Radiometric Reconnaissance in the Garfield and Taylor Park Quadrangles, Chaffee and Gunnison Counties, Colorado

By M. G. Dings and Max Schafer

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RADIOMETRIC RECONNAISSANCE IN THE GARFIELD AND TAYLOR PARK QUADRANGLES, CHAFFEE AND GUNNISON COUNTIES, COLORADO*

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M. G. Dings and Max Schafer

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*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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RADIOMETRIC RECONNAISSANCE IN THE GARFIELD AND TAYLOR PARK QUADRANGLES, CHAFFEE AND GUNNISON COUNTIES, COLORADO

by M. G. Dings and Max Schafer

ABSTRACT

During the summer of 1952 most of the mines and prospects in the Garfield and Taylor Park quadrangles of west-central Colorado were examined radiometrically by the U. S. Geological Survey to determine the extent, grade, and mode of occurrence of radioactive substances.

The region contains a relatively large number of rock types, chiefly pre-Cambrian schists, gneisses, and granites; large and small isolated areas of sedimentary rocks of Paleozoic and Mesozoic ages; and a great succession of intrusive rocks of Tertiary age that range from andesite to granite and occur as stocks, chonoliths, sills, dikes, and one batholith. The prevailing structures are northwest-trending folds and faults. Ores valued at about $30,000,000 have been produced from this region. Silver, lead, zinc, and gold have accounted for most of this value, but small tonnages of copper, tungsten, and molybdenum have also been produced. The principal ore minerals are sphalerite, silver-bearing galena, cerussite, smithsonite, and gold-bearing pyrite and limonite; they occur chiefly as replacement bodies in limestone and as shoots in pyritic quartz veins.

Anomalous radioactivity is uncommon, and the four localities at which it is known are widely separated in space. The uranium content of samples from these localities is low. Brannerite, the only uranium-bearing mineral positively identified in the region, occurs sparingly in a few pegmatites and in one quartz-beryl-pyrite vein. Elsewhere radioactivity is associated with (1) black shale seams in the Manitou dolomite, (2) a quartz-pyrite-molybdenite vein, (3) a narrow border zone of oxidized material surrounding a small lead-zinc ore body in the Manitou dolomite along a strong fault zone.

INTRODUCTION

A reconnaissance radiometric survey of the Garfield and Taylor Park quadrangles in the Sawatch Range of west-central Colorado (fig. 1) was made by M. G. Dings and Max Schafer of the U. S. Geological Survey from early June to late August, 1952. This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. A brief preliminary report on this work has been submitted (Dings, 1952).

The types of deposits examined are described on the following pages. The deposits and areas that were selected for radiometric reconnaissance were determined by the senior author's previous investigations for the Geological Survey in the Garfield quadrangle between 1947 and 1951. The radiometric coverage (pls. 1, 2) although not complete, is extensive, and it is believed to be adequate to show the general degree of radioactivity of the various types of deposits. The only large area in the Garfield quadrangle that was not examined for radioactivity is in the northeast part of the quadrangle between Browns and Chalk Creeks. This area was not visited because it is known to contain only a few weakly mineralized veins that could only be reached and adequately examined by establishing base camps. In the Taylor Park quadrangle the few mineral deposits that are known are widely distributed and, as a rule, mines located on these deposits have yielded only a relatively small tonnage of ore.

Very little geologic work has been done in the Taylor Park quadrangle, and the only geologic map available to the writers was the Geologic Map of Colorado (Burbank, et al., 1935) on a scale of 1:500,000. In the Garfield quadrangle an unpublished report (Dings and Robinson) and an open file

