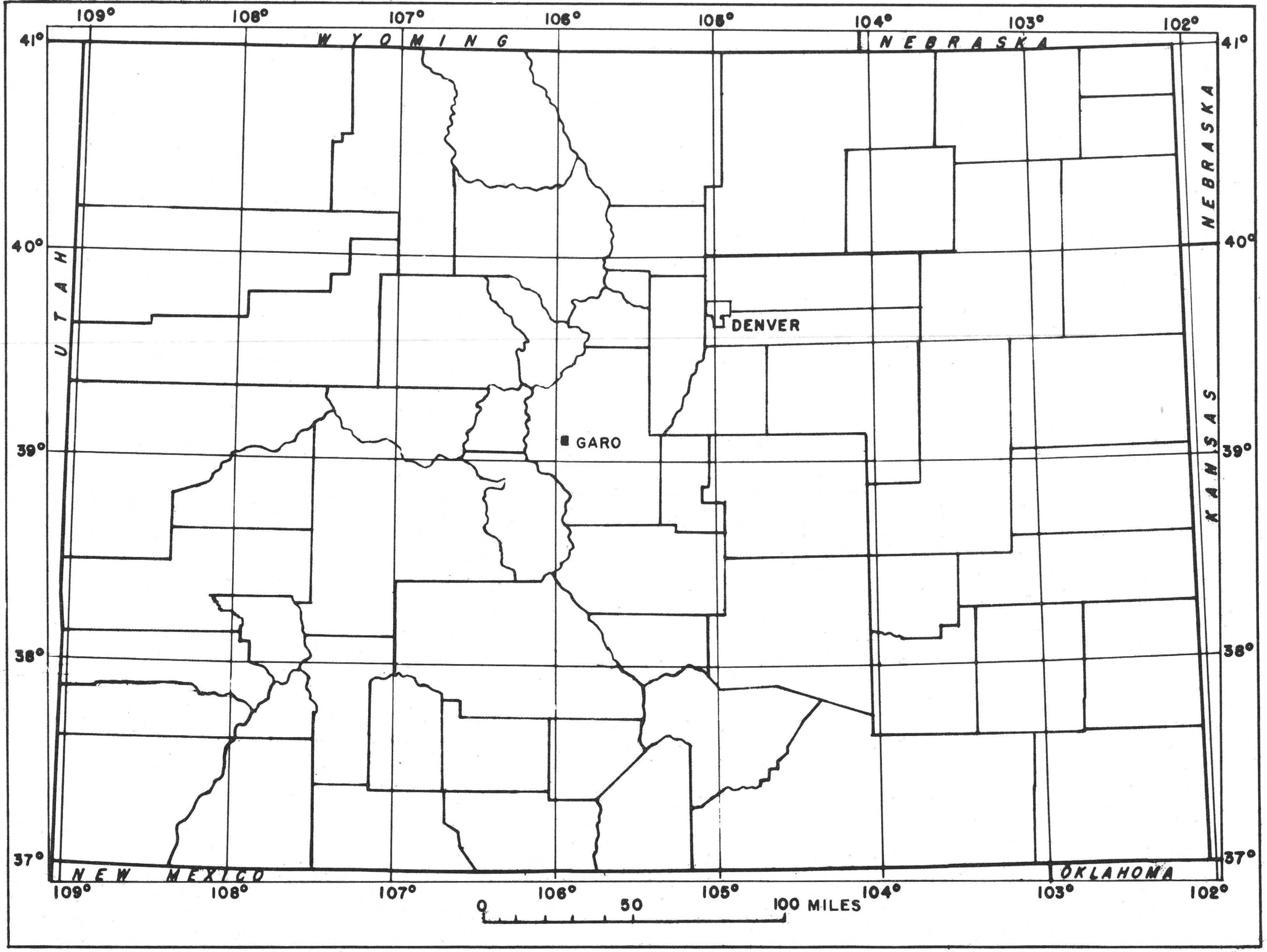

FIGURE I— INDEX MAP OF COLORADO SHOWING GARO

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During June 1952 L. E. Smith of the Atomic Energy Commission and V. R. Wilmarth of the U. S. Geological Survey mapped the geology and topography of approximately half a square mile in the vicinity of the deposit on a scale of 1 inch equals 100 feet. This work was undertaken to obtain information on the structure, mode of occurrence, and extent of the uranium-vanadium-copper bearing sandstones that have been uncovered during the current surface-mining operations and to prepare a base map for use in a diamond-drilling exploration program. The drilling program was commenced in June 1952, and was carried out by the U. S. Bureau of Mines on behalf of the Atomic Energy Commission; the primary objectives were to determine the horizontal and vertical extent of the uranium-vanadium-copper mineralization and, secondarily, to obtain geologic data that would aid in prospecting geologically similar uranium-vanadium-copper deposits.

Geography

The Shirley May (Garo) uranium deposit is at an altitude of 9,100 feet above sea level in the central part of South Park, a broad flat intermontane valley, between the Mosquito Range to the west and the Front Range to the east. In general the winters are long and commonly snowfall is heavy; the summers are short and cool. Records for precipitation at Hartzel, 9 miles southeast of Garo, show that the average yearly rainfall is approximately 11 inches and the average yearly snowfall is about 44 inches. The area is nearly flat at the mine, and water for mining purposes is available in the Middle Fork of the South Platte River, 2 miles north of the mine. Timber for the mine is readily obtained in the mountains west of Fairplay.

Acknowledgments

The writers wish to thank Mr. Gaddis and members of the U. S. Bureau of Mines drilling crews for the excellent cooperation shown by them during the investigation of this property. Special thanks are due L. R. Page of the U. S. Geological Survey and C. C. Towle of the Atomic Energy Commission for many helpful suggestions.