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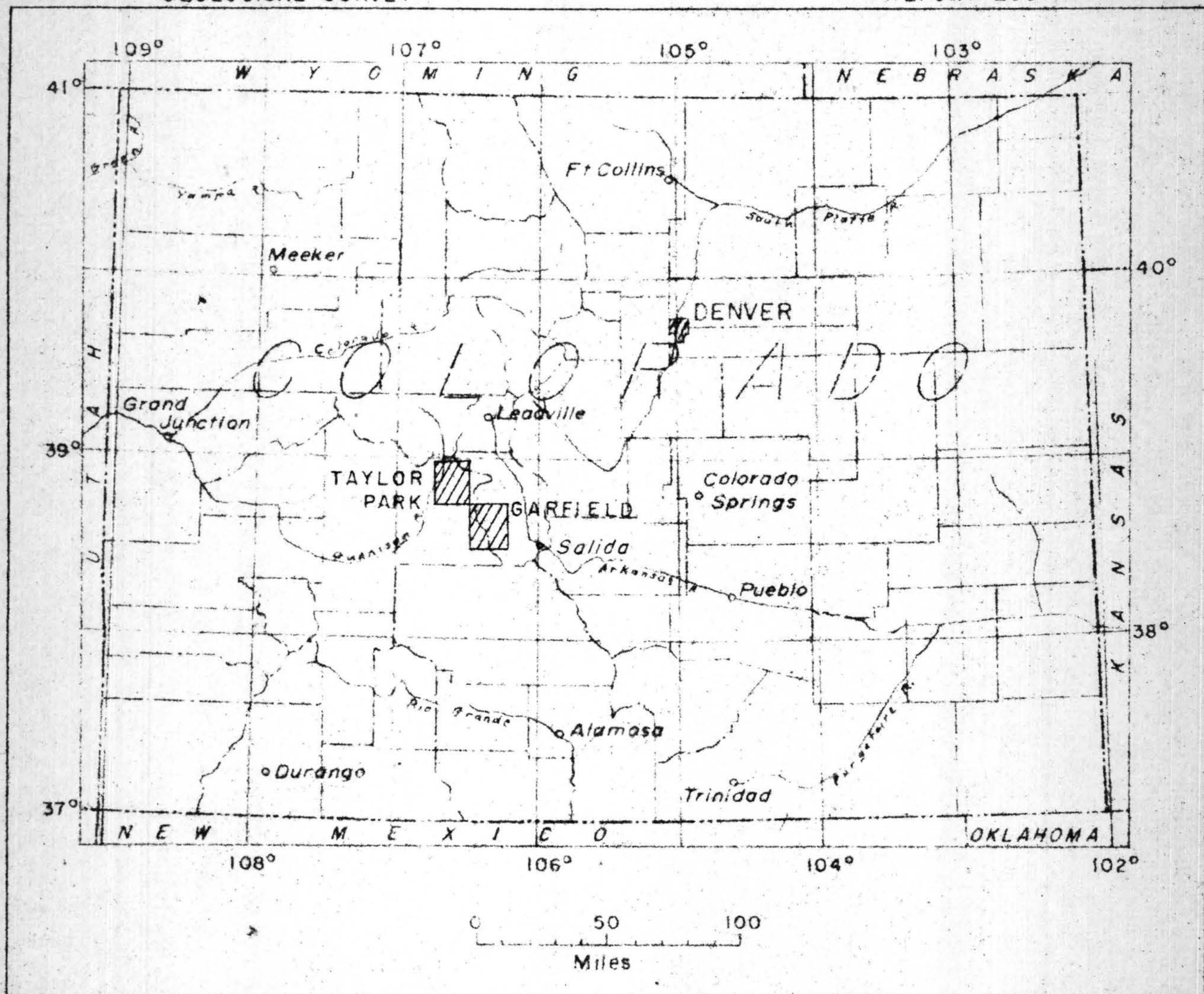

FIGURE I.- INDEX MAP OF COLORADO SHOWING LOCATION OF GARFIELD AND TAYLOR PARK QUADRANGLES.

report (Dings, Robinson, and Brock, 1952) furnished geologic data and base maps for the radiometric survey. The discussion of the geology and ore deposits that follows is largely based upon field work done between 1947 and 1951.

GENERAL GEOLOGY

Pre-Cambrian metamorphic and igneous rocks are exposed in the eastern half of the Taylor Park quadrangle and in the southeastern, central-western, and northwestern parts of the Garfield quadrangle (pl. 1). The metamorphic rocks--quartz-mica schist, quartz-hornblende schist, quartz-hornblende gneiss, and granite gneiss--are intruded by gneissoid granite, hornblende diorite, Pikes Peak granite, and a granite tentatively correlated with the Silver Plume granite.

Sedimentary rocks of Paleozoic age are present in large and small areas in the southern and western parts of the Garfield quadrangle (pl. 1) and in the western part of the Taylor Park quadrangle. The Paleozoic formations, from oldest to youngest, comprise the Sawatch quartzite (Upper Cambrian), Manitou dolomite (Lower Ordovician), Harding sandstone (Middle Ordovician), Fremont dolomite (Upper Ordovician), Chaffee formation (Upper Devonian), Leadville limestone (Mississippian), Belden shale (Pennsylvanian), and the Minturn formation (Pennsylvanian and Permian(?)). In the Garfield quadrangle the Pennsylvanian and Permian (?) beds account for about 5,100 feet of the maximum thickness of about 6,300 feet of Paleozoic beds; in the Taylor Park quadrangle the thickness of the Pennsylvanian and Permian (?) beds is probably somewhat greater than in the Garfield quadrangle. Mesozoic formations are restricted to a few square miles in the southwest corner of the Garfield quadrangle (pl. 1), where the Morrison formation (Upper Jurassic) rests on rocks of pre-Cambrian age and is overlain successively by the Dakota sandstone (Upper Cretaceous) and the lower part of the Mancos shale (Upper Cretaceous).

A great succession of intrusive rocks of Tertiary age (probably Paleocene to Oligocene) occupy a large part of the Garfield quadrangle (pl. 1), where they occur as stocks, chonoliths, sills, dikes, and one batholith, the Princeton. The rocks range in composition from that of a rhyolite to that of an andesite, although by far the greater number are of the composition of a quartz monzonite. The main period of igneous activity culminated in volcanic and flow breccias. In the Taylor Park quadrangle the igneous rocks of Tertiary age are generally small bodies of quartz monzonite that are widely separated in space.

Although they are not shown on the simplified geologic map of the Garfield quadrangle (pl. 1), Quaternary deposits, chiefly of glacial moraine and glacio-fluvial material, are widespread. Quaternary deposits blanket a large area east of Taylor Reservoir (pl. 2), and north of the reservoir they form a wide belt bordering Taylor River and Texas and Italian Creeks.

The prevailing structure in the pre-Cambrian rocks--gneisses and schists--is a northwest-trending series of open folds that formed chiefly during the pre-Cambrian. The dominant foliation strikes northwest. The structure of the sedimentary rocks, particularly those of Paleozoic age is complex. Although in most areas the Paleozoic rocks have been faulted, eroded to a series of discontinuous patches, and in many places invaded by large intrusive bodies, enough of them remain to show the dominant northwest trend of the folds and the faults. Both folding and faulting in the sedimentary rocks are related to the Laramide orogeny. The principal fault is a northwest-trending, northeast-dipping thrust fault, the Tincup fault, that extends through the Garfield and Taylor Park quadrangles. This fault has a probable displacement of several miles in the northern part of the Garfield quadrangle. Between the Tincup and Tomichi mining districts a large part of this fault has been followed and obliterated by intrusion of the Princeton batholith (pl. 1). The prevailing structural trends in the Tertiary intrusions are northwest, northeast, and north.

The Princeton quartz monzonite is the only Tertiary intrusive that caused widespread and pronounced contact metamorphic (pyrometasomatic) effects in the Paleozoic sedimentary rocks. In places, limestone and dolomite strata have been altered to marble for as much as 1½ miles from the outcrop of the batholith. As a rule, argillite, hornfels, quartzite, and lime-silicate rocks are developed close to the batholith intrusive.

ORE DEPOSITS

The ore bodies in the Taylor Park quadrangle are similar to those in the Garfield quadrangle (Dings and Robinson). The deposits in Taylor Park, however, are far less varied mineralogically, and only pyritic quartz veins and replacement bodies in dolomite have been mined on a commercial scale.