GEOLOGY

Rock units

In the vicinity of the Shirley May deposit, the faulted and steeply dipping sedimentary rocks of the Maroon formation of Permian age are covered in part by glacial and in part by stream deposits of Quaternary age (fig. 2). The Maroon formation consists of interbedded, thin- to massive-bedded, maroon to red sandstones, siltstones, conglomerates, and shales, and dark to light gray limestones. The contacts between these rock units are gradational and the facies changes are characteristically abrupt. Locally cross-bedding is well developed in the sandstone beds. The limestone and sandstone beds shown on figure 2 are traceable throughout most of the mapped area and were used as marker beds. Because the limestones are more resistant, they form low northwesterly-trending ridges, whereas the easily eroded sandstones, shales, and siltstones form valleys. In the northern part of the mapped area five of the eight limestone marker beds are exposed (fig. 2). These beds from north to south are:

(1) Limestone bed no. 1, a 4- to 8-foot thick dark red-gray, thin-bedded to massive, finely crystalline limestone that locally contains some red and gray chert. This bed probably correlates with the cherty limestone in drill holes nos. 10 and 12.

(2) Limestone bed no. 2, a 2- to 10-foot thick dark gray, finely crystalline, massive limestone that weathers light gray. Vugs are abundant locally. They are as much as 2 inches in diameter and are lined with coarsely crystalline calcite. Small irregular masses, as much as 4 inches across, of fine- to medium-grained red sandstone occur in places. This limestone is exposed northwest of the mine and can be traced along the strike for about 2,000 feet.

(3) Limestone bed no. 3. This bed contains as much as 95 percent radioactive chert and ranges from 1 to 7 feet in thickness. The chert characteristically weathers to hackly boulders and is generally translucent, but locally it is opaque. It is red, blue, gray, yellow, white, and black. The uranium content ranges from 0.003 to 0.009 percent; the color apparently is not related to the uranium content. The

limestone is a dark to light gray fine- to medium-grained rock that contains small rounded masses of dark-red fine-grained limestone.

(4) Limestone bed no. 4, a light to dark gray, thin-bedded to massive, finely crystalline rock that weathers light gray. It ranges from 2 to 5 feet in thickness and in the northern part of the area grades along strike into red, mottled sandy limestone.

(5) Limestone bed no. 5,a light gray, massive fine to coarsely crystalline limestone. In the area northwest of the mine this bed is flanked by a 2-foot bed of red to brown, sandy limestone, 20 feet to the northeast, and by a light gray sandy limestone, 55 feet to the southwest.

In addition, three other limestone beds are poorly exposed in the southern part of the area.

(6) Limestone bed no. 6, farthest to the southwest (fig. 2) is a 2- to 5-foot thick dark red to brown, massive, finely crystalline rock. Vugs as much as 1 inch in diameter are abundant and commonly contain crystalline calcite.

(7) Limestone bed no. 7, a 4-foot thick bed composed of dark gray to red, mottled, massive, medium-grained limestone, is exposed just southwest of pit no. 1 and in a small pit southwest of pit no 3. This bed grades along the strike into a red sandy limestone.

(8) At the northwest end of pit no. 1 is the only exposure of a bed of dark gray thin-bedded, finely crystalline limestone from 4 inches to 1 foot thick.

Northwest of the mine workings a sandstone marker bed is exposed (fig. 2). The bed is approximately 20 feet southwest of limestone bed no. 2. It is a 6-foot bed of light gray to brown, massive, fine- to medium-grained, calcareous, micaceous sandstone.

At the Shirley May mine three sandstone beds 6 to 13 feet thick contain uranium, vanadium, and copper minerals. The uranium-bearing beds are designated as sandstone beds nos. 1, 2, and 3. Beds no. 1 and no. 2 are exposed only at the mine, but bed no. 3 can be traced along the strike for nearly 4,000 feet. Megascopically these beds are red or white to light buff, thin-bedded, highly micaceous, fine- to coarse-grained rock that near the bottom of the beds contain locally thin layers of quartz and feldspar pebbles.

Arkosic sandstone beds (non-uraniferous) are abundant and are best exposed in the irrigation ditch southeast of the mine workings. These beds are maroon to bright red, very coarse-grained, calcareous, massive rocks that contain abundant coarse mica flakes.

The sedimentary rocks between the limestone and sandstone marker beds are poorly exposed; however, data from drill holes and some outcrops indicate these rocks are for the most part composed of interbedded, thin-bedded, red to light gray shales, siltstones, and sandstones.

Structure

The uranium deposits at the Shirley May mine are on the northeast flank of the Garo anticline, a northwesterly-trending local structure that probably is related to Tertiary tectonic movement. In the area mapped, the complexly faulted sedimentary rocks of the Maroon formation have a prevailing strike of N. 40° - 65° W., and dip 50° - 75° NE.

The major structural features in the vicinity of the mine (fig. 2) are four northerly-trending, steeply dipping faults - faults no. 1, no. 2, no. 3, and no. 4 - that have displaced the sedimentary rocks as much as 1,000 feet, horizontally. Many subsidiary faults have greatly increased the complexity of the structure in the area between faults no. 2 and no. 4, and although only 7 of these faults are shown on figure 2, there are undoubtedly many similar faults in this area. These subsidiary faults have horizontal displacement of from 5 to 50 feet and most of them trend northeast; some terminate against the major faults. It is probable that the subsidiary faults were formed prior to the deposition of the ore and that the known uranium-vanadium-copper deposits are restricted to areas of highly fractured rocks.

Outside of the mine workings the positions and traces of the faults cannot be determined accurately because of a mantle of stream deposits. The surface outcrops and abrupt termination of the limestone and sandstone marker beds, however, indicate the position of the fault. The faults in the mine workings commonly are marked by a zone as much as 4 feet thick that contains gouge, infaulted, and fractured sandstones, siltstones, and shales. The fault zones observed in both the mine workings and the drill holes are not mineralized.

A significant structural feature of the sedimentary rocks in this area is the thinning and thickening of the lithologic units of the Maroon formation along both strike and dip. This results in a variation in the attitude of adjacent bedding planes and may have a bearing on prospecting for uranium at this mine, because a factor that may determine the size of the deposit is the attitude of the favorable host rock. As is shown in figure 3, the divergence of the dip is most pronounced and locally the ore horizons may pinch out at shallow depths coincident with a thinning of sandstone beds no. 1, no. 2, and no. 3 with depth.

ORE DEPOSITS

Distribution

Most of the production of uranium ore from the Shirley May mine has come from sandstone bed no. 1 between fault no. 3 and fault no. 4; small quantities of ore have been mined from sandstone bed no. 3 in pit no. 2, but no ore has been produced from sandstone bed no. 2.