Three periods of ore deposition probably of Tertiary age, are correlated with the magmas that in part formed the Princeton batholith, the Antero stock,--a granite stock in the northeast part of the Garfield quadrangle-- and a volcanic breccia body in the central part of the Tomichi mining district. The ore deposits related to the Princeton quartz monzonite are most widespread and of greatest economic importance. The ore deposits can be divided into four main classes: (1) replacement deposits, (2) vein deposits, (3) magnetite deposits, and (4) beryl-bearing pegmatites and greisen. The replacement and vein deposits account for about 99 percent of the total value of all ore that has been produced in the Garfield quadrangle. The value of ores produced from the vein deposits, largely because of the output from a few mines in the Chalk Creek district, is nearly equal to that produced from the replacement deposits.

Replacement deposits

The replacement deposits, which are genetically related to the magma that in part formed the Princeton batholith, occur in sedimentary rocks—chiefly dolomite and limestone of the Manitou and Leadville formations. Some rich deposits are localized along pre-mineral faults, and others, generally of lesser economic importance, are in bedded or irregular forms. The principal primary sulfide ore minerals are silver-bearing galena, gold-bearing pyrite, sphalerite, and chalcopyrite. Cerussite, smithsonite, gold, silver, cerargyrite, calamine, anglesite, and secondary copper minerals are the main ore minerals in the oxidized zone. The gangue is chiefly calcite, dolomite, limonite, and quartz.

Vein deposits

The veins are separated, according to the characteristic minerals, into the following groups: pyritic quartz, quartz-hubnerite-molybdenite, quartz-fluorite, and quartz-beryl-pyrite. The quartz-hubnerite-molybdenite and nearly all of the pyritic quartz veins are genetically related to the magma that in part formed the Princeton batholith, whereas the quartz-beryl-pyrite veins are genetically related to the Antero stock, and the quartz-fluorite veins are genetically related to the volcanic breccia.

Of the vein deposits only the pyritic quartz veins are of significant economic importance because they are the most abundant and contain nearly all of the gold, silver, lead, zinc, and copper. These veins are chiefly in fissures in the Princeton quartz monzonite along a prominent zone that extends from upper Tomichi Valley northeast almost to the corner of the quadrangle, a distance of about 13 miles. Most of the pyritic quartz veins strike north to N. 35° E. and dip generally from 50° to 90° to the west. They range in length and thickness from stringers a few feet long and a fraction of an inch thick to veins about a mile long and 10 feet thick, although the largest number of veins on which prospecting has been done are 500 to 1,000 feet long and 1 to 3 feet thick. Both oxidized and primary sulfide ores occur in the pyritic quartz veins. The mineralogy of the veins, although varying locally, is almost identical to that for the replacement bodies except the gangue is chiefly quartz rather than calcite and dolomite.

The quartz-hubnerite-molybdenite veins are relatively short and narrow and are restricted to a few square miles in the northwestern part of the quadrangle. In addition to quartz, hubnerite, and molybdenite, pyrite, chalcopyrite, tetrahedrite, sphalerite, galena, scheelite, and secondary copper minerals occur locally in moderate abundance.

The quartz-fluorite veins are chiefly concentrated in the Brittle Silver Basin area in the northern part of the Tomichi district (pl. 1). Sparingly distributed along parts of the veins are pyrite, galena, sphalerite, and rarely, chalcopyrite.

The quartz-beryl-pyrite veins, which are near the east-central border of the quadrangle (pl. 1), are the least common of all classes of veins. The principal vein of this group is the California vein which contains, in addition to beryl, pyrite, and quartz, a variety of other minerals, such as molybdenite, fluorite, wolframite, magnetite, topaz, rutile, tourmaline, and brannerite (Adams, 1953).

Most veins are bordered by a zone of altered country rock. In general silicified and pyritized rock borders the veins; beyond this is a zone characterized by sericite and hydromica which grades outward into chloritized quartz monzonite. Alteration is most intense adjacent to the pyritic quartz veins of the Chalk Creek district. The width of the altered zones is variable but along many veins it is roughly proportional to the width of the vein. The alteration, believed to be genetically related to the Princeton batholith, was developed prior to the introduction of the vein material.