Owing to the complexity of the structure in the immediate vicinity of the mine there is some doubt as to whether the uraniferous parts of the sandstone beds are discontinuous because of faulting, or because of deposition of ore minerals. There is evidence for all variations. In pit no. 1, the uranium-bearing sandstone bed has been mined continuously along the strike for approximately 120 feet, and down dip for about 30 feet; it was as much as 7 feet thick. In this pit, the steeply dipping sandstone bed has been cut by vertical cross faults and a strike fault (fig. 3). This faulting may explain the absence of uranium and other ore minerals in this bed, and at depth southeast of pit no. 1. In pit no. 3 the ore-bearing sandstone bed no. 1 is cut by a strike fault and the mineralized part of the bed appears to pinch out at depth (fig. 3) because of the lenticularity of the host rock. The ore-bearing sandstone in pit no. 2 is unfaulted, but the uraniferous area appears to end abruptly along the strike and down dip with no apparent change in lithology or shape of the sandstone bed. The occurrence of uranium in these deposits is probably controlled by the porosity caused by solution of the calcium carbonate cement and lenticularity of the favorable host rock, and the complex faulting of these beds prior to introduction of ore-bearing solutions.

The uranium content of samples (table 1) from sandstone bed no. 1 ranges from 0.001 to 0.22 percent uranium in pit no. 1, and from 0.013 to 0.48 percent uranium in pit no. 3. The ore mined from these pits, however, averaged between 0.10 and 0.2 percent uranium.

Sandstone bed no. 2 is stratigraphically 50 feet lower than bed no. 1 and where exposed at the surface (fig. 2) does not contain uranium, vanadium, or copper minerals. The bed is as much as 13 feet thick and is a red, white to light gray, soft, fine- to medium-grained highly micaceous sandstone. The lower 6 inches of the bed is a coarse-grained arkosic sandstone that contains quartz and feldspar pebbles as much as 1/16 of an inch in diameter. Where cut in diamond-drill hole no. 5, this sandstone bed contains secondary copper, uranium, and vanadium minerals disseminated throughout the entire thickness of the bed. One 4-foot core sample (table 1) contained 0.018 percent U_3O_8.

Sandstone bed no. 3 is best exposed in pit no. 2 (fig. 3), and is traceable along the strike throughout the mapped area (fig. 2). It is similar texturally and mineralogically to the other uranium-bearing sandstone beds, but is stratigraphically 150 feet lower than sandstone bed no. 1. Bed no. 3 is a red, white to light gray, thin-bedded, fine- to medium-grained, micaceous sandstone with some thin white coarse pebbly layers near the base. The known area of uranium-vanadium-bearing rock extends from the breast of the adit (fig. 2) to the east end of pit no. 2. The only uranium and vanadium minerals visible in August 1952 are in a part of the sandstone bed, as much as 3 feet thick and 4 feet long on the hanging wall of the bed at the east end of pit no. 2. Three channel samples (table 1) taken across this mineralized rock contained 0.003, 0.006, and 0.02 percent U_3O_8, and 0.29, 0.17, and 0.26 percent V_2O_5, respectively.

Character of the ore

The mineralogy and textures of the ore at the Shirley May mine are essentially the same in all three mineralized sandstone beds, although there are variations in the relative proportions of the minerals. The constituent ore minerals, in the order of decreasing abundance, are: malachite, tyuyamunite, volborthite, carnotite, red and dark purple to black vanadium minerals, and azurite. Minor quantities of calciovolborthite

Table 1.--Sample and assay data for Shirley May (Garo) uranium deposit, Park County, Colorado

Field sample number	Location	Length and type of sample	eU (percent)	U (percent)	V_2O_5 (percent)
LD-1	Lower 3.5 feet of uranium-bearing sandstone bed no. 1, in pit no. 1	3.5-foot channel	0.075	0.076	
LD-2	Upper 3.5 feet of uranium-bearing sandstone bed no. 1, pit no. 1	3.5-foot channel	.055	.069	
LD-3	Working face of pit no. 1 (July 1951)	7-foot channel	.052	.070	
GG-40	Northern 2 feet of uranium-bearing sandstone bed no. 1, 17 feet below surface in shaft	2-foot channel	.075	.078	
GG-41	Southern 3 feet of uranium-bearing sandstone bed no. 1, 17 feet below the surface in shaft	3-foot channel	.13	.19	
GA-69	Lower 1.3 feet of sandstone bed no. 1, pit no. 1	1.3-foot channel	.016	.018	0.17
GA-70	Lower 1.2 feet of sandstone bed no. 1, pit no. 1	1.2-foot channel	.034	.035	.13
GA-71	Lower 1.3 feet of sandstone bed no. 1, pit no. 1	1.3-foot channel	.001		.09
GA-72	Across sandstone bed no. 1, pit no. 1	4-foot channel	.004		.19
GA-73	Across sandstone bed no. 1, pit no. 1	3-foot channel	.003		.09
GA-74	Across fault zone	4-foot channel	.002		.10
GA-75	Across fault zone	4-foot channel	.002		.11
G-1-52	Across uranium-bearing sandstone bed no. 1, pit no. 3	4-foot channel	.10	.14	
LD-4	Copper-uranium-vanadium ore from sandstone bed no. 1, pit no. 3.	Channel	.011	.013	
LD-5	Copper-uranium-vanadium ore from sandstone bed no. 1, pit no. 3	Channel	.31	.48	
LD-6	Uranium ore from sandstone bed no. 1 at east end of pit no. 3	Channel	.045	.028	
GG-11	Copper-uranium-vanadium ore from sandstone bed no. 1, pit no. 3	6-foot chip channel	.003	.001	

Table 1.--Sample and assay data for Shirley May (Garo) uranium deposit, Park County, Colorado--Continued

Field sample number	Location	Length and type of sample	eU (percent)	U (percent)	V_2O_5 (percent)
F-6780	Upper 2 feet of sandstone bed no. 1, pit no. 1	2-foot channel	0.019	0.016	0.05
F-6781	Lower 2 feet of sandstone bed no. 1, pit no. 1	2-foot channel	.11	.13	.80
F-6782	Lower 2 feet of sandstone bed no. 1, pit no. 1	2.5-foot channel	.089	.096	.38
F-6763	Across sandstone bed no. 1, pit no. 3	4.5-foot channel	.12	.12	.21
GA-35	Middle part of sandstone bed no. 1, pit no. 3	2-foot channel	.005	.001	.12
GA-36	Middle part of sandstone bed no. 1, pit no. 3	5-foot channel	.007	.001	.10
GA-37	Upper 2 feet of sandstone bed no. 1, pit no. 3	2-foot channel	.006	.003	.20
GA-38	Upper 2 feet of sandstone bed no. 1, pit no. 3	2-foot channel	.002		.05
GA-39	2-foot section across sandstone bed no. 1, pit no. 3 on footwall side of GA-38	2-foot channel	.001		.10
GA-40	2-foot section on footwall side of GA-39 in sandstone bed no. 1, pit no. 3	2-foot channel	.001		.10
GA-41	Lower 2 feet of sandstone bed no. 1, pit no. 3	2-foot channel	.004		.07
GA-46	Upper 4 feet of sandstone bed no. 1, pit no. 3	4-foot channel	.001		.10
GA-47	Middle part of sandstone bed no. 1, pit no. 3 adjacent to GA-40	4-foot channel	.002		.07
GA-49	2.5 feet across sandstone bed no. 1, pit no. 3 adjacent to GA-50	2.5-foot channel	.20	.22	1.37
GA-50	2 feet of sandstone bed no. 1, pit no. 3 adjacent to GA-51	2-foot channel	.003		.05
GA-51	Lower 1 foot of sandstone bed no. 1, pit no. 3	1-foot channel	.005	.001	.21
GA-52	Upper 2 feet of sandstone bed no. 1, pit no. 3	2-foot channel	.001		.08
GA-53	2 feet of sandstone bed no. 1, pit no. 3 adjacent to GA-52	2-foot channel	.003		.14

Table 1.--Sample and assay data for Shirley May (Garo) uranium deposit, Park County, Colorado--Continued

Field sample number	Location	Length and type of sample	eU (percent)	U (percent)	V_2O_5 (percent)
GA-54	Lower 3 feet of sandstone bed no. 1, pit no. 3	3-foot channel	0.002		0.05
GA-55	Lower 2 feet of sandstone bed no. 1, pit no. 3	3-foot channel	.02	0.008	.24
GA-56	Across 2 feet of sandstone bed no. 1, pit no. 3 above GA-55	2-foot channel	.002		.10
GA-57	Across 6 feet of sandstone bed no. 1, pit no. 3 above GA-56	6-foot channel	.001		.12
GA-68	Across sandstone bed no. 2, in small pit west of pit no. 3	6-foot channel	.002		.09
F 13260	Core - sandstone bed no. 2, drill hole no. 5	4-foot split	.016	.018	.17
F 13259	Core from sandstone bed no. 2, drill hole no. 4	4-foot split	.003	.003	.29
GA-62	Across sandstone bed no. 3, at breast of adit	6-foot channel	.002		.10
GA-67	Across sandstone bed no. 2 northwest of pit no. 2	6-foot channel	.002		.12
GG-1-1	Dip slope of uranium-bearing sandstone bed no. 3, pit no. 2	Chip channel	.016	.011	.05
GG-1-2	Total thickness of uranium-bearing sandstone bed no. 3, pit no. 2	7-foot chip channel	.055	.062	.20
F 13262	Bottom of east end, pit no. 2	3-foot channel	.049	.037	.49
F 13263	2.5-feet east of F 13262	3-foot channel	.010	.006	.17
F 13264	2.5 feet west of F 13263	3-foot channel	.002	.001	.08

and chalcocite (?) were found in some specimens from the dump. Limonite, quartz, and calcite are the principal gangue minerals. Primary or hypogene uranium, vanadium, or copper minerals have not been identified.

Tyuyamunite - a yellow hydrated calcium uranium vanadate - the dominant uranium mineral, was identified by X-ray powder pattern and spectrographic analysis. It occurs as disseminated grains in sandstone and as thin seams and coatings along bedding and fracture surfaces. Rounded, crystalline aggregates of tyuyamunite, as much as 1/16 inch across, are common on fracture surfaces in the hard calcite-rich sandstone adjacent to the faults in pit no. 1. The disseminated tyuyamunite is associated with dark green, platy crystals of volborthite, crystalline malachite, massive carnotite, and rounded masses of azurite. Minute rounded masses of a metallic mineral believed to be chalcocite were found in some places.

Grade

Although the grade of the ore shipped in 1919 from the Shirley May mine was reported to be 1 percent (Riley, 1946), the uranium content of samples from sandstone beds no. 1, no. 2, and no. 3 indicate that the average grade of the rock left in the mine is much less. The richest sample collected in the mine was from the footwall of sandstone bed no. 1 and contained 0.48 percent uranium. A small grab sample of selected high-grade uranium ore from the dump was reported (Riley, 1946) to contain 2.39 percent uranium. Of the 46 samples (table no. 1) from the mine, 6 contained more than 0.1 percent uranium, 6 contained from 0.05 to 0.1 percent uranium, and 34 contained less than 0.05 percent uranium.

RADIOMETRIC RECONNAISSANCE IN THE GARO AREA

A radiometric scintillometer grid survey was made of the area 1,000 feet northwest of the Shirley May mine. The only radioactive anomalies noted were on the cherty limestone bed, no. 3, but because of the overburden, the data obtained from this survey are not conclusive.

A reconnaissance scintillometer survey was made also of the Maroon formation where it crops out on the ridge southwest of the Middle Fork of the South Platte between Garo and Fairplay. Readings of two times background were noted in a small pit on a cherty limestone in sec. 4, T. 10 S., R. 77 W. In sec. 10, T. 10 S., R. 77 W. readings of two times background were noted on the dump of a 30-foot shaft sunk in a gray shale member of the Maroon formation. Some of the dump rock is coated with a thin film of malachite. No other anomalies were noted except at cherty limestone outcrops.