Magnetite deposits

The third main class of ore bodies--magnetite deposits--are mainly in limestone and dolomite beds at or near their contact with the Princeton batholith. Most are small bodies that contain magnetite, limonite, and some hematite, and are associated with typical skarn minerals, such as garnet, epidote, and diopside. A few carry recoverable amounts of gold, silver, and copper.

Beryl-bearing pegmatites and greisen

Chiefly of scientific interest is the occurrence of beryl in pegmatites, miarolitic cavities, greisen, and the Antero granite, in the Browns Creek area at the eastern border of the quadrangle. These bodies contain an assemblage of beryl, phenacite, quartz, orthoclase, microcline-perthite, albite, fluorite, muscovite, brannerite, and a few other minerals, and are genetically related to the Antero granite.

Zoning of deposits

The only evidence found of zoning of ore deposits in the Garfield quadrangle is in the Tincup and Quartz Creek mining districts where the relatively high-temperature hubnerite-molybdenite veins are bordered by gold, silver, lead, and zinc deposits, which are characteristic of somewhat lower temperatures.

Structural and stratigraphic control

Several types of structures have governed localization of ore bodies, particularly in the sedimentary beds. Likewise, some stratigraphic zones, such as the Manitou dolomite and beds in the upper part of the Leadville limestone, were especially favorable host rocks for replacement deposits, and in places a combination of stratigraphic and structural control is evident. Some of the largest and richest ore bodies are in favorable stratigraphic zones adjacent to and in pre-mineral faults of moderate displacement. Small faults, particularly bedding slips, have localized many of the smaller ore bodies. Minor concentrations of ore occur along the axes of small folds.

DEPOSITS WITH ANOMALOUS RADIOACTIVITY

No anomalous radioactivity was found in the Taylor Park quadrangle, and only a few weakly radioactive deposits, which are described below, occur at widely spaced intervals in the Garfield quadrangle. The locations of these deposits are shown on plate 1.

Madonna mine

The Madonna mine is half a mile south of Monarch on the steep northwest slope of Monarch Ridge. It is owned by the Utze Lode Company, of which Harold R. Koster of Salida, Colo. is treasurer and mine manager. The mine was discovered in 1878 and has been worked intermittently since that time, although most of the production was during the period 1883-1894. The total value of the Madonna ore has been about $6,000,000 of which lead accounts for about $3,575,000, silver $1,430,000, zinc $735,000, gold $225,000, and copper $35,000.

The mine workings consist of seven adit levels, eight intermediate levels, many raises and winzes, and at least 12,000 feet of drifts and crosscuts. The vertical distance from the highest to lowest (384-foot sublevel) ore bodies is about 1,525 feet. Most of the upper mine workings, which yielded nearly all of the ore, have been largely or entirely inaccessible for the past 35 years. Access to the mine and haulage of ore in recent years has been from level 6, the portal of which is only a short distance above the valley floor. An internal shaft from level 6 extends to the 230-, 305-, and 384-foot sublevels (Dings and Robinson, 1953, pl. 15). In September 1952, the shaft was being deepened and had reached a depth of about 600 feet below level 6.

The mine workings are chiefly in the Manitou dolomite, which rests unconformably on granite of pre-Cambrian age. The rocks are folded and faulted on both a large and small scale; most, if not all, deformation occurred prior to the introduction of the ore-bearing solutions. The main structure is the Madonna fault (reverse type) which strikes northwest and at most places dips steeply southwest. The fault has a maximum displacement of about 300 feet.

The ore shoots border and are contained in the Madonna fault, chiefly in the Manitou dolomite of the northeast (footwall)side of the fault. Nearly all of the ore mined to date has been oxidized. The principal ore minerals are cerussite, smithsonite, calamine, cerargyrite, free gold, argentite, residual grains of silver-bearing galena, and malachite. The gangue is chiefly limonite, locally accompanied by limestone, dolomite, granite, quartz, and, in the lower workings, pyrite.