In secs. 26 and 35 in T. 11 S., R. 77 W. a reconnaissance scintillometer survey was made of the cherty limestone beds in an area where the Maroon formation has been faulted extensively. The limestone is similar to the cherty limestone exposed at the Shirley May mine, but the chert is almost entirely bright red. Readings of three times background were obtained from the cherty limestone beds, but no other radioactive anomalies were noted in the area.

Because there may be a genetic relation between the Shirley May uranium deposit near Garo, and pitchblende-bearing veins along the London fault west of Alma, 16 mines in the vicinity of this fault were examined for radioactive material. As most of the mines examined are inaccessible and only the dump material was examined, the results obtained are not conclusive. Samples of the most radioactive material found contained from 0.002 to 0.003 percent uranium. Details of these examinations will be given in subsequent reports.

RESULTS OF DIAMOND DRILLING

Summary

The purpose of the diamond-drilling program at the Shirley May uranium deposit was (1) to determine the lateral and vertical extent of the uranium-vanadium-copper mineralization in sandstone beds no. 1 and no. 2, (2) to explore the sedimentary beds between the uranium-bearing horizons for possible mineralization, and (3) to obtain geologic data that would aid in prospecting geologically similar deposits.

Diamond drilling by the U. S. Bureau of Mines Special Mineral Investigations Branch started June 17 and was completed August 13, 1952. Twelve holes totalling 2,003 feet were drilled; the core recovery was 98.7 percent. (See table 2 for drilling statistics.) All diamond-drill holes were logged radiometrically with a portable borehole Geiger counter. This counter on radiometric probing gives only relative readings and is more sensitive than a standard field counter. In the drill holes where high radioactivity was detected with the borehole counter the corresponding rock in the core when tested with a beta-gamma survey meter was only slightly abnormally radioactive.

Table 2.--Diamond-drilling statistics, Shirley May (Garo) uranium deposit, Park County, Colorado

Hole No.	Total feet drilled	No. of shifts	Average foot per shift	Average core recovery %
1	222.5	11	20.22	100.0
2	208.0	9	23.10	100.0
3	115.5	6	19.25	98.4
4	270.5	14	19.32	98.7
5	182.8	10	18.28	92.6
6	172.1	10	17.21	98.9
7	99.9	5	19.98	100.0
8	107.0	6	17.83	95.3
9	136.4	8	17.05	93.7
10	176.5	7	25.21	99.0
11	140.0	6	23.33	100.0
12	172.0	8	21.50	98.0
Total	2,003.2	100	20.19	98.7

The mineralized sandstone beds no. 1, no. 2, and no. 3 were drilled in an area of 750 feet along the strike and to as much as 290 feet down the dip, 185 feet vertically below the surface.

Sandstone bed no. 1 was cut by 10 drill holes at vertical depths below the surface that range from 50 to 107 feet (figs.4 and 5). The bed, where cut in the drill holes, is 6 to 10 feet thick, and is a red to white, fine-grained sandstone with a thin zone of conglomerate at the bottom. No uranium minerals were noted in the core or indicated by the radiometric logs of the drill holes, but malachite as a thin coating on a fracture surface was noted at the bottom of the bed in drill hole no. 5.

Sandstone bed no. 2 is a partially mineralized bed found by diamond drilling. It is an 8- to 10-foot thick red, white, and maroon, medium-grained sandstone that is 50 feet stratigraphically below sandstone bed no. 1. This bed was cut by 7 drill holes at vertical depths of 85 to 120 feet and uranium mineralization was indicated by radiometric log in drill holes no. 1, no. 4, and no. 5. In drill hole no. 1 radioactivity of two times background was observed over a zone as much as 6 inches wide. In drill hole no. 4 a 4-foot sample of core contains 0.003 percent U_3O_8, and 0.29 percent V_2O_5 in the area of highest radiometric readings. In drill hole no. 5 the highest radiometric readings were obtained from a 4-foot thick sample of core that contained 0.018 percent U_3O_8, and 0.17 percent V_2O_5.

Sandstone bed no. 3 is a 7-foot thick red, white, micaceous, fine-grained sandstone and was cut by 5 drill holes at vertical depths below the surface of 45 feet to 185 feet. No uranium, vanadium, or copper minerals were noted in the core and no abnormal radioactivity was indicated in the bed by the radiometric logs of the drill holes.

The radioactive cherty limestone bed, exposed at the surface near pit no. 2, is 15 feet stratigraphically above the sandstone bed no. 3. This limestone was cut in the 5 drill holes that penetrated the sandstone bed no. 3. Radiometric logs of holes nos. 1, 4, 7, and 8 indicated that the radioactivity of the chert was twice the normal background. This bed is mineralogically and texturally similar to another radioactive cherty limestone bed cut by drill holes no. 10 and no. 12 but is not exposed in the immediate vicinity of the mine. Its radioactivity is twice normal background. This bed is a light gray limestone that contains red and black chert.

There is a very distinct change in color of the mineralized sandstone beds at depth. Where exposed in the pits the beds are white but in the drill holes only the bottom 6 inches to 2 feet of the beds are white. This color change may be explained by the leaching of the red sandstone by surface and ground water penetrating down dip along the more permeable sections of the sandstones.

There are definite cycles of sedimentation as shown by drilling. Conglomeratic to coarse-grained sandstone, which was deposited first, grades to siltstone and then to shale. The shale deposition ended abruptly and the cycle repeated itself every 10 to 20 feet. This cycle was abruptly interrupted at various stages and repeated.

Description of drill holes

The factual data of the diamond-drilling program such as the elevation, bearing of the hole, hole length and angle, the purpose of each hole with regard to drilling objective and the results of each hole with regard to objectives are contained in table 3. Figures 4 and 5 are the logs of the drill holes.

Diamond-drill hole no. 1

In hole no. 1, sandstone bed no. 1 is a 7-foot thick, dark red, fine- to medium-grained, porous, micaceous sandstone with manganese dioxide and limonite stains on fracture surfaces. Commonly calcite coats some of the fracture surfaces. The bottom 6 inches of this bed has been bleached.

Sandstone bed no. 2 is 12 feet thick, red, fine- to medium-grained sandstone and, at a hole depth of 154 feet, tyuyamunite, volborthite, and malachite coat the surfaces of an open fracture, a quarter of an inch wide. The sandstone has been bleached adjacent to this fracture.

A fault with red clay gouge and sandstone fragments was cut at a vertical depth of 82 feet below the surface. This fault is the westernmost fault in pit no. 1 (fig. 3) and has displaced sandstone bed no. 1. There is no alteration or evidence of uranium mineralization in the fault zone.

Table 3. --Objectives and results of diamond drilling, Shirley May (Garo) uranium deposit, Park County, Colorado

	Drill Hole data			Objectives			Results			
DDH no.	Elevation of collar (feet)	Hole Length (feet)	Inclination of hole (degrees)	To explore beds at vertical depths as shown: bed no. 1 (feet)	bed no. 2 (feet)	bed no. 3 (feet)	Beds intersected at vertical depths as shown: bed no. 1 (feet)	bed no. 2 (feet)	bed no. 3 (feet)	Radioactive chert (feet)
1	9158.2	222.5	-50	75	--	150	66	110	158	138
2	9155.0	208.0	-53	75	90	150	60	85	161	142
3	9157.2	115.5	-54	70	--	---	68	--	---	---
4	9160.7	270.5	-45	60	100	150	64	105	185	170
5	9163.5	182.7	-50	75	120	---	70	119	---	---
6	9168.3	172.0	-50	60	100	---	62	111	---	---
7	9161.8	99.9	-45	--	---	60	--	---	60	45
8	9163.4	107.0	-45	--	---	60	--	---	60	47
9	9159.5	136.4	-45	50	90	--	50	89	--	--
10	9158.0	176.5	-55	100	--	--	98	--	--	--
11	9155.7	140.0	-45	50	90	--	50	87	--	--
12	9156.5	172.0	-55	100	--	--	107	--	--	--

Sandstone bed no. 3 is a 7-foot thick, red to white, fine-grained, micaceous sandstone that contains no uranium, vanadium, or copper minerals. The cherty limestone marker bed, stratigraphically about 15 feet above sandstone bed no. 3, is only slightly radioactive.

Diamond-drill hole no. 2

Sandstone bed no. 1 is a 6-foot thick, red to white, medium-grained sandstone that is conglomeratic at the bottom. No uranium, vanadium, or copper minerals were noted in the core from this bed.

Sandstone bed no. 2 is a 6-foot thick, red to white, fine- to medium-grained sandstone. The bottom 2 feet has been bleached, but does not contain uranium, vanadium, or copper minerals.

The radioactive cherty limestone marker bed is 3 feet thick with a 1-foot layer of gray and red chert at the top.

Sandstone bed no. 3 is a 7-foot thick, red, medium-grained, micaceous sandstone. The bottom 6 inches of this bed is bleached and conglomeratic.

Diamond-drill hole no. 3

Sandstone bed no. 1 is a 10-foot thick, porous, friable, dark red, fine-grained micaceous sandstone in which the bottom one-foot is bleached and conglomeratic. No uranium, vanadium, or copper minerals are present.

Diamond-drill hole no. 4

Sandstone bed no. 1 was cut 57 feet down the dip of the bed, below the bottom of pit no. 3. This sandstone bed is an 8-foot thick porous, red to white, fine- to medium-grained sandstone with 6 inches of conglomeratic sandstone at its base. There are no uranium, vanadium, or copper minerals in the core from this bed.

Sandstone bed no. 2 is a 10-foot thick, maroon, red to white, medium-grained, conglomeratic sandstone. The top 5 feet of the bed is porous conglomeratic sandstone and contains azurite, malachite, volborthite, tyuyamunite, manganese dioxide, and limonite as coatings on the sand grains. A 4-foot sample of the core contains 0.003 percent U_3O_8, 0.29 percent V_2O_5, and 0.38 percent copper.

The radioactive cherty limestone bed is 5 feet thick and has a 1.5-foot thick layer of red, blue, and gray chert near the top. The radiometric log indicates the chert has about twice the normal background count.

No uranium, vanadium, or copper minerals were found in sandstone bed no. 3.

Diamond-drill hole no. 5

Sandstone bed no. 1 is a 7-foot thick, red, white, fine- to medium-grained sandstone. The bottom 6 inches of this bed is a bleached conglomeratic sandstone. At 75 feet there is a bleached zone that contains malachite, manganese dioxide, and limonite as thin coatings on a fracture surface. Uranium minerals were not detected in this hole by the borehole counter.

Sandstone bed no. 2 is a 7-foot thick, porous, red, fine-grained, micaceous sandstone. The top 4 feet of the bed is a white sandstone that contains pyrite crystals and limonite disseminated through the sandstone adjacent to a small fracture. No other minerals are visible but a 4-foot sample of the mineralized sandstone core gave the highest radiometric reading obtained in the drill holes and contained 0.018 percent U_3O_8, 0.17 percent V_2O_5, and copper.

Diamond-drill hole no. 6

Sandstone bed no. 1 is a 6-foot thick, red, white, fine-grained, micaceous sandstone. There is some manganese dioxide stain on a small fracture surface in sandstone bed no. 1, but no uranium, vanadium, or copper minerals are present.

Sandstone bed no. 2 is a 7-foot thick, red, white, fine-grained micaceous sandstone. The top 3 feet of this bed is white and contains small grains of limonite pseudomorphic after pyrite. The borehole counter recorded readings of 1/2 times normal background, but no radioactivity was detected in the core with a standard field counter.

Diamond-drill hole no. 7

Sandstone bed no. 3 is an 8-foot thick, red, fine-grained, micaceous sandstone. The bottom 2 feet of this bed is a white, fine-grained, conglomeratic sandstone, but contains no uranium, vanadium, or copper minerals.

The radioactive cherty limestone bed is a 7-foot thick, light gray limestone with 1.5 feet of red, gray, and blue chert near the top of the bed. The borehole counter recorded readings of twice background from the chert bed.

Diamond-drill hole no. 8

Diamond-drill hole no. 8 was designed to test sandstone bed no. 3 west of pit no. 2 (fig. 2) at a vertical depth of 60 feet below the surface.

The sandstone bed was cut at a vertical depth of 60 feet and is an 8-foot thick, red to white, fine-grained sandstone. Thin coatings of manganese dioxide stain were noted on a small fracture near the top of the sandstone, but no uranium, vanadium, or copper minerals are present.