The only marked anomalous radioactivity is associated with a small ore body that has been stoped on the 384-foot sublevel. This body measures about 15 feet in length, 6 feet in breadth, and 3 feet in thickness, and lies in the Madonna fault. The ore minerals consist chiefly of pyrite, galena, and some sphalerite. Bordering, and in places within, the mass is oxidized ore, chiefly smithsonite, as well as calcite and sparse chlorite. No radioactive minerals have been specifically identified, but radioactivity is most pronounced in porous oxidized material bordering the primary sulfides. According the Allan G. King of the Survey, the uranium occurs in the carbonate gangue and galena in small amounts and in the chlorite in greater but still minor amounts. Most of the radioactive material was found on part of the mine dump at the portal to the adit of level 6. This material is very reliably reported to have come from the 384-foot sublevel, and this is further substantiated by its similarity to radioactive rock seen by the writers on the 384-foot sublevel. Table 1 shows the results of the analyses of both radioactive rock and the sulfide ore from this stope. The average uranium content of the selected material is about 0.05 percent. The primary sulfide ore is very weakly radioactive, averaging 0.004 percent equivalent uranium. The radioactive material is secondary and was probably deposited by surface waters that caused the partial oxidation of the sulfide ore body.

Silent Friend mine

The Silent Friend mine is in the Quartz Creek mining district, half a mile southwest of the mouth of Halls Gulch on the steep east slope of the mountain about 1,000 feet above North Quartz Creek (pl. 1). A very indistinct trail from Halls Gulch leads to the mine. The Silent Friend mine was first worked in the late 70's or early 80's, and the last work of any consequence was in 1890. The total tonnage of ore produced is not known; the ore reportedly contained silver and lead.

Entrance to the mine, which has been caved for many years, was by an incline bearing northwest, and reported to be 300 to 400 feet long. The size of the dump indicates a moderate amount of underground workings, probably the equivalent of about 2,000 feet of tunnel. The ore occurred in the Manitou dolomitic limestone bordering a northwest-trending reverse fault which is a few hundred feet west of the mine entrance (pl. 1). The ore shipped consisted chiefly of silver-bearing galena, a little gold-

Table 1.--Equivalent uranium and uranium, Madonna mine, Monarch, Colorado*

Sample No.	Location	Description	Equivalent uranium (percent)	Uranium (percent)
52-MD-2	On dump northwest of office building at portal to no. 6 adit	Selected chips of strongest radioactive material	0.11	0.15
52-MD-14	do.	Large pieces of selected radioactive material	0.099	0.080
52-MD-17	do.	Grab sample of radioactive material	0.023	0.022
52-MD-15	Separate dump on road to ore bin west of portal to no. 6 adit	Grab samples of primary sulfide "ore"	0.004	N.D.
52-MD-16	384-foot sublevel	Chip sample across width of mineralized body	0.014	0.012

* U. S. Geological Survey Trace Elements Laboratory, Denver, Colo.

bearing pyrite, and minor amounts of cerussite and anglesite. Some ore on the dump contains, in addition to the minerals above, considerable light green and brown sphalerite, chalcoyprite, secondary copper stains, and a little tetrahedrite, all in a quartz and calcite gangue.

The only anomalous radioactivity occurs in dark shale seams in the Manitou dolomite that are a quarter of an inch or less in thickness. The radioactive material--a small amount of limestone with numerous shale seams--is chiefly on the southeast side of the mine dump. Some of the seams are slickensided, which suggests that they came from near the reverse fault and probably close to the main mineralized zone. As a rule, shale seams are uncommon in the Manitou dolomite of this region. According to Allan G. King of the Geological Survey, autoradiographs show that the uranium occurs almost entirely within the black shale, which contains carbonaceous material of an undetermined nature. The identity of the radioactive mineral, or minerals, is not known, and it is notable that no other ore minerals occur in the radioactive shale nor in the fragments of country rock bordering the seams. Numerous traverses in this general area, with special attention to the trace of the fault, failed to disclose any additional anomalous radioactivity.

Table 2 furnishes the results of the analyses of radioactive material from the mine dump.

The radioactive material is probably of secondary origin. Radioactive material at a higher level was probably brought into solution by surface waters and carried downward along the fault zone and precipitated by the carbonaceous shale.