The radioactive cherty limestone bed in this hole is a 7-foot thick, light gray limestone with a 2-foot layer of red, gray, and black chert near the top of the bed. The borehole probe recorded readings of twice normal background at the chert bed.

Diamond-drill hole no. 9

Sandstone bed no. 1 was cut 38 feet down dip of the bed below the bottom of pit no. 3. It is a 7-foot thick, dark red, white, fine-grained sandstone. A thin zone of conglomeratic sandstone at the bottom of the bed contains limonite and manganese dioxide as coatings on a fracture surface.

Sandstone bed no. 2 is a 10-foot thick, maroon, red, white, medium-grained sandstone with a 2-foot thick, white, coarse-grained sandstone near the middle. No uranium, vanadium, or copper minerals are present in this sandstone bed.

A shear zone was cut at a vertical depth of 25 feet and contains a red clay gouge. This shear zone probably correlates with the shear zone shown on figure 2 between pits no. 1 and no. 3.

Diamond-drill hole no. 10

Sandstone bed no. 1 is a 10-foot thick, dark red, white, medium-grained, porous, poorly cemented sandstone. No uranium, vanadium, or copper minerals are present.

A cherty limestone bed mineralogically and texturally similar to the cherty limestone, 15 feet stratigraphically above sandstone bed no. 3, was cut at a vertical depth of 20 feet. The bed is a 6-foot thick, light gray limestone and has 1.5 feet of red, gray, and black chert at the top. The chert bed gives radiometric readings of two times normal background. Below the limestone is a one-foot shear zone with red and green clay gouge that contains chert and limestone fragments.

Diamond-drill hole no. 11

Sandstone bed no. 1 was cut 33 feet down the dip of the sandstone bed from the bottom of pit no. 1. The bed is an 8-foot thick, dark red, maroon, medium-grained, poorly cemented, micaceous sandstone; the bottom 2 feet are bleached. There are no uranium, vanadium, or copper minerals present.

Sandstone bed no. 2 is a 13-foot thick, coarse-grained, red, dark red, white, conglomeratic sandstone. There is some manganese dioxide and limonite stain, but no uranium, vanadium, or copper minerals are present.

A shear zone of red clay gouge with limestone fragments was cut at a hole depth of 67 feet. No alterations or evidence of mineralization was found in the shear zone.

Diamond-drill hole no. 12

Sandstone bed no. 1 is an 8-foot thick, dark red, fine-grained, porous, micaceous sandstone. No uranium, vanadium, or copper minerals were noted in the sandstone bed.

The cherty limestone cut in drill hole no. 10 is 4 feet thick with one foot of gray, red, dark red, and black chert at the bottom. The borehole counter recorded readings above background at the cherty limestone in this hole.

A shear zone of red and green clay was cut at a depth of 116 feet below the surface. The red clay has been altered to green clay but there is no other evidence of mineralization along the shear zone.

Conclusions

An analysis of the data obtained by diamond drilling and by geologic studies of the Shirley May uranium deposit near Garo, Colo., permits certain conclusions regarding the mineralization at this deposit, which also allows certain inferences regarding the future possibilities.

(1) A new sandstone (bed no. 2) that is a favorable host rock for uranium, vanadium, or copper ore bodies was found by diamond drilling. In drill holes no. 4 and no. 5, this bed contained 0.018 and 0.003 percent uranium, and 0.29 and 0.10 percent vanadium, respectively. The bed as exposed by 75 feet of trenching contains no uranium, vanadium, or copper minerals.

(2) Potential uranium ore bodies occur in two white sandstone beds (no. 1 and no. 3) within 120 feet vertically below the surface. The ore bodies previously mined probably do not extend down dip more than 50 feet.

(3) The area of known uranium mineralization is restricted to favorable parts of the sandstone beds within highly faulted areas. Analysis of the structural data suggests the discontinuity of the mineralized zones along strike and dip are related to faulting; however, the significance of faults in respect to the distribution of the uraniferous deposits is not known at present.

(4) It is possible that in sandstone beds no. 1, no. 2, and no. 3 there are other small mineralized areas that were not cut by the diamond-drill holes, but the cost of exploration and mining these bodies is economically prohibitive at this time.

(5) Extensive exploration of the three sandstone beds northwest and southeast of the Shirley May mine is not warranted, unless uraniferous material is discovered at the surface in these areas.

(6) The potential reserves of uranium-bearing rock have been calculated as less than 0.02 percent U_3O_8; however, some rock containing 0.1 or more percent uranium could be recovered by selective mining from ore bodies in pits no. 2 and no. 3.

POTENTIAL URANIUM RESERVES

The total gross production of uranium, vanadium, and copper ore (table 4) from the Shirley May mine is 231.9 tons valued at $4,136.31. Included in the 231.9 tons of ore produced is 52.24 tons of copper ore valued at $299.88; the remaining 179.66 tons of ore contained 593.31 pounds of uranium and 2,568.49 pounds of vanadium valued at $3,836.43.

Table 4. -- Recorded production of Shirley May mine, July 1, 1951 to July 15, 1952

	Weight (short tons)	U_3O_8 (percent)	V_2O_5 (percent)	Cu (percent)	U_3O_8 (pounds)	V_2O_5 (pounds)	Value (dollars)
	53.24			5.15			299.88
	30.40	0.13	0.23		78.51	141.23	433.69
	4.29	.20	.95		17.14	81.14	120.98
	21.53	.30	1.26		131.43	542.12	865.53
	7.35	.18	1.62		26.45	238.03	215.40
	7.66	.17	1.22		26.03	186.80	195.08
	36.54	.16	.83		120.27	609.18	807.30
	71.89	.13	.54		193.48	770.71	1,198.39
Totals	231.90	0.16*	0.72*		593.31	2,568.49	4,136.31