Table 2.--Equivalent uranium and uranium, Silent Friend mine, *
North Quartz Creek, Garfield quadrangle, Colorado

Sample No.	Location	Description	Equivalent uranium (percent)	Uranium (percent)
52-MD-5	Mine dump.	Shale seams in dolomitic limestone	0.038	0.038
52-MD-6	do.	Selected pieces of radioactive shale free of limestone wall rock	0.089	0.067

* U. S. Geological Survey Trace Elements Laboratory, Denver, Colo.

Bon Ton mine

The Bon Ton mine is in the Quartz Creek mining district about 5 miles south of Tincup. During the past 50 years the mine has yielded a little less than 2,000 tons of crude ore with values chiefly in silver, lead, copper, and gold. A few tons of molybdenum ore were produced during World War I. Little or no ore has been mined for the past 30 years. The mine is owned by Mr. A. L. Pearson of Pitkin, Colo.

The entrance to the mine has been caved for several years. The underground workings consist of approximately 600 feet of crosscuts, 700 feet of drifts, and 300 feet of stoping that extends upward along the dip of the vein for a maximum distance of about 50 feet.

The vein is about 600 feet long and $2\frac{1}{2}$ - 5 feet thick; it strikes N. 65° E. and dips 38° - 63° SE. The vein filling is chiefly quartz and pyrite, locally accompanied by chalcopyrite, molybdenite, galena, silver and gold. The country rock is pre-Cambrian gneissic granite.

The only anomalous radioactivity found was in weakly mineralized gangue on the mine dump. The small, weakly radioactive part of the dump is south of, and 25 feet lower than, the mine entrance. A grab sample (52-MD-10) across this area contained only 0.002 percent equivalent uranium. No radioactive mineral, or minerals, could be identified nor could unusually high radioactive patches be isolated within the mass.

Mt. Antero region

The Mt. Antero region, which lies largely within the northeast part of the Garfield quadrangle, was not visited during the course of the present investigation. The radioactive mineral, brannerite, however, had previously been identified from this region by Adams (1953). It occurs locally and in very minor quantities in beryl-rich pegmatites and greissen, and in the California vein associated with pyrite, molybdenite, beryl, and other minor constituents in a quartz gangue. It is notable that all of these beryl bodies are closely related in space and are with little doubt genetically related to the magma that in part formed the albite-rich Antero granite.

GEOLOGIC FACTORS BEARING ON RADIOACTIVE DEPOSITS

The results of this investigation show that the few radioactive deposits found are small, widely distributed, and low in grade. The four radioactive deposits that have been discovered to date in this region are in the Garfield quadrangle which, by comparison, is far more richly mineralized than the Taylor Park quadrangle. In turn, it is noteworthy that both Garfield and Taylor Park are in a part of the Northeast Mineral Belt of Colorado that has been far less productive of metals than other parts, such as Leadville, Idaho Springs, Central City, and the tungsten region around Nederland.

The Garfield and Taylor Park quadrangles contain many geologic features which should, locally at least, favor the occurrence of significant radioactive deposits. Among these features are a wide variety of structures, rock types, mineral assemblages, several ages of mineralization, and many intrusives of pre-Cambrian and Tertiary ages. The absence of significant radioactivity is therefore probably due entirely, or in large part, to an inherently low radioactive content to the ore-bearing solutions. Three of the four radioactive occurrences are associated with mineralization that is genetically related to the Princeton quartz monzonite batholith, and the other occurrence (brannerite in the Mt. Antero region) is related to the Antero granite stock, which is an alkaline rock rich in albite.

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RESOURCE DATA

The known reserves, which are very small, are given below.

Uranium reserves at the Madonna, Silent Friend, and Bon Ton mines, Garfield quadrangle, Colorado

Mine	Reserves (tons)	Uranium (percent)	Equivalent uranium (percent)	Average of selected material (percent)	
Madonna	1/2	0.012 - 0.150		0.05	U
Silent Friend	1/2	0.038 - 0.067 (hand-sorted)		0.05	U
Bon Ton	25		0.002	0.002 (±)	eU
Total	26				

PLANS FOR FURTHER FIELD WORK

No further field work pertaining specifically to a search for radioactive materials in this region is planned nor is it warranted unless some unforeseen and additional deposit of markedly higher radioactivity is discovered.