* Average grade

The largest potential uranium reserves are in sandstone bed no. 1 in pit no. 3. As is shown in figure 3 the dip of the footwall and the hanging wall of the sandstone bed converge downward near the west end of the pit indicating that the mineralized zone would pinch out at approximately 50 feet below the surface; at the east end of the pit the bottom of the ore-bearing part of the sandstone bed will be about 70 feet below the surface. Sandstone bed no. 1 at the surface west of pit no. 3 is not radioactive and drill-hole data indicate that this bed is not mineralized along strike at depth. Therefore, the potential uranium-vanadium-copper-bearing rock in sandstone bed no. 1 (fig. 2 and 3) extends from the reverse fault at the west end of pit no. 3 eastward to the northwest-trending fault at the east end of the pit. In cross section this block of uraniferous sandstone is roughly triangular, with the dip length on the footwall of the bed as the base of the triangle, and the altitude of the triangle as the width of the ore horizon at the surface. The average uranium content, 0.02 percent, was calculated using only the assays (table 1) of the samples from the localities shown on figure 2. The assays were weighted against the length of the sample. The data used in reserves calculations are given in table 5. The owner has shipped ore (table 4) of 0.13 to 0.30 percent U_3O_8, part of which was from pit no. 3; the ratio of this type of ore to total rock moved (1,300) is not available.

The total potential uranium reserves in the uranium-bearing sandstone bed no. 1 exposed in pit no. 1 are difficult to calculate because of the complexity of the structure in sandstone bed no. 1. At the north end of the pit the sandstone bed is not mineralized where exposed and according to Mr. Gaddis (oral communication) the old mine workings that extend some 40 feet north of the pit were driven in a "non-radioactive white sandstone bed"; this is probably an infaulted segment of sandstone bed no. 1. Thus the known potential uranium reserves are in an irregular-shaped fault block (fig. 3) of sandstone that is bounded on the northeast and southwest by vertical shear zones and extends northwestward for a total length of 110 feet. At depth the sandstone bed is cut off at approximately 20 feet below the bottom of pit no. 1 by the northeasternmost shear zone exposed in the pit. This block of uraniferous sandstone is roughly triangular in cross section and is estimated to have an average width of 6 feet at the surface for approximately 60 feet along the strike; it pinches out against faults at depth. The reserve calculations, allowing 12 cubic feet per ton of unbroken rock, are given in table 5. Above the bottom of the pit are two mineralized slabs of sandstone in small northwest-plunging rolls. These contain an estimated 25 tons of uranium-bearing sandstone. The average uranium content, 0.008 percent, was obtained by weighting the length of the samples shown on figure 3 against the chemical analysis. These samples represent material exposed in pit no. 1 in August 1952, but probably are not representative of the ore removed from this pit or of the rock assumed to be present below its bottom. The weighted average of all samples previously taken from this sandstone ore body was 0.07 percent uranium. Ore containing 0.11 to 0.30 percent U_3O_8 was recovered from the uranium-bearing sandstone in this by hand sorting; there are no records to show the proportion of this type of material to the total uraniferous sandstone.

Table 5.--Potential uranium reserves, Shirley May mine, Park County, Colorado

	Production (tons)	Length (feet)	Average width (feet)	Depth (feet) 1/	Volume (cubic feet)	Potential uranium reserves (tons)	Average grade U_3O_8 (percent)
Sandstone bed no. 1, pit no. 3	approx. 1,300	150	9	60	40,000	3,300	0.02
Sandstone bed no. 1, pit no. 1	approx. 6,000	60	6	20	3,600	300	0.008
Sandstone bed no. 2	0	360	4	10	14,000	1,200	0.01
Sandstone bed no. 3, pit no. 2	0	6	3	28	400	30	0.011
Totals	7,300					4,803	0.017

1/ Along the dip of the bed

The potential uranium reserves in sandstone bed no. 2 were calculated from diamond-drill hole data. Sandstone bed no. 2 is not mineralized where exposed at the surface; however, leaching by surface waters may have removed any uranium-vanadium or copper minerals. In drill hole no. 4, a 4-foot sample of core from sandstone bed no. 2 contains 0.018 percent U_3O_8 and 0.17 percent V_2O_5; and in drill hole no. 6

sandstone bed no. 2 is not mineralized. From these data it is apparent that sandstone bed no. 2 contains uranium, vanadium, and copper minerals between faults no. 3 and no. 4. Inasmuch as the structural characteristics of the mineralized zones in sandstone bed no. 2 are not known with certainty the reserves are calculated using an average width of 4 feet, and a length of 360 feet (fig. 2). The reserve calculations are given in table 5. The uranium content as determined from one drill hole core sample is 0.018 percent U_3O_8.

The potential ore reserves of sandstone bed no. 3 can be calculated only for the mineralized rock in pit no. 2. Although uranium and vanadium minerals have been mined along the strike for approximately 80 feet and an average width of 6 feet, the only visible uranium minerals in pit no. 2 are in a sandstone lens as much as 3 feet wide and 6 feet long on the hanging wall of sandstone bed no. 2. Three channel samples across this body contained 0.001, 0.006, and 0.037 percent uranium and have a weighted average of 0.011 percent uranium. Because the walls of the sandstone bed converge (fig. 3), the mineralized part of sandstone bed no. 3 is believed to pinch out at about 28 feet below the surface.

The potential uranium resources of the district cannot be calculated but, as indicated by drill holes nos. 4 and 5, concealed uranium-bearing deposits might be found northwest and southeast of the Shirley May mine, but the size and shape of the known bodies suggest these may be small and of low grade. It should be emphasized that uranium-bearing bodies might exist at any place in sandstone beds nos. 1, 2, and 3, but it is not economically feasible to explore for such bodies at the present time because of the lack of known geologic guides.

REFERENCES CITED

Anderson, T. P., 1950, Atomic Energy Commission Reconnaissance Rept. RR-29.

Gott, G. B., 1951, Garo uranium deposits, Park County, Colorado: U. S. Geol. Survey Trace Elements Memorandum Rept. 222.

Guilotte, G. B., 1944, Report of preliminary field reconnaissance of reported S-37 occurrences in eastern Colorado: Union Mines Development Corp. Rept.

King, R. U., 1951, U. S. Geol. Survey Trace Elements Preliminary Reconnaissance Rept. D-38.

Riley, L. B., 1946, Report on SOM occurrences near Garo, Park County, Colorado: Union Mines Development Corp.

Stark, J. T., et al., 1949, Geology and origin of South Park, Colorado: Geol. Soc. America Mem. 33.